Plate Heat Exchanger Fundamentals

By

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3D INTERACTIVE MEDIA

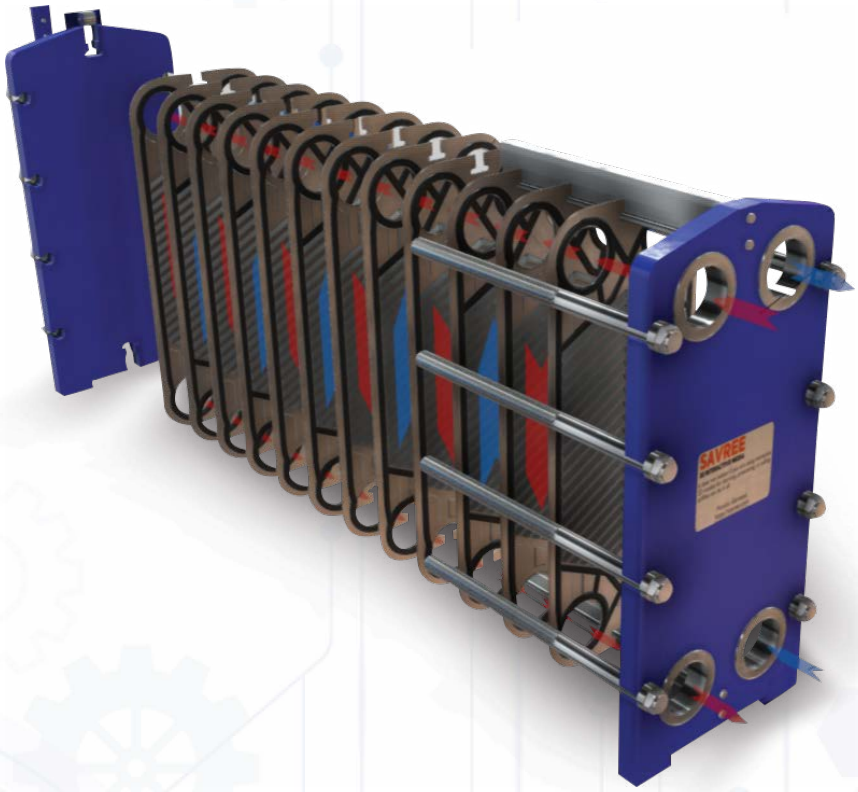

Plate Heat Exchanger

» Handbook

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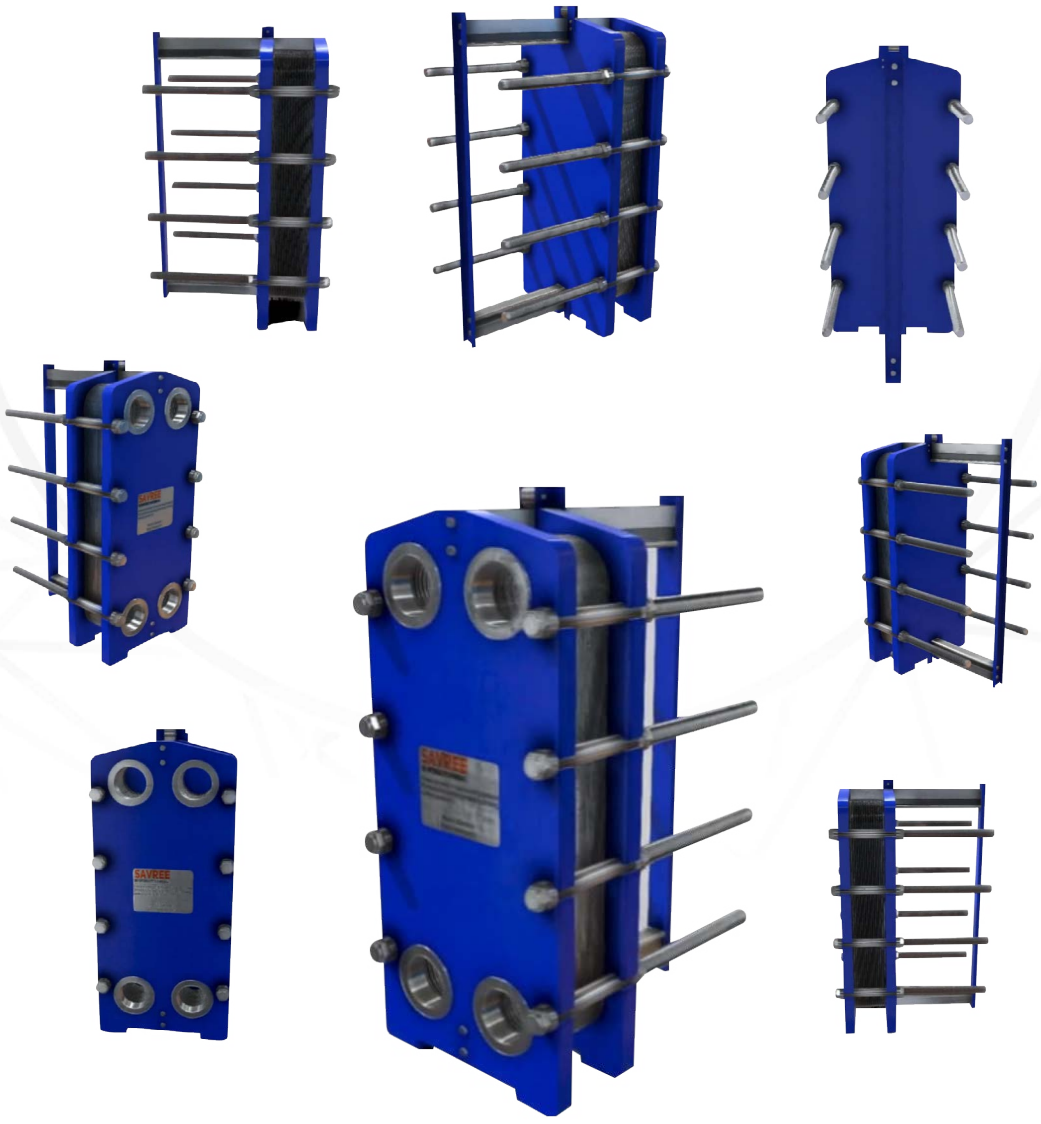
CONTENT

INTRODUCTION

Plate heat exchangers are one of the most common types of heat exchanger employed today; the other common type of heat exchanger is the **shell and tube heat exchanger**. The **spiral heat exchanger** is also used for industrial applications, but its use is minor compared to the other two types of heat exchanger.

Plate heat exchangers have gained widespread application throughout the engineering world because they are **efficient**, **robust** and **relatively easy to maintain**.



ASSEMBLED PLATE HEAT EXCHANGER

PLATE HEAT EXCHANGER (PHE) COMPONENTS

Plate heat exchangers consist of relatively few parts. Because plate heat exchangers are used for transferring heat, they require **inlets** and **outlets** where the flowing mediums -or **fluids**– can enter and leave the heat exchanger. **A fluid may be a liquid or a gas**. As fluids are often assumed to be liquid only, we will use the term **flowing medium** to avoid confusion.

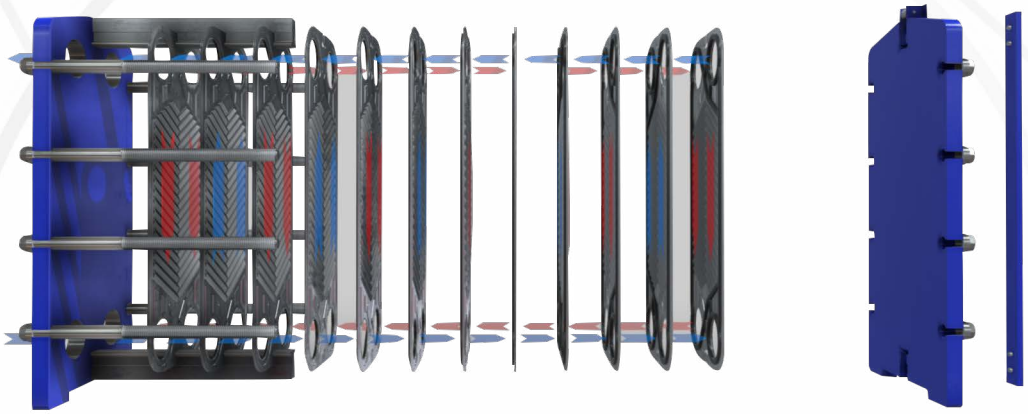


PLATE HEAT EXCHANGER (EXPLODED VIEW)

Gaskets and **plates** are used to separate the flowing mediums and prevent them mixing; gaskets are adhered to one side of each plate only. The plates hang upon a **carry bar** and are pressed together using **clamping bolts**. When the plates are compressed together, they are referred to as a '**plate stack**'. A **guide bar** ensures the plates are aligned correctly when the plate stack is opened and closed.

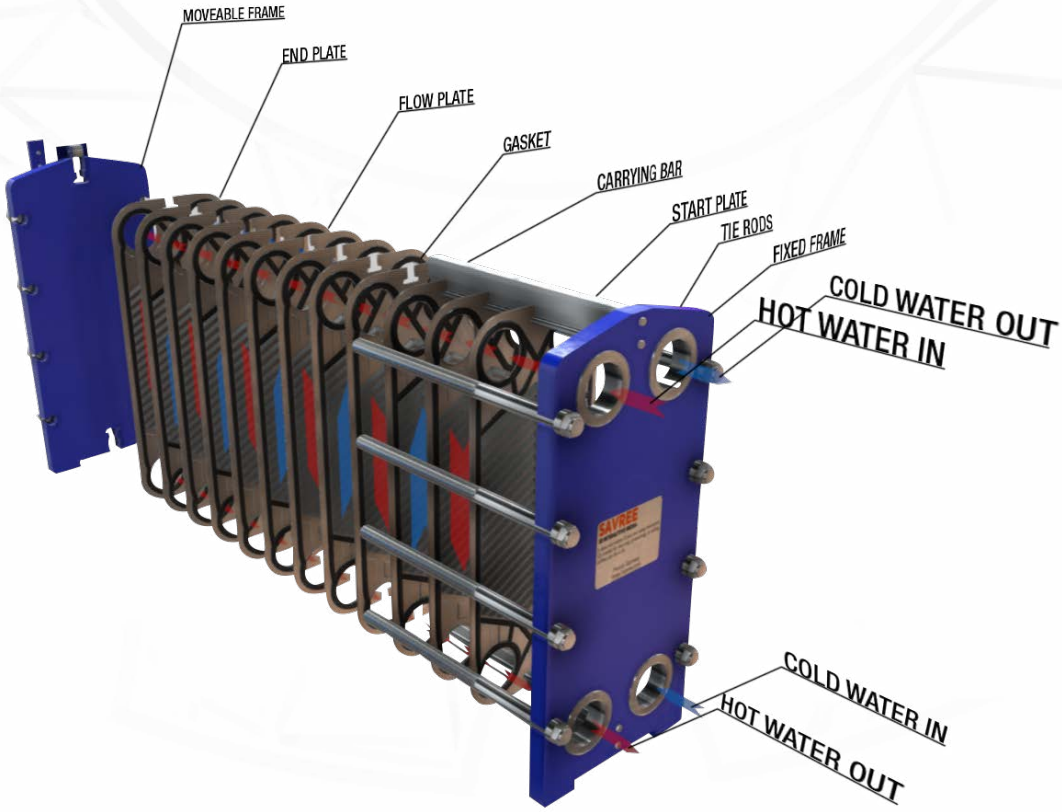
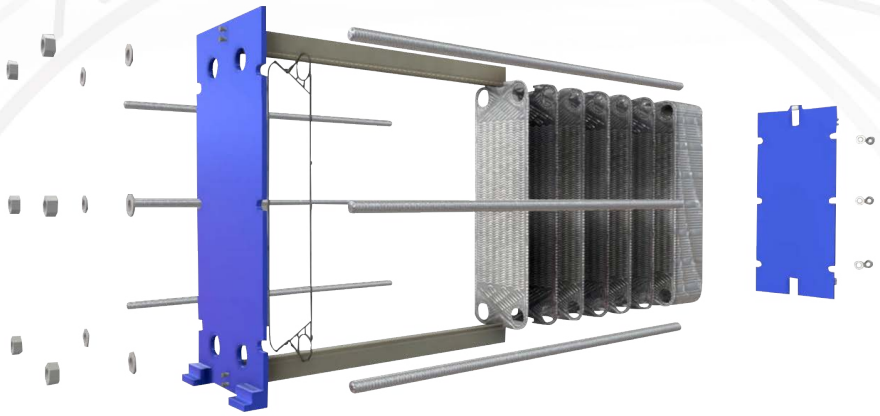


PLATE HEAT EXCHANGER COMPONENTS

The final components of interest are the two covers at opposite ends of the plate stack. One cover is movable whilst the other is fixed. The **movable cover** and **fixed cover** are also sometimes referred to as the **frame plate** and **pressure plate**. Note that the inlets and outlets are mounted to the fixed cover only.



PHE EXPLODED VIEW

HOW PLATE HEAT EXCHANGERS WORK

Throughout this article, we will assume a hypothetical plate heat exchanger has two flowing mediums, one is cold and the other is hot. The hot medium needs to be cooled by the cold medium, and this will occur in the plate heat exchanger.

The hot medium enters the heat exchanger through the hot medium inlet. **Gaskets direct the hot medium as it flows through the heat exchanger**. Each plate has an **alternating gasket pattern**. The hot medium flows into the space between a pair of plates, but does not flow into the space between the next pair of plates because the gaskets prevent this. The process continues so that each second set of plates is filled with the hot flowing medium.

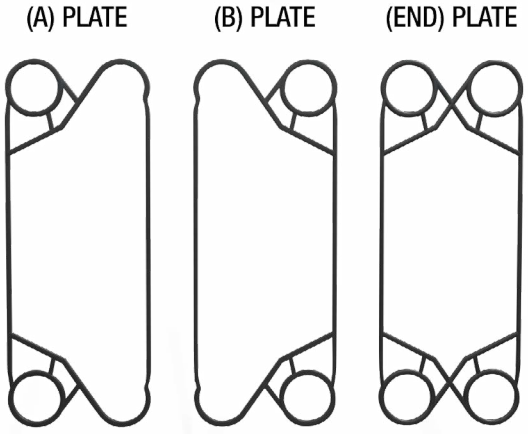
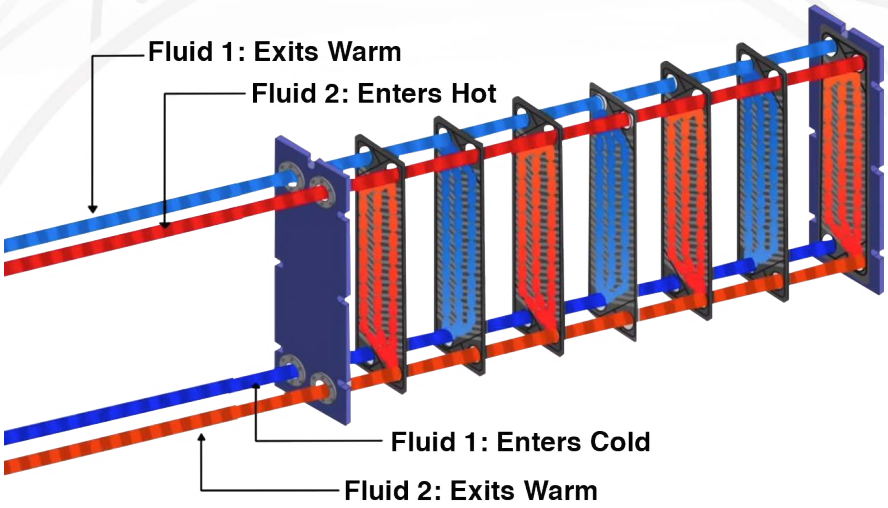


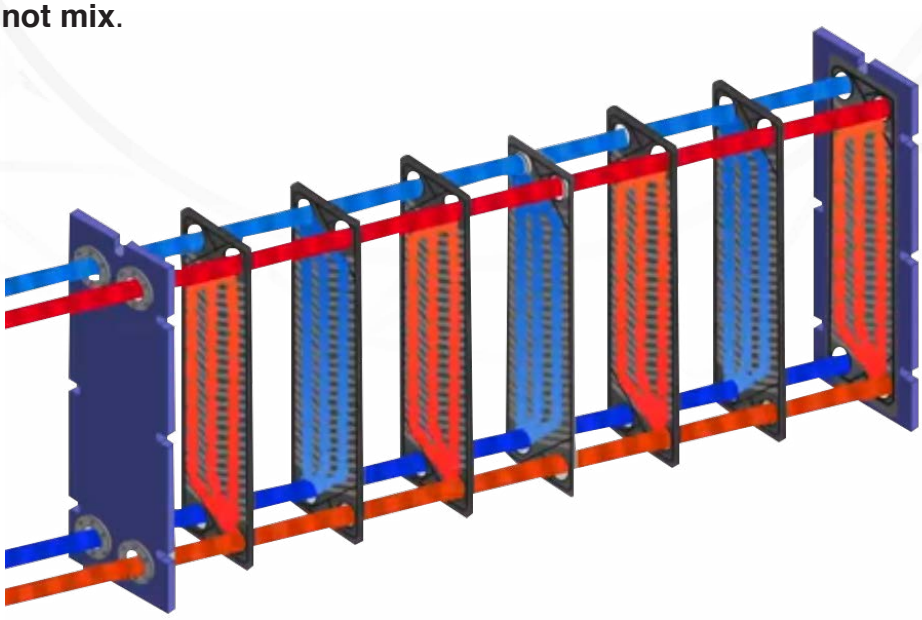
PLATE HEAT EXCHANGER PLATE GASKETS

At the same time, the cold medium enters the heat exchanger through the cold medium inlet, but this time, the gaskets are positioned to allow the cold medium to flow into the space where no hot medium is present. The heat exchanger is now full of both hot and cold flowing mediums. Each medium flows out of its associated outlet and the process is continuous.



FLUID FLOW THROUGH PHE

Notice that the two flowing mediums are always adjacent to each other throughout the heat exchanger. The flowing mediums thus have a hot, cold, hot, cold, flow pattern, as they flow through the heat exchanger. Both flowing mediums are completely separated from each other by the gaskets and plates, **they do not mix**.



ALTERNATING COLD/HOT PATTERN

Due to the close proximity of the flowing mediums, heat is exchanged between them. The hot medium heats-up the plate and the plate passes some of this heat to the cold flowing medium; thus the hot medium temperature decreases whilst the cold medium temperature increases.

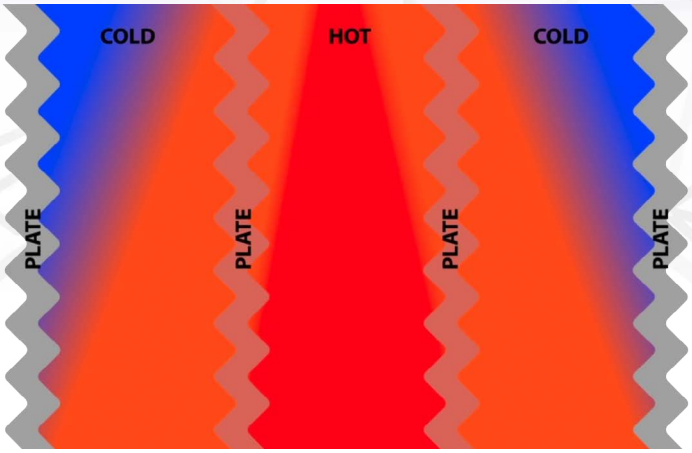
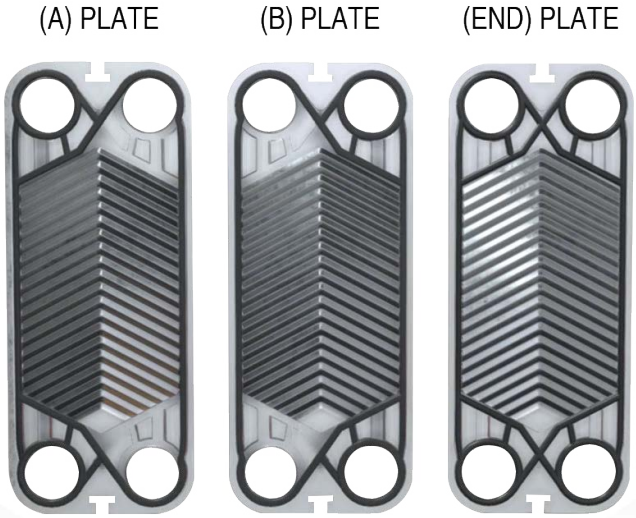


PLATE HEAT TRANSFER

PLATE HEAT EXCHANGER DESIGN

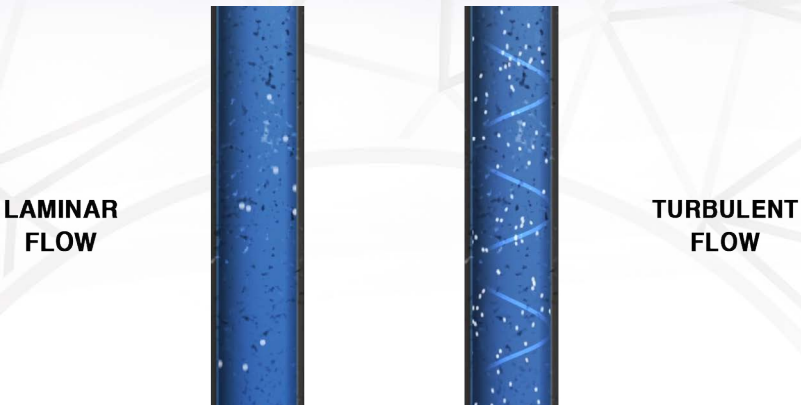
The plates are the main reason plate heat exchangers are so efficient.



PHE PLATES

The plates on a plate heat exchanger may appear to have a simple design, but each plate is full of interesting engineering design features. For example:

- When the plates are compressed together to form a plate stack, **the gap between each of the plates is very small**, which ensures good thermal contact between the two flowing mediums. The gap between the plates is also known as '**clearance**'.
- **Plates are thin** and have a **large contact surface area**, which gives each plate a high heat transfer rate.
- Plates are manufactured from **a material with high thermal conductivity**, which further increases the heat transfer rate.
- **Corrugations** on the plate surfaces **prevent laminar flow and promote turbulent flow**, which increases the heat transfer rate whilst also **reducing the likelihood of deposits accumulating upon the plate surfaces**.



LAMINAR AND TURBULENT FLOW

- The corrugations also serve to stiffen the plate structure, which **allows a thinner plate to be used** compared to a plate that has no corrugations. Note that plate corrugations are sometimes referred to as having a '**herringbone**' pattern.

CORRUGATED HERRINGBONE PATTERN

The plates are not the only part of a plate heat exchanger with extensive design features, the gaskets also have interesting design features:

- Gaskets are able to maintain a seal between the plates even when the system pressure and temperature varies.
- Holes in each gasket -known as **telltales**– are used to **identify leaking gaskets**. This feature allows operators to change the affected plate before the leaking medium leaks through the next gasket and contaminates the other flowing medium.

PLATE HEAT EXCHANGER TELLTALE

- Because the gaskets guide flow through the heat exchanger, it is essential they be installed in the correct order. For this reason, **gaskets are often fitted with markings** so that operators can check each plate is installed in the correct order throughout the entire plate stack. Another way of ensuring the order of the plate stack is correct, is to **spray paint a diagonal line across the entire plate** stack when it is assembled.

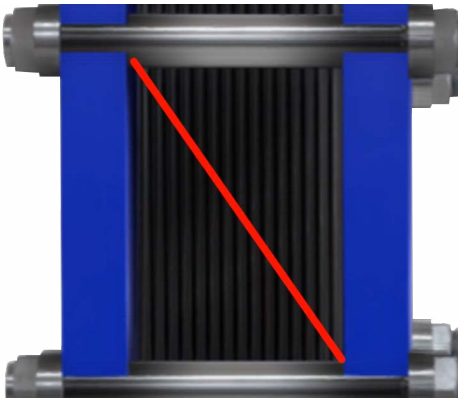


PLATE STACK WITH DIAGONAL LINE

- Although we have only shown two gasket designs so far there are three! Gaskets alternate throughout the heat exchanger **except for the first and last plates within the plate stack**, which press against the fixed and movable covers. Plates that press against the fixed and movable covers are known as **start** and **end plates**, because of their position within the plate stack. The purpose of the start and end plates is to prevent flow into the space between the fixed cover and start plate, and to prevent flow into the space between the movable cover and end plate. In this way, the covers are not actively used to exchange heat; this makes sense as the covers are quite thick, do not have corrugations and are poorly suited to exchange heat.

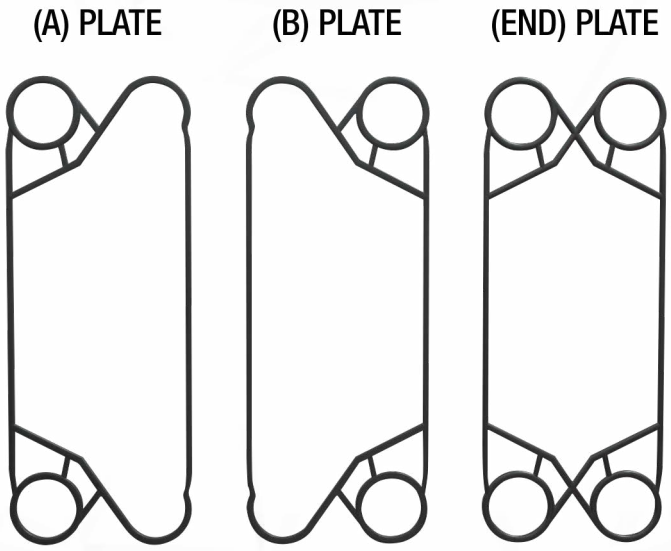
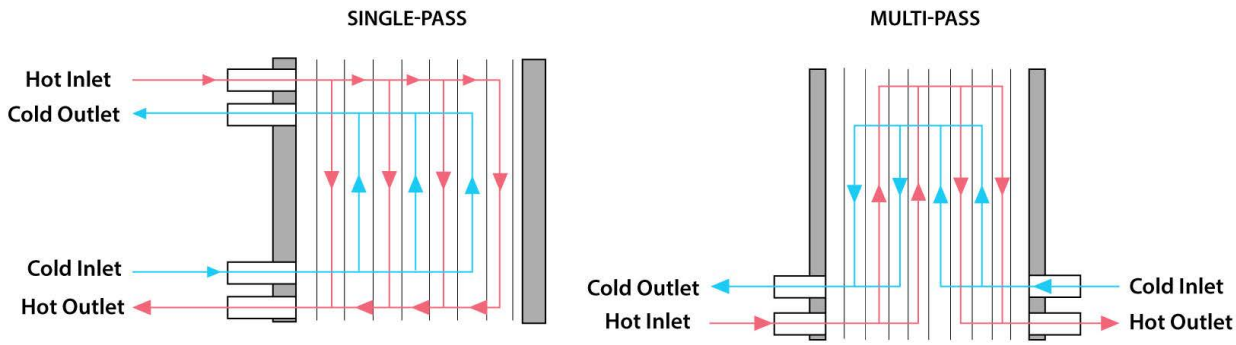


PLATE GASKETS (END PLATE GASKET SHOWN ON THE RIGHT)

VARYING THE COOLING CAPACITY

There are several ways to vary the cooling capacity of a plate heat exchanger:

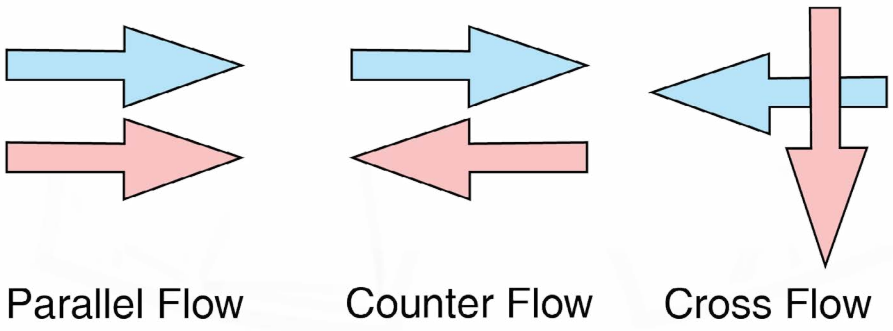
- **Regulate the outlet valves** so that the flow is increased or decreased; this method is useful because no dismantling of the heat exchanger occurs. **Do not throttle/regulate the inlet valves** as this may starve the heat exchanger and cause localised overheating.
- **Increase or decrease the number of plates in the plate stack**. Increasing the number of plates in the plate stack gives a corresponding increase in cooling capacity. Decreasing the number of plates in the plate stack gives a corresponding decrease in cooling capacity. In short, more plates equals more cooling capacity and less plates equals less cooling capacity.
- **Use a single pass or multi-pass design**. Single pass heat exchangers allow the two flowing mediums to flow past each other only once. Multi-pass heat exchangers allow the flowing mediums to flow past each other several times. Most plate heat exchangers use the single pass design.



SINGLE AND MULTI-PASS DESIGN

FLOW TYPES

Flow through a plate heat exchanger may be **parallel**, **cross** or **counter**. Plate heat exchangers usually use counter flow as this is the most efficient type of flow for heat transfer. Counter flow is sometimes known as **contra flow**.



Parallel, Counter and Cross Flow

DESIGN CONSIDERATIONS

Because plate heat exchangers are used for wide ranging applications, they must be designed to withstand the process conditions in which they operate, this may include corrosive and erosive environments. Its possible to construct plate heat exchangers from various materials, including metals, alloys and plastics. Different materials make the plate heat exchanger more suitable for different applications. For example, if a particular flowing medium reacts aggressively when coming into contact with certain metals, polymer-based materials such as Teflon may be used instead.

PLATE HEAT EXCHANGER ADVANTAGES

There are numerous advantages associated with plate heat exchangers:

- Plate heat exchangers **weigh less**, **require less space** and are **more efficient** compared to other heat exchanger designs of the same size.
- **Replacing and cleaning of the plates is a simple task** because the plate stack can be opened easily.
- And unlike shell and tube heat exchangers, **plate heat exchangers do not require additional space for dismantling**.

PLATE HEAT EXCHANGER DISADVANTAGES

But there are also some disadvantages associated with plate heat exchangers:

- Plate heat exchangers tend to be **more expensive** than other heat exchanger designs.
- If there is a leaking gasket causing one flowing medium to mix with the other, the **leaking plate is often difficult to locate**.
- **Replacement of plate gaskets in-situ can be difficult, or impossible**. Some plate gaskets must be returned to the manufacturer for replacement, which costs both time and money.
- When the plates are compressed together to form a plate stack, the **clearance between each of the plates is small, this increases the likelihood of fouling** with a corresponding reduction in heat transfer.
- When reassembling the plate stack, **over-tightening the clamping bolts can lead to crushing of the plates**, which damages the plate corrugations and squeezes-out the gaskets. If the gaskets are squeezed-out, the plate will no longer seal correctly.
- Plate heat exchangers are not suitable for high pressure applications because the gaskets would be expelled by the system pressure; this situation is referred to as '**gasket blow out**'. However, it is possible to get around this problem by using a **gasket-less design**; these designs usually use **brazed or welded plates**. Brazed and welded plate heat exchangers are more suitable for higher temperature and higher pressure applications, but also for applications where leakage would be hazardous/catastrophic e.g. toxic or poisonous flowing mediums.

SUMMARY

This handbook has discussed all of a plate heat exchanger's main components, how it works, its design features, and the advantages and disadvantages associated with this type of heat exchanger. Be sure to check out our **Plate Heat Exchanger Fundamentals** video course and **Introduction to Heat Exchangers** course if you would like to learn more!

Plate Heat Exchanger Fundamentals - Quiz

Updated 3-22-2020

1) When multiple plates are pressed together, they form a…

   a. Plate Matt
   b. Plate Sack
   c. Plate Tap
   d. Plate Stack

2) Which heat exchanger is more efficient?

   a) Plate heat exchanger.
   b) Shell and tube heat exchanger.

3) What is ONE disadvantage of plate heat exchangers compared to other heat exchanger types?

   a. Leaks are easy to find.
   b. They are cheap.
   c. Leaks are difficult to find.
   d. They are difficult to maintain.

4) Which of these is NOT a component of a plate heat exchanger.

   a. Tie bar.
   b. Carry bar.
   c. Crowbar.
   d. Plate

5) Which flow type is the most efficient flow type?

   a. Parallel Flow
   b. Cross Flow
   c. Uni Flow
   d. Counter Flow

6) Any deposits or foreign material on the plate surfaces will reduce the heat transfer rate of the heat exchanger.

   a. True
   b. False

7) Gaskets control the flow direction through the heat exchanger.

a. True
b. False

8) By definition, a heat exchanger exchanges heat without allowing the two flowing mediums to come into contact with each other.

a. True
b. False