Heat transfer is governed by the generalized equation:

\[ Q = U \cdot A \cdot DT \]

where

- \( Q \) is heat transfer rate (Btu/hr) (kw)
- \( U \) is overall heat transfer coefficient (Btu/hr-ft²-°F) (w/m²-°C)
- \( A \) is heat transfer effective area (ft²) (m²)
- \( DT \) is the log mean temperature difference (°F) (°C)

The log mean temperature difference is defined by the service of the exchanger and is not a function of heat exchanger type. If the duty of the exchanger is to cool water for 180°F (82°C) to 90°F (32°C) using 85°F (29°C) cooling water, the only factor which can affect the temperature difference is the exit temperature of the cooling water which is a function of the amount of cooling water used. If the cooling water exit temperature is 95°F (35°C), then the DT is 28.2°F(16°C). Therefore heat exchanger selection is typically based on which type can provide the most cost-effective product of film coefficient and heat transfer area while meeting the other application objectives and design limitations.

**Plate heat exchangers** (PHE) offer a very desirable combination of high overall heat transfer coefficient and low heat transfer surface cost in $/ft². It is virtually impossible to provide a more cost-competitive exchanger for services which can satisfactorily be met with a plate exchanger. However, the plate exchanger is limited to services where duty is not severe and is not suitable for the following:

- Design pressures exceeding 100 psig (7 bar).
- Design temperatures exceeding 340°F (171°C).
- Applications where leakage cannot be tolerated or must be minimized for personnel protection, process control, environmental release or potential contamination of the process. These would include hazardous materials, refrigerants and many gases or vapors.
- Fluids must be compatible with elastomer materials used for plate gaskets.

A distinct advantage of the plate exchanger is that it can be fully disassembled for cleaning and therefore can be the preferred type of exchanger for many applications including those in the food and beverage industries.

**Brazed plate exchangers** are used in many of the same applications as plate exchangers with the following differences. The brazed exchanger maintains the high film coefficients found in conventional PHEs but cannot be disassembled. These exchangers have many small passages which can become plugged if they are used in fouling applications. Sealing is much more reliable than PHEs and consequently brazed exchangers are often used for refrigerants and other gases. The brazed exchangers are limited to temperatures <365°F (185°C) and pressures <450 psig (31 bar) and their design is not tolerant of pressure pulses or spikes. The more economical brazed exchangers use copper as the brazing material so fluids must be compatible with copper.

**Shell and tube heat exchangers** are readily available heat exchangers and are a staple of the heat transfer industry for tube side design pressures up to 500 psig (35 bar) and design temperatures below 500°F (260°C). They are available in a variety of sizes and materials. A shell and tube can probably be used for most any application but it does have some major disadvantages that the spiral tube heat exchanger solves easily.

- When exotic material is required for the tube side, the spiral tube heat exchanger minimizes the material used on the tube side as the manifolds replace channels, heads and tube sheets of a conventional shell and tube exchanger. Higher heat transfer coefficients due to spiral tube construction can also reduce the total required heat transfer area resulting in less tubing required.
- Thermal or pressure cycling can cause leakage at conventional tube/tube sheet joints in a shell and tube heat exchanger which requires special processing. The Sentry spiral tube heat exchanger with its spiral coil design and welded tube to manifold joints is highly resistant to both thermal and pressure cycling.
A shell and tube heat exchanger has a long dimensional profile. If system packaging dictates that a short compact design is required, a spiral tube heat exchanger is much more compact and has almost a square dimensional profile. The long dimensional profile of the shell and tube also becomes a disadvantage when it comes to disassembly and cleaning since an equivalent length to the tube bundle is required for removal. In the spiral tube design, tube bundle removal area is very minimal.

When the heat exchanger application requires that tube side pressures, shell side pressures or both exceed 500 psig (35 bar), a shell and tube design can have a prohibitively high cost as compared to the spiral tube heat exchanger. As the heat transfer requirement increases and/or the pressure drop limit decreases, the shell and tube design typically grows in both diameter and length. This means that not only a longer shell is required but a larger diameter one as well. This can increase the material and labor cost substantially. The spiral tube design typically keeps the same diameter as these parameters change and it's increase in shell length per unit of added heat transfer area is minimal.

Highly viscous fluids flowing inside tubes usually have low Reynold's Numbers with resulting laminar (streamline) flow and low tube side heat transfer coefficients. Because of the shape of the tube bundle, spiral tube heat exchangers have a secondary circulating flow within the tube which tends to move colder, more dense fluid to the outside of the coil. This will result in higher overall heat transfer coefficients and reduce the required area below the required area of the conventional shell & tube exchanger.

In summary, **spiral tube heat exchanger** applications are those where service requirements exceed the capabilities of most other heat exchanger types. The unique properties of the spiral tube design combined with Sentry's engineering and manufacturing capabilities can provide effective solutions for many difficult heat transfer services.

**Design drivers**

- Tube side design pressures exceeding 500 psig (35 bar)
- Design temperatures of either shell or tube side exceeding 500°F (260°C)
- Service with frequent pressure pulses or spikes
- Frequent start up/shut down cycles or other sources of thermal transients
- Highly corrosive fluids requiring exotic materials for containment
- Hazardous materials which require reliable, durable (all welded) containment

**Application niches:**

- Pump seal coolers
- Large sample coolers
- Acid heaters and coolers
- Inter-coolers and after-coolers for reciprocating compressors
- Small molecule gases with low leakage requirements (hydrogen, helium, etc)
- Applications where minimum overall dimensions are required
- Evaporators/condensers where the exchanger can also function as a phase separator
- Cryogenic applications
- High viscosity fluids
- Vent condensers
- Instant hot water heaters
- High-pressure heaters and coolers

Because of our special manufacturing techniques and multi-product usage of stainless steel tubing, Sentry offers the unique ability to provide a welded 304 stainless steel spiral tube bundle for the same price as our competitor's brazed copper tube bundle in lower pressure/temperature applications where copper would typically be used because of cost. This provides the user with greater heat exchanger life and expanded heat exchanger flexibility with no appreciable loss in heat transfer. Additionally, we specialize in spiral tube heat exchangers with 316L stainless steel and a variety of exotic alloy materials including Hastelloy®, Inconel®, Incoly® and specialty stainless steels to name just a few.

Computerized heat transfer calculation and model selection insures a satisfactory exchanger for the desired service. Several standard sizes are available from stock for typical seal cooling applications below 5 GPM. Sentry's flexible manufacturing processes allow optimization of the exchanger design; including tube diameter, number of tubes, tube length and spacing for any OEM application.

Sentry Spiral tube heat exchangers are available in either bolted or all welded shell construction. All welded units provide a significantly lower cost than bolted units when shell side inspection or cleaning is not essential or economic. Standard shell construction utilizes carbon steel with NPT pipe thread connections. Other available materials and connections including flanged, socket weld, butt weld or specialty connectors are available.

ASME Section VIII Division 1 Stamped heat exchangers are available upon request.