Shell & Tube Type Heat Exchangers

Standard and Pre-Engineered

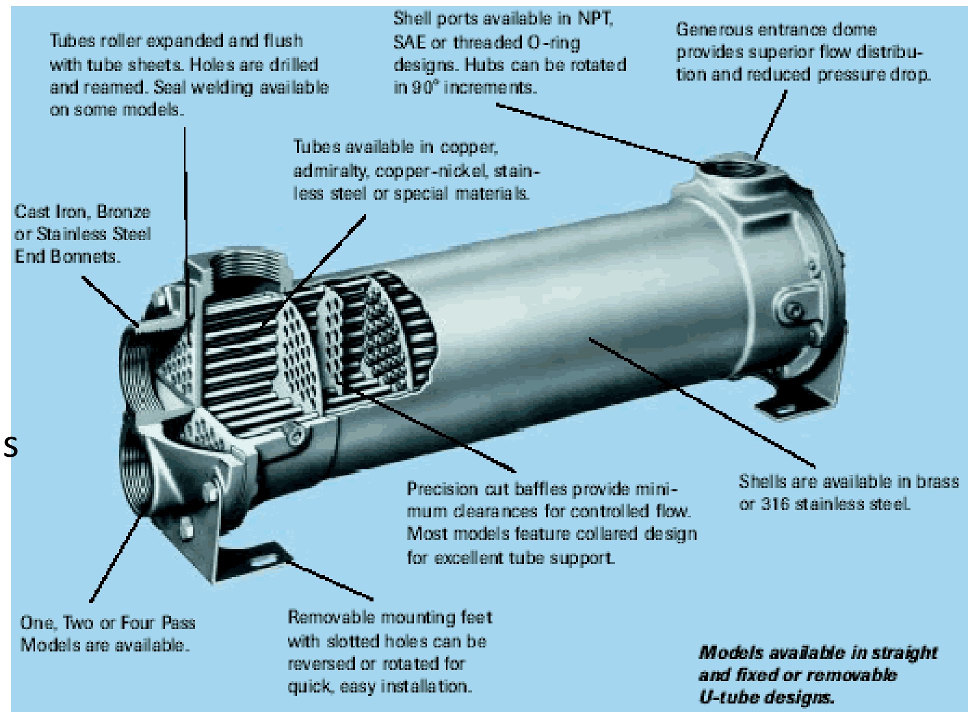
- Pre-Engineered designs with flexibility but some restrictions.
- Approach is to first assess whether a Pre-Engineered design is thermally and mechanically suitable for the application.
- ASME, CRN and TEMA ‘C’ design options
- Fixed tube sheet, U-tube or AEW type designs

Advantages

- Cost
- Lead-time
- Design is understood and known up front

Disadvantages

- Limitation of size and materials
- Do not meet all industry codes and standards

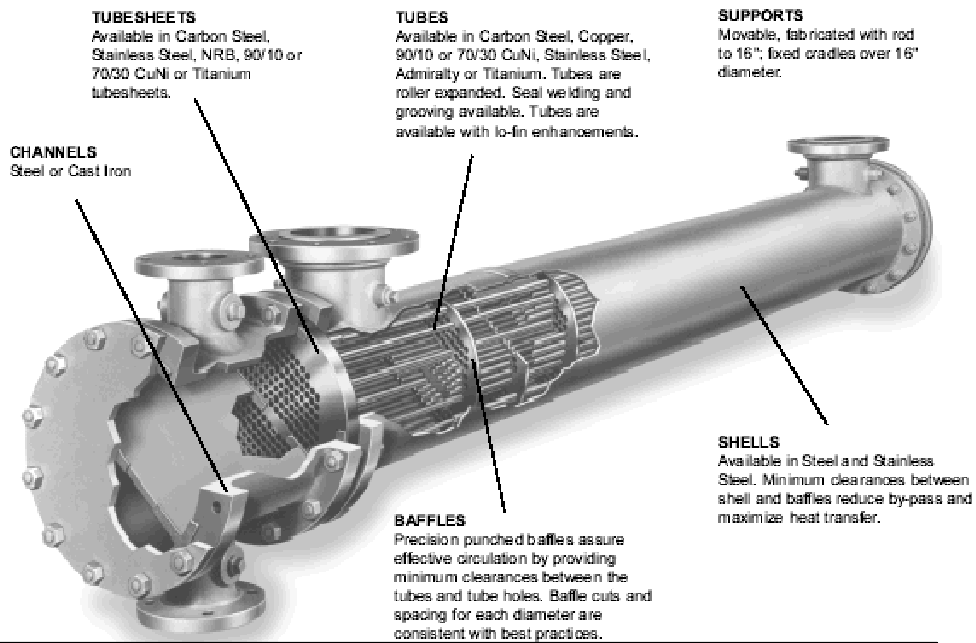


Shell & Tube Type Heat Exchangers

Custom Engineered

- Many Shell & Tube Heat Exchanger application have specific or unique requirements that “Pre-Engineered Exchangers” do not meet.

- Most Custom Engineered Heat Exchangers are designed to TEMA standards

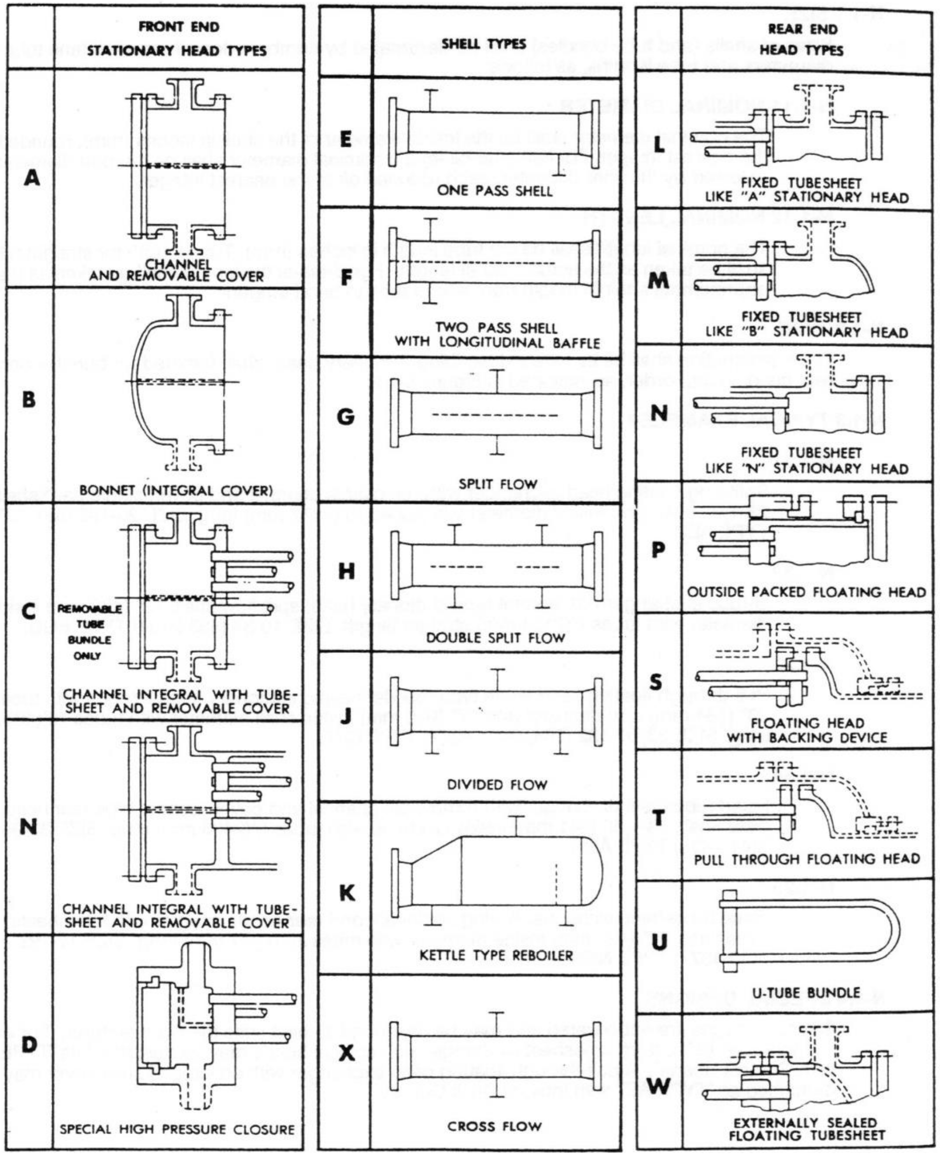


Tubular Exchanger Manufacturers Association (TEMA)

- An organization of members of shell and tube heat exchanger manufacturers responsible for developing design and manufacturing standards for shell and tube heat exchangers.
- TEMA has developed standards for the design and designation of shell and tube heat exchangers. Although all shell and tube heat exchangers do not and are not required to meet TEMA Standards, it is often a requirement of specifications for industrial applications particularly for Custom Engineered Heat Exchangers.

Shell & Tube Type Heat Exchangers

TEMA Types



Courtesy of TEMA

Shell & Tube Type Heat Exchangers

Miniature Shell and Tube Heat Exchangers

The design and fabricating processes for traditional shell and tube heat exchangers make them most efficient in medium to high flow rate applications. Velocities and ultimately heat transfer coefficients fall off in very low flow rate applications and traditional mechanical design standards do not allow additional surface area to be added effectively.

- Materials of construction: 316L SS, Hastelloy©, Inconel© and other alloys.
- Many standard models are available from stock but custom units can be designed.
- Sanitary designs are also available with or without electro polishing.

Typical Applications Industries:

- Point of used cooling or heating
- Product Sampling
- Water for injection (WFI)
- Clean steam condensing and sub-cooling
- Temperature control of high purity product

Industries:

- Aerospace / Defense
- Food and Beverage
- Pharmaceutical / Biotech
- Semiconductor
- Alternative Energy
- Chemical

Shell & Tube Type Heat Exchangers

Hairpin Heat Exchangers

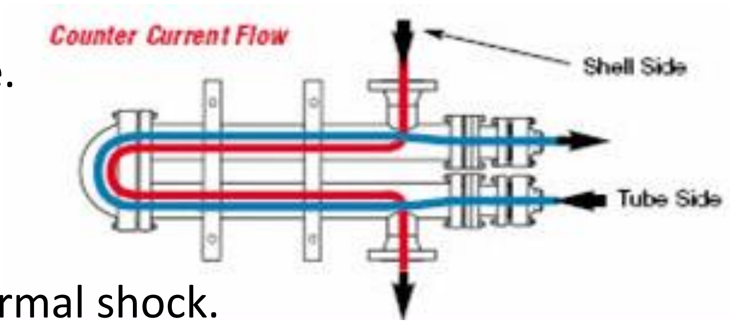
Description

Hairpin heat exchangers utilize true counter-current flow (or close to), which maximizes the temperature differences between the shell side and the tube side fluids.

Applications

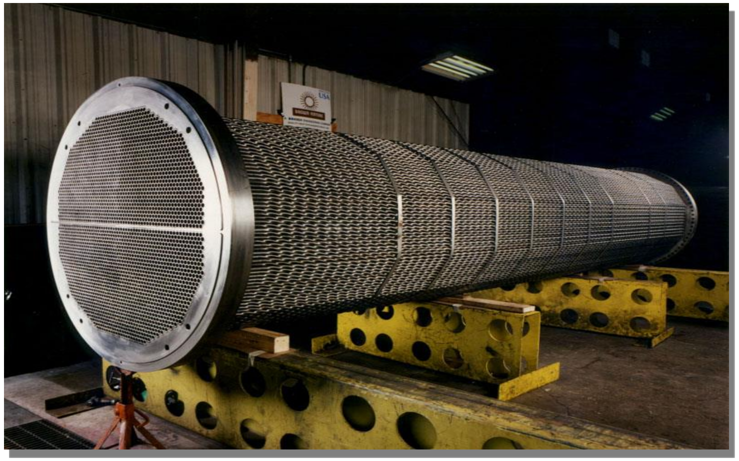
Use a Hairpin Heat Exchanger when…

- A temperature cross exists or is desired.
- High ratio of shell side flow rate to tube side flow rate.
- A low shell side pressure drop is required.
- Heating or cooling low-pressure vapours.
- High pressure tube side application.
- Cyclic service or when the exchanger is subject to thermal shock.
- High terminal temperature differences (300°F or greater).
- Solids are present (slurries, etc.)



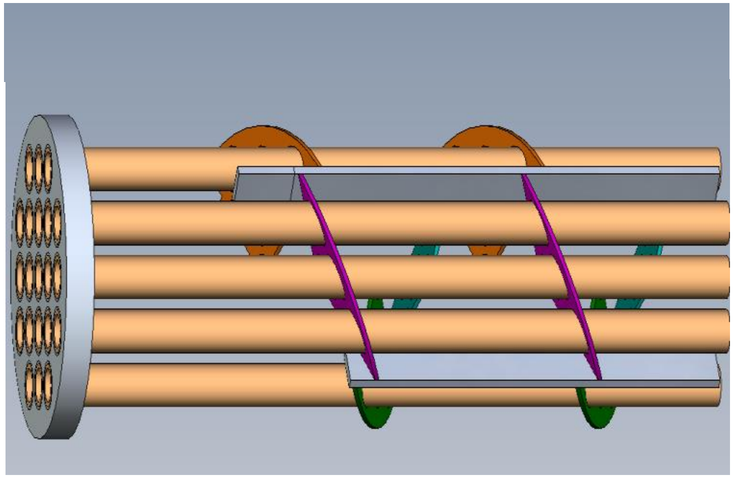
Shell & Tube Type Heat Exchangers

Other Designs



Twisted Tube

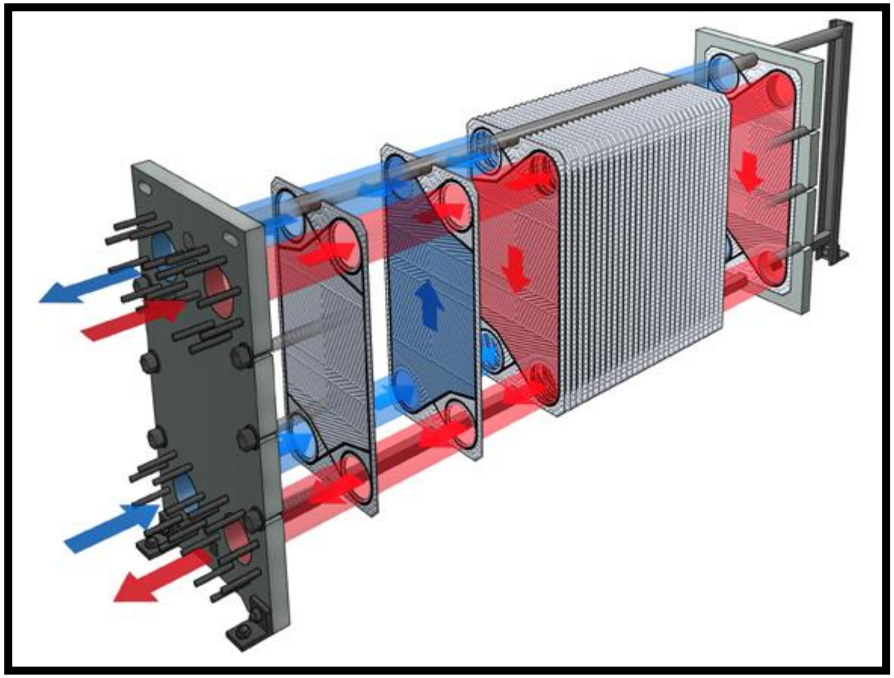
Rod & Baffle



Helical Baffle Design

Double Pipe

Gasketed Plate and Frame Heat Exchangers

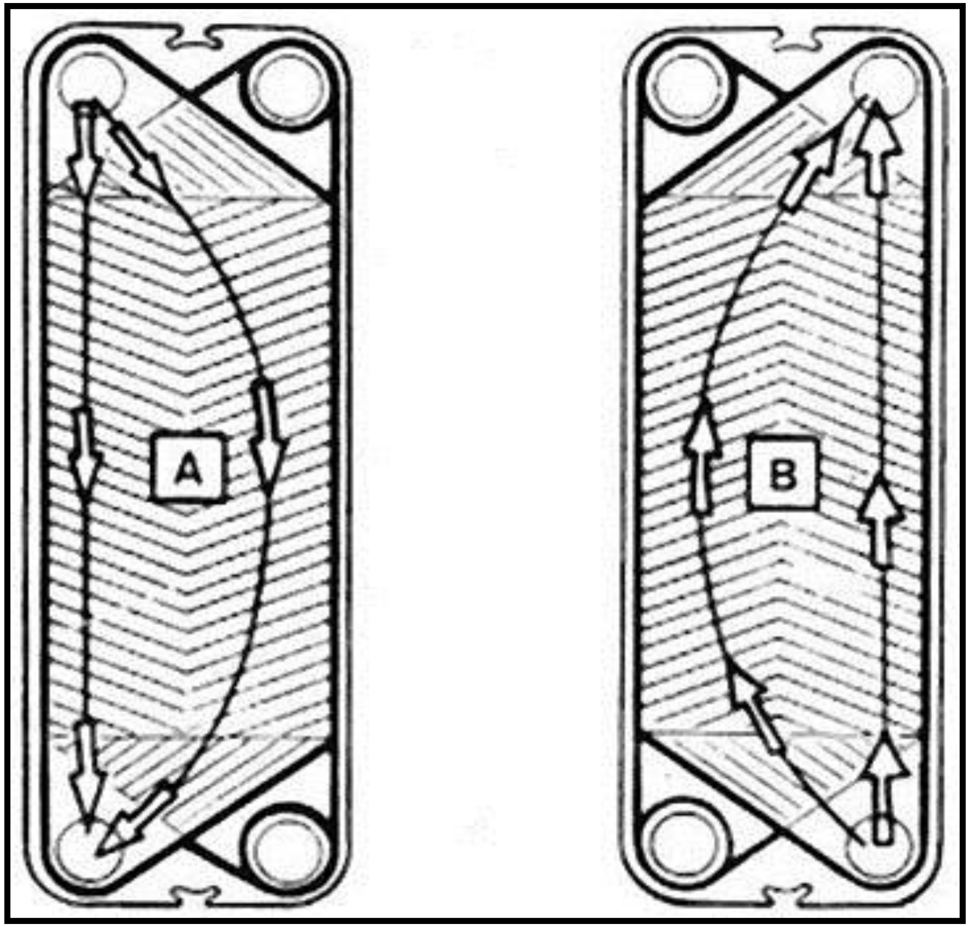


- **Frame Plate**
- **Pressure Plate**
- **Plate Pack**
- **Tightening Bolts**
- **Carry & Guide Bars**
- **Connections**
- **Support Feet**
- **OSHA Guard**

Applications:

- HVAC – water/glycol
- Sanitary – heating/cooling food products
- Process – chemical solution cooling; central plant cooling, general process cooling
- Industrial – chillers, machining fluid coolers, heat transfer fluid cooling, economizers
- Heat Recovery and Free Cooling

Plate Exchanger Working Principle



- High turbulence
- True counter current flow path
- Low fouling
- Highest heat transfer coefficients

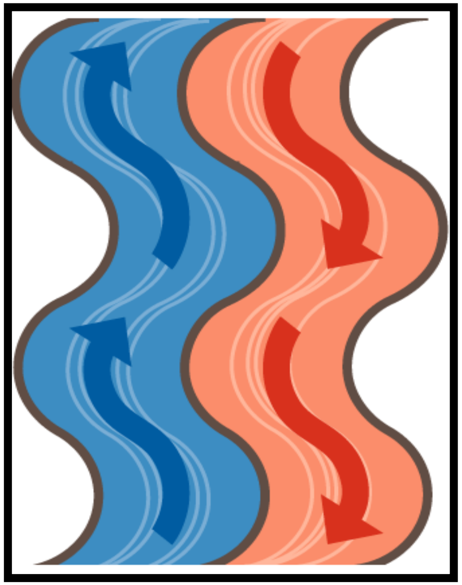
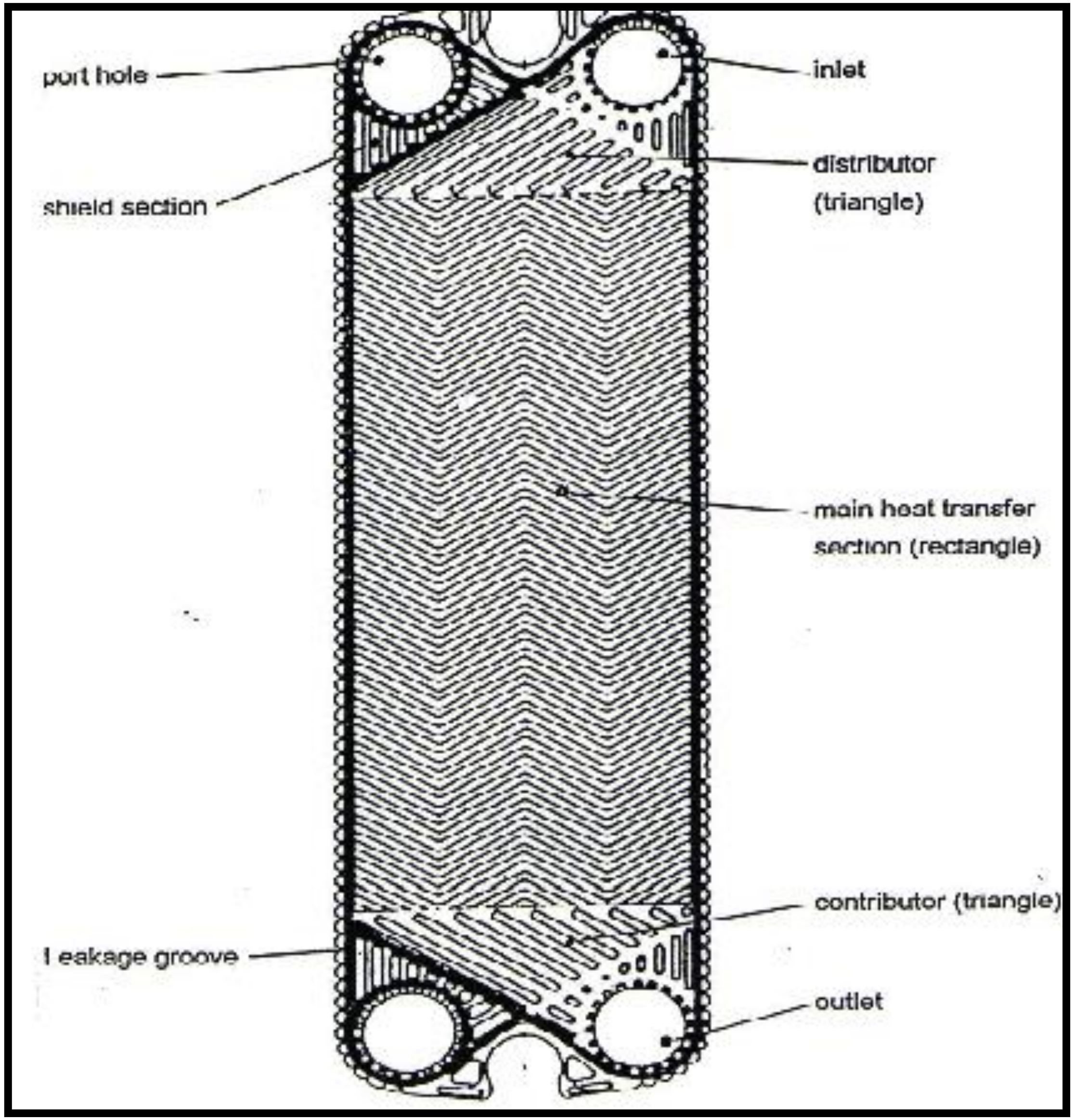


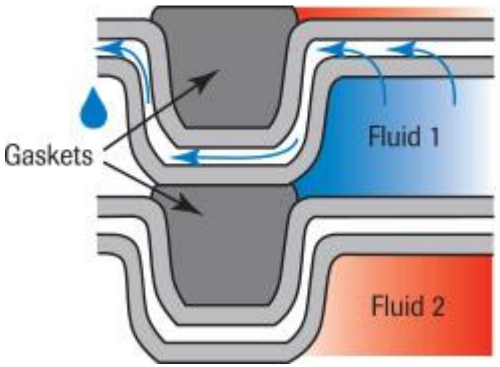
Plate Sections

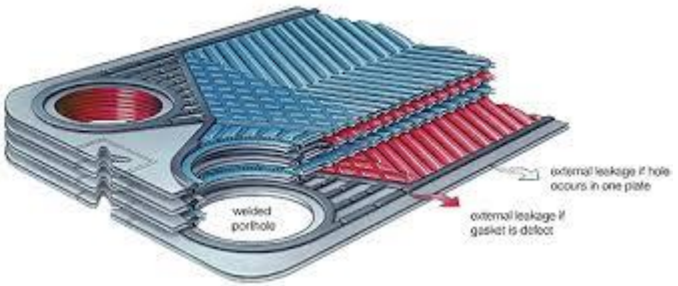


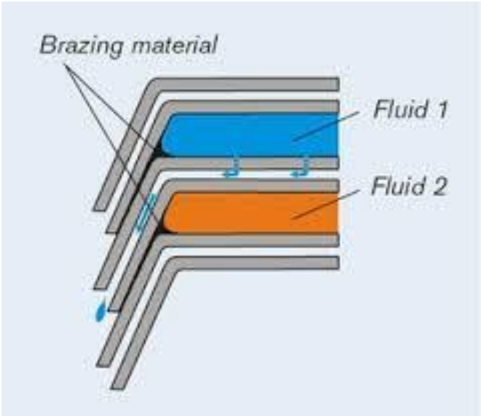
Gasket Materials

Material	Max. Operating Temperature	Products	Relative Cost
NBR	285	oil, water, food and beverage	1
EPDM	320	hot water, steam, acids (low concentration)	1
Viton	320	aggressive chemicals, oil, fat	10
Neoprene	210	Refrigerants	3
Compressed fibers	465	aggressive chemicals, oil, paints	8
Sigmacoat PTFE (Teflon)	320	very aggressive chemicals	30

Double Wall PHE Design





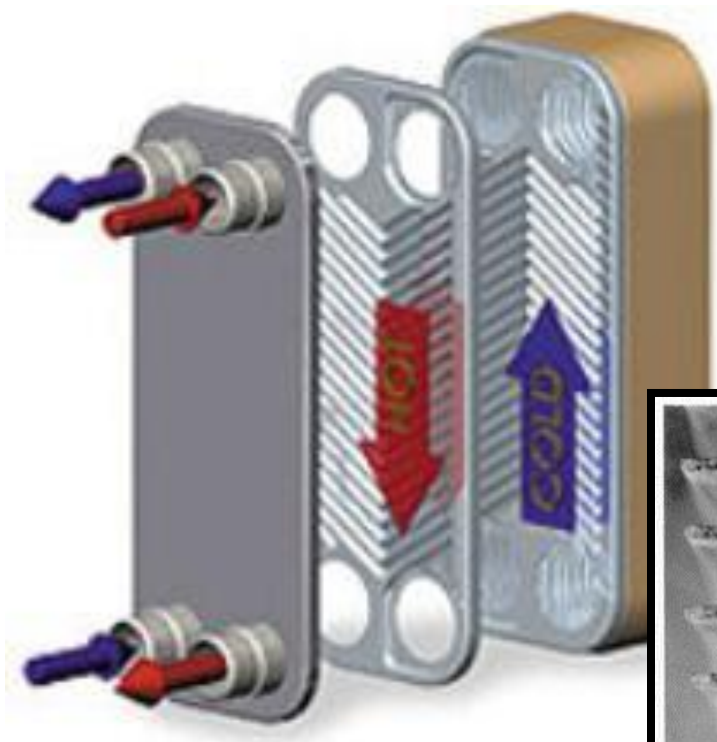


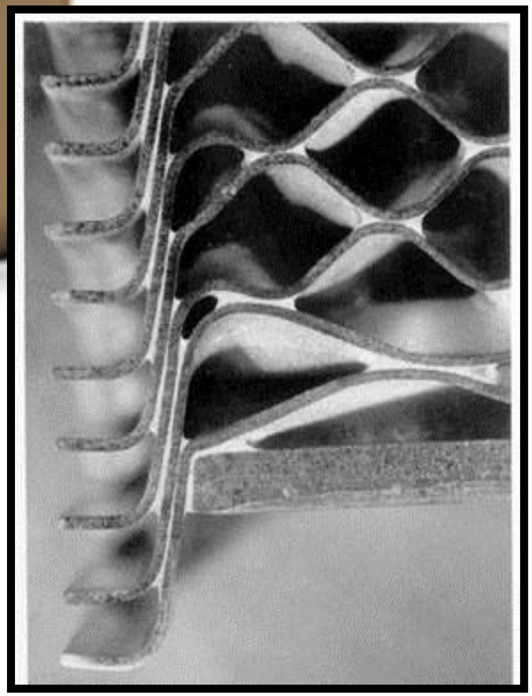
Advantages of PHE’s

- Compact design
- Less material – lower cost for high grade alloys
- High heat transfer coefficients – true counter current flow
- Low temperature differences between hot and cold side
- “Open up” opportunity (gasketed) – easily cleanable
- Redesigning opportunity (gasketed) – adding additional plates
- Low volumetric hold-up of fluids

Brazed Plate Features/Construction

- **Brazed / no gaskets**
- **Compact**
- **Lightweight**
- **Efficient**

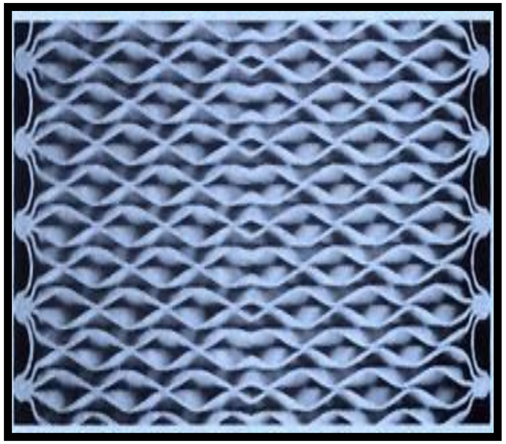




- Standard design pressure:
  - Copper braze: 450 psi
  - Nickel braze: 232 psi
- Max. temperature: 383°F
- Min. temperature: -148 °F
- Plate Materials: 316SS, SMO254
- Connection types: Standard: NPT, soldered
  Optional: SAE type, flanged

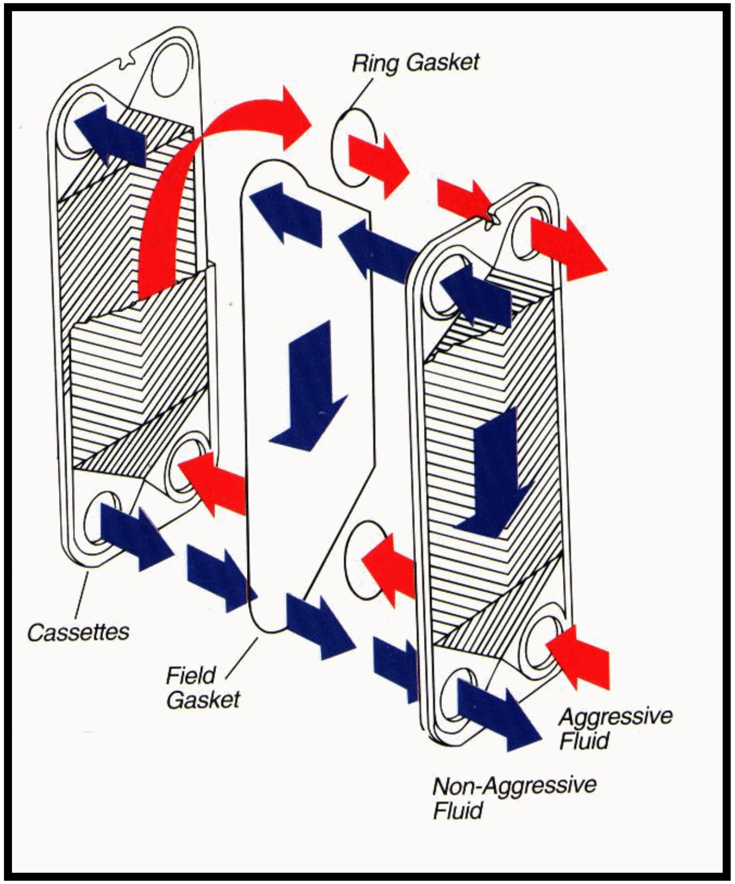
Welded Plate Heat Exchangers

- Fully welded - No gaskets
- Higher temperatures & pressures



Temperature:	**-40 °F to 570°F**
Pressure:	Vacuum to 580 psig
Capacity:	0.5 to 1600 GPM
Plate Materials:	316SS, Ti, Hastelloy
Connections:	1" to 6“ female and male NPT, Studded or Flanged

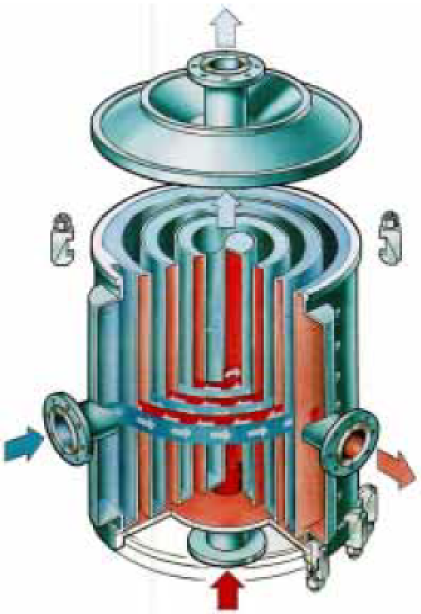
Semi-Welded Design



- Half Welded – Half Gasketed
- Hybrid design allowing minimal gasket surface for one fluid and flexibility to open and clean the plates for the other fluid

• Temperature:	-40 °F to 320°F
• Plate Materials:	304/316SS, Ti, Hastelloy
• Pressure:	Vacuum to 460 psig
• Capacity:	0.5 to 3500 GPM
• Connections:	1" to 8“+ Studded or Flanged

Spiral Type Heat Exchangers



General Construction

- Two metal strips welded form a spiral body containing two separate continuous channels.
- Each channel is normally welded closed on one side and remains open on the opposite side, which faces a cover and which is sealed with a gasket.
- A shell envelops the spiral body and removable covers are fastened to each end.
- Inlet and outlet connections for both channels are attached to the shell and to the covers.

Hybrid Heat Exchangers

Plate and Shell Heat Exchangers



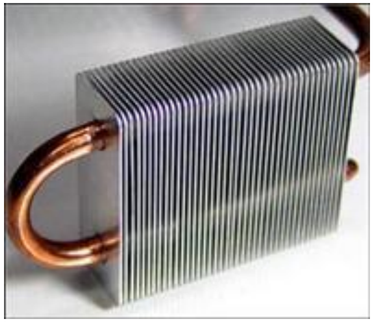

Finned Tube Heat Exchangers

Attachment Methods

Plate Fin

- Highly efficient. Provides a very large surface area that helps evenly distribute heat
- Tube holes are pressed in thin sheets of metal and
- Tubes are inserted and then expanded.
- Fins can be waffled or rippled for greater efficiency.
- Fin thickness can be varied.

Common Applications: HVAC Coils, Steam Coils, Air Preheaters, Air Cooled Heat Exchangers, Compressed Air After-coolers,



Tension Wound or Fin 'L' Footed Fin

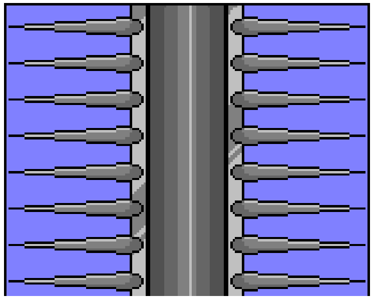
- Fins wrapped tightly around the tube and stapled or welded at the ends
- Can also be solder-coated to help increase corrosion resistance.
- L-Footed is similar to Tension Wound except a lip at the base
  - Increased heat transfer contact area between the tube and the fin
  - Decreases the exposed joint at the fin base.

Common Applications: HVAC Coils, Steam Coils.

Embedded Fin

- Fin inserted and welded into a helical groove cut into the tube.
- Can withstand higher temperatures, and very durable so best suited for applications that involve high temperatures or thermal cycling and where the finside will be subjected to frequent cleaning.

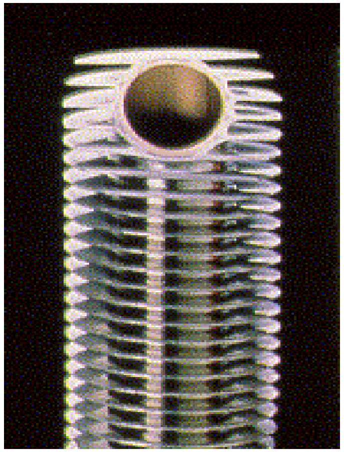
Common Applications: Steam Coils, Air Preheaters, Air Cooled Heat Exchangers.



Finned Tube Heat Exchangers

Attachment Methods

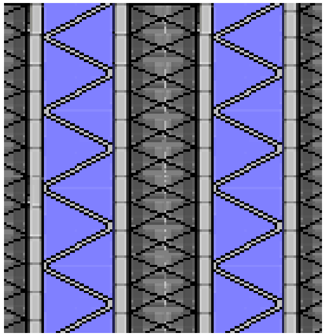
Bi-Metal Extruded Fin (Integral Fin)



- Called Extruded, or Integral Fins
- Created by sliding a liner tube inside a thick-walled tube and then sending this assembly through a press which extrudes the fin from the thick walled tube in a cold worked process.
- The outer tube is pressed into a fin pattern while creating a mechanical bond between the outer (finned) tube and the liner tube.
- Since the fins are one piece there is no exposed bi-metal joint at the base of the fin.
- Liner tube can also be chosen to best suit the tubeside fluids as only a small area of the liner tube is exposed to the gas side.

Common Applications: Steam Coils, Air Preheaters, Motor and Generator Coolers, Transformer Oil Coolers, Air Cooled Heat Exchangers.

Brazed Aluminum (or Plate and Bar) Fin



- Fins are laid between aluminum braze sheets and fitted with headers and face bars.
- The assembled unit is placed into a vacuum braze furnaces where precise control of time and temperature produces a solid unified core.
- Often an internal fin is used on the inside to enhance heat transfer.

Common Applications: Oil Coolers, Compressor Coolers, Charge Air Coolers, Radiators.

Finned Tube Heat Exchangers

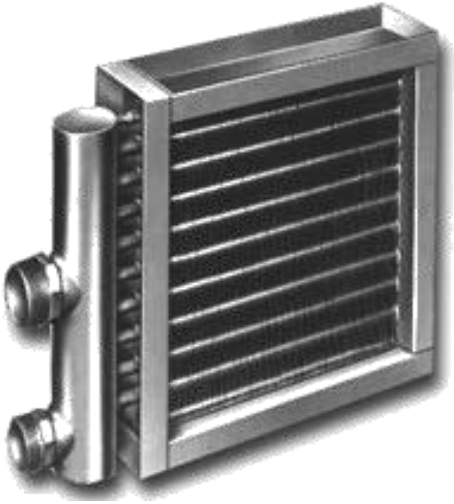
Steam Coils

Description

- Heat air with steam
- Various designs
  - Freeze potential
  - Piping arrangement
  - Thermal Expansion
- Condensate considerations

Applications

- Boiler Air-Preheaters
- Dryer Coils
- Building / Comfort Heating
- Tempering



Steam Coil Air Heater

Finned Tube Heat Exchangers

Cooling Coils

Description

- Cool air with chilled water or glycol
- Typically multiple rows of tubes / multiple passes on fluid side
- Can be cleanable

Applications

- Process air cooling
- Dehumidification
- Building / Comfort cooling

Similar coils can be used for heating applications

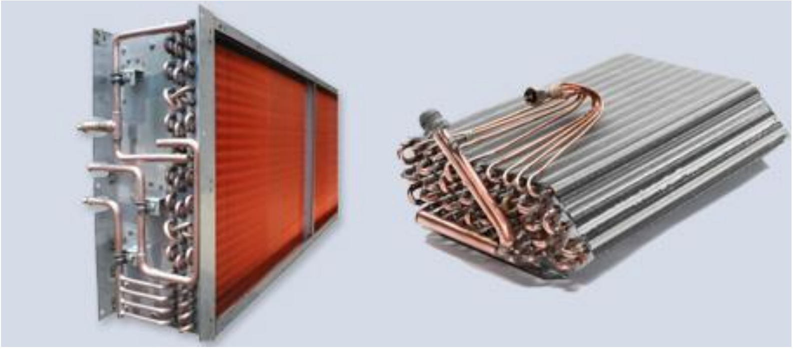
Finned Tube Heat Exchangers

Refrigeration Coils

- Evaporator and Condenser coils are designed and manufactured for applications ranging from residential to industrial. Various applications include process equipment, HVAC, food, dehumidifying and other.

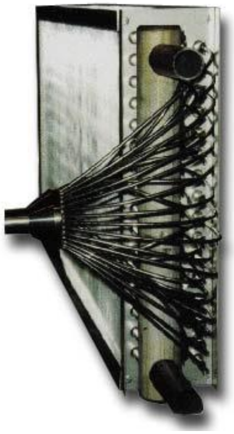
Refrigerant

- Tube sizes range from 5 mm to 1/2 inch. Materials include copper, aluminum, stainless steel, and others. This product is brazed or welded depending on the material and application.



Ammonia

- Tube sizes range from 5/8 inch to 1 inch. Materials include aluminum, hot dip galvanize , stainless steel, and others. This product is normally welded.



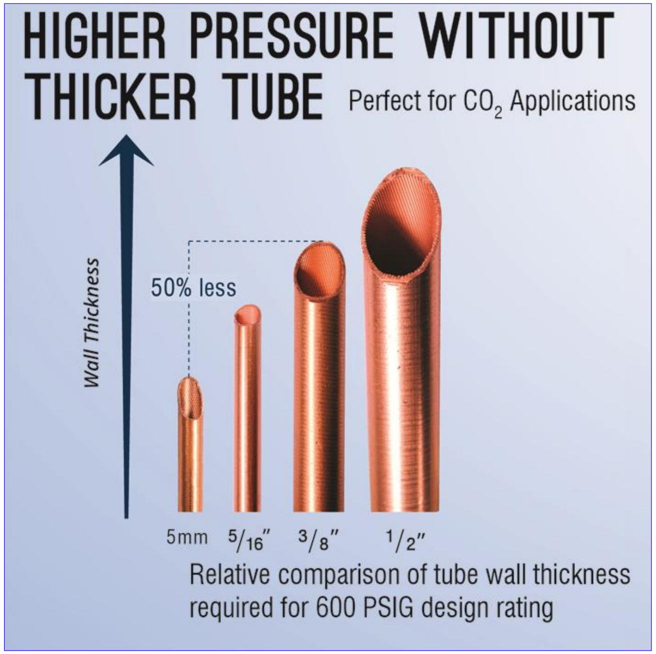
Other

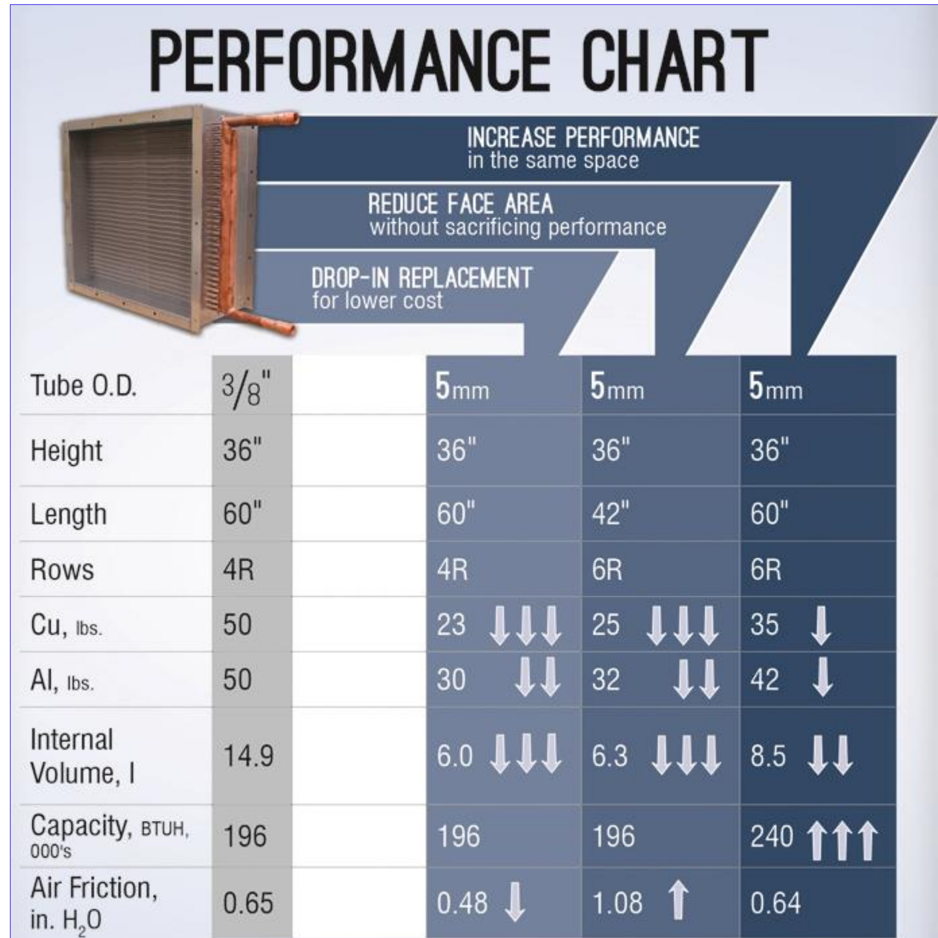
- Tube sizes range from 5 mm to 1 inch. Materials include aluminum, hot dip galvanize , stainless steel, and others. This product is brazed or welded depending on the material and application.

Finned Tube Heat Exchangers

Refrigeration Coils

5mm MicroGroove Tubes





Tube O.D.	3/8"	5mm	5mm	5mm
Height	36"	36"	36"	36"
Length	60"	60"	42"	60"
Rows	4R	4R	6R	6R
Cu, lbs.	50	23 ↓↓↓	25 ↓↓↓	35 ↓
Al, lbs.	50	30 ↓↓	32 ↓↓	42 ↓
Internal Volume, l	14.9	6.0 ↓↓↓	6.3 ↓↓↓	8.5 ↓↓
Capacity, BTUH, 000's	196	196	196	240 ↑↑↑
Air Friction, in. H_2O	0.65	0.48 ↓	1.08 ↑	0.64

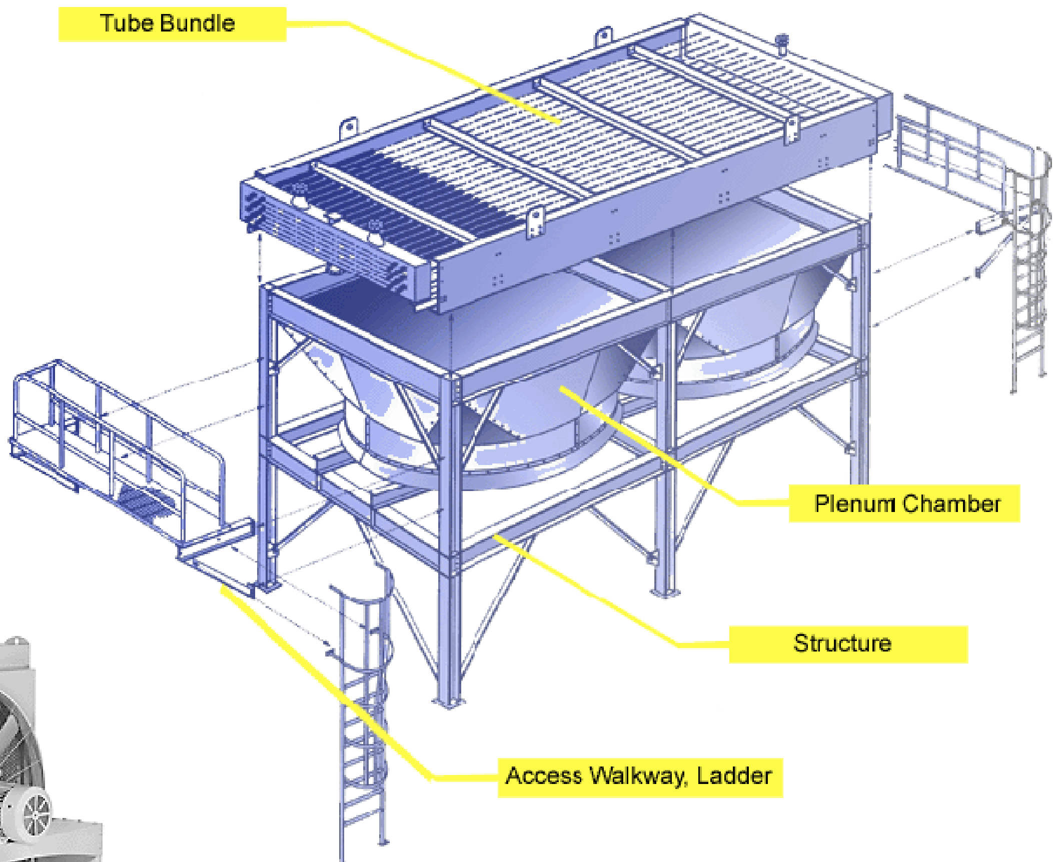
Advantages over 3/8" tube

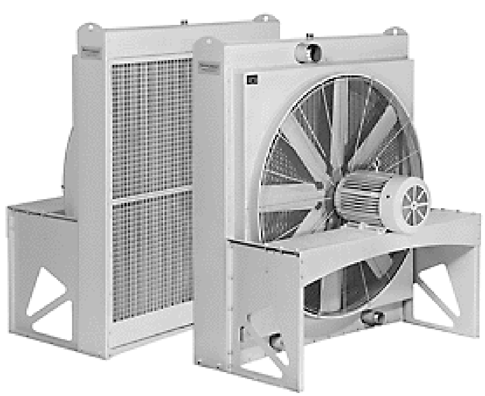
- Smaller size and weight
- Less refrigerant used and required
- Can achieve same capacity in less space
- Can increase performance in same space
- Flexible circuiting
- Durable copper tubing construction
- High performance

Air Cooled Heat Exchangers

Description

- A fluid (liquid or gas), inside a finned tube is cooled or condensed by forcing air over the outside of the finned tube.
- Can be vertical or horizontal air flow.
- Typically self contained
  - Finned Tube Bundle
    - Finned Tubes
    - Headers
    - Side casings
  - Support Structure
  - Fan plenum
  - Fan(s) and Guards
  - Motor(s)
  - Ladders / Walkways (optional)
  - Control Panel (Optional)

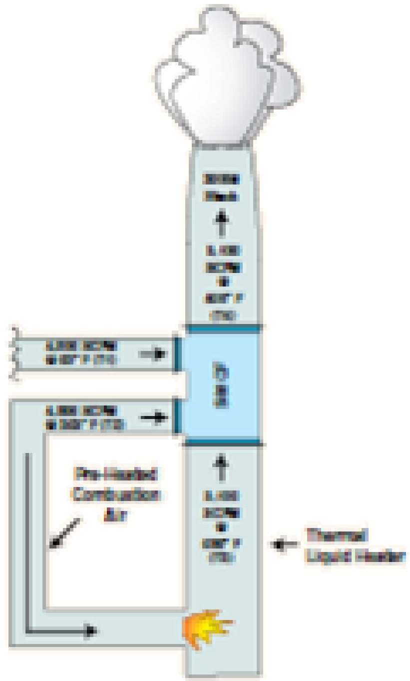




Heat Recovery

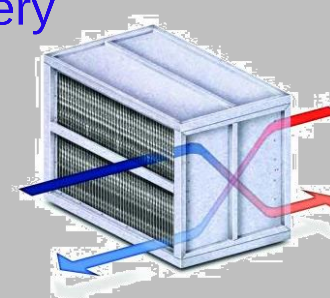
Applications

- Heat Recovery
  - Incentives and credits.



Common Industrial Applications

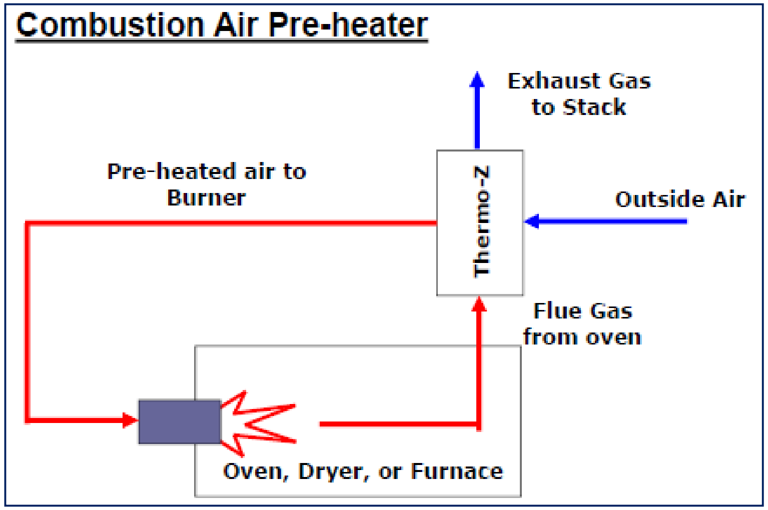
- Incinerators
- Ovens
- Dryers
- Solvent recovery
- Furnaces
- Bag houses
- Rotary kiln
- Oxidizers
- Steam Boilers
- Solid waste recovery
- Annealing operations
- Glass Plants



Heat Recovery

Gas to Gas

- Hot side generally a flue or exhaust gas.
- Cold side typically outside or make up air.

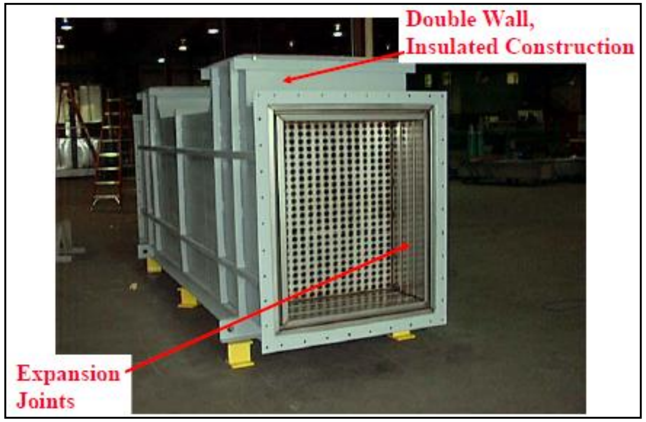


All Welded Matrix Core

Plate Style

- Fully Welded
- Can be used up to 1500°F (815°c)

Temperature and Cleanliness of streams typically determines the type.



Tubular Style

- Fully Welded
- Can be used up to 2000°F (1090°c)

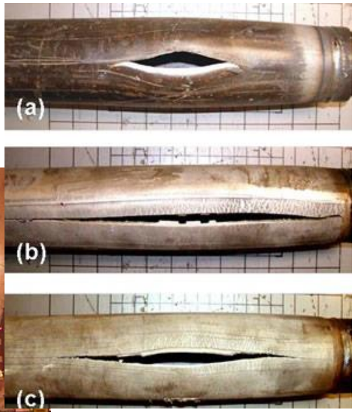
Heat Recovery

Economizers

- Improves boiler efficiency by capturing energy that would be otherwise vented out a stack.
- Standard and non-standard sizes between 200 – 1,000 BHP
- Compact design with removable access panels
- Stainless steel interior with stainless steel heat exchanger
- Carbon steel or stainless steel tube and fin combinations provide maximum performance and value
- ASME Section VIII certified

Design and Operational Considerations

- Fouling
- Corrosion
- Erosion
- Thermal Expansion / Thermal Cycling
- Tube Velocity
- Seasonal Variances
  - In demand
  - Cooling capacity
- Allocation of Streams
- Codes and Standards



CRN / Fitting requirements for liquids not more hazardous than water

(courtesy of CSA B51)