Bolted Joint Assembly Principles for Industrial Heat Exchangers: Overview

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May 12, 2020

HYTORC

Bolting Institute

Why Heat Exchanger Training

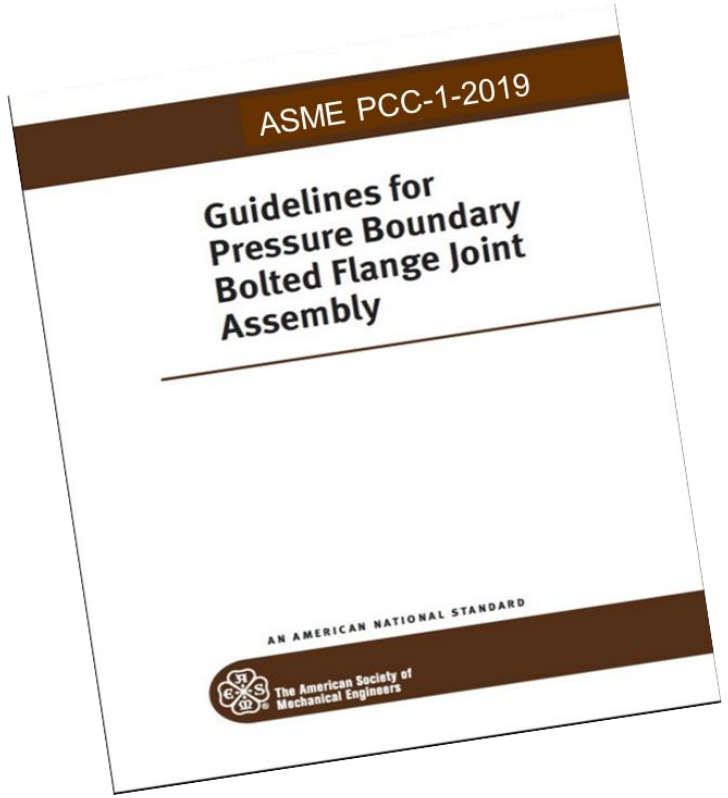
ASME PCC-1-2019 is the standard for industrial bolted joint assembly & Qualified Bolting Specialist (QBS) Training

- Appendix A. lists 3 Supplemental Qualifications for a QBS
- A-2.3.2 Additional Training Required to Obtain a Powered Equipment Supplemental Qualification.
- A-2.3.3 Additional Training Required to Obtain a Heat Exchanger Supplemental Qualification.
- A-2.3.4 Additional Training Required to Obtain a Special Joint Supplemental Qualification.

Who should receive this training

- Anyone interested in learning more about heat exchangers
- Those that posses the minimum experience & have already received a QBS Certification

- **Written as a “guideline”**
- **Accepted as the standard**



Industry Standards

Industry standards self-governed by TEMA

- Tubular Exchanger Manufacturers Association (1939)
- 10th Edition of the Standard (2019)
- Governs design, installation, operation and maintenance
- Establishes classifications, nomenclature and best practices

ASME Section VIII Pressure Vessel and Boiler Code

- Accepted senior standard for all pressure vessels – **code**

Other International standards

- DIN 28 008 and BS-EN-ISO 16812:2019
- Pressure Equipment Directive (PED) 2014/68/EU

Our purpose in this course is not exchanger design but **bolting** for sealing, stability, & process efficiency

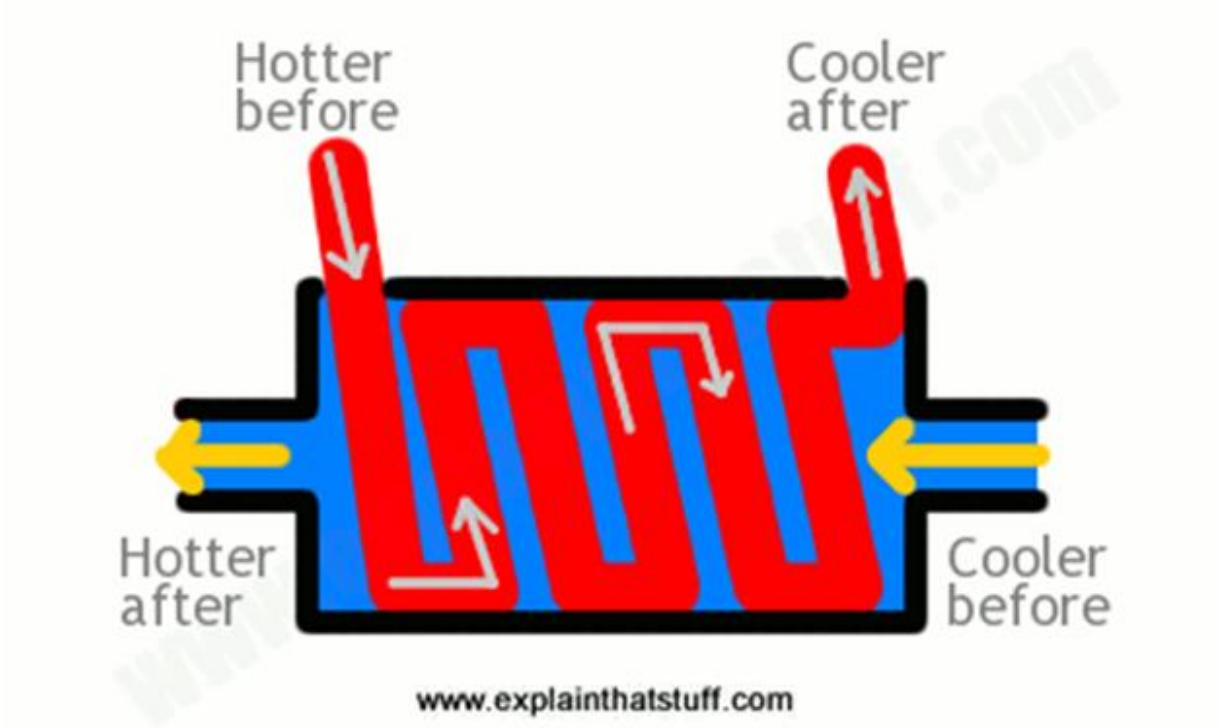
Material Covered In This Course

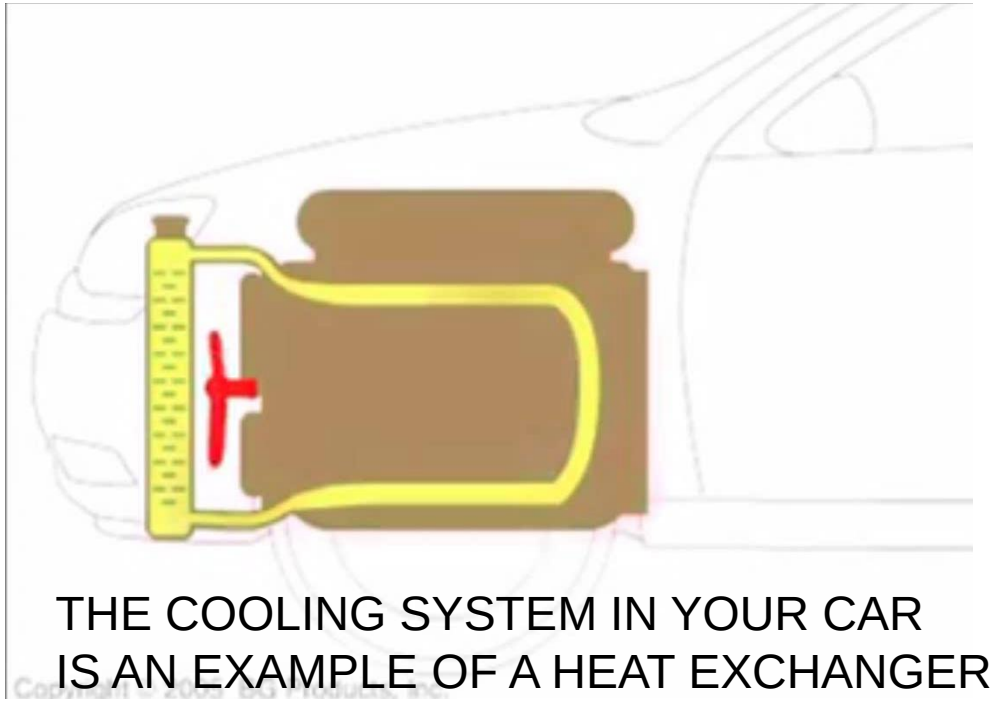
- Industrial Heat Exchangers Types
- Shell & tube exchangers
- Plate exchangers
- Breech-lock/Spiral/Double Pipe/Fin Fan
- What is an exchanger
- How they work
- Component identification
- Nomenclature
- Advantages & disadvantages of each type
- Girth flange sealing challenges
- Threaded tubesheet sealing challenges
- Collar / Shoulder bolts
- Floating heads
- Pass Partition issues
- Gasket surface inspection & measurement
- Nubbins & scrubbing
- Criticality of alignment
- Assembly & disassembly
- Gaskets
- Bundle extraction & insertion
- Header box sealing challenges
- 4 of class room theory & testing
- 4 hours of practical hands on

Principles of Heat Exchanger Bolting

What is a Heat Exchanger?

- A **heat exchanger** is a device that allows **heat** from a fluid (liquid or gas) to pass by a second fluid (another liquid or gas) usually without the two fluids mixing or coming into direct contact.



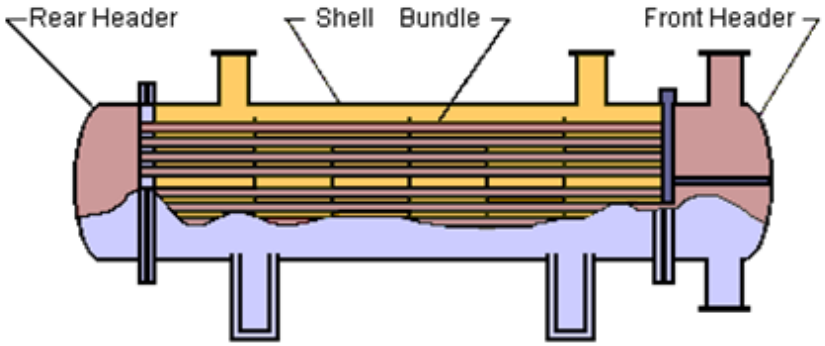


THE COOLING SYSTEM IN YOUR CAR IS AN EXAMPLE OF A HEAT EXCHANGER

Most Common Heat Exchanger Types

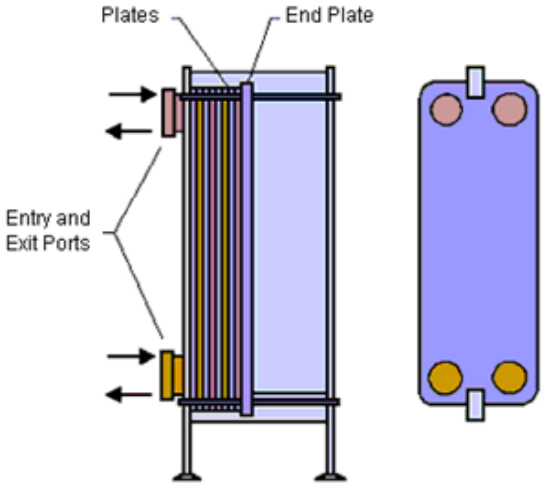
Tubular or "shell and tube"

- Most common in refineries and chemical process plant
- Appendix A concentrates here, and so will we



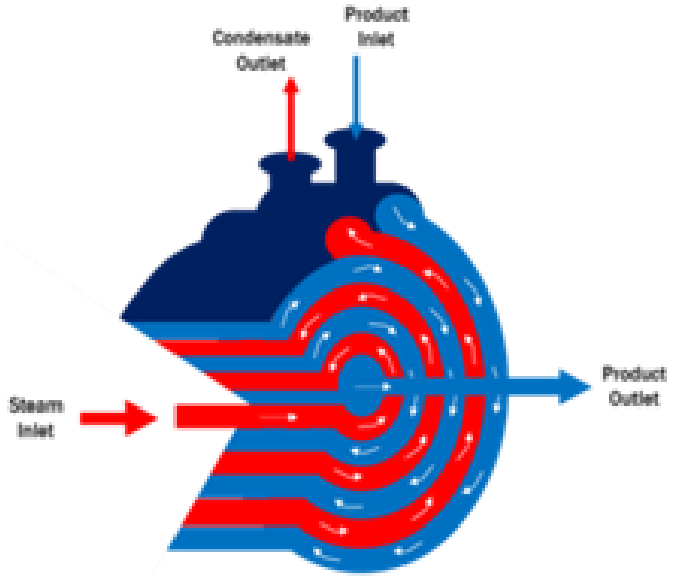
Plate

- Important but specialized

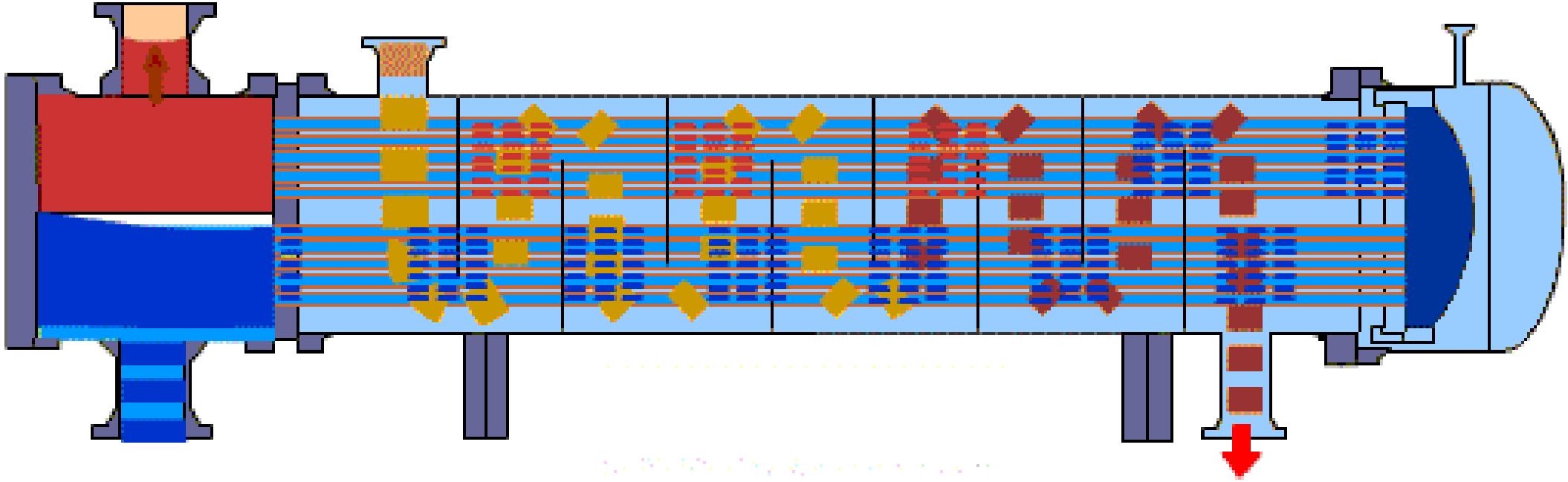


Other (Breech-lock/Spiral/Double Pipe/Fin Fan)

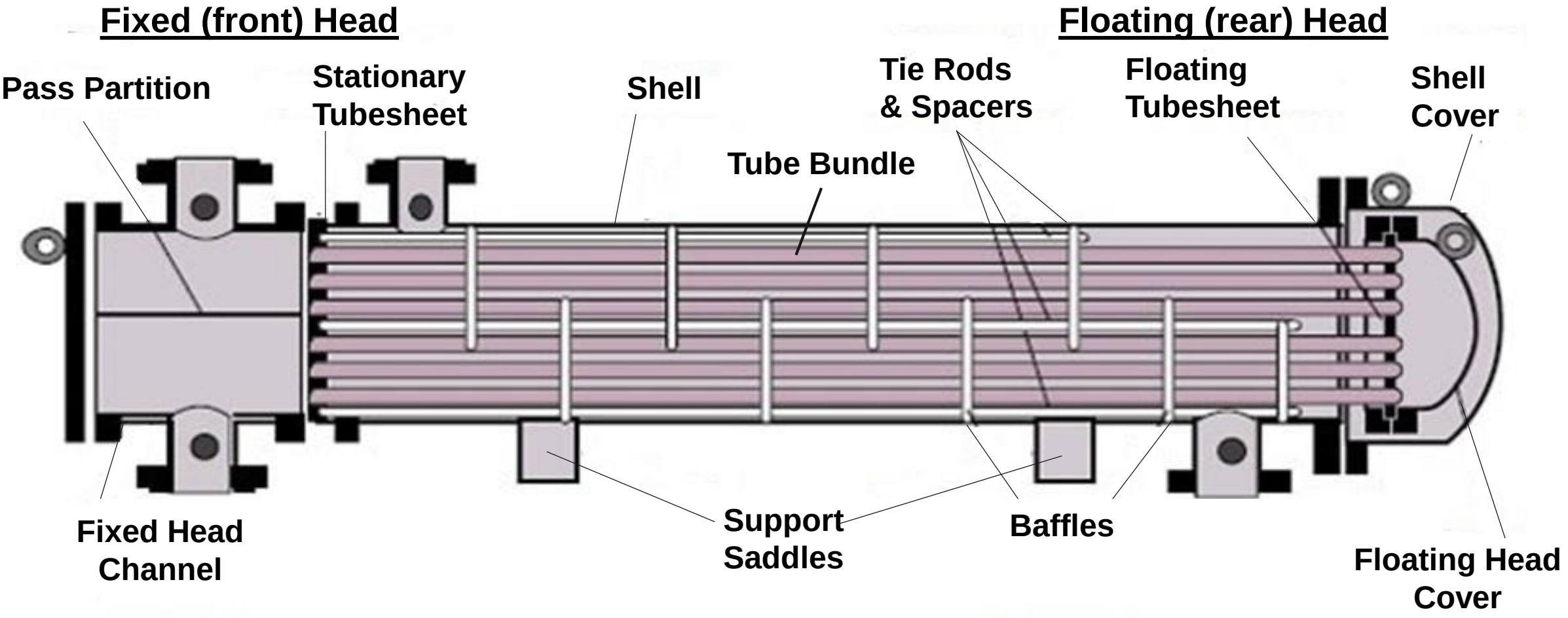
- Less common, but of interest)



Shell And Tube Exchangers



Shell & Tube Nomenclature

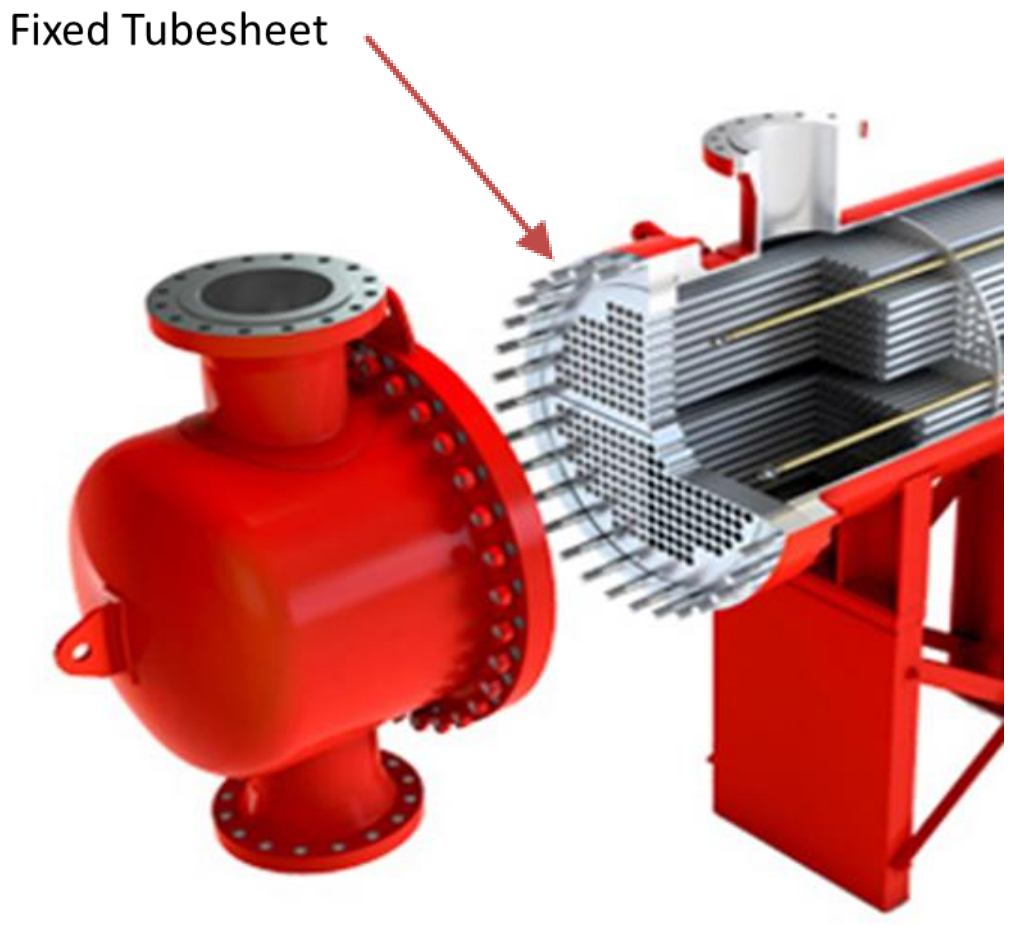


Straight Tube, Two-Pass Shell and Tube Exchanger

S&T Bolting/Sealing Challenges

Five Main Types Of Bolted Joints in Common Shell-&-tube Exchangers:

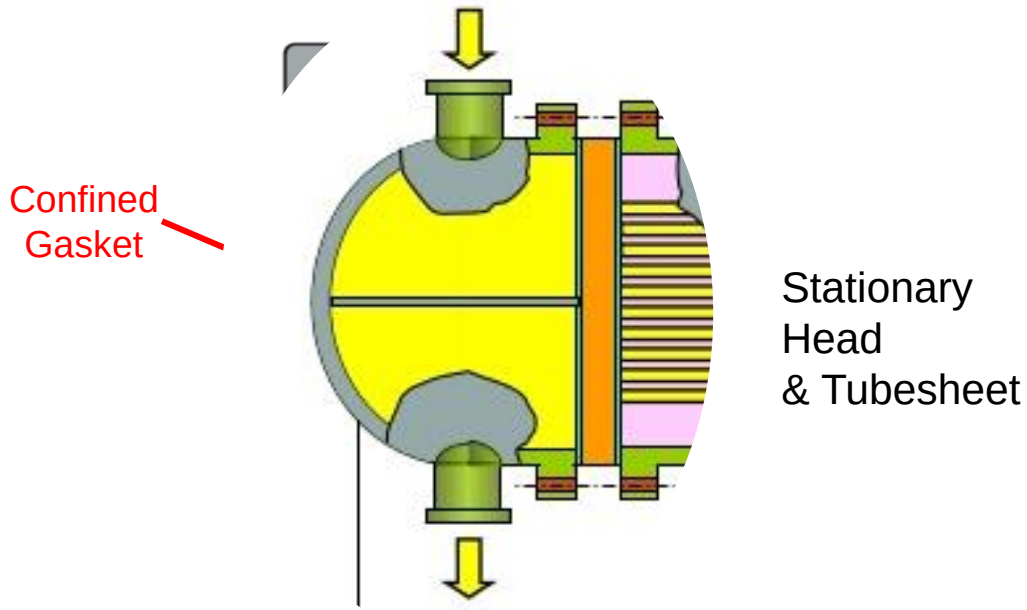
1. Covers(bonnets), Blind Flanges (dollar plates) and Channel flanges
2. Girth flanges especially **TUBESHEETS**
3. Internal bolting in a floating head to allow removal of the tube bundle
4. Nozzle flanges connect to pressurized supply and evacuation lines
5. Pressure test devices, pumps and drains



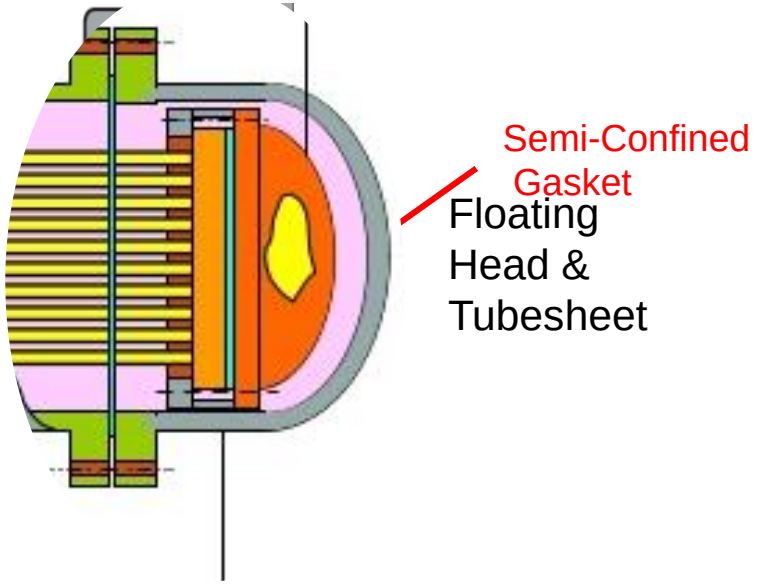
1. Channels / Covers / Tubesheets

- Generally male-female or tongue-and-groove faces to contain gaskets and prevent blowout
- Bolting patterns similar to standard ASME flanges
- Studs with nuts, or hex head bolts may screw into tapped holes on some of these joints
- Tubesheets, (Stationary or floating) may act as spacers requiring 2 gaskets and longer studs

Tongue & Groove Flanges

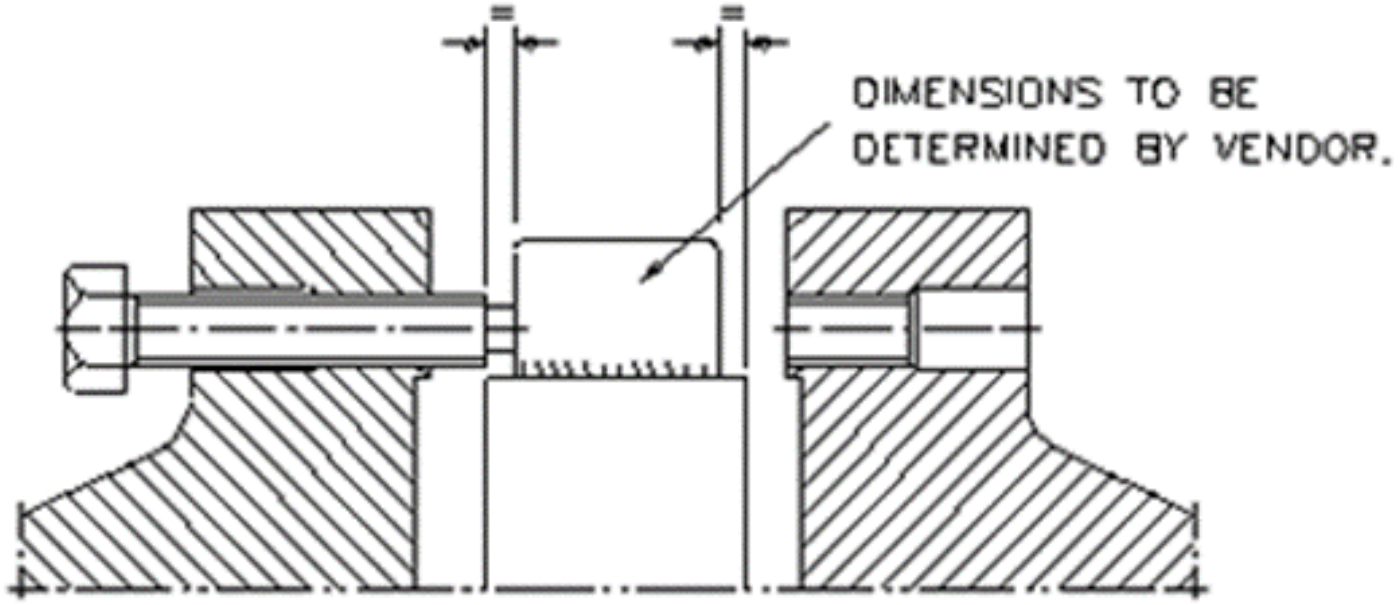


Male/Female Flanges



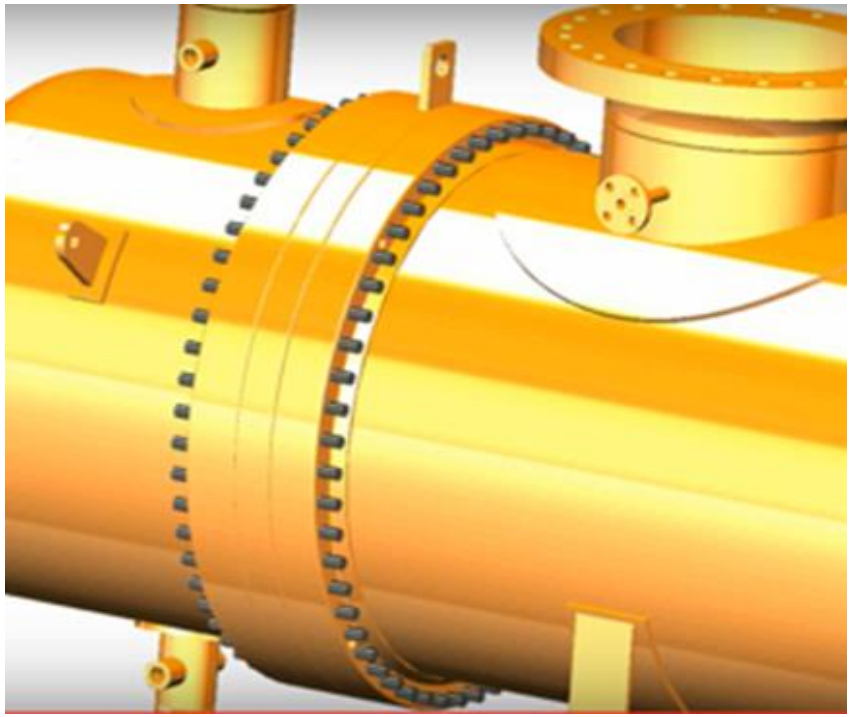
2. Girth Flanges (Tubesheets)

- Mate or join two parts of a pressure vessel
- Usually these are Tubesheets but may be other spacers
- Tubesheet flanges are generally either the male or tongue side of their joint
- Sometimes jack screws are used to separate exchanger sections at girth flanges



Tubesheet Bolting Challenges

- Double-gasketed Tubesheet joints most likely to leak
- Problems caused by the way these joints are bolted
- Many exchangers today still use bolts screwed into threaded holes in the Tubesheet, sometimes independently from either side of the joint – “**Threaded Tubesheets”**



Threaded Tubesheet Issues

PROS 👍

- Bolts can hold tubesheet in place while channel head removed
- Allows tube inspection/cleaning/pressure testing without the channel head installed

Cons 👎

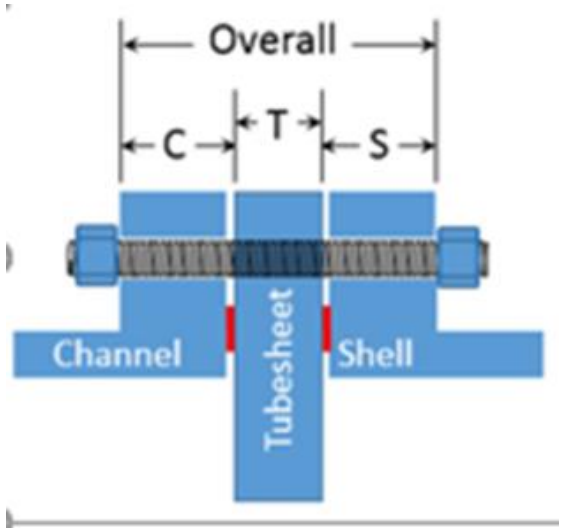
- Shorter bolts cannot stretch effectively – to compensate for bolt relaxation
- As bolts relax at heat-up there is significant load loss on the gasket, risking leaks

Improving Gasket Stress on Threaded Tubesheets

(ENGINEER DECISION)

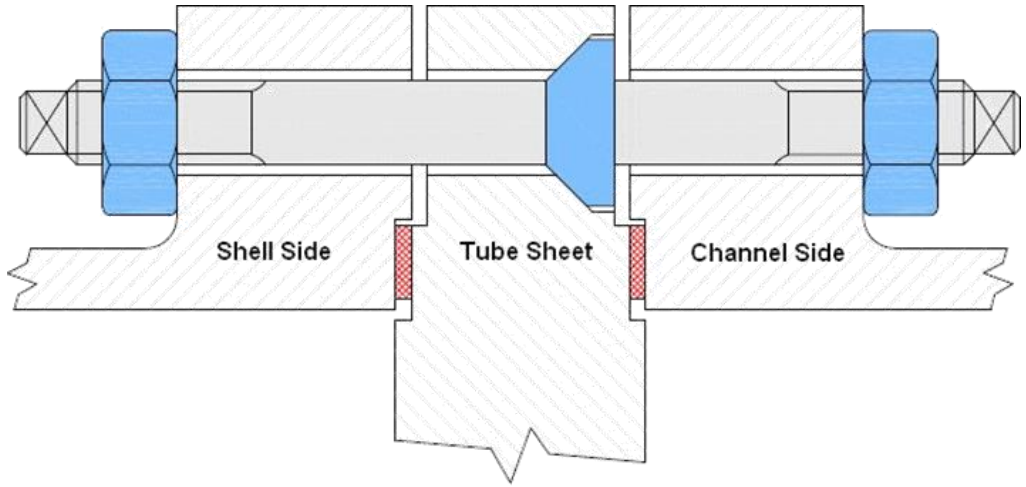
What can be done about a "consistent leaker"

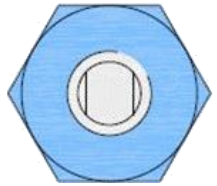
- Drill out tubesheet - replace bolts with through-studs and nuts.
- Retaining every 4th threaded bolt on the shell side can still allow keeping tubesheet-to-shell sealed while removing the channel,
- If there is room, put washers or spacers under the bolt heads and use longer bolts
- Use collar (shoulder) bolts **(see next slide)**



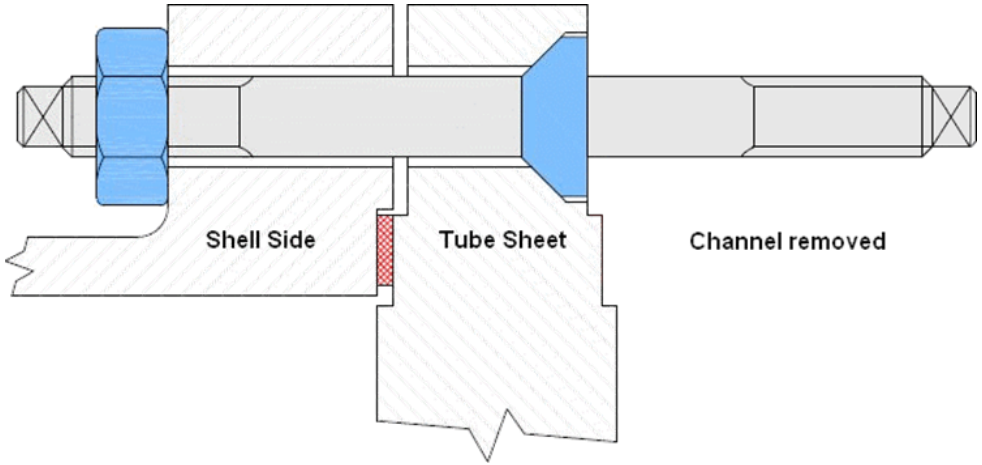
Note: Some tubesheets may have only 4 or 8 threaded holes. The purpose of this is to assist with alignment during assembly.

Collar (or Shoulder) Bolts

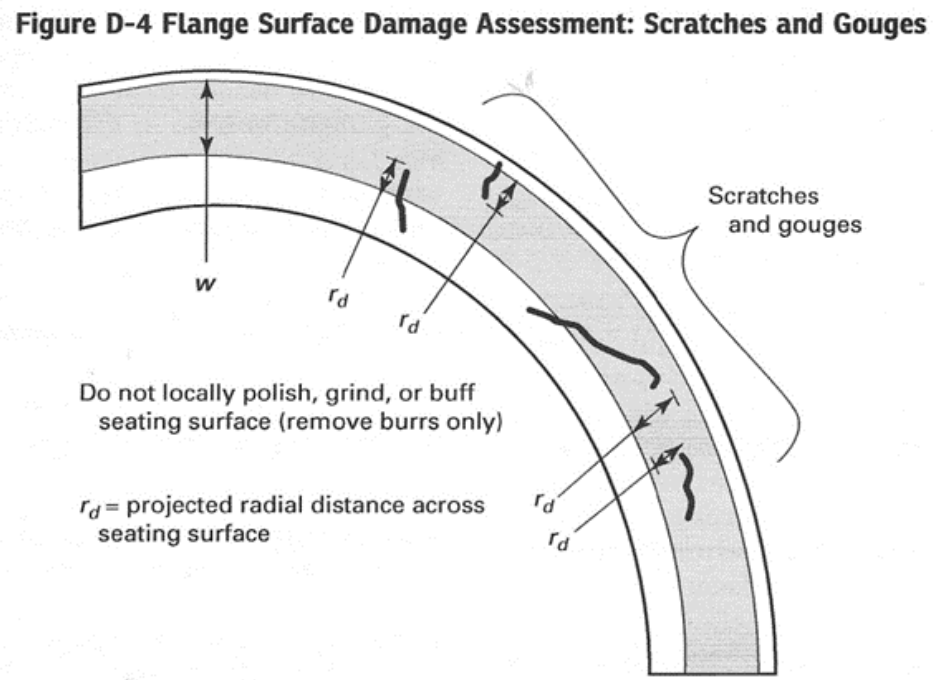




- Holds Tubesheet And Bundle In Place, While Only Channel Is Removed
- Avoids Movement And Breaking Seal On The Shell Side Of The Tubesheet
- Square End On Extended Studs To Prevent Turning
- **Check With Your Supervisor Before Loosening Any Bolts!**
- **Shell-to-Tubesheet Side Must Always be Tightened First!**

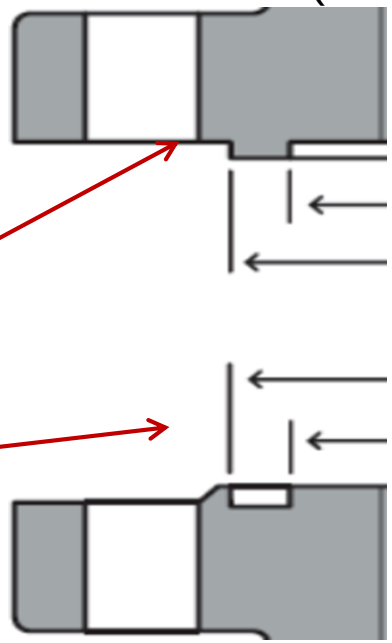


Gasket Surfaces Inspection



Inspect gasket seating area per ASME PCC-1 Appendices C. & D.

- Surface Finish – (typically 125-250 µin. RMS)
- Damage Assessment: Scratches and Gouges
- Damage Assessment: Pits and Dents
- Circumferential flatness
- Acceptable variation in radial (across surface) flatness

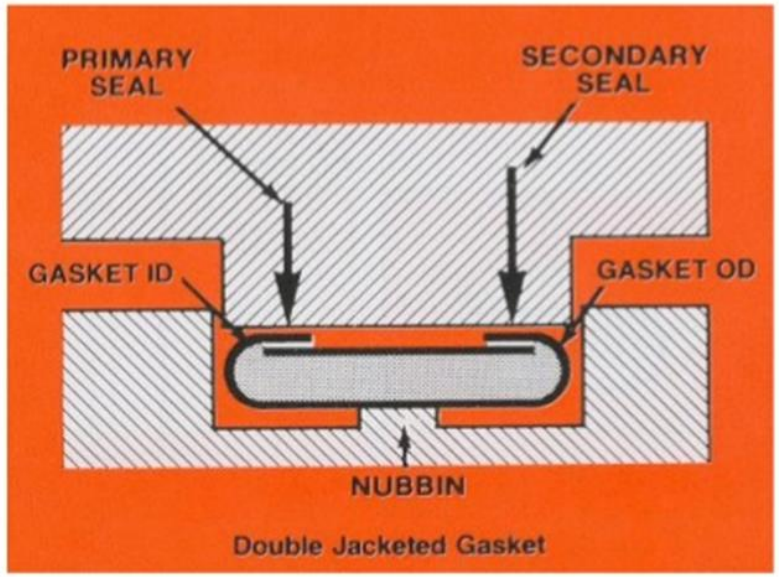


- Dollar plates & tubesheets typically raised faces **¼" high**
- Channel head & shell faces typically recessed **3/16" deep**
- **Measure before you assemble**

What Is A “Nubbin”?

- Nubbin – a raised rectangular ring machined into the center-bottom of a flange gasket groove: designed to concentrate bolt load onto a smaller area of a **double-jacketed** gasket, supposedly to improve sealing

PRESSURE



- Nubbins are no longer preferred by most gasket/flange manufacturers because there are now better gaskets than **double-jacketed** and they are not needed
- Often machined out of the groove
- If nubbin is present – consult your supervisor or engineer for guidance
- Smooth side of a double-jacketed gasket must always face the nubbin

Pass Partition Plate Surface Inspection

- Inspect pass-partition-plate height to gasket surface seating area per ASME PCC-1 Appendix D.
  - Maximum acceptable pass-partition surface height *P* vs. flange face sealing surface:
    flush to -0.010” (hard gaskets) **flush to -0.020”** (soft gaskets)

- Pass-partition gasket fits into grooves on the tubesheet
- If pass-partition surface is <u>too high</u> vs. the flange face:
  - Not enough room for the gasket – uneven compression or crushing
  - Bending and deformation of the flange also likely

- If pass-partition surface is <u>too low</u> vs. the flange face:
  - Gasket may not compress to seal allowing internal leakage
  - Internal leakage reduces efficiency & allows cross-contamination of fluids

Alignment Is Critical on S&T Exchanger Assembly

ASME PCC-1 Appendix E calls for pipe flange alignment:

- Centerline/High Low tolerance within 1/16”
- Rotational tolerance within 1/8”
- These above tolerances are not sufficient to achieve proper assembly on S&T exchangers with pass a partition

Experience has shown that these tolerances need to be reduced to be within 1/32” on these type joints

- The typical pass groove on the dollar plate or tubesheet is only 1/8” wider that the pass partition plate

Thank you

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