

Bolted Joints

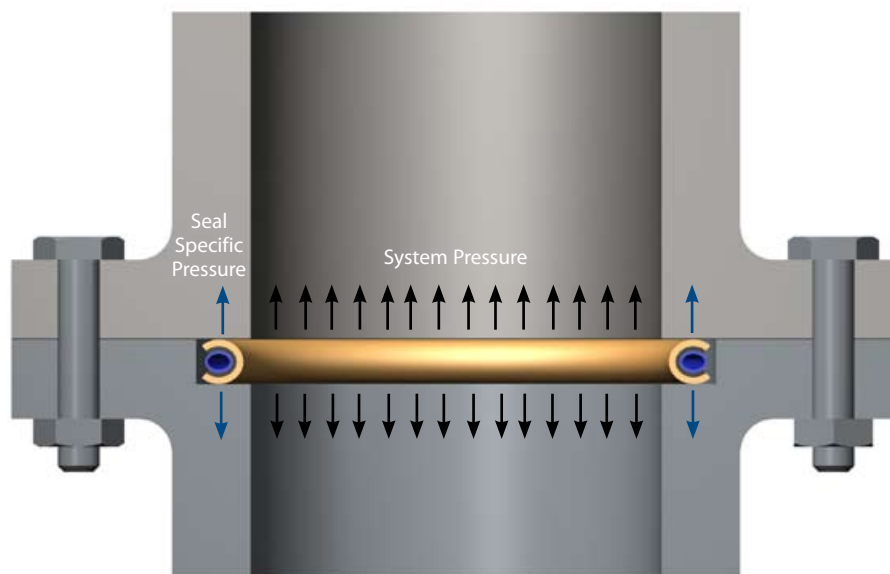
A bolted joint is an assembly that relies on each component to work properly. The performance and success of the bolted joint depends on the quality and design of each of these components. There are three major components of every bolted joint:

1. Flanges (Flange design / Groove dimensions & finish)
2. Bolts / Fasteners
3. Seal / Gasket

The above components cannot be designed mutually exclusive of each other. They must be considered together as a system during the design process. If any part of the bolted joint assembly does not perform properly, the joint as a whole will not perform to expectations and may leak.

Bolt Load and Tightening Torque

When using bolts to fasten the sealing joint the bolts must be of suitable strength and quantity to compress the seal and withstand the maximum hydrostatic load. Additionally, the bolts and flanges must be robust enough to prevent warpage, distortion or separation during service. All service factors must be considered such as thermal stresses, differential expansion, external loads and vibration.



Bolt Load Estimates

The following equations may be used to estimate required bolt loads.

NOTE: These estimates are offered as guidelines only. There are many other factors that the flange designer must consider such as: thermal cycling, vibration, cyclic fatigue, flange thickness, flange rotation, bolt stress relaxation, additional bolt preload, externally applied loads, etc. The customer is responsible for the flange design and for ensuring that the flanges, bolts and bolt loads are sufficient for the application. Please refer to Section VIII of the ASME Boiler and Pressure Vessel Code for code requirements.

$$\text{Total Bolt Load} \geq \text{Seal Seating Load} + \text{Hydrostatic Load} + \text{Safety Factor}$$

Seal Seating Load

Total load required to compress the seal to optimal level. This information can be found for each seal type in the Performance Data sections of the catalog. It is referenced as Y_2 and is given in pounds per circumferential inch (PCI).

$$\text{Seal Seating Load} = \text{Seal Diameter} \times \pi \times Y_2$$

Hydrostatic Load

Load required to contain the system pressure.

$$\text{Hydrostatic Load} = \text{Maximum system pressure} \times (\pi/4) \times (\text{Seal Diameter})^2$$

Safety Factor

This is a customer determined safety factor and must consider: system temperature effects, temperature cycling/spikes, pressure cycling/spikes, vibration, etc.

NOTE: A more detailed calculation is available for the Helicoflex spring energized seals. Please see the Helicoflex Seal product section.

Example Calculation

Seal:

O-Flex metal o-ring, Material = SS321

OD = 4.000in, CS = .125in, wall thickness = .020in

$Y_2 = 1142 \text{ lbs/in}$

Operating Conditions:

Pressure: 500 psi, Temperature: 70 F

Seating Load = $4.000\text{in} \times \pi \times 1142\text{lbs/in} = 14351 \text{ lbs}$

Hydrostatic Load = $500 \text{ lbs/in}^2 \times (\pi/4) \times (4.000\text{in})^2 = 6283 \text{ lbs}$

Total Bolt Load Estimate $\geq 14351 \text{ lbs} + 6283 \text{ lbs} + \text{customer safety factor}$

NOTE: each application should be reviewed to determine if additional bolt preload may be required for proper bolt stretch.

Tightening Torque and Bolt Tension

The following equation may be used to create a rough estimate of the required torque:

$$T = K \times P \times D$$

Where:

- T= tightening torque (in-lbs)
- K*= dynamic coefficient of friction (i.e. minimum = .15 (dry-zinc plated))
- P= total bolt load / number of bolts (lbf)
- D= nominal bolt diameter (in)

(* Also referred to as the “nut factor” in some texts.)

It must be understood that every bolted joint is unique and the tightening torque should be determined for each application through experimentation. A properly tightened bolt is one that is stretched, thus acting like a very rigid spring pulling the mating surfaces together. As the bolt is tightened it begins to stretch and goes into a state of tension. There are many factors that affect how much tension occurs when a given amount of tightening torque is applied. These factors include bolt diameter, bolt grade (strength), and friction. Torque calculations can have significant errors based on these factors, especially friction. Best practice indicates that bolts should be properly lubricated and hardened washers used under the head and nut.

Where possible, it is recommended the fastener elongation, or stretch, be measured directly to ensure proper tension or preload, in the fastener.

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