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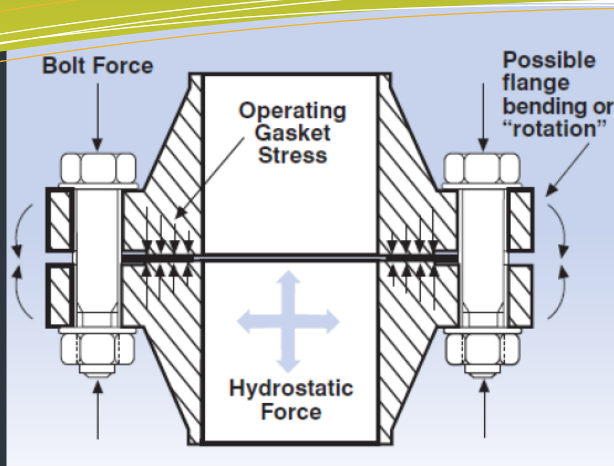

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Total Integrated Solutions

Petracarbon (Thailand) Co., Ltd is a hi-tech company with their primary goal to promote advanced repair & maintenance technologies for oil & gas, chemical, petrochemical, oil refining industries in Thailand and in neighbouring countries.

Beside the usual services, we are also an approved training provider from ECITB (Engineering Construction Industry Training Board) for delivering the Mechanical Joint Integrity (MJI) training courses, that is in line with industry standards and practices.

This ECITB MJI course which focus on skills in perfoming various techniques using range of bolting tools, which enable delegates to learn isolation, dismantling, alignment and tightening techniques on various type of flanges, as well as inspection of components as per industry requirements.

- MJI10: Hand Torque Bolted Connection
- MJI18: Hydraulically Tensioned Bolted Connections
- MJI19: Hydraulically Torqued Bolted Connection

Contact us:

Gasket Stress

Gasket stress is one of a parameter commonly used to describe the unit load on a bolted joint because it directly affects the ability of the gasket to seal. It is the contact pressure between the flange and gasket bearing surface. Gasket types respond differently to a given stress range. Therefore, it is always important to contact the gasket manufacturers to find out the recommended gasket stress and/or how the gasket will react with the load. A soft and conformable gasket may seal at a relatively low gasket stress, whilst a hard metal gasket may require much higher stress.

Since the conditions under which a bolted joint operates during its lifecycle can be complicated, compressive stress definitions have been established to describe gasket condition where it verifies the gasket that will be crushed or seated in order to provide a sufficient sealing joint in preventing a leak.

Four main aspects of gasket stress

There are four ways that we can views the compressive gasket stress:

1. Conforming to the flange surfaces

A flange surface will never be perfect. There could be pittings or corrosion that affects the sealing surface. Therefore, it requires a minimum amount of compression to seat the gasket on the flange surfaces, to form and fill the voids. The gasket must conform to the flange's irregularities to function effectively. If the flanges were perfectly flat and smooth, a gasket might not be needed. With greater imperfections, more compression is needed to force the gasket material to fill up the voids caused by the irregularities.

2. Blocking the Permeabilty of the Gasket Material

Once the gasket has conformed to the flange surface, additional compression may be needed to block any permeability in the gasket body. The permeability through gaskets are different for each material. The rate of leakage decreases as the compressible load increases. This relationship is the basis of the gasket constants as determined by the room temperature tightness (ROTT) test, such as a T3 tightness level (0.00002 mg/sec/mm-dia). These constants were created specifically to provide more than one specific compressive stress that makes a particular

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The state of the fluid, including molecular size, determines the stress required. Required stresses, especially in gaseous services, will increase depending on how tight the seal needs to be. These stresses are higher than the minimum stresses that are necessary to make the gasket conform to the flanges.

3. Withstanding the Internal Pressure

When using non-metallic gaskets, the ability of a bolted joint to hold internal pressure depends on its friction at the mating surfaces. This is related to the compressive load on the gasket, where the minimum compressive stress needs to be high enough to maintain the friction that is needed to keep the gasket from blowing out.

4. Temperature

Temperature is an important factor when determining gasket stress. When temperature is elevated, it will cause gasket and bolt load relaxation. When installing the gasket, it needs to have a high enough stress that will compensate for this. Therefore, it is always important to retorque the gasket 4 to 24 hours at ambient temperature after installation. For some cases, gasket manufacturers recommend a retorque after the first heat cycle depending on the gasket type.

Characterization of Stresses

There are different types of stresses that occur in a system; minimum seating stress, ideal operating stress, minimum operating stress (considering internal pressure) and maximum operating stress specific to a given gasket material. The values for these stresses can be found in ASME PCC-1 (Guidelines for Pressure Boundary Bolted Flange Joint Assembly).

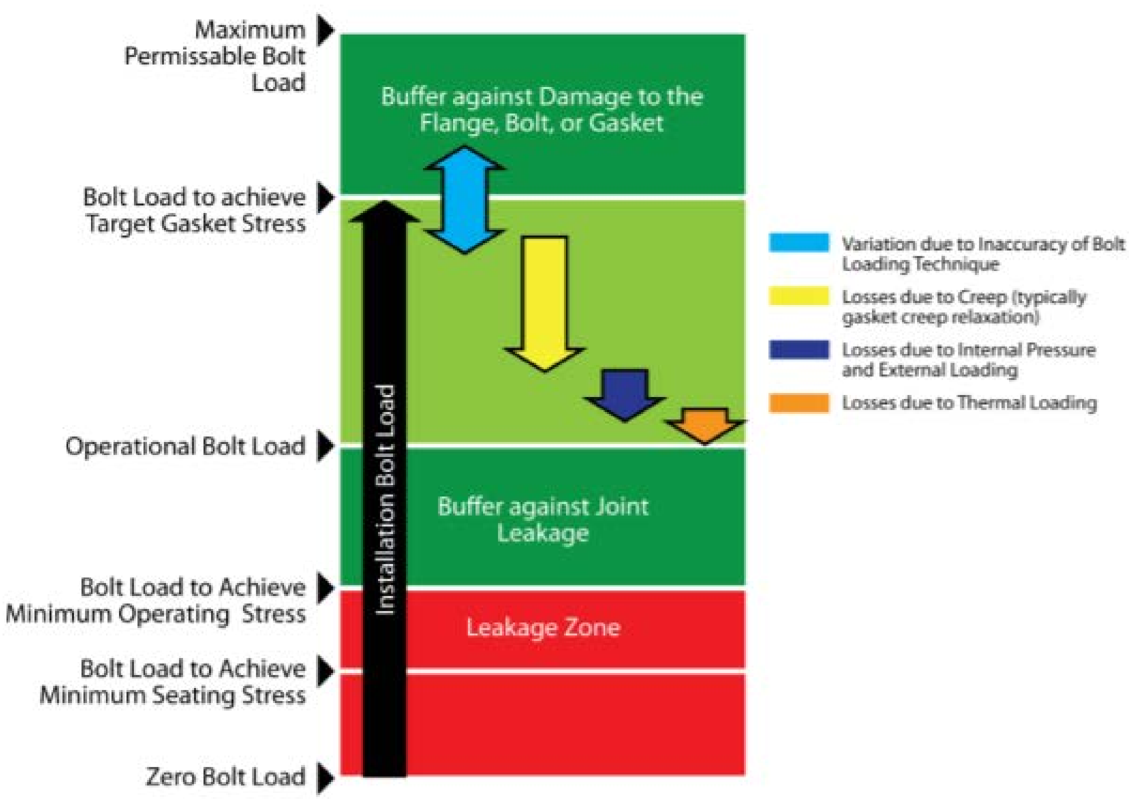
Minimum gasket seating stress (Sgmin-S) is the minimum recommended compressive stress applied to the gasket at assembly temperature to ensure an initial seal during assembly. This value is based on the full gasket area and can be defined as the Y value in ASME Code calculations. This is basically the absolute minimum stress needed to conform to the flanges, assuming that there is little or no internal pressure. Most gasket manufacturers can provide these values on their gasket materials. Often, these values are determined with low-pressure leakage tests on each gasket material. This minimum stress value will normally be used only in flange design calculations.

Minimum gasket operating stress (Sgmin-O) is the minimum recommended compressive stress on the gasket during operating to ensure leakages does not occur. This value is based on the full gasket area. It will normally depend on the design pressure of the assembly.

It will be higher than the seating stress, or Y value, of the gasket. Most gasket manufacturers can provide the minimum operating stress with consideration of the pressure. It is common for these values to increase with increasing gasket thickness. Gasket manufacturers will recommend that installation stress be higher than the minimum seating stress.

Acceptable Assembly Bolt Stress

Several gasket properties must be known to determine the lower limits of assembly bolt stress levels. These include minimum seating stress, percentage gasket relaxation and minimum stress during operation. To establish the upper limits on assembly bolt stress, the maximum acceptable gasket stress and the maximum allowable assembly bolt stress that the flange will withstand must be known. A detailed analysis of this concept can be found in PVRC Bulletin WRC-538 Determination of Pressure Boundary Joint Assembly Loads. Such information can also be found in EN1591 Flanges and their joints – Design rules for gasketed circular flange connections.



Maximum assembly gasket stress (Sgmax) is the maximum permissible gasket stress that could damage the integrity of the gasket in affecting the ability to maintain a seal. Many gasket manufacturers will perform laboratory tests to determine the maximum compressive stress at the assembly temperature that the gasket can withstand without permanent damage. This value is based on full gasket area. Many variables are involved when considering the maximum stress or crush strength of a material, including surface finish, gasket width and thickness, material type and temperature. Most manufacturers will test with smooth surfaces as well as standard ASME serrated flange finishes. Thicker gaskets are usually less resistant to over compression and crushing. Also, serrated flanges tend to allow for higher compressive loads because the rougher surface will grip or hold the gasket better. Smooth surfaces allow the gasket to slip sideways and split at lower stresses.

Because there is a natural variation in any assembly method between calculated and actual compressive stress, most gasket manufactures will supply a maximum recommended stress that is safely below the actual crush test results.

For example, if laboratory tests show damage to a gasket at 25,000 psi stress, the recommended maximum stress might be limited to 15,000 psi. (or -60% of the test result).

Target gasket stress (SgT) is the load that allows the gasket, as well as the entire joint, to operate at optimal performance and sealability. This will be at a value that is not too high to cause damage to the gasket but at the same time, allow sufficient load to the gasket. Additionally, the installation stress creates a preload in the joint that compensates for overall bolted joint relaxation after installation and during operation for the service life of the joint. ASME PCC-1 Guidelines for Pressure Boundary Bolted Flange Joint Assembly recommends that the target stress should be as high as possible, towards the upper limit of the acceptable gasket stress range, as this will give the most amount of buffer against joint leakage.

Determining the Bolt Stress (Bs)

Many reasons exist for using a high target gasket stress. In assemblies running at high pressures or flanges with large internal diameters, there will be significant unloading of the joint when pressurized. Studies conducted by the Pressure Vessel Research Council (PVRC) on pipe bending stresses showed that the bolt stress in the joint was a major factor in keeping the gasket from leaking. The higher the bolt stress, the more bending force the joint could potentially encountered.

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System fluctuations in pressure and temperature will affect the retained/residual bolt load in a joint. Since these factors may reduce the load in the bolts, it is good practice to install the bolts at higher initial stresses, as long as the components are not damaged and bolt material yield is taken into consideration. Stresses in the bolts will have a direct impact on the stresses in the flanges, so these factors must all be considered when selecting the target gasket stress.

So, how to choose the appropriate gasket installation stress? With equipment such as pumps, valves, heat exchangers, assemblies, etc., the manufacturer of those components should be consulted. For standard plant piping, the designer or plant engineer will typically define the maximum bolt stress based on the bolt grade, operating temperature and flange design stresses. Note that this maximum bolt stress is not the same as the allowable stress in ASME design calculations, which is typically only 25 percent of yield. This stress limit is much higher because the ASME Code calculations are meant to force the design to have a significant safety factor and the design stresses are therefore low.

Once the maximum bolt installation stress is known, the gasket manufacturer can provide the recommended gasket stress. They will need to know the service conditions for the assembly to select the correct gasket stress. The Y value from the ASME Code calculations should only be used to design the flanges.

The minimum gasket operating stress might be used if the system is going to run at very low pressures. For example, assemblies using pipe and flange materials with low compressive strengths might need to use the lowest possible gasket stress to affect a seal and avoid damage to the flanges. Flanges running at higher pressures and temperatures will use a stress higher than the minimum operating stress.

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Target Gasket Stress

The simplest method of selecting the target gasket stress is to calculate the available compressive stress at the maximum bolt stress. This maximum bolt stress is typically determined by the plant engineer, and could vary from 40 percent of bolt yield to over 70 percent at some plants. As long as the available gasket stress at maximum bolt stress is below the maximum gasket stress (or crush strength of the gasket) and above the minimum recommended gasket stress for the operating conditions, that can be the target stress.

Another detail when discussing gasket stress and related available bolt load with the manufacturer is to ensure that both are considering gasket stress based on the same gasket compressed area. ASME Boiler and Pressure Vessel Code (BPVC) calculations for the initial bolt load requirement or operating condition (Wm1) and the gasket seating condition (Wm2) are based upon an effective gasket area, which in the case of Wm2 can be as little as half the actual compressed area. Many manufacturers will use the actual compressed area when discussing gasket stress. This can often lead to misunderstandings if not taken into account.

When determining the Wm1 and Wm2, the larger of the two numbers should be the minimum load required to seat the gasket. In most cases the available bolt load in a joint connection is greater than the minimum load on the gasket. If not, higher bolt stresses or changes in the gasket design are required for an effective seal.

Basic Gasket Calculations: