FLUID SEALING ASSOCIATION FSA

From the voice of the fluid sealing industry

SEALING SENSE

# How is gasket stress defined in industry?

This month's "Sealing Sense" was prepared by FSA members Dave Burgess, Brian Hasha & Kris Kolb

Gasket stress is a term commonly used to describe the unit load on its surface. It is one of the most important parameters of a bolted joint because it directly impacts the ability of the gasket to seal. Since the conditions under which a bolted joint operates during its life can be complex, compressive stress definitions have been established to describe conditions throughout this life cycle. Gasket types respond differently to a given stress range, so employing the guidance provided by the gasket manufacturers regarding how their materials react is important. A soft and conformable gasket may seal at a relatively low gasket stress while a hard metal gasket may require much higher stress.

## Four Aspects of Gasket Stress

The compressive stress required on a gasket can be viewed in four ways.

### *Conform to the Flange Surfaces*

A minimum amount of compression is needed to seat the gasket on the flange surfaces. 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 form the gasket into that shape.

### *Block the Gasket Material's Permeability*

Once the gasket has conformed to the flange surface, additional compression may be needed to block any permeability in the gasket body. Permeability through gaskets varies greatly for different types of material, but in almost all cases, leak rates decrease as the compressive load increases. This relationship is the basis of the gasket constants as determined by the room temperature tightness (ROTT) test. These constants were created specifically to provide more than one specific compressive stress that makes a particular gasket type seal.

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.

### *Withstand Internal Pressure*

When using nonmetallic gaskets, the ability of a bolted joint to hold internal pressure depends on friction, which is related to the compressive load on the gasket. The minimum compressive stress will need to be high enough to maintain the friction needed to keep the gasket from blowing out from the internal pressure.

### *Temperature*

The fourth consideration for determining an installation stress is temperature. Elevated temperature will create gasket relaxation and subsequent relaxation in the bolt load. Some load losses can be as high as 50 percent of the initial gasket stress. The initial installation stresses need to be high enough to compensate for this effect. This is the reason that some gasket manufacturers recommend a retorque after the first heat cycle depending on the gasket type (of course, observing the appropriate lock-out and tag-out safety procedures).

## Characterization of Stresses

The minimum seating stress, ideal operating stress, minimum operating stress (considering internal pressure of the system) and maximum operating stress specific to a given gasket material need to be understood and taken into consideration. While many references to values for these stresses have been published, the most updated reference is found in an appendix to recently published *ASME PCC-1-2010 Guidelines for Pressure Boundary Bolted Flange Joint Assembly*. This valuable post construction document also offers insight and recommended guidance on diverse sealing challenges, such as surface finish acceptance for used equipment and misalignment limits for piping systems.

References to gasket stress in this document are shown, but further explanations are needed. Below are the terms and references used in the text and some suggested guidance agreed upon by gasket material manufacturers.

Minimum gasket seating stress (SgminS) 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) 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 suppliers can provide the minimum operating stress with consideration of the pressure. It is not uncommon for these values to increase with increasing gasket thickness. Gasket manufacturers will recommend that installation stress be higher than the minimum seating stress.

Maximum assembly gasket stress (Sgmax) is the stress that could damage the integrity of the gasket and detrimentally affect its ability to maintain a seal. Many gasket manufacturers will perform laboratory tests to determine the maximum stress on a gasket. 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

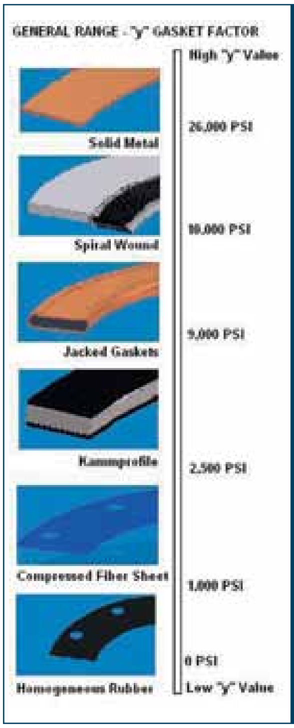


**Figure 1. Y value ranges for gasket materials**

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 grab 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.

**Elevated temperature will create gasket relaxation and subsequent relaxation in the bolt load. Some load losses can be as high as 50 percent of the initial gasket stress.**

Target gasket stress (SgT) is the load that allows the gasket, as well as the entire joint, to operate at optimal performance and sealability. 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 (with consideration given to joint integrity). *ASME PCC-1-2010 Guidelines for Pressure Boundary Bolted Flange Joint Assembly* recommends that the target stress should be as high as possible, "The target gasket stress should be selected to be towards the upper end of the acceptable gasket stress range, as this will give the most amount of buffer against joint leakage."

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 handle.

System fluctuations in pressure and temperature will affect the retained 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 account. 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.

How does one choose the appropriate gasket installation stress? With equipment such as pumps, valves, actuators, sight glass 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 supplier 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.

## 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 75 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 be sure that both are considering gasket stress based on the same gasket compressed area. ASME Boiler and Pressure Vessel Code 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 manufactures will use the actual compressed area when discussing gasket stress. This can often lead to misunderstandings if not taken into account.

**Next Month:** *How can compression packing be applied in severe service?*

*We invite your questions on sealing issues and will provide best effort answers based on FSA publications. Please direct your questions to: sealingsensequestions@fluidsealing.com.*

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"Sealing Sense" is produced by the Fluid Sealing Association (FSA) as part of our commitment to industry consensus technical education for pump users, contractors, distributors, OEMs and reps. As a source of technical information on sealing systems and devices and in cooperation with the European Sealing Association (ESA), the FSA also supports the development of harmonized standards in all areas of fluid sealing technology. The education is provided in the public interest to enable a balanced assessment of the most effective solutions to pump systems technology issues on rational total life cycle cost (LCC) principles.

The Gasket division of the FSA is one of six with a specific product technology focus. As part of its mission, it develops publications such as the *Metallic Gasketing Technical Handbook* as well as joint publications such as the newly revised *ESA/FSA Flange Gaskets – Glossary of Terms, and Guidelines for Safe Seal Usage - Flanges and Gaskets* as well as the *FSA/ESA Gasket Installation Procedures*, which are available in eight languages. These are intended to complement the more detailed manufacturers' documents produced by the member companies.

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