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Isolation Kit Torque Suggestions - Insight into Torque

In this technical write up, my goal is to give the reader a better understanding of why torque is very important to ensure that our isolation gaskets perform as intended. Torque is the action of applying a force in order to turn a body. In the case of bolted joints, torque is most commonly referred to the amount of force being applied to the assembly's nuts in order to achieve a target compressive force, in our case, on a gasket. One may ask "how does a twisting force translate into a compressive force"? Let's break it down.

One of the simplest and most common methods of defining the relation of a twisting force into a compressive force is the "T=KFD" method. This method can be utilized to determine the amount of torque (T) needed to be applied in order to achieve a compressive force (F), while incorporating the friction coefficient (K) and bolt diameter (D). Keeping these factors close in mind, let's go a little deeper.

Here at GPT we incorporate the three common inputs; as described above, but we also incorporate several other aspects in our torque values. These include hydrostatic end forces, gasket material compressive strength, and bolt material's tensile strength. The importance of incorporating these other factors is to ensure that the proper amount of compressive force is being applied to the gasket in order to maintain a seal (while under operational pressure) but also keeping the gaskets compressive stress and the bolts tensile stress within operational limits.

Our gaskets utilizing isolation materials such as Glass Reinforced Epoxy (GRE), have a compressive strength that when exceeded can cause the material to be damaged *(see Image 1)*. Also within the joint assembly are the bolts being utilized. We must keep the tensile strength of the bolt in mind in order to maintain a stress that could be categorized as the "elastic range" of the bolt. Keeping these two values within the limits can be in themselves a "teeter totter" act. Therefore we provide recommended and maximum torque values with our installation instructions to keep these factors in operational ranges.

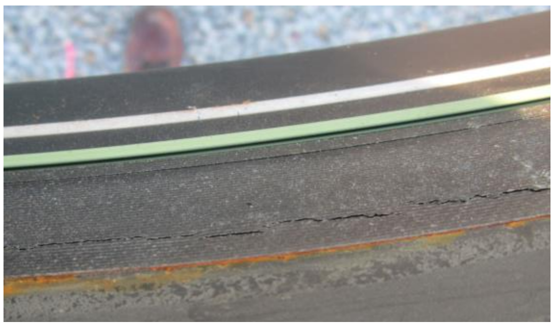


Image 1: GRE over compressed from improper torque.

Our recommended torque values are based on the amount of stress needed to maintain a seal while incorporating the hydrostatic end-forces of the pipeline. The general target stress for the bolt at our recommended torque values is typically around 30% of yield for a SA193 B7 Bolt, which would be around 30,000psi bolt stress. This allows an adequate amount of stress to maintain a seal while exposing the bolt to enough stress to bring some elastic interactions into the mix.

Our maximum torque values are based off of two aspects, a bolt stress of around 50% of yield *(~50,000psi bolt stress)* for a SA193 B7 Bolt or a seating stress on the gasket of no greater than 40,000psi. The reason for including an *"or"* argument in our calculation is because of the limiting factors of the materials as described above. Our calculations target a bolt stress, but in the situation that the resulting seating stress on the gasket is beyond our "desired" maximum seating stress in the gasket, we then reverse calculate a bolt stress to achieve a seating stress of 40,000psi on the gasket. This "desired" maximum seating stress on the gasket is based off of the GRE's compressive strength, including a factor of safety of 1.5.

Now that we have a better understanding of where our torque values come from, let's go back and understand the interactions when using the "T=KFD" method. So the equation is:

Torque (lbs·ft) = Friction Coefficient (unitless) x Force (lbs) x Diameter of Bolt (ft)

We can highlight the importance of each factor by reviewing a couple examples. Let's take an ASME B16.5 Raised Face 4" 2500# flange where we want to know the desired torque needed to achieve a stress of 30,000psi on the gasket. Based on the flange specification, type, size, and pressure class we know the following information:

- Bolt Size: 1 ½" → Bolt Diameter: 1.50" or 0.125ft → Bolt Area: 1.49in^2 or 0.0103ft^2
- Bolt Quantity: 8
- Total Contact Area on Gasket: 15.52in^2 or 0.1077ft^2

Utilizing the target seating stress of 30,000psi, we need to convert this into a force to determine how much force each bolt would have to exert in order to achieve this target . This is done by utilizing the total contact area on the gasket:

Target Gasket Seating Stress x Total Contact Area = Total Force on Gasket

30,000psi x 15.52in^2 = **465,600lbs**

We now have a force, but before we can use the value, we need to determine the force in each bolt. This is in order to find the torque needed for each bolt. In doing this, this force would then be the "F" in our equation. Dividing this total force on the gasket by the amount of bolts we have will give us the amount of force needed in each bolt:

Total Force on Gasket ÷ Total Amount of Bolts = Force per Bolt

465,600lbs ÷ 8 bolts = **58,200lbs/bolt**

Now that we have "F", we can determine our torque:

T=KFD

T= 0.20 x 58,200lbs x 0.125ft

T = 1,455 lbs·ft

By utilizing a seating stress of 30,000psi we know we are within the GRE's compressive limits, but we can also check that we aren't exceeding the maximum desired bolt stress. This is done by utilizing the force in each bolt divided by the bolt area:

Force per Bolt ÷ Bolt Area = Bolt Stress

58,200lbs ÷ 1.49in^2 = **39,060.40psi/bolt**

This bolt stress is well within its limits and within our target values.

Now let's expand on friction coefficients and why we stress its importance in regards to torque values. You probably noticed that I utilized a K=0.20 in the example above. This value is from assuming a friction coefficient of 0.16 and a nut factor of 0.04, thus totaling 0.20. Now let's adjust the "K" in our example and see how much it alters our results.

Utilizing coated studs is a common occurrence in bolted flanges. Coated studs offer many benefits, one being that they offer a very low coefficient of friction. A typical coefficient of friction for a coated stud is 0.12. Let's use this and recalculate our values:

T=KFD

T= 0.12 x 58,200lbs x 0.125ft

T = 873 lbs·ft

We see that the amount of torque needed to achieve the same amount of force is almost half of what was originally calculated. We highlight this in all of our installation instructions, as what has been seen too often is customers will purchase an isolation kit and use our maximum torque values from our installation instructions and not incorporate our notes which highlight adjustments needed for coated studs. The catch to this is that the customer will be utilizing these coated studs, thus unknowingly over shooting our values. In these cases, the customers may experience isolation failures or even leaks due to excessive flange rotation. We have also seen failures where the customer not only used our maximum values with coated studs, but they also apply lubricant to the coated stud, thus decreasing the friction coefficient even more *(see Image 2 & 3).*

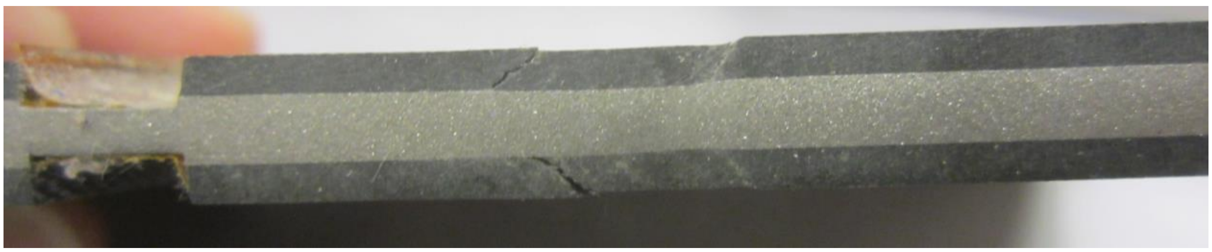
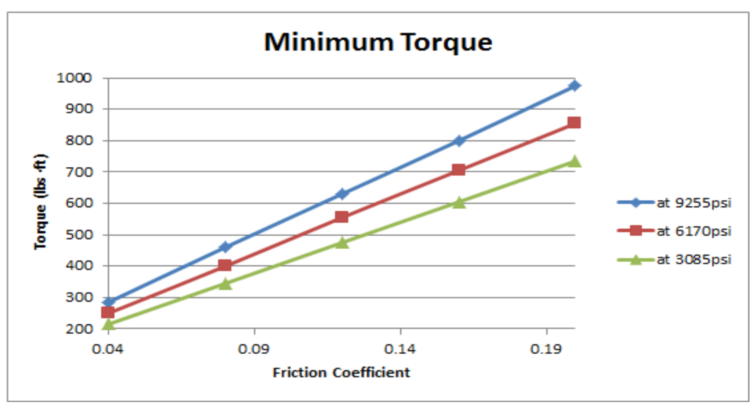


Image 2: GRE permanently deformed and damaged from improper torque.

Image 3: Bolt bending due to excessive flange rotation.

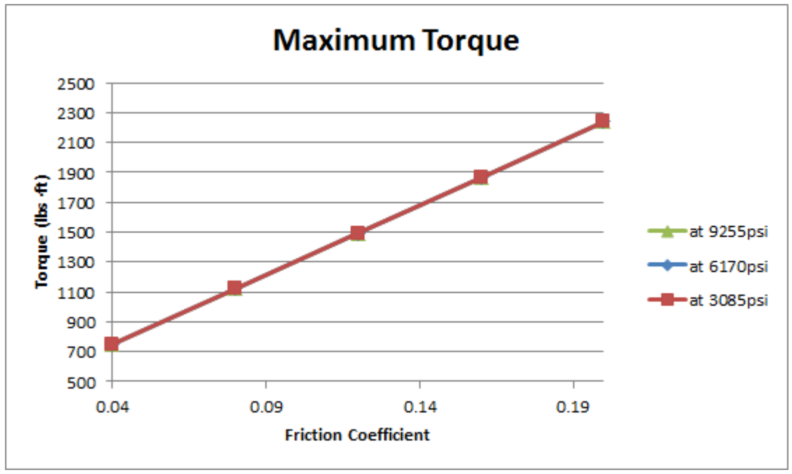
Expanding some more on friction coefficients as well as hydrostatic pressure, we have two graphs showing the change of torque needed for change in friction coefficients and hydrostatic pressures. We notice in Graph 1 to the right, the torque values change with respect to the internal pressures and the friction coefficients. As pressure increases, so does the required torque. This is because the minimum seating stress on the gasket must be maintained. Therefore, when internal pressures increase, the increase in bolt force is required to compensate for the greater internal pressure, all in order to maintain a minimum



Graph 1: Change in minimum torque based on internal pressures.

seating stress on the gasket.

Now looking at our maximum torque values, shown in Graph 2 to the right, you will notice no difference in the required torque with respect to the changes in internal pressures. The only changes in torque are caused by the change in the friction coefficient. The reason that there is no change in the required torque values with the change in internal pressures is because if we recall what our maximum torque value is based on, the target of a bolt stress of 50,000psi or a gasket seating stress of 40,000psi is enough to accommodate the changes in hydrostatic pressure while still keeping the gasket and bolt materials in operational ranges, in terms of the materials compressive and yield strengths.



Graph 2: Maximum torque based on internal pressures.

Although it may seem very in depth, there are many other interactions and factors that can be considered when determining appropriate torque values, that I did not cover in this technical write up. If you have further questions or are wanting to learn more, there are many published technical resources available. Also, here at GPT, we have a team of engineers who are very knowledgeable in technical interactions such as this, and are always willing to help in whatever our coworkers or customers need. So again, this is just the “tip of the iceberg”, if you find that you have more questions, please feel free to reach out to us!

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