Prevent Gasket Blowout—What's Most Important?

SEALING SENSE

First of Two Parts

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Gasket blowout is the most catastrophic of gasket failures. It usually occurs with no discernable warning and causes a sudden and significant release of internal pressure, usually accompanied with loud popping sound or whistle. Depending on the process being contained and/or the amount of stored energy at the time, the result can be fatal.

Part One of this two-part *Sealing Sense* series brings attention to the balance of forces present at the potential moment of gasket blowout and provides guidance on how to protect against this type of gasket failure. Equations are provided to assist with evaluating these forces and results are presented to show that to protect against blowout, clamping force can be significantly more important than gasket tensile strength.

BLOWOUT FORCES

For the purpose of this article, Figure 1 identifies the general condition of potential blowout. It shows an axial "cut" across the thickness of the gasket and the three general forces affecting blowout. Equation 1 provides the force balance in the radial direction. The potential condition of blowout is taken when the sum of these forces is equally balanced. That is, the forces holding the gasket in place and together is equal to the outward force trying to dislodge or damage it.

Equation 1

$F_{Gten} + F_{Clamping} = F_{Blowout}$

These are defined as follows:

F_{Gten} = Force supplied by the (resisting) tensile strength of gasket

$F_{Clamping}$ = Frictional force on gasket from combined axial forces

$F_{Blowout}$ = Outward radial force trying to separate gasket from flanges

These three forces give a general descriptive condition of blowout, but do little to identify the components upon which they are dependent. Equation 2 provides greater detail to draw attention to these components.

Equation 2

$(F_{Gten}) + (F_{Btot}) - (F_{Grelax}) \pm (F_{hyd}) \pm (F_{other}) = F_{Blowout}$

$F_{Clamping}$ has been subdivided into four components. These components are defined as follows:

F_{Btot} = The total initial force on the gasket created from tightening the fasteners to a prescribed target torque

F_{Grelax} = Loss of compressive gasket stress because of time, temperature and load effects

F_{Hyd} = Force resulting from hydraulic load being contained

F_{Other} = General collection of other effects that reduce or increase the clamping force

F_{hyd} and F_{Other}, though normally negative, can be positive and help prevent blowout.

Table 1 lists common conditions that should be considered when evaluating each force. The reader is cautioned that this is only a partial listing. The intent is to bring attention to the type and number of factors that can affect the force balance.

Equation 3 provides a further redefinition and rearrangement of terms that allow the potential blowout pressure to be evaluated directly. Example values are supplied for a

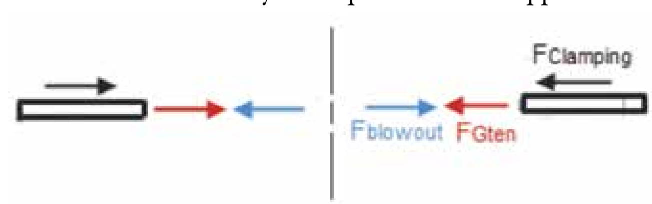

Figure 1. Forces on a gasket

2-inch, Class 150, ASME B16.21 ring gasket.

Equation 3

$$P_{BO} = \frac{[\sigma_{tg} \bullet A_{blowout} + \mu \bullet (F_{Btotal} - \sigma_{gRF} \bullet Ag - F_{Other})]}{\left(\pi \bullet t \bullet D_i + \frac{\mu \bullet \pi \bullet D_i^2}{4}\right)}$$

The added terms are defined as follows:

σ_{tg} = Tensile strength of gasket, 2,700 pound-force per square inch (lbf/in^2)
$A_{blowout}$ = 2 x gasket width x gasket thickness in compressed condition, in^2
μ = Friction factor, gasket on flange face, 0.2
F_{Btotal} = Total bolt load at original tightening torque, 32,914 pound force (lbf)
σ_{gRF} = Loss of gasket stress to time, temperature and loading history, 2,050 lbf/in^2
A_g = Axial area of gasket, 5.84 in^2
D_i = Inner diameter of gasket, 2.38 inches
t = Thickness of gasket in compressed condition (0.0625 inch)
F_{Other} = as above, 10,000 lbf
P_{BO} = Blowout pressure, lbf/in^2

ANALYSIS OF BLOWOUT FACTORS

A way to trial different values to inspect their potential effect on P_{BO} is available. It will be used to test the general belief that gasket tensile strength is always a major factor in preventing gasket blowout. To investigate, two series of calculations are evaluated to the resulting value of P_{BO}.

F_{Gten}	F_{Btot}	F_{Grelax}	F_{Hyd}	F_{Other}
Gasket tensile strength	Nut factor	Softening of gasket modulus at design temperature	Internal pressure being contained (positive or negative)	Differential thermal expansion of components (bolt, flange, gasket)
Coefficient of friction, gasket on flange	Flange misalignment	Cyclic temperature loading of gasket		Piping/ equipment loads
	Tightening procedure	Cyclic pressure loading of gasket		Vibration
	Flange analysis			Flange rotation
	Torque wrench precision			Relative stiffness of flange components
	Bolt condition			

Table 1. Common conditions to evaluate

The first series is performed by holding all values fixed, except σ_{tg}. Its value is progressively reduced in 5 percent increments. In the second series, all values are held fixed except, F_{Other}. This shows the potential effect of an axial piping load or axial flange misalignment that tends to separate the flanges. Its value is progressively increased in 5 percent increments. The results are plotted in Figure 2.

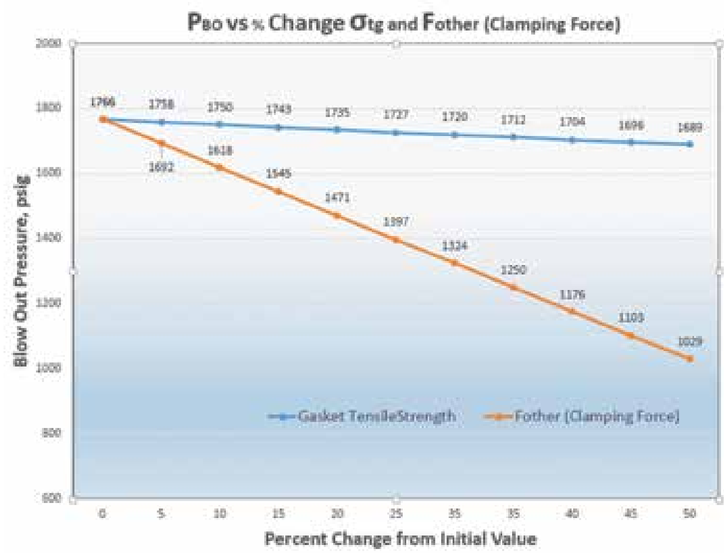

Figure 2. Effect of piping load and gasket tensile strength on blowout pressure

The plot of gasket tensile strength is relatively flat. This shows P_{BO} to have a low sensitivity to changes in gasket tensile strength. On the other hand, P_{BO} shows a significant sensitivity to the effect of the change in axial piping load. During the range considered, the overall change in PBO for tensile strength and the piping load are approximately 4 percent and 41 percent, respectively. In fact, a 5 percent drop in clamping force produces larger drop in blowout pressure than a 50 percent drop in tensile strength. Clearly, the clamping force can play a much larger role in protecting against blowout. This is equally true for any effect that reduces the clamping force.

CONCLUSION

In this example, the total value of clamping force was adjusted by considering a single factor such as piping load or flange misalignment. In reality, the ultimate value of clamping force will be the result of the combined effects of several factors. Unless the value of gasket tensile strength is very high, the clamping force will be most responsible for protecting against blowout.

A review of Table 1 shows a significant number of conditions that can negatively impact blowout pressure. Developing values for these factors can often be a challenge. Next month, Part Two of this *Sealing Sense* series will investigate two strategies to help make this challenge manageable. **P&S**

NEXT MONTH:
Part Two: Prevent Gasket Blowout—What's Most Important?

We invite your suggestions for article topics as well as questions on sealing issues so we can better respond to the needs of the industry. Please direct your suggestions and questions to sealingsensequestions@fluidsealing.com.