Load vs. Deflection Curve

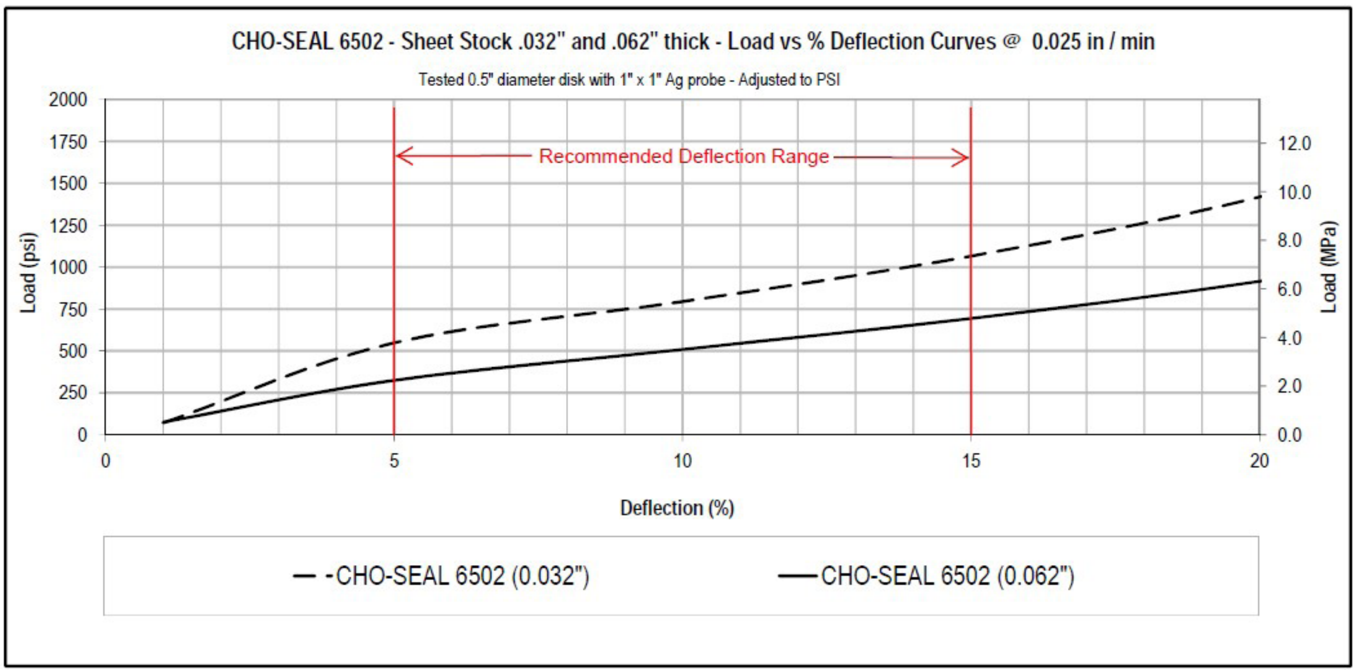
Understanding Elastomer Load vs. Deflection Curves

THE CHALLENGE

Designing EMI shielding or thermal management gaskets into an application requires several data points to successfully incorporate the right gasket into your assembly. Mechanically speaking, every gasket has a certain recommended minimum and maximum deflection range. When supplied with a Load vs. Deflection Curve (example Figure 1) for the gasket, you will be able to determine the expected load necessary to deflect it within the proper range. With the desired load force determined, then the proper hardware size, number of fasteners and torque values can then be set to meet the overall compression needs using the torque formula shown in Figure 2.

DESIGN REQUIREMENTS

Each EMI or thermal gasket will have a recommended minimum and maximum compression value. For example, let's take the case of 0.062" thick sheet stock made in a nickel-plated aluminum filled silicone elastomer (Cho-Seal 6502) material. Shown below in Figure 1 is a Load vs Deflection Curve for this electrically conductive EMI gasket material. Percent deflection is given on the X-axis and load in pounds per square inch (psi) on the Y-axis.



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In this case, the 'Recommended Deflection Range' of 5% to 15% for this sheet format of Cho-Seal 6502 material is listed on the curve. At other times, the recommended deflection range may be provided in a separate table. Note that the gasket shape primarily determines the recommended deflection range, not solely the material type. Be sure to get the right load vs deflection data for the exact gasket shape you are working with. While it would be ideal to have the curve also reflect the exact material that you plan to use, not every material type may be available for every desired shape. Parker Chomerics Applications Engineering may have load versus deflection curves not shown in our published literature.

Looking at the intercept of the minimum value of 5% compression on the X-Axis and the SOLID line denoting the Cho-Seal 6502 at 0.062" thickness, then reading to the left we find on the Y-axis an anticipated load of ~300 psi. At the 15% maximum compression intercept with the SOLID line, the anticipated load on the Y-axis is ~700 psi. The nominal compression for this .062" thick material would then be at 10% compression, with an expected load of ~500 psi. This nominal load then is the ideal load to plan for in your application while accounting for a ±5% compression variation.

The next step is then to determine the gasket 'contact area' or foot print. This is typically a very easy matter given today's computer aided design software. A 2-dimensional or 3-dimensional model can easily determine the gasket's contact area. For this example, lets arbitrarily set contact area (A) equal to 7 square inches.

At this point, you can look to the torque formula below in Figure 2, to manage the remaining variables such as fastener diameter (D), number of fasteners (N) and torque (T) to generate the desired nominal contact pressure required. In this case that target contact pressure (P) we previously determined is 500 psi.

$$P = \frac{(T)(N)}{(.02)(D)(A)}$$

P = Constant Pressure (psi or N/m^2)
T = Torque (in-lbs or N-m)
N = Number of Fasteners
(0.2) = Average Friction Factor
D = Diameter (in. or m)
A = Contact Area (in^2 or m^2)

Continuing this example, the application may demand a fastener of a particular size given the available space. Let's assume for this instance that the hardware size is a #4-40, with a bolt diameter / basic pitch (D) of .0958". Such #4-40 hardware might require a torque (T) of 4 inch-lbs. Looking back to the formula above, the only missing variable now is N, the number of fasteners.

Example Summary:
P = 500 psi   T = 4.0 inch-lbs   D = 0.0958"   A = 7.0 square inches   N = TBD

Solving for N using the formula in Figure 2, you will find that there would need to be 17x #4-40 fasteners set to 4.0 inch-lbs of torque in order to generate a load of ~ 500 psi on a 7.0 square inch gasket.
There are now other considerations to be made:

- What will be my screw spacing? (A long span may elastically deform the cover or flange, so avoid large bolt spacings. A typical 'safe value' for most applications is 2 inches, but that won't be applicable or desirable for all applications.)
- What will be my cover and flange thickness? (Thinner cover and flanges can also elastically deform under load and don't necessarily distribute the fastener load force uniformly. Generally speaking, higher closure force gaskets need greater thicknesses for covers and flanges, such as .093 inch or more. Thin sheet metal at .062" thick should be considered for only low closure force gasketing applications.)

KEY FEATURES

A Load versus Deflection Curve for an EMI or thermal gasket will have a percent deflection on the X-axis and load on the Y-axis. The load on this axis may be in force per area, such as pounds per square inch (psi) for sheet stock material or force per distance, such as pounds per inch (ppi) in the case of an extruded cross section. In both cases for load, it is important to consider the units of measure listed, otherwise the calculation for total load may be wrong. If psi is given, then the contact area is necessary. If ppi is given, then the gasket's perimeter is needed.

The Load versus Deflection Curve will not be fully effective without knowing the gasket's recommended deflection range. Typically, this information is in the curve itself, or in a separate table. If you are unable to find the recommended deflection range for a desired gasket, contact Parker-Chomerics Applications Engineering.

With the gasket's Load versus Deflection Curve, recommended gasket deflection range and using the torque formula in Figure 2, you will be able to solve for various hardware sizes, number and torque value conditions. There will likely be many suitable solutions that would suffice and then the final decision is based on preferences or other outside considerations.

CONCLUSION

Mechanical design for EMI and thermal gaskets can have a formulaic approach. Supplied with the gasket's Load versus Deflection Curve, proper gasket compression range and using the torque formula in Figure 2, you can solve for multiple fastener sizes, number of fasteners and torque value combinations. Then tailor the final solution to best meet your other mechanical requirements.

THE CHOMERICS SOLUTION

Parker-Chomerics Applications Engineering can assist is providing Load versus Deflection Curves for our EMI and thermal management gaskets, provide the recommended deflection range for these gaskets and also assist in offering suitable combinations of fastener size, number and torque values.

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