SPIROL® DESIGN CONSIDERATIONS

Recommended Loading

The integrity of a bolted joint requires that all of the components in the load path be capable of sustaining for indefinite periods, under all environmental conditions, the fastening load initially applied. To do this, all components must be designed for a specific stress, and the fastener being used must be tightened to an appropriate level so as not to exceed the yield point (elastic limit) of any of the components. The reason that metal Compression Limiters are required is because plastic always exhibits stress and strain relaxation under even modest loads. When determining bolted joint characteristics, the following considerations should be evaluated:

- What type of load is really required? For example, does a given plastic flange really need a Class 12.9 cap screw to hold it in place?
- What are the strengths of the components in the joint?
- What will the Compression Limiter be seated against? If it is aluminum or plastic, then that may be the limiting feature.
- Is the bolt being threaded into an Insert? If so, is there adequate thread strength and contact area on the Insert to fully support the Compression Limiter?
- What torque should the bolt be tightened to? SPIROL recommends that the bolt load be 25% to 75% of proof load. Less than 25% and you risk not generating enough frictional retention within the threads. More than 75% and there is a chance due to assembly variations that proof load of the bolt may be exceeded.
- How does torque relate to bolt load? Torque and actual clamping load are very dependant on materials and conditions. The theoretical formula provided on page 9 is only for reference. Actual torque applied must be determined by the end user and is dependant on a variety of factors such as materials and coatings of all the components in the joint as well as the method of applying the torque.

Recommended Tightening Torque

The integrity of the bolted joint requires that none of the components, including the bolt, be stressed beyond the elastic limit. We recommend a clamping load equal to 75% of the proof load of the bolt. The recommended torque values to produce this clamping load are provided on pages 8 and 9.

Determination of Compression Limiter Length

Proper length specifications of both the Compression Limiter and the plastic component are crucial to the proper performance of the bolted joint. The recommended maximum length of the Compression Limiter is the minimum thickness of the plastic component. This assures that when the proper load is applied to the bolt two critical conditions will be met:

- The bolt will be in contact with the Compression Limiter, eliminating the possibility of creep.
- The plastic host will always have a small amount of compression applied.

The amount of compression on the plastic host will be at most the combined thickness and length tolerances of the two components and the amount of compressive deflection on the Compression Limiter. In reality, with good SPC and production controls, the actual compression will be much less.

Allowable Compression of the Plastic Component

For most commonly used molded plastics, it is difficult to determine a specific maximum amount that they can be compressed in a short period of time. There are too many variables involved to make an specific calculation. Such features as the specific plastic, filler, mold design, wall thickness, and stress concentrations all impact the durability of the plastic. As a general guideline, 2%-3% compression of thermoplastic materials is reasonable. Over a short period of time the plastic will usually exhibit stress relaxation, thereby alleviating the compressive load on the plastic and allowing the Compression Limiter to maintain joint integrity. Stated in **formula (1)** below:

(1) $$D_P = T_{max} - L_{min} + D_C$$

Where D_P should typically be less than 3% of T_{max}

Where:

D_P = Required deflection of the plastic component, in units of length.

T_{max} = Maximum thickness of the plastic component, in units of length.

L_{min} = Minimum length of the Compression Limiter, in units of length.

D_C = Deflection of the Compression Limiter under load, in units of length.

Deflection of the Compression Limiter under bolt load can be calculated using **formula (2)** below:

(2) $$D_C = \frac{F_B \times L_C}{A_C \times E_C}$$

Where:

D_C = Deflection of the Compression Limiter under load, in units of length.

F_B = Compressive force generated by the bolt or fastener, in units of force.

L_C = Nominal length of the Compression Limiter, in units of length.

A_C = Cross sectional area of the Compression Limiter, in units of area.

E_C = Modulus of Elasticity (Young's Modulus) of the material of the Compression Limiter, in units of force per area. ***See Table 1.***

Table 1 - Modulus of Elasticity for Common Materials

Material	psi	N/mm² (MPa)
Carbon Steel	30,000,000	206,000
SST (Austenitic)	28,000,000	193,000
SST (Martensitic)	29,000,000	200,000
Brass	15,000,000	103,000
Aluminum	10,000,000	69,000

Table 2 - Deflection Factor C at Proof Load

Compression Limiter Series	Bolt Class / Grade	Carbon Steel	Stainless (Austenitic)	Stainless (Martensitic)	Brass	Aluminum
CL300 / CL500	Class 8.8	0.00160	0.00170	0.00165	0.00320	0.00475
CL350	Class 10.9	0.00230	0.00245	0.00235	0.00455	0.00685
CL101 / CL111	Class 5.8 / Grade 2	0.00125	0.00135	0.00130	0.00255	0.00380

The values for the Deflection Factor C listed in ***Table 2*** are used to simply estimate the actual maximum deflection a Compression Limiter will exhibit when fully loaded to the specified fastener's proof load. **Formula (3)** uses C and the nominal length of the Compression Limiter to calculate deflection.

(3) $$D_C = C \times L_C$$

For deflections at loads other than proof, the results are proportional to the loading.

Force to Seat the Bolt on the Compression Limiter

It is important to always assure that the bolt is seated hard against the Compression Limiter. While proportionally plastic is much more compressible than the Compression Limiter, in the initial assembled state the plastic will be nominally thicker than the length of the Compression Limiter. With the use of flanged bolts or large washers, significant surface area of the plastic can be put under compression, generating high loads. Therefore, it is necessary to calculate the capability of the bolt to compress the plastic and seat against the Compression Limiter in the worst case scenario. **Formula (4)** shows how to calculate the force required to seat the bolt.

(4) $$F_B = \frac{(T_{max} - L_{min}) \times E_P \times A_P}{T_{max}}$$

Where $$A_P = \frac{\pi \times (D_2^2 - D_1^2)}{4}$$

Where:

- F_B = Compressive force generated by the bolt or fastener, in units of force.
- T_{max} = Maximum thickness of the plastic component, in units of length.
- L_{min} = Minimum length of the Compression Limiter, in units of length.
- E_P = Modulus of Elasticity (Young's Modulus) of the plastic component, in units of force per area.
- A_P = Area of the plastic component being placed in compression by the bolt, in units of area.
- D_1 = Minimum hole diameter of the plastic component, in units of length.
- D_2 = Maximum diameter of the portion of the bolt or washer that will be in contact with the plastic, in units of length.

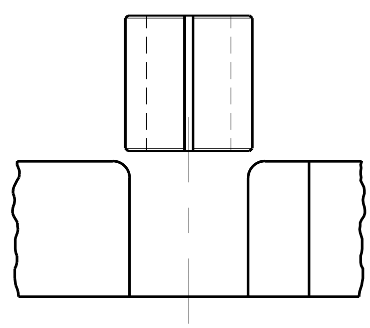
The resultant F_B should be in the range of 50% or less of the proof load of the selected bolt, thereby assuring that sufficient compression is applied to the Compression Limiter after the plastic stress has relaxed.

Headed Compression Limiters

In addition to providing a larger contact area, headed Compression Limiters eliminate the need for a washer. The length and length tolerance under the head needs to be determined following these design guidelines for Compression Limiters to avoid the risk of exceeding the elastic limit of the plastic component. Headed Compression Limiters are only available as solid components because of the tolerances required for proper Compression Limiter operation.

Hole Design

Although the split seam Compression Limiters have a broken edge, this is kept to a minimum in order to maintain the maximum bearing surface area. Accordingly, it is recommended that a radius be molded as a lead-in to the hole in the plastic component to facilitate insertion. This radius is not necessary for solid Compression Limiters as the pilot is smaller than the hole. When a draft angle is required, the hole should taper within the recommended hole size for the length of the Compression Limiter.



Mating Component Material

The clamping load of the bolt is transferred to the mating component through the Compression Limiter. It must be evaluated whether the material of the mating component is strong enough to withstand the clamping force of the bolt. The stress imparted onto the mating component can be calculated by dividing the clamping load applied to the Compression Limiter by the cross sectional area of the Compression Limiter. If this stress exceeds the yield strength of the mating component material, localized permanent deformation may occur, resulting in a loss in clamping load.

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