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 aluminium 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 the 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 4 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. SPIROL recommends a clamping load not to exceed 75% of the proof load of the bolt. The recommended torque values to produce this clamping load are provided on page 4.

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.

Load Rating

SPIROL rates our Compression Limiters by matching the load required to compress the Limiter 2.5% of its nominal length to the clamp load of the nominal sized fastener. **See Standard Offering Breakdown & Materials.**
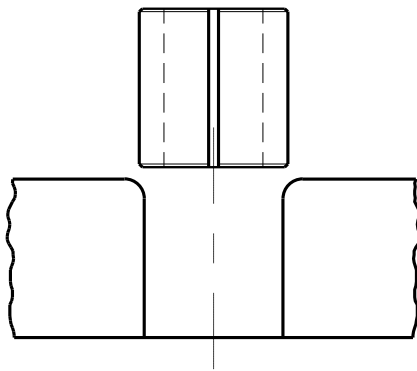
Compression Limiters are rated by the load required to compress the Limiter to a defined, safe distance that meets the requirements of:

- Maintaining integrity of the Limiter, preventing rupturing or excessive swelling.

- Maintaining the integrity of the plastic host by keeping any localised compressive strains within generally accepted, safe limits.

- Maintaining the load of the fastener by preventing stress relaxation, thereby assuring the continued integrity of the bolted connection.

For all engineered thermoplastic materials used in durable manufactured products, allowing 3%-5% maximum compression has been determined to be a safe, conservative limit. Most plastics are perfectly safe being compressed 5%-7%; many even further. Plastics have the characteristic that they will very quickly exhibit stress relaxation in the areas of high compression eliminating the potential of stress cracking and allowing the Compression Limiter to take the fastener load.

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 moulded 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.
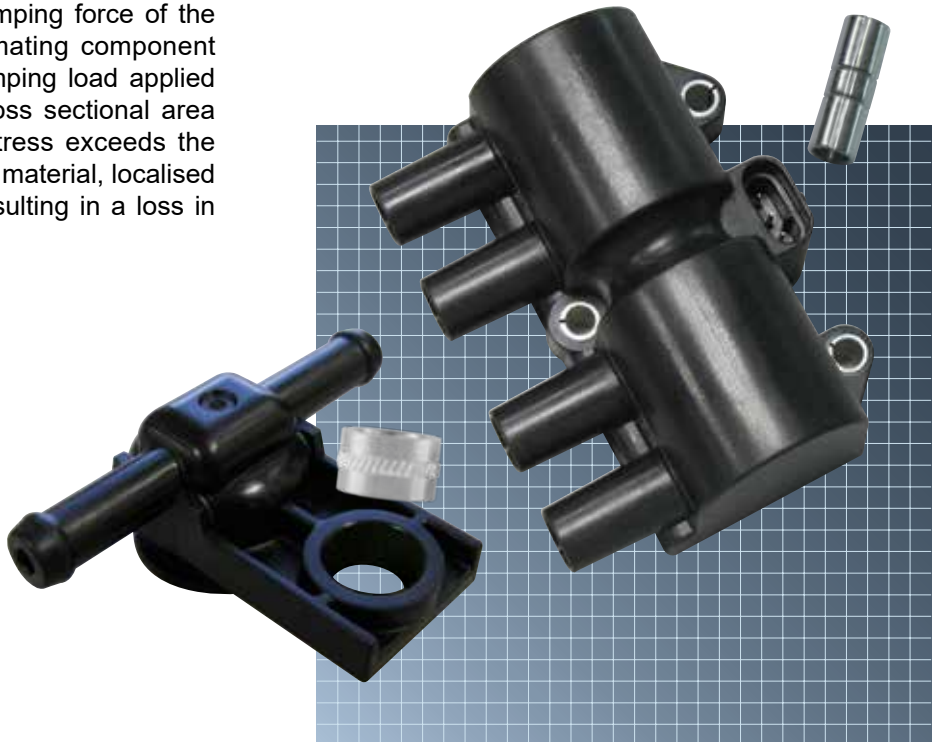
Mating Component Material

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, localised permanent deformation may occur, resulting in a loss in clamping load.

Cost-Effective Fastener Selection

Designers should be prudent about not choosing a bolt class that is too strong for the application and ensuring that the proper tightening torque is applied during the assembly process. A higher bolt class requires a stronger Compression Limiter and potentially stronger mating material. Each adds to the total cost of the assembly. When increased bearing surface at the mating junction is required, Designers should consider selecting either a flange head bolt or including a washer rather than investing in a headed Compression Limiter. In this situation, there is a trade-off between cost and ease of assembly. Flanged bolts and washers cost much less than the added expense of a headed Compression Limiter. In addition, non-headed Compression Limiters are easier to feed.

Selecting the Most Cost-Effective Compression Limiter

Each standard series of Compression Limiters will affect the overall cost of the assembly in different ways. SPIROL Engineering will assist in the determination of which type of Compression Limiter is best suited to meet the performance and installation requirements that results in the lowest total cost of the assembly.

Allowable Compression of the Plastic Component

For most commonly used moulded 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 a 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, 3%-5% 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 5% 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

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 2.*

Force to Seat the Bolt on the Compression Limiter

It is important to always assure that the bolt is seated securely 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 (3)** shows how to calculate the force required to seat the bolt.

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

Where $$A_P = \frac{\pi \times (\varnothing_2^2 - \varnothing_1^2)}{4}$$

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.

$\varnothing_1$ = Minimum hole diameter of the plastic component, in units of length.

$\varnothing_2$ = Maximum diameter of the portion of the bolt or washer that will be in contact with the plastic, in units of length.
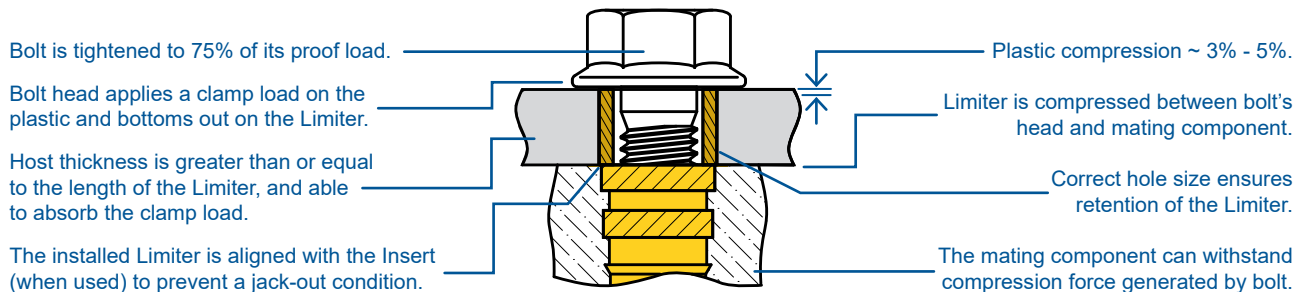
The resultant F_B should be in the range of 75% or less of the proof load of the selected bolt, thereby assuring that sufficient compression is applied to the Compression Limiter after the plastic stress has relaxed.

Material	psi	MPa
Carbon Steel	30,000,000	206,000
Aluminium	10,000,000	69,000
Brass	14,100,000	97,000

Table 2 - Modulus of Elasticity for Common Materials

Note: Compressive strain is an estimated value. Factors such as the rigidity of the plastic host, material, length to diameter ratio of the Compression Limiter, wall thickness, material type, and level of work hardening all affect the actual strain in the Limiter under actual compressive loads in the application. For assistance on determining the most appropriate Compression Limiter for your assembly, please contact SPIROL for complimentary Application Engineering support.

Ideal Bolted Joint

Bolt is tightened to 75% of its proof load.

Bolt head applies a clamp load on the plastic and bottoms out on the Limiter.

Host thickness is greater than or equal to the length of the Limiter, and able to absorb the clamp load.

The installed Limiter is aligned with the Insert (when used) to prevent a jack-out condition.

Plastic compression ~ 3% - 5%.

Limiter is compressed between bolt's head and mating component.

Correct hole size ensures retention of the Limiter.

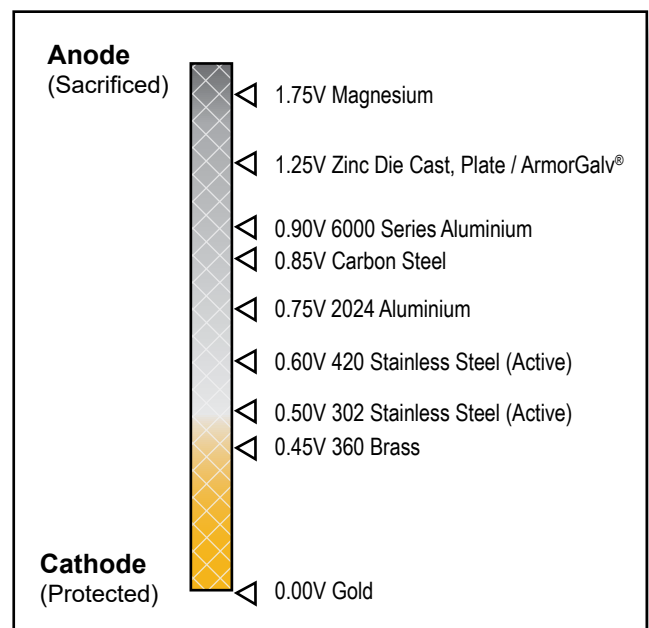The mating component can withstand compression force generated by bolt.

The following design guidelines should be considered when a Compression Limiter is used to ensure its effectiveness in the plastic assembly:

• The length of the Compression Limiter should be equal to or slightly less than the host thickness such that there is a small amount of plastic compression after the bolt is torqued. If the plastic is not compressed, the host may move about the Limiter.

• The bearing surface beneath the bolt's head or washer must extend over the Compression Limiter to contact the plastic component to avoid plastic creep and ensure bolted joint integrity over the life of the assembly. Methods that can be used to achieve this include the use of a flanged bolt, washer or headed Compression Limiter. A washer may be preferred in lower volume and or/non-serviced applications. In higher volume, automated and/or serviceable applications, a non-headed Compression Limiter with a flanged bolt is the easiest to assemble and provides the lowest total cost.

• The amount of material compressed under the bolt's head varies depending on the application's loading and plastic properties. This area of compression must be large enough to withstand forces attempting to pull the assembly apart, yet small enough to allow sufficient plastic compression so that the Compression Limiter contacts both the bolt and the mating component.

• For any given bolt size and class/grade, the recommended clamp load is 25%-75% of the proof load. (Reference page 4)

• It is imperative that the component mating against the Compression Limiter can withstand the compression force generated by the bolt.

• When using an Insert in the mating component, it is essential for the Compression Limiter to be in contact with the face of the Insert to avoid pulling the Insert out of the plastic assembly (jack-out). The Insert must also be able to withstand the load generated by the bolt.

Galvanic compatibility of the materials within the assembly should be considered when an electrolyte is present. Theoretically, galvanic corrosion can be prevented by use of similar metals on the anodic scale and separating dissimilar metals by use of electrical insulators. In reality, protection is difficult to achieve as it is difficult to always use similar metals or provide complete protection from the elements. It is important to consider other measures to minimize the effect of galvanic corrosion. The following factors should be considered:

• Protect the metallic parts from the environment. Without an electrolyte, galvanic corrosion cannot occur.

• Avoid combinations of dissimilar metals that are far apart on the anodic index. For harsh environments such as outdoor use, materials should be within 0.15V, and in warehouses and other uncontrolled indoor environments materials should be within 0.25V. In temperature and humidity controlled environments, materials can be as far apart as 0.50V.

• Avoid small anodes and large cathodes as this increases the corrosion rate of the anode.

Anode
(Sacrificed)

◁ 1.75V Magnesium

◁ 1.25V Zinc Die Cast, Plate / ArmorGalv®

◁ 0.90V 6000 Series Aluminium
◁ 0.85V Carbon Steel

◁ 0.75V 2024 Aluminium

◁ 0.60V 420 Stainless Steel (Active)

◁ 0.50V 302 Stainless Steel (Active)

◁ 0.45V 360 Brass

Cathode
(Protected)

◁ 0.00V Gold

SPIROL®

Innovative fastening solutions.
Lower assembly costs.

Coiled Spring Pins

Slotted Spring Pins

Solid Pins

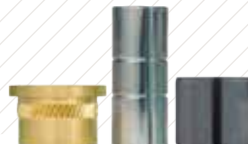**Alignment Dowels / Bushings**

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Compression Limiter Installation Technology

*Please refer to **www.SPIROL.co.uk** for current specifications and standard product offerings.*

SPIROL offers complimentary Application Engineering support! We will assist on new designs as well as help resolve issues, and recommend cost savings on existing designs. Let us help by visiting **Application Engineering Services** on **SPIROL**.co.uk.

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