Screws for Plastic: How to select fasteners for plastic joints

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> **“Piece cost is always insignificant compared to warranty and liability claims resulting from joint failure. ”**

> **“Thread-forming, high-low, thread-cutting, and self-tapping screws are four common threaded fasteners used in plastics.”**

Design engineers are often challenged to find the right type of fastener for the right application. Two of the biggest challenges are lack of experience and information. This guide will give you the information you need to classify the type of plastic joint, and then assist in selection of a fastener that is adequate, and trouble-free. Availability of materials and time limitations can also affect which fastener gets chosen.

Most joints can be categorized into static and dynamic loaded. The four common threaded fasteners used in plastics are: thread forming, high-low, thread cutting, and self-tapping screws. Inserts are popular in dynamic joints and serviceable parts.

Plastic Joint Types

Static Joints

The majority of common plastic attachments fall into this category. Once assembled, these joints experience very little movement, which would cause them to loosen. In these joints, a plastic or metal component is assembled onto a plastic base. A screw driven into a boss of the plastic base secures the two components. A boss is a sleeve-like projection, molded into the plastic base material. Boss design is critical to joint integrity and will be discussed in the following paragraphs.

Figure 1. Screws for Static Joints

Plastic Boss Material	Flex Modulus (psi)†	Thread Forming Screws	Thread Cutting Screws	High-Low Screws	Tapping Screw
Soft	<100,000	Yes	-	Yes	
Normal	<200,000	Yes	-	Yes	Yes
Stiffer	<400,000	Yes	Yes	Yes	
Stiffest	600,000+	-	Yes	-	

† Psi at 23°C, 50% relative humidity

Depending on the stiffness of plastic used, the chart in **Figure 1** will help you select a matching screw type. When designing, do not take fastener cost into consideration. Piece cost is always insignificant compared to warranty and liability claims resulting from joint failure. Best fit and availability should be the main selection factors.

Dynamic Joints

Plastic joints that will experience stress, vibration, temperature changes, or repetitive mechanical use, can be categorized as dynamically-loaded joints. Examples include: handles, latches, seats, power tools, HVAC, appliances, all automotive and truck parts, aircraft parts, and circuit breakers. Basically, if the joint can move or is holding something that can move, it is dynamic. These joints need a thorough design validation to ensure a trouble-free life cycle. A few major factors affecting dynamic joint design are: loads, vibration, material strength, environment, lubricants, torque, bearing area, material properties and fillers.

Information in **Figure 2** provides a good starting point when designing a plastic dynamic joint. Again, the relative difference in cost of screws from one type to another is insignificant compared to the cost associated with joint failure.

Figure 2. Screws for Dynamic Joints

Plastic Boss Material	Flex Modulus (psi)	High-Low Screws	Thread Forming Screws	Metal Insert
Soft	<100,000	-	-	Yes
Normal	<200,000	Yes	Yes	Yes
Stiffer	<400,000	-	Yes	Yes
Stiffest	600,000+	-	-	Yes

† Psi at 23°C, 50% relative humidity

Tapping screws and thread cutting screws are generally not recommended for dynamic joints.

Fasteners for Plastic Joints

Thread Forming Screws

Screws that deform the base material to form their own threads are called thread-forming screws. The thread-forming screws deform a lot of plastic when they are driven. This produces a high resistance to back-out but creates large concentration of stresses in the material. For harder plastics, this can result in failure.

Figure 3. Types of Thread Forming Screws

An effective solution is to use thread-forming screws with 30° thread form. This feature allows the screw to make deeper grooves into the material and capture more of it between the threads, creating an even greater resistance to shear force while reducing stress. Common thread forming screw names are TP30, PT, Boss, and Plastite. However, there are numerous other variations as well.

Figure 4. Typical TP30 Thread Forming Screw

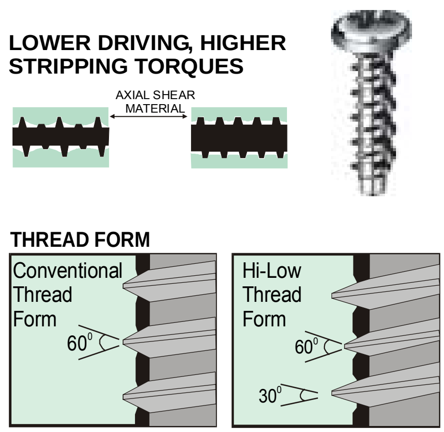
Pros: Low cost, self-threading, use with multiple materials. Best when used in plastics with flex moduli of less than 200,000 psi.
Cons: Not for hard or glass filled plastics, may strip in very thin walled material at higher torque.

High-Low Thread Screws

The High-Low (or Hi-Lo) fastener with its dual thread form improves performance in a broad range of stiffer plastics. This fastener is ideal for use in stiffer plastics with flex moduli between 200,000 to 400,000 psi. The 30° sharp high threads make a deeper cut into the material between the threads. There is also a greater amount of material in contact with the high, sharp thread and the "axial shear" area is increased. All of this contributes to greater resistance to pullout, and stronger attachment, which will minimize the damage done to the material.

Pros: High strip torque
Cons: May need larger boss and larger screw size as rated torsional strength is less than thread forming and tapping screws.

Figure 5. Typical Pan Head High Low Screw



Thread Cutting Screws

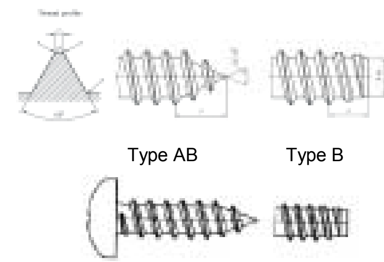
Commonly used in thermoset materials such as Bakelite, and polyesters with a high percentage of glass filler. These very stiff plastics have flex moduli between 400,000 to 1,000,000 psi. As the plastic gets stiffer, more threads of the screw are required to engage securely. This fastener should be limited to static loaded joints.

Figure 6. Thread-Cutting Screws

Tapping Screws

Tapping screws are threaded fasteners with the unique ability to "tap" their own matching internal thread when driven into pre-formed holes in metallic and non-metallic materials. First commercially introduced in 1914, they evolved from wood screws. The common "Type AB" tapping screws are also called "sheet metal screws".

Figure 7. Common Pan Head Tapping Screw



Tapping screws have a 60° thread form similar to machine threads, but the threads are spaced (pitched) farther apart and hardened. This wider pitch allows material to flow between the threads when the screw is driven into the opening. Standard tapping screws come in two styles: Type AB and Type B. For plastic applications, Type B (or blunt tip) is common. The screw shank is always round.

Pros: Commonly available.
Cons: Not suitable for dynamic joints. Has low strip torque.

Metal Inserts

When securing difficult or heavily dynamic plastic joints, the use of threaded metal inserts is the most robust solution. Another common application for inserts is in serviceable parts. When a fastener may need to be taken out of a component without damaging it, an insert is placed in the part for a fastener. Three common types of inserts are ultrasonic, molded-in, and press-fit inserts. Pressure against the outside grooves and friction against the knurls keeps the insert from moving under load. Inside threads of the insert are pre-tapped to accept standard machine screws and bolts.

Threaded Inserts

Ultrasonic inserts are pressed into a plastic substrate while a high frequency ultrasonic vibration melts the plastic in contact with the insert. As the plastic solidifies, the insert becomes secure. Ultrasonic assembly can be used for ABS and Polycarbonate material, but not recommended for glass filled plastics.

Molded-in inserts are placed in the mold prior to molding the plastic. After the component is molded, the insert becomes a permanent part of the plastic part.

Molded-in Inserts

Press fit inserts are pressed into a component shortly after it has been molded. While the plastic is still warm and pliable, the insert is pushed into the part. When the plastic cools, the insert becomes fixed in place.

Brass is the most common insert material. It has excellent machining capabilities and does not require any post treatment. Both of which contribute to lower cost than other materials.

Compression Limiters

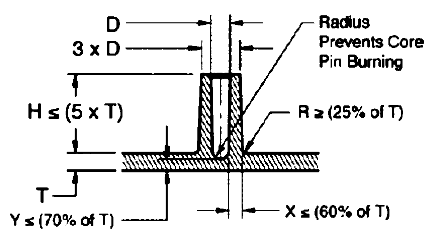
Hollow inserts or bushings are commonly used as compression limiters in dynamic plastic joints. These are available in ultrasonic fit, molded-in or press fit configurations. Hollow bushings keep the plastic from cracking under load when a bolt or screw is used to fasten the plastic part to a metal substrate.

Some Compression Limiter Types

Boss Design

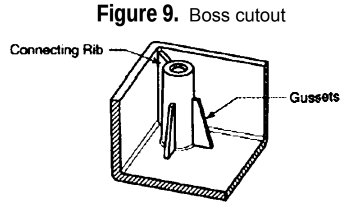
Bosses are used to facilitate the registration of mating parts, for attaching fasteners such as screws, or for accepting threaded inserts.

Figure 8. Boss Cross Section



Wall thickness for bosses should be less than 60 percent of the nominal wall to minimize sinking. However, if the boss is not in a visible area, then the wall thickness can be increased to allow for increased stresses imposed by self-tapping screws. The diameter of the hole in the boss should be equal to 0.7 X diameter of the screw.

Figure 9. Boss cutout



The boss radius should be a minimum of 0.25 X Thickness. Bosses can be strengthened by incorporating gussets at the base or by using connecting ribs attaching to nearby walls.

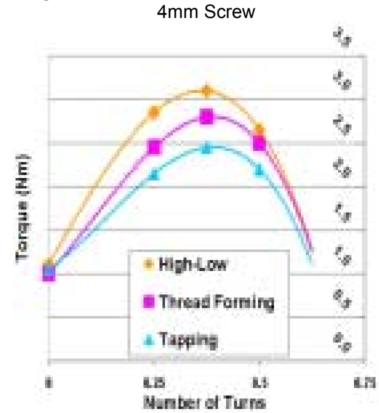
Joint Evaluation

The following factors should be considered when designing for screws:

- **Boss Hole Dimension** – For higher strip torque, use a hole diameter close to 0.7 times the diameter of the screw.

- **Screw Length** – The thread engagement length should be 2.5 times the diameter of the screw.

Figure 10. Comparative Strip Torques for a 4mm Screw



The torque-turn curves in Figure 10 show how different screws respond to applied torque under the same conditions. This figure shows torque-strip ratio after the screw is fully seated. In this example the High-Low screw seats at 1.0 Nm and strips at 3.2Nm. So the torque-strip ratio for this part is 3.2:1.0. In mass production, a torque-strip ratio of more than 3:1 is preferred for robust joints and trouble-free production.

Lokesh Kumar, the chief design engineer at Eisen Electric Corporation, discusses types of plastic joints, screw types needed for plastics joints, plus some alternatives for serviceable joints, and offers tips on boss design and joint evaluation.

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