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Design Issues with Plastic Applications

NOTE: This is intended only as a starting point in the design of joints for plastic materials. Please consult a Textron Fastening Systems applications specialist for assistance in selecting the optimal fastener for your application.

Properties of Plastic Materials
Which Type of Fastener to Use: Screws vs. Rivets

Removability

If an application will require service in the field, the fastener will need external threads so that it can be removed. Both engineered screws and a threaded rivet (Avdel Rivscrew fasteners) are available from Textron Fastening Systems.

A combination of an internally threaded insert, which will be permanently installed in the plastic, and a standard threaded fastener can be used, but may cost more since two parts are being used instead of one. The properties of the plastic and the amount of possible thread engagement need to be carefully studied to see if a single threaded fastener can replace a screw/insert combination.

Avdel brand rivets (unthreaded) are an excellent choice for applications that do not require servicing and reassembly.

Clamp

Clamp load is the total amount of compressive force delivered to the joint by the fasteners holding it together. During installation, clamp load is called “preload” and can be variable for screws. For the first 24 hours after assembly, the clamp load begins to decline. This is referred to as short-term relaxation. After the clamp load stabilizes, it is referred to as “retained clamp load” or “residual clamp load”. Once the joint goes into service, it is subjected to a wide variety of influences (temperature, vibration, etc.) and clamp load is referred to as “in-service clamp load”.

The initial questions that need to be considered during the design stage are:
– how much clamp load is required?
– what kind of clamp load (preload, retained, in-service) is required?

There are many situations to consider:
– If there is a need for mechanical fixation, then high clamp load is likely needed. Screws generally provide higher clamp load than rivets.
– If there is a compressible or fragile layer in the joint, then consistency, at a low clamp load, is required. Rivets generally provide more consistency at low clamp loads.
– If a grounding path for a circuit is needed, high clamp load isn’t needed, but an assurance that the joint will never have zero clamp load is needed.
– Joints subject to a lot of physical loading, including twisting, shear, and pulling, require higher clamp loads to keep them rigid. Also, if sealing is required, high clamp load is needed. Again, screws generally provide higher clamp loads.
– If the assembly will be subject to very large temperature swings, it is difficult to maintain clamp load, due to the differences in thermal expansion between the plastic material and the metal fasteners. This applies to rivets as well as screws. Design modifications may compensate for this.
– Preload can be adjusted on threaded fasteners by changing the seating torque. For rivets, this is determined by the breaker groove/broach load and cannot be adjusted, except at the design stage.

With all the variables involved, it is important to thoroughly study, with the help of a TFS applications engineer, the performance values of the material and fastener that may be used.

View an overview of the effects of creep on plastic materials

Blind Installation

All TFS fasteners listed on this site can be used in blind-side applications of plastic materials, since the material will act as the nut for the threaded fasteners.

The Properties of Plastic Materials

The fastening performance of plastics (thermoplastics and thermosets) is affected by several factors:

– Flexural modulus (stiffness of material)
– Filler and reinforcement content (amount of glass, etc. added to material)
– Thermal expansion rate
– Creep rate

Flexural Modulus and Threaded Fasteners

Flexural modulus is the best indicator of how a plastic will respond to threaded fasteners. Generally, the lower the flexural modulus, the more the material will flow and allow for the formation of threads. Thermoplastics with a higher flexural modulus also allow the formation of threads, but usually require a fastener with a low helix angle to avoid excessive drive torque.

Plastics with a high flexural modulus (above 1,300,000 p.s.i.), including thermosets, are generally too stiff for thread forming and may require thread-cutting fasteners.

There are definite exceptions to these guidelines that can adversely affect performance. Involve a Textron Fastening Systems application engineer early in the design process to maximize joint reliability.

Examples:

Included Materials	Flexural Modulus (PSI)
Ductile Thermoplastics	
Polyethylene (PE)	150,000
Polypropylene (PP)	200,000
Polycarbonate (PC)	340,000
ABS, 0-20% glass fill	350,000
Polyamide 66 (PA)	350,000
Acetal (AC)	400,000
Polystyrene (PS)	430,000
Polypropylene, 40% talc fill (PP40)	500,000
Polypheylene Sulfide	550,000
Moderate Thermoplastics	
ABS, 20% glass fill	650,000
Polyamide 66, 12% glass fill	800,000
Polycarbonate, 20% glass fill (PC20)	850,000
Polycarbonate, 30% glass fill (PC30)	1,100,000
Polybutylene Terephthalates 30% glass fill (PBT30)	1,100,000
Polyamide 66, 30% glass fill (PA30)	1,200,000
Liquid Crystal Polymer (LCP)	1,400,000
Stiff Thermoplastics	
Polyphenylene Sulfide, 40% fill (PPS40)	1,700,000
Phenolic, 20% glass fill	1,750,000
Polyester, 50% glass fill	2,100,000

The Effects of Fillers on Fastening

Fillers and reinforcements change one or more properties of the thermoplastics. They can also affect fastening performance.

For example, impact-resistant resins tend to act more ductile than their flexural modulus would indicate. Lubricants added for molding, such as silicone, tend to reduce drive torque, causing more clamp to be generated at a given seating torque.

It is important to test your application early in the design process to ensure optimal performance.

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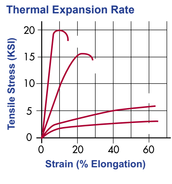
Thermal Expansion Rate



The stress/strain curve for thermoplastics is very temperature dependent. Plastics expand and contract more than metals do when subjected to the same thermal loading.

Since very few joints operate at consistent temperatures, thermal expansion or contraction is virtually universal. This will affect clamp load.

However, this is only a problem if the application uses materials with dissimilar expansion rates and the temperature change is significant. Design modifications can be made to compensate for this.

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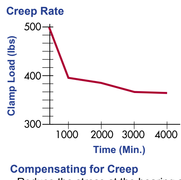
Creep Rate



Under load or heat all plastics will creep, or permanently deform. Creep will, in turn, cause a loss in clamp load. The chart at left demonstrates the loss of clamp load, at a stable temperature, over 64 hours, of a #8 Plastite fastener driven into acetal resin.

Compensating for Creep

- Reduce the stress at the bearing surface by one or more of the following:
  - increase the fastener head diameter
  - add a flat washer
  - reduce the clearance hole diameter
  - reduce initial clamp load at assembly
- Add a spring element to the joint such as a helical and flat washer combination or engineered spring washer
- Add a metal sleeve in the clamped component to carry some of the clamp load
  - Use a shoulder bolt to transfer the load to the nut member
  - Increase stiffness of plastic by adding a filler or changing the base resin
  - Increase the grip length of the fastener

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