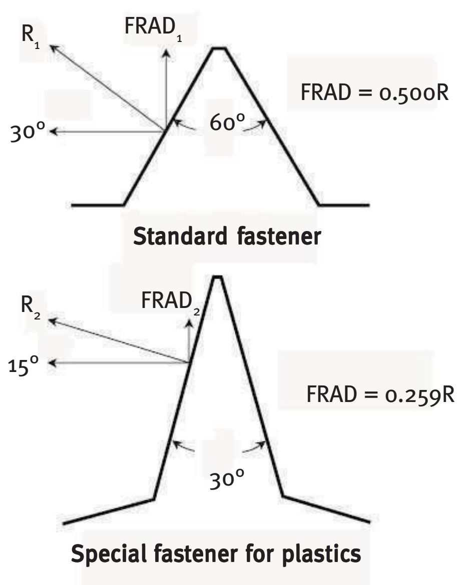
# Fasteners for Plastics vs. Standard Screws

## Narrow thread profiles maximize performance

Tapping screws and other standard fasteners have a wide thread profile (also called flank angle) of 60°. Special fasteners for plastics have special thread profiles to meet the needs of these unique materials. These narrower thread profiles, ranging from 30° to 48°, reduce radial stress and expansion. This in turn maximizes fastener performance.
Because radial stress is reduced, special fasteners for plastics allow the use of smaller bosses than standard screws.
Using smaller bosses can reduce your overall costs through decreased material usage and molding cycle times.



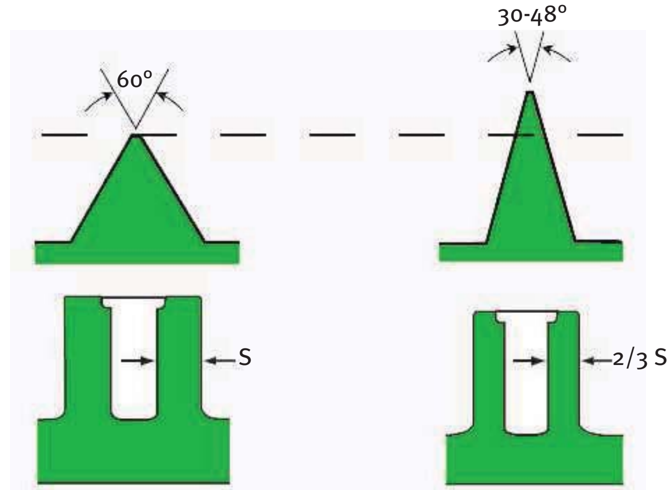

## Increased resistance to pull-out

In the illustrations on the right, CM represents the area subjected to shear when an axial load is applied.

Because the special fastener for plastics has a smaller minor diameter (mø) and a higher thread profile, it contains a larger volume of material (CM) and has a larger axial shear area.

This greater area of thread engagement means the special fastener for plastics is more resistant to pull-out.

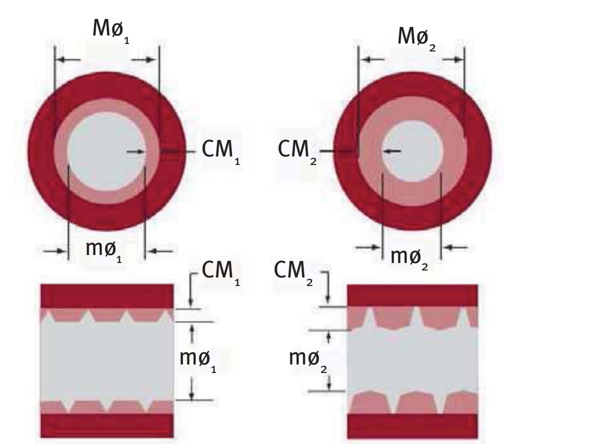
Standard fastener | Special fastener for plastics




## Lowered radial stress prevents boss damage

Radial force (FRAD) is an undesirable force since it creates outward stress and can damage the boss. Although the same volume of material is displaced between the 60° thread and the 30° thread, the radial force generated by the 30° thread is approximately one-half that of the 60° thread.

In the photo at right, the plastic boss with a 60° thread fastener shows radial stress and subsequent damage. The plastic boss with a special fastener for plastics shows reduced radial stress.

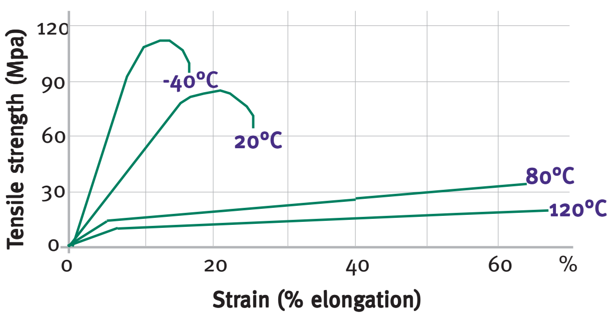



Standard fastener | Special fastener for plastics

## Properties of Plastics

# Flexural modulus

Flexural modulus is the best indicator of how a plastic will respond to fasteners. Generally, the lower the flexural modulus, the more the material will flow and allow 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, including thermosets, are too stiff for thread forming and will require thread-cutting fasteners. There are definite exceptions to these guidelines which can adversely affect fastening performance. Involve our application specialists early in the design process to maximize joint reliability.

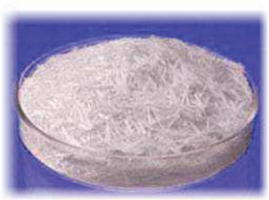



# Thermal expansion rate

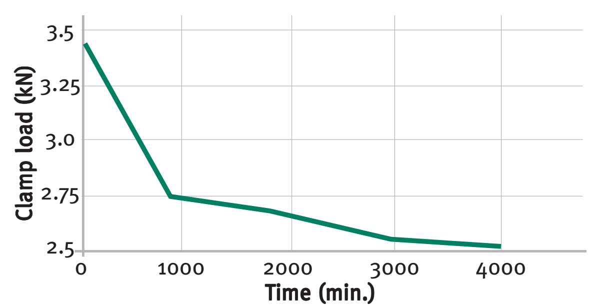
The stress/strain curve for thermoplastics is very temperature dependent. Plastics expand much faster than metals do when subjected to the same thermal loading.
Since very few joints operate at constant temperatures, thermal expansion or contraction is virtually universal. This will affect clamp load. However, this is only a problem if the application uses materials with dissimilar expansion rates and the temperature change is significant.

# Effects of fillers on fastening

Fillers and reinforcements change one or more properties of the thermoplastic. 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 but can negatively affect clamp load.



Again, it is important to test your application early in the design process to ensure optimal performance.



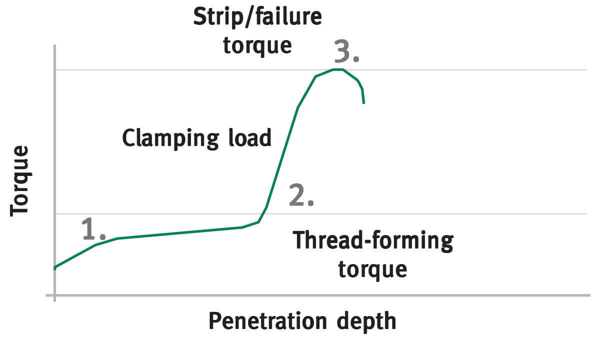

# Creep rate

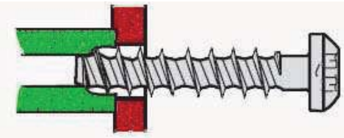
Under load or heat all plastics will creep, or permanently deform. Creep will, in turn, cause a loss in clamp load. The chart above demonstrates the loss of clamp load, at a stable temperature, over 64 hours for a 4.0 mm screw fastener driven into acetal resin. However, creep can be compensated for in joint design through a variety of methods.

## Thread forming and strippping torque

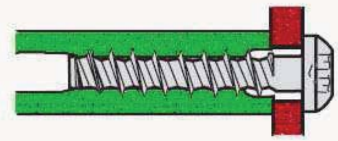
Because friction increases as penetration increases, the differential between the thread-forming torque and the strip (failure) torque must be maximized.

*Proper seating torque varies from application to application, so contact an applications engineer for assistance.*

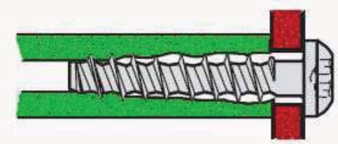


1. Thread-forming begins



2. Screw head in contact with plastic; clamp load generated

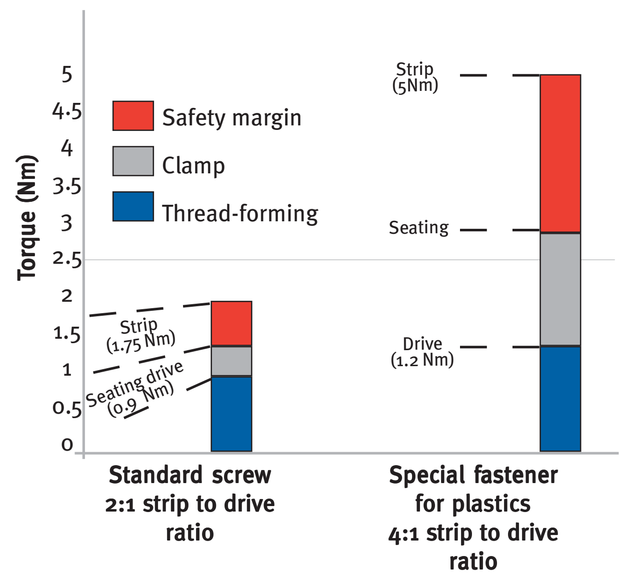


3. Strip-out torque level met or exceeded; boss damage occurs

## Drive-to-strip ratio

As demonstrated in the chart on the right – based on testing – the fastener for plastic has a much higher drive-to-strip ratio, so the joint is less likely to be damaged during installation.
The standard screw has a safety margin of only 0.6 Nm. The special fastener for plastic has a safety margin of 2.1 Nm.

*Note: The chosen seating torque was 65% of the failure torque, based on testing.*




## Influence of driver speed

Increased drive gun speed can negatively affect the quality of the joint.
During installation, as the RPMs increase, so does the amount of heat that is generated. Too much heat can break down the plastic and lower the failure torque level.

## Determining proper seating torque

National Engineered Fasteners Inc.can run complete tests on your application to determine your optimal fastening solution, including fastener selection, joint design and seating torque.

# Selecting the Right Fastener

The following chart is intended only as a starting point in the selection of fasteners. The fastener must be matched to the properties of the material. Drive to strip ratios, clamp retention, and other performance issues are directly affected by the fastener you choose. Please contact an National Engineered Fasteners Inc applications engineer for assistance in selecting the optimum fastener for your design.

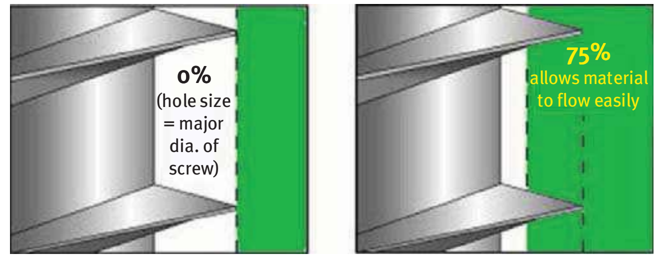
| | | Material | Flexural modulus psi | Flexural modulus N/mm² | 45 | 30 | 40 | 30S |
|---|---|---|---|---|---|---|---|---|
| Thermoplastics | Ductile | Polyethylene (PE) | 150,000 | 1,030 | | | | |
| | | Polypropylene (PP) | 200,000 | 1,380 | | | | |
| | | Polycarbonate (PC) | 340,000 | 2,340 | | | | |
| | | ABS, 0-20% glass fill | 350,000 | 2,410 | | | | |
| | | Polyamide 66 (PA) | 350,000 | 2,410 | | | | |
| | | Acetal (AC) | 400,000 | 2,760 | | | | |
| | | Polystyrene (PS) | 430,000 | 2,960 | | | | |
| | | Polyprophylene, 40% talc fi ll (PP40) | 500,000 | 3,450 | | | | |
| | | Polypheylene Sulfide | 550,000 | 3,790 | | | | |
| | Moderate | ABS, 20% glass fill | 650,000 | 4,480 | | | | |
| | | Polyamide 66, 12% glass fill | 800,000 | 5,510 | | | | |
| | | Polycarbonate, 20% glass fill (PC20) | 850,000 | 5,860 | | | | |
| | Hard | Polycarbonate, 30% glass fill (PC30) | 1,100,000 | 7,580 | | | | |
| | | Polybutylene Terephthalates 30% glass fill (PBT30) | 1,100,000 | 7,580 | | | | |
| | | Polyamide 66, 30% glass fill (PA30) | 1,200,000 | 8,270 | | | | |
| | | Liquid Crystal Polymer (LCP) | 1,400,000 | 9,650 | | | | |
| Thermosets | | Polyphenylene Sulfi de, 40% fill (PPS40) | 1,700,000 | 11,720 | | | | |
| | | Phenolic, 20% glass fill | 1,750,000 | 12,060 | | | | |
| | | Polyester, 50% glass fill | 2,100,100 | 14,480 | | | | |

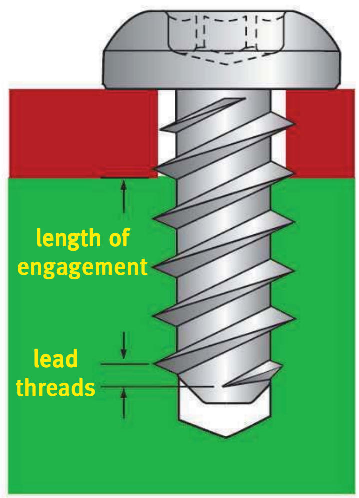
## Thread engagement and pilot hole diameter

Thread engagement is the amount of thread flank depth that is filled by the application material. It is often expressed as a percentage. A hole diameter equal to the major diameter of the threads would have a thread engagement of 0%.

In moderately stiff materials, you should start with a hole size that provides 75% to 80% thread engagement. A hole that creates a thread engagement of over 100% does not improve performance. It will, however, increase required drive torque, because the walls of the hole must expand to make room for the screw.

If the hole size is fixed, you will need to adjust the thread style or length of engagement to reach the appropriate performance requirements. Each fastener for plastics has its own parameters. For optimal performance, contact an applications engineer for assistance.



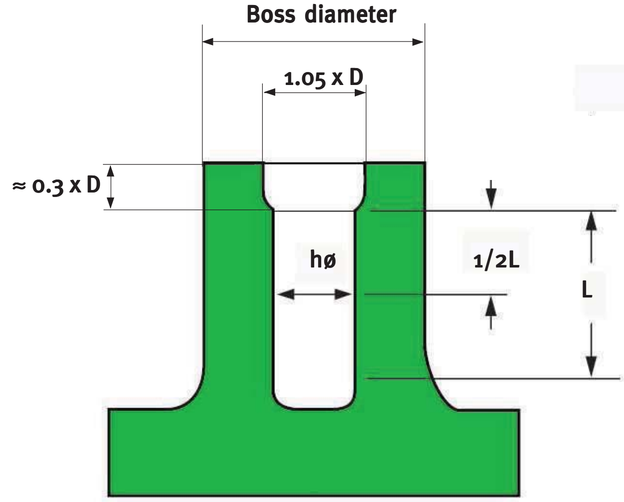

## length of engagement

Length of engagement is the measurement of full-sized fastenerthreads engaged in the nut material. The length of the lead thread (usually about one-half the fastener diameter) is not counted in the length of engagement, since its reduced size minimizes any performance benefits. Length of engagement is often expressed in relationship to the nominal diameter of the screw; e.g. 2 to 2-1/2 diameters of engagement.

## Boss design

Drafted holes ease molding in thermoplastics, but can affect thread engagement. Always utilize the minimum amount of draft possible to retain good mold function. Generally, the nominal hole size (hØ) is calculated at a depth equal to half of the fastener's total length of engagement (L), not including the counterbore.

Follow the specific boss design recommendations listed for each fastener.




L = full length of engagement

## Compensating for the effect of a creep in a joint

As stated previously, under load or heat, all plastics will creep.
There are several methods to compensate for, or reduce, the effects of creep in a joint.

- 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
- 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

## Testing to determine proper seating torque

The following are general recommendations only.

**1.** Gather enough sample applications to generate a statistically significant sampling – a minimum of 30 per specific joint condition. These samples must include all components in the joint stack-up such as clamping components, nut members and fasteners.

**2.** Use a drive gun that can torque the fasteners to failure and has the same RPM as the drive gun that will be used in production.

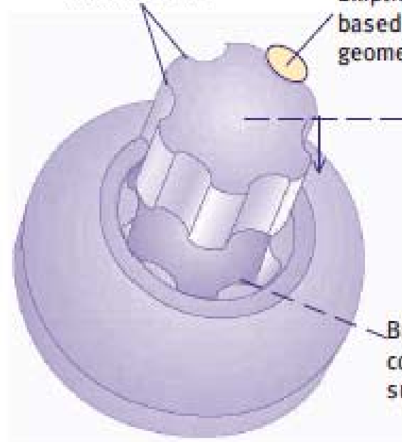
**3.** Use a torque measuring device and a strip chart or graph and capture the peak drive torque and ultimate torque values. Drive the fasteners to failure. Calculate the average of the peak drive values and of the ultimate torque values.

**4.** Next calculate the average of these two resulting values. This is the target seating torque. Factor a value of ±10% for gun accuracy. Compare this torque window to $+3\sigma$ of the average drive torque value and $-3\sigma$ of the average ultimate torque value. If there is no overlap of the two regions, the torque window will allow the fasteners to be seated without failure at assembly. If there is overlap in either of the two regions, a redesign of the joint is warranted.

## Features and benefits

### Straight Sidewalls & Reduced Recess Fall Away

- Increase tool engagement
- Virtually eliminates camout
- Ensures proper torque transfer
- Greatly reduces end load requirements
- Can reduce worker fatigue and muscular stress during manual assembly




### Elliptically-based Geometry and Lobe Engagement

- Broadens contact surface to maximize engagement of driver and recess
- Eliminates damaging point-to-point contact

### 0° Drive Angle

- Optimizes torque transmission
- Virtually eliminates radial stresses to increase tool bit life
- Enables use of recesses with thinner walls

### Six Lobes with Large Cross-Sectional Areas

- Enables faster tool engagement
- Maximizes torque transfer
- Increases torsional strength

### Inch and Metric in One Drive Tool

- Same-sized drive tool seats both inch- and metric-sized fasteners
- Allows adding or converting to metrics without a tooling change
- Reduces the number of tools required by field service personnel

## Greatly Increased Strength and Reliability

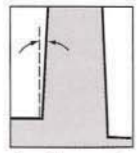
- 100% average improvement in driver bit life – many customers report driving 2 to 10 times more fasteners per bit
- 25% average improvement in driver bit torsional strength
- Increased bit strength allows for higher removal torque capability

# Terms

**BOSS:** Protuberance on a plastic part designed to add strength and/or facilitate fastening or alignment

**CREEP:** Permanent deformation of a material caused by time, temperature and pressure.

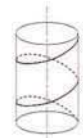
**DRAFT ANGLE:** The amount of slope in the boss hole and/or outside edge, measured from a line perpendicular to the bottom of the boss



**draft angle**

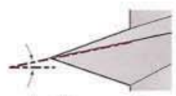
**FILLERS:** Additives or reinforcements that are added to a polymer to change one or more of its characteristics such as strength, wear resistance, etc.

**FLANK ANGLE:** See thread profile



**helix**

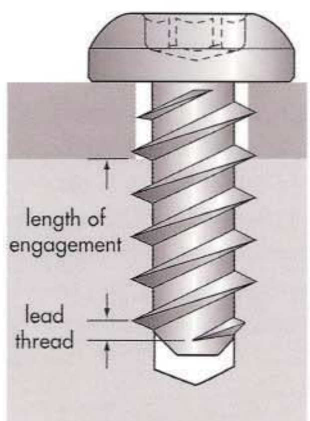
**HELIX ANGLE:** The angle between the helix of the thread and a line perpendicular to the axis of the screw.



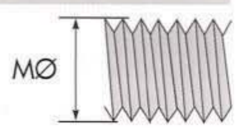
**helix angle**

**LEAD THREAD:** The thread length from where it starts to where it becomes full size. This distance is usually one-half the fastener diameter.

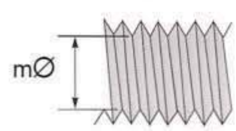
**LENGTH OF ENGAGEMENT:** The length of full-sized fastener threads that engage in the nut material. The length of the lead thread is not counted in the length of engagement, since its reduced size minimizes any performance benefits. The length of engagement is usually expressed in relationship to the nominal diameter of the screw (e.g. 2 to 2-1/2 diameters of engagement).




**MAJOR DIAMETER:** The outside or largest diameter of an external thread.




**MINOR DIAMETER:** The inside or smallest diameter of an external thread.




**NOMINAL DIAMETER:** The major diameter of a screw or, in tri-round fasteners, the "C" dimension.

**PEAK DRIVE TORQUE:** Amount of force required to pull the members of a joint together; the point at which clamp begins to generate.

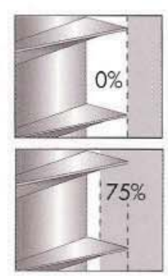
**RADIAL STRESS (hoop stress):** Forces that propagate from the screw towards the outside diameter of the boss.

**SHEAR:** Force that tends to divide an object along a plane parallel to the opposing stresses.

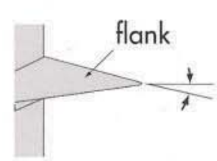
**THERMOPLASTIC:** These widely used polymers are characterized by their ductility (fillers may be added to increase stiffness). Thermoplastics can be remelted and reformed several times without degrading the material.

**THERMOSET:** These polymers are characterized by extreme stiffness. The initial molding process causes a chemical reaction which "cures" the material, so the resin cannot be reprocessed.

**THREAD ENGAGEMENT:** The amount of thread tooth that is filled by the application material. This measurement is usually expressed as a percentage and is used to determine optimal hole size.




**THREAD PROFILE:** The angle between the flank of the thread and a line perpendicular to the screw axis.




**ULTIMATE TORQUE:** The amount of force at which a fastener begins to strip or otherwise fail in a joint.