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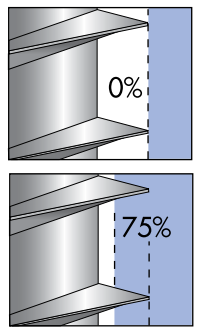
innovative ideas in fastening, componentry and assembly
TEXTRON Fastening Systems

Applications Focus

Hole Sizes and Thread Engagement: A Critical Relationship

A design engineer's dream: You're done with your design, and it looks fabulous. The nightmare: on the assembly line, the screws strip out or begin to break. Or worse, the joints fail after your new product has been purchased by customers, and the warranty costs are going up and up and up... A good design gone bad. What happened?

Often, the problem can be traced to hole design, fastener selection, or the relationship between the two. Each threaded fastener, and sometimes each fastener size, has its own parameters. Unfortunately, there are no simple "rules of thumb" to go by. The sheer number of materials, and the variations therein, make that impossible. So, what is a good starting point when selecting hole sizes, or the fasteners to go in them?



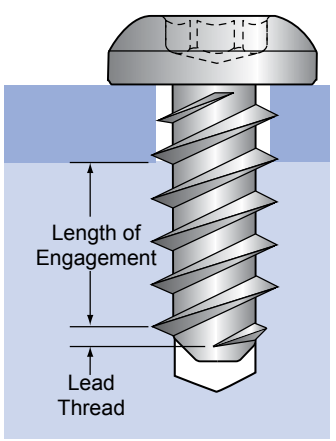
Thread Engagement
Expressed as a percentage

Thread engagement is one issue that needs to be considered early in the design stage. 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 that is equal to the major (outside) diameter of the threads would have a thread engagement of 0%.

A hole that creates a thread engagement of over 100% does not necessarily improve performance. It will, however, increase required torque, because the walls of the hole must expand to make room for the screw. Depending on the material, even a thread engagement of 80% may be too high. If the thread engagement is too high, the seating torque may exceed the screw strength, leading to a failure of the fastener, such as a snapped head or damaged threads.

Too much thread engagement can result in increased radial stress (left image)

Length of engagement is another issue to consider. This is the measurement of fastener threads that are penetrating the nut material. The length of the lead thread – the smaller portion near the point, where the threads begin – is not counted in the length of engagement, since its reduced size minimizes any performance benefits.



Length of Engagement
The length of the lead thread is not included.

Length of engagement is usually expressed in relationship to the nominal diameter of the screw, e.g. 2 to 2-l/2 diameters of engagement. In some applications, there is not enough material to provide the needed length of engagement. Often in these cases, a combination of a threaded insert and a screw must be used.

Which hole size should I use?

Screws with standard machine threads use absolute hole sizes per thread diameter. That is because they have a high thread tolerance. But the trade-off for this simplicity is that the screw can loosen or strip out easily. Engineered fasteners require proper thread engagement to perform as designed. For instance, Taptite® tri-lobular fasteners help prevent loosening in metal applications. The exact type of metal, though, affects the recommended hole size. Also, the type of hole – whether it is created with a drill, punched, or extruded – also affects thread engagement. Mag-Form® fasteners are the optimum fastener for magnesium applications. But the size of the fastener and the forming process of the magnesium (die-cast or squeeze-cast) make a critical difference in thread engagement recommendations.

Since Mag-Form screws (left) use a compressive force to create threads in magnesium, the result is close-bonding threads. A thread-cutter of the same size requires a larger hole for chips, so the thread engagement is much lower.

Plastics are another demanding group of materials. There are several fasteners engineered to provide optimum joint integrity in thermoplastics. But then there are many different types of thermoplastics, and each one of those can have differing amounts of filler. In moderately stiff materials, you should start with a thread engagement of l5-80%. If available, use specific values from general tests or tests on your actual application.

In plastics, incorrect hole size and/or installation torque can result in damaged holes.

Drafted holes ease molding, but can affect thread engagement. Always utilize the minimum amount of draft possible to retain good mold function while optimizing thread engagement. In plastics and other materials, the fastener installation process also affects joint quality, including thread engagement, so seating torque must be seriously considered and tested during the design stage. Failure to do this may result in stripped, melted or otherwise damaged holes, or broken fasteners.

Do your homework early

Some starting points for thread engagement and hole size may be given for each product, but since there is a range of values that may work, it is always recommended that testing be done on a prototype as soon as possible in the product design stage. Consult hole size charts for each product to see specific values and recommendations (see below for some useful links). once you've narrowed your hole size range, it is also imporlant to consider how the joint may be affected by outside forces while in-service, including vibration, temperature changes, shear, and aging. Your fastener supplier can provide test data and insight to help minimize problems.

Proper thread engagement, which is directly related to hole size, influences joint strength and integrity. Thoroughly designing your joint, from the hole to the assembly process, can help put many performance issues to rest you can have sweet dreams of success.