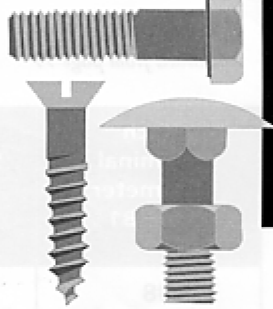
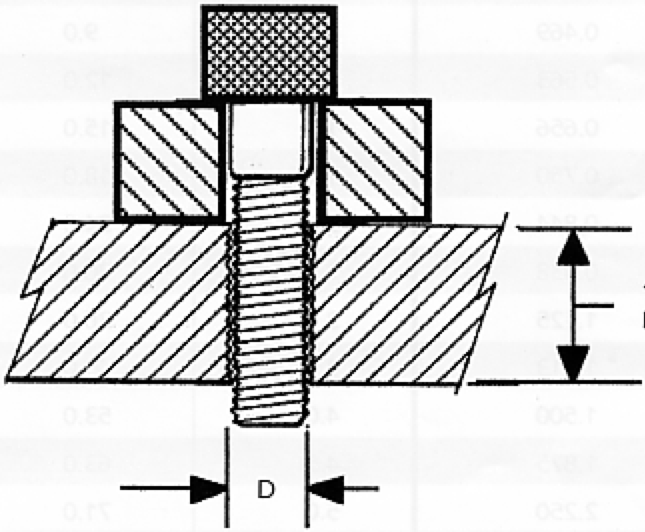


BEWARE! Long Thread Engagement Lengths Can Cause Binding

by Joe Greenslade



Several times I have been contacted by a frustrated fastener supplier who tells me he is supplying an externally threaded fastener that freely enters a GO thread ring gage, but it is binding in an internally threaded component that accepts a GO plug gage.

I immediately ask the following two questions:

1. When fully assembled, how long is the length of thread engagement between the mating threads?
2. What classes of gages are being used to inspect the two threads?

In most of the cases I have been told the internal thread is a drilled and tapped component with threads that engage a depth equal to or greater than two times the thread's nominal major diameter. In other words, if we are discussing a 1/2-inch diameter thread, the length of engagement is 1 inch or more.

Maximum standard length of thread engagement is equal to one and one-half times the nominal major diameters.

When mating threaded components gage correctly but bind during assembly, the problem is that the components are being inspected with standard ring and plug gages that have a length of engagement less that of the application's. The length of thread engagement for standard thread gages is equal to approximately one nominal thread diameter. When an application's length of engagement exceeds one and one-half nominal thread diameters of length, binding can occur due to the accumulation of lead error between the two components.

On page 78 is a chart showing the maximum lengths of engagement within which standard gages apply. The inch guideline is in ASME B1.1 Section 5 and the metric guidelines come from ISO 965-1. On inch threads the length of thread engagement is relative to nominal major diameter. Metric lengths of thread engagement are relative to the pitch length of the thread. These two different methods of establishing maximum standard length of engagement correlate very closely to each other for similar screw thread sizes.

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Joe Greenslade has been active in the fastener industry since 1970. He has held positions with major fastener producers in sales engineering, marketing, product design, manufacturing management, and research and development management.

Mr. Greenslade holds twelve U.S. patents on various fastener related products. He has authored over 136 trade journal articles on fastener applications, manufacturing and quality issues. He is one of the fastener industry's most frequent speakers at trade association meetings and conferences. He is the youngest person ever inducted to the Fastener Industry Hall of Fame.

Mr. Greenslade is active in numerous fastener industry associations and societies, holding office in several of them.

In addition to guiding the activities of Greenslade & Company, Mr. Greenslade works as a consultant with fastener suppliers and end users on product design, applications engineering, and quality issues. In this capacity he works to resolve fastener applications problems, to help select the best fastening approaches in new product designs, to assist in the standardization of fasteners used within an organization, and to provide training on various aspects of fastening technology and fastener quality assurance. He also serves as Expert Witness in litigation involving fastener related issues.

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Inch Nominal Diameter ASME B1 .1	Maximum Standard Length of Engagement (inches)	Metric Pitch Length ISO 965-1 (millimeters)	Maximum Standard Length of Engagement (millimeters)
#8	0.246	0.5	4.5
#10	0.285	0.6	5.0
#12	0.324	0.7	6.0
1/4	0.375	0.8	7.5
5/16	0.469	1.0	9.0
3/8	0.563	1.25	12.0
7/16	0.656	1.5	15.0
1/2	0.750	1.75	18.0
9/16	0.844	2.0	24.0
5/8	0.938	2.5	30.0
3/4	1.125	3.0	36.0
7/8	1.313	3.5	45.0
1	1.500	4.0	53.0
1-1/4	1.875	4.5	63.0
1-1/2	2.250	5.0	71.0

According to the standards, if a length of engagement longer than one and one-half diameters is used, additional tolerance should be allowed on either/or both the internal and external thread dimensions. Very few fastener designers or users know of these provisions in the standards. Many designers are afraid to use additional tolerance for fear that the joint might be weakened.

Many product designers operate on the misconception that extra long lengths of thread engagement make an assembly stronger or more reliable. This is a somewhat logical, but erroneous, conclusion.

Coarse threads and looser thread fits have fewer binding problems than do finer threads and closer thread fits.

Another troublesome misconception held by many designers is that fine threads are in some way superior to coarse threads. The truth is that fine threads cause many more assembly problems than do coarse threads. Within one nominal major diameter length of engagement there are from 30% to 50% more fine threads engaged than there are coarse threads. The greater the number of threads there are within any length of engagement, the greater the tendency for thread binding. Another factor contributing to thread binding is the class of fit. The closer the fit (3A/3B vs. 2A/2B), the greater the tendency for thread binding.

In a good assembly design, a fastener failure should result in breaking the screw or bolt and not in stripping the internal thread.

A basic engineering concept for joint design is to design a joint so that if there is a fastener failure, the failure will be a broken externally threaded component instead of a stripped internal thread. The basis for this reasoning is simple. When a screw or bolt breaks, the joint failure is obvious and corrective action to repair the assembly can be taken immediately before further damage is caused. If, however, an internal thread is stripped, the bolt or screw may stay intact with the assembly and total joint failure will not occur until the assembly is placed into service and the operating loads are applied. Failures at this time can result in substantial damage and/or possible human injury.

Generally a steel screw or bolt can be driven to torsional failure in a steel internally threaded component when the length of engagement is equal to one thread diameter. When using a steel screw or bolt in an aluminum assembly having a length of thread engagement equal to one and one-half to two thread diameters, the screw or bolt can usually be driven to torsional failure without the internal thread stripping.

Lengths of thread engagement longer than those needed to torsionally fail the screw or bolt are valueless regarding joint strength and reliability. Not only are longer lengths of engagement not beneficial, in many cases they can be detrimental. When threads bind during assembly, the screw or bolt is prohibited from becoming properly stressed. This results in a loose joint that may fail prematurely.

The only applications that justify a length of engagement greater than one diameter in steel or two diameters in aluminum are where the application is used as a means of providing length adjustments.

A simple, practical gaging practice can avoid binding problems.

To minimize thread binding when lengths of thread engagement are going to be greater than one and one-half nominal diameters, the thread producers of both the internal and external threads should use special thread gages having a thread length equal to the actual application.

The external thread should be inspected using a GO ring gage with a special thickness equal to the application's engagement length. Ring gages having a non-standard thickness are always considered "specials." The class of gage to be used on external threads before plating or coating is 2A for inch threads and 6g for metric threads. The class to be used after coating or plating threads is 3A GO for inspecting inch threads and 6h GO for gaging metric threads.

The internal thread should also be inspected using a GO plug gage with a thread length equal to the length of thread engagement in the application. A 2B gage should be used for inspecting inch threads and a 6H gage should be used for inspecting metric threads. In many cases, special internal thread lengths of engagement can be inspected using what is referred to as a standard "reversible GO plug gage."

Here is my suggestion for the best "fix" for an immediate thread-binding problem caused by excessive length of thread engagement.

When a problem of this nature is encountered I have found the most practical "fix" is to retap the internal threads with taps having a larger pitch diameter. Re-tapping the internal thread with an oversized tap will generally eliminate thread binding in the application without compromising joint strength. Taps having oversized pitch diameters are usually readily available from tap suppliers. After the immediate problem is dealt with, the use of special gages as described above should be used when future components are produced.

Knowing the application before the sale can head off a lot of problems.

It is always a good idea for fastener suppliers to know the application in which parts they supply are being used. Knowing the application before the sale can provide valuable information that may help the supplier anticipate and head off avoidable future potential problems. I know this seldom happens, but I encourage suppliers to try to understand the applications whenever possible prior to the sale.

If you do investigate an application before the sale and learn a designer wants to use a length of thread engagement longer than one and one-half nominal major diameters, I hope you will share this article with him and avoid potentially serious thread binding problems before they start. ■

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