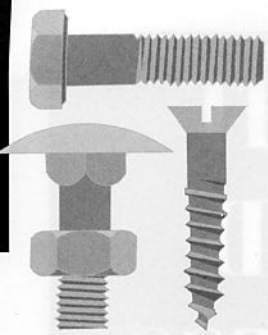


Fastener Ultimate Tensile Strength Explained

by Joe Greenslade

The relationship of a fastener's grade and its ultimate tensile strength is confusing to a lot of fastener suppliers and users alike. Many can state from memory that an SAE Grade 5 bolt has a tensile strength of 120,000 PSI, but they are unclear as to what that actually means in terms of how much weight a Grade 5 bolt of a given size can hold without breaking. Logic would indicate that a 1/2-13 Grade 5 bolt can hold much more weight than a 1/4-20 Grade 5 bolt, but many fastener suppliers and users are unclear as to how to determine how much weight a given fastener can hold.

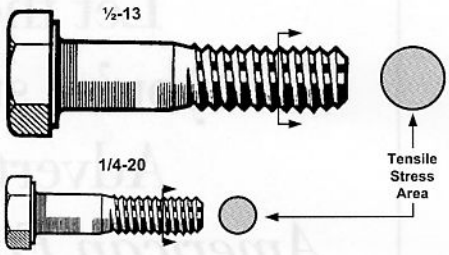
A big part of the confusion on this subject comes from the fact that there are two different kinds of "tensile strength" referred to when discussing a fastener's strength. The first "tensile strength" refers to the strength of the fastener's grade (inches) or strength class (metric). In this context the tensile strength is referring to the strength of the material the fastener is made from regardless of the fastener's diameter. The tensile strength of an inch fastener grade is given in terms of how many "pounds per square inch" (PSI) the material can hold. In metric strength classes the tensile strength is given in megapascals (MPa). A megapascal is the number of kilonewtons per square millimeter the fastener can hold before breaking. When talking about a given fastener grade or strength class, within certain diameters, the tensile strength of that grade or strength class is the same regardless of the fastener's diameter.

The second kind of tensile strength related to fasteners is the "ultimate tensile strength" (UTS). This pertains to a fastener of a particular diameter and grade or strength class. The UTS of each different diameter within a grade or strength class differs based on the cross sectional area of the fastener's thread at a position roughly half way between the root diameter and pitch diameter of the thread. This diameter on a thread is called its "tensile stress area" (TSA).

The TSA of threads is calculated using one of the two following formulas:

Inch: $TSA = 0.7854 (D - 0.9743/ TPI)^2$

Metric: $TSA = 0.7854 (D - 0.9382p)^2$



Fasteners with larger threads have larger tensile stress areas than those having smaller threads; therefore those within a given grade or strength class with larger threads can hold more weight before breaking (see Table 1).

A part's ultimate tensile strength is more important to know than the tensile strength rating of the fastener's grade or strength class when considering which fastener to use in an application. In designing an assembly, first an engineer must determine how much total stress (how many pounds of force) will be exerted on an assembly when it is in use. Then the engineer must determine how many fasteners having a given minimum ultimate tensile strength will be required to endure the anticipated maximum total stress of the assembly plus a reasonable safety factor.

Fortunately, those wanting to know the ultimate tensile strength of a particular fastener do not have to do the calculations explained in Table 1. The ultimate tensile strengths are tabulated in various standards. Handy charts tabulating these values can be found in SAE J429 for inch bolts and SAE J1199 for metric bolts. These standards are found in the SAE HS-4000 Manual that can be obtained from www.sae.org. Similar charts can also be found on page B-56 of the Sixth Edition of the *Inch Industrial Fastener Institute Standards Book* (The Green Book) and on page B-65 of the 3rd Edition of the *Metric Industrial Fastener Institute Standards Book.*

Understanding fastener strength terms, how fastener strength is derived, and where to find fastener strength values are important knowledge for both suppliers and users. Hopefully, the explanation provided in this article will help some to grasp this information more clearly. ■

Table 1.

Inch:	**Bolt size**	**1/4-20**	**1/2-13**
	Tensile stress area (TSA)	0.0318 square inches	0.1420 square inches
	Grade 5 tensile strength	120,000 PSI	120,000 PSI
	Ultimate tensile strength (UTS)	3,820 pounds	17,000 pounds
Metric:	**Bolt size**	**M6 X 1.0**	**M12 X 1.75**
	Tensile stress area (TSA)	20.1 square mm	84.3 square mm
	Class 10.9 tensile strength	1040 MPa	1040 MPa
	Ultimate tensile strength (UTS)	20.9 kN	87.7 kN
	Conversion to pounds = kN X 224.8	4,698 pounds	19,715 pounds

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.