INDUSTRIAL FASTENERS INSTITUTE
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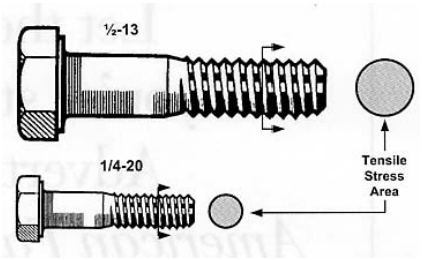
Fastener Ultimate Tensile Strength Explained



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 ½-13 Grade 5 bolt can hold much more weight than a ¼-20 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 given grade or strength class with larger threads can hold more weight before breaking. As an example:

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	M6X1.0	M12X1.75
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

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 above. The ultimate tensile strengths are tabulated in various standards. Handy charts tabulating these values can be found in Section B, Materials and Coatings, in the 7th Edition of the Inch Industrial Fastener Institute Standards Book and the same section in the 3rd Edition of the Metric Industrial Fastener Institute Standards Book. Subscribers to the ***IFI Technology Connection***™ obtain the ultimate tensile strength values automatically when they look up any part online.

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.