How to Estimate the Tensile Strength of a Steel Fastener When Only Its Hardness is Known

by Joe Greenslade

Occasionally a fastener user or supplier wants to know what the minimum ultimate tensile strength of a given externally threaded fastener is when all that is known about the part is its thread size and its hardness. An estimate of a bolt or screw's minimum ultimate tensile strength (UTS), can be easily calculated by using data from a chart in SAE J417 in combination with data from charts in ASME B1.1 for inch parts, or ISO 898-1 for metric parts. For the reader's convenience excerpts from those charts are included in this article.

When one knows a steel part's hardness, either from testing or from its specification, the relative tensile strength can be found in Table 1 of SAE J417. Hardnesses are indicated in Vickers, Brinell, and Rockwell hardness scales. Each hardness value has a corresponding tensile strength (TS) expressed in both pounds per square inch (PSI) and megapascals (MPa).

Once the tensile strength is known, the tensile stress area (TSA) of the part's thread size can be determined by referring to Tables 8 and 9 in ASME B1.1 for inch parts or Tables 6 and 7 in ISO 898-1 for metric parts.

If the parts in question have a tapping screw thread instead of a machine screw thread, refer to Tables 5, 6, 7, and 8 in ASME B18.6.4 to find the minor diameter size. Then calculate the area of the minor diameter (MDA) and use that area instead of the tensile stress area when calculating the part's ultimate tensile strength. (See tables on page 7.)

CALCULATION FORMULA

To determine the part's estimated minimum ultimate tensile strength, the following formulas are used:

Inch parts with machine screw threads:

TS (PSI) X TSA (square inches) = UTS (pounds force)

Example: 3/8-16 bolt, Rockwell C 31

TS (142,000) X TSA (0.0775) = UTS (11,005 pounds)

Metric parts with machine screw threads:

TS (MPa) X TSA (square millimeters) = UTS (newtons force)

Example: M12X1.75 bolt, Vickers hardness 255

TS (805) X TSA (84.3) = UTS (67,861 newtons)

Inch parts with tapping screw threads:

TS (PSI) X MDA (square inches) = UTS (pounds force)

Example: #10-16 screw, Rockwell C 28 core hardness

TS (131,000) X MDA (0.0156) = UTS (2,043 pounds)

The minimum ultimate tensile strength values obtained using this method are only estimates. If more precise data about a particular part is needed, sample parts should be evaluated by tensile testing full size parts.

Those wanting information on a wider range of thread sizes or hardnesses can obtain the standards referred to above from the Society of Automotive Engineers (SAE) by calling 742-776-4841. For more information on this or other related fastener subjects, this article's author can be reached at 815-654-3211. ■

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.

Vickers Hardness	Rockwell Hardness	Inch Calculations	Metric Calculations
		Pounds per Square Inch (PSI)	MegaPascals
470	RC 46.9	228 000	1570
460	RC 46.1	222 000	1530
450	RC 45.3	217 000	1495
440	RC 44.5	212 000	1460
430	RC 43.6	205 000	1410
420	RC 42.7	199 000	1370
410	RC 41.8	193 000	1330
400	RC 40.8	187 000	1290
390	RC 39.8	180 000	1240
380	RC 38.8	175 000	1205
370	RC 37.7	170 000	1170
360	RC 36.6	164 000	1130
350	RC 35.5	159 000	1095
340	RC 34.4	155 000	1070
330	RC 33.3	150 000	1035
320	RC 32.2	146 000	1005
310	RC 31.0	142 000	980
300	RC 29.8	138 000	950
295	RC 29.2	136 000	935
290	RC 28.5	133 000	915
285	RC 27.8	131 000	905
280	RC 27.1	129 000	890
275	RC 26.4	127 000	875
270	RC 25.6	124 000	855
265	RC 24.8	122 000	840
260	RC 24.0	120 000	825
255	RC 23.1	117 000	805
250	RC 22.2	115 000	795
245	RC 21.3	113000	780
240	RC 20.3	111 000	765
230	RB 96.7	106 000	730
220	RB 95.0	101 000	695
210	RB 93.4	97 000	670
200	RB 91.5	92 000	635
190	RB 89.5	88 000	605
180	RB 87.1	84 000	580
170	RB 85.0	79 000	545
160	RB 81.7	75 000	515
150	RB 78.7	71 000	490
140	RB 75.0	66 000	455
130	RB 71.2	62 000	425
120	RB 66.7	57 000	390
Ref: SAE J41 7			

Inch Thread Size	Tensile Stress Area (Sq. in.s)
1/4-20	0.0318
5/16-18	0.0524
3/8-16	0.0775
7/16-14	0.1063
1/2-13	0.1419
9/16-12	0.1820
5/8-11	0.2260
3/4-10	0.3340
7/8-9	0.4620
1-8	0.6060
1/4-28	0.0364
5/16-24	0.0580
3/8-24	0.0878
7/16-20	0.1187
1/2-20	0.1599
9/16-18	0.2030
5/8-18	0.2560
3/4-16	0.3730
7/8-9	0.5090
1-12	0.6630
Ref: ASME B1.1	

Metric Thread Size	Tensile Stress Area (Sq. mm)
M6 X1.0	20.1
M8 X1.25	36.8
M10 X1.5	58.0
M12 X1.75	84.3
M14 X2.0	115.0
M16 X2.0	157.0
M18 X2.5	192.0
M20 X2.5	245.0
M24 X3.0	353.0
M8 X1.0	39.2
M10 X1.0	64.5
M12 X1.5	88.1
M14 X1.5	125.0
M16 X1.5	167.0
M18 X1.5	216.0
M20 X1.5	272.0
M24 X2.0	384.0
Ref: ISO 898-1	

Sheet Metal Screw Threads	
Size	Minor Dia. Area (MDA)
#4-24	0.0057
#6-20	0.0084
#8-18	0.0115
#10-16	0.0156
#12-14	0.0210
1/4-14	0.0292
5/16-12	0.0475
3/8-12	0.0763
Ref: ASME B18.6.4	