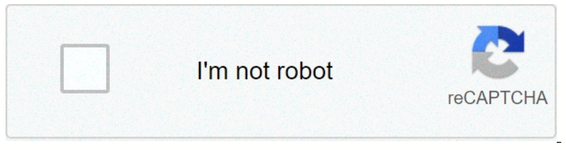


I'm not robot!

Grade 2 torque spec

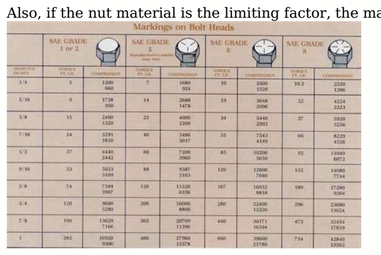
There are several factors that determine a proper bolt torque specification. Some of them are listed below... Material containing the external thread (bolt) Most bolt torque charts, including this one, are based on the material strength of the bolt - the component containing the external thread. Reference 2 below recommends a fastener preload in the range of 60% - 90% of the bolt material proof load. This RepairEngineering bolt torque chart was created assuming a value at the mid-point of that range... at 75% of the material proof strength. Bolt proof load is defined as the maximum force that the material can support without experiencing permanent deformation. Although material properties vary, an approximate estimate of proof strength is 85% - 90% of its yield strength. As noted in the chart, bolt proof strength varies depending on the fastener grade and also upon its diameter in some cases. Material containing the internal thread (nut) In order to determine the torque value of a bolt and nut assembly based on just the material strength of the bolt itself, the materials of the assembly should follow this guideline... The proof strength of the nut (the material containing the internal thread) should be equal or greater than the ultimate tensile strength of the bolt (the material with the external thread). If the nut material is the limiting factor in the fastening system, then obviously increasing the material strength of the bolt will have no effect on increasing the clamping capability of the assembly.

ASTM A354-BD / SAE GRADE 8

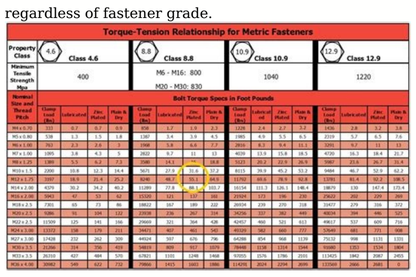
Bolt Size	TPI	Proof Load (lbs) [1]	Clamp Load (lbs) [2]	Tightening Torque (ft lbs)	
				Lubricated	Plain
1/4	20	3800	2850	6	12
5/16	18	6300	4725	12	25
3/8	16	9300	6975	22	44
7/16	14	12750	9563	35	70
1/2	13	17050	12788	53	107
9/16	12	21850	16388	77	154
5/8	11	27100	20325	106	212
3/4	10	40100	30075	188	376
7/8	9	55450	41588	303	606
1	8	72700	54525	454	909
1 1/8	7	91550	68663	644	1287
1 1/4	7	120000	90000	938	1875
1 3/8	6	138600	103950	1191	2382
1 1/2	6	168600	126450	1581	3161
1 3/4	5	228000	171000	2494	4988
2	4 1/2	300000	225000	3750	7500
2 1/4	4 1/2	390000	292500	5484	10969
2 1/2	4	480000	360000	7500	15000
2 3/4	4	517650	388238	8897	17794
3	4	626850	470138	11753	23507
3 1/4	4	745500	559125	15143	30286
3 1/2	4	874650	655988	19133	38266
3 3/4	4	1014300	760725	23773	47545
4	4	1163400	872550	29085	58100

SAE J429 grade 8 bolts do not exceed 1-1/2" diameter.

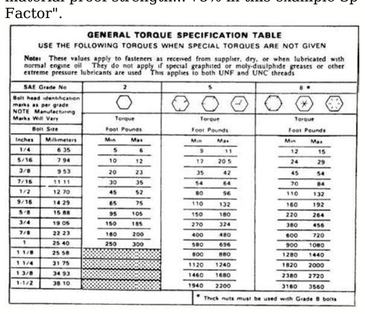
Also, if the nut material is the limiting factor, the maximum clamping capability (and corresponding bolt torque) of the assembly needs to be de-rated accordingly. Unlike most bolt torque charts, this particular chart also lists clamp loads and torque values that correspond with bolt material stresses of 10,000 and 25,000 psi...



regardless of fastener grade.



This listing may be useful when determining an appropriate de-rated torque value when engaging with lower proof-strength materials. Thread Engagement Obviously, regardless of the material strength of the bolt and the nut, an effective clamping system will not occur unless proper fastener thread engagement exists. The objective is to assure that the engaging threads will not strip under the loading that the bolt is able to apply. At first, it would seem logical to simply increase the length of thread engagement by as much as required to overcome the limitations of engaging with a material of limited proof strength. In reality, however, only the first few threads of a threaded connection are actually involved in sharing the fastener clamping force. This is due to thread form error and slight differences in thread size and pitch that result in an inconsistent make-up between the male and female threads. A common rule-of-thumb is to provide a minimum length of thread engagement equal to the (major) diameter of the fastener. A more conservative rule-of-thumb is to use a thread engagement length of 1-1/2 times diameter. Bolt Thread Tensile Stress Area The tensile stress area of the threaded portion of a fastener is determined by the size (diameter) of the bolt and by the thread pitch (spacing), as follows... As = 0.7854 x [d - (0.9743/n)]2 where: As = Bolt Thread Tensile Stress Area (in2) d = Nominal Bolt Diameter (in.) n = Thread Pitch (Threads Per Inch) Bolt Clamp Pre-Load Force Bolt clamp pre-load force is calculated using the bolt material proof strength and its tensile stress area. It is calculated using the following formula... Fi = 0.75 x Sp x As where: Fi = Bolt Clamp Pre-Load Force (lbf) .75 = Percentage of bolt material proof strength... 75% in this example Sp = Bolt material Proof Strength (lbf / in2) As = Bolt Thread Tensile Stress Area (in2) Nut "K Factor" There are several factors that affect the relationship between the applied bolt torque and the resulting bolt tension. All of those factors are summarized in single variable that is known as the nut "K Factor".



The table below lists a typical range for the "K Factor" as well as the values used in calculating the RepairEngineering Bolt Torque Chart. Note that the "K Factor" values used to calculate the RepairEngineering Bolt Torque Chart were picked somewhat arbitrarily. Any other "K Factor" value in the range could be equally valid depending on the specific requirements of a particular application. Bolt Condition "K Factor" Typical Range "K Factor" value as used in the RepairEngineering Bolt Torque Chart Lubricated 0.12-0.16 0.15 Zinc Plated 0.17-0.22 0.18 Plain-Dry 0.19-0.25 0.20 Bolt Torque Calculation The relationship between bolt torque and its corresponding pre-load force (tension) is given in the following formula... T = K Fi d where: T = Torque required to create a desired bolt pre-load (in-lb) K = Nut "K Factor" (dimensionless) Fi = Bolt Pre-Load Force (lbf) d = Bolt Nominal Diameter (in) Bolt torque provides only an indirect approximation of material stress. It is estimated that only about 10% of the tightening torque actually results in useful bolt tensioning. The remaining 90% is lost due various forms of friction that occur during the tightening process.

In addition, a proper bolt torque value can be inconsistent from fastener-to-fastener due to several factors including variations in material, coatings, surface finishes, fit tolerances, installation method, etc. For these reasons, it is not practical to provide a single bolt torque chart or formula that is accurate for all situations.
This information is voluntary, and is intended only for general-purpose reference as explained in this disclaimer. Testing of actual fastener components is recommended to determine appropriate torque values for all critical-use applications. This Bolt Torque Chart was created using reference information from various sources, including the following... 1. Machinery's Handbook - 24th Edition 2. Mechanical Engineering Design - 4th Edition Return to Bolt Torque Chart Top Grade: Finish: Diameter: The below estimated torque calculations are only offered as a guide. Use of its content by anyone is the sole responsibility of that person and they assume all risk. Due to many variables that affect the torque-tension relationship like human error, surface texture, and lubrication the only way to determine the correct torque is through experimentation under actual joint and assembly conditions. A307 Grade 2 A325 A449 Grade 5 A193 B7 A320 L7 A354 BC A490 A354 BD Grade 8 ASTM A307 Bolt Size TPI Proof Load (lbs)1 Clamp Load (lbs)2 Tightening Torque (ft lbs) Galv+Waxed Galv Plain 1⁄4 20 1,053 790 2 4 3 5⁄16 18 1,735 1,302 3 8 7 3⁄8 16 2,567 1,925 6 15 12 7⁄16 14 3,521 2,640 10 24 19 1⁄2 13 4,700 3,525 15 37 29 9⁄16 12 6,028 4,521 21 53 42 5⁄8 11 7,485 5,614 29 73 58 3⁄4 10 11,062 8,297 52 130 104 7⁄8 9 15,301 11,476 84 209 167 1 8 20,071 15,053 125 314 251 1 1⁄8 7 25,271 18,953 178 444 355 1 1⁄4 7 32,093 24,070 251 627 501 1 3⁄8 6 38,254 28,690 329 822 657 1 1⁄2 6 46,534 34,900 436 1,091 873 1 3⁄4 5 62,928 47,196 688 1,721 1,377 2 4 1⁄2 82,800 62,100 1,035 2,588 2,070 2 1⁄4 4 1⁄2 107,640 80,730 1,514 3,784 3,027 2 1⁄2 4 132,480 99,360 2,070 5,125 4,140 2 3⁄4 4 163,282 122,461 2,806 7,016 5,613 3 4 197,726 148,295 3,707 9,268 7,415 3 1⁄4 4 235,152 176,364 4,777 11,941 9,553 3 1⁄2 4 275,890 206,917 6,035 15,088 12,070 3 3⁄4 4 319,939 239,954 7,499 18,746 14,997 4 4 366,970 275,227 9,174 22,936 18,348 Top of page SAE Grade 2 Bolt Size TPI Proof Load (lbs) 1 Clamp Load (lbs) 2 Tightening Torque (ft lbs) Galv+Waxed Galv Plain 1⁄4 20 1,750 1,313 3 7 5 5⁄16 18 2,900 2,175 6 14 11 3⁄8 16 4,250 3,188 10 25 20 7⁄16 14 5,850 4,388 16 40 32 1⁄2 13 7,800 5,850 24 61 49 9⁄16 12 10,000 7,500 35 88 70 5⁄8 11 12,400 9,300 48 121 97 3⁄4 10 18,400 13,800 86 216 173 7⁄8 9 15,200 11,400 83 208 166 1 8 20,000 15,000 125 313 250 1 1⁄8 7 25,200 18,900 177 443 354 1 1⁄4 7 32,000 24,000 250 625 500 1 3⁄8 6 38,100 28,575 327 819 655 1 1⁄2 6 46,400 34,800 435 1,088 870 Top of page ASTM A325 Bolt Size TPI Tension Tightening Torque Range (ft lbs) (Min - Max) Min Max Galv+Waxed Plain 1⁄2 13 12,000 14,000 50 - 58 100 - 117 5⁄8 11 19,000 23,000 99 - 120 198 - 240 3⁄4 10 28,000 34,000 175 - 213 350 - 425 7⁄8 9 39,000 47,000 284 - 343 569 - 685 1 8 51,000 61,000 425 - 508 850 - 1,017 1 1⁄8 7 64,000 77,000 600 - 722 1,200 - 1,444 1 1⁄4 7 81,000 98,000 844 - 1,021 1,687 - 2,042 1 3⁄8 6 97,000 117,000 1,111 - 1,341 2,223 - 2,681 1 1⁄2 6 118,000 143,000 1,475 - 1,788 2,950 - 3,575 Top of page ASTM A449 / SAE Grade 5* Bolt Size TPI Proof Load (lbs) 1 Clamp Load (lbs) 2 Tightening Torque (ft lbs) Galv+Waxed Galv Plain 1⁄4 20 2,700 2,025 4 11 8 5⁄16 18 4,450 3,338 9 22 17 3⁄8 16 6,600 4,950 15 39 31 7⁄16 14 9,050 6,788 25 62 49 1⁄2 13 12,050 9,038 38 94 75 9⁄16 12 15,450 11,588 54 136 109 5⁄8 11 19,200 14,400 75 188 150 3⁄4 10 28,400 21,300 133 333 266 7⁄8 9 39,250 29,438 215 537 429 1 8 51,500 38,625 322 805 644 1 1⁄8 7 56,450 42,338 397 992 794 1 1⁄4 7 71,700 53,775 560 1,400 1,120 1 3⁄8 6 85,450 64,088 734 1,836 1,469 1 1⁄2 6 104,000 78,000 975 2,438 1,950 1 3⁄4 5 104,500 78,375 1,143 2,857 2,286 2 4 1⁄2 137,500 103,125 1,719 4,297 3,438 2 1⁄4 4 1⁄2 178,750 134,063 2,514 6,284 5,027 2 1⁄2 4 220,000 165,000 3,438 8,594 6,875 2 3⁄4 4 271,150 203,363 4,660 11,651 9,321 3 4 328,350 246,263 6,157 15,391 12,313 * SAE J429 grade 5 bolts do not exceed 1-1/2" diameter. Top of page ASTM A193 B7 / ASTM A320 L7 / ASTM A354 BC Bolt Size TPI Proof Load (lbs) 1 Clamp Load (lbs) 2 Tightening Torque (ft lbs) Galv+Waxed Galv Plain 1⁄4 20 3,350 2,513 5 13 10 5⁄16 18 5,500 4,125 11 27 21 3⁄8 16 8,150 6,113 19 48 38 7⁄16 14 11,150 8,363 30 76 61 1⁄2 13 14,900 11,175 47 116 93 9⁄16 12 19,100 14,325 67 168 134 5⁄8 11 23,750 17,813 93 232 186 3⁄4 10 35,050 26,288 164 411 329 7⁄8 9 48,500 36,375 265 663 530 1 8 63,650 47,738 398 995 796 1 1⁄8 7 80,100 60,075 563 1,408 1,126 1 1⁄8 8 82,934 62,201 583 1,458 1,166 1 1⁄4 7 101,750 76,313 795 1,987 1,590 1 1⁄4 8 105,006 78,754 820 2,051 1,641 1 3⁄8 6 121,300 90,975 1,042 2,606 2,085 1 3⁄8 8 129,492 97,119 1,113 2,782 2,226 1 1⁄2 6 147,550 110,663 1,383 3,458 2,767 1 1⁄2 8 156,687 117,515 1,469 3,672 2,938 1 3⁄4 5 199,500 149,625 2,182 5,455 4,364 1 3⁄4 8 218,400 163,800 - - 4,778 2 4 1⁄2 262,500 196,875 3,281 8,203 6,563 2 8 290,850 218,138 - - 7,271 2 1⁄4 4 1⁄2 341,250 255,938 4,799 11,997 9,598 2 1⁄4 8 373,801 280,351 - - 10,513 2 1⁄2 4 420,000 315,000 6,563 16,406 13,125 2 1⁄2 8 466,200 349,650 - - 14,569 2 3⁄4 4 468,500 351,263 8,050 20,124 16,100 2 3⁄4 8 515,851 386,888 - - 17,732 3 4 567,150 425,363 10,634 26,585 21,268 3 8 618,451 463,838 - - 23,192 3 1⁄4 4 674,500 505,875 13,701 34,252 27,402 3 1⁄4 8 730,550 547,913 - - 29,679 3 1⁄2 4 791,350 593,513 17,311 43,277 34,622 3 1⁄2 8 851,201 638,401 - - 37,240 3 3⁄4 4 917700 688275 21,509 53,771 43,017 3 3⁄4 8 982,300 736,725 - - 46,045 4 4 1052600 789450 26,315 65,788 52,630 4 8 1,121,950 841,463 - - 56,098 Top of page ASTM A490 Bolt Size TPI Tension (lbs) Tightening Torque Range (ft lbs) (Min - Max) Min Max Plain Lubricated 1⁄2 13 15,000 18,000 125 - 150 63 - 75 5⁄8 11 24,000 29,000 250 - 302 125 - 151 3⁄4 10 35,000 42,000 438 - 525 219 - 263 7⁄8 9 49,000 59,000 715 - 860 357 - 430 1 8 64,000 77,000 1,067 - 1,283 533 - 642 1 1⁄8 7 80,000 96,000 1,500 - 1,800 750 - 900 1 1⁄4 7 102,000 122,000 2,125 - 2,542 1,063 - 1,271 1 3⁄8 6 121,000 145,000 2,773 - 3,323 1,386 - 1,661 1 1⁄2 6 148,000 178,000 3,700 - 4,450 1,850 - 2,225 Top of page ASTM A354-BD / SAE Grade 8* Bolt Size TPI Proof Load (lbs) 1 Clamp Load (lbs) 2 Tightening Torque (ft lbs) Plain Lubricated 1⁄4 20 3,800 2,850 12 6 5⁄16 18 6,300 4,725 25 12 3⁄8 16 9,300 6,975 44 22 7⁄16 14 12,750 9,563 70 35 1⁄2 13 17,050 12,788 107 53 9⁄16 12 21,850 16,388 154 77 5⁄8 11 27,100 20,325 212 106 3⁄4 10 40,100 30,075 376 188 7⁄8 9 55,450 41,588 606 303 1 8 72,700 54,525 909 454 1 1⁄8 7 91,550 68,663 1,287 644 1 1⁄4 7 120,000 90,000 1,875 938 1 3⁄8 6 138,600 103,950 2,382 1,191 1 1⁄2 6 168,600 126,450 3,161 1,581 1 3⁄4 5 228,000 171,000 4,988 2,494 2 4 1⁄2 300,000 225,000 7,500 3,750 2 1⁄4 4 1⁄2 390,000 292,500 10,969 5,484 2 1⁄2 4 480,000 360,000 15,000 7,500 2 3⁄4 4 517,650 388,238 17,794 8,897 3 4 626,850 470,138 23,507 11,753 3 1⁄4 4 745,500 559,125 30,286 15,143 3 1⁄2 4 874,650 655,988 38,266 19,133 3 3⁄4 4 1,014,300 760,725 47,545 23,773 4 4 1,163,400 872,550 58,100 29,085 * SAE J429 grade 8 bolts do not exceed 1-1/2″ diameter. 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