About the Author/JOE GREENSLADE

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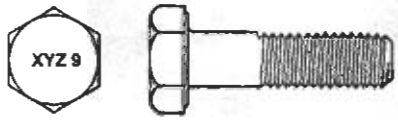
Joe has been in the fastener industry in a variety of capacities since 1970. He has written over 220 fastener technology related articles and has spoken to many fastener industry organizations throughout the United States. Joe has been awarded 12 U.S. Patents for fastener inspection devices.

Joe is an active member of the American Society of Mechanical Engineers (ASME), the American Society for Testing and Materials (ASTM), the National Fastener Distributor's Association (NFDA), and a member of the Board of Directors of the American Association for Laboratory Accreditation (A2LA). He is a former member of the Industrial Fasteners Institute (IFI). He was a member of the Fastener Quality Act Task Force representing the fastener industry. Joe also serves on the Screw Thread Improvement Task Force working with government and industry to improve aerospace related thread specifications, and thread gaging and calibration procedures.

No Standards Cover Grade 9 Bolts

There are NO industrial standards that cover the chemical and physical specifications for Grade 9 bolts. SAE J429 does not cover Grade 9. ASTM does not have a Grade 9. The IFI does not publish a specification for Grade 9 bolts. It is generally accepted that Grade 9 bolts are approximately 20% stronger that SAE J429 Grade 8 bolts. In other words, Grade 9 bolts have an ultimate tensile strength of 170,000 to 180,000 PSI. Unfortunately, since there is no standard to follow, all Grade 9 bolt manufacturers are probably not using exactly the same criteria for making and inspecting this bolt grade.



Below I am going to list a few issues and give a few suggestions that fastener suppliers should consider when selling Grade 9 bolts:

1. Grade 9 recommended requirements:

Grade 9 bolts should conform to the chemical and physical requirements of ASTM A 574, except for the angle used for the wedge tensile test. ASTM A 574 is the specification governing alloy steel socket head cap screws. The fundamental requirements of ASTM A 574 specification are:

a. Chemistry:

The material must be alloy steel consisting of the following chemical components when doing a "product analysis":

i. Carbon, minimum 0.31%
ii. Phosphorous, maximum 0.040%
iii. Sulfur, maximum 0.045%
iv. One or more of the following alloy elements:
  1. chromium
  2. nickel
  3. molybdenum
  4. vanadium

b. Hardness (see Table 1):

i. Bolts through 1/2", Rockwell C39 – 45
ii. Bolts over 1/2", Rockwell C37- 45

c. Proof load (see Table 1):

i. Bolts through 1/2", 140,000 PSI
ii. Bolts over 1/2", 135,000 PSI

d. Wedge tensile strength (see Table 1):

i. Bolts through 1/2" , 180,000 PSI
ii. Bolts over 1/2", 170,000 PSI

Wedge angle note: Since most Grade 9 bolts are made with hex heads a smaller wedge angle should be used when performing the wedge tensile test. I suggest the wedge angles specified for testing Property Class 12.9 in ISO 898-1 be followed instead of ASTM A 574 in this one testing requirement. The wedge angle requirements are as follows:

1. Bolts two nominal diameters in length and greater should use:
   a. Bolts 3/4" and smaller: 6° wedge angle
   b. Bolts over 3/4": 4° wedge angle
2. Bolts with lengths less than 2 nominal diameters and/or threaded to the head should use:
   a. 4° wedge angle

2. Hydrogen embrittlement:

Bolt suppliers should realize that because of the high hardness of Grade 9 bolts they are highly susceptible to hydrogen embrittlement and should take every precaution to prevent its occurrence. Following are two recommendations:

a. Avoid supplying electro-plated Grade 9 bolts if possible.

b. If you do supply electro-plated Grade 9 bolts:
   i. Bake the bolts at 400° F within one hour after plating for a minimum of 4 hours "at temperature"
   ii. Perform a hydrogen embrittlement test on every lot of elector-plated Grade 9 bolts:

1. Select the number of sample parts specified for hydrogen embrittlement testing from ASTM F 1470 based on the bolt's lot size.
2. Place one or more ASTM F 436 hardened washers on each bolt and thread them into either a hardened test plate or into ASTM A 562 DH thick hex nuts or ASTM A194 2H thick hex nuts.
3. Using a calibrated torque wrench tighten the bolts to the values 30% greater than the tightening values for plain bolts shown in Table 2 in this article (example: Table 2 tightening torque for 5/8-11 = 270 ft.lb.s; Test torque = 270 X 1.30 = 351 ft.lb.s).
4. After 24 and 48 hours re-apply the same test torque in the clock-wise direction as used in the original tightening.

5. If any bolt breaking during any portion of the testing the bolts should be rejected.

3. Applicable nuts for Grade 9 bolts:

A fundamental engineering principle is to select a nut to use with a given bolt that has a minimum proof strength rating equal to or greater than the bolt so that all failures will result in bolts breaking instead of nuts stripping.

Grade 9 bolts present another standards problem in this regard. There are no standard commercial nuts that have 180,000 PSI in the size range of 1/4" through 1/2" . For bolts over 1/2", there are two commercial nut grades that do exceed the 170,000 PSI. minimum tensile value for the bolts:

a. ASTM A563 Grade DH thick hex nuts (175,000 PSI minimum proof load strength).
b. ASTM A194 Grade 2H thick hex nuts (175,000 PSI minimum proof load strength).

4. Applicable tightening torque for Grade 9 bolts:

No bolt performs as it should in service unless it is stressed to the proper pre-load. The major sources of bolt loosening and bolt fatigue failures are the result of the bolts not being properly tightened during installation.

Table 3 in this article provides the recommended tightening values for 1/4" through 1 1/2" plain finished Grade 9 bolts based on the conventional torque calculation formula T = (KDF)/12 where:

a. T is the calculated tightening torque expressed in foot pounds.
b. K is the "nut factor". For plain finished bolts the K is 0.20.
c. D is the bolt's nominal diameter expressed on inches (example: 1/2 bolt is 0.500 inches).
d. F is the tensional force equal to 75% of the yield is equal to 75% of the bolt's yield strength. The yield strength expressed in pounds of force is calculated by multiplying the tensile stress area of the bolt times the yield strength of the grade expressed in PSI. For determining the F use the

Table 1 : Suggested Physical Requirments for Grade 9 Bolts

Bolt Size	Tensile Stress Area	Tensile Strength (PSI)	Proof Load (lb.s force)	Wedge Tensile Strength (lb.s force)	Wedge Angle (length 2 D or greater)	Wedge Angle (length less than 2 D)	Rockwell Hardness (C scale)
1/4-20	0.0318	180,000	4,452	5,724	6 degree	4 degree	39-45
1/4-28	0.0364	180,000	5,096	6,552	6 degree	4 degree	39-45
5/16-18	0.0524	180,000	7,336	9,432	6 degree	4 degree	39-45
5/16-24	0.0580	180,000	8,120	10,440	6 degree	4 degree	39-45
3/8-16	0.0775	180,000	10,850	13,950	6 degree	4 degree	39-45
3/8-24	0.0878	180,000	12,292	15,804	6 degree	4 degree	39-45
7/16-14	0.1063	180,000	14,882	19,134	6 degree	4 degree	39-45
7/16-20	0.1187	180,000	16,618	21,366	6 degree	4 degree	39-45
1/2-13	0.1419	180,000	19,866	25,542	6 degree	4 degree	39-45
1/2-20	0.1599	180,000	22,386	28,782	6 degree	4 degree	39-45
9/16-12	0.1820	170,000	24,570	30,940	6 degree	4 degree	37-45
9/16-18	0.2030	170,000	27,405	34,510	6 degree	4 degree	37-45
5/8-11	0.2260	170,000	30,510	38,420	6 degree	4 degree	37-45
5/8-18	0.2560	170,000	34,560	43,520	6 degree	4 degree	37-45
3/4-10	0.3340	170,000	45,090	56,780	6 degree	4 degree	37-45
3/4-10	0.3730	170,000	50,355	63,410	6 degree	4 degree	37-45
7/8-9	0.4620	170,000	62,370	78,540	4 degree	4 degree	37-45
7/8-14	0.5090	170,000	68,715	86,530	4 degree	4 degree	37-45
1-8	0.6060	170,000	81,810	103,020	4 degree	4 degree	37-45
1-12	0.6630	170,000	89,505	112,710	4 degree	4 degree	37-45
1 1/8-7	0.7630	170,000	103,005	129,710	4 degree	4 degree	37-45
1 1/8-12	0.8560	170,000	115,560	145,520	4 degree	4 degree	37-45
1 1/4-7	0.9690	170,000	130,815	164,730	4 degree	4 degree	37-45
1 1/4-12	1.0730	170,000	144,855	182,410	4 degree	4 degree	37-45
1 3/8-6	1.1550	170,000	155,925	196,350	4 degree	4 degree	37-45
1 3/8-12	1.3150	170,000	177,525	223,550	4 degree	4 degree	37-45
1 1/2-6	1.4050	170,000	189,675	238,850	4 degree	4 degree	37-45
1 1/2-12	1.5810	170,000	213,435	268,770	4 degree	4 degree	37-45

following yield strength values:

i. Bolts 1/2" and smaller: 162,000 PSI (75% = 121,500 PSI)
ii. Bolts over 1/2": 153,000 PSI (75% = 114,750 PSI)

e. The right side of the equation is divided by 12 to covert the raw answer from inch pounds to foot pounds.

5. Markings for Grade 9 bolts:

Since there are no industrial specifications covering Grade 9 bolts there is no one method of marking them to identify their grade. Some suppliers have used nine radial lines on the top of the head similar to the six lines used to identify SAE J429 Grade 8 bolts. Many other suppliers use a letter in front of a "9" on the top of the head such as "L9" by Brighton-Best, "PFC9" by Porteous Fastener, "A9" by Ajax Fasteners, and "T9" by TriState Tool & Die Company.

If you supply Grade 9 bolts I make the following suggestions:

1. Grade 9 bolt manufacturers should publish a specification sheet so distributors and end users know what specifications are being followed when these bolts are manufactured.
2. Distributors of Grade 9 bolts should ask their manufacturers or importers to provide a specification of the Grade 9 bolts they buy and share this information with all Grade 9 bolt end users so they know what they are receiving.
3. Try not to supply elector-plated Grade 9 bolts. If you must supply electro-plated Grade 9 bolts insist that your supplier provide you with a certification indicating that the lot of bolts being supplied have been baked AND tested as suggested above.

For more fastener related technical information visit the Articles page of the web site www.greensladeandcompany.com or contact the author at 800-435-2657 or via e-mail at greensladeandcompany@sbcglobal.net.

Table 2 : Calculated Tightening Values for Plain Finished Grade 9 Bolts

Bolt Size	"D"	Tensile Stress Area	Yield Strength (PSI)	Yield Strength (lb.s force)	"F" 75% of Yield Strength (lb.s force)	"K" for Plain Finish	"T" Calculated Tightening Torque (ft. lb.s)
1/4-20	2500	0.0318	162,000	5,152	3,864	0.2	16
1/4-28	2500	0.0364	162,000	5,897	4,423	0.2	18
5/16-18	3125	0.0524	162,000	8,489	6,367	0.2	33
5/16-24	3125	0.0580	162,000	9,396	7,047	0.2	37
3/8-16	3750	0.0775	162,000	12,555	9,416	0.2	59
3/8-24	3750	0.0878	162,000	14,224	10,668	0.2	67
7/16-14	4375	0.1063	162,000	17,221	12,915	0.2	94
7/16-20	4375	0.1187	162,000	19,229	14,422	0.2	105
1/2-13	5000	0.1419	162,000	22,988	17,241	0.2	144
1/2-20	5000	0.1599	162,000	25,904	19,428	0.2	162
9/16-12	5625	0.1820	153,000	27,846	20,885	0.2	196
9/16-18	.5625	0.2030	153,000	31,059	23,294	0.2	218
5/8-11	6250	0.2260	153,000	34,578	25,934	0.2	270
5/8-18	6250	0.2560	153,000	39,168	29,376	0.2	306
3/4-10	7500	0.3340	153,000	51,102	38,327	0.2	479
3/4-10	7500	0.3730	153,000	57,069	42,802	0.2	535
7/8-9	.8750	0.4620	153,000	70,686	53,015	0.2	773
7/8-14	8750	0.5090	153,000	77,877	58,408	0.2	852
1-8	1.000	0.6060	153,000	92,718	69,539	0.2	1,159
1-12	1.000	0.6630	153,000	101,439	76,079	0.2	1,268
1 1/8-7	1.1250	0.7630	153,000	116,739	87,554	0.2	1,642
1 1/8-12	1.1250	0.8560	153,000	130,968	98,226	0.2	1,842
1 1/4-7	1.2500	0.9690	153,000	148,257	111,193	0.2	2,317
1 1/4-12	1.2500	1.0730	153,000	164,169	123,127	0.2	2,565
1 3/8-6	1.3750	1.1550	153,000	176,715	132,536	0.2	3,037
1 3/8-12	1.3750	1.3150	153,000	201,195	150,896	0.2	3,458
1 1/2-6	1.5000	1.4050	153,000	214,965	161,224	0.2	4,031
1 1/2-12	1.5000	1.5810	153,000	241,893	181,420	0.2	4,535