



Mechanical Properties of Externally Threaded Fasteners

Specification	Material	Size Range (in.)	Min. Proof Strength (psi)	Min. Tensile Strength (psi)	Core Hardness Rockwell		Min. Yield Strength (psi)	Grade Identification Marking	Compatible Nuts
					Min.	Max.			
SAE J429-Grade 1	Low or medium carbon steel	1/4 - 1 1/2	33,000	60,000	B70	B100	36,000		ASTM A563 Grade A Hex
SAE J429-Grade 2		1/4 - 3/4 7/8 - 1 1/2	55,000 33,000	74,000 60,000	B80 B70	B100 B100	57,000 36,000		
ASTM A307-Grade A	Low or medium carbon steel	1/4 - 4		60,000	B69	B100			ASTM A563 Grade A (Hex up to 1-1/2 & Heavy Hex 1-1/2 and over)
ASTM A307-Grade B	Low or medium carbon steel	1/4 - 4		60,000(min)	B69	B95			ASTM A563 Grade A Heavy Hex
SAE J429-Grade 5	Medium carbon steel: quenched & tempered	1/4 - 1 1 1/8 - 1 1/2	85,000 74,000	120,000 105,000	C25 C19	C34 C30	92,000 81,000		SAE J995 Grade 5 Hex
ASTM A325 - Type 1	Medium carbon steel: quenched & tempered	1/4 - 1 1 1/8 - 1 1/2	85,000 74,000	120,000 105,000	C25 C19	C34 C30	92,000 81,000		ASTM A563 Grade C Heavy Hex, DH if Galv
ASTM A449-Type1	Medium carbon steel: quenched & tempered	1/4 - 1 1 1/8 - 1 1/2 1 3/4 - 3	85,000 74,000 55,000	120,000 105,000 90,000	C25 C19	C34 C30	92,000 81,000 58,000		SAE J995 Grade 5 up to 1-1/2, ASTM A563 Grade A Heavy Hex 1-1/2 & over, DH Heavy Hex if Galv
ASTM A354- Grade BC	Medium carbon alloy steel: quenched & tempered	1/4 - 2-1/2 Over 2-1/2	105,000 95,000	125,000 105,000	C26 C22	C36 C33	109,000 99,000		ASTM A563 Grade C Heavy Hex, DH if Galv
SAE J429-Grade 8	Medium carbon alloy steel: quenched & tempered	1/4 - 1 1/2	120,000	150,000	C33	C39	130,000		SAE J995 Grade 8 Hex
ASTM A354 Grade BD	Medium carbon alloy steel: quenched & tempered	1/4 - 2-1/2 Over 2-1/2	120,000 105,000	150,000 140,000	C33 C31	C39 C39	130,000 115,000		ASTM A563 Grade DH Heavy Hex
ASTM A490-Type 1	Medium carbon alloy steel: quenched & tempered	1/2 - 1-1/2	120,000	150,000 (min) 173,000 (max)	C33	C39	130,000		ASTM A563 Grade DH Heavy Hex
SAE J429-Grade 8.2	Medium carbon boron steel: quenched & tempered	1/4 - 1	120,000	150,000	C33	C39	130,000		SAE J995 Grade 8 Hex
FNL Grade 9	Medium carbon alloy steel: quenched & tempered	1/4 - 1-1/4	140,650	180,000	C38	C42	159,500		FNL Grade 9 Thick Hex Nut
ASTM A574 Socket Head Cap Screw	Medium carbon alloy steel: quenched & tempered	#0 - 1/2 over 1/2 - 2	140,000 135,000	180,000 170,000	C39 C37	C45 C45	 153,000		
ASTM F835 Socket Button & Flat Countersunk Head Cap Screw	Medium carbon alloy steel: quenched & tempered	#0 - 1/2 over 1/2		145,000 135,000	C39 C37	C44 C44			
ASTM F1554 Anchor Bolts, Steel Grade 36	Low or medium carbon steel	1/4 - 4-in		58,000(min) 80,000 (max)			36,000		ASTM A563 Grade A (hex up to 1-1/2 & Heavy Hex 1-1/2 and over)

Notes

1, 2, 3

1. Compatible denotes commercially available nut having suitable mechanical properties and dimensional configuration or style which will make it possible to obtain the desired bolt load. Higher strength nuts may be a suitable substitute provided bolt standard allows.
2. Galvanized nuts are intended for use with externally threaded fasteners that are hot-dip or mechanically galvanized or have a coating of sufficient thickness to require over-tapping of the nut to provide assembly.
3. ASTM A194 2H heavy hex nut may be used in lieu as a substitute for ASTM A563 DH heavy hex nut



Mechanical Properties of Internally Threaded Fasteners

Specification	Material	Nominal Size(in.)	Proof Load Stress (psi)		Hardness Rockwell		Grade Identification Marking
			Plain	Galvanize coating (1)	Min.	Max.	
ASTM A563-Grade 0	Carbon Steel	1/4 - 1 1/2	69,000*	52,000*	B55	C32	
ASTM A563-Grade A		1/4 - 1 1/2	90,000*	68,000*	B68	C32	
ASTM A563-Grade A Heavy Hex		1/4 - 4	100,000* 90,000**	75,000* 68,000**	B68	C32	
ASTM A563-Grade C Heavy Hex	Carbon Steel, may be quenched and tempered	1/4 - 4	144,000		B78	C38	
ASTM A563-Grade DH Heavy Hex	Carbon Steel, quenched and tempered	1/4 - 4	175,000	150,000	C24	C38	
ASTM A194-Grade 2H Heavy Hex	Medium Carbon Steel	1/4 - 1 1/2	175,000		C24	C35	
		Over 1 1/2				C35	
FNL Grade 9 Thick Hex Nut	Carbon Steel	1/4 - 5/8	180,000		C32	C38	
		3/4 - 1 1/2			C35	C40	
ASTM A194-Grade 8 Heavy Hex	AISI 304	1/4 - 1 1/2	80,000		B60	C32	
ASTM A194-Grade 8M Heavy Hex	AISI 316	1/4 - 1 1/2	80,000		B60	C32	

SAE J995 Grade Identification

Grade	Material	Nominal Size(in.)	Proof Load Stress (psi)	Rockwell Hardness		Grade Identification Marking
				Min.	Max.	
5	Carbon steel	1/4 - 4	120,000*		C32	
			109,000**			
		Over 1 - 1 1/2	105,000*		C32	
			94,000**			
8	Medium carbon or alloy steel, quenched & tempered	1/4 - 5/8	150,000	C24	C32	
		Over 5/8 - 1		C26	C34	
		Over 1 - 1 1/2		C26	C36	

(1): Galvanize coating refers to nuts that have been plated with a plating or coating of sufficient thickness to require overlapping of the nut to provide assembly; for example hot-dip or mechanical galvanizing.

* UNC and 8 UN

** UNF, 12 UN & finer

***When a zinc coated A194 2H nut is supplied, the zinc coating, overlapping, lubrication and rotational capacity testing shall be in accordance with ASTM A563 and the proof stress reduced accordingly. Nuts coated with zinc shall have an asterisk "*" marked after the grade symbol. Nuts coated with cadmium shall have a plus sign "+" marked after the grade symbol.



ASTM A193: Alloy Steel and Stainless Steel Bolting Materials for High-Temperature Service

Specification & Grade	Size Range (in.)	Min. Tensile Strength (psi)	Min. Yield Strength (psi)	Core Hardness Rockwell (max)	Description	Grade Identification Marking	Compatible ASTM A194 Heavy Hex Nut
ASTM A193 B7	2 1/2 & under	125,000	105,000	C35	Chromium-Molybdenum alloy (4140, 4142, 4145, 4140H, 4142H, 4145H) used for high-pressure, high-temperature applications.		
	Over 2 1/2 - 4	115,000	95,000	C35			
	Over 4 - 7	100,000	75,000	C35			
ASTM A193 B7M	4 & under	100,000	80,000	B99	Similar to B7 except heat-treated to limit the maximum hardness. Considered in areas where stress embrittlement may be a factor.		
	Over 4 - 7	100,000	75,000	B99			
ASTM A193 B16	2 1/2 & under	125,000	105,000	C35	A chromium-Molybdenum-Vanadium alloy used for high-pressure, high-temperature service applications. Offers slightly higher temperature resistance than B7.		
	Over 2 1/2 - 4	110,000	95,000	C35			
	Over 4 - 8	100,000	85,000	C35			
ASTM A193 B8 Class 1	1/4 & larger	75,000	30,000	B96	A 304 Stainless Steel used for high temperature applications. This material has been carbide solution treated.		
ASTM A193 B8M Class 1	1/4 & larger	75,000	30,000	B96	A 316 Stainless Steel used for high temperature applications. This material has been carbide solution treated.		

Compatible denotes commercially available nut having suitable mechanical properties and dimensional configuration or style which will make it possible to obtain the desired bolt load. Higher strength nuts or nuts of equal strength may be a suitable substitute provided bolt standard allows.

Mechanical Properties of Common Stainless Steel Fasteners in Accordance with ASTM F593

Stainless Alloy Group	Condition	Nominal Dia. (in.)	Tensile Strength (psi)	Core Hardness Rockwell		Min. Yield Strength (psi)	Grade Identification Marking
				Min.	Max.		
1 (304, 304L, 305, 384, 18-9LW, 302HQ)	CW	1/4 - 5/8	100,000 - 150,000	B95	C32	65,000	
		3/4 - 1 1/2	85,000 - 140,000	B80	C32	45,000	
2 (316, 316L)	CW	1/4 - 5/8	100,000 - 150,000	B95	C32	65,000	
		3/4 - 1 1/2	85,000 - 140,000	B80	C32	45,000	



Tensile Stress, Thread Root and Thread Stripping Areas

Nominal Size	Coarse Thread				8 Thread Series				Fine Thread			
	Thread Pitch (tpi)	Tensile Stress Area (sq in.)	Thread Root Area (sq in)	Int Thread Stripping Area Asn sq in per in of engagement	Thread Pitch (tpi)	Tensile Stress Area (sq in.)	Thread Root Area (sq in)	Int Thread Stripping Area Asn sq in per in of engagement	Thread Pitch (tpi)	Tensile Stress Area (sq in)	Thread Root Area (sq in)	Int Thread Stripping Area Asn sq in per in of engagement
0	0.060								80	0.0018	0.00150	0.106
1	0.073	64	0.00262	0.00218					72	0.00278	0.00237	0.130
2	0.086	56	0.00370	0.00310					64	0.00394	0.00339	0.156
3	0.099	48	0.00487	0.00406					56	0.00523	0.00451	0.186
4	0.112	40	0.00604	0.00496					48	0.00661	0.00566	0.216
5	0.125	40	0.00796	0.00672					44	0.00831	0.00716	0.246
6	0.138	32	0.00909	0.00745					40	0.01015	0.00874	0.274
8	0.164	32	0.0140	0.0120					36	0.0147	0.01285	0.331
10	0.190	24	0.0175	0.0145					32	0.02	0.01752	0.389
12	0.216	24	0.0242	0.0206					28	0.0258	0.02258	0.450
1/4	0.250	20	0.0318	0.0269					28	0.0364	0.03255	0.521
5/16	0.313	18	0.0525	0.0455					24	0.0581	0.05262	0.663
3/8	0.375	16	0.0775	0.0678					24	0.0878	0.08084	0.800
7/16	0.438	14	0.106	0.094					20	0.119	0.10927	0.908
1/2	0.500	13	0.142	0.126					20	0.160	0.14862	1.08
9/16	0.563	12	0.182	0.162					18	0.203	0.18917	1.23
5/8	0.625	11	0.226	0.202					18	0.256	0.23999	1.37
3/4	0.750	10	0.335	0.302					16	0.373	0.35125	1.66
7/8	0.875	9	0.462	0.419					14	0.510	0.48047	1.96
1	1.000	8	0.606	0.551					12 UNF	0.663	0.62445	2.27
1	1.000								14 UNS	0.680	0.64631	2.23
1 1/8	1.125	7	0.763	0.693		0.791	0.728	2.63	12	0.856	0.81180	2.54
1 1/4	1.250	7	0.969	0.890		1.000	0.929	3.27	12	1.073	1.02369	2.83
1 3/8	1.375	6	1.155	1.054		1.234	1.160	3.21	12	1.315	1.26013	3.11
1 1/2	1.500	6	1.406	1.294		1.492	1.410	3.5	12	1.581	1.52111	3.39

The 1-12 is the standard inch series fine thread to the Unified screw thread system. The 1-14 is considered a UNS (Unified Special). However, the majority of all 1-in fine threads manufactured are 1-14 (UNS).

Tensile Stress Area = $0.7854(D - 0.9743/h)^2$

D = nominal thread diameter

n = threads per inch

Thread Root Area = $0.7854(D - 1.3/h)^2$

D = nominal thread diameter

n = threads per inch

Int Thread Stripping Area per inch of Engagement = $3.1416 \times D_{\text{min}} \times n \left[\frac{1}{2n} + 0.57735(D_{\text{min}} - E_{\text{int}}) \right]$

The values listed are for 2B internal threads

n = threads per inch

D_{min} = minimum major diameter of external thread

E_{int} = maximum pitch diameter of internal thread