TABLE 9

THREAD ROOT AREAS AND UNIT AXIAL LOAD

THREAD SIZE	MAJOR DIA	A SECTION AREA AT THREAD ROOT	K AXIAL LOAD IN LBS PER IN-LB TORQUE
0-80	.060	.0015	74
1-64	.073	.0022	65
1-72	.073	.0024	66
2-56	.086	.0031	55
2-64	.086	.0034	56
3-48	.099	.0041	50
3-56	.099	.0045	51
4-40	.112	.0050	42
4-48	.112	.0057	43
5-40	.125	.0067	36
5-44	.125	.0072	37
6-32	.138	.0075	34
6-40	.138	.0085	35
8-32	.164	.0120	30
8-36	.164	.0128	31
10-24	.190	.0145	26
10-32	.190	.0175	27
12-24	.216	.0206	23
12-28	.216	.0226	24
.250-20	.250	.0269	20.6
.250-28	.250	.0326	21.5
.250-32	.250	.0352	21.7
.312-18	.3125	.0454	16.6
.312-24	.3125	.0524	17.1
.312-32	.3125	.0590	17.6

THREAD SIZE	MAJOR DIA	A SECTION AREA AT THREAD ROOT	K AXIAL LOAD IN LBS PER IN LB TORQUE
.375-16	.3750	.0679	14.3
.375-24	.3750	.0809	14.9
.375-32	.3750	.0890	15.3
.438-14	.4375	.0930	12.2
.438-20	.4375	.1090	12.6
.438-28	.4375	.1217	13.0
.500-13	.5000	.1257	10.9
.500-20	.5000	.1486	11.4
.500-28	.5000	.1634	11.7
.562-12	.5625	.1620	9.9
.562-18	.5625	.1888	10.3
.562-24	.5625	.2054	10.5
.625-11	.6250	.2018	8.72
.625-18	.6250	.2400	9.24
.625-24	.6250	.2586	9.33
.750-10	.7500	.3020	7.34
.750-16	.7500	.3513	7.64
.750-20	.7500	.3725	7.68
.875-9	.8750	.4193	6.52
.875-14	.8750	.4805	6.78
.875-20	.8750	.5200	6.92
1.000-8	1.0000	.5510	5.73
1.000-14	1.0000	.6464	5.99
1.000-20	1.0000	.6921	6.09

REVISED
APPROVED AP 60

What's the right torque for bolts?

This is one of the toughest questions we're asked. Too many variable conditions. But the following may help.

The bolt takes two stresses during wrenching: (1) Torsion; (2) Tension. Tension is what you want. Torsion is the necessary evil due to friction. Probably 90% of applied torque goes to overcome friction.

With the friction factor changed by lubrication, plating, etc., the torque needed to produce a given tension is hard to predict. However, a useful empirical formula exists for *normal* friction conditions.

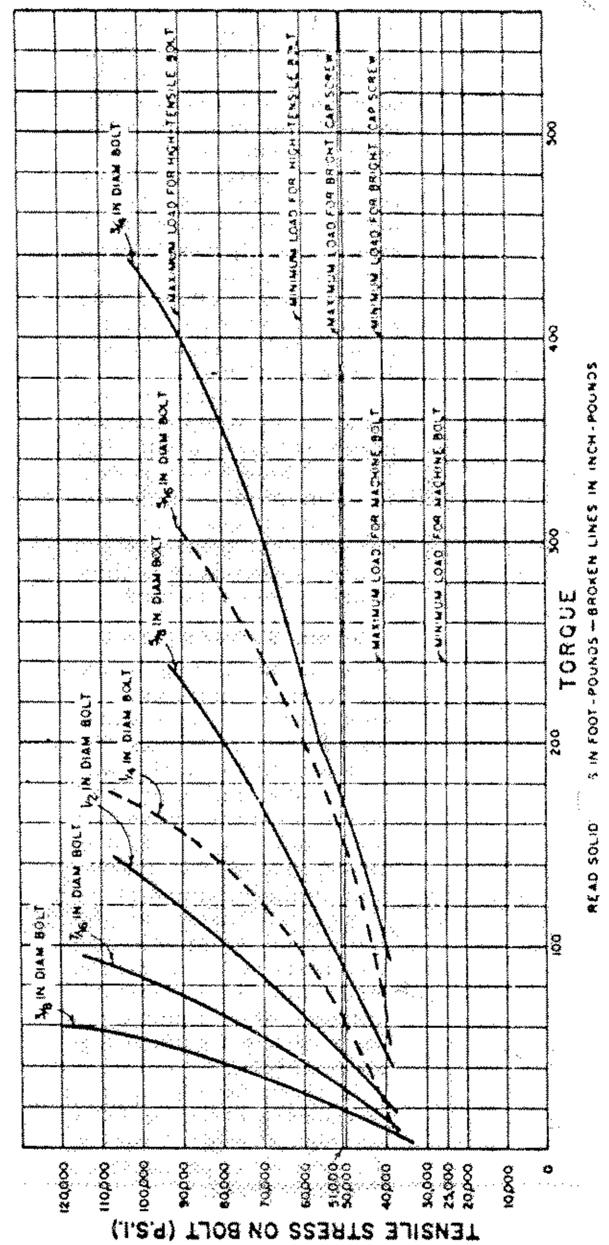
Inch-lbs. Torque =
0.2 x bolt diameter x bolt tension

Many tests show that the 0.2 torque coefficient is approximately constant for the usual friction conditions, for all diameters, and for both coarse and fine thread. Average deviation is about 7%. But when are conditions "*normal*"? The only *sure* way to check torque is to set up a pilot assembly and try it out.

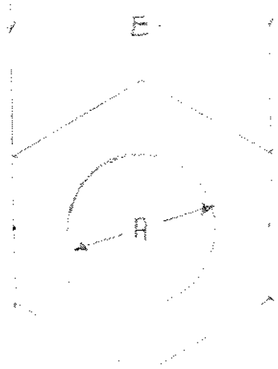
In pilot testing for rigid joints, tighten a few bolts with torque wrench to failure, and then set torque at 75% of that load; or even at yield strength, since torsion component vanishes leaving bolt under tension only, which is well below ultimate strength.

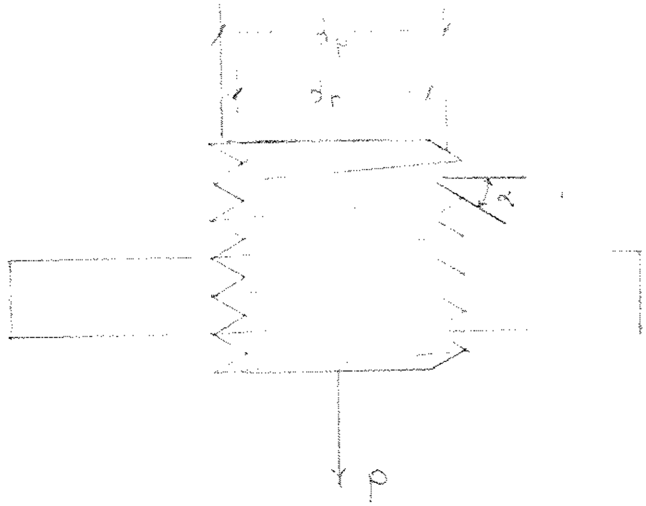
We've worked up curves giving suggested torques for various size bolts.

TORQUE CURVE

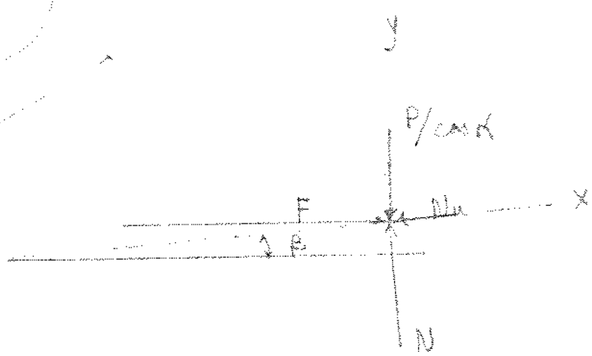


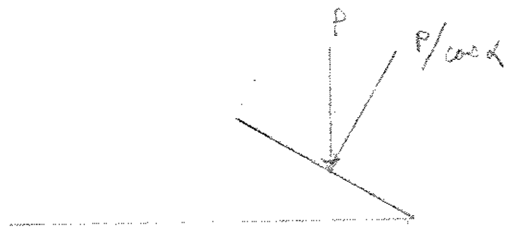
Tension - Torque Relationship





$\beta = \sin^{-1} \frac{1}{\pi n d_p}$





$$\Sigma F_y = N - (P/\cos\alpha)\cos\beta - F\sin\beta = 0$$

$$\Sigma F_x : F\cos\beta - (P/\cos\alpha)\sin\beta - N\mu = 0$$

eliminate N —
substitute $\tan\phi$ for μ
and through some algebra

$$\frac{F}{P} = \frac{\tan(\phi+\beta)}{\cos\alpha} = m$$

The torque acting on the Bolt

$$T = \frac{1}{2} F d_p + \frac{1}{2} P D \nu$$

$$\therefore \quad \frac{P}{T} = \frac{2}{D\nu + m d_p}$$

P = applied tensile load (lbs.)

T = applied torque to bolt head or nut (in-lb)

ν = friction coefficient from nut or head to washer = 0.14 for unlubricated

μ = friction coef. in thread = 0.12 for unlubricated

D = mean diameter of nut = A + E/2

ϕ = $\tan^{-1} \mu$

β = $\sin^{-1} \frac{1}{\pi n d_p}$ (helix angle)

n = threads/in

d_p = pitch dia. = $\frac{\text{nom dia.} + \text{root}}{2}$

Example: Find the torque required to produce a 6 kip tensile load in an unlubricated 7/8" 9 UNC bolt

$$d_p = \frac{.875 + .731}{2} = .803$$

$$r = 0.14$$

$$\mu = 0.12$$

$$\phi = \tan^{-1} 0.12 = .119429$$

$$\beta = \sin^{-1} \frac{1}{\pi n d_p} = \sin^{-1} \frac{1}{\pi n d_p} =$$

$$= \sin^{-1} \frac{1}{22.709} = .044059$$

$$\phi + \beta = .163488$$

$$\tan(\phi+\beta) = .16496$$

$$\alpha = 30°$$

$$\cos\alpha = .866026$$

$$m = \frac{\tan(\phi+\beta)}{\cos\alpha} = \frac{.16496}{.866026} = .1904792$$

$$D = \frac{.875 + 1.3125}{2} = 1.09375$$

$$Dr = 1.09375 \times .14 = .153125$$

$$m d_p = .1904792 \times .803 = .1529547$$

$$\frac{P}{T} = \frac{2}{Dr + m d_p} = 6.53 \ \frac{lb}{in\text{-}lb}$$

$$T_6 = \frac{P}{6.53} = \frac{6000}{6.53} = 918 \text{ in-lb}$$

918 in-# = 0.2 × 7/8" × 6000# = 1050#