APPENDIX J
CALCULATION OF TARGET TORQUE

The Target Torque required to tighten bolting is computed as follows:

$$T = \frac{F}{2}\left[d_n f_n + d_2 \left(\frac{f_2 + \cos\alpha \tan\lambda}{\cos\alpha - f_2 \tan\lambda} \right) \right]$$

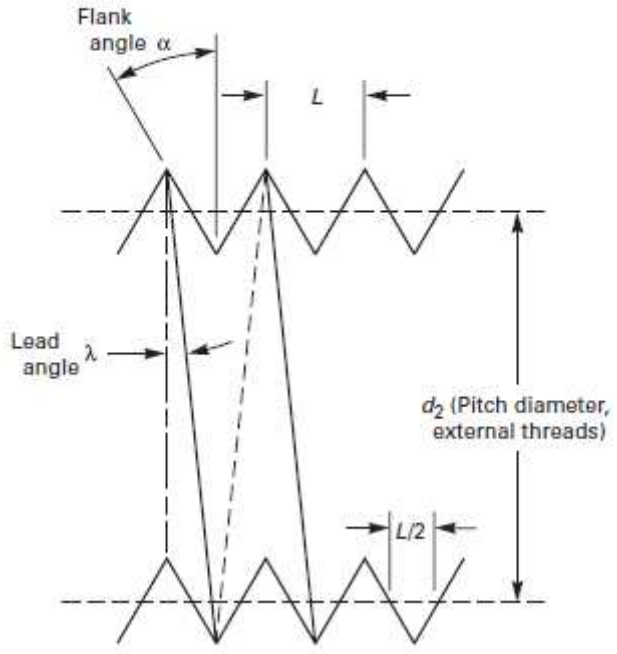
where

d_n = mean diameter of the nut (or bolt head) bearing face, mm (in.) (this diameter is equal to the simple average of the diameter of the nut washer face and the nominal bolt size)
d_2 = pitch diameter (or mean thread contact diameter), mm (in.) (see Fig. J-1)
F = Target bolt tensile load, N (lb)
f_n = coefficient of friction between the bolt nut (or bolt head) and the flange (or washer), (dimensionless)
f_2 = coefficient of friction between bolt/nut threads, (dimensionless)
T = Target Torque, N·mm (in.-lb)
α = thread flank angle, deg (see Fig. J-1)
λ = lead angle, deg (see Fig. J-1)

For Metric and Unified screw threads, the flank angle, α, is equal to 30 deg, the lead angle, λ, is equal to $\tan^{-1}\left(\frac{L}{\pi d_2}\right)$, and the lead, L, is equal to the pitch of the threads (e.g., for Unified 8-thread series, this will be $\frac{1}{8}$ in.).

NOTE: This Appendix uses ASME B1.7 bolting terminology; see B1.7 for definitions of terminology. The formula used in this Appendix was obtained from Chapter 3 of the *Handbook of Bolts and Bolted Joints*, Bickford, John H. and Nassar, Sayed, eds. 1998. New York: Marcel Dekker, Inc.

Fig. J-1 Thread Profile



λ Lead angle $\tan\lambda = \frac{L}{\pi(d_2)}$

10.2 Bolt Elongation (Bolt Stretch) Determination

When bolt elongation (bolt stretch) measurement is selected as the load-control technique to be used, the required bolt elongation is computed according to the following equation (assumes the bolt is threaded full length):

$$\Delta L = \left(\frac{S_b \times L_{eff}}{E}\right)\left(\frac{A_r}{A_{ts}}\right)$$

where

A_r = root area, mm^2 (in.^{2}). See Appendix H for bolt root areas.

A_{ts} = tensile stress area, mm^2 (in.^{2}). See Appendix H for bolt tensile stress areas.

E = modulus of elasticity, MPa (ksi)

L_{eff} = effective stretching length, mm (in.). The conventional assumption is that the effective stretching length in a through-bolted joint system is the distance between mid-thickness of the nuts, where the nominal thickness of a heavy hex series nut is one nominal bolt diameter. By the same standard, the effective length of the portion of a bolt that is studded into a tapped hole is one-half of a nominal bolt diameter.

S_b = Target Bolt Stress (root area), MPa (ksi). It is noted that bolt stresses computed in accordance with Mandatory Appendix 2 of Section VIII, Division 1 of the ASME Boiler and Pressure Vessel Code are based on root area. If Target Bolt Stress (tensile stress area) is used, drop the A_r/A_{ts} term from the ΔL computation.

ΔL = bolt elongation (bolt stretch), mm (in.). Select a tolerance on this computed value and include it in the joint assembly procedure.

APPENDIX H
BOLT ROOT AND TENSILE STRESS AREAS

Table H-1 Bolt Root and Tensile Stress Areas

SI Units			U.S. Customary Units			
Bolt Size, Basic Thread Designation [Notes (1), (2)]	Root Area, mm^2	Tensile Stress Area, mm^2 [Note (3)]	Bolt Size, in.	Threads per Inch	Root Area, $in.^2$	Tensile Stress Area, $in.^2$ [Note (3)]
M14-2	102.1	115.4	1/2	13	0.1257	0.1419
M16-2	141.0	156.7	5/8	11	0.2017	0.2260
M20-2.5	220.4	244.8	3/4	10	0.3019	0.3345
M24-3	317.3	352.5	7/8	9	0.4192	0.4617
M27-3	419.1	459.4	1	8	0.5509	0.6057
M30-3	535.0	580.4	1 1/8	8	0.7276	0.7905
M33-3	665.1	715.6	1 1/4	8	0.9289	0.9997
M36-3	809.3	864.9	1 3/8	8	1.155	1.234
M39-3	976.6	1 028	1 1/2	8	1.405	1.492
M42-3	1 140	1 206	1 5/8	8	1.680	1.775
M45-3	1 327	1 398	1 3/4	8	1.979	2.082
M48-3	1 527	1 604	1 7/8	8	2.303	2.414
M52-3	1 817	1 900	2	8	2.652	2.771
M56-3	2 132	2 222	2 1/4	8	3.422	3.557
M64-3	2 837	2 940	2 1/2	8	4.291	4.442
M70-3	3 432	3 545	2 3/4	8	5.258	5.425
M76-3	4 083	4 207	3	8	6.324	6.506
M82-3	4 791	4 925	3 1/4	8	7.487	7.686
M90-3	5 822	5 970	3 1/2	8	8.748	8.963
M95-3	6 518	6 674	3 3/4	8	10.11	10.34
M100-3	7 253	7 418	4	8	11.57	11.81

NOTES:

(1) Metric thread designations are given in bolt size (mm) and pitch (mm) (e.g., M14-2 refers to a 14 mm diameter bolt with a 2 mm pitch thread).

(2) The side-by-side placement of the two tables is not meant to infer direct conversion between the listed SI and U.S. Customary units.

(3) The root and tensile stress areas are based on coarse-thread series for sizes M27 and smaller, and 3 mm pitch thread series for sizes M30 and larger (coarse-thread series for sizes 1 in. and smaller, and 8-pitch thread series for sizes 1 1/8 in. and larger).