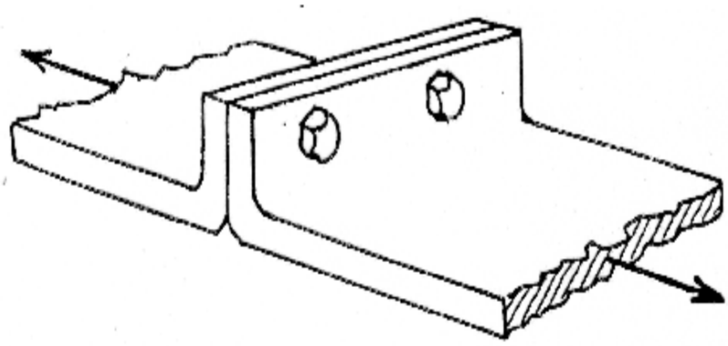
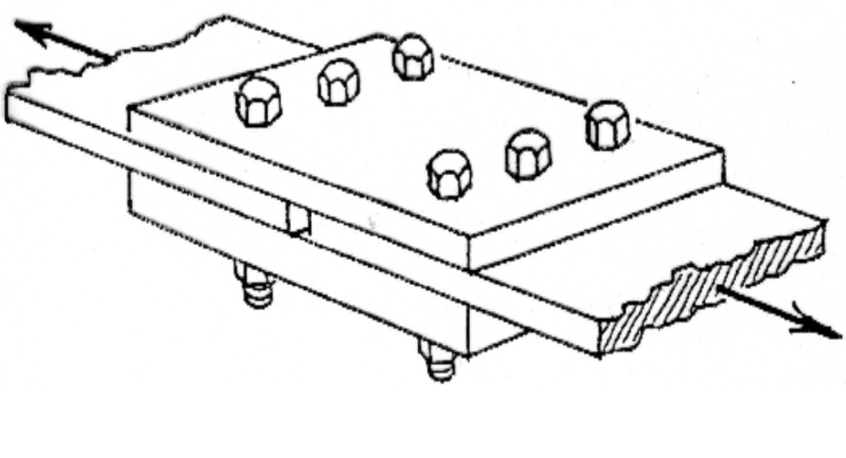




B. Inch Series Thread Forms

In the United States our principal inch series thread form standards are ASME B1.1 1989 [2] and Federal Standard FED-STD-H 28/2B [3]. Both

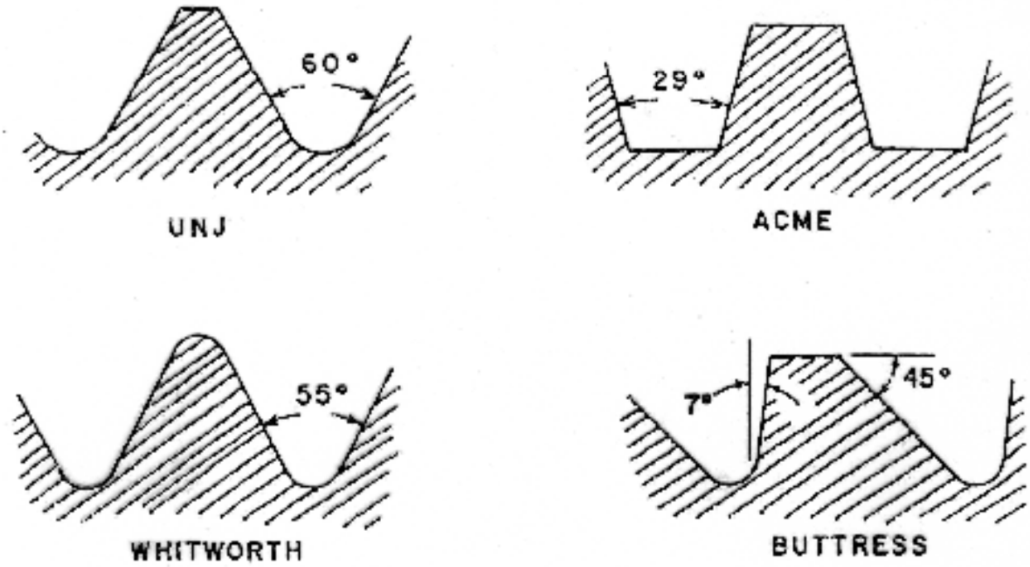


Figure 3.1 Three well-known thread forms which are *not* currently used with threaded fasteners and, for comparison, one which is (the UNJ form). The ACME is a well-known machine tool thread used for traversing screws. The Whitworth is a now-obsolete fastener thread form once used in the U.K. It has now been replaced by a 60-in.-series ISO form.

C. Metric Thread Forms

The currently popular metric threads are identified by the code letters M and MJ. The basic geometry of metric and inch series threads is identical,

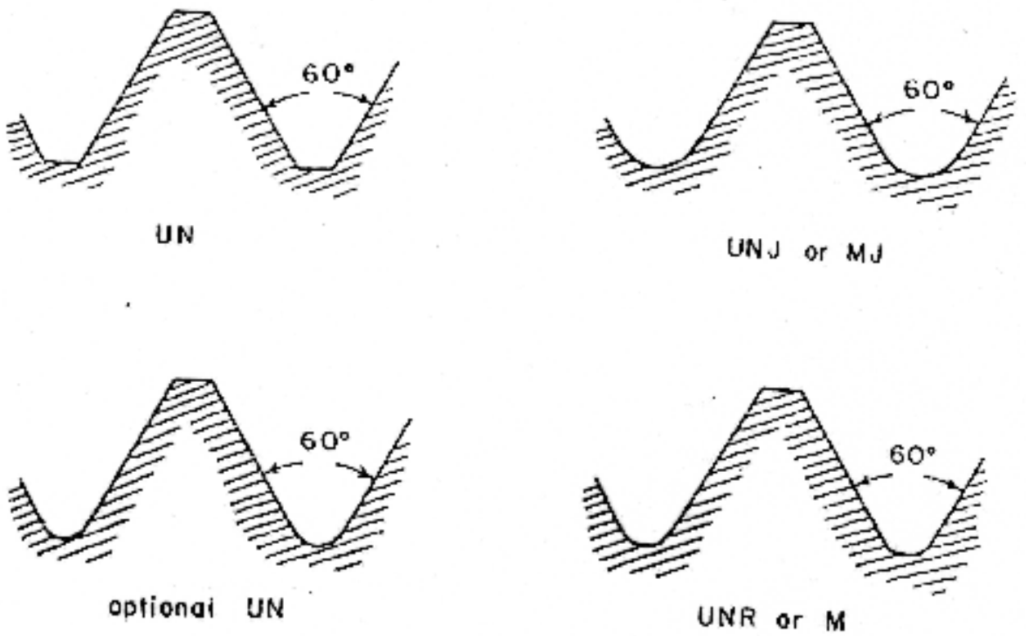


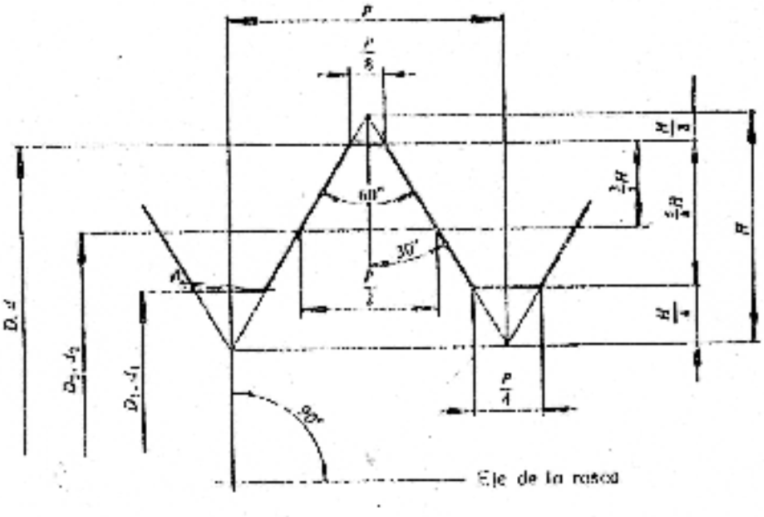
Figure 3.2 These are the thread forms most commonly used in the Western world at the present time. Each is a 60° included angle form. They differ from each other primarily in the way the roots of the external (male) threads are shaped. The UN form has flat, or, optionally, slightly rounded roots. The UNJ and metric MJ forms have generously rounded roots. The UNR and metric M forms have slightly rounded roots.

NORMA VENEZOLANA (COVENIN 142-87)
ROSCAS ISO DE USO GENERAL (ISO 68-1973(E))
PERFIL BASICO

1.- <u>OBJETO Y CAMPO DE APLICACION</u>: Esta norma establece el perfil básico para roscas ISO en sistema métrico y en pulgadas.

2.- <u>DEFINICION</u>: Es el perfil teórico asociado con los tamaños básicos de los diametros mayores, medios y menores de la rosca.

Las desviaciones se aplican en estos tamaños básicos.



D = Diámetro mayor de la rosca interna
d = Diámetro mayor de la rosca externa
D_2 = Diámetro medio de la rosca interna
d_2 = Diámetro medio de la rosca externa
D_1 = Diámetro menor de la rosca interna
d_1 = Diámetro menor de la rosca externa
P = Paso
H = Altura del triángulo fundamental

5 DIMENSIONES

5.1 DIMENSIONES BÁSICAS

$$H = \frac{\sqrt{3}}{2} P = 0{,}866\ 025\ 404\ P$$

$$\frac{5}{8} H = 0{,}541\ 265\ 877\ P$$

$$\frac{3}{8} H = 0{,}324\ 759\ 526\ P$$

$$\frac{H}{4} = 0{,}216\ 506\ 351\ P$$

$$\frac{H}{8} = 0{,}108\ 253\ 175\ P$$

TABLA 1

Dimensiones en mm

Paso P	H	$\frac{5}{8}H$	$\frac{3}{8}H$	$\frac{H}{4}$	$\frac{H}{8}$
0,2	0,173 205	0,108 253	0,064 952	0,043 301	0,021 651
0,25	0,216 506	0,135 316	0,081 190	0,054 127	0,027 063
0,3	0,259 808	0,162 380	0,097 428	0,064 952	0,032 476
0,35	0,303 109	0,189 443	0,113 666	0,075 777	0,037 889
0,4	0,346 410	0,216 506	0,129 904	0,086 603	0,043 301
0,45	0,389 711	0,243 570	0,146 142	0,097 428	0,048 714
0,5	0,433 013	0,270 633	0,162 380	0,108 253	0,054 127
0,6	0,519 615	0,324 760	0,194 856	0,129 904	0,064 952
0,7	0,606 218	0,378 886	0,227 332	0,151 554	0,075 777
0,75	0,649 519	0,405 949	0,243 570	0,162 380	0,081 190
0,8	0,692 820	0,433 013	0,259 808	0,173 205	0,086 603
1	0,866 025	0,541 266	0,324 760	0,216 506	0,108 253
1,25	1,082 532	0,676 582	0,405 949	0,270 633	0,135 316
1,5	1,299 038	0,811 899	0,487 139	0,324 760	0,162 380
1,75	1,515 544	0,947 215	0,568 329	0,378 886	0,189 443
2	1,732 051	1,082 532	0,649 519	0,433 013	0,216 506
2,5	2,165 063	1,353 165	0,811 899	0,541 266	0,270 633
3	2,598 076	1,623 798	0,974 279	0,649 519	0,324 760
3,5	3,031 089	1,894 431	1,136 658	0,757 772	0,378 886
4	3,464 102	2,165 063	1,299 038	0,866 025	0,433 013
4,5	3,897 114	2,435 696	1,461 418	0,974 279	0,487 139
5	4,330 127	2,706 329	1,623 798	1,082 532	0,541 266
5,5	4,763 140	2,976 962	1,786 177	1,190 785	0,595 392
6	5,196 152	3,247 595	1,948 557	1,299 038	0,649 519
8	6,928 203	4,330 127	2,598 076	1,732 051	0,866 025

DIMENSIONES PULGADAS

$$H = \frac{0.866\,025\,404}{n}$$

$$\frac{5}{8}H = \frac{0.541\,265\,877}{n}$$

$$\frac{3}{8}H = \frac{0.324\,759\,526}{n}$$

$$\frac{H}{4} = \frac{0.216\,506\,351}{n}$$

$$\frac{H}{8} = \frac{0.108\,253\,175}{n}$$

n es el número de hilos por pulgada

TABLA 2

Dimensiones en Pulgs

Número de hilos por pulgada	Paso P	H	$\frac{5}{8}H$	$\frac{3}{8}H$	$\frac{H}{4}$	$\frac{H}{8}$
80	0.012 500	0.010 825	0.006 766	0.004 059	0.002 706	0.001 353
72	0.013 889	0.012 028	0.007 518	0.004 511	0.003 007	0.001 504
64	0.015 625	0.013 532	0.008 457	0.005 074	0.003 383	0.001 691
56	0.017 857	0.015 465	0.009 665	0.005 799	0.003 866	0.001 933
48	0.020 833	0.018 042	0.011 276	0.006 766	0.004 511	0.002 255
44	0.022 727	0.019 682	0.012 301	0.007 381	0.004 921	0.002 460
40	0.025 000	0.021 651	0.013 532	0.008 119	0.005 413	0.002 706
36	0.027 778	0.024 056	0.015 035	0.009 021	0.006 014	0.003 007
32	0.031 250	0.027 063	0.016 915	0.010 149	0.006 766	0.003 383
28	0.035 714	0.030 929	0.019 331	0.011 599	0.007 732	0.003 866
24	0.041 667	0.036 084	0.022 553	0.013 532	0.009 021	0.004 511
20	0.050 000	0.043 301	0.027 063	0.016 238	0.010 825	0.005 413
18	0.055 556	0.048 113	0.030 070	0.018 042	0.012 028	0.006 014
16	0.062 500	0.054 127	0.033 829	0.020 297	0.013 532	0.006 766
14	0.071 429	0.061 859	0.038 662	0.023 197	0.015 465	0.007 732
13	0.076 923	0.066 617	0.041 636	0.024 982	0.016 654	0.008 327
12	0.083 333	0.072 169	0.045 105	0.027 063	0.018 042	0.009 021
11	0.090 909	0.078 730	0.049 206	0.029 524	0.019 682	0.009 841
10	0.100 000	0.086 603	0.054 127	0.032 476	0.021 651	0.010 825
9	0.111 111	0.096 225	0.060 141	0.036 084	0.024 056	0.012 028
8	0.125 000	0.108 253	0.067 658	0.040 595	0.027 063	0.013 532
7	0.142 857	0.123 718	0.077 324	0.046 394	0.030 929	0.015 465
6	0.166 667	0.144 338	0.090 211	0.054 127	0.036 084	0.018 042
5	0.200 000	0.173 205	0.108 253	0.064 952	0.043 301	0.021 651
4.5	0.222 222	0.192 450	0.120 281	0.072 169	0.048 113	0.024 056
4	0.250 000	0.216 506	0.135 316	0.081 190	0.054 127	0.027 063

4 COMBINACIONES DIAMETRO/PASO

TABLA 2 – DIAMETRO / PASO

Dimensiones en mm

Diámetro nominal			PASOS										
Col. 1 1ra Selección	Col. 2 2da Selección	Col. 3 3ra Selección	Para rosca gruesa	Para rosca fina									
				3	2	1,5	1,25	1	0,75	0,5	0,35	0,25	0,2
1			0,25										0,2
	1,1		0,25										0,2
1,2			0,25										0,2
	1,4		0,3										0,2
1,6			0,35										0,2
	1,8		0,35										0,2
2			0,4									0,25	
	2,2		0,45									0,25	
2,5			0,45								0,35		
3			0,5								0,35		
	3,5		0,6								0,35		
4			0,7							0,5			
	4,5		0,75							0,5			
5			0,8							0,5			
		5,5								0,5			
6			1						0,75				
		7	1						0,75				
8			1,25					1	0,75				
		9	1,25					1	0,75				
10			1,5				1,25	1	0,75				
		11	1,5					1	0,75				
12			1,75			1,5	1,25	1					
	14		2			1,5	1,25*	1					
		15				1,5		1					
16			2			1,5		1					
		17				1,5		1					
	18		2,5		2	1,5		1					
20			2,5		2	1,5		1					
	22		2,5		2	1,5		1					
24			3		2	1,5		1					
		25			2	1,5		1					
		26				1,5							
	27		3		2	1,5		1					
		28			2	1,5		1					
30			3,5	(3)	2	1,5		1					
		32			2	1,5							
	33		3,5	(3)	2	1,5							
		35**				1,5							
36			4	3	2	1,5							
		38				1,5							
	39		4	3	2	1,5							

* Solamente para bujías de motores

** Solamente para tuercas de seguridad de rodamientos

Deberá evitarse en lo posible los pasos indicados entre paréntesis

(10)

4 COMBINACIONES DIAMETRO/PASO

TABLA 1 – DIAMETRO/PASO

Diámetro nominal		Diámetro Básico Mayor	NUMERO DE HILOS POR PULGADA										
			Serie con pasos graduados			Serie con pasos constantes							
Prima-rios	Segun-dario	Pulg	Rosca gruesa * UNC	Rosca fina * UNF	Rosca Extra Fina UNEF	Series de 4 Hilos UN	Series de 6 Hilos UN	Series de 8 Hilos UN	Series de 12 Hilos UN	Series de 16 Hilos UN	Series de 20 Hilos UN	Series de 28 Hilos UN	Series de 32 Hilos UN
1	2	3	4	5	6	7	8	9	10	11	12	13	14
No. 0		0.060 0		80									
	No. 1	0.073 0	64	72									
No. 2		0.086 0	56	64									
	No. 3	0.099 0	48	56									
No. 4		0.112 0	40	48									
No. 5		0.125 0	40	44									
No. 6		0.138 0	32	40									UNC
No. 8		0.164 0	32	36									UNC
No. 10		0.190 0	24	32									UNF
	No. 12	0.216 0	24	28	32							UNF	UNEF
1/4		0.250 0	20	28	32						UNC	UNF	UNEF
5/16		0.312 5	18	24	32						20	28	UNEF
3/8		0.375 0	16	24	32					UNC	20	28	UNEF
7/16		0.437 5	14	20	28					16	UNF	UNEF	32
1/2		0.500 0	13	20	28					16	UNF	UNEF	32
9/16		0.562 5	12	18	24				UNC	16	20	28	32
5/8		0.625 0	11	18	24				12	16	20	28	32
	11/16	0.687 5			24				12	16	20	28	32
3/4		0.750 0	10	16	20				12	UNF	UNEF	28	32
	13/16	0.812 5			20				12	16	UNEF	28	32
7/8		0.875 0	9	14	20				12	16	UNEF	28	32
	15/16	0.937 5			20				12	16	UNEF	28	32
1		1.000 0	8	12	20			UNC	UNF	16	UNEF	28	32
	1 1/16	1.062 5			18			8	12	16	20	28	
1 1/8		1.125 0	7	12	18			8	UNF	16	20	28	
	1 3/16	1.187 5			18			8	12	16	20	28	
1 1/4		1.250 0	7	12	18			8	UNF	16	20	28	
	1 5/16	1.312 5			18			8	12	16	20	28	
1 3/8		1.375 0	6	12	18		UNC	8	UNF	16	20	28	
	1 7/16	1.437 5			18		6	8	12	16	20	28	
1 1/2		1.500 0	6	12	18		UNC	8	UNF	16	20	28	
	1 9/16	1.562 5			18		6	8	12	16	20		
1 5/8		1.625 0			18		6	8	12	16	20		
	1 11/16	1.687 5			18		6	8	12	16	20		
1 3/4		1.750 0	5				6	8	12	16	20		
	1 13/16	1.812 5					6	8	12	16	20		
1 7/8		1.875 0					6	8	12	16	20		

* Series seleccionadas para tornillos, pernos y tuercas, y primera escogencia para aplicaciones generales en ingeniería

MATERIALES PARA TORNILLOS Y TUERCAS. PROPIEDADES MECANICAS

Specifications for Steel Used in Millimeter Series Screws and Bolts

SAE Class	Diameter d (mm)	Proof Load (Strength)[a] S_p (MPa)	Yield Strength[b] S_y (MPa)	Tensile Strength S_u (MPa)	Elongation, Minimum (%)	Reduction of Area, Minimum (%)	Core Hardness, Rockwell Min	Core Hardness, Rockwell Max
4.6	5 thru 36	225	240	400	22	35	B67	B87
4.8	1.6 thru 16	310	—	420	—	—	B71	B87
5.8	5 thru 24	380	—	520	—	—	B82	B95
8.8	17 thru 36	600	660	830	12	35	C23	C34
9.8	1.6 thru 16	650	—	900	—	—	C27	C36
10.9	6 thru 36	830	940	1040	9	35	C33	C39
12.9	1.6 thru 36	970	1100	1220	8	35	C38	C44

[a]Proof load (strength) corresponds to permanent deformation not over 0.0025 mm measured on actual bolts.
[b]Yield strength corresponds to 0.2 percent offset measured on machine test specimens.
Source: Society of Automotive Engineers standard J1199 (1979).

Specifications for Steel Used in Inch Series Screws and Bolts

SAE Grade	Diameter d (in.)	Proof Load (Strength)[a] S_p (ksi)	Yield Strength[b] S_y (ksi)	Tensile Strength S_u (ksi)	Elongation, Minimum (%)	Reduction of Area, Minimum (%)	Core Hardness, Rockwell Min	Core Hardness, Rockwell Max	Grade Identification Marking on Bolt Head
1	¼ thru 1½	33	36	60	18	35	B70	B100	None
2	¼ thru ¾	55	57	74	18	35	B80	B100	None
2	Over ¾ to 1½	33	36	60	18	35	B70	B100	None
5	¼ thru 1	85	92	120	14	35	C25	C34	
5	Over 1 to 1½	74	81	105	14	35	C19	C30	
5.2	¼ thru 1	85	92	120	14	35	C26	C36	
7	¼ thru 1½	105	115	133	12	35	C28	C34	
8	¼ thru 1½	120	130	150	12	35	C33	C39	

[a]Proof load (strength) corresponds to permanent deformation not over 0.0001 in. measured on actual bolts.
[b]Yield strength corresponds to 0.2 percent offset measured on machine test specimens.
Source: Society of Automotive Engineers standard J429k (1979).

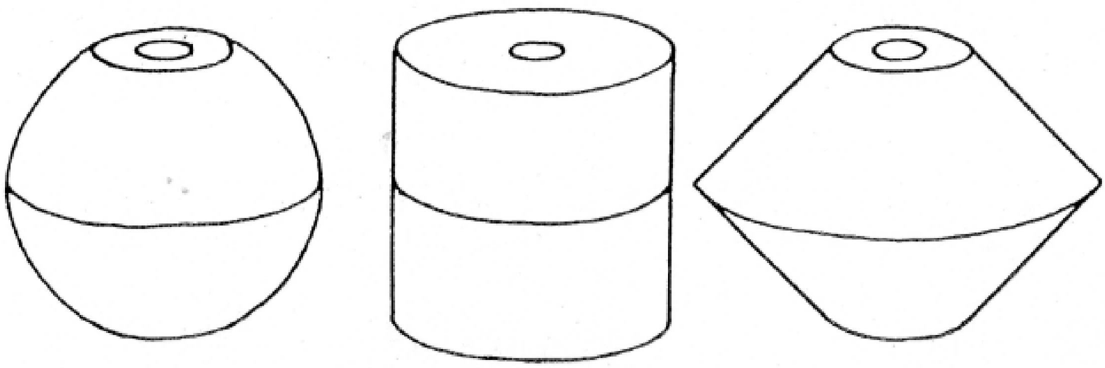


Figure 5.9 Equivalent shapes substituted for joint members in calculating joint stiffness and deformation.

Table 4.16 Room Temperature Strength of Typical Joint Materials (ksi)

Joint material	Strength			Ref.
	Yield	Tensile	Shear	
Structural steels				
Low-carbon steels (A36, Fe37)	33–36	58–80	41–56	48
High-strength steel (A588)	42–50	63–70	44–49	48
High-strength, low-alloy steel (A242, A441, A572, Fe52)	40–65	60–80	42–56	48
Quenched and tempered carbon steel (A537)	50–60	70–100	49–70	48
Quenched and tempered alloy steel (A514, A517)	90–100	100–130	70–91	48
Automotive materials				
Steels				
SAE J414				
1010 hot rolled	26	47	35	
1010 cold drawn	44	53	37	
1020 hot rolled	30	55	41.2	
1020 cold drawn	51	61	43	
1035 hot rolled	39.5	72	54	
1035 cold drawn	67	80	56	
Aluminum die castings	14–24	46	19–29	
SAE J453				
Grade 303, 306, 308, 309				
Gray iron castings				
SAE J859				
G1800	—	18	—	
G2500	—	25	31	55
G3000	—	30	38	
etc.				
Malleable iron castings				
SAE J158				
M3210	32	50		
M4504	45	65		
M5003	50	75		
M5503	55	75		
M7002	70	90		
M8501	85	105		
Ductile iron castings				
SAE J434				
D4018	40	60		
D4512	45	65		
D5506	55	80		
D7003	70	100		

Table 4.4 Yield Strength (ksi) vs. Temperature

Spec.	Grade	Temp. °F (°C) 70 (20)	400 (204)	600 (316)	800 (427)	1000 (538)	1200 (649)	1400 (760)	1600 (871)	1800 (982)	Ref
ASTM	B6	85	76	72							
A193	B7	75–105	65–92	60–85	53–74						1, 8
	B8–Cl 1	30	21	18	17						
	B16	85–105	79–98	75–93	67–83						
ASTM A307	GR B	36	31	27							9
ASTM A320	L7,L43,L7A	105	92	84	73						1
ASTM A325	Type 1	81	70								
ASTM	BC	94–109	87–96	81–89							1
A354	BD	125	110	102							
ASTM	651	50–70	13–56	36–51	33–46						
A453	660	85	82	81	80						8
ASTM	B21–B24										
A540	Cl 1	150	134	124							
	Cl 2	140	125	116							

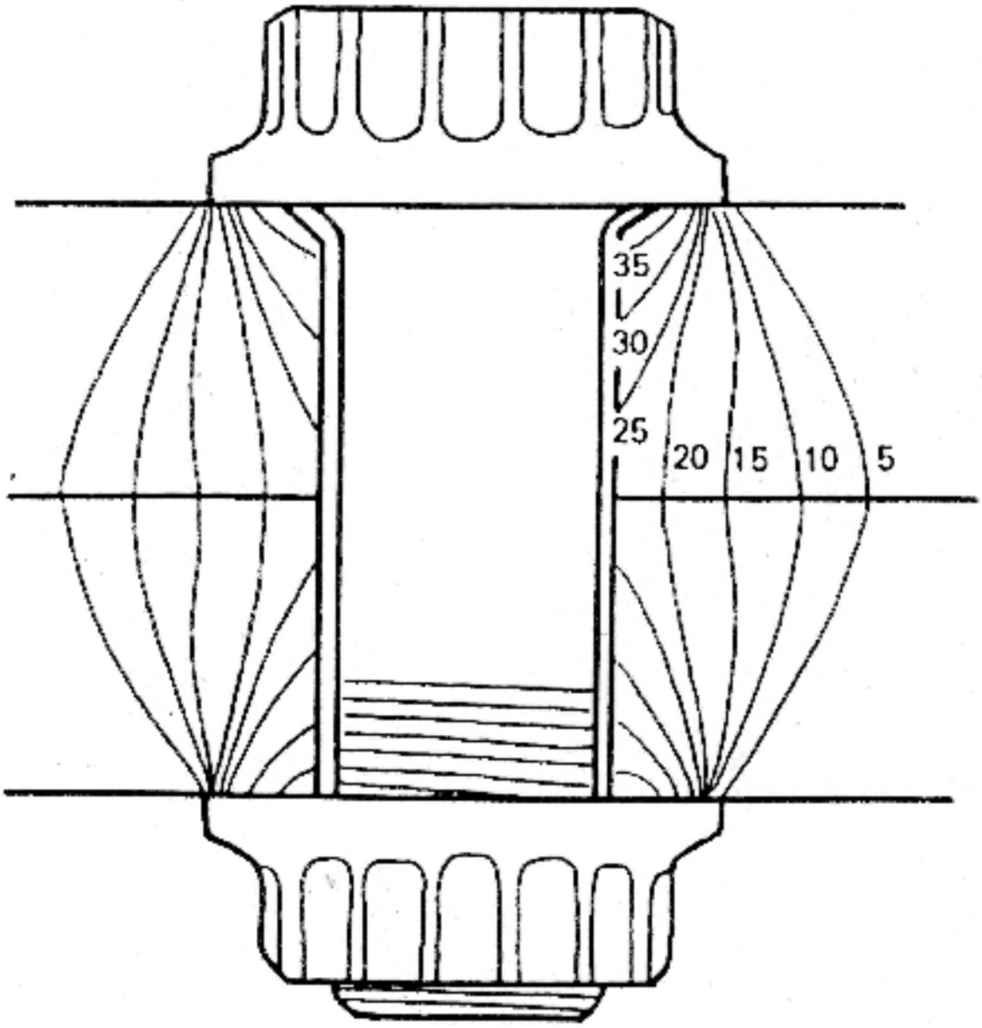
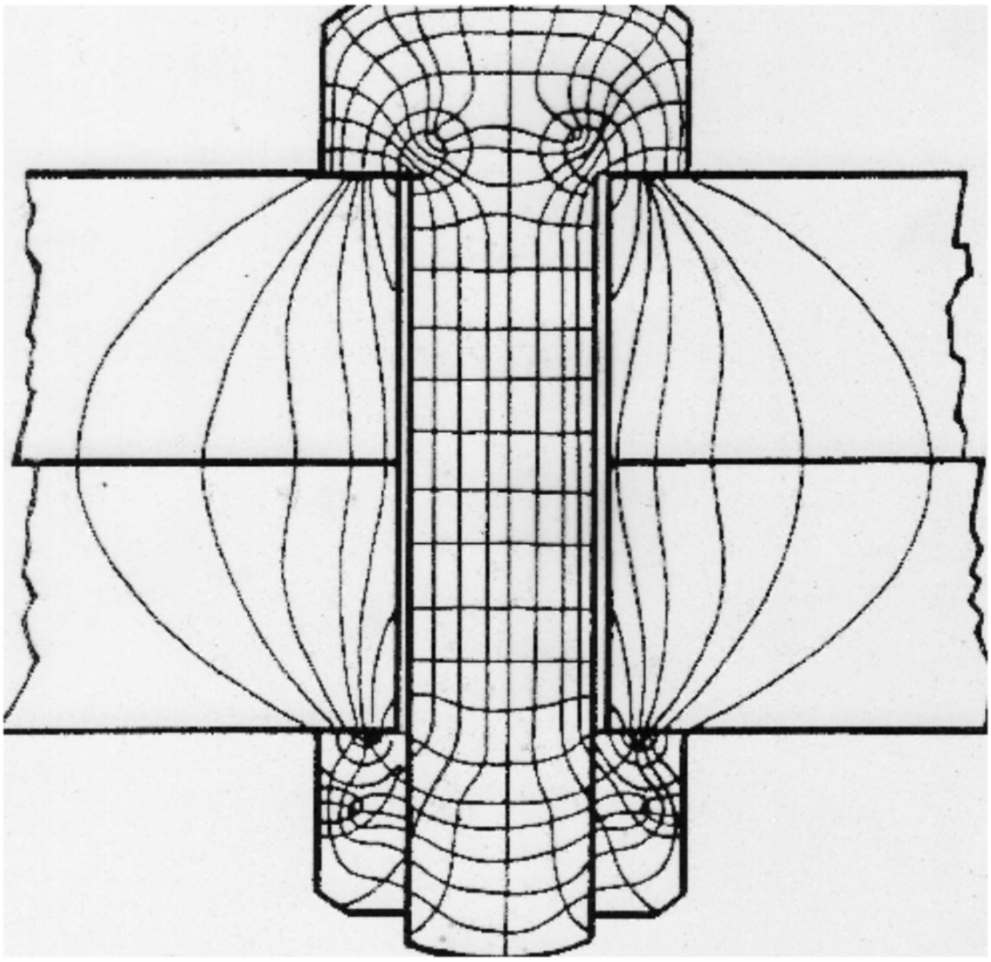


Figure 2.14 Lines of equal compressive stress in joint loaded to 100 kip. Values given are in ksi.



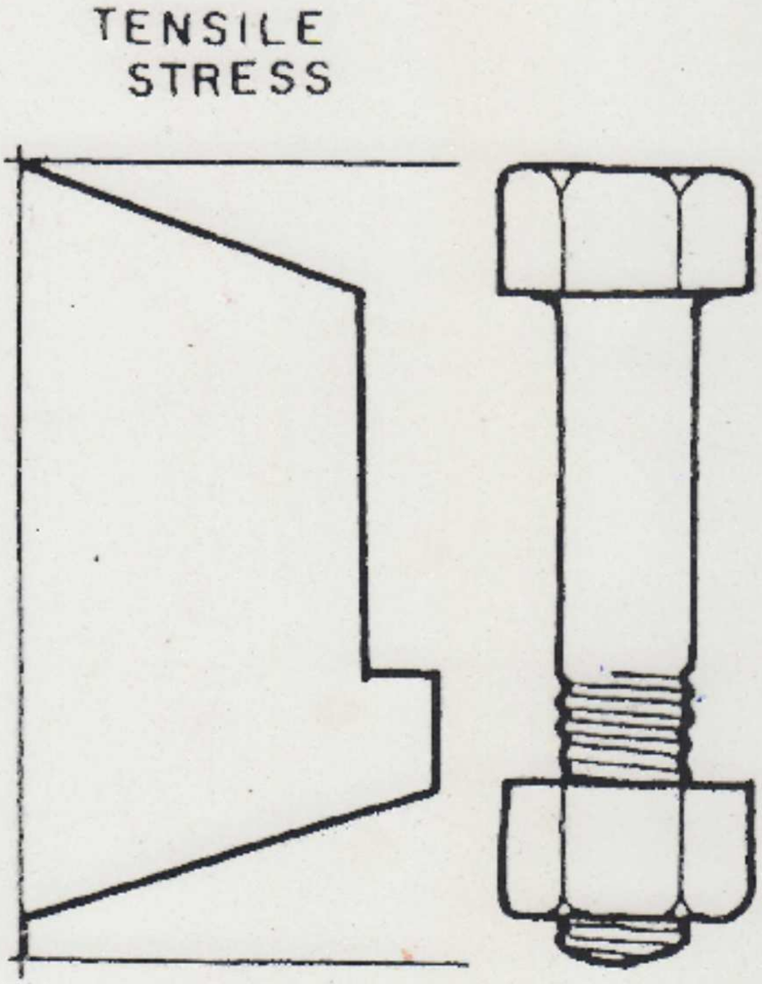


Figure 2.4 The magnitude of tensile s
assumed in bolt calculations.

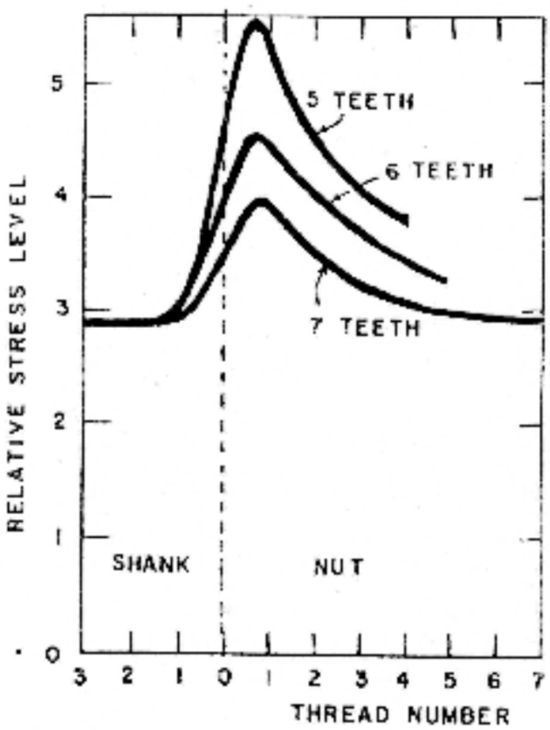


Figure 2.8 Peak stresses in three different nuts, having five, six, and seven teeth, respectively.

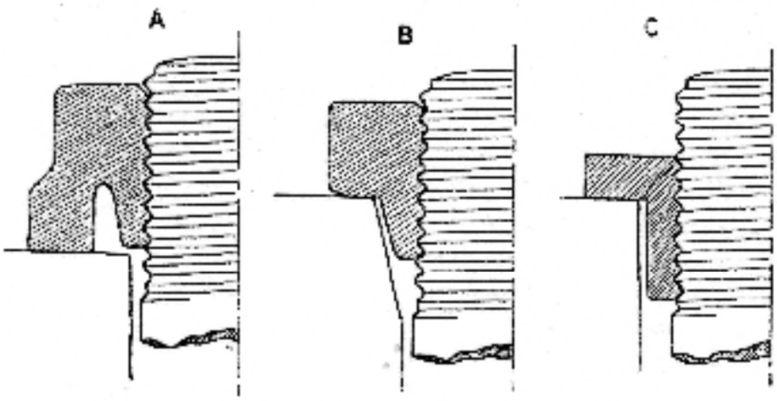


Figure 2.9 Nuts which are partially loaded in tension, such as those shown here, see a more uniform tooth stress distribution than do conventional nuts.

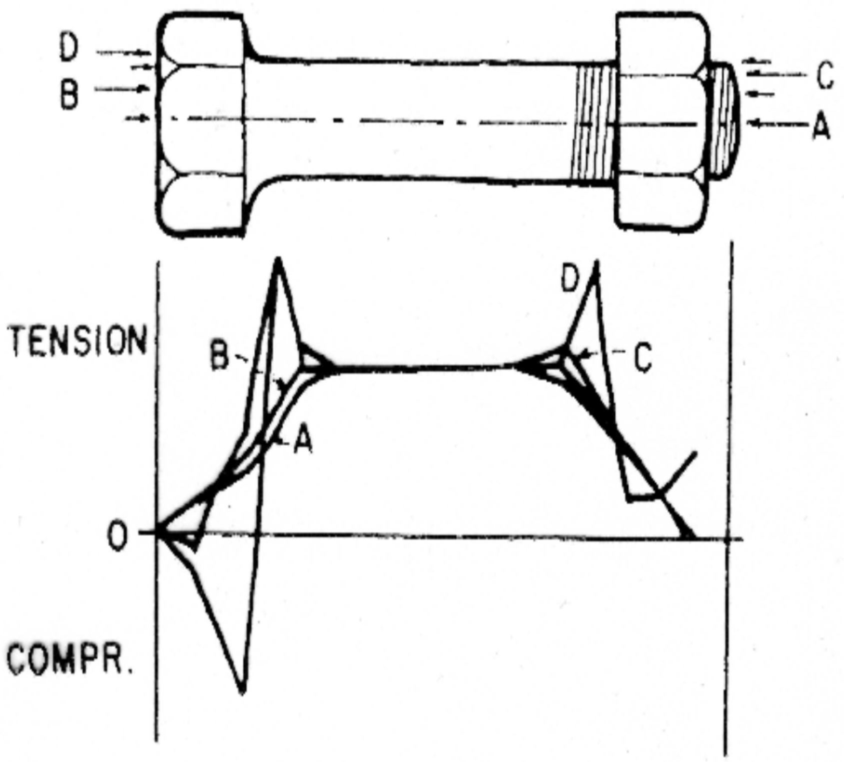


Figure 2.5 More accurate view of the tensile stress al
the axis of the bolt

One of the main reasons that values for gasket stiffness are not published is that the stress-deflection behavior of gaskets is nonlinear, as already mentioned. To define stiffness you must know which part of the behavior curve you're interested in. Figure 5.18 illustrates this problem. It includes stress-deflection curves for several gaskets, as they are initially loaded (part A of each curve) and subsequently unloaded and reloaded in use (part B). Typically the B portion of the curve has a very steep slope

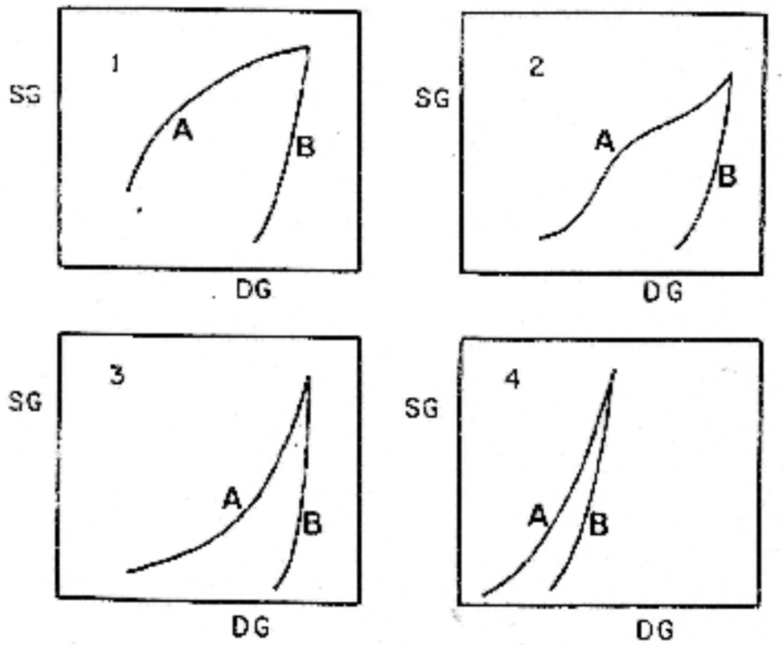


Figure 5.18 Curves of gasket stress (SG) vs. gasket deflection (DG) for four types of gasket: (1) spiral wound, flexible, graphite filled; (2) spiral wound, asbestos filled; (3) stainless steel, double jacketed, with flexible graphite envelope; and (4) compressed asbestos. In each plot the A curve shows the behavior of the gasket as it is first loaded. Curve B shows the behavior as it is unloaded and reloaded. As can be seen, the behavior is nonlinear, with gasket stiffness varying from point to point.

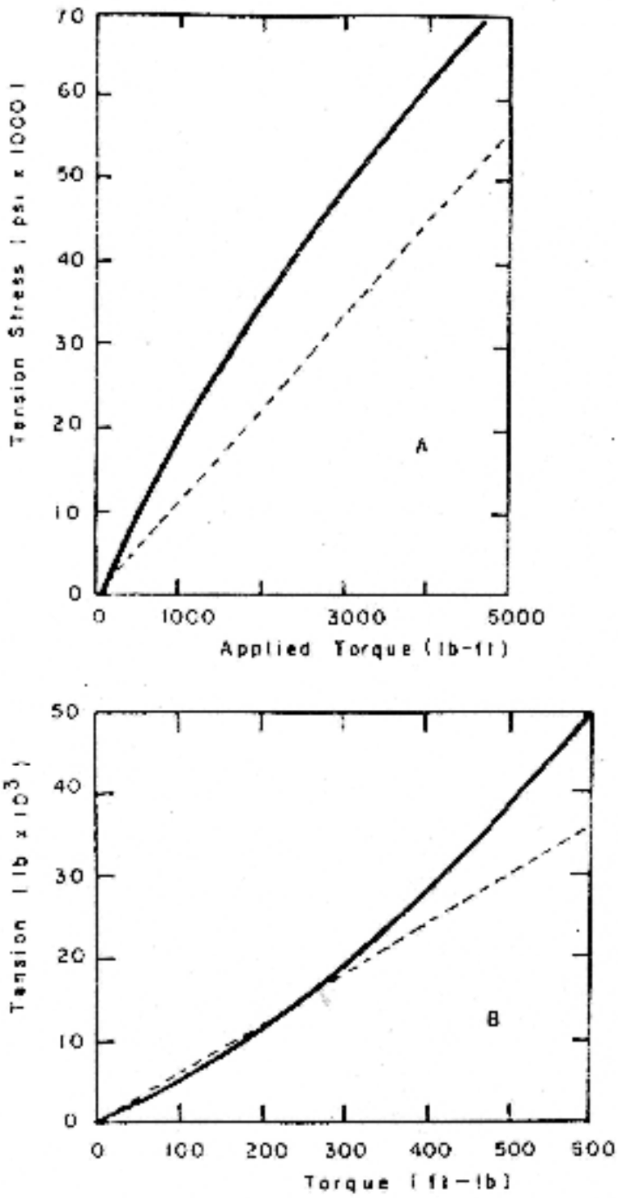


Figure 7.11 The relationship between torque and preload is not always a straight line, as these experimentally derived curves show. Curve A is for a $2\frac{1}{4}$–8 × 12, B16 stud. Curve B is for a 1-in.-diameter ASTM A325 bolt with a $2\frac{1}{4}$-in. grip length. The dashed line in each case is the theoretical line for nut factors of 0.132 and 0.2, respectively.

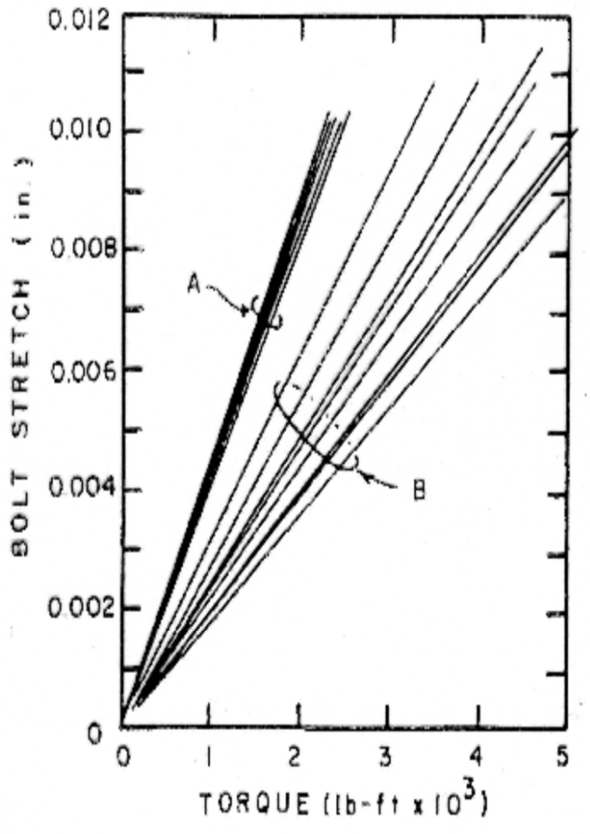


Figure 7.10 Torque-preload tests on lubricated (group A) and unlubricated (group B) $2\frac{1}{4}$-8 × 12, B16 studs.

Torque Control of Bolt Preload

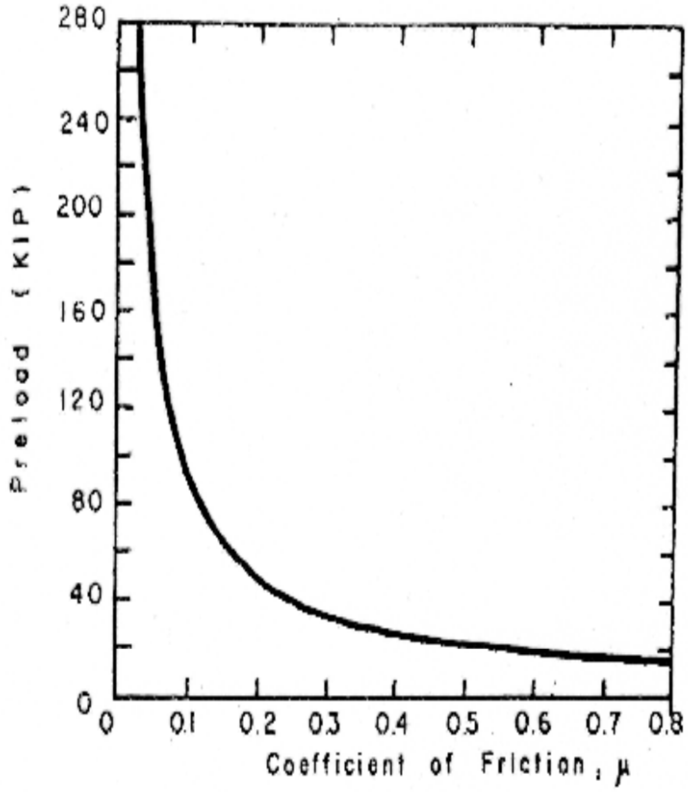
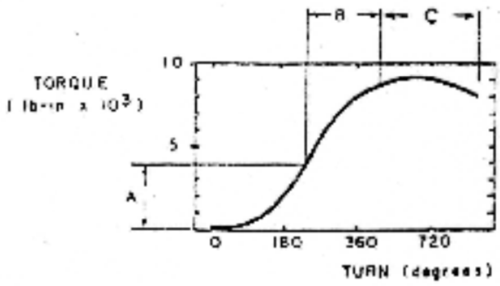


Figure 7.8 Theoretical preload achieved for a given input torque as a function of the coefficient of friction.

TORQUE TURN

Usually turn is coupled with torque and called torque/turn or turn of nut process. The process is illustrated by the following graph:



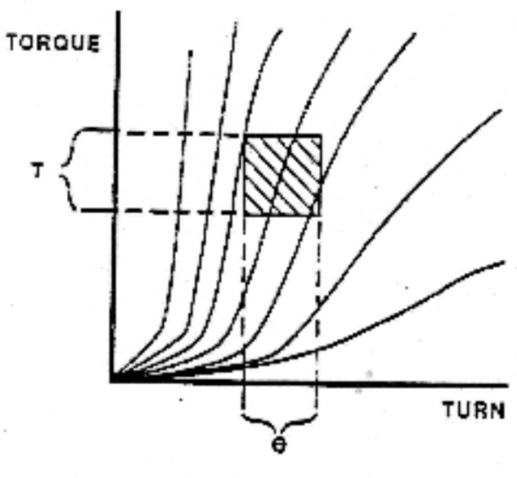
The process has three regions:

A — The snugging where all the plies of the joint are brought into contact.

B — The seating torque; usually loosely defined as the full effort of a man on a spud wrench.

C — Measured turn which usually brings the bolts beyond the proportional limit.

Window Control



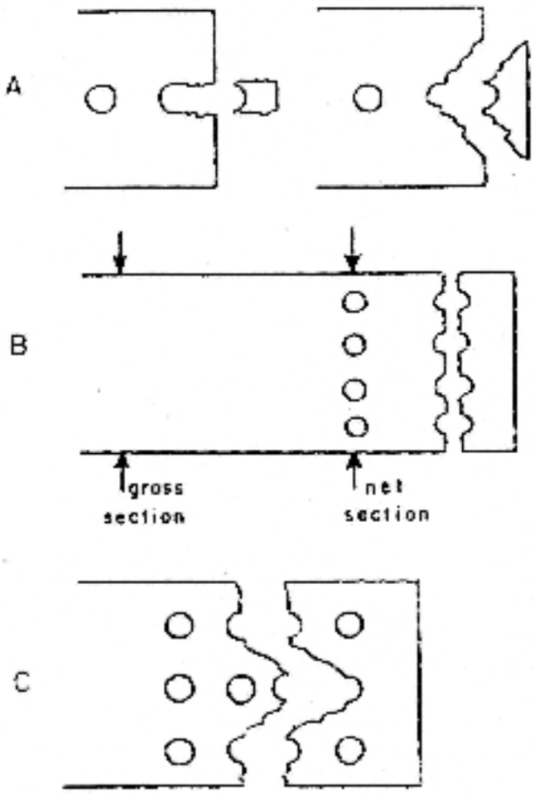


Figure 2.16 Some static failure modes of axial shear joints. (A) Tear-out or marginal failure. (B) Failure through the "net section." (C) Zigzag failure.

2. Failure of the "net section" of the plate because the bolts are spaced too closely, or because the plate is too thin or too soft (Fig. 2.16B)
3. A zigzag failure when there is too short a distance between bolt holes (Fig. 2.16C)

DESIGNACION DE ROSCAS SEGUN DIN:

Elementos constructivos

Designaciones de roscas. Las roscas se designan con mayor precisión por medio de símbolos.

Designaciones de rosca abreviadas (extracto de DIN 202 y ampliación):

Rosca derecha de una sola entrada (un paso)					
			Designación de rosca		
Clase de rosca		Según DIN	Signo delante del dato de medida	Datos de medida	Ejemplo de configuración
Rosca de filete triangular	Rosca métrica ISO	13 h. 21	M	Diámetro exterior de la rosca en mm	M 20
Rosca de filete triangular	Rosca métrica	13 h. 1	M	Diámetro exterior de la rosca en mm	M 20
Rosca de filete triangular	Rosca métrica fina	244 a 247 516 a 521	M	Diámetro exterior de la rosca × paso en mm	M 20 × 1,5
Rosca de filete triangular	Rosca métrica fina ISO	13 h. 35 a 41	M	Diámetro exterior de la rosca × paso en mm	M 20 × 1,5
Rosca de filete triangular	Rosca métrica cónica (cono 1 : 16)	158	M	Diámetro exterior de la rosca × paso en mm y cono	M 10 × 1 cón.
Rosca de filete triangular	Rosca Whitworth	11		Diámetro exterior de la rosca en pulgadas	[illegible]
Rosca de filete triangular	Rosca Whitworth de tubo	259	R	Diámetro nominal (= diámetro interior) del tubo en pulgadas	R [illegible]
Rosca trapecial		103 378, 379	Tr	Diámetro exterior de la rosca en mm × paso en mm	Tr 50 × 8
Rosca de filete en diente de sierra		513 a 515	S	Diámetro exterior en mm × paso en mm	S 100 × 12
Rosca de filete redondo		405	Rd	Diámetro exterior de la rosca en mm × paso en pulgadas	Rd 30 × 1"/8

Datos especiales:

Rosca a la izquierda: se indica mediante la palabra *izquierda* colocada detrás o debajo de la designación de la rosca.	M 20 × 1,5 izquierda
Rosca a la derecha de varios pasos: se pone detrás de la designación de la rosca una nota con el número de pasos.	M 20 (2 entradas)
En casos de roscas de varios pasos se pone además entre paréntesis una indicación con el número de pasos. Como paso se pone siempre la medida del desplazamiento axial para una revolución de la rosca.	Tr 50 × 8 (izq. 2 entradas)
Si una pieza tiene roscas derechas e izquierdas, se indica no solamente la rosca izquierda sino también la derecha (mediante la palabra *derecha*).	Rd 30 × 1"/8 derecha
Las roscas herméticas al gas y al vapor llevan la indicación *hermética*.	M 20 hermét.
Para las roscas especiales y para aquellas a las que se exigen determinadas condiciones, hay que consignar el número de la hoja de normas. DIN 2999 se refiere, por ejemplo, a rosca exterior cónica e interior cilíndrica.	R 1"/2 – DIN 2999

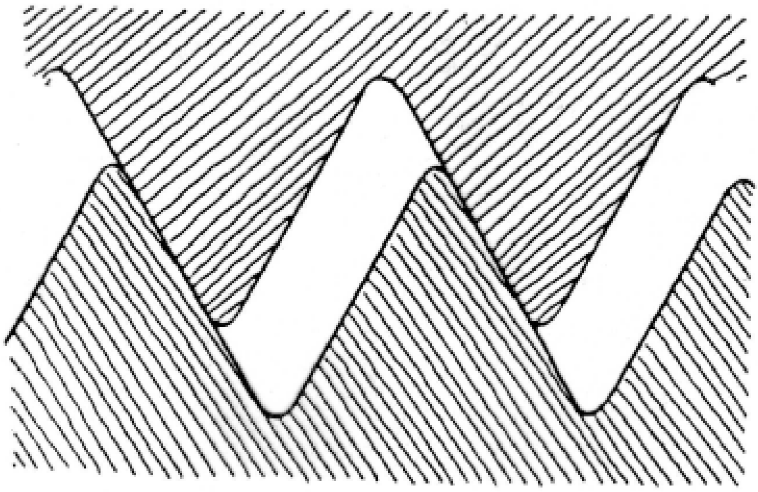


Figure 6.13 Poor thread engagement may be a major source of plastic defor[
tion and therefore joint relaxation.

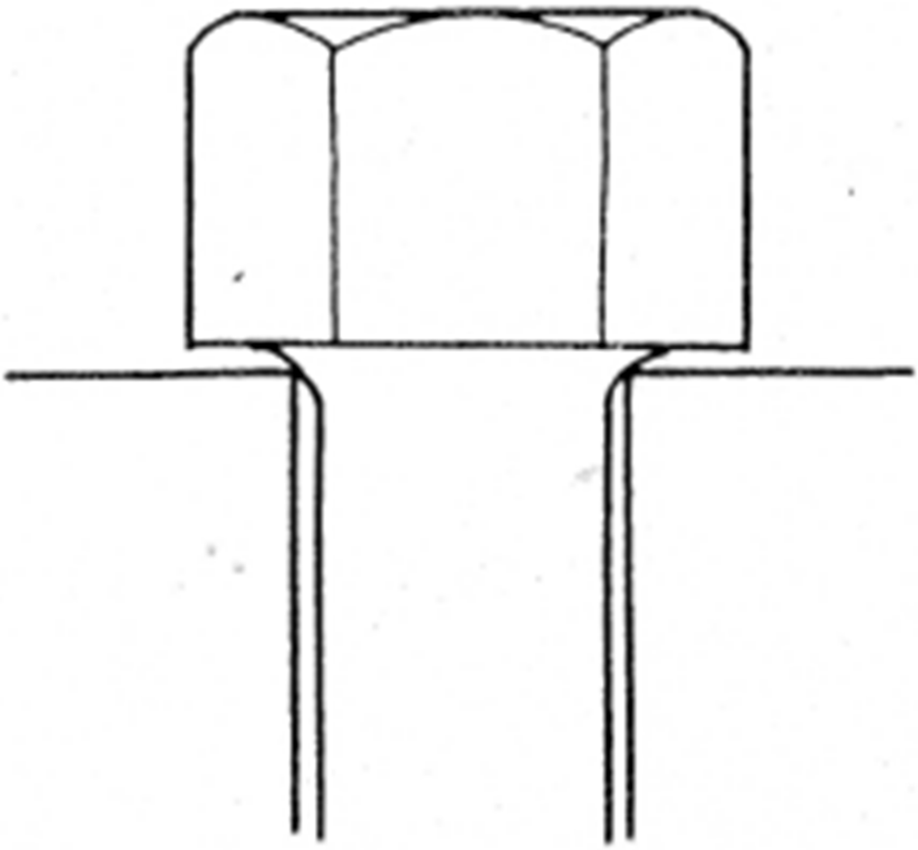


Figure 6.14 Oversized fillets and/or undersized holes may result in total relax tion of a preloaded fastener.

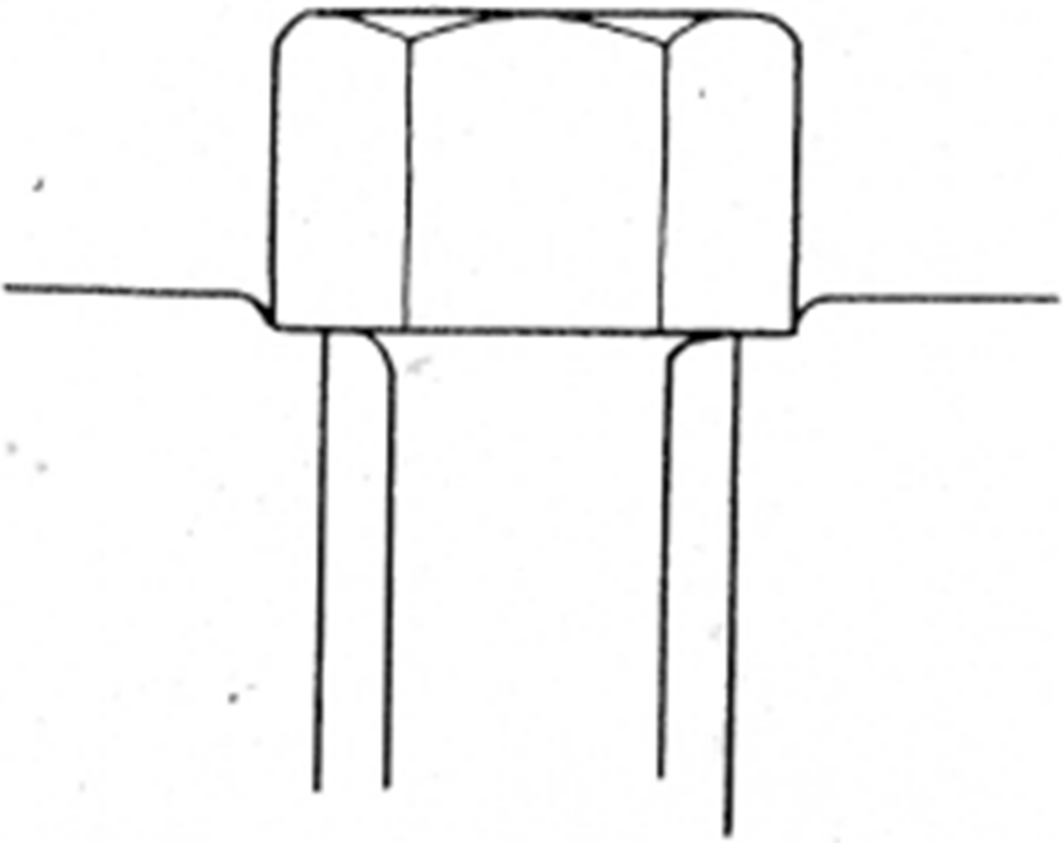


Figure 6.15 Oversized holes may also increase contact stress levels and there fore increase embedment relaxation.

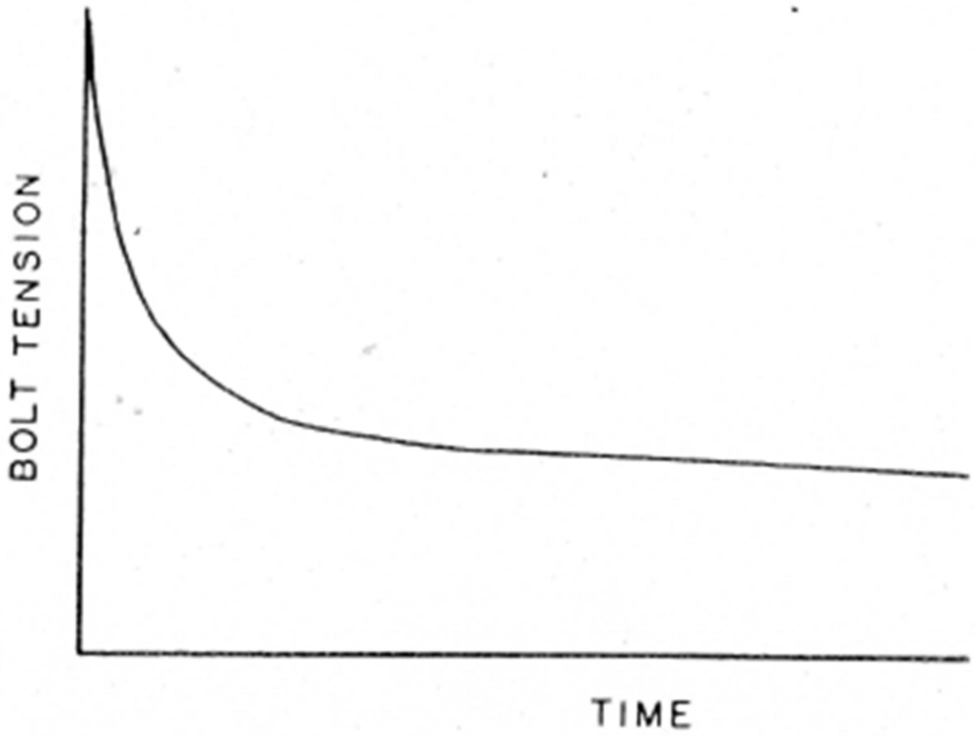


Figure 6.18 Most short-term relaxation occurs in the first few seconds or minutes following initial tightening, but continues at a lesser rate for a long period of time.

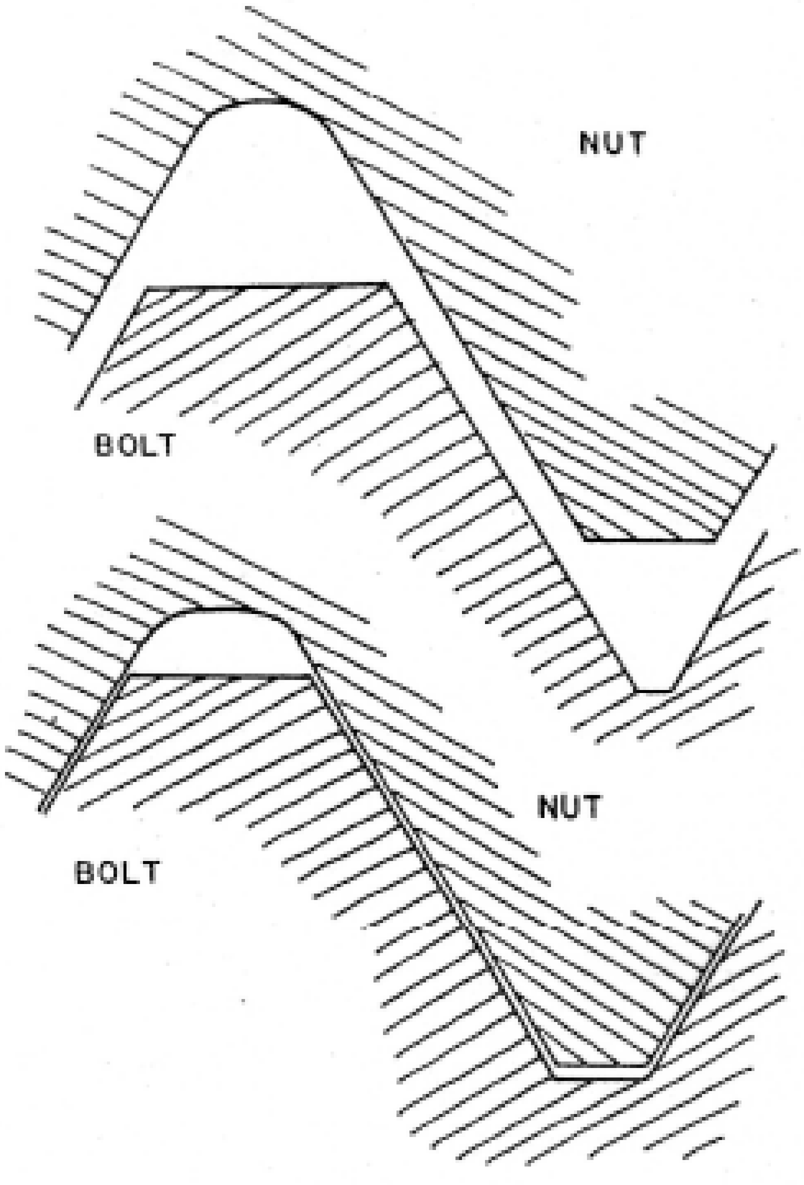
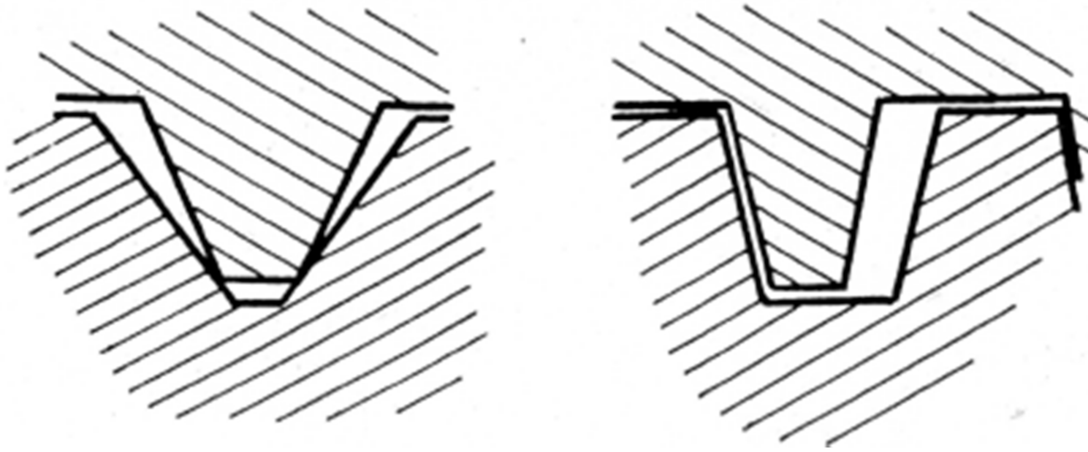


Figure 3.6 The lower sketch shows the clearance between male and female Class 2A UN threads when only the basic allowance separates them. The upper sketch shows how much this clearance increases when the full manufacturing tolerance is added to the allowance. In effect, the lower sketch shows the maximum material condition for bolt and nut; the upper sketch the minimum material condition for both. The bolt thread is reduced in diameter by the allowance and tolerance, and the roots of the teeth are rounded. The diameter of the nut teeth has been increased slightly by the manufacturing tolerance, and the roots of the teeth are rounded.



Incorrect tooth angles can also result in improper engagement and loss of thread strength.

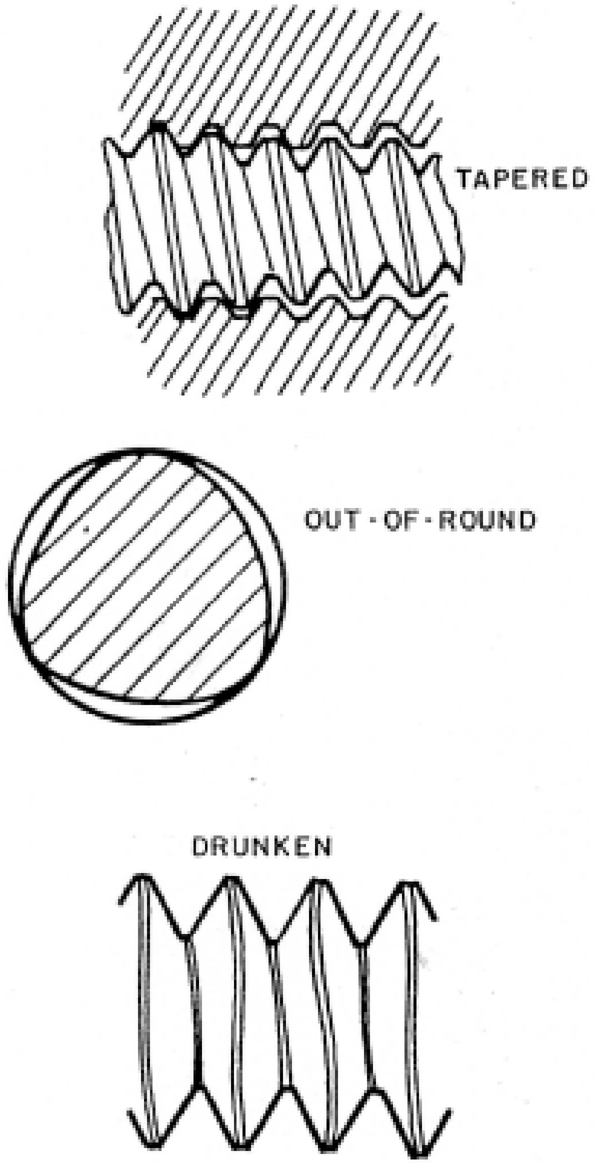


Figure 3.9 Tapered out-of-round or drunken threads all reduce thread-stripping strength.

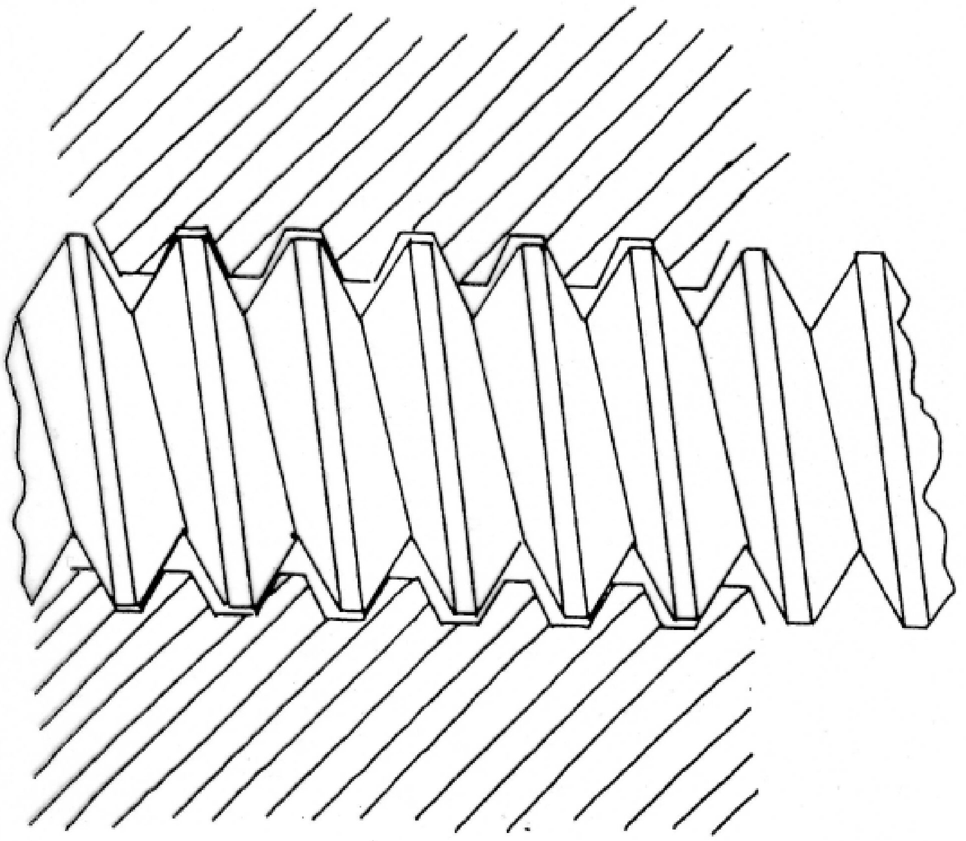


Figure 3.10 If the pitch of the male threads differs significantly from that of th
female threads, they may be in contact for only part of the length of engagemen

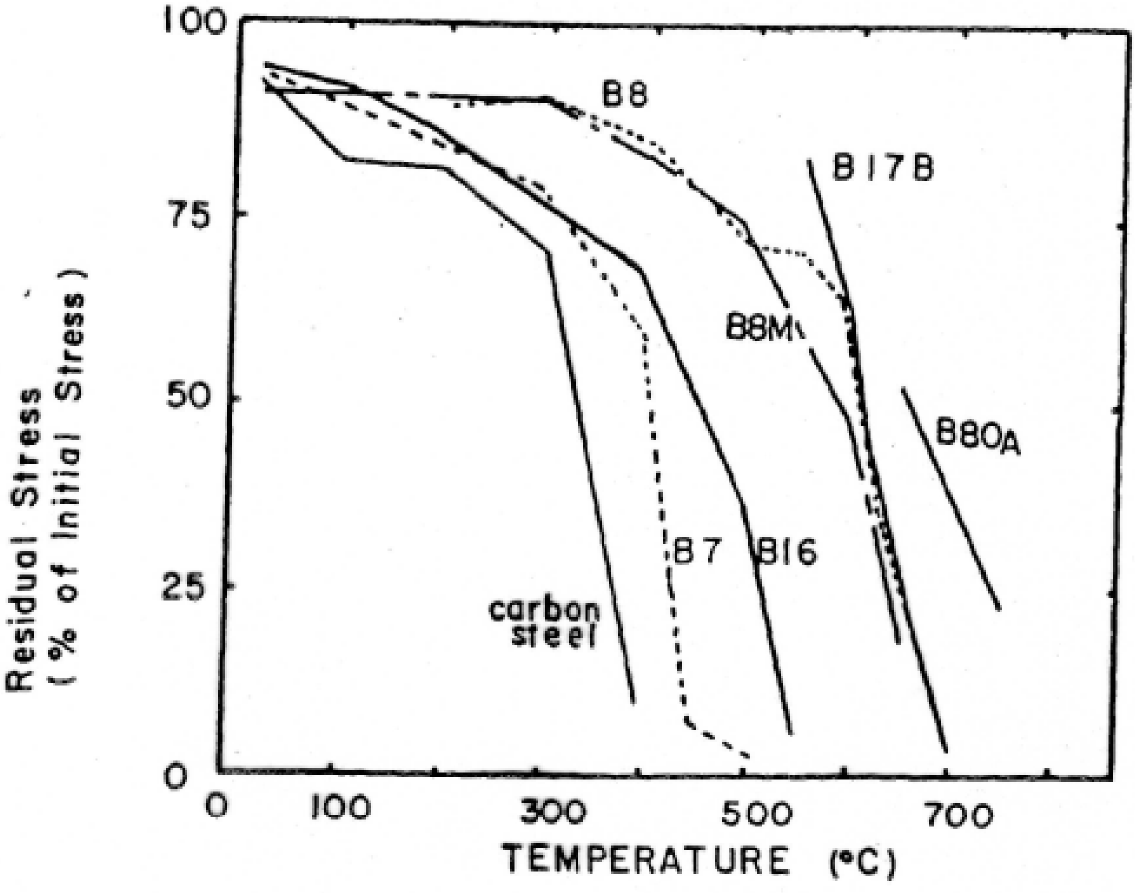


Figure 4.3 Stress relaxation of petrochemical bolting materials as a function of service temperature. Exposure in each case was for 1000 hr at the temperatures shown [19].

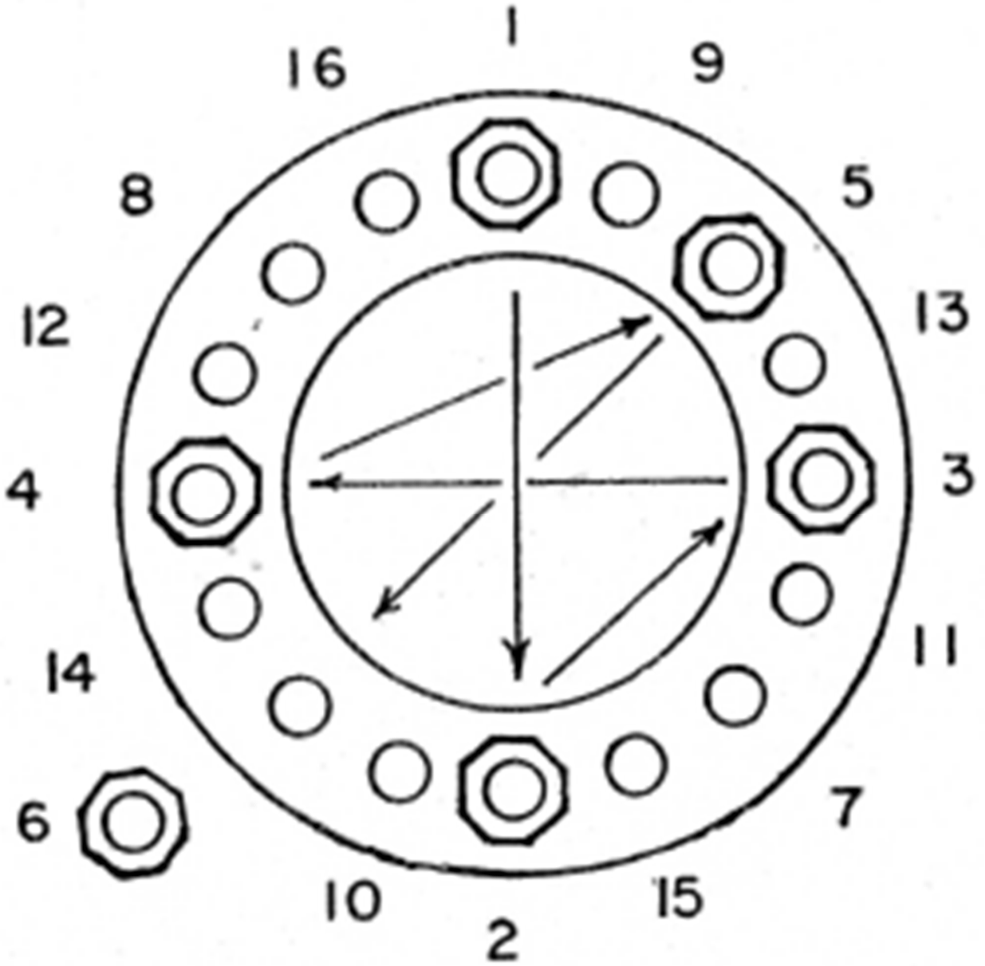


Figure 6.2 We'll tighten the bolts of our example joint in the "star pattern" sequence shown here. We'll use three passes, at one-third, two-thirds, and final torque, following the same sequence on each pass.

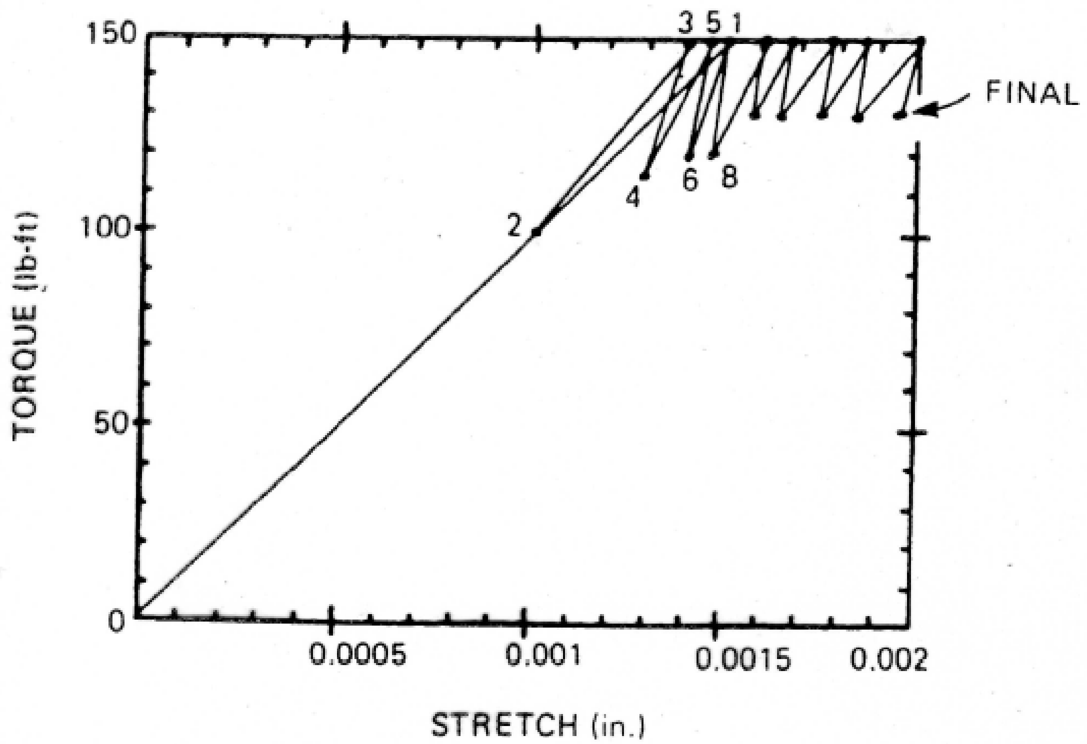


Figure 6.20 Torque-stretch-relaxation history of a $\frac{5}{8}$–18 × $1\frac{3}{4}$ Grade 5 bolt. A torque of 150 lb-ft was applied repeatedly to this fastener, with a pause for relaxation between each pass. Final preload was 33% greater than that achieved on the first pass.

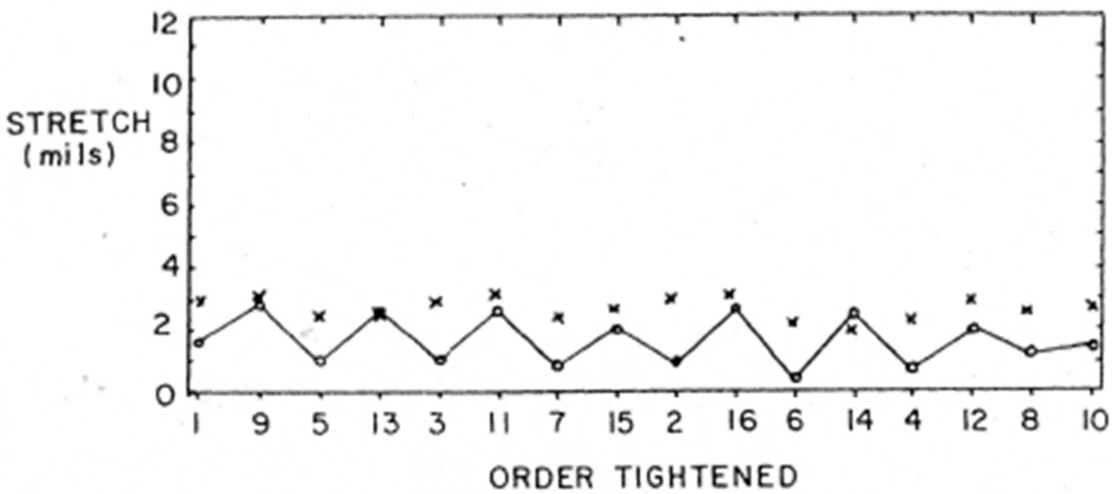


Figure 6.23 The elongation or stretch achieved in the 16 bolts of a gasketed flanged joint as the bolts are initially tightened one by one (x's) and after all have been tightened (solid line). Numbers on the horizontal axis show the location of the bolts, and the order in which they were tightened. The second bolt tightened, #2, is located 180° away from #1. The third and fourth bolts tightened are halfway between bolts 1 and 2, etc. The difference between the x's and solid line shows the loss of initial preload in the bolts as a result of elastic interactions.

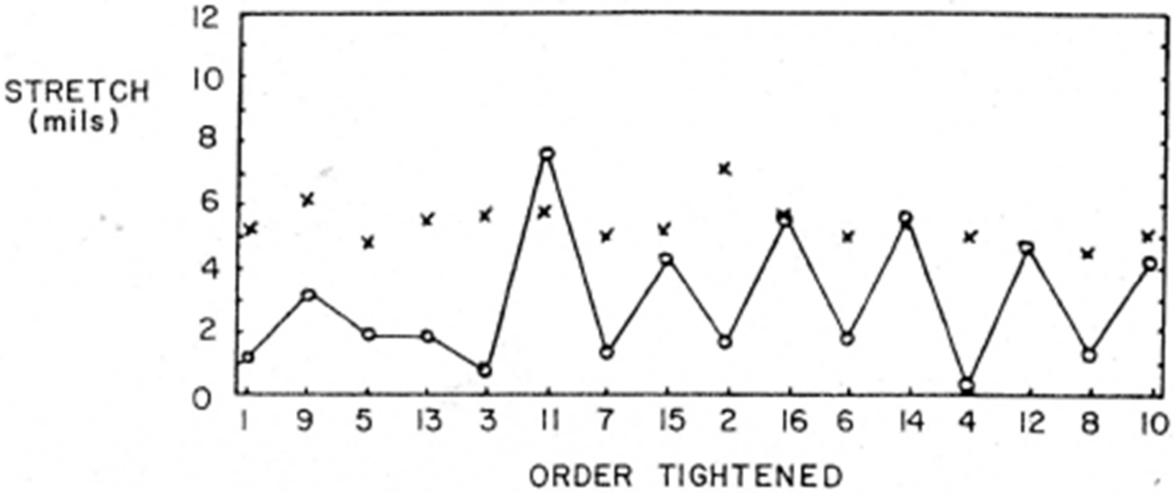


Figure 6.24 Initial and residual preloads in the 16 bolts of the joint shown in Fig. 6.23 after a second tightening pass at a higher torque.

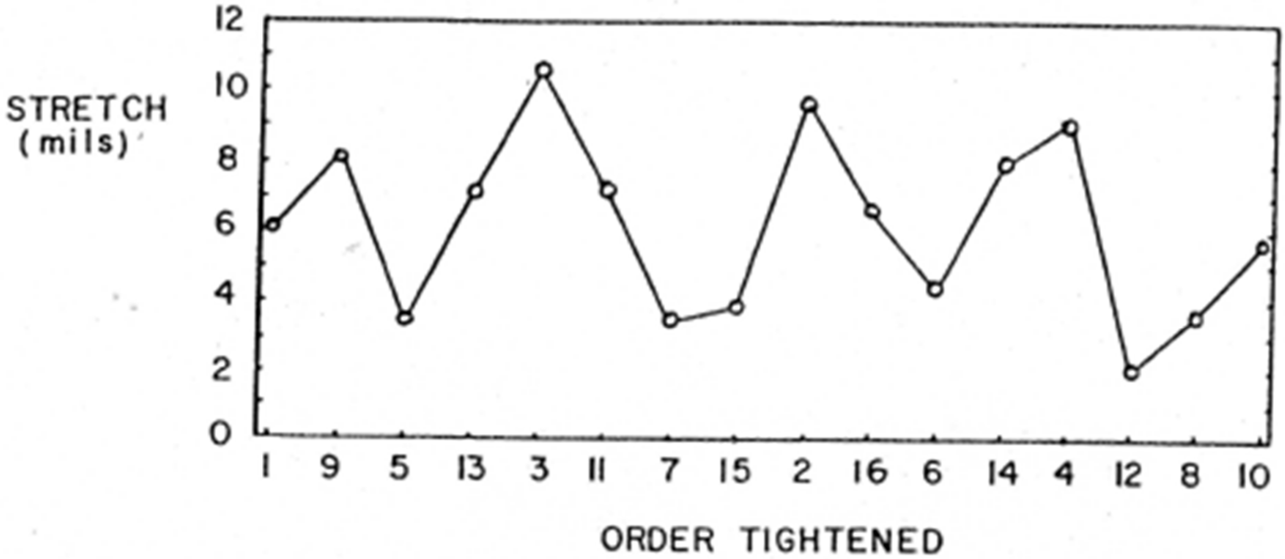


Figure 6.25 Final tension in the 16 bolts of the joint of Figs. 6.23 and 6.24 after a final cross-bolting pass at a final (highest) torque.

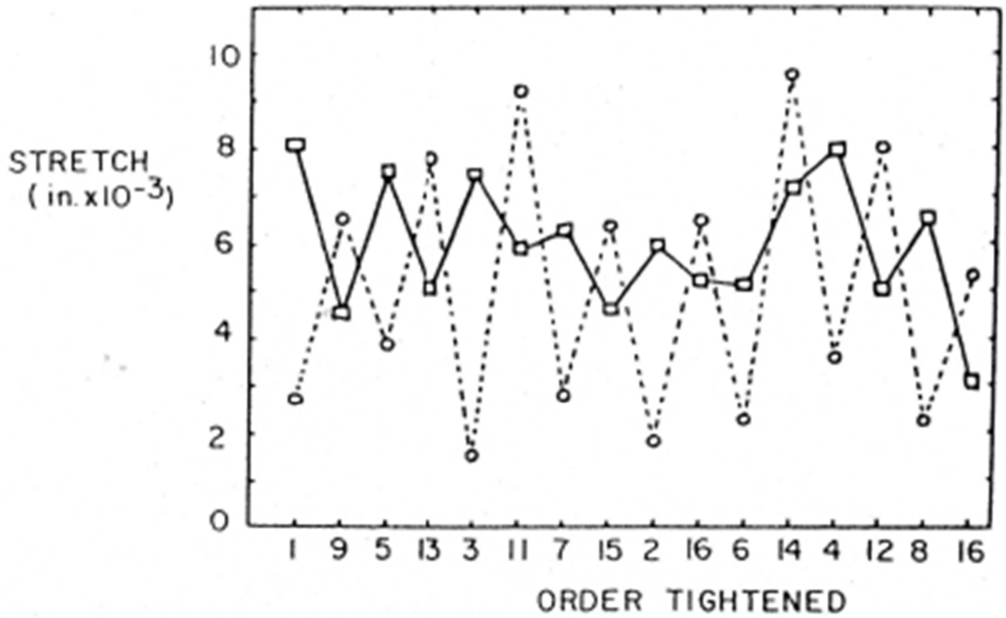


Figure 6.26 The dashed line shows the pattern of final, residual tension in the 16 bolts of the joint described in Figs. 6.23–6.25 after that joint has been loosened and then retightened with the same torques and procedure used earlier. The solid line shows the change in pattern of residual tensions after a fourth and final pass in reverse order (the last bolt was tightened first, etc.).

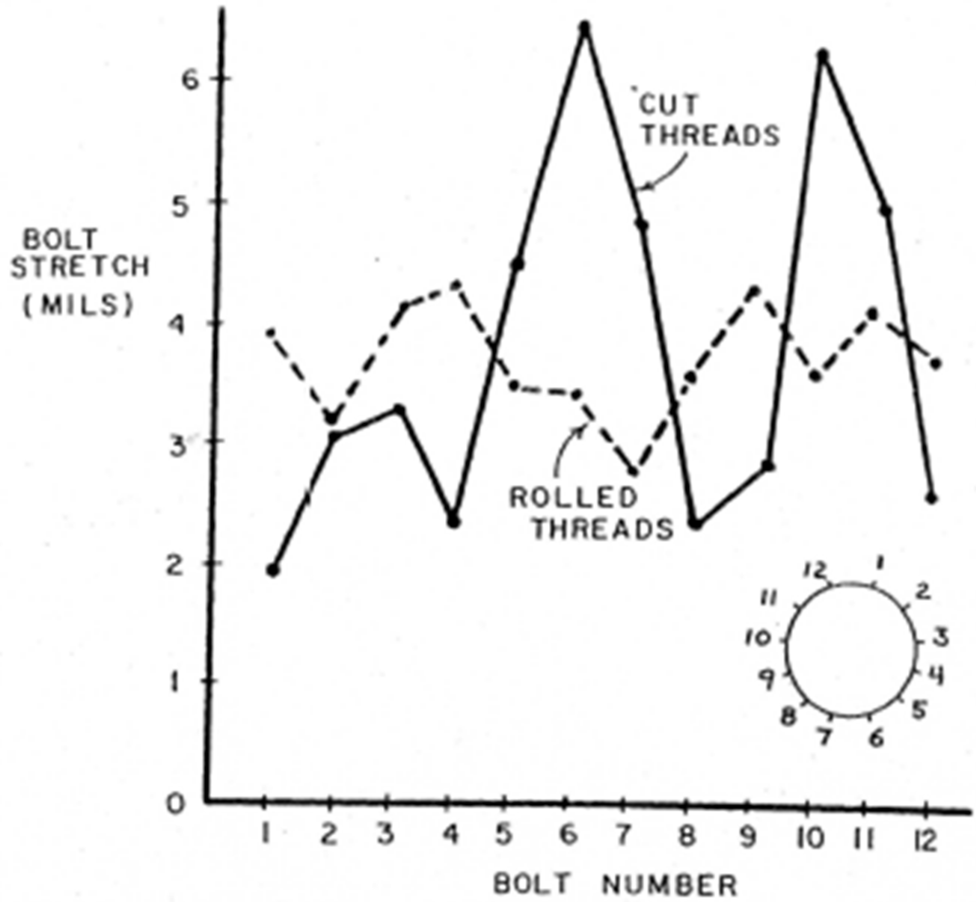


Figure 7.3 This shows the pattern of residual preload on two large, pressure vessel joints after a two-pass bolt-up procedure. Studs with cut threads were used in one joint, studs with rolled threads in the other. The engineer reported that the studs with rolled threads ended up with a higher average preload and with less scatter in preload than did those with cut threads.

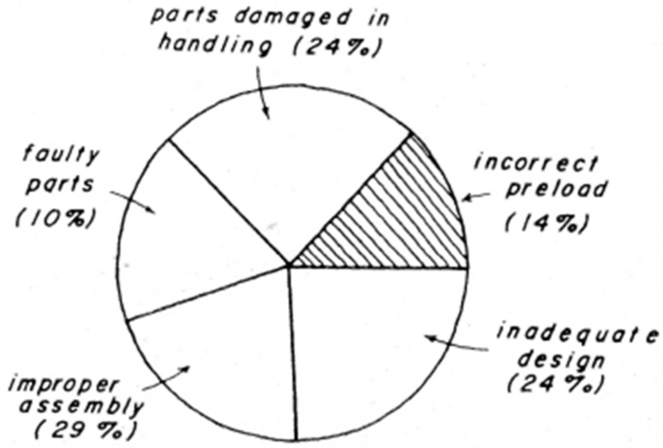
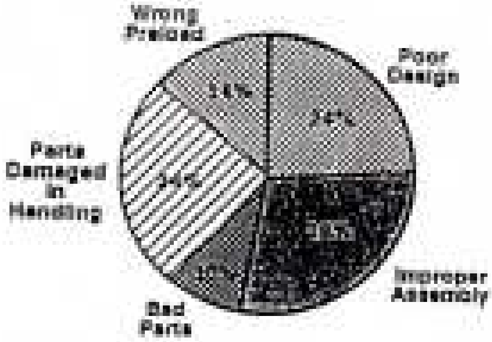


Figure 7.12. A summary of the causes of bolted joint failure on the Skylab program. All fastners have been torqued. (Modified from Ref. 14.)

Failure Modes

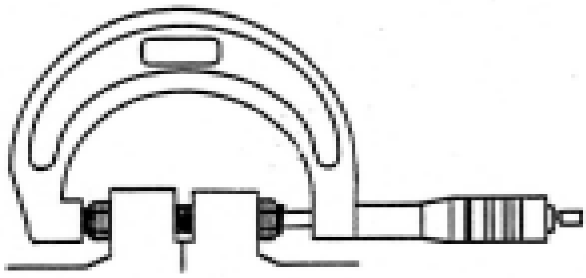
CAUSES FOR JOINT FAILURES IN NASA'S SKY LAB PROGRAM



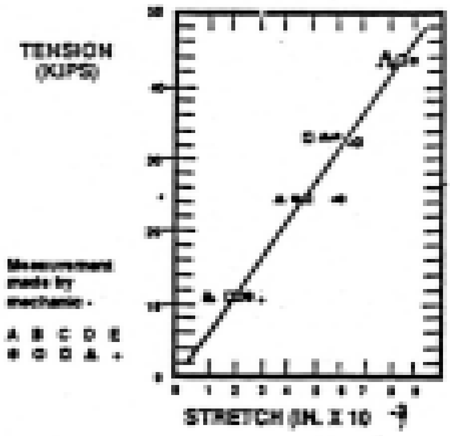
Corrective Actions

Failure mode & cause	Correction
Yielding of bolt: • Overtightening; over loads in service	Better assembly specs and control; joint design; size & number of fasteners
Threads stripping: • Soft nuts, short thread length, shallow threads	Use grade 10 nuts; thread length 1.00D in steel, 1.25D with stud, 1.50D with cap screw in cast iron, 2.00D in Al; 55-65% thread depth; coarse thread in cast iron & non-ferrous
Shear failures: • Transverse loads act on shear planes	Increase clamp loads to increase friction; bushings to carry shear loads on pivot joints; design for shear through body of bolt, not threads; larger bolts
Fatigue failures: • Low clamp load with high cyclic stress	Wrench to higher percentage of bolt strength; larger bolts
• Stress concentration at radii under head, first thread or first thread under load	Proper radii under head and at root of thread; more threads (3-6) exposed to load; threads rolled after heat treatment
• Bending stresses increase stress at concentration points	Increase clamp load to reduce bending stresses; increase ductility of bolt by smaller size, or low C boron steels
Loosening of nut: • Axial vibration • Self-loosening by friction changes	Increase clamp load; use locking device on bolt or threads
Wear of surface due to transverse vibration	Increase clamping load; decrease bearing surface stress
Embedment of bearing surfaces: • High compressive stresses on soft joints	Increase bearing surface area with flanged hex, closer clearance holes, or washer; harder joint materials
Loss of clamp force on early loading: • High localized stresses and crushing of surface roughness	Spot face, flatten, clean off dirt, mask paint from surface, check gaskets

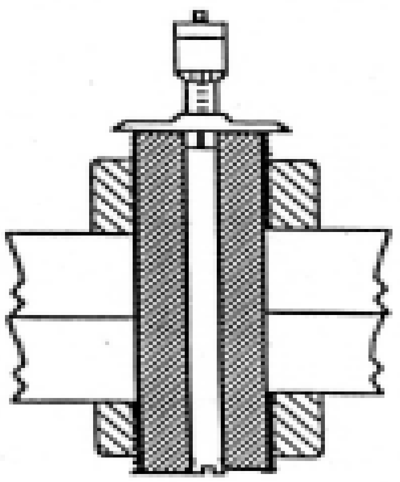
Micrometer—for small fasteners



Stretch Measurements Using Micrometer

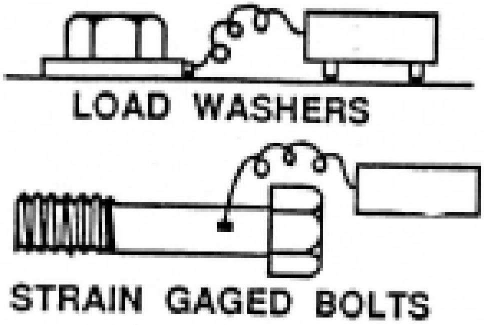


Depth Micrometer

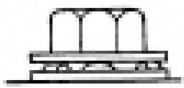


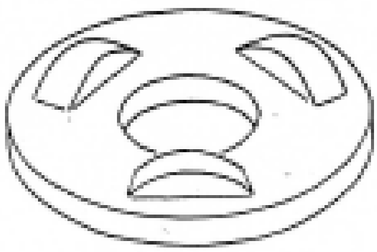
Tension Control

Strain Gages



Crush Washers





Rot

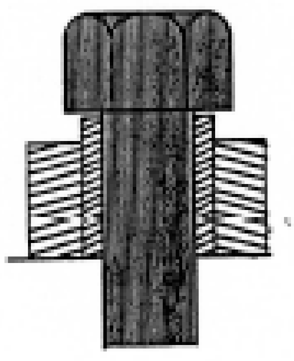
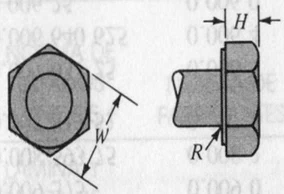


TABLA A-26

Dimensiones de pernos de cabeza cuadrada o hexagonal



TAMAÑO NOMINAL, in	CUADRADA		HEXAGONAL REGULAR			HEXAGONAL PESADA			HEXAGONAL ESTRUCTURAL		
	TIPO DE CABEZA										
	W	H	W	H	$R_{mín}$	W	H	$R_{mín}$	W	H	$R_{mín}$
$\frac{1}{4}$	$\frac{3}{8}$	$\frac{11}{64}$	$\frac{7}{16}$	$\frac{11}{64}$	0.01						
$\frac{5}{16}$	$\frac{1}{2}$	$\frac{13}{64}$	$\frac{1}{2}$	$\frac{7}{32}$	0.01						
$\frac{3}{8}$	$\frac{9}{16}$	$\frac{1}{4}$	$\frac{9}{16}$	$\frac{1}{4}$	0.01						
$\frac{7}{16}$	$\frac{5}{8}$	$\frac{19}{64}$	$\frac{5}{8}$	$\frac{19}{64}$	0.01						
$\frac{1}{2}$	$\frac{3}{4}$	$\frac{21}{64}$	$\frac{3}{4}$	$\frac{11}{32}$	0.01	$\frac{7}{8}$	$\frac{11}{32}$	0.01	$\frac{7}{8}$	$\frac{5}{16}$	0.009
$\frac{5}{8}$	$\frac{15}{16}$	$\frac{27}{64}$	$\frac{15}{16}$	$\frac{27}{64}$	0.02	$1\frac{1}{16}$	$\frac{27}{64}$	0.02	$1\frac{1}{16}$	$\frac{25}{64}$	0.021
$\frac{3}{4}$	$1\frac{1}{8}$	$\frac{1}{2}$	$1\frac{1}{8}$	$\frac{1}{2}$	0.02	$1\frac{1}{4}$	$\frac{1}{2}$	0.02	$1\frac{1}{4}$	$\frac{15}{32}$	0.021
1	$1\frac{1}{2}$	$\frac{21}{32}$	$1\frac{1}{2}$	$\frac{43}{64}$	0.03	$1\frac{5}{8}$	$\frac{43}{64}$	0.03	$1\frac{5}{8}$	$\frac{39}{64}$	0.062
$1\frac{1}{8}$	$1\frac{11}{16}$	$\frac{3}{4}$	$1\frac{11}{16}$	$\frac{3}{4}$	0.03	$1\frac{13}{16}$	$\frac{3}{4}$	0.03	$1\frac{13}{16}$	$\frac{11}{16}$	0.062
$1\frac{1}{4}$	$1\frac{7}{8}$	$\frac{27}{32}$	$1\frac{7}{8}$	$\frac{27}{32}$	0.03	2	$\frac{27}{32}$	0.03	2	$\frac{25}{32}$	0.062
$1\frac{3}{8}$	$2\frac{1}{16}$	$\frac{29}{32}$	$2\frac{1}{16}$	$\frac{29}{32}$	0.03	$2\frac{3}{16}$	$\frac{29}{32}$	0.03	$2\frac{3}{16}$	$\frac{27}{32}$	0.062
$1\frac{1}{2}$	$2\frac{1}{4}$	1	$2\frac{1}{4}$	1	0.03	$2\frac{3}{8}$	1	0.03	$2\frac{3}{8}$	$\frac{15}{16}$	0.062
TAMAÑO NOMINAL, mm											
M5	8	3.58	8	3.58	0.2						
M6			10	4.38	0.3						
M8			13	5.68	0.4						
M10			16	6.85	0.4						
M12			18	7.95	0.6	21	7.95	0.6			
M14			21	9.25	0.6	24	9.25	0.6			
M16			24	10.75	0.6	27	10.75	0.6	27	10.75	0.6
M20			30	13.40	0.8	34	13.40	0.8	34	13.40	0.8
M24			36	15.90	0.8	41	15.90	0.8	41	15.90	1.0
M30			46	19.75	1.0	50	19.75	1.0	50	19.75	1.2
M36			55	23.55	1.0	60	23.55	1.0	60	23.55	1.5