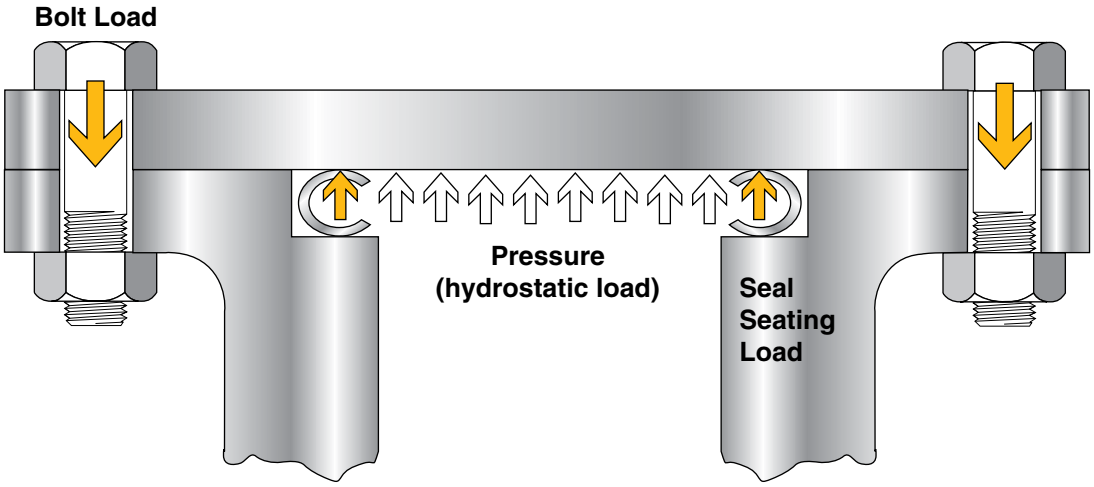
Installation Guidelines

Bolt Load & Tightening Torque Guidelines

The metal seal seating load, or load required to compress the seal, is typically achieved by tightening a number of bolts spaced around the flange. The number, size, and grade of these bolts must be sufficient to compress the seal during installation and withstand the system operating pressure which acts upon the surface of the flange.

Note: These bolt load and tightening torque guidelines are not intended to be used as design criteria and are only offered as a general guide. Many other factors such as flange thickness, flange rotation, thermal cycling, bolt stress relaxation, externally applied loads, temperature derating, impulse and fatigue, etc., must be considered by the design engineer to ensure proper bolt and torque selection.



Bolt Load Required ≥ Hydrostatic Load + Seal Seating Load + Safety Margin

The equation below provides the tightening torque required to produce a bolt load for various bolt geometries.

$$T = Lr_t \left(\frac{\cos\theta_n \tan\alpha + \mu_1}{\cos\theta_n - \mu_1 \tan\alpha} + \frac{r_c}{r_t} \mu 2 \right)$$

Where:
- T = torque applied to the bolt, in-lb
- L = bolt load, lb
- r_t = bolt pitch radius, inches
- r_c = mean bearing circle radius, inches
- θ_n = angle from bolt axis to force component normal component normal to thread surface, degrees
- α = bolt helix angle, degrees
- μ_1 = thread coefficient of friction
- μ_2 = bearing circle coefficient of friction

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The table below was generated from the equation on the previous page for Unified and American National threads. This table can be used as a guideline for estimating the bolt load and tightening torque requirements.

Seal Seating Load:

Step 1: Obtain the seal seating load (lb/inch circumference) from the tables on pages C-16 through C-39.

Step 2: Multiply the seating load by the seal circumference to obtain the total seal seating load (lb).

Hydrostatic Load:

Step 3: Calculate the differential area: $(\pi/4) \bullet (\text{Seal O.D.})^2$

Step 4: Multiply the pressure (psi) by the differential area to obtain the hydrostatic load (lb).

Number of Bolts required:

Step 5: Total clamping load = seal seating load + hydrostatic load.

Step 6: Divide total clamping load by the maximum clamping load for the chosen bolt size from the table to obtain the number of bolts required.

Apply suitable safety and design margin:

Step 7: The design engineer must consider other influences such as elevated temperatures and pressure impulses. A sufficient safety margin should be applied when determining the required number of bolts in order to meet Code or other design requirements.

			 SAE Grade 2 Bolts			 SAE Grade 5 Bolts			 SAE Grade 7 Bolts			 SAE Grade 8 Bolts		
Size	Bolt O.D. (in)	Bolt Stress Area (sq. in.)	Maximum Bolt Clamping Load (lb)	Torque Dry (in-lb)	Torque Lubricated (in-lb)	Maximum Bolt Clamping Load (lb)	Torque Dry (in-lb)	Torque Lubricated (in-lb)	Maximum Bolt Clamping Load (lb)	Torque Dry (in-lb)	Torque Lubricated (in-lb)	Maximum Bolt Clamping Load (lb)	Torque Dry (in-lb)	Torque Lubricated (in-lb)
4 - 40	0.1120	0.0060	260	6	5	410	10	7	500	12	9	580	14	10
4 - 48	0.1120	0.0066	290	7	5	450	11	8	550	13	10	630	15	11
6 - 32	0.1250	0.0091	400	11	8	620	18	12	760	22	15	870	25	17
6 - 40	0.1250	0.0102	450	12	8	690	19	13	860	24	16	980	27	18
8 - 32	0.1640	0.0140	620	22	16	950	34	24	1180	42	30	1340	48	34
8 - 36	0.1640	0.0147	650	23	16	1000	35	25	1230	43	31	1410	49	35
10 - 24	0.1900	0.0175	770	33	23	1190	50	36	1470	62	45	1680	71	51
10 - 32	0.1900	0.0200	880	36	26	1360	56	39	1680	69	49	1920	79	56
1/4 - 20	0.2500	0.0318	1400	74	53	2160	110	82	2670	140	100	3050	160	120
1/4 - 28	0.2500	0.0364	1600	82	58	2480	130	89	3060	160	110	3490	180	130
5/16 - 18	0.3125	0.0524	2310	150	100	3560	230	160	4400	280	200	5030	320	230
5/16 - 24	0.3125	0.0580	2550	160	110	3940	240	170	4870	300	210	5570	350	240
3/8 - 16	0.3750	0.0775	3410	250	180	5270	390	280	6510	480	340	7440	550	390
3/8 - 24	0.3750	0.0878	3860	280	190	5970	430	300	7380	530	370	8430	610	420
7/16 - 14	0.4375	0.1063	4680	410	290	7230	640	450	8930	780	560	10200	900	640
7/16 - 20	0.4375	0.1187	5220	450	310	8070	690	480	9970	850	590	11400	980	680
1/2 - 13	0.5000	0.1419	6240	620	440	9650	950	670	11900	1170	830	13600	1340	950
1/2 - 20	0.5000	0.1599	7040	670	470	10900	1040	720	13400	1280	890	15400	1470	1020
9/16 - 12	0.5625	0.1820	7570	850	600	12400	1390	980	15300	1710	1210	17500	1950	1380
9/16 - 18	0.5625	0.2030	8440	920	640	13800	1500	1040	17100	1860	1290	19500	2120	1470
5/8 - 11	0.6250	0.2260	9400	1150	810	15400	1890	1330	19000	2330	1640	21700	2660	1880
5/8 - 18	0.6250	0.2560	10600	1260	870	17400	2070	1430	21500	2550	1760	24600	2920	2020
3/4 - 10	0.7500	0.3340	13900	2030	1430	22700	3320	2330	28100	4110	2880	32100	4690	3290
3/4 - 16	0.7500	0.3730	15500	2200	1520	25400	3610	2490	31300	4450	3070	35800	5090	3510
7/8 - 9	0.8750	0.4620	10300	1750	1230	28800	4890	3430	38800	6590	4620	44400	7540	5290
7/8 - 14	0.8750	0.5090	11400	1890	1300	31800	5260	3630	42800	7080	4880	48900	8090	5580
1 - 8	1.0000	0.6060	13600	2640	1850	37800	7330	5130	50900	9870	6910	58200	11290	7900
1 - 12	1.0000	0.6630	14900	2820	1950	41400	7840	5410	55700	10550	7270	63600	12040	8310
11/8 - 7	1.1250	0.7630	17100	3740	2620	45200	9870	6920	64100	14000	9810	73200	15990	11200
11/8 - 12	1.1250	0.8560	19200	4070	2800	50700	10750	7380	71900	15240	10470	82200	17420	11970
11/4 - 7	1.2500	0.9690	21700	5230	3650	57400	13830	9650	81400	19610	13680	93000	22410	15630
11/4 - 12	1.2500	1.0730	24000	5630	3860	63500	14890	10200	90100	21120	14470	10300	24150	16550
13/8 - 6	1.3750	1.1550	25900	6890	4820	68400	18200	12730	97000	25810	18050	110900	29510	20630
13/8 - 12	1.3750	1.3150	29500	7580	5180	77800	19990	13670	110500	28400	19410	126200	32430	22170
11/2 - 6	1.5000	1.4050	31500	9090	6330	83200	24020	16730	118000	34060	23730	134900	38940	27130
11/2 - 12	1.5000	1.5810	35400	9900	6750	93600	26160	17850	132800	37120	25320	151800	42430	28950

Maximum bolt clamping load is a recommended maximum and is 80% of the bolt proof load. Sizes 1/4 to 1-1/2 are in accordance with ANSI B18.2.1-1981 for standard hex bolts. Sizes 4 to 10 are in accordance with ANSI B18.6.3-1972 for hex head machine screws. Dry torque assumes $\mu_1 = \mu_2 = 0.15$. Lubricated torque assumes $\mu_1 = \mu_2 = 0.10$.