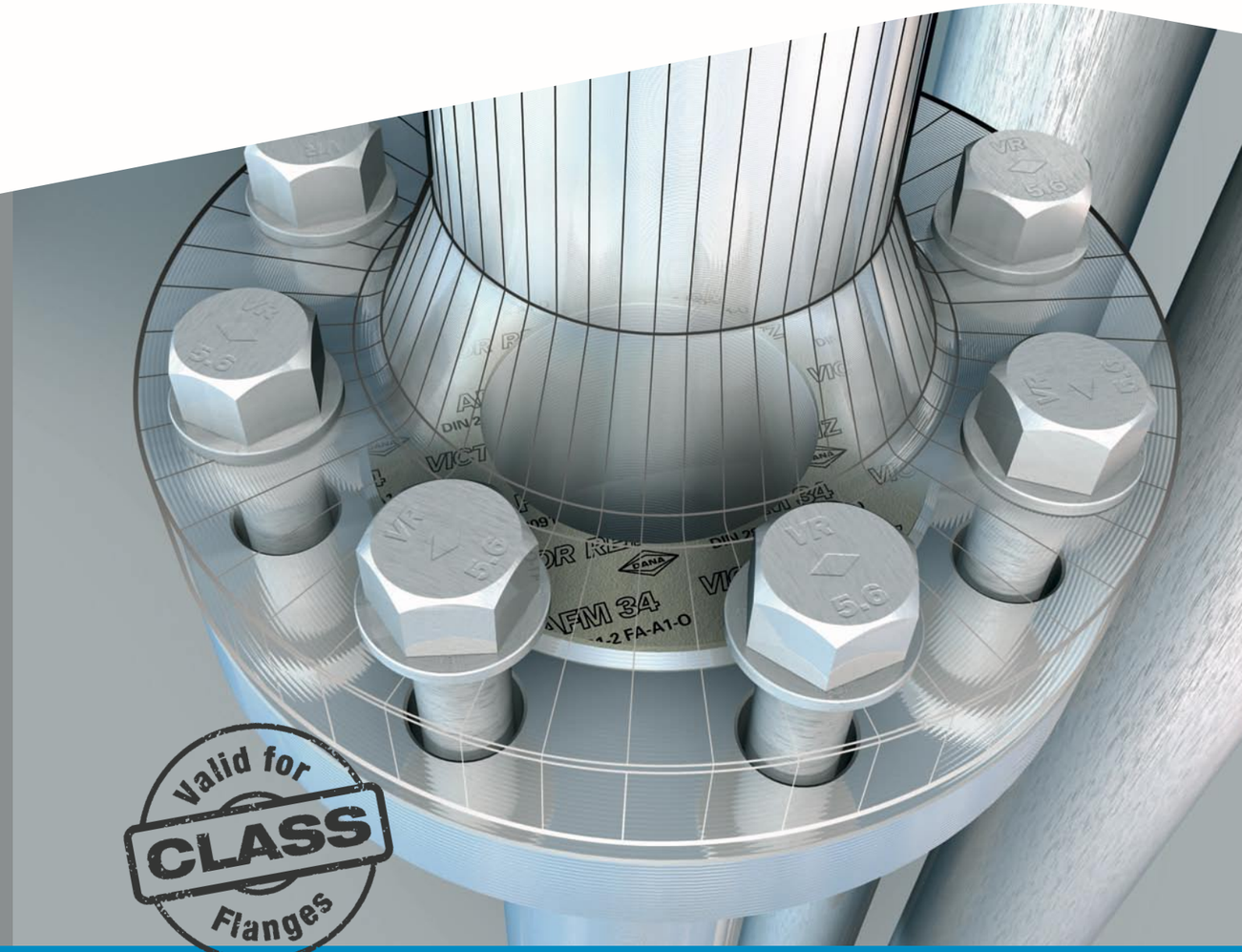

Sealing surface pressure and bolt force

Class-designated welding neck flange with raised-face in accordance with EN 1759-1, ASME B16.5, ASME B16.47, Form A and ASME B16.47 Form B

For fiber-composite and spiral-wound gaskets in accordance with EN 12560-1, ASME B16.20 and ASME B16.21

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Notes about the tables

The tables provide an overview of the average sealing surface pressure on welding neck flanges with raised-face in the following combinations:

Flanges in accordance with EN 1759-1 (up to 24”):
- Flat gaskets in accordance with EN 12560-1
- Spiral-wound gaskets in accordance with ASME B16.20 (Class 150, 300, 600 and 900)

Flanges in accordance with ASME B16.5 (up to 24”):
- Spiral-wound gaskets in accordance with ASME B16.20 (Class 150 to 2500)

Flanges in accordance with ASME B16.47A (26 to 60”, formerly MSS SP 44):
- Flat gaskets in accordance with ASME B16.21
- Spiral-wound gaskets in accordance with ASME B16.20

Flanges in accordance with ASME B16.47B (26 to 60”, formerly API 605):
- Flat gaskets in accordance with ASME B16.21
- Spiral-wound gaskets in accordance with ASME B16.20

This applies for the use of metric bolts (rigid or expansion bolts) and inch-thread bolts of various bolt qualities and materials. As an alternative to a particular inch-thread bolt, the metric bolt with the next closest dimension is selected, while ensuring that these bolts also fit into the bolt holes. The numerical values of the average sealing surface pressure for spiral-wound gaskets with an internal and external eccentric and back-up ring are based on the precondition that only the zone of the spiral-wound gasket ring is compressed – this means that the massive steel eccentric and back-up ring are not subjected to axial load, but merely serve as radial support. They are also based on the additional precondition that the width and therefore the compressed area of the spiral-wound gasket ring zone remain constant. In certain cases, however, high internal and external radial force may occur due to force transferal of the shaped metal bands of the spiral-wound gasket in combination with the high mounted bolt force (axial sealing force) and with graphite or PTFE as a low-friction value sealing tape material, which on the one hand increases the radial compression or deformation of the sealing tape material and thus the cross-sectional sealing, but can also be so large that they lead to an enlargement of some mm Ø of the eccentric and back-up rings that are subject to tensile load, and thus to a modification of the sealing surface pressure. Even the inner ring can show significant compression deformation or indentation. If the eccentric and back-up rings do in fact take on axial load, the deformation and thus the sealing surface pressure of the spiral-wound gasket zone would then hardly increase, aside from the fact that in this situation the spiral-wound gasket would certainly be tightly sealed.

Table 1

This table contains the specification for number and size of bolts, total bolt force F_S and average sealing surface pressure Q. When using standardized flat gaskets, the size of the sealing surface is determined by the outer diameter of the seal and the inner diameter of the gasket. Because the number and size of bolts are determined by the size of the particular flange, the average sealing surface pressure necessarily stems from the strength of the bolts that are used. In order to achieve the minimum sealing surface pressure required for installing a gasket while also avoiding exceeding the maximum compression of the gasket in question (referring to manufacturer’s specifications), you must make the right choice from among the approved bolt steels and types (rigid or expansion bolts). The conversion factors in Table 3 help you to do so.

The table values for F_S and Q, based on the bolt quality 8.8 when exploiting the yield point at normal temperature to 80 %: $\sigma_{allowed} = \sigma_{0.2} \times 0.8 = 512\ N/mm^2$. When using this bolt quality, the sealing surface pressures that occur lie within a range between which the required minimum sealing surface pressure is achieved whereas the maximum allowable surface pressure is not exceeded. Calculation of the bolt force for rigid bolts is based on the stressed cross-section of the thread; for expansion bolts it is based on the reduced-shaft cross-section – see Table 2.

In the selection of bolts, the application criteria to be considered include those of operating pressure, operating temperature, corrosion, nominal diameter and bolt size, which are more precisely specified in relevant regulations, such as AD 2000 – Bulletin B7, W2, W7, W10, DIN EN ISO 3506-1 and -2, DIN 2510-2, -3 and -5, DIN EN 10088-2 and -3, and ASME BPVC-VIII-1, among others.

Table 2

Specifications are consolidated here for dimensions, cross-sections, maximum allowable bolt force and maximum allowable tightening torque for all bolts from M5 to M100x6 for rigid bolts (stressed cross-section) and expansion bolts (reduced-shaft cross-section) and for inch-thread screws from 1/4” to 4”.
For organization’s sake, bolt force and tightening torque of the expansion bolts also relate to the 8.8 bolt quality (allowable stress $\sigma_{allowed} = 512\ N/mm^2$).

Expansion bolts are, however, mostly manufactured of high-temperature steels. Thus, determining the total bolt force and average sealing surface pressure requires conversion based on the steel type used (conversion factors can be found in Table 3).

Table 2 contains further specifications required for known bolt force F_S for calculation of the tightening torque M_A according to the following formula:
$M_A = F_S\ [0.161 \times P + 0.583 \times \mu_{total} \times d_2 + 0.25 \times \mu_{total}\ (s + d_L)]$
Here, the following definitions apply:

P	=	Thread pitch in mm
μ_{total}	=	Total coefficient of friction for all friction surfaces
d_2	=	Diameter of screw thread flank in mm
s	=	Outer diameter of bolt and nut bearing faces in mm. For expansion bolts, d_M is to be used instead.
d_L	=	Bolt hole size in mm

Here, the following is selected: $\mu_{total} = 0.14$. This applies to oiled friction surfaces that are not galvanized, cadmium-plated, phosphatized or the like. For MoS_2 pastes, this formula applies: $\mu_{total} \approx 0.10$.

Table 3

This table contains specifications for bolts of various qualities and steel types, as well as their mechanical strength properties. With the help of conversion factors, which are given for each screw quality for both the cold yield strength and the various warm yield strengths, you can determine the total bolt force and sealing pressure for bolts other than 8.8 as well (see example). The stability calculation must also be carried out with consideration of various (100,000 h) rupture stress values, such as creep breaking and yield points, at the calculation temperature. According to AD 2000-B7, the bolt stability calculation should be based on the lowest characteristic value from these mechanical strength properties.

Table 1a

Bolt forces and surface pressures for nonmetallic flat gaskets

IBC form gaskets in accordance with EN 12560-1: 2001 up to 24” for flanges in accordance with EN 1759-1:

Example of conversion for 8.8 bolt quality at 20 °C into material No. 1.4401 at 100 °C

Conversion factor according to Table 3: 0.27

Class 600/NPS 26” (28 bolts 1 7/8”)

F_S = 796 x 0.27 = 215 kN

F_{Stotal} = 28 x F_S = 22290 x 0.27 = 6018 kN

M_A = 6790 x 0.27 = 1833 Nm

Q = 227 x 0.27 = 61 N/mm²

Nominal diameter		Gasket diameter d_i x d_a in mm		Number and size of bolts		Total bolt force F_{Stotal} in kN		Average sealing surface pressure Q in N/mm²		Gasket diameter d_i x d_a in mm		Number and size of bolts		Total bolt force F_{Stotal} in kN		Average sealing surface pressure Q in N/mm²	
NPS	DN	Class 150								Class 300							
		Metric (M) or inch (I) bolts								Metric (M) or inch (I) bolts							
		M	I	M	I	M	I	M	I	M	I	M	I	M	I	M	I
1/2	15	22xd$_a$ [1]	22x47.5	4xM12	4x1/2”	173	187	298	320	22xd$_a$ [1]	22x54	4xM12	4x1/2”	173	187	298	320
3/4	20	27xd$_a$ [1]	27x57	4xM12	4x1/2”	173	187	198	215	27xd$_a$ [1]	27x66.5	4xM16	4x5/8”	322	299	370	344
1	25	34xd$_a$ [1]	34x66.5	4xM12	4x1/2”	173	187	155	167	34xd$_a$ [1]	34x73	4xM16	4x5/8”	322	299	287	267
1 1/4	32	43xd$_a$ [1]	43x76	4xM12	4x1/2”	173	187	101	109	43xd$_a$ [1]	43x82.5	4xM16	4x5/8”	322	299	188	175
1 1/2	40	49xd$_a$ [1]	49x85.5	4xM12	4x1/2”	173	187	75	81	49xd$_a$ [1]	49x95	4xM20	4x3/4”	500	440	215	190
2	50	61xd$_a$ [1]	61x104.5	4xM16	4x5/8”	322	299	87	80	61xd$_a$ [1]	61x111	8xM16	8x5/8”	634	598	173	161
2 1/2	65	73xd$_a$ [1]	73x124	4xM16	4x5/8”	322	299	73	68	73xd$_a$ [1]	73x130	8xM20	8x3/4”	1000	880	227	200
3	80	89xd$_a$ [1]	89x136.5	4xM16	4x5/8”	322	299	50	46	89xd$_a$ [1]	89x149	8xM20	8x3/4”	1000	880	155	136
4	100	115xd$_a$ [1]	115x174.5	8xM16	8x5/8”	643	598	72	67	115xd$_a$ [1]	115x181	8xM20	8x3/4”	1000	880	111	96
5	125	141xd$_a$ [1]	141x196.5	8xM20	8x3/4”	1000	880	88	77	141xd$_a$ [1]	141x216	8xM20	8x3/4”	1000	880	88	77
6	150	169xd$_a$ [1]	169x222	8xM20	8x3/4”	1000	880	70	62	169xd$_a$ [1]	169x251	12xM20	12x3/4”	1500	1320	106	93
8	200	220xd$_a$ [1]	220x279	8xM20	8x3/4”	1000	880	52	46	220xd$_a$ [1]	220x308	12xM24	12x7/8”	2170	1840	113	96
10	250	273xd$_a$ [1]	273x339.5	12xM24	12x7/8”	2170	1840	91	77	273xd$_a$ [1]	273x362	16xM27	16x1”	3760	3200	157	134
12	300	324xd$_a$ [1]	324x409.5	12xM24	12x7/8”	2170	1840	69	58	324xd$_a$ [1]	324x422	16xM30	16x1 1/8”	4590	4180	145	132
14	350	356xd$_a$ [1]	356x450.5	12xM27	12x1”	2820	2400	82	70	356xd$_a$ [1]	356x485.5	20xM30	20x1 1/8”	5740	5220	167	152
16	400	407xd$_a$ [1]	407x514	16xM27	16x1”	3760	3200	87	74	407xd$_a$ [1]	407x539.5	20xM33	20x1 1/4”	7100	6600	164	151
18	450	458xd$_a$ [1]	458x549	16xM30	16x1 1/8”	4590	4180	78	71	458xd$_a$ [1]	458x597	24xM33	24x1 1/4”	8520	7920	145	135
20	500	508xd$_a$ [1]	508x606.5	20xM30	20x1 1/8”	5740	5220	88	80	508xd$_a$ [1]	508x654	24xM33	24x1 1/4”	8520	7920	130	121
24	600	610xd$_a$ [1]	610x717.5	20xM33	20x1 1/4”	7100	6600	84	79	610xd$_a$ [1]	610x774.5	24xM39	24x1 1/2”	12000	11830	143	141

Nominal diameter		Gasket diameter d_i x d_a in mm		Number and size of bolts		Total bolt force F_{Stotal} in kN		Average sealing surface pressure Q in N/mm²		Gasket diameter d_i x d_a in mm		Number and size of bolts		Total bolt force F_{Stotal} in kN		Average sealing surface pressure Q in N/mm²	
NPS	DN	Class 600								Class 900							
		Metric (M) or inch (I) bolts								Metric (M) or inch (I) bolts							
		M	I	M	I	M	I	M	I	M	I	M	I	M	I	M	I
1/2	15	22xd$_a$ [1]	22x54	4xM12	4x1/2”	173	187	298	320	22xd$_a$ [1]	22x63.5	4xM20	4x3/4”	500	440	860	759
3/4	20	27xd$_a$ [1]	27x66.5	4xM16	4x5/8”	322	299	370	344	27xd$_a$ [1]	27x69.5	4xM20	4x3/4”	500	440	505	506
1	25	34xd$_a$ [1]	34x73	4xM16	4x5/8”	322	299	287	267	34xd$_a$ [1]	34x79	4xM24	4x7/8”	724	612	645	546
1 1/4	32	43xd$_a$ [1]	43x82.5	4xM16	4x5/8”	322	299	188	175	43xd$_a$ [1]	43x89	4xM24	4x7/8”	724	612	423	358
1 1/2	40	49xd$_a$ [1]	49x95	4xM20	4x3/4”	500	440	215	190	49xd$_a$ [1]	49x98	4xM27	4x1”	948	800	405	345
2	50	61xd$_a$ [1]	61x111	8xM16	8x5/8”	634	598	173	161	61xd$_a$ [1]	61x142.5	8xM24	8x7/8”	1450	1220	390	328
2 1/2	65	73xd$_a$ [1]	73x130	8xM20	8x3/4”	1000	880	227	200	73xd$_a$ [1]	73x165	8xM27	8x1”	1880	1600	427	363
3	80	89xd$_a$ [1]	89x149	8xM20	8x3/4”	1000	880	155	136	89xd$_a$ [1]	89x168	8xM24	8x7/8”	1450	1220	225	189
4	100	115xd$_a$ [1]	115x193.5	8xM24	8x7/8”	1450	1220	162	136	115xd$_a$ [1]	115x206	8xM30	8x1 1/8”	2300	2090	257	233
5	125	141xd$_a$ [1]	141x241	8xM27	8x1”	1880	1600	164	140	141xd$_a$ [1]	141x247.5	8xM33	8x1 1/4”	2840	2640	248	230
6	150	169xd$_a$ [1]	169x266.5	12xM27	12x1”	2820	2400	199	169	169xd$_a$ [1]	169x289	12xM30	12x1 1/8”	3440	3130	242	220
8	200	220xd$_a$ [1]	220x320.5	12xM30	12x1 1/8”	3440	3130	178	163	220xd$_a$ [1]	220x358.5	12xM36	12x1 3/8”	5020	4880	261	253
10	250	273xd$_a$ [1]	273x400	16xM33	16x1 1/4”	5680	5280	238	222	273xd$_a$ [1]	273x435	16xM36	16x1 3/8”	6690	6510	280	273
12	300	324xd$_a$ [1]	324x457	20xM33	20x1 1/4”	7100	6600	225	209	324xd$_a$ [1]	324x498.5	20xM36	20x1 3/8”	8360	8140	265	258
14	350	356xd$_a$ [1]	356x492	20xM36	20x1 3/8”	8360	8140	244	237	356xd$_a$ [1]	356x520.5	20xM39	20x 1 1/2”	10000	9860	293	287
16	400	407xd$_a$ [1]	407x565	20xM39	20x1 1/2”	10000	9860	230	227	407xd$_a$ [1]	407x574.5	20xM42	20x1 5/8”	11480	11760	265	271
18	450	458xd$_a$ [1]	458x612.5	20xM42	20x1 5/8”	11480	11760	195	200	458xd$_a$ [1]	458x638	20xM48	20x1 7/8”	15080	15920	257	271
20	500	508xd$_a$ [1]	508x682.5	24xM42	24x1 5/8”	13780	14110	211	216	508xd$_a$ [1]	508x698.5	20xM52	20x2”	18280	18300	280	280
24	600	610xd$_a$ [1]	610x790.5	24xM48	24x1 7/8”	18100	19100	215	227	610xd$_a$ [1]	610x838	20xM64	20x2 1/2”	27400	29340	326	349

[1] The outer diameter of gaskets for use with metric bolts is not standardized, but is also not relevant for calculation of the surface pressure..

Table 1b

Bolt forces and surface pressures for nonmetallic flat gaskets

Gaskets in accordance with ASME B16.21: 1992 26” to 60” for flanges in accordance with ANSI B16.47A: 1990 (formerly MSS SP 44) and ANSI B16.47B: 1990 (formerly API 605)

Example of conversion for 8.8 bolt quality at 20 °C into material No. 1.4401 at 100 °C

Conversion factor according to Table 3: 0.27

Class 600/NPS 26” (28 bolts 1$^{7/8}$”)

F_S = 796 x 0.27 = 215 kN

F_{Stotal} = 28 x F_S = 22290 x 0.27 = 6018 kN

M_A = 6790 x 0.27 = 1833 Nm

Q = 227 x 0.27 = 61 N/mm²

Norm	Nominal diameter	Gasket diameter d_i x d_a in mm	Number and size of bolts		Total bolt force F_{Stotal} in kN		Average sealing surface pressure Q in N/mm²	
	NPS	Class 150						
		Metric (M) or inch (I) bolts						
			M	I	M	I	M	I
ANSI B16.47A	26	660x775	24xM33	24x1$^{1/4}$”	8520	7920	86	80
	28	711x832	28xM33	28x1$^{1/4}$”	9940	9240	94	88
	30	762x883	28xM33	28x1$^{1/4}$”	9940	9240	82	76
	32	813x940	28xM39	28x1$^{1/2}$”	14000	13800	102	101
	34	864x991	32xM39	32x1$^{1/2}$”	16000	15780	110	109
	36	915x1048	32xM39	32x1$^{1/2}$”	16000	15780	97	96
	38	965x1111	32xM39	32x1$^{1/2}$”	16000	15780	93	91
	40	1016x1162	36xM39	36x1$^{1/2}$”	18000	17750	99	98
	42	1067x1219	36xM39	36x1$^{1/2}$”	18000	17750	80	79
	44	1118x1276	40xM39	40x1$^{1/2}$”	20000	19720	85	84
	46	1168x1327	40xM39	40x1$^{1/2}$”	20000	19720	81	80
	48	1219x1384	44xM39	44x1$^{1/2}$”	22000	21690	77	76
	50	1270x1435	44xM45	44x1$^{3/4}$”	29436	30230	103	100
	52	1321x1492	44xM45	44x1$^{3/4}$”	29436	30230	99	96
	54	1372x1549	44xM45	44x1$^{3/4}$”	29436	30230	96	93
	56	1422x1607	48xM45	48x1$^{3/4}$”	32112	32980	92	90
	58	1473x1664	48xM45	48x1$^{3/4}$”	32112	32980	89	87
	60	1524x1715	52xM45	52x1$^{3/4}$”	34790	35730	182	187

Norm	Nominal diameter	Gasket diameter d_i x d_a in mm	Number and size of bolts		Total bolt force F_{Stotal} in kN		Average sealing surface pressure Q in N/mm²	
	NPS	Class 300						
		Metric (M) or inch (I) bolts						
			M	I	M	I	M	I
ANSI B16.47A	26	660x835	28xM42	28x1$^{5/8}$”	16070	16460	163	167
	28	711x899	28xM42	28x1$^{5/8}$”	16070	16460	152	156
	30	762x953	28xM45	28x1$^{3/4}$”	18730	19240	155	159
	32	813x1006	28xM48	28x1$^{7/8}$”	21110	22290	154	163
	34	864x1057	28xM48	28x1$^{7/8}$”	21110	22290	146	154
	36	915x1118	32xM52	32x 2”	29250	29280	178	178
	38	965x1054	32xM39	32x1$^{1/2}$”	16000	15780	160	158
	40	1016x1115	32xM42	32x1$^{5/8}$”	18370	18815	159	163
	42	1067x1165	32xM42	32x1$^{5/8}$”	18370	18815	152	155
	44	1118x1219	32xM45	32x1$^{3/4}$”	21410	21980	155	159
	46	1168x1273	28xM48	28x1$^{7/8}$”	21110	22290	145	153
	48	1219x1324	32xM48	32x1$^{7/8}$”	24135	25472	147	151
	50	1270x1378	32xM52	32x2”	29250	29280	159	159
	52	1321x1429	32xM52	32x2”	29250	29280	154	154
	54	1372x1492	28xM56	28x2$^{1/4}$”	29029	32930	136	154
	56	1422x1543	28xM56	28x2$^{1/4}$”	29029	32930	131	149
	58	1473x1594	32xM56	32x2$^{1/4}$”	33248	37620	136	154
	60	1524x1645	32xM56	32x2$^{1/4}$”	33248	37620	132	149

Norm	Nominal diameter	Gasket diameter d_i x d_a in mm	Number and size of bolts		Total bolt force F_{Stotal} in kN		Average sealing surface pressure Q in N/mm²	
	NPS	Class 400						
		Metric (M) or inch (I) bolts						
			M	I	M	I	M	I
ANSI B16.47A	26	660x832	28xM45	28x1$^{3/4}$”	18730	19240	190	196
	28	711x892	28xM48	28x1$^{7/8}$”	21110	22290	200	211
	30	762x946	28xM52	28x2”	25590	25620	212	212
	32	813x1003	28xM52	28x2”	25590	25620	187	187
	34	864x1054	28xM52	28x2”	25590	25620	176	176
	36	915x1118	32xM52	32x2”	29250	29280	178	178
	38	965x1073	32xM45	32x1$^{3/4}$”	21410	21980	195	200
	40	1016x1132	32xM48	32x1$^{7/8}$”	24130	25470	192	202
	42	1067x1178	32xM48	32x1$^{7/8}$”	24130	25470	183	193
	44	1118x1232	32xM52	32x2”	29250	29280	196	196
	46	1168x1289	36xM52	36x2”	32900	32940	194	194
	48	1219x1346	28xM56	28x2$^{1/4}$”	29029	32930	165	188
	50	1270x1403	32xM56	32x2$^{1/4}$”	33248	37620	175	198
	52	1321x1454	32xM56	32x2$^{1/4}$”	33248	37620	170	193
	54	1372x1518	28xM64x6	28x2$^{1/2}$”	38360	41080	174	186
	56	1422x1568	32xM64x6	32x2$^{1/2}$”	43840	47230	180	194
	58	1473x1619	32xM64x6	32x2$^{1/2}$”	43840	47230	174	188
	60	1524x1683	32xM68x6	32x2$^{3/4}$”	50040	57400	182	209

Norm	Nominal diameter	Gasket diameter d_i x d_a in mm	Number and size of bolts		Total bolt force F_{Stotal} in kN		Average sealing surface pressure Q in N/mm²	
	NPS	Class 600						
		Metric (M) or inch (I) bolts						
			M	I	M	I	M	I
ANSI B16.47A	26	660x867	28xM48	28x1$^{7/8}$”	21110	22290	215	227
	28	711x914	28xM52	28x2”	25590	25620	243	243
	30	762x972	28xM52	28x2”	25590	25620	240	272
	32	813x1022	28xM56	28x2$^{1/4}$”	29029	32930	212	240
	34	864x1073	28xM56	28x2$^{1/4}$”	29029	32930	200	227
	36	915x1130	28xM64	28x2$^{1/2}$”	38360	41080	234	250
	38	965x1105	28xM56	28x2$^{1/4}$”	29090	32930	206	233
	40	1016x1156	32xM56	32x2$^{1/4}$”	33248	37620	210	237
	42	1067x1219	28xM64	28x2$^{1/2}$”	38360	41080	217	232
	44	1118x1270	32xM64	32x2$^{1/2}$”	43840	46940	220	236
	46	1168x1327	32xM64	32x2$^{1/2}$”	43840	46940	212	227
	48	1219x1390	32xM68	32x2$^{3/4}$”	50040	57400	200	230
	50	1270x1448	28xM76x6	28x3”	55750	60200	235	253
	52	1321x1499	32xM76x8	32x3”	63720	68800	254	275
	54	1372x1556	32xM76x8	32x3”	63720	68800	234	253
	56	1422x1613	32xM80x6	32x3$^{1/4}$”	71170	81280	253	289
	58	1473x1664	32xM80x6	32x3$^{1/4}$”	71170	81280	232	265
	60	1524x1721	28xM90x6	28x3$^{1/2}$”	78590	82880	234	248

Norm	NPS	Class 75						
		Metric (M) or inch (I) bolts						
			M	I	M	I	M	I
ANSI B16.47B	26	660x708	36xM16	36x5/8”	2890	2993	60	62
	28	711x758	40xM16	40x5/8”	3215	2992	62	58
	30	762x810	44xM16	44x5/8”	3538	3290	65	61
	32	813x860	48xM16	48x5/8”	3860	3590	67	62
	34	864x911	52xM16	52x5/8”	4180	3890	67	62
	36	914x973	40xM20	40x3/4”	5000	4400	66	58
	38	965x1024	40xM20	40x3/4”	5000	4400	63	55
	40	1016x1074	44xM20	44x3/4”	5500	4840	66	58
	42	1067x1125	48xM20	48x3/4”	6000	5280	69	60
	44	1118x1181	36xM24	36x7/8”	6616	5508	66	55
	46	1169x1232	40xM24	40x7/8”	7240	6120	68	57
	48	1219x1283	44xM24	44x7/8”	7964	6732	71	60
	50	1270x1334	44xM24	44x7/8”	7964	6732	69	63
	52	1321x1388	48xM24	48x7/8”	8688	7344	72	61
	54	1372x1438	48xM24	48x7/8”	8688	7344	73	62
	56	1423x1445	40xM27	40x1”	9400	5000	65	55
	58	1473x1546	44xM27	44x1”	10340	8800	68	58
	60	1524x1597	44xM27	44x1”	10340	8800	66	56

Norm	NPS	Class 150						
		Metric (M) or inch (I) bolts						
			M	I	M	I	M	I
ANSI B16.47B	26	660x725	36xM20	36x3/4”	4500	3960	82	72
	28	711x776	40xM20	40x3/4”	5000	4400	85	75
	30	762x827	44xM20	44x3/4”	5500	4840	87	77
	32	813x881	48xM20	48x3/4”	6000	5280	89	79
	34	864x935	40xM24	40x7/8”	7240	6120	90	77
	36	914x987	44xM24	44x7/8”	7964	7344	93	85
	38	965x1045	40xM27	40x1”	9400	8000	112	95
	40	1016x1095	44xM27	44x1”	10340	8800	60	50
	42	1067x1146	48xM27	48x1”	11280	9600	104	88
	44	1118x1197	52xM27	52x1”	12220	10400	108	92
	46	1169x1256	40xM30	40x1$^{1/8}$”	11480	10440	91	83
	48	1219x1306	44xM30	44x1$^{1/8}$”	12630	11480	92	83
	50	1270x1358	48xM30	48x1$^{1/8}$”	13760	12520	96	87
	52	1321x1408	52xM30	52x1$^{1/8}$”	11076	13570	74	91
	54	1372x1464	56xM30	56x1$^{1/8}$”	16070	14620	105	96
	56	1423x1515	60xM30	60x1$^{1/8}$”	17220	15660	107	97
	58	1473x1580	48xM33	48x1$^{1/4}$”	17040	15840	103	96
	60	1524x1630	52xM33	52x1$^{1/4}$”	18460	17160	99	92

Norm	NPS	Class 300						
		Metric (M) or inch (I) bolts						
			M	I	M	I	M	I
ANSI B16.47B	26	660x771	32xM33	32x1$^{1/4}$”	11360	10560	134	125
	28	711x826	36xM33	36x1$^{1/4}$”	12780	11880	143	133
	30	762x886	36xM36	36x1$^{3/8}$”	15050	14650	144	140
	32	813x940	32xM39	32x1$^{1/2}$”	16000	15780	133	132
	34	864x994	36xM39	36x1$^{1/2}$”	18000	17750	142	140
	36	914x1048	32xM42	32x1$^{5/8}$”	18370	18820	127	130
	38	965x1099	36xM36	36x1$^{5/8}$”	20665	21170	136	139
	40	1016x1149	40xM42	40x1$^{5/8}$”	22960	23520	156	150
	42	1067x1200	36xM54	36x1$^{3/4}$”	24080	24730	136	139
	44	1118x1251	40xM45	40x1$^{3/4}$”	26757	27485	144	148
	46	1169x1318	36xM48	36x1$^{7/8}$”	27144	28656	122	129
	48	1219x1368	40xM48	40x1$^{7/8}$”	30160	31840	140	147
	50	1270x1420	44xM48	44x1$^{7/8}$”	33176	35024	148	156
	52	1321x1429	48xM48	48x1$^{7/8}$”	36190	38210	156	163
	54	1372x1530	48xM48	48x1$^{7/8}$”	36190	38210	150	157
	56	1423x1594	36xM56	36x2$^{1/4}$”	37404	42336	141	159
	58	1473x1656	40xM56	40x2$^{1/4}$”	41560	47040	153	173
	60	1524x1707	40xM56	40x2$^{1/4}$”	41560	47040	131	149

Norm	NPS	Class 400						
		Metric (M) or inch (I) bolts						
			M	I	M	I	M	I
ANSI B16.47B	26	660x746	28xM36	28x1$^{3/8}$”	11704	11396	216	210
	28	711x800	24xM39	24x1$^{1/2}$”	12000	11830	203	200
	30	762x857	28xM39	28x1$^{1/2}$”	14000	13800	198	195
	32	813x911	28xM42	28x1$^{5/8}$”	16070	16460	202	207
	34	864x962	32xM42	32x1$^{5/8}$”	18370	18815	207	212
	36	914x1022	28xM45	28x1$^{3/4}$”	19240	18985	196	191
	38							
	40							
	42							
	44							
	46							
	48							
	50							
	52							
	54							
	56							
	58							
	60							

Table 1c

Bolt forces and surface pressures for spiral-wound gaskets

Gaskets in accordance with ASME B16.20: 1993 up to 24” for flanges in accordance with ASME B16.5: 1988 (Class 150, 300, 600 and 900 identical to EN 1759-1)

Example of conversion for 8.8 bolt quality at 20 °C into material No. 1.4401 at 100 °C

Conversion factor according to Table 3: 0.27

Class 600/NPS 26” (28 bolts 1$^{7/8}$”)

F_S = 796 x 0.27 = 215 kN

F_{Stotal} = 28 x F_S = 22290 x 0.27 = 6018 kN

M_A = 6790 x 0.27 = 1833 Nm

Q = 227 x 0.27 = 61 N/mm²

Class 150 – Metric (M) or inch (I) bolts

Nominal diameter NPS	DN	Gasket diameter d_i x d_a in mm	Number and size of bolts M	I	Total bolt force F_{Stotal} in kN M	I	Average sealing surface pressure Q in N/mm² M	I
1/2	15	14.2x47.8	4xM12	4x1/2”	173	187	342	370
3/4	20	20.6x57.2	4xM12	4x1/2”	173	187	238	258
1	25	27x66.8	4xM12	4x1/2”	173	187	173	187
1$^{1/4}$	32	38.1x76.2	4xM12	4x1/2”	173	187	160	175
1$^{1/2}$	40	44.5x85.9	4xM12	4x1/2”	173	187	113	120
2	50	55.6x105	4xM16	4x5/8”	322	299	165	155
2$^{1/2}$	65	65.5x124	4xM16	4x5/8”	322	299	141	130
3	80	81x136.7	4xM16	4x5/8”	322	299	97	90
4	100	106.4x160.8	8xM16	8x5/8”	643	598	133	125
5	125	131.8x196.9	8xM20	8x3/4”	1000	880	133	115
6	150	157.2x222.3	8xM20	8x3/4”	1000	880	120	105
8	200	216x279.4	8xM20	8x3/4”	1000	880	85	75
10	250	268x339.9	12xM24	12x7/8”	2170	1840	138	115
12	300	317.5x409.7	12xM24	12x7/8”	2170	1840	111	95
14	350	349.3x450.9	12xM27	12x1”	2820	2400	132	110
16	400	400x514.4	16xM27	16x1”	3760	3200	131	110
18	450	449.3x549.4	16xM30	16x1$^{1/8}$”	4590	4180	112	100
20	500	500x606.6	20xM30	20x1$^{1/8}$”	5740	5220	127	115
24	600	603.3x717.6	20xM33	20x1$^{1/4}$”	7100	6600	120	110

Class 300 – Metric (M) or inch (I) bolts

NPS	DN	Gasket diameter d_i x d_a in mm	Number and size of bolts M	I	Total bolt force F_{Stotal} in kN M	I	Average sealing surface pressure Q in N/mm² M	I
1/2	15	14.2x54	4xM12	4x1/2”	173	187	342	370
3/4	20	20.6x66.8	4xM16	4x5/8”	322	299	444	410
1	25	27x73.2	4xM16	4x5/8”	322	299	320	300
1$^{1/4}$	32	38.1x89.4	4xM16	4x5/8”	322	299	298	275
1$^{1/2}$	40	44.5x95.3	4xM20	4x3/4”	500	440	325	285
2	50	55.6x111.3	8xM16	8x5/8”	634	598	324	310
2$^{1/2}$	65	65.5x130.3	8xM20	8x3/4”	1000	880	440	385
3	80	81x149.4	8xM20	8x3/4”	1000	880	300	265
4	100	106.4x180.8	8xM20	8x3/4”	1000	880	206	180
5	125	131.8x215.9	8xM20	8x3/4”	1000	880	133	115
6	150	157.2x251	12xM20	12x3/4”	1500	1320	180	160
8	200	216x308.1	12xM24	12x7/8”	2170	1840	184	155
10	250	268x362	16xM27	16x1”	3760	3200	240	205
12	300	317.5x422.4	16xM30	16x1$^{1/8}$”	4590	4180	235	215
14	350	349.3x485.9	20xM30	20x1$^{1/8}$”	5740	5220	270	245
16	400	400x539.8	20xM33	20x1$^{1/4}$”	7100	6600	248	230
18	450	449.3x596.9	24xM33	24x1$^{1/4}$”	8520	7920	207	195
20	500	500x654.1	24xM33	24x1$^{1/4}$”	8520	7920	188	175
24	600	603.3x774.7	24xM39	24x1$^{1/2}$”	12000	11830	203	200

Class 400 – Metric (M) or inch (I) bolts

NPS	DN	Gasket diameter d_i x d_a in mm	Number and size of bolts M	I	Total bolt force F_{Stotal} in kN M	I	Average sealing surface pressure Q in N/mm² M	I
1/2	15							
3/4	20							
1	25							
1$^{1/4}$	32							
1$^{1/2}$	40							
2	50							
2$^{1/2}$	65							
3	80							
4	100	106.4x177.8	8xM24	8x7/8”	1450	1220	238	200
5	125	131.8x212.9	8xM24	8x7/8”	1450	1220	186	155
6	150	157.2x247.7	12xM24	12x7/8”	2170	1840	207	175
8	200	209.5x304.8	12xM27	12x1”	2820	2400	193	165
10	250	260x358.9	16xM30	16x 1$^{1/8}$”	4590	4180	230	210
12	300	317.5x419.1	16xM33	16x1$^{1/4}$”	5680	5280	217	200
14	350	349.3x482.6	20xM33	20x1$^{1/4}$”	7100	6600	266	245
16	400	400x536.7	20xM36	20x1$^{3/8}$”	8360	8140	242	230
18	450	449.3x593.9	24xM36	24x1$^{3/8}$”	10030	9770	224	220
20	500	500x647.7	24xM39	24x1$^{1/2}$”	12000	11830	243	240
24	600	603.3x768.4	24xM45	24x1$^{3/4}$”	16060	16490	273	280

Class 600 – Metric (M) or inch (I) bolts

NPS	DN	Gasket diameter d_i x d_a in mm	Number and size of bolts M	I	Total bolt force F_{Stotal} in kN M	I	Average sealing surface pressure Q in N/mm² M	I
1/2	15	14.2x54	4xM12	4x1/2”	173	187	342	370
3/4	20	20.6x66.8	4xM16	4x5/8”	322	299	444	410
1	25	27x73.2	4xM16	4x5/8”	322	299	320	300
1$^{1/4}$	32	38.1x89.4	4xM16	4x5/8”	322	299	298	275
1$^{1/2}$	40	44.5x95.3	4xM20	4x3/4”	500	440	325	285
2	50	55.6x111.3	8xM16	8x5/8”	634	598	324	310
2$^{1/2}$	65	65.5x130.3	8xM20	8x3/4”	1000	880	440	385
3	80	81.0x149.4	8xM20	8x3/4”	1000	880	300	265
4	100	106.4x193.8	8xM24	8x7/8”	1450	1220	238	200
5	125	131.8x241.3	8xM27	8x1”	1880	1600	242	205
6	150	157.2x266.7	12xM27	12x1”	2820	2400	269	230
8	200	209.5x320.8	12xM30	12x1$^{1/8}$”	3440	3130	235	215
10	250	260x400	16xM33	16x1$^{1/4}$”	5680	5280	285	265
12	300	317.7x457.2	20xM33	20x1$^{1/4}$”	7100	6600	270	250
14	350	349.3x492.3	20xM36	20x1$^{3/8}$”	8360	8140	313	305
16	400	400x566.2	20xM39	20x1$^{1/2}$”	10000	9860	290	280
18	450	449.3x612.9	20xM42	20x1$^{5/8}$”	11480	11760	257	265
20	500	500x682.8	24xM42	24x1$^{5/8}$”	13780	14110	280	286
24	600	603.3x790.7	24xM48	24x1$^{7/8}$”	18100	19100	307	325

Class 900 – Metric (M) or inch (I) bolts

NPS	DN	Gasket diameter d_i x d_a in mm	Number and size of bolts M	I	Total bolt force F_{Stotal} in kN M	I	Average sealing surface pressure Q in N/mm² M	I
1/2	15							
3/4	20							
1	25							
1$^{1/4}$	32							
1$^{1/2}$	40							
2	50							
2$^{1/2}$	65							
3	80	81x160.8	8xM24	8x7/8”	1450	1220	337	285
4	100	106.4x206.5	8xM30	8x1$^{1/8}$”	2300	2090	378	345
5	125	131.8x247.6	8xM33	8x1$^{1/4}$”	2840	2640	365	340
6	150	157.2x289.1	12xM30	12x1$^{1/8}$”	3440	3130	328	300
8	200	209.5x358.9	12xM36	12x1$^{3/8}$”	5020	4880	380	370
10	250	268x435.1	16xM36	16x1$^{3/8}$”	6690	6510	418	405
12	300	314.4x498.6	20xM36	20x1$^{3/8}$”	8360	8140	346	340
14	350	343x520.7	20xM39	20x1$^{1/2}$”	10000	9860	379	375
16	400	393.7x574.8	20xM42	20x1$^{5/8}$”	11480	11760	378	385
18	450	444.4x638.3	20xM48	20x1$^{7/8}$”	15080	15920	341	360
20	500	495.3x698.5	20xM52	20x2”	18280	18300	420	420
24	600	603.3x838.2	20xM64	20x2$^{1/2}$”	27400	29340	525	560

Class 1500 – Metric (M) or inch (I) bolts

NPS	DN	Gasket diameter d_i x d_a in mm	Number and size of bolts M	I	Total bolt force F_{Stotal} in kN M	I	Average sealing surface pressure Q in N/mm² M	I
1/2	15	14.2x63.5	4xM20	4x3/4”	500	440	985	870
3/4	20	20.6x63.5	4xM20	4x3/4”	500	440	690	605
1	25	27x79.5	4xM24	4x7/8”	725	610	725	610
1$^{1/4}$	32	33.3x88.9	4xM24	4x7/8”	725	610	443	375
1$^{1/2}$	40	41.5x98.6	4xM27	4x1”	948	800	485	410
2	50	52.3x143	8xM24	8x7/8”	1450	1220	470	395
2$^{1/2}$	65	63.5x165.1	8xM27	8x1”	1880	1600	495	420
3	80	81x174.8	8xM30	8x1$^{1/8}$”	2300	2090	484	440
4	100	106.4x209.6	8xM33	8x1$^{1/4}$”	2840	2640	435	405
5	125	131.8x254	8xM39	8x1$^{1/2}$”	4000	3944	457	450
6	150	157.2x282.7	12xM36	12x1$^{3/8}$”	5020	4880	440	430
8	200	206x352.6	12xM42	12x1$^{5/8}$”	6890	7055	448	460
10	250	258.0x435.1	12xM48	12x1$^{7/8}$”	9048	9550	448	475
12	300	314.4x520.7	16xM52	16x2”	14620	14640	610	610
14	350	340x577.9	16xM56	16x2$^{1/4}$”	16620	18810	625	705
16	400	387.4x641.4	16xM64	16x2$^{1/2}$”	21920	23470	637	680
18	450	438.2x704.9	16xM68	16x2$^{3/4}$”	25020	28700	566	650
20	500	489x755.7	16M76x6	16x3”	31860	34400	654	705
24	600	577.9x901.7	16xM90x6	16x3$^{1/2}$”	44910	47360	695	733

Class 2500 – Metric (M) or inch (I) bolts

NPS	DN	Gasket diameter d_i x d_a in mm	Number and size of bolts M	I	Total bolt force F_{Stotal} in kN M	I	Average sealing surface pressure Q in N/mm² M	I
1/2	15	14.2x69.9	4xM20	4x3/4”	500	440	985	870
3/4	20	20.6x76.2	4xM20	4x3/4”	500	440	690	605
1	25	27x85.9	4xM24	4x7/8”	725	610	725	610
1$^{1/4}$	32	33.3x104.9	4xM27	4x1”	940	800	602	490
1$^{1/2}$	40	41.4x117.6	4xM30	4x1$^{1/8}$”	1150	1045	585	537
2	50	52.3x146	8xM27	8x1”	1880	1600	610	520
2$^{1/2}$	65	63.5x168.4	8xM30	8x1$^{1/8}$”	2300	2090	606	550
3	80	81x196.9	8xM33	8x1$^{1/4}$”	2840	2640	598	555
4	100	106.4x235	8xM39	8x1$^{1/2}$”	4000	3944	610	600
5	125	131.8x279.4	8xM45	8x1$^{3/4}$”	5352	5496	610	628
6	150	157.2x317.5	8xM52	8x2”	7310	7320	642	642
8	200	200.2x387.4	12xM52	12x2”	10970	10980	714	714
10	250	247.7x476.3	12xM64	12x2$^{1/2}$”	16440	17604	875	937
12	300	292.1x549.4	12xM72x6	12x2$^{3/4}$”	21265	21530	778	787
14	350							
16	400							
18	450							
20	500							
24	600							

Table 1d

Bolt forces and surface pressures for spiral-wound gaskets

Gaskets in accordance with ASME B16.20: 1993 26” to 60” for flanges in accordance with ANSI B16.47A: 1990 (formerly MSS SP 44) and ANSI B16.47B: 1990 (formerly API 605)

Example of conversion for 8.8 bolt quality at 20 °C into material No. 1.4401 at 100 °C

Conversion factor according to Table 3: 0.27

Class 600/NPS 26” (28 bolts 1$^{7/8}$”)

F_S = 796 x 0.27 = 215 kN

F_{Stotal} = 28 x F_S = 22290 x 0.27 = 6018 kN

M_A = 6790 x 0.27 = 1833 Nm

Q = 227 x 0.27 = 61 N/mm²

Norm	Nominal diameter	Gasket diameter di x da in mm	Number and size of bolts		Total bolt force F_{Stotal} in kN		Average sealing surface pressure Q in N/mm²	
	NPS	Class 150						
		Metric (M) or inch (I) bolts						
			M	I	M	I	M	I
ANSI B16.47A	26	654x775	24xM33	24x1$^{1/4}$”	8520	7920	248	230
	28	705x832	28xM33	28x1$^{1/4}$”	9940	9240	269	250
	30	758x883	28xM33	28x1$^{1/4}$”	9940	9240	252	235
	32	807x940	28xM39	28x1$^{1/2}$”	14000	13800	300	295
	34	857x991	32xM39	32x1$^{1/2}$”	16000	15780	325	320
	36	908x1048	32xM39	32x1$^{1/2}$”	16000	15780	260	256
	38	959x1111	32xM39	32x1$^{1/2}$”	16000	15780	250	245
	40	1010x1162	36xM39	36x1$^{1/2}$”	18000	17750	265	260
	42	1061x1219	36xM39	36x1$^{1/2}$”	18000	17750	230	230
	44	1111x1276	40xM39	40x1$^{1/2}$”	20000	19720	230	230
	46	1162x1327	40xM39	40x1$^{1/2}$”	20000	19720	220	220
	48	1213x1384	44xM39	44x1$^{1/2}$”	22000	21690	233	230
	50	1264x1435	44xM45	44x1$^{3/4}$”	29436	30230	283	290
	52	1315x1492	44xM45	44x1$^{3/4}$”	29436	30230	272	280
	54	1359x1549	44xM45	44x1$^{3/4}$”	29436	30230	262	270
	56	1410x1607	48xM45	48x1$^{3/4}$”	32112	32980	275	285
	58	1461x1664	48xM45	48x1$^{3/4}$”	32112	32980	266	275
	60	1511x1715	52xM45	52x1$^{3/4}$”	34790	35725	280	285

Norm	Nominal diameter	Gasket diameter di x da in mm	Number and size of bolts		Total bolt force F_{Stotal} in kN		Average sealing surface pressure Q in N/mm²	
	NPS	Class 300						
		Metric (M) or inch (I) bolts						
			M	I	M	I	M	I
ANSI B16.47A	26	654x835	28xM42	28x1$^{5/8}$”	16070	16460	283	290
	28	705x899	28xM42	28x1$^{5/8}$”	16070	16460	265	270
	30	758x952	28xM45	28x1$^{3/4}$”	18730	19240	285	295
	32	807x1006	28xM48	28x1$^{7/8}$”	21110	22290	300	320
	34	857x1057	28xM48	28x1$^{7/8}$”	21110	22290	285	300
	36	908x1118	32xM52	32x2”	29250	29280	375	375
	38	953x1054	32xM39	32x1$^{1/2}$”	16000	15780	270	265
	40	1003x1114	32xM42	32x1$^{5/8}$”	18370	18815	240	245
	42	1054x1165	32xM42	32x1$^{5/8}$”	18370	18815	225	230
	44	1105x1219	32xM45	32x1$^{3/4}$”	21410	21980	232	238
	46	1153x1273	28xM48	28x1$^{7/8}$”	21110	22290	220	230
	48	1212x1324	32xM48	32x1$^{7/8}$”	24135	25470	240	255
	50	1245x1378	32xM52	32x2”	29250	29280	280	280
	52	1321x1429	32xM52	32x2”	29250	29280	270	270
	54	1353x1492	28xM56	28x2$^{1/4}$”	29029	32930	282	290
	56	1403x1543	28xM56	28x2$^{1/4}$”	29029	32930	250	285
	58	1448x1594	32xM56	32x2$^{1/4}$”	33248	37620	270	307
	60	1524x1645	32xM56	32x2$^{1/4}$”	33248	37620	263	295

Norm	Nominal diameter	Gasket diameter di x da in mm	Number and size of bolts		Total bolt force F_{Stotal} in kN		Average sealing surface pressure Q in N/mm²	
	NPS	Class 400						
		Metric (M) or inch (I) bolts						
			M	I	M	I	M	I
ANSI B16.47A	26	660x832	28xM45	28x1$^{3/4}$”	18730	19240	330	340
	28	711x892	28xM48	28x1$^{7/8}$”	21110	22290	345	365
	30	758x946	28xM52	28x2”	25590	25620	390	390
	32	813x1003	28xM52	28x2”	25590	25620	365	365
	34	864x1054	28xM52	28x2”	25590	25620	345	345
	36	918x1118	32xM52	32x2”	29250	29280	375	375
	38	953x1073	32xM45	32x1$^{3/4}$”	21410	21980	270	275
	40	1003x1127	32xM48	32x1$^{7/8}$”	24130	25470	288	304
	42	1053x1178	32xM48	32x1$^{7/8}$”	24130	25470	274	290
	44	1105x1232	32xM52	32x2”	29250	29280	320	320
	46	1168x1289	36xM52	36x2”	32900	32940	340	340
	48	1207x1346	28xM56	28x2$^{1/4}$”	29090	32930	290	325
	50	1257x1403	32xM56	32x2$^{1/4}$”	33248	37620	317	360
	52	1308x1454	32xM56	32x2$^{1/4}$”	33248	37620	304	345
	54	1352x1518	28xM64	28x2$^{1/2}$”	38360	41080	336	360
	56	1403x1569	32xM64	32x2$^{1/2}$”	43840	46940	371	400
	58	1454x1619	32xM64	32x2$^{1/2}$”	43840	46940	365	390
	60	1518x1683	32xM68	32x2$^{3/4}$”	50040	57400	395	450

Norm	Nominal diameter	Gasket diameter di x da in mm	Number and size of bolts		Total bolt force F_{Stotal} in kN		Average sealing surface pressure Q in N/mm²	
	NPS	Class 600						
		Metric (M) or inch (I) bolts						
			M	I	M	I	M	I
ANSI B16.47A	26	647x867	28xM48	28x1$^{7/8}$”	21110	22290	372	392
	28	699x914	28xM52	28x2”	25590	25620	420	422
	30	758x972	28xM52	28x2”	25590	25620	390	390
	32	813x1022	28xM56	28x2$^{1/4}$”	29090	32930	415	470
	34	864x1073	28xM56	28x2$^{1/4}$”	29090	32930	392	445
	36	918x1130	28xM64x6	28x2$^{1/2}$”	38360	41080	490	525
	38	953x1105	28xM56	28x2$^{1/4}$”	29090	32930	360	405
	40	1010x1156	32xM56	32x2$^{1/4}$”	33248	37620	388	440
	42	1067x1219	28xM64	28x2$^{1/2}$”	38360	41080	425	456
	44	1111x1270	32xM64	32x2$^{1/2}$”	43840	46940	463	495
	46	1162x1327	32xM64	32x2$^{1/2}$”	43840	46940	443	475
	48	1219x1391	32xM68	32x2$^{3/4}$”	50040	57400	485	555
	50	1270x1448	28xM76x6	28x3”	55750	60200	520	560
	52	1321x1499	32xM76x6	32x3”	63720	68800	570	620
	54	1378x1556	32xM76x6	32x3”	63720	68800	550	595
	56	1429x1613	32xM80x6	32x3$^{1/4}$”	71170	81280	595	675
	58	1473x1664	32xM80x6	32x3$^{1/4}$”	71170	81280	570	650
	60	1530x1734	28xM90x6	28x3$^{1/2}$”	78590	82880	610	640

Norm	Nominal diameter	Gasket diameter di x da in mm	Number and size of bolts		Total bolt force F_{Stotal} in kN		Average sealing surface pressure Q in N/mm²	
	NPS	Class 900						
		Metric (M) or inch (I) bolts						
			M	I	M	I	M	I
ANSI B16.47A	26	667x883	20xM68	20x2$^{3/4}$”	31280	35880	550	630
	28	711x946	20xM76x6	20x3”	39820	43000	655	705
	30	775x1010	20xM76x6	20x3”	39820	43000	610	660
	32	813x1073	20xM80x6	20x3$^{1/4}$”	44480	50800	635	725
	34	864x1137	20xM90x6	20x3$^{1/2}$”	56120	59200	760	800
	36	921x1200	20xM90x6	20x3$^{1/2}$”	56120	59200	715	755
	38	1010x1200	20xM90x6	20x3$^{1/2}$”	56120	59200	655	700
	40	1061x1251	24xM90x6	24x3$^{1/2}$”	67344	71040	747	790
	42	1111x1302	24xM90x6	24x3$^{1/2}$”	67344	71040	720	760
	44	1156x1369	24xM95x6	24x3$^{3/4}$”	77050	81840	785	835
	46	1219x1435	24xM100x6	24x4”	86040	93360	835	905
	48	1270x1486	24xM100x6	24x4”	86040	93360	800	870
	50							
	52							
	54							
	56							
	58							
	60							

Norm	NPS	Class 150						
		Metric (M) or inch (I) bolts						
			M	I	M	I	M	I
ANSI B16.47B	26	654x728	36xM20	36x3/4”	4500	3960	164	145
	28	705x776	40xM20	40x3/4”	5000	4400	170	150
	30	757x827	44xM20	44x3/4”	5500	4840	175	153
	32	807x881	48xM20	48x3/4”	6000	5280	180	160
	34	857x935	40xM24	40x7/8”	7240	6120	163	140
	36	908x988	44xM24	44x7/8”	7964	7344	170	155
	38	959x1045	40xM27	40x1”	9400	8000	147	145
	40	1010x1096	44xM27	44x1”	10340	8800	153	130
	42	1061x1146	48xM27	48x1”	11280	9600	187	160
	44	1111x1197	52xM27	52x1”	12220	10400	164	140
	46	1162x1256	40xM30	40x1$^{1/8}$”	11480	10440	140	130
	48	1213x1307	44xM30	44x1$^{1/8}$”	12630	11480	170	155
	50	1264x1357	48xM30	48x1$^{1/8}$”	13760	12520	157	140
	52	1315x1408	52xM30	52x1$^{1/8}$”	11076	13570	121	150
	54	1365x1464	56xM30	56x1$^{1/8}$”	16070	14620	192	174
	56	1422x1515	60xM30	60x1$^{1/8}$”	17220	15660	227	205
	58	1478x1580	48xM33	48x1$^{1/4}$”	17040	15840	250	235
	60	1535x1630	52xM33	52x1$^{1/4}$”	18460	17160	260	240

Norm	NPS	Class 300						
		Metric (M) or inch (I) bolts						
			M	I	M	I	M	I
ANSI B16.47B	26	654x772	32xM33	32x1$^{1/4}$”	11360	10560	274	255
	28	705x826	36xM33	36x1$^{1/4}$”	12780	11880	288	265
	30	758x886	36xM36	36x1$^{3/8}$”	15050	14650	316	308
	32	807x940	32xM39	32x1$^{1/2}$”	16000	15780	317	310
	34	857x994	36xM39	36x1$^{1/2}$”	18000	17750	335	330
	36	908x1048	32xM42	32x1$^{5/8}$”	18370	18820	325	330
	38	972x1099	36xM36	36x1$^{5/8}$”	20665	21170	337	345
	40	1022x1149	40xM42	40x1$^{5/8}$”	22960	23520	354	364
	42	1086x1200	36xM45	36x1$^{3/4}$”	24080	24730	357	370
	44	1124x1251	40xM45	40x1$^{3/4}$”	26757	27485	388	390
	46	1178x1318	36xM48	36x1$^{7/8}$”	27144	28656	284	300
	48	1231x1368	40xM48	40x1$^{7/8}$”	30160	31840	313	330
	50	1267x1419	44xM48	44x1$^{7/8}$”	33176	35024	415	440
	52	1318x1465	48xM48	48x1$^{7/8}$”	36190	38210	435	460
	54	1365x1530	48xM48	48x1$^{7/8}$”	36190	38210	318	335
	56	1429x1594	36xM56	36x2$^{1/4}$”	37404	42336	356	405
	58	1484x1656	40xM56	40x2$^{1/4}$”	41560	47040	447	505
	60	1557x1707	40xM56	40x2$^{1/4}$”	41560	47040	395	490

Norm	NPS	Class 400						
		Metric (M) or inch (I) bolts						
			M	I	M	I	M	I
ANSI B16.47B	26	654x746	28xM36	28x1$^{3/8}$”	11704	11396	345	335
	28	702x800	24xM39	24x1$^{1/2}$”	12000	11832	300	295
	30	754x857	28xM39	28x1$^{1/2}$”	14000	13800	264	260
	32	800x911	28xM42	28x1$^{5/8}$”	16070	16465	255	260
	34	851x962	32xM42	32x1$^{5/8}$”	18370	18820	295	303
	36	899x1022	28xM45	28x1$^{3/4}$”	18730	19236	267	275
	38	953x1073	32xM45	32x1$^{3/4}$”	21410	21985	270	275
	40	1000x1125	32xM48	32x1$^{7/8}$”	24130	25470	288	305
	42	1051x1176	32xM48	32x1$^{7/8}$”	24130	25470	274	290
	44	1105x1231	32xM52	32x2”	29250	29280	320	320
	46	1168x1289	36xM52	36x2”	32900	32940	340	340
	48	1207x1346	28xM56	28x2$^{1/4}$”	29090	32930	288	325
	50	1257x1403	32xM56	32x2$^{1/4}$”	33248	37620	315	355
	52	1308x1451	32xM56	32x2$^{1/4}$”	33248	37620	305	345
	54	1353x1518	28xM64	28x2$^{1/2}$”	38360	41080	335	360
	56	1403x1569	32xM64	32x2$^{1/2}$”	43840	46940	371	398
	58	1454x1619	32xM64	32x2$^{1/2}$”	43840	46940	359	385
	60	1518x1683	32xM64	32x2$^{1/2}$”	43840	46940	345	370

Norm	NPS	Class 600						
		Metric (M) or inch (I) bolts						
			M	I	M	I	M	I
ANSI B16.47B	26	645x765	28xM42	28x1$^{5/8}$”	16070	16464	292	300
	28	692x819	28xM45	28x1$^{3/4}$”	18730	19230	320	330
	30	754x880	28xM48	28x1$^{7/8}$”	21110	22290	330	348
	32	794x934	28xM52	28x2”	25590	25620	374	375
	34	851x997	24xM56	24x2$^{1/4}$”	24935	28224	342	385
	36	902x1048	28xM56	28x2$^{1/4}$”	29090	32930	378	430
	38	953x1105	28xM56	28x2$^{1/4}$”	29090	32930	360	405
	40	1010x1156	32xM56	32x2$^{1/4}$”	33248	37620	388	440
	42	1067x1219	28xM64	28x2$^{1/2}$”	38360	41080	425	456
	44	1111x1270	32xM64	32x2$^{1/2}$”	43840	46940	463	495
	46	1162x1327	32xM64	32x2$^{1/2}$”	43840	46940	443	475
	48	1219x1390	32xM68	32x2$^{3/4}$”	50040	57400	485	555
	50	1270x1448	28xM76x6	28x3”	55750	60200	520	560
	52	1321x1499	32xM76x6	32x3”	63720	68800	570	620
	54	1378x1556	32xM76x6	32x3”	63720	68800	550	595
	56	1429x1613	32xM80x6	32x3$^{1/4}$”	71170	81280	595	675
	58	1473x1664	32xM80x6	32x3$^{1/4}$”	71170	81280	570	650
	60	1530x1734	28xM90x6	28x3$^{1/2}$”	78570	82880	610	640

Norm	NPS	Class 900						
		Metric (M) or inch (I) bolts						
			M	I	M	I	M	I
ANSI B16.47B	26	673x838	20xM64	20x2$^{1/2}$”	27400	29340	423	455
	28	724x902	20xM68	20x2$^{3/4}$”	31275	35880	453	520
	30	787x959	20xM76x6	20x3”	39825	43000	600	648
	32	838x1016	20xM76x6	20x3”	39825	43000	562	605
	34	845x1022	20xM80x6	20x3$^{1/4}$”	44480	50800	590	675
	36	927x1124	24xM76x6	24x3”	47790	51600	617	665
	38	1010x1200	20xM90x6	20x3$^{1/2}$”	56120	59200	663	700
	40	1061x1251	24xM90x6	24x3$^{1/2}$”	67344	71040	747	790
	42	1111x1302	24xM90x6	24x3$^{1/2}$”	67344	71040	720	760
	44	1156x1369	24xM95x6	24x3$^{3/4}$”	77050	81840	785	835
	46	1219x1435	24xM100x6	24x4”	86040	93360	835	905
	48	1270x1486	24xM100x6	24x4”	86040	93360	800	870
	50							
	52							
	54							
	56							
	58							
	60							

Table 2a

Bolts with metric threads

Dimensions, stressed cross-sections, forces and tightening torques

Basis for calculation:

Bolt quality 8.8 at 20 °C; $R_{p0.2}$ = 640 N/mm²

Allowable stress: $\sigma_{allowed} = 0.8 \cdot R_{p0.2}$ = 512 N/mm²

(For expansion bolts, high-temperature materials are normally used)

For conversion into other bolt materials see Table 3

Calculation of allowable tightening torque:

$M_A = F_S\,[0.161 \times P + 0.583 \times \mu_{total} \times d_2 + 0.25 \times \mu_{total}\,(s + d_L)]$

Friction value (threads and nut bearing faces): μ_{total} = 0.14

For expansion bolts, d_M is to be used instead.

General bolt data				Data for rigid bolts					Data for expansion bolts						
DIN 13-1: 1999 DIN 13-28: 1975		ISO 273: 1979	DIN ISO 272: 1979	DIN 13-1: 1999		DIN 13-28: 1975			DIN 2510-5: 1971	DIN 2510-2: 1971		DIN 2510-3: 1974			
d_m	P	d_L	s	d_2	d_3	A_s	F_s	M_A	d_M	d_2	d_3	$d_{2'}$	A_d	F_s	M_A
Thread size	Thread pitch	Bolt hole diameter	Nut bearing face = «Normal» width across flats	Diameter of screw thread flank	Diameter of root of thread	Stressed cross-section	Allowable bolt force	Allowable tightening torque	Nut bearing face	Screw thread flank. min.	Root of thread. min.	Reduced-shaft diameter	Reduced-shaft cross-section	Allowable bolt force	Allowable tightening torque
	mm	mm	mm	mm	mm	mm²	kN	Nm		mm	mm	mm	mm	mm²	kN
M3	0.5	3.4	5.5	2.68	2.4	5.03	2.57	1.6	No standard size						
M4	0.7	4.5	7	3.55	3.15	8.78	4.5	3.6	No standard size						
M5	0.8	5.5	8	4.5	4	14.2	7.27	7	No standard size						
M6	1	6.6	10	5.4	4.8	20.1	10.3	12	No standard size						
M8	1.25	9	13	7.2	6.5	36.6	18.7	29	No standard size						
M10	1.5	11	16	9	8.2	58	29.7	57	No standard size						
M12	1.75	14	18	10.9	9.9	84.3	43.2	100	21	10.5	9.4	8.5	56.7	29	67
M14	2	16	21	12.7	11.6	115	58.9	155	No standard size						
M16	2	18	24	14.7	13.6	157	80.4	240	26	14.4	13.1	12	113	57.9	175
M18	2.5	20	27	16.4	14.9	193	98.8	335	No standard size						
M20	2.5	22	30	18.4	16.9	245	125	465	31	18	16.4	15	177	90.5	335
M22	2.5	24	34	20.4	18.9	303	155	635	No standard size						
M24	3	26	36	22.1	20.3	353	181	805	35	21.6	19.7	18	254	130	580
M27	3	30	41	25.1	23.3	459	235	1180	40	24.6	22.7	20.5	330	169	850
M30	3.5	33	46	27.7	25.7	561	287	1600	45	27.3	25	23	415	213	1190
M33	3.5	36	50	30.7	28.7	694	355	2160	49	30.3	28	25.5	511	261	1590
M36	4	39	55	33.4	31.1	817	418	2790	53.5	32.9	30.3	27.5	594	304	2020
M39	4	42	60	36.4	34.1	976	500	3590	58.5	35.9	33.3	30.5	731	374	2690
M42	4.5	45	65	39.1	36.5	1121	574	4460	63.5	38.6	35.7	32.5	830	425	3300
M45	4.5	48	70	42.1	39.5	1306	669	5540	68.5	41.6	38.7	35.5	990	507	4200
M48	5	52	75	44.8	41.9	1473	754	6720	73.5	44.2	41	37.5	1104	565	5040
M52	5	56	80	48.8	45.9	1758	900	8590	78.5	48.2	45	41	1320	676	6450
M56	5.5	62	85	52.4	49.3	2030	1039	10700	83.5	51.9	48.3	44	1521	779	8020
M60	5.5	66	90	56.4	53.3	2362	1209	13250	No standard size						
M64	6	70	95	60.1	56.6	2676	1370	16000	93.5	59.5	55.5	51	2043	1046	12200
M68	6	74	100	64.1	60.6	3055	1564	19200	No standard size						
M72x6	6	78	105	68.1	64.6	3463	1773	22900	103.5	67.5	63.6	58.5	2688	1376	17800
M76x6	6	82	110	72.1	68.6	3889	1991	27000	No standard size						
M80x6	6	86	115	76.1	72.6	4344	2224	31600	113.5	75.5	71.6	66	3421	1752	24900
M90x6	6	96	130	86.1	82.6	5590	2862	45500	128	85.5	81.6	75	4418	2262	36000
M95x6	6	101	135	91.1	87.2	6270	3210	53500	No standard size						
M100x6	6	107	145	96.0	92.2	7000	3584	63150	143.0	95.4	91.5	84	5541	2837	50000

Table 2b

Bolts with inch threads

Dimensions, stressed cross-sections, forces and tightening torques

Basis for calculation:

Bolt quality 8.8 at 20 °C; $R_{p0.2}$ = 640 N/mm²

Allowable stress: $\sigma_{allowed} = 0.8 \times R_{p0.2}$ = 512 N/mm²

For conversion into other bolt materials see Table 3

Calculation of allowable tightening torque:

$M_A = F_S\,[0.161 \times P + 0.583 \times \mu_{total} \times d_2 + 0.25 \times \mu_{total}\,(s + d_L)]$

Friction value (threads and nut bearing faces): μ_{total} = 0.14

General bolt data					Data for bolts and thread bolts					
ANSI B18.2.1; 1981		ANSI B1.1: 1982		ANSI B16.5: 1981	ANSI 18.2.1: 1981 ANSI B16.47: 1990	ANSI B1.1: 1982 ANSI 18.2.2: 1981	ANSI B1.1: 1982	ANSI B1.1: 1982		
d_z	d_m		P	d_L	s	d_2	d_3	A_s	F_s	M_A
Thread size	Thread size	Threads per inch [1]	Thread pitch	Bolt hole diameter	Nut bearing face = width across flats [2]	Diameter of screw thread flank [1]	Diameter of root of thread	Stressed cross-section	Allowable bolt force	Allowable tightening torque
Inch	mm		mm	mm	mm	mm	mm	mm²	kN	Nm
(1/4)	6.35	20	1.27	(7.0)	12.4	5.4	4.6	20.5	10.5	14
(5/16)	7.94	18	1.41	(9.0)	13.9	6.9	6.0	33.8	17.3	28
(3/8)	9.53	16	1.59	(11.0)	17.0	8.4	7.3	50.0	25.6	49
(7/16)	11.1	14	1.81	(12.5)	18.5	9.8	8.6	68.8	35.1	76
1/2	12.7	13	2.00	15.7	21.6	11.3	10.0	91.5	46.8	120
(9/16)	14.3	12	2.12	(17.0)	23.1	12.7	11.4	119	60.9	165
5/8	15.9	11	2.31	19.0	26.2	14.2	12.7	146	74.8	235
3/4	19.1	10	2.54	22.5	30.8	17.2	15.5	215	110	405
7/8	22.2	9	2.82	25.0	35.4	20.2	18.3	298	153	645
1	25.4	8	3.18	28.5	40.0	23.1	21.1	391	200	960
1 1/8	28.6	8	3.18	31.5	44.6	26.3	24.4	510	261	1390
1 1/4	31.8	8	3.18	35.0	49.2	29.5	27.4	645	330	1940
1 3/8	34.9	8	3.18	38.0	53.8	32.6	30.6	795	407	2600
1 1/2	38.1	8	3.18	41.0	58.4	35.8	33.7	963	493	3410
1 5/8	41.3	8	3.18	44.5	63.0	39.0	36.9	1148	588	4390
1 3/4	44.5	8	3.18	48.0	67.6	42.1	40.1	1342	687	5490
1 7/8	47.6	8	3.18	51.0	72.3	45.3	43.3	1555	796	6790
2	50.8	8	3.18	54.0	76.9	48.5	46.4	1787	915	8280
2 1/4	57.2	8	3.18	60.5	86.1	54.8	52.8	2297	1176	11900
2 1/2	63.5	8	3.18	66.5	95.3	61.2	59.1	2865	1467	16390
2 3/4	69.9	8	3.18	73.0	105	67.5	65.5	3505	1794	21980
3	76.2	8	3.18	79.0	114	73.9	71.8	4200	2150	28590
(3 1/4)	82.6	8	3.18	(86.0)	123	80.2	78.1	4961	2540	36510
3 1/2	88.9	8	3.18	92.0	132	86.5	84.5	5781	2960	45620
3 3/4	95.1	8	3.18	98.5	141.3	93.1	91.4	6671	3415	56350
4	101.6	8	3.18	104.8	150.5	99.2	97.8	7619	3900	68420

[1] Applies to UNC threads (= "roughly") up to 1" and 8 UN-threads from 1 1/8". Thread tolerance class 2A for bolts and thread bolts («heavy hex bolts» and «stud bolts») or 2B for nuts.

Note: There are no US-standard screw bolts with reduced shafts (expansion bolts) in accordance with DIN 2510.

[2] Valid for heavy-design bolts and nuts («heavy hex bolts» and «heavy hex nuts»). Thread sizes in brackets are not standardized; the associated bolt-hole diameter is estimated.

Table 3

Bolt materials and mechanical strength properties (in N/mm²)

Material	Material number	Tensile strength R_m mind.	Yield point R_{el} or 0.2 % of yield point $R_{p\,0.2}$						
			Values in brackets: conversion factors compared to material quality 8.8 at 20 °C (= 1.00)						
		20 °C	20 °C	100 °C	200 °C	300 °C	400 °C	500 °C	600 °C
Carbon steel									
DIN EN ISO 898-1: 1999									
4.6		400	240 (0.38)						
5.6		500	300 (0.47)	270 (0.42)	230 (0.36)	195 (0.30)			
6.8		600	480 (0.75)						
8.8		800	640 (1.00)	590 (0.92)	540 (0.84)	480 (0.75)			
10.9		1040	940 (1.47)	875 (1.37)	790 (1.23)	705 (1.10)			
12.9		1220	1100 (1.72)	1020 (1.59)	925 (1.45)	825 (1.29)			
High-temperature steels									
DIN EN 10269: 1999									
25CrMo4 (Ø ≤ 100 mm)	1.7218	600	440 (0.69)	428 (0.67)	412 (0.64)	363 (0.57)	304 (0.48)	235 (0.37)	
42CrMo4 (Ø ≤ 60 mm)	1.7225	860	730 (1.14)	702 (1.10)	640 (1.00)	562 (0.88)	475 (0.74)	375 (0.59)	
	~ ASTM: B7								
21CrMoV5-7 (Ø ≤ 160 mm)	1.7709	700	550 (0.86)	530 (0.83)	500 (0.78)	460 (0.72)	410 (0.64)	350 (0.55)	
40CrMoV4-6 (Ø ≤ 100 mm)	1.7711	850	700 (1.09)	670 (1.05)	631 (0.99)	593 (0.93)	554 (0.87)	470 (0.73)	
	~ ASTM: B16								
High-temperature steels									
DIN EN 10269: 1999									
X22CrMoV12-1	1.4923	800	600 (0.94)	560 (0.88)	530 (0.83)	480 (0.75)	420 (0.66)	335 (0.52)	
X7CrNiMoBNb16-16	1.4986	650	500 (0.78)	470 (0.73)	432 (0.68)	393 (0.61)	353 (0.55)	314 (0.49)	255 (0.40)
X6NiCrTiMoVB25-15-2	1.4980	900	600 (0.94)	580 (0.91)	560 (0.88)	540 (0.84)	520 (0.81)	490 (0.77)	430 (0.67)
Stainless steels									
DIN EN 10088-3: 2005[1]									
X5CrNi18-10	1.4301	500	190 (0.30)	155 (0.24)	127 (0.20)	110 (0.17)	98 (0.15)	92 (0.14)	
	~ AISI 304								
X5CrNiMo17-12-2	1.4401	500	200 (0.31)	175 (0.27)	145 (0.23)	127 (0.20)	115 (0.18)	110 (0.17)	
	~ AISI 316								
X6CrNiTi18-10	1.4541	500	190 (0.30)	175 (0.27)	155 (0.24)	136 (0.21)	125 (0.20)	119 (0.19)	
	~ AISI 321								
X6CrNiMoTi17-12-2	1.4571	500	200 (0.31)	185 (0.29)	165 (0.26)	145 (0.23)	135 (0.21)	129 (0.20)	
	~ AISI 316Ti								
Stainless steels for bolts									
DIN EN ISO 3506-1: 1998									
A2-50, A4-50, A5-50, ≤ M 39		500	210 (0.33)	[3]	[3]	[3]	[3]		
A2-70, A4-70, A5-70, ≤ M 24[2]		700	450 (0.70)	382 (0.60)	360 (0.56)	338 (0.53)	315 (0.49)		
A2-80, A4-80, A5-80, ≤ M 24[2]		800	600 (0.94)	510 (0.80)	480 (0.75)	450 (0.70)	420 (0.66)		

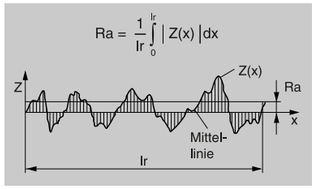
[1] Data applies to quenched steel. Strain-hardened steels possess significantly higher values.
See «Stainless steels for bolts» A2-70 to A5-80.

[2] For larger nominal diameters, the mechanical properties must be stipulated in consultation with the manufacturer.

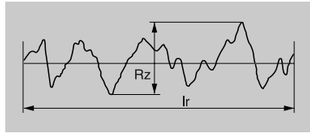
[3] Apply values for the corresponding «Stainless steels» types in accordance with DIN EN 10088-3.

A few terms for surface roughness in accordance with DIN EN ISO 4287:1998

Arithmetical average roughness Ra:
Arithmetical average of the ordinate value amounts within one measured section lr.

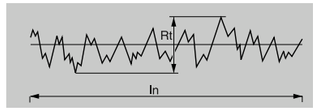


Highest point of the roughness profile Rz:
Sum of the height of the highest point of the profile and the depth of the lowest point of the profile from a single measured section lr.



Comment: This definition in accordance with DIN EN ISO 4287 differs from the earlier definition in accordance with DIN 4768 in that it relates to a single measured section, whereas the older definition defined Rz as the average of single values from five consecutive individual measured sections. However, since in accordance with DIN EN ISO 4288: 1998, Rz is normally calculated as an arithmetic average of the highest point of the profiles of five single measured sections, this value for Rz once again corresponds to the earlier numerical value Rz.

Total height of the roughness profile Rt:
Sum of the height of the highest point of the profile and the depth of the lowest point of the profile within a single measured section ln.



Comment: Since the measured length ln consists of multiple single measured sections lr (see below), Rt is greater or equal to Rz.
Comment: The previous «maximum surface roughness» R_{max} is not defined in DIN EN ISO 4287.

Correlation between Ra and Rz:
There are no mathematical correlations between these two roughness values. Typically, Rz is four to ten times greater than Ra.

Determination of measured section:
The single measured section lr and the measured section consisting of five single measured sections ln have a fixed ratio to the measured roughness (DIN EN ISO 4288):

Arithmetical average roughness Ra in µm	Greatest roughness value Rz in µm	Single measured section lr in mm	Measured section ln in mm
> (0.006) ... 0.02	> (0.025) ... 0.1	0.08	0.40
> 0.02 ... 0.1	> 0.1 ... 0.5	0.25	1.25
> 0.1 ... 2.0	> 0.5 ... 10.0	0.80	4.0
> 2.0 ... 10.0	> 10.0 ... 50.0	2.5	12.5
> 10.0 ... 80.0	> 50.0 ... 200	8.0	40.0