Joint technology

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Catalogue 7 chapter 3

Tightening torque

For a screw joint to work properly and be able to resist large static or changing forces for a long period of time, the screws must be pretightened, for example by tightening with a certain torque. The pretightening must normally be held at such a level, that the total stress in the screw does not exceed the yield stress of the screw material.

Calculation of tightening torque
To specify a tightening torque you must know four factors:

1. Screw thread diameter	2. Screw property class
3. The friction conditions	4. Tightening method

There are several different collections of tables. The tables that follow apply to a common condition - the tightening of untreated oiled screws/nuts, using a hand torque wrench or a screw driver/nut runner with torque control (variation ≤ ± 5%).

Table 18 = Metric coarse threads M (untreated, oiled).
Table 18.1 = Metric coarse threads M (untreated, oiled, Holo-krome®screws).
Table 19 = Metric fine threads M (untreated, oiled).
Table 20 = Unified coarse threads UNC (untreated, oiled).
Table 20.1 = Unified fine threads UNF (untreated, oiled).
Table 21 = Metric coarse threads M (waxed, stainless or acidproof).
Table 22 = Unified coarse threads UNC (waxed, stainless or acidproof).
Table 23 = Calculation values and conversion factors (C) for different friction conditions.

For every other method or every other friction condition the values must be adjusted. In the column to the left the thread diameters are listed and the table heading states the different property classes. How the tables are used is described below.

Theory:
Tightening torque Mv in Nm is calculated using the following equation:

$$M_v = \frac{k}{\kappa\left(1 + \frac{S_F}{F_{Fm}}\right)} (d + P) \cdot A_s \cdot \sigma_s \cdot 10^{-3}$$

The included factors are:

M_v = tightening torque, Nm
k = factor in the torque equation (see the following)
κ = the relationship between effective and tensile stress (see the following)
S_F = the pre-stress force's spread when tightening, N (see table 23)
F_{Fm} = $\sigma_F \cdot A_s$ = average pre-stress force, N
d = the screw thread's outer diameter, mm
P = pitch, mm
A_s = the stress area for the thread, mm²
σ_s = general denomination for $R_{p0,2}$ or R_{eL} in formulas, N/mm²
$R_{p0,2}$ = extension limit at 0,2% extension, N/mm²
R_{eL} = lower yield stress, N/mm²

The factor k takes into account the pitch's and the friction's effect on the torque and is, in its basic form written:

$$k = \frac{d_2 \cdot \tan(\varphi + \rho') + D_k \cdot \mu_u}{2\,(d + P)}$$

Due to geometrical correlations and because there usually are the same friction coefficients in thread and contact surface, k can be written as follows:

$$k = \frac{[0{,}161 \cdot P + \mu_{tot}(0{,}583 \cdot d_2 + 0{,}5 \cdot D_k)]}{d + P}$$

An analysis of the k-value at different thread diameters and friction conditions shows that the faults are no bigger than approximately ±5% if the expression finally is simplified to:

$$k = 1{,}078 \cdot \mu_{tot} + 0{,}0168$$

The included factors are:

d_2 = the screw thread's average diameter, mm
φ = the thread's pitch angle
ρ' = the thread's friction angle (depends on friction coefficient μ_g in the thread and is received from $\tan \rho' = \mu_g$)
D_k = the contact surface's friction diameter, mm
μ_u = friction coefficient at contact surface (see first column in table 23)
μ_{tot} = at torque-force-exchange active friction coefficient (see table 23)

The factor κ pays regard to the torsional stress that arises in the screw due to the thread friction. The torsional stress decreases the possibility to load a screw axially. With help from the deviation working hypothesis for calculation of the active stress (the comparison stress), you get:

$$\kappa = \frac{\sigma_e}{\sigma_F} = \sqrt{1 + \frac{12}{d_{As}^2}\left(\frac{P}{\pi} + 1{,}155 \cdot \mu_g \cdot d_2\right)^2}$$

The included factors are:

σ_e = active stress, with maximum value = σ_s, N/mm²
σ_F = the screw's pre-stress, N/mm²
$d_{As} = \sqrt{4\,As/\pi}$ = diameter of the stress area, mm
P = pitch, mm
μ_g = the friction coefficient in thread (see table 23)
d_2 = screw thread's average diameter, mm

Values for k and κ at different friction coefficients (different materials, surfaces and lubrication states), received from the formulas, are presented in table 23. The value of κ mainly depends on the friction coefficient in the thread (μ_g) and has therefore in the table been regarded as independent from the thread, as well as from the value of k.

Degree of pre-stress

The relationship between the pre-tension (σ_F) and the screw's yield stress or extension limit (σ_s) is denoted degree of pre-stress and can be calculated with the formula:

$$G_F = \frac{F_{Fm}}{F_s} = \frac{\sigma_F}{\sigma_s} = \frac{1}{\kappa\left(1 + \frac{S_F}{F_{Fm}}\right)}$$

The included factors are:

G_F = degree of pre-stress

F_{Fm} = $\sigma_F \bullet A_s$ = average pre-stressing force, N

F_s = $\sigma_s \bullet A_s$ = the screw's yield load, N

σ_F = the screw's pre-stress, N/mm^2

σ_s = general denomination for $R_{p0,2}$ or R_{eL} in formulas, N/mm^2

S_F = spread of the pre-stress when tightening, N

The degree of pre-stress cannot be freely chosen. The practicable pre-stress is limited by both the friction relationship and by the uncertainty of the tightening. A certain friction relationship and tightening method therefore gives a definite degree of pre-stress, because the active stress is not allowed to exceed the nominal yield stress (σ_s).

Conversion for different friction conditions

Table 23 contains values that can be used in the formulas when calculating tightening torque. Furthermore the table contains a conversion factor (C), that is used for converting tightening torques stated in other tables, so that they are vaild for other friction conditions.

The conversion factor (C) is 1,00 for screws and nuts made of steel that are untreated (not surface treated) before oiled, because the two following torque tables for steel joints refer to this combination. At more effective lubrication, for example with molybdenum disulphide (MoS_2), the friction decreases and the conversion factor becomes 0,86, which means a decrease from the table value for tightening torque with 14%.

From the table it is evident that the degree of pre-stress (G_F) increases from 0,71 to 0,75 when lubricating with molybdenum disulphide, thanks to lower torsional stress (lower κ) and lower variation of the pre-stress force (S_F), in spite of a lower torque.

If you choose screws and nuts that are untreated and dry instead of untreated and oiled, it leads to an increase in friction but in spite of this the torque should be decreased, because the conversion factor decreases from 1,00 to 0,96. The reason for this is that the higher friction increases the torsional stress at the same time as the variation of the pre-stress increases. This is why the degree of pre-stress (G_F) has to be decreased so that the active stress does not exceed the yield stress (σ_s). Consequently the degree of pre-stress gives valuable information about how efficiently the joints are used.

The conversion factor (C) is equal to 1,00 even for screws and nuts of stainless steel that are waxed, because the last torque table refers to this combination. Lubrication with oil or emulsion instead increases the friction and the variation of the pre-stress which leads to that the torque should be decreased even in these cases (the conversion factor decreases from 1,00 to 0,84). Otherwise the yield stress (σ_s) could be exceeded.

Tightening torque for steel screw joints

A screw joint from steel in property class 8.8 according to ISO 898-1 and with thread M10 requires, according to the torque table for steel joints with metric coarse threads, a tightening torque of 47 Nm. An increase of property to class 12.9 increases the torque requirement to 79 Nm. A screw joint in the lowest included property class 4.6 requires 17 Nm fo M10, which is less than 1/4 of what is required for property class 12.9. From this you see how important it is to adjust the torque based on the property class and not only based on screw diameter.

In most cases the manufacturer of screw and nut drivers specifies suitable screw diameters for a particular machine. This information is however completely worthless for the user. What he needs to know is which torque interval the machine is meant for. According to the example a torque of 79 Nm was suitable for property class 12.9 and screw M10. Almost the same torque, 81 Nm, is needed for a screw in property class 8.8 with the thread diameter M12. In these two cases a machine that delivers 75-90 Nm can be chosen.

The following example shows how the tables can be used:

Hexagon screw M10 in property class 8.8, nut in property class 8 and washers with hardness min. 200 HB. All fasteners are bright zincplated and dry. For tightening, a screw driver should be used that has an adjustable torque control with the spread max ±5%.

From the torque table you receive the tightening torque M_V = 47 Nm for untreated, oiled steel joints.
Also you receive σs = 640 N/mm^2 and A_s = 58 mm^2.

This gives the yield load F_s =
$\sigma s \bullet A_s = 640 \bullet 58$ N = 37120 N = 37,1 kN.

From table 23 you receive the following calculation values and conversion factor for the friction relationship:

$S_F/F_{Fm} = \pm 0{,}29$ $G_F = 0{,}62$ $C = 0{,}96$

No conversion with regards to the screw type is needed.

This gives:

Tightening torque =
$M_V \bullet C = 47 \bullet 0{,}96$ Nm = 45 Nm

The average pre-stress force F_{Fm} =
$F_s \bullet G_F = 37{,}1 \bullet 0{,}62$ kN = 23 kN

The variation of the pre-stress force S_F =

$$\frac{S_F}{F_{Fm}} \bullet F_{Fm} = \pm 0{,}29 \bullet 23 \text{ kN} = \pm 6{,}7 \text{ kN}$$

Table 18

Tightening torque (M_V) in Nm for non-treated, oiled steel screw joints when using dynamometric wrenches. (Torque variation max ± 5%).
Metric coarse threads, M

Thread M	d	P	A_s	Property class according to ISO 898-1				
	mm	mm	mm²	4.6	5.8	8.8	10.9	12.9
1,6	1,6	0,35	1,27	0,065	0,10	0,17	0,24	0,29
1,8	1,8	0,35	1,70	0,096	0,16	0,25	0,36	0,43
2	2	0,4	2,07	0,13	0,22	0,35	0,49	0,58
2,2	2,2	0,45	2,48	0,17	0,29	0,46	0,64	0,77
2,5	2,5	0,45	3,39	0,26	0,44	0,70	0,98	1,2
3	3	0,5	5,03	0,46	0,77	1,2	1,7	2,1
3,5	3,5	0,6	6,78	0,73	1,2	1,9	2,7	3,3
4	4	0,7	8,78	1,1	1,8	2,9	4,0	4,9
4,5	4,5	0,75	11,3	1,6	2,6	4,1	5,8	7,0
5	5	0,8	14,2	2,2	3,6	5,7	8,1	9,7
6	6	1	20,1	3,7	6,1	9,8	14	17
8	8	1,25	36,6	8,9	15	24	33	40
10	10	1,5	58	17	29	47	65	79
12	12	1,75	84,3	30	51	81	114	136
14	14	2	115	48	80	128	181	217
16	16	2	157	74	123	197	277	333
18	18	2,5	192	103	172	275	386	463
20	20	2,5	245	144	240	385	541	649
22	22	2,5	303	194	324	518	728	874
24	24	3	353	249	416	665	935	1 120
27	27	3	459	360	600	961	1 350	1 620
30	30	3,5	561	492	819	1 310	1 840	2 210
33	33	3,5	694	663	1 100	1 770	2 480	2 980
36	36	4	817	855	1 420	2 280	3 210	3 850
39	39	4	976	1 100	1 830	2 930	4 120	4 940
42	42	4,5	1 121	1 360	2 270	3 640	5 110	6 140
45	45	4,5	1 306	1 690	2 820	4 510	6 340	7 610
48	48	5	1 473	2 040	3 400	5 450	7 660	9 190
52	52	5	1 758	2 620	4 370	6 990	9 830	11 800
56	56	5,5	2 030	3 270	5 440	8 710	12 200	14 700
60	60	5,5	2 362	4 050	6 750	10 800	15 200	18 200
64	64	6	2 676	4 900	8 170	13 100	18 400	22 000
68	68	6	3 055	5 910	9 860	15 800	22 200	26 600
72	72	6	3 460	7 060	11 800	18 800	26 500	31 800
76	76	6	3 889	8 340	13 900	22 200	31 300	37 500
80	80	6	4 344	9 770	16 300	26 100	36 600	44 000
85	85	6	4 948	11 800	19 600	31 400	44 200	53 000
90	90	6	5 591	14 000	23 400	37 400	52 700	63 200
95	95	6	6 273	16 600	27 600	44 200	62 200	74 600
100	100	6	6 995	19 400	32 300	51 700	72 700	87 300
$\sigma_S = R_{eL}$ or $R_{p0,2}$ N/mm² nominal				240	400	640	900	1 080
$\dfrac{k}{\kappa\left(1+\dfrac{S_F}{F_{Fm}}\right)} \cdot \sigma_S$ N/mm²				26,16	43,60	69,76	98,10	117,72

Table 19 **Tightening torque (M_v) in Nm for non-treated, oiled steel screw joints when using dynamometric wrenches. (Torque variation max ± 5%). Metric fine threads, M**

Thread M	d mm	P mm	A_s mm^2	Property class according to ISO 898-1 4.6	5.8	8.8	10.9	12.9
2 × 0,25	2	0,25	2,45	0,14	0,24	0,38	0,54	0,65
2,2 × 0,25	2,2	0,25	3,03	0,19	0,32	0,52	0,73	0,87
2,5 × 0,25	2,5	0,25	3,70	0,28	0,46	0,74	1,0	1,2
3 × 0,35	3	0,35	5,60	0,49	0,82	1,3	1,8	2,2
3,5 × 0,35	3,5	0,35	7,90	0,80	1,3	2,1	3,0	3,6
4 × 0,5	4	0,5	9,79	1,2	1,9	3,1	4,3	5,2
4,5 × 0,5	4,5	0,5	12,8	1,7	2,8	4,5	6,3	7,5
5 × 0,5	5	0,5	16,1	2,3	3,9	6,2	8,7	10
6 × 0,75	6	0,75	22,0	3,9	6,5	10	15	17
8 × 1	8	1	39,2	9,2	15	25	35	42
10 × 1,25	10	1,25	61,2	18	30	48	68	81
10 × 1	10	1	64,5	19	31	49	70	84
12 × 1,5	12	1,5	88,1	31	52	83	117	140
12 × 1,25	12	1,25	92,1	32	53	85	120	144
14 × 1,5	14	1,5	125	51	84	135	190	228
16 × 1,5	16	1,5	167	76	127	204	287	344
18 × 1,5	18	1,5	216	110	184	294	413	496
20 × 1,5	20	1,5	272	153	255	408	574	688
22 × 1,5	22	1,5	333	205	341	546	768	921
24 × 2	24	2	384	261	435	696	979	1 170
27 × 2	27	2	496	376	627	1 000	1 410	1 690
30 × 2	30	2	621	520	866	1 390	1 950	2 340
33 × 2	33	2	761	697	1 160	1 860	2 610	3 130
36 × 3	36	3	865	883	1 470	2 350	3 310	3 970
$\sigma_s = R_{eL}$ or $R_{p0,2}$ N/mm^2 nominal				240	400	640	900	1 080
$\frac{k}{\kappa\left(1+\frac{S_F}{F_{Fm}}\right)} \cdot \sigma_s$ N/mm^2				26,16	43,60	69,76	98,10	117,72

Table 20 **Tightening torque (M_v) in Nm for non-treated, oiled steel screw joints when using dynamometric wrenches. (Torque variation max ± 5%). Unified coarse threads, UNC**

Thread UNC	d mm	P mm	A_s mm^2	Property class 4.6	5.8	8.8	10.9	12.9
No 4	2,845	0,635	3,90	0,31	0,58	0,94	1,3	1,7
No 5	3,175	0,635	5,14	0,45	0,84	1,4	1,9	2,4
No 6	3,505	0,794	5,86	0,58	1,1	1,7	2,5	3,1
No 8	4,166	0,794	9,04	1,0	1,9	3,1	4,4	5,5
No 10	4,826	1,058	11,31	1,5	2,9	4,6	6,5	8,1
No 12	5,486	1,058	15,58	2,3	4,4	7,0	10	12
1/4	6,35	1,270	20,5	3,6	6,7	11	15	19
5/16	7,938	1,411	33,8	7,3	14	22	31	38
3/8	9,525	1,588	50,0	13	24	38	54	68
7/16	11,112	1,814	68,6	20	38	61	87	108
1/2	12,7	1,954	91,5	31	57	93	131	163
9/16	14,288	2,117	117	44	82	133	187	234
5/8	15,875	2,309	146	61	114	183	259	323
3/4	19,05	2,540	216	107	200	322	455	568
7/8	22,225	2,822	298	172	320	516	729	909
1	25,4	3,175	391	257	479	772	1 090	1 360
1 1/8	28,575	3,629	492	365	679	1 090	1 550	1 930
1 1/4	31,75	3,629	625	509	947	1 530	2 160	2 690
1 3/8	34,925	4,233	745	672	1 250	2 020	2 850	3 550
1 1/2	38,1	4,233	907	884	1 650	2 650	3 750	4 680
1 3/4	44,45	5,080	1 225	1 400	2 600	4 190	5 930	7 390
2	50,8	5,644	1 612	2 100	3 900	6 290	8 890	11 100
2 1/4	57,15	5,644	2 095	3 030	5 640	9 090	12 800	16 000
2 1/2	63,5	6,350	2 580	4 150	7 720	12 500	17 600	21 900
2 3/4	69,85	6,350	3 183	5 590	10 400	16 800	23 700	29 500
3	76,2	6,350	3 850	7 320	13 600	22 000	31 000	38 700
3 1/4	82,55	6,350	4 580	9 380	17 740	28 100	39 800	49 600
3 1/2	88,9	6,350	5 373	11 800	21 900	35 400	50 000	62 300
3 3/4	95,25	6,350	6 230	14 600	27 100	43 700	61 800	77 100
4	101,6	6,350	7 150	17 800	33 100	53 300	75 400	94 000
$\sigma_s = R_{eL}$ or $R_{p0,2}$ N/mm^2 nominal				248	393	634	896	1 117
$\frac{k}{\kappa\left(1+\frac{S_F}{F_{Fm}}\right)} \cdot \sigma_s$ N/mm^2				23,03	42,84	69,11	97,66	121,75

Table 20.1

Tightening torque (M_V) in Nm for non-treated, oiled steel screw joints when using dynamometric wrenches. (Torque variation max ± 5%).
Unified fine threads UNF

Thread UNF	d mm	P mm	A_s mm^2	Property class 4.6	5.8	8.8	10.9	12.9
No 4	2,845	0,529	4,26	0,33	0,62	0,99	1,4	1,8
No 5	3,175	0,577	5,36	0,46	0,86	1,4	2,0	2,4
No 6	3,505	0,635	6,55	0,62	1,2	1,9	2,6	3,3
No 8	4,166	0,706	9,50	1,1	2,0	3,2	4,5	5,6
No 10	4,826	0,794	12,90	1,7	3,1	5,0	7,1	8,8
No 12	5,486	0,907	16,64	2,5	4,6	7,4	10	13
1/4	6,35	0,907	23,5	3,9	7,3	12	17	21
5/16	7,938	1,058	37,5	7,8	14	23	33	41
3/8	9,525	1,058	56,7	14	26	41	59	73
7/16	11,112	1,27	76,6	22	41	66	93	115
1/2	12,7	1,27	103	33	62	99	141	175
9/16	14,288	1,411	131	47	88	142	201	250
5/8	15,875	1,411	165	66	122	197	279	347
3/4	19,05	1,588	241	115	213	344	486	606
7/8	22,225	1,814	329	182	339	547	772	963
1	25,4	2,117	428	271	505	814	1 150	1 430
1 1/8	28,575	2,117	552	390	726	1 170	1 660	2 060
1 1/4	31,75	2,117	692	540	1 000	1 620	2 290	2 850
1 3/8	34,925	2,117	848	723	1 350	2 170	3 070	3 820
1 1/2	38,1	2,117	1 020	945	1 760	2 840	4 000	5 000
$\sigma_s = R_{eL}$ or $R_{p0,2}$ N/mm^2 nominal				248	393	634	896	1 117
$\frac{k}{\kappa\left(1 + \frac{S_F}{F_{Fm}}\right)} \cdot \sigma_s$ N/mm^2				27,03	42,84	69,11	97,66	121,75

Tightening torque for stainless screw joints

To be able to pre-stress stainless screws (including acidproof screws), effective lubrication is needed - otherwise the threads will jam. The property values according to ISO 3506 for stainless screws do not correspond with those for ordinary steel screws. A special torque table has for that reason been included for stainless screw joints. There, the torque values are calculated for waxed products, which is regarded to be a normal state. The degree of pre-stress at this state is used when comparing with other friction conditions.

Lubrication with molybdenum disulphide (MoS_2) provides similar friction conditions as with waxing.

The following example shows how the table could be used:

A hexagon screw M10 in property class A4 - 80 is pre-stressed with a waxed nut in the same property class. The tightening is made by using a dynamometric wrench on the nut.

From the torque table you receive the tightening torque M_V = 44 Nm, for waxed stainless screw joints.
You also get $\sigma_s = 600$ N/mm² and $A_s = 58$ mm².

This gives the yield load F_s =
$\sigma_s \cdot A_s = 600 \cdot 58$ N = 34800 N = 34,8 kN

From table 23 you receive the following calculation values and conversion factor for the friction relationship:

$S_F/F_{Fm} = \pm 0{,}23$ $G_F = 0{,}65$ $C = 1{,}00$

No conversion with regards to the screw type is needed.

This gives:

Tightening torque =
$M_V \cdot C = 44 \cdot 1{,}00$ Nm = 44 Nm

The average pre-stress force F_{Fm} =
$F_s \cdot G_F = 34{,}8 \cdot 0{,}65$ kN = 22,6 kN

The variation of the pre-stress force S_F =
$\frac{S_F}{F_{Fm}} \cdot F_{Fm} = \pm 0{,}23 \cdot 22{,}6$ kN = ± 5,2 kN

Table 21

Tightening torque (M_V) in Nm for waxed, stainless or acidproof screw joints when using dynamometric wrenches. (Torque variation max ± 5%). Metric coarse threads, M

Thread M	d mm	P mm	A_S mm²	Property class according to ISO 3506					
				Austenitic (A)			Ferritic (F) and martensitic (C)		
				50	70	80	45 | 50	60 | 70	80
1,6	1,6	0,35	1,27	0,057	0,12	0,16	0,068	0,11	0,17
2	2	0,4	2,07	0,11	0,25	0,33	0,14	0,22	0,35
2,5	2,5	0,45	3,39	0,23	0,50	0,66	0,28	0,45	0,70
3	3	0,5	5,03	0,41	0,87	1,2	0,48	0,79	1,2
3,5	3,5	0,6	6,78	0,64	1,4	1,8	0,76	1,3	2,0
4	4	0,7	8,78	1,0	2,0	2,7	1,1	1,9	2,9
5	5	0,8	14,2	1,9	4,1	5,4	2,3	3,7	5,8
6	6	1	20,1	3,3	7,0	9,3	3,9	6,3	9,9
8	8	1,25	36,6	7,8	17	22	9,3	15	24
10	10	1,5	58	15	33	44	18	30	47
12	12	1,75	84,3	27	57	76	32	52	82
14	14	2	115	43	91	121	51	83	130
16	16	2	157	65	140	187	78	127	199
18	18	2,5	192	91	195	260	108	178	277
20	20	2,5	245	127	273	364	152	249	388
22	22	2,5	303	171	367	490	204	335	523
24	24	3	353	220	472	629	262	430	671
27	27	3	459	318	682	909	379	621	969
30	30	3,5	561	434	930	1 240	517	848	1 320
33	33	3,5	694	585	1 250	1 670	697	1 140	1 780
36	36	4	817	755	1 620	2 160	899	1 470	2 300
39	39	4	976	969	2 080	2 770	1 150	1 890	2 950
$\sigma_S = R_{eL}$ or $R_{p0,2}$ N/mm² nominal				210	450	600	250	410	640
$\frac{k}{\kappa\left(1+\frac{S_F}{F_{Fm}}\right)} \cdot \sigma_s$ N/mm²				23,10	49,50	66,00	27,50	45,10	70,40

(Excerpt + completing from SMS handbook 516:1990)

Table 22

Tightening torque (M_V) in Nm for waxed, stainless or acidproof screw joints when using dynamometric wrenches. (Torque variation max ± 5%). Unified coarse threads, UNC

Thread UNC	d mm	P mm	A_s mm²	Property class						
				Austenitic (A)			Ferritic (F) and martensitic (C)			
				50	70	80	45 | 50	60	70	80
1/4	6,35	1,270	20,5	3,6	7,0	10	4,3	7,0	7,7	11
5/16	7,938	1,411	33,8	7,3	14	21	8,7	14	16	22
3/8	9,525	1,588	50,0	13	25	37	15	25	28	39
7/16	11,112	1,814	68,6	20	40	59	24	40	44	62
1/2	12,7	1,954	91,5	31	60	89	37	60	66	94
9/16	14,288	2,117	117	44	87	127	53	87	95	135
5/8	15,875	2,309	146	61	120	175	73	120	131	187
3/4	19,05	2,540	216	108	210	308	128	210	231	328
7/8	22,225	2,822	298	172	337	493	205	337	369	525
1	25,4	3,175	391	258	504	737	307	504	553	787
1 1/8	28,575	3,629	492	366	715	1 050	436	715	784	1 120
1 1/4	31,75	3,629	625	511	997	1 460	608	997	1 090	1 560
1 3/8	34,925	4,233	745	674	1 320	1 930	802	1 320	1 440	2 050
1 1/2	38,1	4,233	907	887	1 730	2 530	1 060	1 730	1 900	2 700
$\sigma_S = R_{eL}$ or $R_{p0,2}$ N/mm² nominal				210	410	600	250	410	450	640
$\frac{k}{\kappa\left(1+\frac{SF}{F_{Fm}}\right)} \cdot \sigma_s$ N/mm²				23,10	45,10	66,00	27,50	45,10	49,50	70,40

Table 18.1

Recommended tightening torque (M_V) in Nm for non-treated, oiled steel Holo-Krome® screws when using dynamometric wrenches. (Torque variation max ± 5%).
Metric coarse threads, M

Thread M	d mm	P mm	A_S mm^2	Holo-Krome®
1,6	1,6	0,35	1,27	0,29
2	2	0,4	2,07	0,66
2,5	2,5	0,45	3,39	1,32
3	3	0,5	5,03	2,4
4	4	0,7	8,78	5,6
5	5	0,8	14,2	11,4
6	6	1	20,1	19,3
8	8	1,25	36,6	46,3
10	10	1,5	58	88,3
12	12	1,75	84,3	161,8
14	14	2	115	257,4
16	16	2	157	397,3
18	18	2,5	192	551,6
20	20	2,5	245	772,3
24	24	3	353	1338,9
30	30	3,5	561	2684,5
36	36	4	817	4708,7
42	42	4,5	1 121	7538,8

Table 23

Calculation values and conversion factors (C) for different friction conditions. (Tightening with dynamometric wrenches, torque variation max ± 5%)

Material, surface condition 1) Screw	Nut or goods thread	Lubrication state	μ_{tot}	$\frac{S_F}{F_{Fm}}$ ±	k	κ	G_F	C 3)
Steel, untreated	Steel, untreated	dry oil MoS_2 wax	0.14 0.125 0.10 0.06	0.29 0.16 0.16 0.11	0.168 0.152 0.125 0.082	1.24 1.21 1.15 1.08	0.62 0.71 0.75 0.83	0.96 1.00 0.86 0.63
Steel, phos	Steel, phos or untreated	dry oil MoS_2 wax	0.125 0.10 0.08 0.06	0.29 0.16 0.11 0.11	0.152 0.125 0.103 0.082	1.21 1.15 1.11 1.08	0.64 0.75 0.81 0.83	0.90 0.86 0.77 0.63
Steel, fzb, fzy or fzm	Steel, fzb, fzy, fzm or untreated	dry oil/emulsion wax	0.14 0.10 0.06	0.29 0.16 0.11	0.168 0.125 0.082	1.24 1.15 1.08	0.62 0.75 0.83	0.96 0.86 0.63
	Light metal	oil/emulsion	0.125	0.23	0.152	1.21	0.67	0.94
Zinc-iron	Zinc-iron	dry wax	0.16 0.06	– 0.082	– 1.08	– 0.11	–	1.05 0.63
Steel, fzv	Steel, fzv or untreated	oil (state of delivery) dry oil/emulsion wax	0.14 0.20 0.14 0.06	0.16 0.29 0.16 0.11	0.168 0.232 0.168 0.082	1.24 1.41 1.24 1.08	0.69 0.55 0.69 0.83	1.07 1.17 1.07 0.63
	Light metal	oil/emulsion	0.16	0.29	0.189	1.29	0.60	1.04
Steel, Polyseal	Steel, Polyseal or untreated	dry oil emulsion wax	0.20 0.14 0.10 0.06	0.29 0.16 0.16 0.11	0.232 0.168 0.125 0.082	1.41 1.24 1.15 1.08	0.55 0.69 0.75 0.83	1.17 1.07 0.86 0.63
Stainless steel 2)	Stainless steel or 2) light metal	wax oil/emulsion	0.14 0.20	0.23 0.29	0.168 0.232	1.24 1.41	0.65 0.55	1.00 0.84

1) Phos = phosphatised, fzb = zincplated + bright chromated, fzy = zincplated + yellow chromated, fzm = mechanically zincplated, fzv = hot dip galvanized.
2) Stainless steel also embodies, like in ISO 3506, so called acid-proof steel.
3) Use conversion factor C when converting the tightening torque for another material, other surface treatment or other lubrication state has been set to 1,00 for untreated, oiled screws and nuts from steel, and also for waxed screws and nuts from stainless steel. The torques in previous tables refer to these combinations. You can easily recalculate them for other combinations by multiplying with the factor C that is stated in the table for the actual combination.

Tightening of screws

For each screw joint's function the achieved clamping force when assembling is crucial. As a principal the screw should be tightened to its yield stress. As friction also arises when tightening, something that further loads the screw, the active clamping force must stay below the yield stress. The allowed tightening torque and the achieved clamping force can be seen in the following tables.

These values depend very much on the actual friction.

Some friction values:

Untreated, lightly oiled:	0,10-0,14
Dacromet 500:	0,12-0,18
Hot dip galvanized:	0,16-0,30
Zincplated + wax Gleitmo 605:	0,09-0,11

In normal cases (black, lightly oiled) it is possible to calculate with the friction value 0,12. For other cases values could be found in the table below.

Screw acc. to ISO 4014, 4017, 4762, DIN 931, 933, 912.

Table 97 Torque up to 90% of yield stress (Friction coefficient = 0,08 and 0,10)

Only recommended values.

	Friction coefficient = 0,08						Friction coefficient = 0,10					
Diameter	Clamping force N			Tightening torque Nm			Clamping force N			Tightening torque Nm		
	8,8	10,9	12,9	8,8	10,9	12,9	8,8	10,9	12,9	8,8	10,9	12,9
M 4	4 350	6 150	7 400	2,1	2,9	3,5	4 200	5 900	7 100	2,4	3,3	4,0
M 5	7 150	10 100	12 100	4,2	6,0	7,1	6 900	9 700	11 600	4.9	7,0	8,0
M 6	10 100	14 200	17 000	7,0	10	12	9 750	13 700	16 400	8,0	12	14
(M 7)	14 800	20 700	24 900	12	16	20	14 400	20 200	24 200	13	19	23
M 8	18 500	26 100	31 300	17	24	29	17 900	25 100	30 200	20	28	34
(M 9)	24 700	34 700	41 600	25	35	43	23 800	33 400	40 100	29	41	49
M 10	29 500	41 400	49 700	34	48	58	28 400	40 000	48 000	40	56	67
M 12	43 000	60 500	72 500	60	84	100	41 500	58 500	70 000	69	98	115
M 14	59 000	82 500	99 000	95	135	160	56 500	80 000	96 000	110	155	185
M 16	81 000	114 000	137 000	145	205	245	78 500	110 000	132 000	170	240	285
M 18	98 500	138 000	166 000	200	285	340	95 000	134 000	160 000	235	330	395
M 20	127 000	178 000	214 000	285	400	480	122 000	172 000	206 000	330	465	560
M 22	158 000	222 000	266 000	380	530	640	152 000	214 000	257 000	445	620	750
M 24	183 000	257 000	308 000	490	690	830	176 000	248 000	298 000	570	800	960
M 27	239 000	337 000	404 000	720	1 000	1 200	232 000	326 000	391 000	840	1 200	1 400
M 30	292 000	410 000	493 000	980	1 400	1 650	282 000	397 000	476 000	1 150	1 600	1 950
M 8 x 1	20 200	28 400	34 100	18	26	31	19 500	27 000	33 000	22	30	36
M 10 x 1,25	31 600	44 400	53 300	36	51	61	30 500	42 900	51 500	42	59	71
M 12 x 1,25	48 200	68 000	81 500	64	91	110	46 600	65 500	78 500	76	105	130
M 12 x 1,5	45 400	64 000	76 500	62	87	105	43 900	62 000	74 000	72	100	120
M 14 x 1,5	65 000	91 500	110 000	100	140	170	63 000	88 500	106 000	120	165	200
M 16 x 1,5	88 000	124 000	148 000	150	215	255	85 000	120 000	144 000	180	250	300
M 18 x 1,5	114 000	161 000	193 000	220	310	370	111 000	156 000	187 000	260	365	435
M 20 x 1,5	144 000	203 000	244 000	305	430	510	140 000	197 000	236 000	380	510	610
M 22 x 1,5	178 000	250 000	300 000	405	570	680	172 000	242 000	291 000	480	680	810
M 24 x 2	203 000	286 000	343 000	520	730	880	197 000	277 000	332 000	610	860	1 050
M 27 x 2	264 000	371 000	445 000	760	1 050	1 300	256 000	359 000	431 000	900	1 250	1 500
M 30 x 2	331 000	466 000	559 000	1 050	1 500	1 800	321 000	452 000	542 000	1 250	1 750	2 100

Table 98 Torque up to 90% of yield stress (Friction coefficient = 0,125 and 0,14)

Only recommended values.

	Friction coefficient = 0,125						Friction coefficient = 0,14					
Diameter	Clamping force N			Tightening torque Nm			Clamping force N			Tightening torque Nm		
	8,8	10,9	12,9	8,8	10,9	12,9	8,8	10,9	12,9	8,8	10,9	12,9
M 4	4 000	5 650	6 750	2,7	3,8	4,6	3 900	5 450	6 550	2,9	4,1	4,9
M 5	6 550	9 200	11 100	5,5	8,0	9,5	6 350	8 950	10 700	6,0	8,5	10
M 6	9 250	13 000	15 600	9,5	13	16	9 000	12 600	15 100	10	14	17
(M 7)	13 600	19 100	22 900	15	22	26	13 200	18 500	22 200	16	23	28
M 8	17 000	23 900	28 700	23	32	39	16 500	23 200	27 900	25	35	41
(M 9)	22 600	31 900	38 200	34	47	57	22 000	30 900	37 100	36	51	61
M 10	27 100	38 000	45 700	46	64	77	26 200	36 900	44 300	49	69	83
M 12	39 500	55 500	66 700	80	110	135	38 300	54 000	64 500	86	120	145
M 14	54 000	76 000	91 300	125	180	215	52 500	74 000	88 500	135	190	230
M 16	75 000	105 000	126 000	195	275	330	73 000	102 000	123 000	210	295	355
M 18	90 500	127 000	153 000	270	390	455	88 000	124 000	148 000	290	405	485
M 20	117 000	164 000	197 000	385	540	650	114 000	160 000	192 000	410	580	690
M 22	145 000	205 000	245 000	510	720	870	141 000	199 000	239 000	550	780	930
M 24	169 000	237 000	284 000	660	930	1 100	164 000	230 000	276 000	710	1 000	1 200
M 27	221 000	311 000	374 000	980	1 400	1 650	215 000	302 000	363 000	1 050	1 500	1 800
M 30	269 000	379 000	454 000	1 350	1 850	2 250	262 000	368 000	442 000	1 450	2 000	2 400
M 8 × 1	18 600	26 200	31 500	25	35	42	18 100	25 500	30 600	27	38	45
M 10 × 1,25	29 100	40 900	49 100	49	68	82	28 300	39 800	47 700	52	73	88
M 12 × 1,25	44 600	62 500	75 000	88	125	150	43 300	61 000	73 000	95	135	160
M 12 × 1,5	41 900	59 000	70 500	83	115	140	40 700	57 000	68 500	90	125	150
M 14 × 1,5	60 500	85 000	102 000	140	195	235	58 500	82 500	99 000	150	210	250
M 16 × 1,5	81 500	114 000	137 000	210	295	350	79 000	111 000	133 000	225	315	380
M 18 × 1,5	106 000	149 000	179 000	305	425	510	103 000	145 000	174 000	325	460	550
M 20 × 1,5	134 000	189 000	226 000	425	600	720	130 000	183 000	220 000	460	640	770
M 22 × 1,5	165 000	232 000	279 000	570	800	960	161 000	226 000	271 000	610	880	1 050
M 24 × 2	188 000	265 000	318 000	720	1 000	1 200	183 000	257 000	309 000	780	1 100	1 300
M 27 × 2	245 000	344 000	413 000	1 050	1 500	1 800	238 000	335 000	402 000	1 150	1 600	1 950
M 30 × 2	308 000	433 000	520 000	1 450	2 050	2 500	300 000	422 000	506 000	1 600	2 250	2 700

Table 99 Torque up to 90% of yield stress (Friction coefficient = 0,16 and 0,20)

Only recommended values.

	Friction coefficient = 0,16						Friction coefficient = 0,20					
Diameter	Clamping force N			Tightening torque Nm			Clamping force N			Tightening torque Nm		
	8,8	10,9	12,9	8,8	10,9	12,9	8,8	10,9	12,9	8,8	10,9	12,9
M 4	3 700	5 200	6 250	3,1	4,4	5,0	3 400	4 800	5 750	3,5	4,9	6
M 5	6 100	8 600	10 300	6,5	9,0	11	5 600	7 900	9 450	7,0	10	12
M 6	8 600	12 100	14 500	11	15	18	7 900	11 100	13 300	12	17	20
(M 7)	12 600	17 800	21 300	18	25	30	11 600	16 300	19 600	20	28	34
M 8	15 800	22 300	26 700	26	37	45	14 500	20 500	24 500	30	40	50
(M 9)	21 100	29 700	35 600	39	55	66	19 400	27 300	32 700	44	62	74
M 10	25 200	35 500	42 600	53	75	90	23 400	32 600	39 100	60	84	100
M 12	36 800	51 500	62 000	92	130	155	33 900	47 600	57 000	105	145	175
M 14	50 500	71 000	85 000	145	205	250	46 300	65 000	78 000	165	230	280
M 16	70 000	98 000	118 000	230	320	385	64 500	90 500	108 000	255	380	435
M 18	84 000	118 000	142 000	310	435	520	77 500	109 000	131 000	350	495	590
M 20	109 000	153 000	184 000	445	630	750	100 000	141 000	169 000	500	710	850
M 22	136 000	191 000	229 000	600	840	1 000	125 000	176 000	211 000	680	950	1 150
M 24	157 000	221 000	265 000	770	1 100	1 300	145 000	203 000	244 000	870	1 200	1 450
M 27	207 000	291 000	349 000	1 150	1 600	1 950	190 000	268 000	321 000	1 300	1 800	2 200
M 30	252 000	354 000	425 000	1 550	2 200	2 600	232 000	326 000	391 000	1 750	2 450	2 950
M 8 × 1	17 400	24 400	29 300	29	41	49	16 000	22 500	27 000	33	46	55
M 10 × 1,25	27 200	38 200	45 900	57	80	95	25 000	35 100	42 200	64	90	105
M 12 × 1,25	41 600	58 500	70 000	105	145	175	38 400	54 000	64 500	115	165	195
M 12 × 1,5	39 100	55 000	66 000	97	135	165	36 000	50 500	60 500	110	155	185
M 14 × 1,5	56 500	79 000	95 000	160	225	270	52 000	73 000	87 500	185	255	310
M 16 × 1,5	76 000	107 000	128 000	245	345	410	70 000	98 500	118 000	275	390	465
M 18 × 1,5	99 000	139 000	167 000	355	500	600	91 000	128 000	154 000	405	570	680
M 20 × 1,5	126 000	176 000	212 000	500	700	840	116 000	163 000	195 000	570	800	960
M 22 × 1,5	154 000	217 000	261 000	670	940	1 150	143 000	201 000	241 000	760	1 050	1 300
M 24 × 2	176 000	248 000	297 000	850	1 200	1 450	163 000	229 000	275 000	960	1 350	1 600
M 27 × 2	229 000	322 000	387 000	1 250	1 750	2 100	211 000	297 000	357 000	1 400	2 000	2 400
M 30 × 2	288 000	406 000	487 000	1 750	2 450	2 950	266 000	374 000	449 000	2 000	2 800	3 350

Fasteners with socket head cap screw grip, sixpoint socket grip and low head

Table 100

Screw type	DIN 6912		DIN 7984		BN 1206	BN 9524	ISO 7379	DIN 7991	ISO14581	DIN 7991	ISO 7380	BN 6404	ISO 7380	ISO 4026/DIN 913, ISO 4027/DIN 914, ISO 4028/DIN 915, ISO 4029/DIN 916	
	Maximum tightening torque (Nm)														
< Thread	8.8	A2-70 A4-70	8.8	A2-70 A4-70	10.9	8.8	12.9	10.9	8.8	A2-70 A4-70	10.9	8.8	A2-70 A4-70	45 H[1]	A2 A4
M 3			1	0,6				1	1	0,5	1	1	0,5	0,5	0,2
M 4	2	1	2	1,2	2	2		2	2	1	2	2	1	1	0,5
M 5	6	4	4	2,5	5	5	4	5	5	2,5	4	4	2	3	1,5
M 6	9	5	8	5	5	5	9	9	9	4,5	8	8	4	5	2,5
M 8	20	12	12	7	10	10	25	15		8	12	12	6	10	5
M10	40	24	35	21	18		40	40		20	30		15	20	10
M12	65	40	50	30			70	65		33	60		30	45	22
M14	110	66						100		50				45	22
M16	180	110	110	66			200	110		55				90	45
M18														140	70
M20	280	170	200	120			400	150		75				140	70
M22														220	110
M24			390	235				400		200				220	110

[1] Property class and mechanical features according to ISO 898-5 are valid for set screws without extension strain.

Friction

Screw DIN 912 zincplated 8 µm + blue chromated class 8.8 M10x60. Test performed at Nylok Scandinavia. Machine Schatz Analyse.

5 tests were made in each round. Average values of the total friction are presented.

Table 101

Type of treatment:	Friction:
Zincplating	0,11
Zincplating + wax Gleitmo 605	0,08
Zincplating + Tuflok 2 - 180 degrees	0,12
Zincplating + Tuflok 2 - 180 degrees + wax Gleitmo 605	0,07
Zincplating + Tuflok 2 - 360 degrees	0,13
Zincplating + Tuflok 2 - 360 degrees + wax Gleitmo 605	0,08

Correction factors for screws and nuts

Screws with countersunk head: Due to the size of the contact surface and the sinking angle, these screws, meet a larger friction force contact surfaces and therefore require that the tightening torque is increased with approx. 30%.

Stud screws: For assembly of stud screw joints it is first required to fasten the end of the goods into the threaded hole, and then the joint's nut is tightened. When fastening the end of the goods the torque does not need to overcome friction against any contact surface. In line with what has been said about the distribution of the tightening torque, you could calculate with approximately half of the torque required for pre-stressing the screw through tightening the nut.

Collar screws and collar nuts: Even these have a larger contact surface than ordinary screws and nuts, and consequently a greater friction radius, which leads to that the tightening torque has to be increased with approx. 10%.

Set screws: When assembling set screws no friction against any contact surface has to be overcomed. However the bedding's resistance against the screws end must be overcomed. The screw's end design and the bedding's shape (plane or cylindrical surface, pre-drilled hole etc) will effect, but the required torque is 50% - 70% of what is required for ordinary screws. Set screws with point requires the lower torque, while set screws with chamfered, plane, or cupped ends have larger friction radius and therefore require the higher torque.

Table 102 Tightening torques in Nm for locking nuts

Tightening torques according to DIN 267/15 for locking nuts according to DIN 6925, ISO 7042. Clamping part according to DIN 267/15.

	class 8	class 10 and 12		class 8	class 10 and 12
M3	0,43	0,6	M18	42,0	56,0
M4	0,9	1,2	M20	54,0	72,0
M5	1,6	2,1	M22	68,0	90,0
M6	3,0	4,0	M24	80,0	106,0
M8	6,0	8,0	M27	94,0	123,0
M10	10,5	14,0	M30	108,0	140,0
M12	15,5	21,0	M33	122,0	160,0
M14	24,0	31,0	M36	136,0	180,0
M16	32,0	42,0	M39	150,0	200,0

Table 103 Tightening torque for Brass

Thread *d*	**M2**	**M2,5**	**M3**	**M3,5**	**M4**	**M5**	**M6**	**M8**	**M10**
M_A max [Nm]	0,14	0,28	0,5	0,79	1,2	2,2	3,9	9	17

For more information regarding tightening torques for fasteners in brass, copper and aluminium, please refer to min. breaking torque on page 217 table 197.

Table 104 Tightening torque for Copper

Thread *d*	**M4**	**M5**	**M6**	**M8**	**M10**	**M12**
F_V (N)	3000	5550	7800	14300	22800	33400
M_A max [Nm]	2,4	4,7	8	19	39	67

For more information regarding tightening torques for fasteners in brass, copper and aluminium, please refer to min. breaking torque on page 217 table 197.

Table 105 Tightening torque for Nylon, Polyamide 6.6

Thread *d*	**M3**	**M4**	**M5**	**M6**	**M8**	**M10**	**M12**	**M14**	**M16**
Screws M_A max [Nm]	0,1	0,2	0,5	1	2	3	4	6	7,5
Nuts M_A max [Nm]	0,1	0,3	0,6	1,5	3	4	5	7,5	9

Screw in thin plate jointing

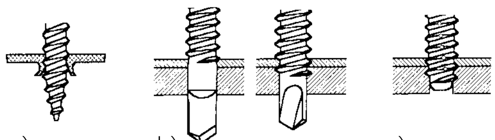
The most common fasteners for shaped plate are screws. Screws for plate joints can be divided into three groups:

- Penetrating screw.
- Drilling screw.
- Thread pressing screw.

Penetrating screw
The penetrating screw is provided with an elongated crest of thread, sometimes with double thread starts and with a relatively high pitch (see figure a).

The penetrating screw is aimed at a plate thickness of 1,0 mm maximum and is mainly used for indoor fixing of sheet material.

When using penetrating screw it has sometimes occurred cracking in the plate material. At dynamic loading penetrating screw also has a tendency of unscrewing itself out of the bedding. The drilling screw is therefore preferred for these kinds of constructions. When tightened into thin plate the screw should have a reduced bit point of drill and a low pitch.



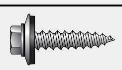
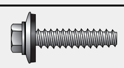
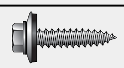
a) b) c)

Points for a) penetrating, b) drilling and c) thread pressing screw.

Drilling screw
For tightening into thicker materials a drilling screw is used. This type of screw is provided with a bit point of drill that entails that the drilling, forming of the thread and tightening is carried out in one stage (see figure b).
For tightening and joining of plate products there are a great number of variants for more or less all existing applications. These screws have a drill capacity between 1,0 mm and 12 mm.

Thread pressing screw
The thread pressing screw is the oldest type of structural steel sheet screw and requires preboring or prepunching of the material. The screw shape flows an inner thread by the screw threads pushing aside the material at the edge of the hole (see figure c).
Thread pressing screws can be found in three different performances according to table 207.

Table 207 Screw points for thread pressing screws

Screw point	Type	Fields of application
	A	wood bedding
	B	steel bedding > 3,0 mm
	C (AB)	steel bedding < 3,0 mm

When using thread pressing screw the bore diameter must be adjusted to the bedding's thickness for the thread shape flow to be optimal. The table below shows examples of recommendations.

Table 208 Examples of recommended bore diameter d_h for different material thickness t_l for 6,3 mm screw

Screw points	Thickness t_l	Bore diameter d_h
Type C, ϕ 6,3	1,0 - 2,0	5,05
	2,0 - 3,0	5,35
Type B, ϕ 6,3	4,0 - 6,0	5,65
	6,0 - 10	5,80
	>10	5,85
Type A, ϕ 6,4 (wood)		4,1

Assemblage of joint with penetrating-, drilling- or thread pressing screw
In joints with thin plate it is easy to tighten the screw too much, i.e. to screw the threads broken in the plate. To avoid this one should work with machines equipped with depth stop bolt or torque controlling.

Tightening of screw with sealing plates
Screws with sealing plates are not to be tightened so hard that the plates are damaged and so that the sealing function is not fulfilled. Both these demands are automatically fulfilled when assembling with a machine with depth stop bolt and manual tightening, which is stopped when the sealing has got the right compression. For torque controlled assembly on the other hand, the bore diameter needs to be selected so that the torque of the forming of the thread is not going to be larger than the torque of tightening, which is required to give the sealing plate the right compression. For thread pressing screws a screwdriver with depth stop bolt is the principal recommendation.

Screwdrivers
For thread pressing screw a low rotation screw driver (300-600 effective rotations per minute) with depth stop bolt is recommended. For drilling screw a screwdriver with 1500 to 2000 rotations per minute and depth stop bolt is recommended. For screws with release an infinitely variable drilling machine without depth stop bolt could be used.

Source: SBI.

Types of jointing in thin plate

Table 209 shows the fasteners which are usually used in joint and fastenings of thin plate constructions. For external plate in corrosive class C4, for example for uninsulated buildings, drilling or thread pressing screws are used with grommet with vulcanised EPDM-rubber under the screw head. Screws without sealing are used to fasten the supporting plate in insulated buildings.

Table 209 Examples of building screws for tightening into steel and wood

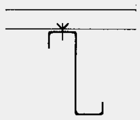
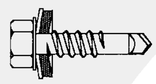
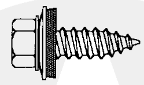
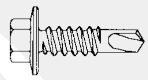
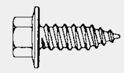
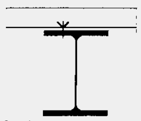
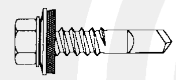
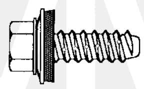
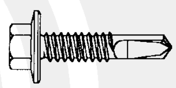
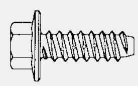
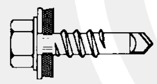
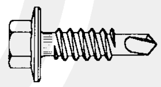
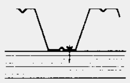
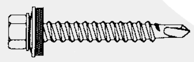
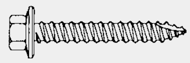
Fields of application	Outdoor, stainless steel, up to corrosive class C4 according to the table on page 611.		Indoor, zincplated carbonised steel, corrosive class C1 according to the table on page 611.	
	Drilling	Tapping screws	Drilling	Tapping screws
 Plate for light beam	 ϕ 4,8, 5,5 and 6,3	 ϕ 4,8 and 6,3 C-point	 ϕ 4,8, 5,5 and 6,3	 ϕ 4,8 and 6,3 C-point
 Plate for beam	 ϕ 5,5	 ϕ 6,3 B-point	 ϕ 5,5 and 6,3	 ϕ 6,3 B-point
 Plate for plate	 ϕ 4,8, 5,5 and 6,3		 ϕ 4,8, 5,5 and 6,3	
 Plate for wood	 ϕ 4,8, 5,5 (Lacquered carbonised steel, stainless, aluminium, C2-C4)	 ϕ 4,8, 6,5 A-point	 ϕ 4,8, 6,5	 ϕ 4,8, 5,5

Table 210 Material in fasteners with regards to corrosiveness and thin plate construction, with regards to the risk of corrosion only

Class of corrosive-ness	Material in thin plate construction	Material in fasteners					
		Aluminium	Zincplated and possibly chromate steel, film thickness ≥ 7µm	Hot dip galvanised steel[b], film thickness ≥ 45µm	Stainless steel, case-hardened (C1)[d, e]	Stainless steel (A2)[d] (A4)[d]	Monel[a]
C1	A, B, C	X	X	X	X	X	X
	D, E, R	X	X	X	X	X	X
C2	A	X	-	X	X	X	X
	C, D, E	X	-	X	X	X	X
	R	X	-	X	X	X	X
C3	A	X	-	X	-	X	X
	C, E	X	-	X	(X)[C]	(X)[C]	-
	D	X	-	X	-	(X)[C]	X
	R	-	-	X	X	X	X
C4	A	X	-	(X)[C]	-	(X)[C]	-
	D	-	-	X	-	(X)[C]	-
	E	X	-	X	-	(X)[C]	-
	R	-	-	X	-	X	X
C5-I[g)]	A	X	-	-	-	(X)[C]	-
	D[f]	-	-	X	-	(X)[C]	-
	R	-	-	-	-	X	-
C5-M[g)]	A	X	-	-	-	(X)[C]	-
	D[f]	-	-	X	-	(X)[C]	-
	R	-	-	-	-	X	-

Generally, fasteners of steel without coating can be used in class of corrosiveness C1.

A = Aluminium regardless of surface finish.
B = Bare steel plate.
C = Hot dip galvanised, Z275, or aluzinc coated, AZ150, steel plate.
D = Hot dip galvanised steel plate + coating of paint or plastic.
E = Aluzinc coated, AZ185, steel plate.
R = Stainless steel.
X = Type of material recommended with regards to corrosion.
(X) = Type of material recommended with regards to corrosion on given condition.

\- = Type of material is not recommended with regards to corrosion.
a = Only concerns rivet.
b = Only concern screw and nut.
c = Isolating washer of durable material between plate and fastener.
d = Stainless steel according to SS-EN 10 088.
e = Risk for tarnishing exists.
f = Plate material only after contact with the supplier.
g) = There are austenitic manganess steel which are stable in all classes of corrosiveness. In aggressive atmosphere C5-I and marine environment there should be an isolating washer between fastener and plate. Sometimes the corrosion resistance is increased further in marine environment through zincification of acidproof screws.

Source: SBI.

Guidance on the use of plain washers

Table 211 Guidance on the use of plain washers with screws and nuts

Washer	Hardness washer		min. 100 HV	min. 200 HV	min. 300 HV
Screw	Property class	≤ 6.8	yes	yes	yes
		8.8	no	yes	yes
		9.8	no	no	yes
		10.9	no	no	yes
		12.9	no	no	no
Nut	Property class	≤ 6	yes	yes	yes
		8	no	yes	yes
		9	no	no	yes
		10	no	no	yes
		12	no	no	no
Case-hardened thread rolling screws			yes	yes	yes
Stainless steel bolts, screws and nuts			–	yes	–

Shearing forces for different pins

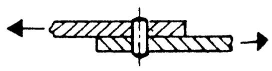
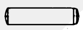
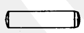
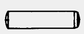
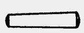
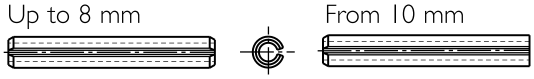


Table 29

				Force F in Newton (N)											Diameter									
Material	**Permitted Shearing force τ to in N/mm²**	**Standard**		**0,6**	**0,8**	**1**	**1,2**	**1,5**	**2**	**2,5**	**3**	**3,5**	**4**	**4,5**	**5**	**6**	**8**	**10**	**12**	**13**	**14**	**16**	**18**	**20**
9S Mn Pb 28 K Free cutting steel	<Ø 10~400 Ø 10-16~360 >Ø 16~320	CP ISO 2338 DIN 7		110	220	350	500	800	1400	2100	3050		5050		8250	11400	20250	31600	45000	49000	62000	78000		110000
		KP turned ISO 2339 DIN 1																						
1.0718		Grooved pin DIN 1470/1471/ 1472/1473/1474/ 1475			220	350	500	800	1400	2100	3050		5050		8250	11400	20250	31600	45000	49000	62000	78000		110000
St 60-2K 1.0060	<Ø 5~560 Ø 5-10~520 >Ø 10~490	KP grinded ISO 2339 DIN 1				440		990	1750	2750	3950		7030		10200	14700	26100	40820	55370					
		DIN 258 GKP													10200	14700	26100	40820	55370			98500		153800
		DIN 7977 GKP													10200	14700	26100	40820	55370			98500		153800
		DIN 7978 KPIG														14700	26100	40820	55370			98500		153800
Hardened steel HRC 58-62	~1500	DIN 6325 CPK						2650	4710	7360	10600		18840		29400	42400	75300	117700	169500		230800	301500		471000
Stainless 1.4305		CP ISO 2338 DIN 7		See resp. material (9 S Mn Pb 28K)																				
		KP ISO 2339 DIN 1																						

Spring pins acc. to ISO 8752

Up to 8 mm   From 10 mm

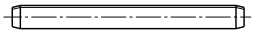


Material: Spring steel hardened and tempered to 420-560 HV.

Table 212

Nominal diameter mm	1	1,5	2	2,5	3	3,5	4	4,5	5	6	8	10	12	13	14	16	18	20
Shear force double lap joint min. kN	0,7	1,58	2,82	4,38	6,32	9,06	11,24	15,36	17,54	26,04	42,76	70,16	104,1	115,1	144,7	171	222,5	280,6

Spiral pins, medium duty acc. to ISO 8750

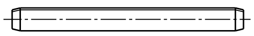


Material: Spring steel hardened and tempered to 420-545 HV.

Table 213

Nominal diameter mm	0,8	1	1,2	1,5	2	2,5	3	3,5	4	5	6	8	10	12	14	16	20
Shear force double lap joint min. kN	0,4	0,6	0,9	1,45	2,5	3,9	5,5	7,5	9,6	15	22	39	62	89	120	155	250

Spiral pins, heavy duty acc. to ISO 8748



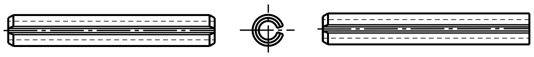
Material: Spring steel hardened and tempered to 420-545 HV.

Table 214

Nominal diameter mm	1,5	2	2,5	3	3,5	4	5	6	8	10	12	14	16	20
Shear force double lap joint min. kN	1,9	3,5	5,5	7,6	10	13,5	20	30	53	84	120	165	210	340

Spring pins, light duty acc. to ISO 13337

Up to 8 mm   From 10 mm

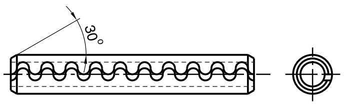


Material: Spring steel hardened and tempered to 420-560 HV.

Table 215

Nominal diameter mm	2	2,5	3	3,5	4	4,5	5	6	8	10	12	13	14	16	18	20
Shear force double lap joint min. kN	1,5	2,4	3,5	4,6	8,0	8,8	10,4	18	24	40	48	66	84	98	126	158

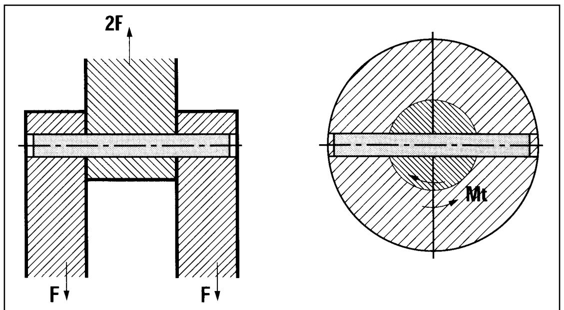
Connex type S



Material: Spring steel acc. to AISI 6150, hardened to 42-50 HRC.

Table 216

Nominal diameter mm	1	1,5	2	2,5	3	4	5	6	8	10	12	14	15	16	18	20
Shear force double lap joint min. kN	0,7	1,58	2,82	4,38	6,32	10,6	17,54	26,06	42,76	70,16	104,1	144,7	157,7	171	222,5	280,6



Double lap joint

Spring forces for washers

Table 30 DIN 127, DIN 128 type A, DIN 6913, DIN 7980 (Helical spring washers)

For screw	4	5	6	8	10	12	14	16	18
Pressing force [1] N	3050	5050	7050	12900	20600	30000	41300	56300	69000
Least remaining spring force N	600	1000	2100	3900	6200	9000	16500	22500	27600

For screw	20	22	24	27	30	33[2]	36
Pressing force [1] N	88000	110000	127000	167000	204000	255000	298000
Least remaining spring force N	35200	55000	63000	83000	102000	127000	149000

1) Corresponding to 6.8.
2) Is not valid for DIN 127, DIN 128 type A.

Table 31 DIN 137 type B (Spring washers, wavy)

For screw	4	5	6	7	8	10	12	14	16
Pressing force [1] N	2700	4000	6150	9000	11300	18000	26200	36100	49200
Least remaining spring force N	270	400	615	1350	1700	2700	3900	9000	12300

For screw	18	20	22	24	27	30	33	36
Pressing force [1] N	60000	78000	97000	111000	146000	178000	223000	261000
Least remaining spring force N	15000	19500	24200	27800	36500	44500	55700	65200

1) Corresponding to 5.8.

Table 32 DIN 6796 (Conical spring washers)

For screw	4	5	6	7	8	10	12	14	16
Pressing force [1] N	4050	6700	9400	13700	17200	27500	40000	55000	75000
Least remaining spring force N	1400	2300	4200	6200	7700	12400	18000	25000	34000

For screw	18	20	22	24	27	30
Pressing force [1] N	95000	122000	152000	175000	230000	280000
Least remaining spring force N	57000	73000	91000	122000	161000	196000

1) Corresponding to 8.8.

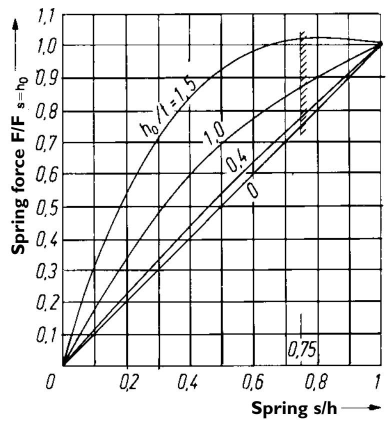
Spring forces for spring washer DIN 2093

Spring washer for static and dynamic load

Disc springs are especially suitable in designs where you have high forces but limited space. By stratifying the springs in different ways, you can obtain different forces and characteristics.
See below.

Single spring characteristics

When shifting (dynamic) load, the deflection should only be used up to 0,75·h_0. The diagram shows how the characteristics are affected by the relation between the maximum reflection and material thickness (h_0/t). Data on the relation can be found in the dimension tables.

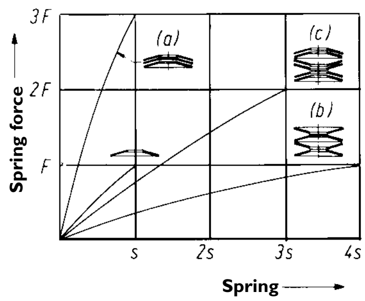


Characteristics for different combinations

a 3 parallel piled springs. Force according to the table, times the number of parallel springs.

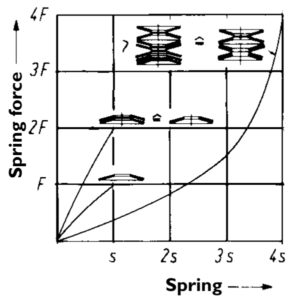
b Single piled springs. Force according to the table. Spring according to the table times the number of springs.

c 2 parallel piled springs in series. Force according to the table times the number of parallel springs (in this case 2). Spring h_0 times the number of series (in this case 3).

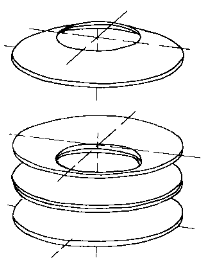


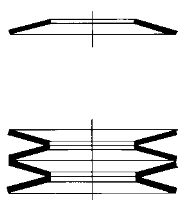
Progressive characteristic

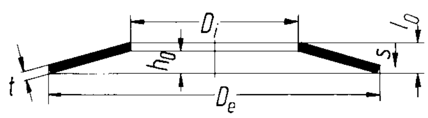
By stacking various numbers of springs with different thickness, you can obtain varied progressive spring graphs.



D_e = Outside diameter
D_i = Hole diameter
t = Goods thickness
l_0 = Non-loaded length
h_0 = Cup height = max. spring
s = Spring
F = Spring force in N
1 kp = 9,80665 N
1 N = 0,10197 kp



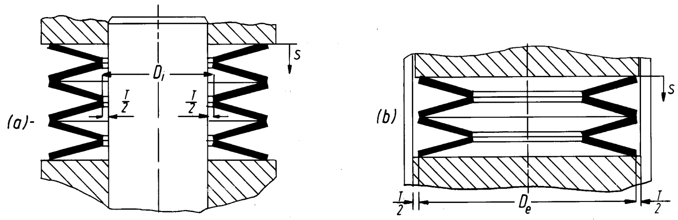




Spring control

a/Internal b/External

D_i or D_a mm			Play T mm
	–	16	0,2
> 16	–	20	0,3
> 20	–	26	0,4
> 6	–	31,5	0,5
> 31,5	–	50	0,6
> 50	–	80	0,8
> 80	–	140	1,0
> 140	–	150	1,6
>	–	250	2,0



Spring force for stainless materials: ~Table value - 12%

Table 30 Spring forces for spring washer DIN 2093

Dimension mm						F = Spring force in Newton				s = Spring			
						s = 0,25 h_0		s = 0,50 h_0		s = 0,75 h_0		s = 1,0 h_0	
D_e	D_i	t	l_0	h_0	h_0/t	s	F	s	F	s	F	s	F
8	3,2	0,3	0,55	0,25	0,833	0,062	45,6	0,125	79,1	0,187	104,3	0,25	125,5
8	3,2	0,4	0,6	0,2	0,5	0,05	69,2	0,1	130,1	0,15	185,5	0,2	238
8	3,2	0,5	0,7	0,2	0,4	0,05	128,4	0,1	246,4	0,15	357,4	0,2	464,9
8	4,2	0,2	0,45	0,25	1,25	0,062	21,2	0,125	33,3	0,187	39,2	0,25	42
8	4,2	0,3	0,55	0,25	0,833	0,062	51,6	0,125	89,3	0,187	117,9	0,25	141,8
8	4,2	0,4	0,6	0,2	0,5	0,05	78,2	0,1	147	0,15	209,5	0,2	268,9
10	3,2	0,3	0,65	0,35	1,166	0,087	51,1	0,175	81,6	0,262	98,3	0,35	108
10	3,2	0,4	0,7	0,3	0,75	0,075	75,1	0,15	132,9	0,225	179,1	0,3	219,6
10	3,2	0,5	0,85	0,35	0,7	0,087	165,3	0,175	296,1	0,262	404	0,35	500,4
10	4,2	0,4	0,7	0,3	0,75	0,075	79,3	0,15	140,3	0,225	189,1	0,3	231,8
10	4,2	0,5	0,75	0,25	0,5	0,062	109,8	0,125	206,3	0,187	294	0,25	377,3
10	4,2	0,6	0,85	0,25	0,416	0,062	181,5	0,125	347,2	0,187	502,3	0,25	652
10	5,2	0,25	0,55	0,3	1,2	0,075	30,4	0,15	48,2	0,225	57,5	0,3	62,6
10	5,2	0,4	0,7	0,3	0,75	0,075	87,8	0,15	155,3	0,225	209,3	0,3	256,5
10	5,2	0,5	0,75	0,25	0,5	0,062	121,5	0,125	228,3	0,187	325,3	0,25	417,5
12	4,2	0,4	0,8	0,4	1,0	0,1	85,1	0,2	141,4	0,3	178,3	0,4	205,6
12	4,2	0,5	0,9	0,4	0,8	0,1	142,6	0,2	249	0,3	331,4	0,4	401,7
12	4,2	0,6	1,0	0,4	0,666	0,1	224,1	0,2	404,9	0,3	556,8	0,4	694,1
12	5,2	0,5	0,9	0,4	0,8	0,1	150,4	0,2	262,7	0,3	349,6	0,4	423,8
12	5,2	0,6	0,95	0,35	0,583	0,087	195,9	0,175	361,2	0,262	506,1	0,35	640,7
12	6,2	0,5	0,85	0,35	0,7	0,087	133,5	0,175	239,2	0,262	326,4	0,35	404,2
12	6,2	0,6	0,95	0,35	0,583	0,087	213,6	0,175	393,8	0,262	551,7	0,35	698,5
12,5	6,2	0,35	0,8	0,45	1,285	0,112	83,5	0,225	129,8	0,337	151,2	0,45	160,2
12,5	6,2	0,5	0,85	0,35	0,7	0,087	120	0,175	215,1	0,262	293,4	0,35	363,4
12,5	6,2	0,7	1,0	0,3	0,428	0,075	239,4	0,15	456,8	0,225	659,2	0,3	854,9
14	7,2	0,35	0,8	0,45	1,285	0,112	68	0,225	105,7	0,337	123,2	0,45	130,5
14	7,2	0,5	0,9	0,4	0,8	0,1	120,1	0,2	209,8	0,3	279,2	0,4	338,4
14	7,2	0,8	1,1	0,3	0,375	0,075	283,8	0,15	547,2	0,225	796,8	0,3	1040
15	5,2	0,4	0,95	0,55	1,375	0,137	101,2	0,275	154,4	0,412	175,5	0,55	180,7
15	5,2	0,5	1,0	0,5	1,0	0,125	132,8	0,25	220,6	0,375	278,2	0,5	320,9
15	5,2	0,6	1,05	0,45	0,75	0,112	170,8	0,225	302,1	0,337	407,2	0,45	499
15	5,2	0,7	1,25	0,55	0,785	0,137	340,2	0,275	596,4	0,412	796,5	0,55	968,6
15	6,2	0,5	1,0	0,5	1,0	0,125	138,1	0,25	229,4	0,375	289,4	0,5	333,7
15	6,2	0,6	1,05	0,45	0,75	0,112	177,6	0,225	314,2	0,337	423,5	0,45	519
15	6,2	0,7	1,1	0,4	0,571	0,1	222,4	0,2	411,1	0,3	577,5	0,4	732,6
15	8,2	0,7	1,1	0,4	0,571	0,1	256,3	0,2	473,9	0,3	665,6	0,4	844,4
15	8,2	0,8	1,2	0,4	0,5	0,1	366,8	0,2	689,3	0,3	982,3	0,4	1261
16	8,2	0,4	0,9	0,5	1,25	0,125	83,7	0,25	131,2	0,375	154,3	0,5	165,4
16	8,2	0,6	1,05	0,45	0,75	0,112	172	0,225	304,3	0,337	410	0,45	502,5
16	8,2	0,9	1,25	0,35	0,388	0,087	362,5	0,175	697	0,262	1013	0,35	1319
18	6,2	0,4	1,0	0,6	1,5	0,15	84,6	0,3	126,1	0,45	138,6	0,6	136,7
18	6,2	0,5	1,1	0,6	1,2	0,15	129,9	0,3	205,7	0,45	245,4	0,6	267
18	6,2	0,6	1,2	0,6	1,0	0,15	191,1	0,3	317,3	0,45	400,3	0,6	461,6
18	6,2	0,7	1,4	0,7	1,0	0,175	354,1	0,35	588	0,525	741,7	0,7	855,5
18	6,2	0,8	1,5	0,7	0,875	0,175	479,5	0,35	821,6	0,525	1072	0,7	1277
18	8,2	0,7	1,25	0,55	0,785	0,137	254,6	0,275	446,2	0,412	596	0,55	724,7
18	8,2	0,8	1,3	0,5	0,625	0,125	308,9	0,25	563,8	0,375	782,6	0,5	983,5
18	8,2	1,0	1,5	0,5	0,5	0,125	559	0,25	1051	0,375	1497	0,5	1921
18	9,2	0,45	1,05	0,6	1,333	0,15	120,7	0,3	185,8	0,45	213,7	0,6	222,9
18	9,2	0,7	1,2	0,5	0,714	0,125	233,4	0,25	416,6	0,375	566,4	0,5	699,4
18	9,2	1,0	1,4	0,4	0,4	0,1	450,6	0,2	885	0,3	1254	0,4	1631
20	8,2	0,5	1,15	0,65	1,3	0,162	128,3	0,325	198,8	0,487	230,8	0,65	243,4
20	8,2	0,6	1,3	0,7	1,166	0,175	214,4	0,35	342,1	0,525	412	0,7	453
20	8,2	0,7	1,35	0,65	0,928	0,162	261,5	0,325	442	0,487	568,5	0,65	668
20	8,2	0,8	1,4	0,6	0,75	0,15	315	0,3	557,3	0,45	751	0,6	920,5
20	8,2	0,9	1,5	0,6	0,666	0,15	423,2	0,3	764,5	0,45	1051	0,6	1311
20	8,2	1,0	1,6	0,6	0,6	0,15	555,6	0,3	1020	0,45	1424	0,6	1789
20	10,2	0,4	0,9	0,5	1,25	0,125	53,4	0,25	83,7	0,375	98,5	0,5	105,5
20	10,2	0,5	1,15	0,65	1,3	0,162	141,3	0,325	218,9	0,487	254,1	0,65	268
20	10,2	0,8	1,35	0,55	0,687	0,137	304,3	0,275	546,8	0,412	748,2	0,55	929
20	10,2	0,9	1,45	0,55	0,611	0,137	411,7	0,275	754	0,412	1050	0,55	1323
20	10,2	1,0	1,55	0,55	0,55	0,137	543,6	0,275	1010	0,412	1425	0,55	1815
20	10,2	1,1	1,55	0,45	0,409	0,112	548,2	0,225	1050	0,337	1521	0,45	1976
22,5	11,2	0,6	1,4	0,8	1,333	0,2	240,4	0,4	369,9	0,6	425,4	0,8	443,9
22,5	11,2	0,8	1,45	0,65	0,812	0,162	306,3	0,325	533,4	0,487	707,4	0,65	855,1
22,5	11,2	1,25	1,75	0,5	0,4	0,125	693,1	0,25	1330	0,375	1929	0,5	2509
23	8,2	0,7	1,5	0,8	1,142	0,2	279,4	0,4	448,4	0,6	543,6	0,8	601,9
23	8,2	0,8	1,55	0,75	0,937	0,187	332	0,375	560	0,562	718,5	0,75	842,4
23	8,2	0,9	1,7	0,8	0,888	0,2	485,7	0,4	829,2	0,6	1078	0,8	1279
23	10,2	0,9	1,65	0,75	0,833	0,187	463,1	0,375	801,9	0,562	1058	0,75	1273
23	10,2	1,0	1,7	0,7	0,7	0,175	538,2	0,35	964,2	0,525	1315	0,7	1629
23	12,2	1,0	1,6	0,6	0,6	0,15	474,7	0,3	871,7	0,45	1217	0,6	1536

Table 30 Spring forces for spring washer DIN 2093

Dimension mm						F = Spring force in Newton				s =Spring			
						s = 0,25 h_0		s = 0,50 h_0		s = 0,75 h_0		s = 1,0 h_0	
D_e	D_l	t	l_0	h_0	h_0/t	s	F	s	F	s	F	s	F
23	12,2	1,25	1,85	0,6	0,48	0,15	863,4	0,3	1630	0,45	2331	0,6	3000
23	12,2	1,5	2,1	0,6	0,4	0,15	1432	0,3	2748	0,45	3986	0,6	5184
25	12,2	0,7	1,6	0,9	1,285	0,225	331,2	0,45	514,6	0,675	599,6	0,9	635,4
25	12,2	0,9	1,6	0,7	0,777	0,175	366,8	0,35	644,3	0,525	862,3	0,7	1050
25	12,2	1,5	2,05	0,55	0,366	0,137	1040	0,275	2007	0,412	2926	0,55	3821
28	10,2	0,8	1,75	0,95	1,187	0,237	347,9	0,475	552,5	0,712	661,5	0,95	722,7
28	10,2	1,0	2,0	1,0	1,0	0,25	615,2	0,5	1022	0,75	1289	1,0	1486
28	10,2	1,25	2,25	1,0	0,8	0,25	1030	0,5	1799	0,75	2394	1,0	2902
28	10,2	1,5	2,2	0,7	0,466	0,175	1003	0,35	1899	0,525	2723	0,7	3511
28	12,2	1,0	1,95	0,95	0,95	0,237	589,9	0,475	991,7	0,712	1268	0,95	1482
28	12,2	1,25	2,1	0,85	0,68	0,212	843,8	0,425	1519	0,637	2083	0,85	2590
28	12,2	1,5	2,25	0,75	0,5	0,187	1149	0,375	2159	0,562	3077	0,75	3949
28	14,2	0,8	1,8	1,0	1,25	0,25	434,8	0,5	681	0,75	801,4	1,0	858,2
28	14,2	1,0	1,8	0,8	0,8	0,2	476,4	0,4	832	0,6	1107	0,8	1342
28	14,2	1,25	2,1	0,85	0,68	0,212	907,4	0,425	1634	0,637	2240	0,85	2785
28	14,2	1,5	2,15	0,65	0,433	0,162	1033	0,325	1970	0,487	2841	0,65	3680
31,5	16,3	0,8	1,85	1,05	1,312	0,262	384,3	0,525	593,8	0,787	686,8	1,05	721,6
31,5	16,3	1,25	2,15	0,9	0,72	0,225	790,5	0,45	1409	0,675	1913	0,9	2359
31,5	16,3	1,5	2,4	0,9	0,6	0,225	1260	0,45	2314	0,675	3230	0,9	4077
31,5	16,3	1,75	2,45	0,7	0,4	0,175	1391	0,35	2669	0,525	3871	0,7	5036
31,5	16,3	2,0	2,75	0,75	0,375	0,187	2199	0,375	4239	0,562	6173	0,75	8054
34	12,3	1,0	2,2	1,2	1,2	0,3	587,2	0,6	930	0,9	1110	1,2	1208
34	12,3	1,25	2,45	1,2	0,96	0,3	946,4	0,6	1587	0,9	2024	1,2	2359
34	12,3	1,5	2,7	1,2	0,8	0,3	1447	0,6	2527	0,9	3363	1,2	4076
34	14,3	1,25	2,4	1,15	0,92	0,287	912,8	0,575	1546	0,862	1993	1,15	2347
34	14,3	1,5	2,55	1,05	0,7	0,262	1224	0,525	2192	0,787	2990	1,05	3704
34	16,3	1,5	2,55	1,05	0,7	0,262	1291	0,525	2313	0,787	3155	1,05	3908
34	16,3	2,0	2,85	0,85	0,425	0,212	2097	0,425	4003	0,637	5783	0,85	7498
35,5	18,3	0,9	2,05	1,15	1,277	0,287	457,7	0,575	712,4	0,862	831,9	1,15	883,8
35,5	18,3	1,25	2,25	1,0	0,8	0,25	730,9	0,5	1277	0,75	1699	1,0	2059
35,5	18,3	2,0	2,8	0,8	0,4	0,2	1864	0,4	3576	0,6	5187	0,8	6747
40	14,3	1,25	2,65	1,4	1,12	0,35	904,1	0,7	1459	1,05	1780	1,4	1984
40	14,3	1,5	2,8	1,3	0,866	0,325	1188	0,65	2040	0,975	2668	1,3	3184
40	14,3	1,75	3,05	1,3	0,742	0,325	1722	0,65	3051	0,975	4119	1,3	5056
40	14,3	2,0	3,05	1,05	0,525	0,262	1800	0,525	3363	0,787	4769	1,05	6096
40	16,3	1,5	2,8	1,3	0,866	0,325	1224	0,65	2102	0,975	2749	1,3	3281
40	16,3	1,75	3,1	1,35	0,771	0,337	1881	0,675	3309	1,012	4435	1,35	5410
40	16,3	2,0	3,1	1,1	0,55	0,275	1972	0,55	3663	0,825	5169	1,1	6580
40	18,3	2,0	3,15	1,15	0,575	0,287	2182	0,575	4030	0,862	5656	1,15	7171
40	20,4	1,0	2,3	1,3	1,3	0,325	565,3	0,65	875,8	0,975	1017	1,3	1072
40	20,4	1,5	2,65	1,15	0,766	0,287	1109	0,575	1953	0,862	2621	1,15	3201
40	20,4	2,0	3,1	1,1	0,55	0,275	2175	0,55	4041	0,825	5701	1,1	7258
40	20,4	2,25	3,15	0,9	0,4	0,225	2336	0,45	4481	0,675	6500	0,9	8456
40	20,4	2,5	3,45	0,95	0,38	0,237	3351	0,475	6453	0,712	9390	0,95	12243
45	22,4	1,25	2,85	1,6	1,28	0,4	1041	0,8	1620	1,2	1891	1,6	2007
45	22,4	1,75	3,05	1,3	0,742	0,325	1524	0,65	2701	0,975	3646	1,3	4475
45	22,4	2,5	3,5	1,0	0,4	0,25	2773	0,5	5320	0,75	7716	1,0	10037
48	16,3	1,5	3,0	1,5	1,0	0,375	1048	0,75	1740	1,125	2195	1,5	2531
50	18,4	1,25	2,85	1,6	1,28	0,4	756,9	0,8	1178	1,2	1375	1,6	1459
50	18,4	1,5	3,15	1,65	1,1	0,412	1166	0,825	1890	1,237	2319	1,65	2600
50	18,4	2,0	3,65	1,65	0,825	0,412	2229	0,825	3868	1,237	5114	1,65	6163
50	18,4	2,5	4,15	1,65	0,66	0,412	3870	0,825	7002	1,237	9643	1,65	12038
50	18,4	3,0	4,2	1,2	0,4	0,3	4179	0,6	8018	0,9	11630	1,2	15128
50	20,4	2,0	3,5	1,5	0,75	0,375	1966	0,75	3478	1,125	4687	1,5	5745
50	20,4	2,5	3,85	1,35	0,54	0,337	3008	0,675	5601	1,012	7919	1,35	10098
50	22,4	2,0	3,6	1,6	0,8	0,4	2247	0,8	3924	1,2	5222	1,6	6329
50	22,4	2,5	3,9	1,4	0,56	0,35	3261	0,7	6044	1,05	8510	1,4	10817
50	25,4	1,25	2,85	1,6	1,28	0,4	853,7	0,8	1328	1,2	1550	1,6	1646
50	25,4	1,5	3,1	1,6	1,066	0,4	1242	0,8	2028	1,2	2512	1,6	2844
50	25,4	2,0	3,4	1,4	0,7	0,35	1949	0,7	3491	1,05	4762	1,4	5898
50	25,4	2,25	3,75	1,5	0,666	0,375	2905	0,75	5249	1,125	7217	1,5	8997
50	25,4	2,5	3,9	1,4	0,56	0,35	3473	0,7	6347	1,05	9063	1,4	11519
50	25,4	3,0	4,1	1,1	0,366	0,275	4255	0,55	8214	0,825	11976	1,1	15640
56	28,5	1,5	3,45	1,95	1,3	0,487	1458	0,975	2559	1,462	2622	1,95	2766
56	28,5	2,0	3,6	1,6	0,8	0,4	1910	0,8	3335	1,2	4438	1,6	5379
56	28,5	2,5	4,2	1,7	0,68	0,424	3638	0,85	6550	1,275	8978	1,7	11164
56	28,5	3,0	4,3	1,3	0,433	0,325	4142	0,65	7895	0,975	11388	1,3	14752
60	20,5	2,0	4,2	2,2	1,1	0,55	2528	1,1	4097	1,65	5026	2,2	5636
60	20,5	2,5	4,7	2,2	0,88	0,55	4151	1,1	7102	1,65	9255	2,2	11008
60	20,5	3,0	5,2	2,2	0,733	0,55	6434	1,1	11429	1,65	15465	2,2	19022
60	25,5	2,5	4,4	1,9	0,76	0,475	3447	0,95	6081	1,425	8175	1,9	9997
60	25,5	3,0	4,65	1,65	0,55	0,412	4495	0,825	8352	1,237	11784	1,65	15002

Table 30 Spring forces for spring washer DIN 2093

Dimension mm						F = Spring force in Newton s = 0,25 h_0		s = 0,50 h_0		s = Spring s = 0,75 h_0		s = 1,0 h_0	
D_e	D_i	t	l_0	h_0	h_0/t	s	F	s	F	s	F	s	F
60	30,5	2,5	4,5	2,0	0,8	0,5	4059	1,0	7088	1,5	9432	2,0	11433
60	30,5	2,75	4,75	2,0	0,727	0,5	5125	1,0	9177	1,5	12356	2,0	15217
60	30,5	3,0	4,7	1,7	0,566	0,425	5083	0,85	9407	1,275	13226	1,7	16792
60	30,5	3,5	5,0	1,5	0,428	0,375	6591	0,75	12574	1,125	18153	1,5	23528
63	31	1,8	4,15	2,35	1,305	0,587	2364	1,175	3658	1,762	4238	2,35	4463
63	31	2,5	4,25	1,75	0,7	0,437	2942	0,875	5270	1,312	7189	1,75	8904
63	31	3,0	4,7	1,7	0,566	0,425	4524	0,85	8373	1,275	11772	1,7	14946
63	31	3,5	4,9	1,4	0,4	0,35	5399	0,7	10359	1,05	15025	1,4	19545
70	24,5	3,0	5,3	2,3	0,766	0,575	5080	1,15	8948	1,725	12007	2,3	14663
70	24,5	3,5	6,0	2,5	0,714	0,625	8446	1,25	15076	1,875	20495	2,5	25309
70	25,5	2,0	4,5	2,5	1,25	0,625	2408	1,25	3771	1,875	4437	2,5	4755
70	30,5	2,5	4,9	2,4	0,96	0,6	3755	1,2	6297	1,8	8031	2,4	9360
70	30,5	3,0	5,1	2,1	0,7	0,525	4676	1,05	8376	1,575	11426	2,1	14152
70	35,5	3,0	5,1	2,1	0,7	0,525	5028	1,05	9007	1,575	12287	2,1	15218
70	35,5	3,5	5,3	1,8	0,514	0,45	6077	0,9	11384	1,35	16177	1,8	20714
70	35,5	4,0	5,8	1,8	0,45	0,45	8757	0,9	16634	1,35	23923	1,8	30919
70	35,5	4,0	5,8	1,8	0,45	0,45	9167	0,9	17018	1,35	23923	2,05	33656
70	40,5	4,0	5,7	1,7	0,425	0,425	9025	0,85	17230	1,275	24889	1,7	32274
70	40,5	4,0	5,7	1,7	0,425	0,425	9423	0,85	17604	1,275	24889	1,95	35467
70	40,5	5,0	6,4	1,4	0,28	0,35	13646	0,7	26719	1,05	39410	1,4	51911
70	40,5	5,0	6,4	1,4	0,28	0,35	14004	0,7	27059	1,05	39410	1,7	61324
71	36	2,0	4,6	2,6	1,3	0,65	2861	1,3	4432	1,95	5144	2,6	5426
71	36	2,5	4,5	2,0	0,8	0,5	2894	1,0	5054	1,5	6725	2,0	8152
71	36	4,0	5,6	1,6	0,4	0,4	7379	0,8	14157	1,2	20535	1,6	26712
71	36	4,0	5,6	1,6	0,4	0,4	7685	0,8	1445	1,2	20535	1,85	29661
80	30,5	2,5	5,3	2,8	1,12	0,7	3664	1,4	5911	2,1	7211	2,8	8039
80	31	3,0	5,5	2,5	0,833	0,625	4531	1,25	7847	1,875	10352	2,5	12451
80	31	4,0	6,1	2,1	0,525	0,525	7319	1,05	13677	1,575	19394	2,1	24791
80	31	4,0	6,1	2,1	0,525	0,525	7717	1,05	14049	1,575	19394	2,35	26327
80	35,5	4,0	6,2	2,2	0,55	0,55	8118	1,1	15083	1,65	21280	2,2	27093
80	35,5	4,0	6,2	2,2	0,55	0,55	8577	1,1	15512	1,65	21280	2,45	28564
80	36	3,0	5,7	2,7	0,9	0,675	5401	1,35	9196	2,025	11919	2,7	14106
80	41	2,25	5,2	2,95	1,311	0,737	3698	1,475	5715	2,212	6613	2,95	6950
80	41	3,0	5,3	2,3	0,766	0,575	4450	1,15	7838	1,725	10518	2,3	12844
80	41	4,0	6,2	2,2	0,55	0,55	8726	1,1	16213	1,65	22874	2,2	29122
80	41	4,0	6,2	2,2	0,55	0,55	9220	1,1	16674	1,65	22874	2,45	30703
80	41	5,0	6,7	1,7	0,34	0,425	11821	0,85	22928	1,275	33559	1,7	43952
80	41	5,0	6,7	1,7	0,34	0,425	12211	0,85	23296	1,275	33559	2,0	50035
90	46	2,5	5,7	3,2	1,28	0,8	4232	1,6	6585	2,4	7684	3,2	8157
90	46	3,5	6,0	2,5	0,714	0,625	5836	1,25	10416	1,875	14161	2,5	17487
90	46	5,0	7,0	2,0	0,4	0,5	11267	1,0	21617	1,5	31354	2,0	40786
90	46	5,0	7,0	2,0	0,4	0,5	11713	1,0	22035	1,5	31354	2,3	45141
100	41	4,0	7,2	3,2	0,8	0,8	8715	1,6	15219	2,4	20251	3,2	24547
100	41	4,0	7,2	3,2	0,8	0,8	9215	1,6	15683	2,4	20251	3,4	24574
100	41	5,0	7,75	2,75	0,55	0,687	12345	1,375	22937	2,062	32361	2,75	41201
100	41	5,0	7,75	2,75	0,55	0,687	13013	1,375	23561	2,062	32361	3,05	43381
100	51	2,7	6,2	3,5	1,296	0,875	4779	1,75	7410	2,625	8609	3,5	9091
100	51	3,5	6,3	2,8	0,8	0,7	5624	1,4	9823	2,1	13070	2,8	15843
100	51	4,0	7,0	3,0	0,75	0,75	8673	1,5	15341	2,25	20674	3,0	25338
100	51	4,0	7,0	3,0	0,75	0,75	9156	1,5	15789	2,25	20674	3,2	25555
100	51	5,0	7,8	2,8	0,56	0,7	13924	1,4	25810	2,1	36339	2,8	46189
100	51	5,0	7,8	2,8	0,56	0,7	14689	1,4	26525	2,1	36339	3,1	48503
100	51	6,0	8,2	2,2	0,366	0,55	17061	1,1	32937	1,65	48022	2,2	62711
100	51	6,0	8,2	2,2	0,366	0,55	17753	1,1	33589	1,65	48022	2,6	71153
100	51	7,0	9,2	2,2	0,314	0,55	27374	1,1	52454	1,65	75840	2,65	115982
112	57	3,0	6,9	3,9	1,3	0,975	5834	1,95	9038	2,925	10489	3,9	11064
112	57	4,0	7,2	3,2	0,8	0,8	7639	1,6	13341	2,4	17752	3,2	21518
112	57	4,0	7,2	3,2	0,8	0,8	8192	1,6	13855	2,4	17752	3,45	21468
112	57	6,0	8,5	2,5	0,416	0,625	15800	1,25	30215	1,875	43707	2,5	56737
112	57	6,0	8,5	2,5	0,416	0,625	16536	1,25	30906	1,875	43707	2,9	62863
125	51	4,0	8,5	4,5	1,125	1,125	10096	2,25	16265	3,375	19817	4,5	22060
125	51	4,0	8,5	4,5	1,125	1,125	10705	2,25	16830	3,375	19817	4,7	21268
125	51	5,0	8,9	3,9	0,78	0,975	13063	1,95	22931	2,925	30669	3,9	37342
125	51	5,0	8,9	3,9	0,78	0,975	13804	1,95	23619	2,925	30669	4,15	37492
125	51	6,0	9,4	3,4	0,566	0,85	17027	1,7	31514	2,55	44307	3,4	56254
125	51	6,0	9,4	3,4	0,566	0,85	17944	1,7	32369	2,55	44307	3,75	58923
125	61	5,0	9,0	4,0	0,8	1,0	14615	2,0	25526	3,0	33965	4,0	41170
125	61	5,0	9,0	4,0	0,8	1,0	15455	2,0	26305	3,0	33965	4,25	41217
125	61	6,0	9,6	3,6	0,6	0,9	19789	1,8	36336	2,7	50722	3,6	64028
125	61	6,0	9,6	3,6	0,6	0,9	21079	1,8	37539	2,7	50722	4,0	66696
125	61	8,0	10,9	2,9	0,362	0,725	34434	1,45	65305	2,175	93577	3,4	138144
125	64	3,5	8,0	4,5	1,285	1,125	8514	2,25	13231	3,375	15416	4,5	16335

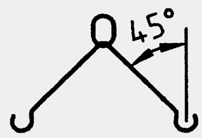
Table 30 Spring forces for spring washer DIN 2093

Dimension mm						F = Spring force in Newton				s = Spring			
						s = 0,25 h_0		s = 0,50 h_0		s = 0,75 h_0		s = 1,0 h_0	
D_e	D_i	t	l_0	h_0	h_0/t	s	F	s	F	s	F	s	F
125	64	5,0	8,5	3,5	0,7	0,875	12238	1,75	21924	2,625	29908	3,5	37041
125	64	5,0	8,5	3,5	0,7	0,875	13031	1,75	22661	2,625	29908	3,8	37673
125	64	6,0	9,6	3,6	0,6	0,9	20348	1,8	37362	2,7	52155	3,6	65836
125	64	6,0	9,6	3,6	0,6	0,9	21674	1,8	38599	2,7	52155	4,0	68579
125	64	7,0	10	3,0	0,428	0,75	25528	1,5	47615	2,25	67216	3,45	95795
125	64	8,0	10,6	2,6	0,325	0,65	31118	1,3	59520	1,95	85926	3,1	129972
125	71	6,0	9,3	3,3	0,55	0,825	19538	1,65	36302	2,475	51217	3,3	65207
125	71	6,0	9,3	3,3	0,55	0,825	20725	1,65	37411	2,475	51217	3,7	68887
125	71	8,0	10,9	2,9	0,362	0,725	38416	1,45	72705	2,175	103964	3,45	154927
125	71	10	11,8	1,8	0,18	0,45	42821	0,9	84082	1,35	124124	2,5	223282
140	72	3,8	8,7	4,9	1,289	1,225	9514	2,45	14773	3,675	17195	4,9	18199
140	72	5,0	9,0	4,0	0,8	1,0	12014	2,0	20982	3,0	27920	4,0	33843
140	72	5,0	9,0	4,0	0,8	1,0	12847	2,0	21756	3,0	27920	4,3	33792
140	72	8,0	11,2	3,2	0,4	0,8	31903	1,6	59967	2,4	85251	3,7	123137
150	61	5,0	10,3	5,3	1,06	1,325	15292	2,65	25021	3,975	31041	5,3	35207
150	61	5,0	10,3	5,3	1,06	1,325	16221	2,65	25883	3,975	31041	5,55	34160
150	61	6,0	10,8	4,8	0,8	1,2	19560	2,4	34161	3,6	45456	4,8	55098
150	61	6,0	10,8	4,8	0,8	1,2	20684	2,4	35204	3,6	45456	5,1	55161
150	61	7,0	11,8	4,8	0,685	1,2	30593	2,4	53294	3,6	70442	5,25	89248
150	71	6,0	10,85	4,85	0,808	1,212	21067	2,425	36714	3,637	48749	4,85	58978
150	71	6,0	10,85	4,85	0,808	1,212	22703	2,425	38235	3,637	48749	5,25	58662
150	71	8,0	12,05	4,05	0,506	1,012	35885	2,025	65655	3,037	91060	4,55	124679
150	81	8,0	12	4,0	0,5	1,0	38230	2,0	70060	3,0	97319	4,5	133637
150	81	10	13,4	3,4	0,34	0,85	57601	1,7	109889	2,65	158300	4,0	236018
160	82	4,3	9,9	5,6	1,302	1,4	12162	2,8	18832	4,2	21843	5,6	23022
160	82	4,3	9,9	5,6	1,302	1,4	12653	2,8	19288	4,2	21843	5,75	22250
160	82	6,0	10,5	4,5	0,75	1,125	17203	2,25	30431	3,375	41008	4,5	50260
160	82	6,0	10,5	4,5	0,75	1,125	18496	2,25	31633	3,375	41008	4,9	50562
160	82	10	13,5	3,5	0,35	0,875	50547	1,75	96216	2,625	138331	4,1	204958
160	82	11	14,5	3,5	0,318	0,875	66678	1,75	127338	2,625	183518	4,3	284160
180	92	4,8	11	6,2	1,291	1,55	14646	3,1	22731	4,65	26442	6,2	27966
180	92	4,8	11	6,2	1,291	1,55	15352	3,1	23387	4,65	26442	6,4	26839
180	92	6,0	11,1	5,1	0,85	1,275	16558	2,55	28552	3,825	37502	5,1	44930
180	92	6,0	11,1	5,1	0,85	1,275	17866	2,55	29767	3,825	37502	5,5	44355
180	92	10	14	4,0	0,4	1,0	46850	2,0	88141	3,0	125417	4,6	180562
180	92	13	16,5	3,5	0,269	0,875	84574	1,75	163392	2,625	237883	4,4	381593
200	82	8	14,2	6,2	0,775	1,55	35519	3,1	60470	4,65	78034	6,7	95329
200	82	10	15,5	5,5	0,55	1,375	52053	2,75	94245	4,125	129445	6,1	173523
200	82	12	16,6	4,6	0,383	1,15	67868	2,3	128082	3,45	182737	5,35	266449
200	92	10	15,6	5,6	0,56	1,4	55657	2,8	100501	4,2	137688	6,2	183777
200	92	12	16,8	4,8	0,4	1,2	74572	2,4	140170	3,6	199269	5,55	287825
200	92	14	18,1	4,1	0,292	1,025	95817	2,05	184267	3,075	267227	5,05	418519
200	102	5,5	12,5	7,0	1,272	1,75	19817	3,5	30882	5,25	36111	7,0	38423
200	102	5,5	12,5	7,0	1,272	1,75	20659	3,5	31663	5,25	36111	7,2	37138
200	102	8	13,6	5,6	0,7	1,4	33367	2,8	57955	4,2	76378	6,1	96202
200	102	10	15,6	5,6	0,56	1,4	58756	2,8	106099	4,2	145357	6,2	194014
200	102	12	16,2	4,2	0,35	1,05	66983	2,1	127401	3,15	183020	4,95	272297
200	102	14	18,2	4,2	0,3	1,05	103986	2,1	199671	3,15	289181	5,15	450249
200	112	12	16,2	4,2	0,35	1,05	71671	2,1	136317	3,15	195830	4,95	291355
200	112	14	17,5	3,5	0,25	0,875	90576	1,75	175719	2,625	256758	4,45	418407
200	112	16	19,8	3,8	0,237	0,95	146464	1,9	284370	2,85	415725	5,0	699348
225	112	6,5	13,6	7,1	1,092	1,775	23582	3,55	37417	5,325	44580	7,4	48614
225	112	8	14,5	6,5	0,812	1,625	32870	3,25	55412	4,875	70749	7,0	85127
225	112	12	17	5,0	0,416	1,25	64497	2,5	120738	3,75	171016	5,75	244783
225	112	16	20,5	4,5	0,281	1,125	128407	2,25	247489	3,375	359590	5,6	569897
250	102	10	18	8,0	0,8	2,0	58157	4,0	98485	6,0	126387	8,6	152967
250	102	12	19	7,0	0,583	1,75	75052	3,5	134524	5,25	182962	7,75	242024
250	127	7	14,8	7,8	1,114	1,95	26895	3,9	42527	5,85	50466	8,1	54733
250	127	8	16	8,0	1,0	2,0	38439	4,0	61836	6,0	74819	8,5	83455
250	127	10	17	7,0	0,7	1,75	51871	3,5	90206	5,25	119053	7,6	149964
250	127	12	19,3	7,3	0,608	1,825	87633	3,65	156021	5,475	210806	8,05	275879
250	127	14	19,6	5,6	0,4	1,4	93239	2,8	175145	4,2	248828	6,5	360229
250	127	16	21,8	5,8	0,362	1,45	141529	2,9	267853	4,35	383017	6,9	570770

Permitted loads for lifting eyes

The table is valid for LT and LH
DIN 580 and DIN 582
SS 1915 and 1916

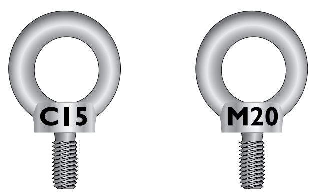
Table 37

Thread	Diameter	Thread	Diameter	Max load in kg 	Max load in kg 
	6*			70	50
	8		5/16*	140	100
	10		3/8*	230	170
	12		1/2*	340	240
	14*			490	340
	16		5/8*	700	500
	20		3/4*	1200	860
	22*			1500	1050
	24		1"*	1800	1290
	27*			2500	1650
M	30	UNC	1 1/4*	3200	2300
	33*			4300	3200
	36		1 1/2*	4600	3300
	42		1 3/4*	6300	4500
	45*			8000	5500
	48		2"*	8600	6100
	52*			9900	7300
	56			11500	8200
	64		2 1/2*	16000	11000
	72		3"*	20000	14000
	80			28000	20000
	100			40000	29000

* Recommended values, not according to standard.

N.B!

- Lifting eye screws and nuts must be screwed hard to the surface.
- When two lifting eye screws or nuts are used, their relative distance must be such as that the eyes are at the same level. Since they must be screwed hard to the surface, it may be necessary to put washers between flange and surface in order to get the eyes in the same level. A larger angle between the lifting straps than 90° is not allowed.
- Assembly is not permitted on a plane which is substantially divergent from a plane perpendicular to the lifting angle straight up.
- Maximum permitted load is only valid for lifting eyes manufactured according to the given standard, and if the assembly is performed according to the above.



Lifting eye bolts in steel and stainless steel stand the smallest breaking forces in axial tensile test according to the table below

Table 217 Min. breaking force

Thread	M8	M10	M12	M16	M20	M24	M30	M36
Min. breaking force kN	8,4	13,8	19,8	41,4	70,8	106	188	270

Thread	M42	M48	M56	M64	M72x6	M80x6	M100x6
Min. breaking force kN	372	504	678	942	1180	1650	2350

Source: DIN 580.

Clamping lengths for screws with M-thread

The clamping length L_l, can be calculated with the following formula:

L_l = l-m-2 (P+t)
l = nominal screw length
m = nut height
P = pitch of the thread
t = washer thickness

The clamping lengths are calculated with each screw according to below, normal nut, performance 1 and 2 round washers, product class A

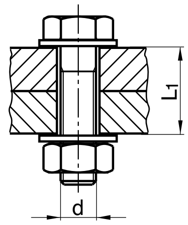


Table 89 Hexagon screw

Thread d	Clamping length L_l max.																	
	Nominal screw length l																	
	6	8	10	12	16	20	25	30	35	40	45	50	55	60	65	70	80	90	100
M3	1,5[1]	3,5[1]	5,5[1]	7,5[1]	11,5[1]	15,5[1]	20,5[1]	25,5[1]											
M4		1,6[1]	3,6[1]	5,6[1]	9,6[1]	13,6[1]	18,6[1]	23,6[1]	28,6[1]	33,6[1]									
M5			1,5	3,5	7,5	11,5	16,5	21,5	26,5	31,5	36,5[1]	41,5[1]							
M6				1,2	5,2	9,2	14,2	19,2	24,2	29,2	34,2	39,2	44,2[1]	49,2[1]					
M8					3,1	7,1	12,1	17,1	22,1	27,1	32,1	37,1	42,1	47,1	52,1	57,1[1]	67,1[1]		
M10						4,2	9,2	14,2	19,2	24,2	29,2	34,2	39,2	44,2	49,2	54,2	64,2	74,2	84,2
M12							5,3	10,3	15,3	20,3	25,3	30,3	35,3	40,3	45,3	50,3	60,3	70,3	80,3
M14								7,8	12,8	17,8	22,8	27,8	32,8	37,8	42,8	47,8	57,8	67,8	77,8
M16									9,6	14,6	19,6	24,6	29,6	34,6	39,6	44,6	54,6	64,6	74,6
M20										10,4	15,4	20,4	25,4	30,4	35,4	40,4	50,4	60,4	70,4
M24										3,9[1]	8,9[1]	13,9	18,9	23,9	28,9	33,9	43,9	53,9	63,9
M30											3,8[1]	8,8[1]	13,8[1]	18,8	23,8	28,8	38,8	48,8	58,8
M36													4,8[1]	9,8[1]	14,8[1]	19,8	29,8	39,8	49,8

Table 90 Hexagon socket head cap screw

Thread d	Clamping length L_l max.																	
	Nominal screw length l																	
	6	8	10	12	16	20	25	30	35	40	45	50	55	60	65	70	80	90	100
M3	1,5	3,5	5,5	7,5	11,5	15,5	20,5	25,5											
M4		1,6	3,6	5,6	9,6	13,6	18,6	23,6	28,6	33,6									
M5			1,5	3,5	7,5	11,5	16,5	21,5	26,5	31,5	36,5	41,5							
M6				1,2	5,2	9,2	14,2	19,2	24,2	29,2	34,2	39,2	44,2	49,2					
M8					3,1	7,1	12,1	17,1	22,1	27,1	32,1	37,1	42,1	47,1	52,1	57,1	67,1		
M10						4,2	9,2	14,2	19,2	24,2	29,2	34,2	39,2	44,2	49,2	54,2	64,2	74,2	84,2
M12							5,3	10,3	15,3	20,3	25,3	30,3	35,3	40,3	45,3	50,3	60,3	70,3	80,3
M14							2,8	7,8	12,8	17,8	22,8	27,8	32,8	37,8	42,8	47,8	57,8	67,8	77,8
M16								4,6	9,6	14,6	19,6	24,6	29,6	34,6	39,6	44,6	54,6	64,6	74,6
M20									5,4	10,4	15,4	20,4	25,4	30,4	35,4	40,4	50,4	60,4	70,4
M24										3,9	8,9	13,9	18,9	23,9	28,9	33,9	43,9	53,9	63,9
M30											3,8	8,8	13,8	18,8	23,8	28,8	38,8	48,8	58,8
M36													4,8	9,8	14,8	19,8	29,8	39,8	49,8

Table 91 Cross and slot screw with rounded head

Thread d	Clamping length L_l max.																	
	Nominal screw length l																	
	6	8	10	12	16	20	25	30	35	40	45	50	55	60	65	70	80	90	100
M3	1,5	3,5	5,5	7,5	11,5	15,5	20,5	25,5											
M4		1,6	3,6	5,6	9,6	13,6	18,6	23,6	28,6	33,6									
M5			1,5	3,5	7,5	11,5	16,5	21,5	26,5	31,5	36,5	41,5							
M6				1,2	5,2	9,2	14,2	19,2	24,2	29,2	34,2	39,2	44,2	49,2					
M8					3,1	7,1	12,1	17,1	22,1	27,1	32,1	37,1	42,1	47,1	52,1	57,1	67,1		
M10						4,2	9,2	14,2	19,2	24,2	29,2	34,2	39,2	44,2	49,2	54,2	64,2		

Table 92 Collar screw (with collar nut)

Thread d	Clamping length L_l max.																	
	Nominal screw length l																	
	10	12	16	20	25	30	35	40	45	50	55	60	65	70	80	90	100	
M3																		
M4																		
M5	3,4	5,4	9,4	13,4	18,4	23,4	28,4	33,4	38,4	43,4	48,4							
M6		4	8	12	17	22	27	32	37	42	47	52						
M8			5,5	9,5	14,5	19,5	24,5	29,5	34,5	39,5	44,5	49,5	54,5	59,5	69,5			
M10				7	12	17	22	27	32	37	42	47	52	57	67	77	87	
M12					9,5	14,5	19,5	24,5	29,5	34,5	39,5	44,5	49,5	54,5	64,5	74,5	84,5	
M14						12	17	22	27	32	37	42	47	52	62	72	82	
M16							15	20	25	30	35	40	45	50	60	70	90	
M20																		
M24																		
M30																		
M36																		

1) Only product class A and B.

Instructions for dimensioning of screw unions

To choose the right method of assembly is very important within jointing techniques. The choice of method directly influences the screw dimension that is needed, and is therefore an important parameter in the screw union calculation. In addition to the method of assembly, variations in for example the factors mentioned below influence the bias variation in a screw union.

- Machine spread (variations in the equipment).
- Operator error (managerial or reading error).
- Pulling speed.
- Coefficients of friction.
- Screw resistance.
- Geometrics.
- Surface finish.
- Flatness.

The most common method of assembly for screw unions is moment assembly. The screw is appropriately pulled to a determined priming speed grade; it should be situated within the screw's elastic area. In the elastic area there is no risk for any permanent extension of the screw.
In the following section there is a complement to earlier sections about tightening torque, priming speed grade and friction etc. that can be found on page 301 and after.

Contact surfaces friction

It is important to divide the fasteners friction. If the friction of the contact surface is decreased with 10%, the essential clamp power is increased by 10%.

In the table mentioned below you can find the guideline values for contact surface friction for some commonly occurring material combinations.

Table 231 Guideline values for the smallest contact surface friction for common material combinations

Material	Minimum contact surface friction
Steel - Steel	0,10
Steel - Lacquered surface	0,10
Cast iron - Cast iron	0,15
Cast iron - Steel	0,15
Aluminium - Aluminium	0,18
Aluminium - Steel	0,15
Aluminium - Lacquered surface	0,10
Lacquered surface - Lacquered surface	0,08

Surface pressure

When assembling a screw union it is important that the clamped parts' allowed surface pressure is not exceeded. If the value is exceeded it can cause subsidence in the union or, in the worst case, lead to a breakdown of in-bound material.

In the table below we show the allowed surface pressure for washers and some common materials.

The surface pressure is calculated according to the following:

Surface pressure $P_h = \frac{4F}{\pi(d_w^2 - d_h^2)}$

d_h = Bore diameter
d_w = The fasteners external contact diameter against the bedding
F = Power

Table 232 Maximum surface pressure for washers and material

Washer/ Material	Tensile strength	Maximum surface pressure (N/mm^2)
Washer HB 100		450
Washer HB 200		950
Washer HB 300		1450
Structural steel SS-1330	370	260
Structural steel SS-1672	800	700
Structural steel St 37-2	340	490
Low-alloy steel for heat treatment Cq 45	700	630
Low-alloy steel for heat treatment SS-2173	1000	900
Toughened steel SS-2244	100	850
Sintered steel SINT - D30	510	450
Stainless steel A2 SS-2333 (AISI 304)	500	630
Stainless steel A4 SS-2347, 2348 (AISI 316, 316L)	510	460
Cast iron, grey cast iron GG-25	250	900
Cast iron, nodular iron GGG-50	500	900
Die-cast aluminium GD-AlSi9Cu3	240	290

When calculating a screw's quality consideration should be taken so that the chosen screw does not give higher surface pressure than the material allows.

Table 233 Maximum surface pressure if the screw is loaded to yield point in tension

Dimension	8.8 (N/mm^2)	10.9 (N/mm^2)	12.9 (N/mm^2)
M5	275	390	465
M6	290	410	490
M8	340	475	570
M10	350	495	590
M12	535	755	905
M14	510	720	860
M16	505	715	855
M20	480	675	810
M22	480	675	810
M24	460	650	780
M27	535	755	905
M30	475	670	800
M33	470	665	795
M36	475	670	800