

Surface pressure when mounted

Typical values for allowable surface pressures for different materials

The limit pressure per unit area should not be exceeded when tightening the screw or the nut otherwise the threaded connection can loosen as a result of seating effects.

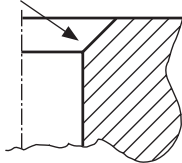
Based on VDI 2230, 1986 edition, with proven limiting values

The values given apply to holes without chamfers and with sufficiently large external diameter for the tensioned part at room temperature.

Materials for the locking parts	Tensile strength	Surface pressure ⁴⁾
	R_m [N/mm ²]	p_G [N/mm ²]
St 37	370	260
St 50	500	420
C 45	800	700
42 CrMo 4	1000	850
30 CrNiMo 8	1200	750
X 5 CrNiMo 18 10	500 to 700	210
X 10 CrNiMo 18 9	500 to 750	220
Titan, unalloyed	390 to 540	300
GG 15	150	600
GG 25	250	800
GG 35	350	900
GG 40	400	1100
GGG 35,5	350	480
DG MgAl 9	300	220
GK MgAl 9	200	140
AlZnMg Cu 0,5	450	370

⁴⁾ Boundary conditions which affect the surface pressure

Chamfer



Chamfers at the hole (contact surfaces with the fastening element) can for steels result in permitted values for surface pressure up to 25 % higher being achieved (supporting effect).

Poweroperated screwdriver



When tightening using a power screwdriver, for steels the permissible limiting value of surface pressure can be up to 25 % lower!

Based on VDI 2230, edition of 2015 with typical values determined experimentally

Abbreviated term for the material EN designation	Material number	Tensile strength $R_{m \min}$	Limiting surface pressure ^{a) 1)}
		[N/mm ²]	p_G [N/mm ²]
S235 JRG1 (USt 37-2)	1.0036	340	490
E295 (St 50-2)	1.0050	470	710
S355 JO (St 52-3U)	1.0553	490	760
Cq 45	1.1192	700	770
34 CrMo 4	1.7720	900	1170
34 CrNiMo 6	1.6582	1100	1430
38 MnSi-VS 5-BY	1.5231	900	990
16 MnCr 5	1.7131	1000	1300
X4 CrNi 18 12	1.4303	500	630
X5 CrNiMo 17 12 2	1.4401	530	630
X6 NiCrTiMoVB 25-15-2	1.4980	960	1200
NiCr20TiAl	2.4952	1000	1000
GJL-250 (GG-25)	0.6020	250	850 b)
GJS-400 (GGG-40)	0.7040	400	600 b)
GJS-500 (GGG-50)	0.7050	500	750 b)
GJS-600 (GGG-60)	0.7060	600	900 b)
AlMgSi 1 F31 (AW-6082)	3.2315.62	290	360
AlMgSi 1 F28	3.2315.61	260	325
AlMg4.5Mn F27 (AW-5083)	3.3547.08	260	325
AlZnMgCu 1.5 (AW-7075)	3.4365.71	540	540
GK-AlSi9Cu3	3.2163.01	160	200
GD-AlSi9Cu3	3.2163.05	240	300
GK-AlSi7Mg wa	3.2371.62	250	310
GD-AZ 91	(3.5812)	240	280
TiAl6V4	3.7165.10	890	1340

^{a)} *Italic numerical values:* Not yet tested according to the method in [53] or in [64].

Recommendation for steels by using the Brinell hardness: $p_G \approx 3 \text{ HB}$

^{b)} According to the method in [64]

Note: All numerical values are short-term values at room temperature and have to be considered as guide values. In the specific instance it may come to deviations due to a large number of influencing factors (geometry, relaxation, etc.).

[Values in parentheses] see literature reference VDI 2230

¹⁾ If an indentation is not permissible, i.e. only the surface roughness can be leveled, the surface pressure must not lead to the offset yield strength being exceeded in all operating conditions. In this case, it is recommended to use a maximum of 70 % of the table reference value. This will be printed in the next edition of VDI 2230 under Table A9 along with other additional information.

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Guide values for surface condition in area of contact surfaces

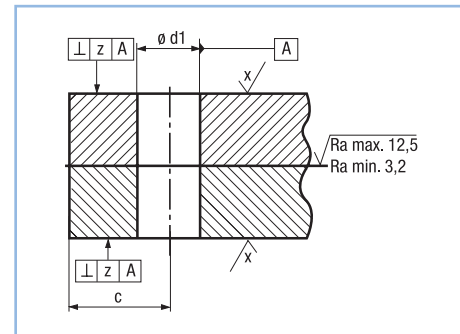
Roughness, shape and position tolerance

Thread	M4	M5	M6	M8	M10	M12	M16	M20
Rec. minimum edge distance c [mm]	6	7,5	9	12	15	18	24	30
maximum deviation from rectangularity z [mm]	0,04	0,08	0,08	0,09	0,11	0,13	0,17	0,21
maximum roughness Ra x [μm]	3,2	3,2	3,2	3,2	3,2	3,2	3,2	6,3

Comparison table of possible symbols, classes and values Rz for surface roughness according to DIN 4768

(ISO 4288, Geometrical Product Specifications Surface texture: Roules and procedures for the assessment of surface texture)

Designation	Measuring range					Units
max. Rz value ($\approx R_t$)	40	25	25	16	10	μm
max. Ra value	6,3	3,2	2	1,6	1,6	μm
Roughness classes	N9	N8	N8	N7	N7	–
Old symbols	▽ ▽	▽ ▽	▽ ▽	▽ ▽	▽ ▽ ▽	–



Surface pressure under the head of a hexagon screw

according to DIN 931/933 (ISO 4014/4017) with coarse thread

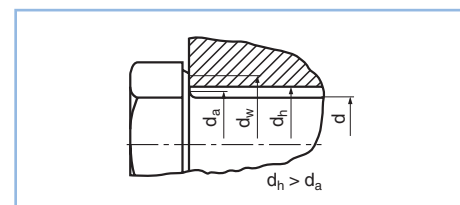
Nominal thread-Ø	Width across flats	Ø of the bearing surface	Through hole (ISO 273) medium H13	Bearing surface	Stressed cross-section	Surface pressure under the head ¹⁾ [N/mm²]		
d	S _{max} [mm]	d _{w min} [mm]	d _h [mm]	A _p [mm²]	A _{s nom} [mm²]	Property class 8.8	10.9	12.9
M4	7	5,9	4,5	11,4	8,78	385	568	665
M5	8	6,9	5,5	13,6	14,2	528	777	909
M6	10	8,9	6,6	28	20,1	364	532	625
M8	13	11,6	9	42,1	36,6	442	649	761
M10	16 (ISO)	14,63	11	73,1	58	405	594	695
M10	17	15,6	11	96,1	58	308	452	529
M12	18 (ISO)	16,63	13,5	74,1	84,3	580	853	999
M12	19	17,4	13,5	94,6	84,3	454	668	782
M14	21 (ISO)	19,64	15,5	114,3	115	517	759	888
M14	22	20,5	15,5	141,4	115	418	613	718
M16	24	22,5	17,5	157,1	157	515	756	885
M18	27	25,3	20	188,6	192	541	769	901
M20	30	28,2	22	244,4	245	532	761	888
M22	32	30	24	254,5	303	637	908	1065
M22	34 (ISO)	31,71	24	337,3	303	480	685	803
M24	36	33,6	26	355,8	353	528	750	880
M27	41	38	30	427,3	459	576	821	960
M30	46	42,7	33	576,7	561	520	740	865

¹⁾ The values shown in the tables for surface pressure are for a 90% utilisation of the yield strength of the screw $R_{p0,2}$ and $\mu_G = 0,12$ (reference: VDI 2230, edition 2015)

$$A_{s \text{ nom}} = \pi/4 \cdot ((d_2 + d_3)/2)^2$$

d_2 = basic pitch diameter of external thread according to ISO 724

d_3 = minor diameter of external thread



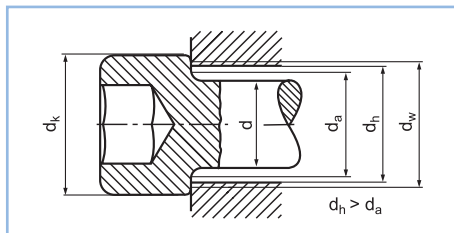
Surface pressure when mounted

Surface pressure under the head of a socket head cap screw

according to DIN 912 (ISO 4762/14579) and coarse thread

Nominal thread Ø	Ø of head	Ø of the bearing surface	Through hole (ISO 273) medium H13	Bearing surface	Stressed cross-section	Surface pressure under the head ¹⁾ [N/mm ²]		
d	d _K [mm]	d _{w min} [mm]	d _h [mm]	A _p [mm ²]	A _{s nom} [mm ²]	Property class		
						8.8	10.9	12.9
M4	7	6,53	4,5	17,6	8,78	250	370	432
M5	8,5	8,03	5,5	26,9	14,2	268	394	461
M6	10	9,38	6,6	34,9	20,1	292	427	502
M8	13	12,33	9	55,8	36,6	333	489	574
M10	16	15,33	11	89,5	58	331	485	567
M12	18	17,23	13,5	90	84,3	478	702	822
M14	21	20,17	15,5	130,8	115	452	663	776
M16	24	23,17	17,5	181,1	157	447	656	767
M18	27	25,87	20	211,5	192	482	686	804
M20	30	28,87	22	274,5	245	474	678	791
M22	33	31,81	24	342,3	303	473	675	792
M24	36	34,81	26	420,8	353	447	635	744
M27	40	38,61	30	464	459	530	756	884
M30	45	43,61	33	638,4	561	470	669	782

¹⁾ The values shown in the tables for surface pressure are for a 90 % utilisation of the yield strength of the screw
 $R_{p0,2}$ and $\mu_G = 0,12$ (reference: VDI 2230, edition 2015)



Surface pressure under the screw head

It is not possible to precisely define the permissible surface pressure for a particular type of material used to make a component. The effect of the production process, the alignment of fibers in the material, surface finishing and temperature changes all play a decisive role.

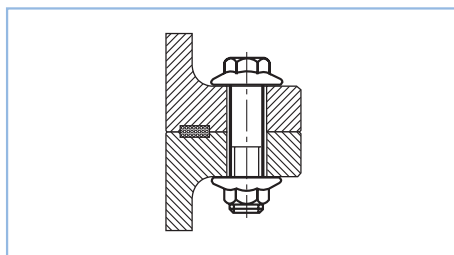
The following measures can help reduce the surface pressure:

- use of flange screws and flange nuts.
- chamfered holes. Field investigations have shown up to a 20 % increase in permissible surface pressure.
- through hole to ISO 273 – select a fine hole.

Advantages of flange screws and flange nuts:

- less intrusion.
- clamping force in the fastening during mounting tends to remain stable.
- flange products are more economic than large washers under normal screws and nuts (fewer fastening elements and quicker assembly).
- flange screws and nuts allow greater hole tolerances and so are more economically efficient.
- flange nuts have a better stability against shaking than normal screws and nuts.

Typical application



Surface pressure when mounted

Guide to the use of flat washers for screws and nuts

according to ISO 887

An overview of suitable combinations of flat washers with screws and nuts, allowing for different property classes (hardness classes).

Limiting conditions such as strength of component, surface structure, production process, alignment of fibers and operating temperatures must be considered when making the selection.

Screws	Nuts	Use of washers with corresponding hardness permitted		
Property class	Property class	Washers – hardness class and assigned tensile strength [N/mm ²] according to ISO 18265		
		100 HV 320	200 HV 640	300 HV 965
		Permitted reference values pressure per unit area [N/mm ²]		
		200–300	300–500	500–800
Case-hardened, thread-forming screws		yes	yes	yes
Stainless steel, screws and nuts		–	yes	–
≤ 6.8	≤ 6	yes	yes	yes
8.8	8	no	yes	yes
9.8	9	no	no	yes
10.9	10	no	no	yes
12.9	12	no	no	no

Guide to the use of flat washers for screws and nuts for austenitic stainless steel

Recommendation without reference to standards

Screws	Nuts	Use of washers with corresponding hardness permitted		
Property class	Property class	Washers – hardness class and assigned tensile strength [N/mm ²] according to ISO 18265		
		100 HV 320	140 HV 450	200 HV 640
	A2-50 / A4-50	yes	yes	yes
	70	no	yes	yes
	80	no	no	yes