## 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.

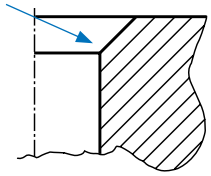
### Based on VDI 2230, 1986 edition, with proven limiting values

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 $R_m$ [N/mm²] | Surface pressure[4] $\rho_G$ [N/mm²] |
|---|---|---|
| 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).

**Power-operated screw-driver**

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 $R_{m\,min}$ [N/mm²] | Limiting surface pressure[a) 1)] $\rho_G$ [N/mm²] |
|---|---|---|---|
| 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: $\rho_G \approx 3$ 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

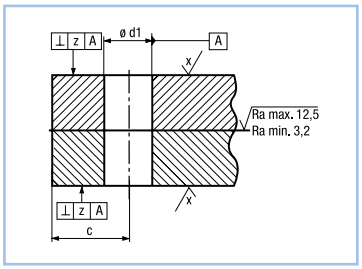
[1)] If an indentation is not permissible, i.e. only the surface roughness can be leveled, the surface pressure must not lead to the offset yield strength being exceeded in all operating conditions. In this case, it is recommended to use a maximum of 70 % of the table reference value. This will be printed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

Surface pressure when mounted

### 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 (≅ $R_t$) | 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

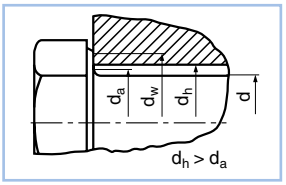
| Nominal thread Ø d | Width across flats $S_{max}$ [mm] | Ø of the bearing surface $d_{w\,min}$ [mm] | Through hole (ISO 273) medium H13 $d_h$ [mm] | Bearing surface $A_p$ [mm²] | Stressed cross-section $A_{s\,nom}$ [mm²] | Surface pressure under the head[1] [N/mm²] Property class 8.8 | 10.9 | 12.9 |
|---|---|---|---|---|---|---|---|---|
| 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 $R_{p\,0,2}$ and $\mu_G$ = 0,12 (reference: VDI 2230, edition 2015)

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

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

$d_3$ = minor diameter of external thread

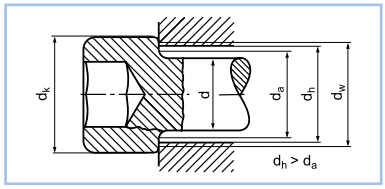


## Surface pressure under the head of a socket head cap screw

according to DIN 912 (ISO 4762/14759) and coarse thread

| Nominal thread Ø<br>d | Ø of head<br>$d_K$<br>[mm] | Ø of the bearing surface<br>$d_{w\,min}$<br>[mm] | Through hole (ISO 273) medium H13<br>$d_h$<br>[mm] | Bearing surface<br>$A_p$<br>[mm²] | Stressed cross-section<br>$A_{s\,nom}$<br>[mm²] | Surface pressure under the head[1] [N/mm²]<br>Property class<br>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 $R_{p\,0,2}$ and $\mu_G$ = 0,12 (reference: VDI 2230, edition 2015)

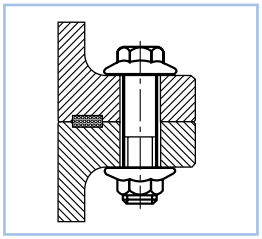



## Surface pressure under the screw head

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.

**Typical application**



**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.

## 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 strength 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** Property class | **Nuts** Property class | Use of washers with corresponding hardness permitted | | |
|---|---|---|---|---|
| | | Washers – hardness class and assigned tensile strength [N/mm²] acc. ISO 18265 | | |
| | | **100 HV** 320 | **200 HV** 640 | **300 HV** 965 |
| | | Permitted reference values pressure per unit area [N/mm²] | | |
| | | 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** Property class | **Nuts** Property class | Use of washers with corresponding hardness permitted | | |
|---|---|---|---|---|
| | | Washers – hardness class and assigned tensile strength [N/mm²] acc. 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 |