

Marking and mechanical requirements for bolts, screws and studs of steel

Identification

Hexagon and hexalobular head bolts and screws

Hexagon and hexalobular head bolts and screws (including products with flange) shall be marked with the manufacturer's identification mark and with the marking symbol of the property class given in table 188.

The marking is obligatory for all property classes, preferably on the top of the head by indenting or embossing or on the side of the head by indenting (see the figure below).

In the case of bolts or screws with flange, marking shall be on the flange where the manufacturing process does not allow marking on the top of the head.

Marking is required for hexagon and hexalobular head bolts and screws with nominal diameters $d \geq 5$ mm.

In the case of small screws or when the shape of the head does not allow the marking as given in table 188 the clock face marking symbols as given in table 24 may be used.

Table 188 Marking symbols

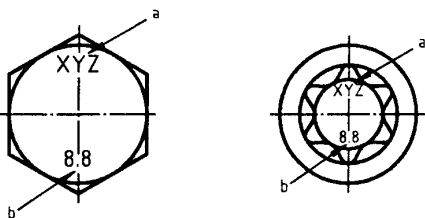
Property class	3.6	4.6	4.8	5.6	5.8	6.8	8.8	9.8	10.9	10.9	12.9
Marking symbol ^{a,b}	3.6	4.6	4.8	5.6	5.8	6.8	8.8	9.8	10.9	10.9 ^b	12.9
^a The full-stop in the marking symbol may be omitted.											
^b When low carbon martensitic steels are used for property class 10.9 (see table 4).											

Table 24 Clock-face system for marking bolts and screws

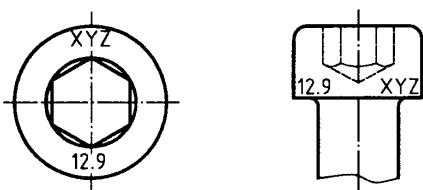
	3.6	4.6	Property class 4.8		5.6	5.8
Marking symbols						
	6.8	8.8	9.8	Property class 10.9	10.9	12.9
^a The twelve o'clock position (reference mark) shall be marked either by the manufacturer's identification mark or by a point.						
^b The property class is marked by a dash or a double dash and in the case of 12.9 by a point.						

Examples of marking on hexagon and hexalobular head bolts and screws

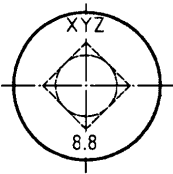
- a Manufacturer's identification mark
b Property class



Examples of marking on hexagon socket head cap screws



Example of marking cup head square neck bolts



Studs

Studs with nominal thread diameters $d \geq 5$ mm, of property class 5.6 and property classes 8.8 and higher shall be marked by indenting with the marking symbol of the property class as given in the table below and the manufacturer's identification mark on the unthreaded part of the stud (see the figure).

If marking on the unthreaded part is not possible, marking of property class only on the nut end of the stud is allowed, (see the figure). For studs with interference fit, the marking shall be at the nut end with manufacturer's identification marking only if it is possible.

Marking of studs

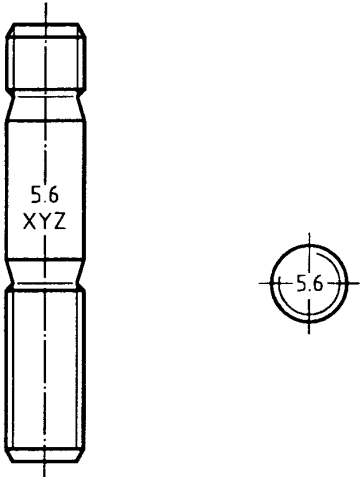


Table 189 Alternative marking symbols for studs

Property class	5.6	8.8	9.8	10.9	12.9
Marking symbol	—	○	+	□	△

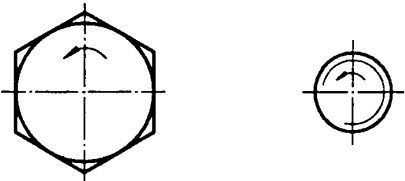
The symbols in the table are permissible as an alternative identification of property classes.

Marking of bolts and screws with left-hand thread

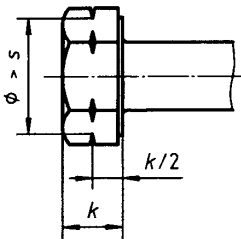
Bolts and screws with a left-hand thread shall be marked with the symbol shown in the figure, either on the top of the head or on the point.

Alternative marking for left-hand thread as shown in the figure may be used for hexagon bolts and screws.

Left-hand thread marking



Alternative left-hand thread marking



Source: EN ISO 898-1.

Screws and stud screws

Table 4 specifies the kind of steel for the different property classes for screws and stud screws.

According to table 4 the min. tempering temperature is compulsory for property classes 8.8 up to 12.9. The chemical composition is only compulsory for the screws that are not to be tensile tested.

Table 4 Steel Chemical composition

Property class	Material and treatment	Chemical composition limits (check analysis) % (m/m)					Tempering temperature °C min.
		C min.	C max.	P max.	S max.	B ^a max.	
3.6^b	Carbon steel	—	0,20	0,05	0,06	0,003	—
4.6^b		—	0,55	0,05	0,06	0,003	—
4.8^b		0,13	0,55	0,05	0,06	0,003	—
5.6							
5.8^b		—	0,55	0,05	0,06	0,003	—
6.8^b							
8.8^c	Carbon steel with additives (for example B, Mn or Cr), quenched and tempered	0,15 ^d	0,40	0,035	0,035	0,003	425
	Carbon steel quenched and tempered	0,25	0,55	0,035	0,035		
9.8	Carbon steel with additives (for example B, Mn or Cr), quenched and tempered	0,15 ^d	0,35	0,035	0,035	0,003	425
	Carbon steel quenched and tempered	0,25	0,55	0,035	0,035		
10.9^{e f}	Carbon steel with additives (for example B, Mn or Cr), quenched and tempered	0,15 ^d	0,35	0,035	0,035	0,003	340
10.9^f	Carbon steel quenched and tempered	0,25	0,55	0,035	0,035	0,003	425
	Carbon steel with additives (for example B, Mn or Cr), quenched and tempered	0,20 ^d	0,55	0,035	0,035		
	Alloy steel quenched and tempered ^g	0,20	0,55	0,035	0,035		
12.9^{f h i}	Alloy steel quenched and tempered ^g	0,28	0,50	0,035	0,035	0,003	380

- a) Boron content can reach 0,005% provided that non-effective boron is controlled by addition of titanium and/or aluminium.
- b) Free cutting steel is allowed for these property classes with the following maximum sulfur, phosphorus and lead contents: sulfur 0,34%, phosphorus 0,11%, lead 0,35%.
- c) For nominal diameters above 20 mm the steels specified for property class 10.9 may be necessary in order to achieve sufficient hardenability.
- d) In case of plain carbon boron steel with a carbon content below 0,25% (ladle analysis), the minimum manganese content shall be 0,6% for property class 8.8 and 0,7% for 9.8, 10.9 and 10.9.
- e) Products shall be additionally identified by underlining the symbol of the property class. All properties of 10.9 as specified in table 11 shall be met by 10.9, however; its lower tempering temperature gives it different stress relaxation characteristics at elevated temperatures.

- f) For the materials of these property classes, it is intended that there should be a sufficient hardenability to ensure a structure consisting of approximately 90% martensite in the core of the threaded sections for the fasteners in the "as-hardened" condition before tempering.
- g) This alloy steel shall contain at least one of the following elements in the minimum quantity given: chromium 0,30%, nickel 0,30%, molybdenum 0,20%, vanadium 0,10%. Where elements are specified in combinations of two, three or four and have alloy contents less than those given above, the limit value to be applied for class determination is 70% of the sum of the individual limit values shown above for the two, three or four elements concerned.
- h) A metallographically detectable white phosphorus enriched layer is not permitted for property class 12.9 on surfaces subjected to tensile stress.
- i) The chemical composition and tempering temperature are under investigation.

Source: EN ISO 898-1.

Mechanical properties of fasteners

Set screws and similar threaded fasteners not under tensile stresses.

Set screws shall be made of steel conforming to the requirements specified in table 4.1.

Table 4.1 – Steel specifications

Property class	Material	Heat treatment	Chemical composition, %			
			C		P	S
			max.	min.	max.	max.
14H	Carbon steel ^{1) 2)}	—	0,50	—	0,11	0,15
22H	Carbon steel ³⁾	Quenched and tempered	0,50	—	0,05	0,05
33H	Carbon steel ³⁾	Quenched and tempered	0,50	—	0,05	0,05
45H	Alloy steel ^{3) 4)}	Quenched and tempered	0,50	0,19	0,05	0,05

1) Free-cutting steel may be used, with lead content 0,35% max., phosphorus content 0,11 % max. and sulphur content 0,34% max.

2) Case hardening is allowed in the case of square-head set screws.

Source: SS-ISO 898/5.

3) Steel with lead content 0,35% max. may be used.

4) Shall contain one or more of alloying elements chromium, nickel, molybdenum, vanadin or boron.

Screws with metric ISO-thread

Excerpt from the Swedish and international standard ISO 898-1 for screws with metric ISO-thread.

The international standard ISO 898-1 is intended to simplify the entering of standardised mechanical properties and classes, and also to be a practical aid in the daily work. Presented here are the values for tensile loads, proof loads and yield loads.

All documentation is available in the Swedish standard.

ISO 898-1. Fasteners — Mechanical properties — Part 1: Screws and stud bolts with metric ISO-thread.

It applies to screws and stud bolts.

- With nominal diameter up to 39 mm.
- With triangular ISO-threads and with diameters and splits according to SS 1700, SS 1701 and SS 2160.
- In all existing shapes.
- From non-alloyed or alloyed steel.

It does not apply to set screws and similar fasteners. It does not apply when special demands are made for weldability, corrosion resistance and ability to resist temperatures above +300°C or below -50°C.

Property classes

The property classes are represented with two numbers separated by a dot. The standardised classes are: 3.6, 4.6, 4.8, 5.6, 5.8, 6.8, 8.8, 9.8, 10.9 and 12.9.

The first number indicates 1/100 of the nominal tensile strength (Rm) in N/mm².

The second number indicates 10 times the nominal yield stress (ReL or Rp0,2) and nominal tensile strength (Rm).

If you multiply the two numbers you get 1/10 of the nominal yield stress in N/mm².

Example for property class 8.8

Nominal tensile strength = 8 · 100 = 800 N/mm².

Nominal yield stress / Nominal tensile strength · 10 = 8

Nominal yield stress = 8 · 8 · 10 = 640 N/mm².

Table 10 System of coordinates

Nominal tensile strength, Rm, nom N/mm²		300	400	500	600	700	800	900	1000		1200		1400
Min. elongation after fracture, Amin %	7												
	8					6.8						12.9	
	9												
	10									10.9			
	12				5.8				9.8 ^a				
	14							8.8					
	16												
	18												
	20												
	22												
	25			4.6	5.6								
	30		3.6										
Relationship between yield stress and tensile strength													
Second figure of symbol											.6	.8	.9
$\frac{\text{Lower yield stress } R_{el}^b}{\text{Nominal tensile strength } R_{m, nom}} \times 100 \%$											60	80	90
$\frac{\text{Stress at 0,2% non-proportional elongation } R_{p0,2}^b}{\text{Nominal tensile strength } R_{m, nom}} \times 100 \%$													

NOTE Although a great number of property classes are specified in this part of ISO 898, this does not mean that all classes are appropriate for all items. Further guidance for application of the specific property

classes is given in the relevant product standards. For non-standard items, it is advisable to follow as closely as possible the choice already made for similar standard items.

^a Applies only to thread diameter d ≤ 16 mm.

^b Nominal values according to table 11 apply.

Source: EN ISO 898-1.

Table 11 Mechanical and physical properties of bolts, screws and studs

Sub-clause number	Mechanical and physical property		Property class										
			3.6	4.6	4.8	5.6	5.8	6.8	d≤16 ^c mm	8.8 ^a d>16 ^c mm	9.8 ^b	10.9	12.9
5.1	Nominal tensile strength, $R_{m, nom}$	N/mm ²	300	400		500		600	800	800	900	1000	1200
5.2	Minimum tensile strength, $R_{m, min}^{d, e}$	N/mm ²	330	400	420	500	520	600	800	830	900	1040	1220
5.3	Vickers hardness, HV $F \geq 98$ N	min.	95	120	130	155	160	190	250	255	290	320	385
		max.	220 ^f					250	320	335	360	380	435
5.4	Brinell hardness, HB $F = 30 D^2$	min.	90	114	124	147	152	181	238	242	276	304	366
		max.	209 ^f					238	304	318	342	361	414
5.5	Rockwell hardness, HR	min. HRB	52	67	71	79	82	89	—	—	—	—	—
		HRC	—	—	—	—	—	—	22	23	28	32	39
		max. HRB	95,0 ^f					99,5	—	—	—	—	—
		HRC	—					—	32	34	37	39	44
5.6	Surface hardness, HV 0.3	max.	—					— ^g					180
5.7	Lower yield stress R_{eL}^h , N/mm ²	nom.	240	320	300	400	480	—	—	—	—	—	—
		min.	190	240	340	300	420	480	—	—	—	—	—
5.8	Stress at 0.2 % non-proportional elongation $R_{p0.2}^i$, N/mm ²	nom.	—					—	640	640	720	900	1080
		min.	—					—	640	660	720	940	1100
5.9	Stress under proof load, S_p	S_p/R_{eL} or $S_p/R_{p0.2}$	0,94	0,94	0,91	0,93	0,90	0,92	0,91	0,91	0,90	0,88	0,88
		N/mm ²	180	225	310	280	380	440	580	600	650	830	970
5.10	Breaking torque, M_B	Nm min.	—					See ISO 898-7					
5.11	Percent elongation after fracture, A	min.	25	22	—	20	—	—	12	12	10	9	8
5.12	Reduction area after fracture, Z	% min.	—					52		48	48	44	
5.13	Strength under wedge loading ^e		The values for full size bolts and screws (no studs) shall not be smaller than the min. values for tensile strength shown in 5.2.										
5.14	Impact strength, KU	J min.	—			25	—		30	30	25	20	15
5.15	Head soundness		No fracture										
5.16	Minimum height of non-decarburized thread zone, E		—					$\frac{1}{2}H_I$			$\frac{2}{3}H_I$	$\frac{3}{4}H_I$	
	Maximum depth of complete decarburization, G	mm	—					0,015					
5.17	Hardness after retempering		—					Reduction of hardness 20 HV maximum					
5.18	Surface integrity		In accordance with ISO 6157-1 or ISO 6157-3 as appropriate										

a For bolts of property class 8.8 in diameters $d \leq 16$ mm, there is an increased risk of nut stripping in the case of inadvertent over-tightening inducing a load in excess of proof load. Reference to ISO 898-2 is recommended.

b Applies only to nominal thread diameters $d \leq 16$ mm.

c For structural bolting the limit is 12 mm.

d Minimum tensile properties apply to products of nominal length $l \geq 2,5 d$. Minimum hardness applies to products of length $l < 2,5 d$ and other products which cannot be tensile-tested (e.g. due to head configuration).

e When testing full-size bolts, screws and studs, the tensile loads, which are to be applied for the calculation of R_m , shall meet the values given in tables 14 and 16.

f A hardness reading taken at the end of bolts, screws and studs shall be 250 HV, 238 HB or 99,5 HRB maximum.

g Surface hardness shall not be more than 30 Vickers points above the measured core hardness on the product when readings of both surface and core are carried out at HV 0,3. For property class 10.9, any increase in hardness at the surface which indicates that the surface hardness exceeds 390 HV is not acceptable.

h In cases where the lower yield stress R_{eL} cannot be determined, it is permissible to measure the stress at 0,2 % non-proportional elongation $R_{p0,2}$. For the property classes 4.8, 5.8 and 6.8 the values for R_{eL} are given for calculation purposes only, they are not test values.

i The yield stress ratio according to the designation of the property class and the minimum stress at 0,2 % non-proportional elongation $R_{p0,2}$ apply to machined test specimens. These values if received from tests of full size bolts and screws will vary because of processing method and size effects.

Source: EN ISO 898-1.

Table 11.1 Mechanical properties of fasteners - set screws and similar threaded fasteners not under tensile stresses

Mechanical properties		Property class*				
		14H	22H	33H	45H	
Vickers hardness HV	min.	140	220	330	450	
	max.	290	300	440	560	
Brinell hardness HB, $F = 30 D^2$	min.	133	209	314	428	
	max.	276	285	418	532	
Rockwell hardness	HRB	min.	75	95	—	—
		max.	105	—	—	—
	HRC	min.	—	—	33	45
		max.	—	30	44	53
Minimum height of non-decarburized thread zone, E		—	$\frac{1}{2} H_1$	$\frac{2}{3} H_1$	$\frac{3}{4} H_1$	
Maximum depth of complete decarburization, G		mm	—	0,015	0,015	**
Surface hardness HV 0,3		max.	—	320	450	580

* Classes 14H, 22H and 33H are not for hexagon socket set screws.

** No complete decarburization permitted in property class 45H.

Source: SS-ISO 898/5.

Table 14 Min. tensile loads, metric ISO coarse threads

Thread d	Nominal stress area A _S mm ²	Property class									
		3.6	4.6	4.8	5.6	5.8	6.8	8.8	9.8	10.9	12.9
		Min. tensile load (A _S · R _m), N									
M3	5,03	1 660	2 010	2 110	2 510	2 620	3 020	4 020	4 530	5 230	6 140
M3,5	6,78	2 240	2 710	2 850	3 390	3 530	4 070	5 420	6 100	7 050	8 270
M4	8,78	2 900	3 510	3 690	4 390	4 570	5 270	7 020	7 900	9 130	10 700
M5	14,2	4 690	5 680	5 960	7 100	7 380	8 520	11 350	12 800	14 800	17 300
M6	20,1	6 630	8 040	8 440	10 000	10 400	12 100	16 100	18 100	20 900	24 500
M7	28,9	9 540	11 600	12 100	14 400	15 000	17 300	23 100	26 000	30 100	35 300
M8	36,6	12 100	14 600	15 400	18 300	19 000	22 000	29 200	32 900	38 100	44 600
M10	58,0	19 100	23 200	24 400	29 000	30 200	34 800	46 400	52 200	60 300	70 800
M12	84,3	27 800	33 700	35 400	42 200	43 800	50 600	67 400 ¹⁾	75 900	87 700	103 000
M14	115	38 000	46 000	48 300	57 500	59 800	69 000	92 000 ¹⁾	104 000	120 000	140 000
M16	157	51 800	62 800	65 900	78 500	81 600	94 000	125 000 ¹⁾	141 000	163 000	192 000
M18	192	63 400	76 800	80 600	96 000	99 800	115 000	159 000	—	200 000	234 000
M20	245	80 800	98 000	103 000	122 000	127 000	147 000	203 000	—	255 000	299 000
M22	303	100 000	121 000	127 000	152 000	158 000	182 000	252 000	—	315 000	370 000
M24	353	116 000	141 000	148 000	176 000	184 000	212 000	293 000	—	367 000	431 000
M27	459	152 000	184 000	193 000	230 000	239 000	275 000	381 000	—	477 000	560 000
M30	561	185 000	224 000	236 000	280 000	292 000	337 000	466 000	—	583 000	684 000
M33	694	229 000	278 000	292 000	347 000	361 000	416 000	576 000	—	722 000	847 000
M36	817	270 000	327 000	343 000	408 000	425 000	490 000	678 000	—	850 000	997 000
M39	976	322 000	390 000	410 000	488 000	508 000	586 000	810 000	—	1 020 000	1 200 000

¹⁾ Valid values for structural screws are 70 000, 95 500 and 130 000 N respectively.

Table 16 Min. tensile loads, metric ISO fine threads

Thread d	Nominal stress area A_S mm ²	Property class									
		3.6	4.6	4.8	5.6	5.8	6.8	8.8	9.8	10.9	12.9
		Min. tensile load ($A_S \cdot R_m$), N									
M 8 × 1	39,2	12 900	15 700	16 500	19 600	20 400	23 500	31 360	35 300	40 800	47 800
M 10 × 1	64,5	21 300	25 800	27 100	32 300	33 500	38 700	51 600	58 100	67 100	78 700
M 12 × 1,5	88,1	29 100	35 200	37 000	44 100	45 800	52 900	70 500	79 300	91 600	107 500
M 14 × 1,5	125	41 200	50 000	52 500	62 500	65 000	75 000	100 000	112 000	130 000	152 000
M 16 × 1,5	167	55 100	66 800	70 100	83 500	86 800	100 000	134 000	150 000	174 000	204 000
M 18 × 1,5	216	71 300	86 400	90 700	108 000	112 000	130 000	179 000	—	225 000	264 000
M 20 × 1,5	272	89 800	109 000	114 000	136 000	141 000	163 000	226 000	—	283 000	332 000
M 22 × 1,5	333	110 000	133 000	140 000	166 000	173 000	200 000	276 000	—	346 000	406 000
M 24 × 2	384	127 000	154 000	161 000	192 000	200 000	230 000	319 000	—	399 000	469 000
M 27 × 2	496	164 000	194 000	208 000	248 000	258 000	298 000	412 000	—	516 000	605 000
M 30 × 2	621	205 000	248 000	261 000	310 000	323 000	373 000	515 000	—	646 000	758 000
M 33 × 2	761	251 000	304 000	320 000	380 000	396 000	457 000	632 000	—	791 000	928 000
M 36 × 3	865	285 000	346 000	363 000	432 000	450 000	519 000	718 000	—	900 000	1 055 000
M 39 × 3	1030	340 000	412 000	433 000	515 000	536 000	618 000	855 000	—	1 070 000	1 260 000

Table 58 Min. tensile loads for hot dip galvanized screws and nuts

Thread d	Pitch P	Stress area $A_{s \min}$ mm ²	Property class screw and nut			
			4/4.6	5/5.6	8/8.8	10/10.9
			Min. tensile loads for screw and nut ($A_{s \min} \cdot R_m$) N			
M 6	1	16,4	6 560	8 200	13 100	17 100
M 8	1,25	31,3	12 500	15 700	25 000	32 600
M 10	1,5	50,9	20 400	25 500	40 700	52 900
M 12	1,75	75,1	30 000	37 600	60 100	78 100
M 14	2	104	41 600	52 000	83 200	108 000
M 16	2	144	57 600	72 000	115 000	150 000
M 18	2,5	177	70 800	88 500	147 000	184 000
M 20	2,5	227	90 800	114 000	188 000	236 000
M 22	2,5	284	114 000	142 000	236 000	295 000
M 24	3	329	132 000	165 000	273 000	342 000
M 27	3	433	173 000	216 000	359 000	450 000
M 30	3,5	530	212 000	265 000	440 000	551 000
M 33	3,5	659	264 000	330 000	547 000	685 000
M 36	4	777	311 000	389 000	645 000	808 000

Our fasteners meet the demands set by DIN 267/10.

Table I90 Minimum ultimate tensile loads for hexagon socket countersunk head screws acc. to ISO 10642 (80% of the values specified in ISO 898-1)

Thread d	Property class		
	8.8	10.9	12.9
	Minimum ultimate tensile load N		
M3	3 220	4 180	4 910
M4	5 620	7 300	8 560
M5	9 080	11 800	13 800
M6	12 900	16 700	19 600
M8	23 400	30 500	35 700
M10	37 100	48 200	56 600
M12	53 900	70 200	82 400
M14	73 600	96 000	112 000
M16	100 000	130 000	154 000
M20	162 000	204 000	239 000

Table 93 Qualities at increased temperature

Property class	Temperature °C				
	+20	+100	+200	+250	+300
	Lower yield stress, R_{eL} , or Extension limit, $R_{p0.2}$ N/mm ²				
5.6	300	270	230	215	195
8.8	640	590	540	510	480
10.9	940	875	790	745	705
12.9	1100	1020	925	875	825

Values specified in the table are only a guideline, and approximate information of the decrease in the mechanical features that could be expected when performing tests

of the ultimate tensile stress at increased temperatures. The values should not be used as requirements when testing screws and stud screws.

Table I3 Translation of property (ISO class - Grade class)

ISO-class	Old corresponding property classes in			
	Sweden	Germany	U.K.	U.S.
3.6 4.6	D40 D40	4A 4D, 4P	A, B	SAE grade 1
4.8 5.6		4S 5D		SAE grade 2
5.8 6.8	D60 D60	5S, 6G 6S	P	SAE grade 3
8.8 9.8	D80 D100	6G	S, T	SAE grade 5
10.9 12.9	D120 D140	10K 12K	V X	SAE grade 8 ASTM A574