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МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ

Mechanical properties of fasteners —

Part 1 :
Bolts, screws and studs

Caractéristiques mécaniques des éléments de fixation —

Partie 1 : Boulons, vis et goujons

Reference number
ISO 898-1 : 1988 (E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 898-1 was prepared by Technical Committee ISO/TC 2, *Fasteners.*

This second edition cancels and replaces the first edition (ISO 898-1 : 1978), to which the following major alterations have been made :

a) the chemical compositions and tempering temperatures of steels have been revised;

b) the maximum hardness values for bolts, screws and studs of property classes 3.6 to 5.8 and 8.8 have been increased;

c) the surface hardnesses for bolts, screws and studs of property classes 8.8 to 12.9 have been revised;

d) the application of test programmes A and B has been revised and specified more clearly;

e) property classes 4.8, 5.8 and 6.8 are no longer tested according to test programme A;

f) the surface integrity test has been added to test programme A, the wedge loading test for bolts and screws with nominal thread diameter $d < 4$ mm or nominal length $l < 2{,}5d$ has been deleted from test programme B;

g) for nominal thread diameters 10 and 12 mm, the metric fine pitch was changed from 1,25 to 1 and 1,5 respectively, because these are the preferred pitches (see also ISO 8676 and ISO 8765) : the minimum tensile loads and proofing loads were changed as a consequence;

h) the application of the wedge loading test for bolts and screws with head bearing diameter above $1{,}7d$ has been specified.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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Mechanical properties of fasteners —

Part 1 :
Bolts, screws and studs

1 Scope and field of application

This part of ISO 898 specifies the mechanical properties of bolts, screws and studs when tested at room temperature (see ISO 1). Properties will vary at higher and lower temperature.

This part of ISO 898 applies to bolts, screws and studs

— with nominal thread diameter $d \leqslant 39$ mm (coarse and fine pitch);

— with triangular ISO thread according to ISO 68;

— with diameter/pitch combinations according to ISO 261 and ISO 262;

— with thread tolerance according to ISO 965-1 and ISO 965-2;

— of any shape;

— made of carbon steel or alloy steel.

It does not apply to set screws and similar threaded fasteners (see ISO 898-5).

It does not specify requirements for such properties as

— weldability;

— corrosion-resistance (see ISO 3506);

— ability to withstand temperatures above +300 °C or below −50 °C.

NOTE — The designation system of this part of ISO 898 may be used for sizes outside the limits laid down in this clause (e.g. $d > 39$ mm), provided that all mechanical requirements of the property classes are met.

2 References

ISO 1, *Standard reference temperature for industrial length measurements.*

ISO 68, *ISO general purpose screw threads — Basic profile.*

ISO 83, *Steel — Charpy impact test (U-notch).*

ISO 225, *Fasteners — Bolts, screws, studs and nuts — Symbols and designations of dimensions.*

ISO 261, *ISO general purpose metric screw threads — General plan.*

ISO 262, *ISO general purpose metric screw threads — Selected sizes for screws, bolts and nuts.*

ISO 273, *Fasteners — Clearance holes for bolts and screws.*

ISO 965-1, *ISO general purpose metric screw threads — Tolerances — Part 1 : Principles and basic data.*

ISO 965-2, *ISO general purpose metric screw threads — Tolerances — Part 2 : Limits or sizes for general purpose bolt and nut threads — Medium quality.*

ISO 6157-1, *Fasteners — Surface discontinuities — Part 1: Bolts, screws and studs for general requirements.* [1)]

ISO 6157-3, *Fasteners — Surface discontinuities — Part 3: Bolts, screws and studs for special requirements.* [1)]

ISO 6506, *Metallic materials — Hardness test — Brinell test.*

ISO 6507-1, *Metallic materials — Hardness test — Vickers test — Part 1:* HV 5 *to* HV 100.

ISO 6507-2, *Metallic materials — Hardness test — Vickers test — Part 2:* HV 0,2 *to less than* HV 5.

ISO 6508, *Metallic materials — Hardness test — Rockwell test — Scales A, B, C, D, E, F, G, H, K.*

ISO 6892, *Metallic materials — Tensile testing.*

3 Designation system

The designation system for property classes of bolts, screws and studs is shown in table 1. The abscissae show the nominal tensile strength values, R_m, in newtons per square millimetre, while the ordinates show those of the minimum elongation after fracture, A min., as a percentage.

1) At present at the stage of draft.

The property class symbol consists of two figures:

— the first indicates 1/100 of the nominal tensile strength in newtons per square millimetre (see R_m in table 3);

— the second figure indicates 10 times the ratio between lower yield stress R_{eL} (or proof stress $R_{p0,2}$) and nominal tensile strength R_m (yield stress ratio).

The multiplication of these two figures will give 1/10 of the yield stress in newtons per square millimetre.

Lower yield stress R_{eL} (or proof stress $R_{p0,2}$) and minimum tensile strength R_m are equal to or greater than the nominal values (see table 3).

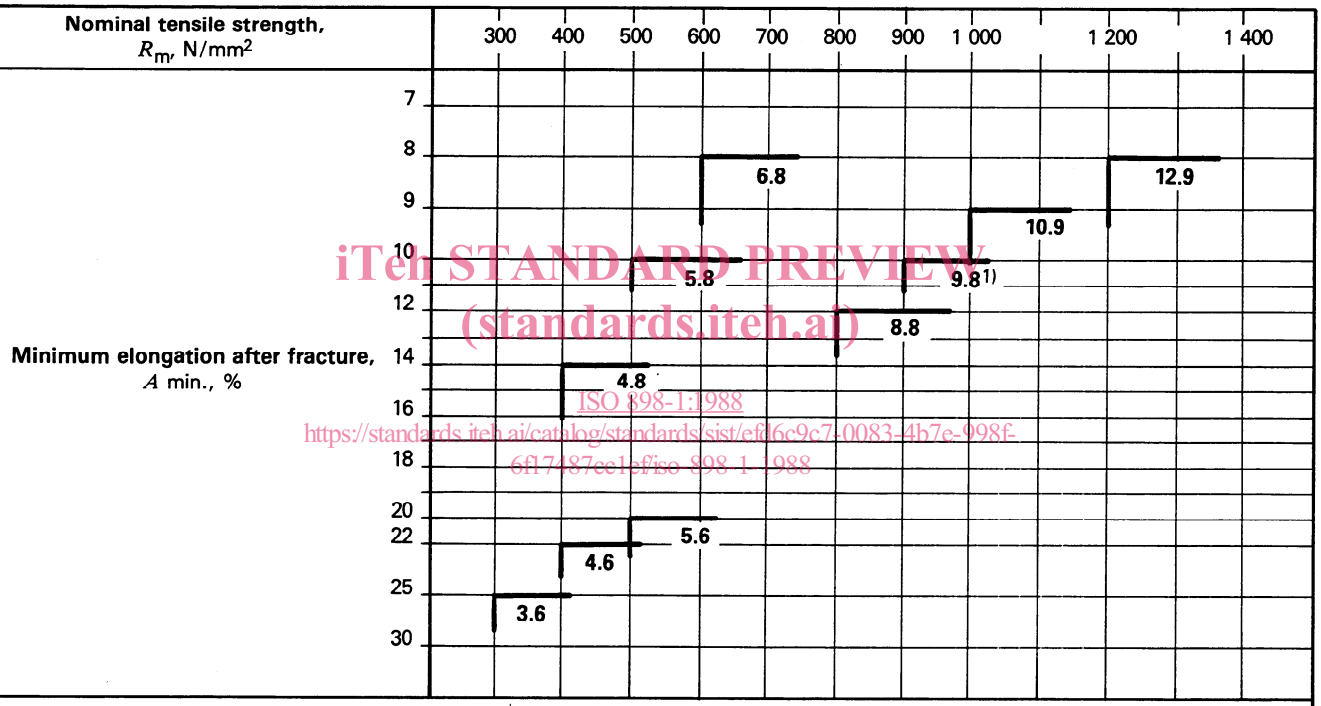
4 Materials

Table 2 specifies steels for the different property classes of bolts, screws and studs.

The minimum tempering temperatures listed in table 2 are mandatory for property classes 8.8 to 12.9 in all cases.

The chemical composition limits are mandatory only for those fasteners which are not subject to tensile testing.

Table 1 — System of coordinates



Relationship between yield stress and tensile strength

Second figure of symbol		.6	.8	.9
$\frac{\text{Lower yield stress } R_{eL} \text{ or proof stress } R_{p0,2}}{\text{Nominal tensile strength } R_m} \times 100$	%	60	80	90

1) Applies only to thread diameter $d < 16$ mm.

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 standard. For non-standard items, it is advisable to follow as closely as possible the choice already made for similar standard items.

Table 2 — Steels

Property class	Material and treatment	Chemical composition limits (check analysis) % C min.	C max.	P max.	S max.	Tempering temperature °C min.
3.6[1]	Carbon steel	—	0,20	0,05	0,06	—
4.6[1]		—	0,55	0,05	0,06	—
4.8[1]						
5.6		0,15	0,55	0,05	0,06	—
5.8[1]		—	0,55	0,05	0,06	
6.8[1]						
8.8[2]	Carbon steel with additives (e.g. Boron or Mn or Cr) quenched and tempered	0,15[3]	0,40	0,035	0,035	425
	or					
	Carbon steel quenched and tempered	0,25	0,55	0,035	0,035	
9.8	Carbon steel with additives (e.g. Boron or Mn or Cr) quenched and tempered	0,15[3]	0,35	0,035	0,035	425
	or					
	Carbon steel quenched and tempered	0,25	0,55	0,035	0,035	
10.9[4]	Carbon steel with additives (e.g. Boron or Mn or Cr) quenched and tempered	0,15[3]	0,35	0,035	0,035	340
10.9[5]	Carbon steel quenched and tempered	0,25	0,55	0,035	0,035	425
	or					
	Carbon steel with additives (e.g. Boron or Mn or Cr) quenched and tempered	0,20[3]	0,55	0,035	0,035	
	or					
	Alloy steel quenched and tempered[7]	0,20	0,55	0,035	0,035	
12.9[5], [6]	Alloy steel quenched and tempered[7]	0,20	0,50	0,035	0,035	380

1) 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 %.

2) For nominal diameters above 20 mm the steels specified for property class 10.9 may be necessary in order to achieve sufficient hardenability.

3) In case of plain carbon boron alloyed 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 and 10.9.

4) Products shall be additionally identified by underlining the symbol of the property class (see clause 9).

5) 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.

6) A metallographically detectable white phosphorous enriched layer is not permitted for property class 12.9 on surfaces subjected to tensile stress.

7) Alloy steel shall contain one or more of the alloying elements chromium, nickel, molybdenum or vanadium.

5 Mechanical properties

When tested by the methods described in clause 8, the bolts, screws and studs shall, at room temperature, have the mechanical properties set out in table 3.

Table 3 — Mechanical properties of bolts, screws and studs

Sub-clause No.	Mechanical property		Property class 3.6	4.6	4.8	5.6	5.8	6.8	8.8[1] $d \leq$ 16 mm	8.8[1] $d >$ 16 mm[2]	9.8[3]	10.9	12.9
5.1 and 5.2	Tensile strength, R_m[4), 5)], N/mm²	nom.	300	400		500		600	800	800	900	1 000	1 200
		min.	330	400	420	500	520	600	800	830	900	1 040	1 220
5.3	Vickers hardness, HV, $F \geq 98$ N	min.	95	120	130	155	160	190	250	255	290	320	385
		max.	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.	238						304	318	342	361	414
5.5	Rockwell hardness, HR	min. HRB	52	67	71	79	82	89	—	—	—	—	—
		min. HRC	—	—	—	—	—	—	22	23	28	32	39
		max. HRB	99,5						—	—	—	—	—
		max. HRC	—						32	34	37	39	44
5.6	Surface hardness, HV 0,3	max.	—						6)				
5.7	Lower yield stress, R_{eL}[7)], N/mm²	nom.	180	240	320	300	400	480	—	—	—	—	—
		min.	190	240	340	300	420	480	—	—	—	—	—
5.8	Proof stress, $R_{p0,2}$, N/mm²	nom.	—						640	640	720	900	1 080
		min.	—						640	660	720	940	1 100
5.9	Stress under proofing 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/mm²	180	225	310	280	380	440	580	600	650	830	970
5.10	Elongation after fracture, A	min.	25	22	14	20	10	8	12	12	10	9	8
5.11	Strength under wedge loading[5)]		The values for full size bolts and screws (not studs) shall not be smaller than the minimum values for tensile strength shown in 5.2										
5.12	Impact strength, J	min.	—			25	—		30	30	25	20	15
5.13	Head soundness		no fracture										
5.14	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				

1) 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 proofing load. Reference to ISO 898-2 is recommended.

2) For structural bolting the limit is 12 mm.

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

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

5) For testing of full-size bolts, screws and studs, the loads given in tables 6 to 9 shall be applied.

6) 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.

7) In cases where the lower yield stress R_{eL} cannot be determined, it is permissible to measure the proof stress $R_{p0,2}$.

6 Mechanical properties to be determined

Two test programmes, A and B, for mechanical properties of bolts, screws and studs, using the methods described in clause 8, are set out in table 5.

The application of programme B is always desirable, but is mandatory for products with breaking loads less than 500 kN.

Programme A is suitable for machined test pieces and for bolts with a shank area less than the stress area.

Table 4 — Key to test programmes (see table 5)

Size	Bolts and screws with thread diameter $d \leq 4$ mm or length $l < 2{,}5d$ [1)]	Bolts and screws with thread diameter $d > 4$ mm and length $l \geq 2{,}5d$
Test decisive for acceptance	○	●

1) Also bolts and screws with special head or shank configurations which are weaker than the threaded section.

Table 5 — Test programmes A and B for acceptance purposes
(These procedures apply to mechanical but not chemical properties.)

Test group	Property		Test programme A				Test programme B			
			Test method		Property class		Test method		Property class	
					3.6, 4.6, 5.6	8.8, 9.8 10.9 12.9			3.6, 4.6 4.8, 5.6 5.8, 6.8	8.8, 9.8 10.9 12.9
I	5.1 and 5.2	Minimum tensile strength, R_m	8.1	Tensile test	●	●	8.2	Tensile test[1]	●	●
	5.3	Minimum hardness[2]	8.3	Hardness test[3]	○	○	8.3	Hardness test[3]	○	○
	5.4 and 5.5	Maximum hardness			● ○	● ○			● ○	● ○
	5.6	Maximum surface hardness				● ○				● ○
II	5.7	Minimum lower yield stress, R_{eL}	8.1	Tensile test	●					
	5.8	Proof stress, $R_{p0,2}$	8.1	Tensile test		●				
	5.9	Stress under proofing load, S_p					8.4	Proofing load test	●	●
III	5.10	Minimum elongation after fracture, A min.	8.1	Tensile test	●	●				
	5.11	Strength under wedge loading[4]					8.5	Wedge loading test[1]	●	●
IV	5.12	Minimum impact strength	8.6	Impact test[5]	●[6]	●	8.6			
	5.13	Head soundness[7]					8.7	Head soundness test	○	○
V	5.14	Maximum decarburized zone	8.8	Decarburization test		● ○	8.8	Decarburization test		● ○
	5.15	Minimum tempering temperature	8.9	Retempering test		● ○	8.9	Retempering test		● ○
	5.16	Surface integrity	8.10	Surface integrity test	● ○	● ○	8.10	Surface integrity test	● ○	● ○

1) If the wedge loading test is satisfactory, the axial tensile test is not required.

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

3) Hardness may be Vickers, Brinell or Rockwell. In case of doubt, the Vickers hardness test is decisive for acceptance.

4) Special head bolts and screws with configurations which are weaker than the threaded section are excluded from wedge tensile testing requirements.

5) Only for bolts, screws and studs with thread diameters $d \geq 16$ mm and only if required by the purchaser.

6) Only property class 5.6.

7) Only for bolts and screws with thread diameters $d < 16$ mm and lengths too short to permit wedge load testing.

7 Minimum ultimate tensile loads and proofing loads

See tables 6, 7, 8 and 9

Table 6 — Minimum ultimate tensile loads — ISO metric coarse pitch thread

Thread[1]	Nominal stress area $A_{s,nom}$ mm²	Property class									
		3.6	4.6	4.8	5.6	5.8	6.8	8.8	9.8	10.9	12.9
		Minimum ultimate tensile load ($A_s \times R_m$), 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	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[2]	75 900	87 700	103 000
M14	115	38 000	46 000	48 300	57 500	59 800	69 000	92 000[2]	104 000	120 000	140 000
M16	157	51 800	62 800	65 900	78 500	81 600	94 000	125 000[2]	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

Table 7 — Proofing loads — ISO metric coarse pitch thread

Thread[1]	Nominal stress area $A_{s,nom}$ mm²	Property class									
		3.6	4.6	4.8	5.6	5.8	6.8	8.8	9.8	10.9	12.9
		Proofing load ($A_s \times S_p$), N									
M3	5,03	910	1 130	1 560	1 410	1 910	2 210	2 920	3 270	4 180	4 880
M3,5	6,78	1 220	1 530	2 100	1 900	2 580	2 980	3 940	4 410	5 630	6 580
M4	8,78	1 580	1 980	2 720	2 460	3 340	3 860	5 100	5 710	7 290	8 520
M5	14,2	2 560	3 200	4 400	3 980	5 400	6 250	8 230	9 230	11 800	13 800
M6	20,1	3 620	4 520	6 230	5 630	7 640	8 840	11 600	13 100	16 700	19 500
M7	28,9	5 200	6 500	8 960	8 090	11 000	12 700	16 800	18 800	24 000	28 000
M8	36,6	6 590	8 240	11 400	10 200	13 900	16 100	21 200	23 800	30 400	35 500
M10	58	10 400	13 000	18 000	16 200	22 000	25 500	33 700	37 700	48 100	56 300
M12	84,3	15 200	19 000	26 100	23 600	32 000	37 100	48 900[3]	54 800	70 000	81 800
M14	115	20 700	25 900	35 600	32 200	43 700	50 600	66 700[3]	74 800	95 500	112 000
M16	157	28 300	35 300	48 700	44 000	59 700	69 100	91 000[3]	102 000	130 000	152 000
M18	192	34 600	43 200	59 500	53 800	73 000	84 500	115 000	—	159 000	186 000
M20	245	44 100	55 100	76 000	68 600	93 100	108 000	147 000	—	203 000	238 000
M22	303	54 500	68 200	93 900	84 800	115 000	133 000	182 000	—	252 000	294 000
M24	353	63 500	79 400	109 000	98 800	134 000	155 000	212 000	—	293 000	342 000
M27	459	82 600	103 000	142 000	128 000	174 000	202 000	275 000	—	381 000	445 000
M30	561	101 000	126 000	174 000	157 000	213 000	247 000	337 000	—	466 000	544 000
M33	694	125 000	156 000	215 000	194 000	264 000	305 000	416 000	—	570 000	673 000
M36	817	147 000	184 000	253 000	229 000	310 000	359 000	490 000	—	678 000	792 000
M39	976	176 000	220 000	303 000	273 000	371 000	429 000	586 000	—	810 000	947 000

1) Where no thread pitch is indicated in a thread designation, coarse pitch is specified. This is given in ISO 261 and ISO 262.

2) For structural bolting 70 000, 95 500 and 130 000 N, respectively.

3) For structural bolting 50 700, 68 800 and 94 500 N, respectively.