INTERNATIONAL STANDARD ISO 898/I

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

Mechanical properties of fasteners — Part I : Bolts, screws and studs

Caractéristiques mécaniques des éléments de fixation — Partie I : Boulons, vis et goujons

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up 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.

International Standard ISO 898/I was developed by Technical Committee ISO/TC 2, *Fasteners*, and was circulated to the member bodies in May 1978.

It has been approved by the member bodies of the following countries :

Australia	India	Poland
Canada	Japan	South Africa, Rep. of
Czechoslovakia	Korea, Rep. of	Sweden
Denmark	Mexico	Switzerland
Finland	Netherlands	Turkey
France	New Zealand	United Kingdom
Germany, F.R.	Norway	U.S.A.

The member body of the following country expressed disapproval of the document on technical grounds :

Italy

This International Standard cancels and replaces ISO Recommendation R 898/I-1968, of which it constitutes a technical revision.

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CONTENTS

Mechanical properties of fasteners — Part I : Bolts, screws and studs

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies the mechanical properties of bolts, screws and studs.

It applies to bolts, screws and studs

- with nominal diameters up to and including 39 mm;
- of any triangular ISO thread and with diameters and pitches according to ISO 68, ISO 261 and ISO 262;
- of any shape;
- made of carbon steel or alloy steel.

It does not apply to set screws and similar threaded fasteners.

It does not specify requirements for such properties as

- weldability;
- corrosion resistance;
- ability to withstand temperature above + 300 °C or below − 50 °C.

NOTE — The designation system of this International Standard may be used for sizes outside the limits laid down in the scope (i.e. larger sizes than 39 mm) provided that all mechanical requirements of the property classes are met.

2 REFERENCES

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

ISO/R 79, *Brinell hardness test for steel and cast iron.*

ISO/R 80, *Rockwell hardness test (B and C scales) for steel.*

ISO/R 81, *Vickers hardness test for steel.*

ISO 82, *Steel — Tensile testing.*

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

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/R 273, *Clearance holes for metric bolts,* 1,6 *up to and including* 39 mm *thread diameter.*

ISO 6157/I, *Fasteners — Surface discontinuities — Part I : Bolts, screws and studs with thread sizes* M5 *to* M39.[1)]

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 N/mm^2) while the ordinates show those of the elongation after fracture (A_5 in %).

The symbol consists of two figures :

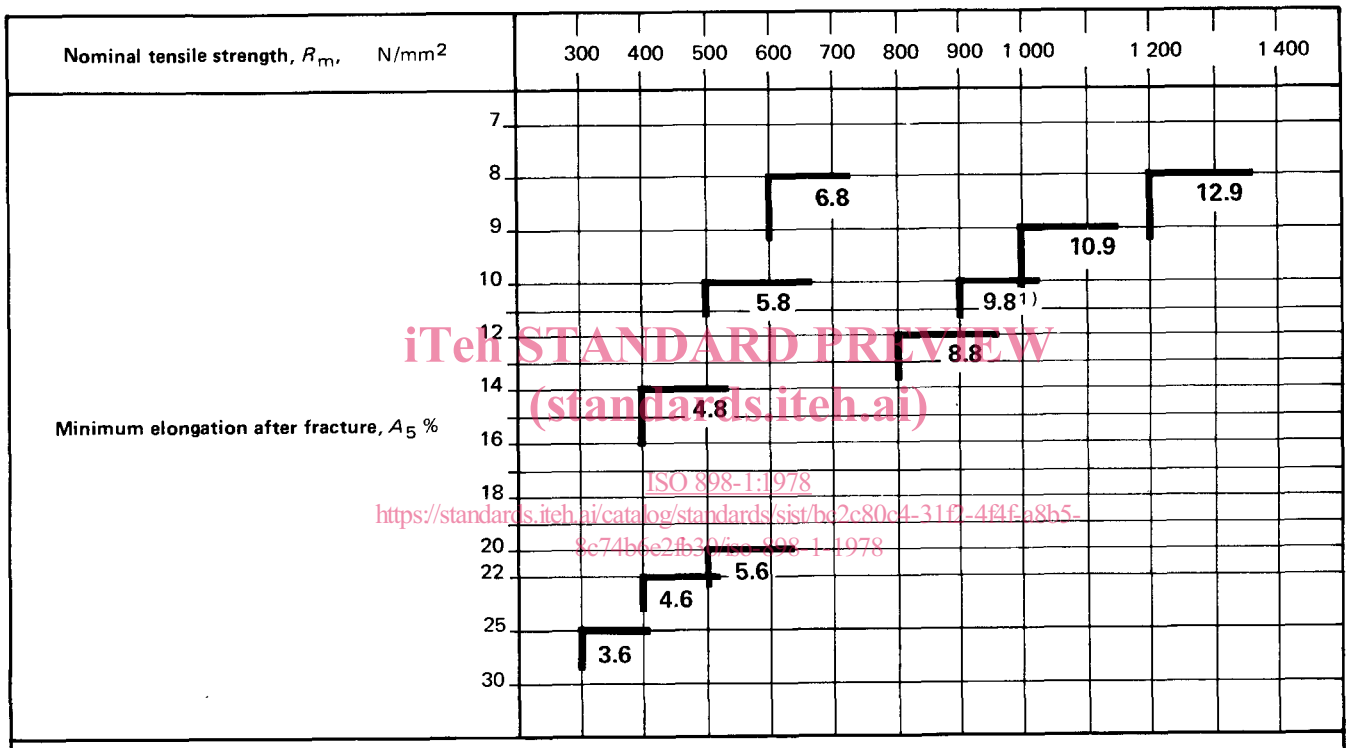
- the first indicates 1/100 of the nominal tensile strength in newtons per square millimetre (see R_m in table 3);
- the second figure indicated 10 times the ratio between nominal yield stress (R_{eL} or $R_{p0,2}$) and nominal tensile strength R_m (yield stress ratio).

The multiplication of these two figures will give 1/10 of the nominal yield stress (R_{eL} or $R_{p0,2}$) in newtons per square millimetre.

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

1) At present at the stage of draft.

TABLE 1 — **System of co-ordinates**



Relationship between yield stress and tensile strength				
Second figure of symbol		.6	.8	.9
Nominal yield stress R_{eL} or $R_{p0,2}$ / Nominal tensile strength R_m × 100	%	60	80	90

1) Applies only to sizes up to 16 mm thread diameter.

NOTE — Although a great number of property classes are specified in this International Standard 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.

4 MATERIALS

Table 2 specifies steels for the different property class 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.

Materials and heat treatments other than those listed in table 2 may be used by special agreement between purchaser and supplier when the latter can demonstrate that all mechanical properties are maintained.

TABLE 2 – **Steels**

Property class	Material and treatment	Chemical composition limits (check analysis) %				Tempering temperature °C[1]
		C		P	S	
		min.	max.	max.	max.	min.
3.6[2]	Low carbon steel	–	0,20	0,05	0,06	–
4.6[2]	Low or medium carbon steel	–	0,55	0,05	0,06	–
4.8[2]						
5.6	Low or medium carbon steel	–	0,55	0,05	0,06	–
5.8[2]						
6.8[2]						
8.8[6]	Low carbon steel with additives (e.g. boron or Mn or Cr), quenched and tempered	0,15	0,35	0,04	0,05	425
8.8[3]	Medium carbon steel, quenched and tempered	0,25	0,55	0,04	0,05	450[7]
9.8[6]	Low carbon steel with additives (e.g. boron or Mn or Cr), quenched and tempered	0,15	0,35	0,04	0,05	410
9.8	Medium carbon steel, quenched and tempered	0,25	0,55	0,04	0,05	410
10.9[6]	Low carbon steel with additives (e.g. boron or Mn or Cr), quenched and tempered	0,15	0,35	0,04	0,05	340
10.9[5]	Medium carbon steel, quenched and tempered	0,25	0,55	0,04	0,05	425
	or					
	Medium carbon steel with additives (e.g. boron or Mn or Cr), quenched and tempered	0,20[8]	0,55			
	or					
	Alloy steel[4]	0,20	0,55	0,035	0,035	
12.9[5]	Alloy steel[4]	0,20	0,50	0,035	0,035	380

1) The mean of three hardness readings on a bolt tested before and after retempering shall not differ more than 20 Vickers points when retempered at a temperature 10 °C less than the specified minimum tempering temperature for 30 min.

2) Free-cutting steel is allowed for these classes with the following maximum sulphur, phosphorus and lead content :

sulphur 0,34 %; phosphorus 0,11 %; lead 0,35 %

3) For sizes above M20 the steels specified for class 10.9 may be necessary in order to achieve sufficient hardenability.

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

5) For the materials of these 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 of the fasteners in the "as hardened" condition before tempering.

6) Products made of low carbon martensitic steel shall be additionally identified by underlining the symbol of the property class (see clause 9).

7) For size M20 and larger a tempering temperature of 425 °C may be used.

8) In some countries this level of carbon is classified as low carbon steel.

5 MECHANICAL PROPERTIES

When tested by the methods described in clause 8, the bolts, screws and studs shall have, at room temperature, 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 ⩽ M16	8.8 > M16[1]	9.8[2]	10.9	12.9
5.1 and 5.2	Tensile strength, R_m, N/mm²	nominal	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[3], HV, $F \geqslant 98$ N	min.	95	120	130	155	160	190	230	255	280	310	372
		max.	220					250	300	336	360	382	434
5.4	Brinell hardness[3], HB, $F = 30\,D^2$	min.	90	114	124	147	152	181	219	242	266	295	353
		max.	209					238	285	319	342	363	412
5.5	Rockwell hardness[3], HR	min. HRB	52	67	71	79	82	89	–	–	–	–	–
		min. HRC	–	–	–	–	–	–	20	23	27	31	38
		max. HRB	95					99	–	–	–	–	–
		max. HRC	–			–		–	30	34	36	39	44
5.6	Surface hardness, HV 0,3	max.							320	356	380	402	454
5.7	Yield stress[4], R_{eL}, N/mm²	nominal	180	240	320	300	400	480	–	–	–	–	–
		min.	190	240	340	300	420	480	–	–	–	–	–
5.8	Stress at permanent set limit, $R_{p0,2}$, N/mm²	nominal	–						640	640	720	900	1 080
		min.	–						640	660	720	940	1 100
5.9	Stress under proof load, S_p	S_p/R_{eL} or $R_{p0,2}$	0,94	0,94	0,91	0,94	0,91	0,91	0,91	0,91	0,91	0,88	0,88
		N/mm²	180	225	310	280	380	440	580	600	650	830	970
5.10	Elongation after fracture, A_5, %	min.	25	22	14	20	10	8	12	12	10	9	8
5.11	Strength under wedge loading		The values for full size bolts and screws (not studs) should equal 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 structural bolting ⩾ M12.

2) Applies only to sizes up to 16 mm thread diameter.

3) Hardness values calculated on ISO/TC 17/SC6 N 357.

4) In a case where the yield stress, R_{eL}, cannot be determined, it is permissible to measure the stress at permanent set limit, $R_{p0,2}$.

6 MECHANICAL PROPERTIES TO BE DETERMINED

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

Programme B shall be used wherever the capacity of available testing equipment permits.

For all cases marked with ○ in table 4, this programme is the referee method.

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

For all cases marked with • in table 4, this programme is the referee method.

TABLE 4 – **Key to test programmes** (table 5)

Size	Bolts and screws with thread diameters ⩽ 4 mm or length < 3 d[1)]	Bolts and screws with thread diameters > 4 mm and length ⩾ 3 d
Test decisive for acceptance	○	•

1) Also bolts and screws with special head 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 4.8, 5.6 5.8, 6.8	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[7]	●	●
	5.3 5.4 and 5.5	Minimum hardness[1]	8.3	Hardness test[2]	○	○	8.3	Hardness test[2]	○	○
		Maximum hardness			● ○	● ○			● ○	● ○
	5.6	Maximum surface hardness				● ○				● ○
II	5.7	Minimum yield stress, R_{eL}	8.1	Tensile test	●					
	5.8	Stress at permanent set limit, $R_{p0,2}$	8.1	Tensile test		●				
	5.9	Stress under proof load, S_p					8.4	Proof load test	●	●
III	5.10	Minimum elongation after fracture, A_5	8.1	Tensile test	●	●				
	5.11	Strength under wedge loading[3]					8.5	Wedge loading test	● ○	● ○
IV	5.12	Minimum impact strength	8.6	Impact test[4]	●[5]	●				
	5.13	Head soundness[6]					8.7	Head soundness test	○	○
V	5.14	Maximum decarburized zone	8.8	Decarburization test		● ○	8.8	Decarburization test		● ○
	5.15	Retempering	8.8	Retempering test		● ○	8.8	Retempering test		● ○
	5.16	Surface integrity	8.9	Surface integrity test			8.9	Surface integrity test	● ○	● ○

1) Minimum hardness readings can replace tensile tests also for bolts, screws and studs with thread diameters > 4 mm and length ⩾ 3 d for simplifying the procedure, but for referee purposes tensile tests are decisive.

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

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

4) Only for bolts, screws and studs with thread diameters ⩾ 16 mm and only if required by the purchaser.

5) Only property class 5.6.

6) Only for bolts and screws with thread diameters ⩽ 16 mm and lengths too short to permit wedge load testing.

7) If the wedge loading test is applied, the axial tensile test is not required.

7 MINIMUM ULTIMATE TENSILE LOADS AND PROOF LOADS

See tables 6, 7, 8 and 9.

TABLE 6 — **Minimum ultimate tensile loads — ISO metric coarse thread**

Nominal thread diameter mm	Pitch of the thread mm	Nominal stress area mm^2	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									
3	0,5	5,03	1 660	2 010	2 110	2 510	2 620	3 020	4 020	4 530	5 230	6 140
3,5	0,6	6,78	2 240	2 710	2 850	3 390	3 530	4 070	5 420	6 100	7 050	8 270
4	0,7	8,78	2 900	3 510	3 690	4 390	4 570	5 270	7 020	7 900	9 130	10 700
5	0,8	14,2	4 690	5 680	5 960	7 100	7 380	8 520	11 350	12 800	14 800	17 300
6	1	20,1	6 630	8 040	8 440	10 000	10 400	12 100	16 100	18 100	20 900	24 500
7	1	28,9	9 540	11 600	12 100	14 400	15 000	17 300	23 100	26 000	30 100	35 300
8	1,25	36,6	12 100	14 600	15 400	18 300	19 000	22 000	29 200	32 900	38 100	44 600
10	1,5	58,0	19 100	23 200	24 400	29 000	30 200	34 800	46 400	52 200	60 300	70 800
12	1,75	84,3	27 800	33 700	35 400	42 200	43 800	50 600	67 400[1]	75 900	87 700	103 000
14	2	115	38 000	46 000	48 300	57 500	59 800	69 000	92 000[1]	104 000	120 000	140 000
16	2	157	51 800	62 800	65 900	78 500	81 600	94 000	125 000[1]	141 000	163 000	192 000
18	2,5	192	63 400	76 800	80 600	96 000	99 800	115 000	159 000	—	200 000	234 000
20	2,5	245	80 800	98 000	103 000	122 000	127 000	147 000	203 000	—	255 000	299 000
22	2,5	303	100 000	121 000	127 000	152 000	158 000	182 000	252 000	—	315 000	370 000
24	3	353	116 000	141 000	148 000	176 000	184 000	212 000	293 000	—	367 000	431 000
27	3	459	152 000	184 000	193 000	230 000	239 000	275 000	381 000	—	477 000	560 000
30	3,5	561	185 000	224 000	236 000	280 000	292 000	337 000	466 000	—	583 000	684 000
33	3,5	694	229 000	278 000	292 000	347 000	361 000	416 000	576 000	—	722 000	847 000
36	4	817	270 000	327 000	343 000	408 000	425 000	490 000	678 000	—	850 000	997 000
39	4	976	322 000	390 000	410 000	488 000	508 000	586 000	810 000	—	1 020 000	1 200 000

TABLE 7 — **Proof loads — ISO metric coarse thread**

Nominal thread diameter mm	Pitch of the thread mm	Nominal stress area mm^2	Property class									
			3.6	4.6	4.8	5.6	5.8	6.8	8.8	9.8	10.9	12.9
			Proof load ($A_s \times S_p$), N									
3	0,5	5,03	910	1 130	1 560	1 410	1 910	2 210	2 920	3 270	4 180	4 880
3,5	0,6	6,78	1 220	1 530	2 100	1 900	2 580	2 980	3 940	4 410	5 630	6 580
4	0,7	8,78	1 580	1 980	2 720	2 460	3 340	3 860	5 100	5 710	7 290	8 520
5	0,8	14,2	2 560	3 200	4 400	3 980	5 400	6 250	8 230	9 230	11 800	13 800
6	1	20,1	3 620	4 520	6 230	5 630	7 640	8 840	11 600	13 100	16 700	19 500
7	1	28,9	5 200	6 500	8 960	8 090	11 000	12 700	16 800	18 800	24 000	28 000
8	1,25	36,6	6 590	8 240	11 400	10 200	13 900	16 100	21 200	23 800	30 400	35 500
10	1,5	58,0	10 400	13 000	18 000	16 200	22 000	25 500	33 700	37 700	48 100	56 300
12	1,75	84,3	15 200	19 000	26 100	23 600	32 000	37 100	48 900[2]	54 800	70 000	81 800
14	2	115	20 700	25 900	35 600	32 200	43 700	50 600	66 700[2]	74 800	95 500	112 000
16	2	157	28 300	35 300	48 700	44 000	59 700	69 100	91 000[2]	102 000	130 000	152 000
18	2,5	192	34 600	43 200	59 500	53 800	73 000	84 500	115 000	—	159 000	186 000
20	2,5	245	44 100	55 100	76 000	68 600	93 100	108 000	147 000	—	203 000	238 000
22	2,5	303	54 500	68 200	93 900	84 800	115 000	133 000	182 000	—	252 000	294 000
24	3	353	63 500	79 400	109 000	98 800	134 000	155 000	212 000	—	293 000	342 000
27	3	459	82 600	103 000	142 000	128 000	174 000	202 000	275 000	—	381 000	445 000
30	3,5	561	101 000	126 000	174 000	157 000	213 000	247 000	337 000	—	466 000	544 000
33	3,5	694	125 000	156 000	215 000	194 000	264 000	305 000	416 000	—	570 000	673 000
36	4	817	147 000	184 000	253 000	229 000	310 000	359 000	490 000	—	678 000	792 000
39	4	976	176 000	220 000	303 000	273 000	371 000	429 000	586 000	—	810 000	947 000

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

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