INTERNATIONAL STANDARD

ISO 898-1

Third edition
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Mechanical properties of fasteners made of carbon steel and alloy steel —

Part 1:
Bolts, screws and studs

Caractéristiques mécaniques des éléments de fixation en acier au carbone et en acier allié —

Partie 1: Vis et goujons

Reference number
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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. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 898-1 was prepared by Technical Committee ISO/TC 2, *Fasteners*, Subcommittee SC 1, *Mechanical properties of fasteners*.

This third edition cancels and replaces the second edition (ISO 898-1:1988) which has been technically revised.

ISO 898 consists of the following parts, under the general title *Mechanical properties of fasteners made of carbon steel and alloy steel*:

— *Part 1: Bolts, screws and nuts*

— *Part 2: Nuts with specified proof load values — Coarse thread*

— *Part 5: Set screws and similar threaded fasteners not under tensile stresses*

— *Part 6: Nuts with specified proof load values — Fine pitch thread*

— *Part 7: Torsional test and minimum torques for bolts and screws with nominal diameter from 1 mm to 10 mm*

Annex A of this part of ISO 898 is for information only.

Mechanical properties of fasteners made of carbon steel and alloy steel —

Part 1:
Bolts, screws and studs

1 Scope

This part of ISO 898 specifies the mechanical properties of bolts, screws and studs made of carbon steel and alloy steel when tested at an ambient temperature range of 10 °C to 35 °C.

Products conforming to the requirements of this part of ISO 898 are evaluated only in the ambient temperature range and may not retain the specified mechanical and physical properties at higher and lower temperatures. Attention is drawn to annex A which provides examples of lower yield stress and stress at 0,2 % non-proportional elongation at elevated temperatures.

At temperatures lower than the ambient temperature range, a significant change in the properties, particularly impact strength, may occur. When fasteners are to be used above or below the ambient temperature range it is the responsibility of the user to ensure that the mechanical and physical properties are suitable for his particular service conditions.

Certain fasteners may not fulfill the tensile or torsional requirements of this part of ISO 898 because of the geometry of the head which reduces the shear area in the head as compared to the stress area in the thread such as countersunk, raised countersunk and cheese heads (see clause 6).

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

— with coarse pitch thread M1,6 to M39, and fine pitch thread M8 × 1 to M39 × 3;

— with triangular ISO thread in accordance with ISO 68-1;

— with diameter/pitch combinations in accordance with ISO 261 and ISO 262;

— with thread tolerance in accordance with ISO 965-1 and ISO 965-2;

— made of carbon steel or alloy steel.

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

It does not specify requirements for such properties as

— weldability;

— corrosion-resistance;

— ability to withstand temperatures above + 300 °C (+ 250 °C for 10.9) or below − 50 °C;

— resistance to shear stress;

— fatigue resistance.

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 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 898. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 898 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 68-1:1998, *ISO general purpose screw threads – Basic profile – Part 1: Metric screw threads.*

ISO 83:1976, *Steel – Charpy impact test (U-notch).*

ISO 261:1998, *ISO general purpose metric screw threads – General plan.*

ISO 262:1998, *ISO general purpose metric screw threads – Selected sizes for screws, bolts and nuts.*

ISO 273:1979, *Fasteners – Clearance holes for bolts and screws.*

ISO 724:1978, *ISO general purpose metric screw threads – Basic dimensions*.

ISO 898-2:1992, *Mechanical properties of fasteners made of carbon steel and alloy steel – Part 2: Nuts with specified proof load values – Coarse thread*.

ISO 898-5:1998, *Mechanical properties of fasteners made of carbon steel and alloy steel – Part 5: Set screws and similar threaded fasteners not under tensile stresses.*

ISO 898-7:1992, *Mechanical properties of fasteners made of carbon steel and alloy steel – Part 7: Torsional test and minimum torques for bolts and screws with nominal diameters 1 mm to 10 mm*.

ISO 965-1:1998, *ISO general purpose metric screw threads – Tolerances – Part 1: Principles and basic data.*

ISO 965-2:1998, *ISO general purpose metric screw threads – Tolerances – Part 2: Limits of sizes for general purpose external and internal screw threads – Medium quality.*

ISO 6157-1:1988, *Fasteners – Surface discontinuities – Part 1: Bolts, screws and studs for general requirements.*

ISO 6157-3:1988, *Fasteners – Surface discontinuities – Part 3: Bolts, screws and studs for special requirements.*

ISO 6506:1981, *Metallic materials – Hardness test – Brinell test*.

ISO 6507-1:1997, *Metallic material – Hardness test – Vickers test – Part 1: Test method*.

ISO 6508:1986, *Metallic materials – Hardness test – Rockwell test (scales A - B - C - D - E - F - G - H - K).*

ISO 6892:1998, *Metallic materials – Tensile testing at ambient temperature*.

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.

The property class symbol consists of two figures:

— the first figure indicates 1/100 of the nominal tensile strength in newtons per square millimetre (see 5.1 in table 3);

— the second figure indicates 10 times the ratio between lower yield stress R_{eL} (or stress at 0,2 % non-proportional elongation $R_{p0,2}$) and nominal tensile strength $R_{m, nom}$ (yield stress ratio).

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

The minimum lower yield stress $R_{eL,\ min.}$ (or minimum stress at 0,2 % non-proportional elongation $R_{p0,2,\ min.}$) and minimum tensile strength $R_{m,\ min.}$ are equal to or greater than the nominal values (see table 3).

4 Materials

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

The chemical composition shall be assessed in accordance with the relevant ISO standards.

5 Mechanical and physical properties

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

Table 1 — System of coordinates

Nominal tensile strength $R_{m,\,nom}$ N/mm^2	300	400	500	600	700	800	900	1 000	1 200	1 400
Minimum elongation after fracture, A_{min} percent 7										
8										
9					6.8				12.9	
10								10.9		
12				5.8			9.8[a]			
14						8.8				
16			4.8							
18										
20										
22				5.6						
25			4.6							
30		3.6								

Relationship between yield stress and tensile strength			
Second figure of symbol	.6	.8	.9
$\frac{\text{Lower yield stress } R_{eL}{}^{b}}{\text{Nominal tensile strength } R_{m,\,nom}} \times 100\ \%$ or $\frac{\text{Stress at 0,2 \% non-proportional elongation } R_{p0,2}{}^{b}}{\text{Nominal tensile strength } R_{m,\,nom}} \times 100\ \%$	60	80	90

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 $d \leqslant 16$ mm.

b Nominal values according to table 3 apply.

Table 2 — Steels

Property class	Material and treatment	Chemical composition limits (check analysis) % (*m*/*m*)					Tempering temperature
		C		P	S	B [a]	°C
		min.	max.	max.	max.	max.	min.
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]							
5.6		0,13	0,55	0,05	0,06		–
5.8 [b]		–	0,55	0,05	0,06	0,003	
6.8 [b]							
8.8 [c]	Carbon steel with additives (e.g. 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 (e.g. 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 (e.g. 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 (e.g. 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 classe 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 (see clause 9). All properties of 10.9 as specified in table 3 shall be met by 10.9, however, its lower tempering temperature gives it different stress relaxation characteristics at elevated temperatures (see annex A).

[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 phosphorous 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.

Table 3 — 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	8.8[a]		9.8[b]	10.9	12.9
									$d \leqslant 16$[c] mm	$d > 16$[c] mm			
5.1	Nominal tensile strength, $R_{m,\,nom}$	N/mm^2	300	400		500		600	800	800	900	1 000	1 200
5.2	Minimum tensile strength, $R_{m,\,min}$[d e]	N/mm^2	330	400	420	500	520	600	800	830	900	1 040	1 220
5.3	Vickers hardness, HV	min.	95	120	130	155	160	190	250	255	290	320	385
	$F \geqslant 98$ N	max.	220[f]					250	320	335	360	380	435
5.4	Brinell hardness, HB	min.	90	114	124	147	152	181	238	242	276	304	366
	$F = 30\,D^2$	max.	209[f]					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	95,0[f]					99,5	—	—	—	—	—
		max. HRC	—					—	32	34	37	39	44
5.6	Surface hardness, HV 0,3	max.	—						[g]				
5.7	Lower yield stress R_{eL}[h], N/mm^2	nom.	180	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	1 080
		min.	—					—	640	660	720	940	1 100
5.9	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
	Stress under proof load, S_p	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 minimum 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		—						$\frac{1}{2} H_1$			$\frac{2}{3} H_1$	$\frac{3}{4} H_1$
	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 $d \leqslant 16$ 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 $d \leqslant 16$ mm.

[c] For structural bolting the limit is 12 mm.

[d] Minimum tensile properties apply to products of nominal length $l \geqslant 2{,}5\,d$. 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 6 and 8.

[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.

6 Mechanical and physical properties to be determined

Two test programmes, A and B, for mechanical and physical properties of bolts, screws and studs, using the methods described in clause 8, are set out in table 5. Regardless of the choice of test programme, all requirements of table 3 shall be met.

The application of programme B is always desirable, but is mandatory for products with ultimate tensile loads less than 500 kN if the application of programme A is not explicitly agreed.

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 $d \leqslant 3$ mm or length $l < 2{,}5\ d$[a]	Bolts and screws with thread diameter $d > 3$ mm and length $l \geqslant 2{,}5\ d$
Test decisive for acceptance	❍	●

[a] 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	5.2	Minimum tensile strength, $R_{m,\,min.}$	8.1	Tensile test	●	●	8.2	Tensile test [a]	●	●
	5.3 and 5.4 and 5.5	Minimum hardness [b]	8.4	Hardness test [c]	❍	❍	8.4	Hardness test [c]	❍	❍
		Maximum hardness			● ❍	● ❍			● ❍	● ❍
	5.6	Maximum surface hardness				● ❍				● ❍
II	5.7	Minimum lower yield stress $R_{eL,.min.}$ [d]	8.1	Tensile test	●					
	5.8	Stress at 0,2 % non-proportional elongation, $R_{p0,2}$ [d]	8.1	Tensile test		●				
	5.9	Stress under proof load, S_p					8.5	Proof load test	●	●
	5.10	Breaking torque, M_B					8.3	Torsional test [e]		❍
III	5.11	Minimum percent elongation after fracture, A_{min} [d]	8.1	Tensile test	●	●				
	5.12	Minimum reduction of area after fracture Z_{min}	8.1	Tensile test		●				
	5.13	Strength under wedge loading [f]					8.6	Wedge loading test [a]	●	●
IV	5.14	Minimum impact strength, KU	8.7	Impact test [g]	● [h]	●				
	5.15	Head soundness [i]					8.8	Head soundness test	❍	❍
V	5.16	Maximum decarburized zone	8.9	Decarburization test		● ❍	8.9	Decarburization test		● ❍
	5.17	Hardness after retempering	8.10	Retempering test [j]		● ❍	8.10	Retempering test [j]		● ❍
	5.18	Surface integrity	8.11	Surface discontinuity inspection	● ❍	● ❍	8.11	Surface discontinuity inspection	● ❍	● ❍

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

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

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

d Only for bolts or screws with length $l \geqslant 6d$.

e Only if bolts or screws cannot be tensile tested.

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

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

h Only property class 5.6.

i Only for bolts and screws with thread diameters $d \leqslant 10$ mm and lengths too short to permit wedge load testing

j Test not mandatory, to be applied as a referee test in the case of dispute only.