INTERNATIONAL STANDARD

ISO 3506-1

Third edition
2020-04

Fasteners — Mechanical properties of corrosion-resistant stainless steel fasteners —

Part 1: **Bolts, screws and studs with specified grades and property classes**

Fixations — Caractéristiques mécaniques des fixations en acier inoxydable résistant à la corrosion —

Partie 1: Vis, goujons et tiges filetées de grades et classes de qualité spécifiés

Reference number
ISO 3506-1:2020(E)

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 2, *Fasteners*.

This third edition cancels and replaces the second edition (ISO 3506-1:2009), which has been technically revised.

The main changes compared to the previous edition are as follows:

— annexes common to several parts of the ISO 3506 series have been withdrawn from this document and are now included in a new document (ISO 3506-6);

— duplex (austenitic-ferritic) stainless steels for property classes 70, 80 and 100 have been added (see Figure 1);

— property class 100 for austenitic stainless steel grades as well as grade A8 have been added (see Figure 1);

— finish (see 6.3) has been added;

— the matching of stainless steel bolt and nut grades (see 6.4) has been added;

— calculated minimum ultimate tensile loads and minimum loads at 0,2 % non-proportional elongation (see Tables 4 to 7) and rounding rules have been added;

— reduced loadability for fasteners due to head or shank design (see 8.2) has been added;

— requirements and guidance for inspection procedures (see 8.3 to 8.6) have been added;

— operational temperature ranges (see Clause 1) have been clarified;

— the applicability of test methods (see Clause 8), also in relation to full and reduced loadability, has been added;

— the tensile test procedure (see 9.1) has been entirely amended, and application to fasteners with reduced loadability (see 9.2 and 9.3) has been added;

- the wedge tensile test (see 9.4) and hardness test (see 9.6) have been improved;
- marking and labelling (see Clause 10) have been improved, and fasteners with reduced loadability have been included;
- mechanical properties at elevated temperatures and application at low temperatures (see Annex A) have been improved;
- the structure and content of this document have been brought in line with ISO 898-1.

A list of all parts in the ISO 3506 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The ISO 3506 series consists of the following parts, under the general title *Fasteners — Mechanical properties of corrosion-resistant stainless steel fasteners*:

— *Part 1: Bolts, screws and studs with specified grades and property classes*

— *Part 2*: *Nuts with specified grades and property classes*

— *Part 3*[1]*: Set screws and similar fasteners not under tensile stress*

— *Part 4*[1]*: Tapping screws*

— *Part 5*[2]*: Special fasteners (also including fasteners from nickel alloys) for high temperature applications*

— Part 6: *General rules for the selection of stainless steels and nickel alloys for fasteners*

The properties of stainless steel fasteners result from the chemical composition of the material (especially corrosion resistance) and from the mechanical properties due to the manufacturing processes. Ferritic, austenitic and duplex (austenitic-ferritic) stainless steel fasteners are generally manufactured by cold working; they consequently do not have homogeneous local material properties when compared to quenched and tempered fasteners.

Austenitic-ferritic stainless steels referred to as duplex stainless steels were originally invented in the 1930s. Standard duplex grades used today have been developed since the 1980s. Fasteners made of duplex stainless steels have been long established in a range of applications. This document was revised to reflect their standardization.

All duplex stainless steel grades show improved resistance to stress corrosion cracking compared to the commonly used A1 to A5 austenitic grades. Most duplex grades also show higher levels of pitting corrosion resistance, where D2 matches at least A2 and where D4 matches at least A4.

Complementary detailed explanations about definitions of stainless steel grades and properties are specified in ISO 3506-6.

1) It is intended to revise ISO 3506-3 and ISO 3506-4 in the future in order to include the reference to ISO 3506-6.

2) Under preparation.

Fasteners — Mechanical properties of corrosion-resistant stainless steel fasteners —

Part 1:
Bolts, screws and studs with specified grades and property classes

1 Scope

This document specifies the mechanical and physical properties of bolts, screws and studs, with coarse pitch thread and fine pitch thread, made of corrosion-resistant stainless steels, when tested at the ambient temperature range of 10 °C to 35 °C. It specifies property classes in relation to austenitic, martensitic, ferritic and duplex (austenitic-ferritic) steel grades for fasteners.

The term “fasteners” is used in this document when bolts, screws and studs are considered all together.

ISO 3506-6 provides general rules and additional technical information on suitable stainless steels and their properties.

Fasteners conforming to the requirements of this document are evaluated at the ambient temperature specified in paragraph 1. It is possible that they do not retain the specified mechanical and physical properties at elevated and/or lower temperatures.

NOTE 1 Fasteners conforming to the requirements of this document are used without restriction in applications ranging from –20 °C to +150 °C; however, fasteners conforming to this document are also used for applications outside this range down to –196 °C and up to +300 °C. For more details, see Annex A and ISO 3506-6.

Outside the temperature range of –20 °C to +150 °C, it is the responsibility of the user to determine the appropriate choice for a given application in consultation with an experienced fastener metallurgist and by taking into account e.g. stainless steel composition, duration of exposure at elevated or low temperature, the effect of the temperature on the fasteners mechanical properties and clamped parts, and the corrosive service environment of the bolted joint.

NOTE 2 ISO 3506-5 is developed in order to assist in the selection of appropriate stainless steel grades and property classes intended for use at temperatures up to +800 °C.

This document applies to bolts, screws and studs:

— with ISO metric thread in accordance with ISO 68-1,

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

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

— with thread tolerances in accordance with ISO 965-1 and ISO 965-2,

— with specified property classes, and

— of any shape.

Stainless steel grades and property classes can be used for sizes outside the diameter limits of this document (i.e. for d < 1,6 mm or d > 39 mm), provided that all applicable chemical, mechanical and physical requirements are met.

Certain bolts, screws and studs might not fulfil the tensile or torsional requirements of this document because of the geometry of their head or unthreaded shank, thus resulting in reduced loadability (e.g. when shear area in the head is less than the stress area in the thread; see 8.2.2).

This document does not apply to set screws and similar threaded fasteners not under tensile stress (see ISO 3506-3).

It does not specify requirements for functional properties such as:

— torque/clamp force properties,

— shear strength,

— fatigue resistance, or

— weldability.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1891-4, *Fasteners — Vocabulary — Part 4: Control, inspection, delivery, acceptance and quality*

ISO 3506-6, *Fasteners — Mechanical properties of corrosion-resistant stainless steel fasteners — Part 6: General rules for the selection of stainless steels and nickel alloys for fasteners*

ISO 6506-1, *Metallic materials — Brinell hardness test — Part 1: Test method*

ISO 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method*

ISO 6508-1, *Metallic materials — Rockwell hardness test — Part 1: Test method*

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

ISO 7500-1, *Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system*

ISO 9513, *Metallic materials — Calibration of extensometer systems used in uniaxial testing*

ISO 16228, *Fasteners — Types of inspection documents*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
stainless steel bolt and screw with full loadability
bolt and screw with head stronger than the threaded and unthreaded shanks (with unthreaded shank diameter $d_s \approx d_2$ or $d_s > d_2$) or screw threaded to the head, and fulfilling the minimum ultimate tensile load

3.2
stainless steel stud with full loadability
stud with unthreaded shank diameter $d_s \approx d_2$ or $d_s > d_2$, and fulfilling the minimum ultimate tensile load

3.3
stainless steel bolt and screw with reduced loadability
bolt and screw with head weaker than the threaded and unthreaded shanks, or with an unthreaded shank diameter $d_s < d_2$

3.4
stainless steel stud with reduced loadability
stud with unthreaded shank diameter $d_s < d_2$

3.5
stainless steel
steel with at least 10,5 % (mass fraction) of chromium (Cr) and maximum 1,2 % (mass fraction) of carbon (C)

3.6
austenitic stainless steel
stainless steel (3.5) with high amounts of chromium and nickel which usually cannot be hardened by heat treatment, providing excellent resistance to corrosion, good ductility, and usually low or non-magnetic properties

3.7
martensitic stainless steel
stainless steel (3.5) with high amounts of chromium but very little nickel or other alloying elements, which can be hardened by heat treatment for increasing strength but with reduced ductility, and with highly magnetic properties

3.8
ferritic stainless steel
stainless steel (3.5) containing less than 0,1 % carbon and typically 11 % to 18 % chromium, which usually cannot be hardened by heat treatment, and with highly magnetic properties

3.9
duplex stainless steel
stainless steel (3.5) with a micro-structure that includes both austenitic and ferritic phases providing excellent resistance to corrosion, containing a higher amount of chromium and a reduced quantity of nickel compared to austenitic steel, with high strength, and with magnetic properties

4 Symbols

For the purposes of this document, the following symbols apply.

A total elongation after fracture, mm

$A_{s,nom}$ nominal stress area in thread, mm^2

A_{ds} cross-sectional area of waisted shank, mm^2

b thread length, mm

d nominal thread diameter of the fastener, mm

d_1 basic minor diameter of external thread, mm

d_2 basic pitch diameter of external thread, mm

d_3 minor diameter of external thread (for nominal stress area calculation), mm

d_a inner diameter of the bearing face, mm

d_h hole diameter for adaptors and wedge, mm

d_s diameter of unthreaded shank, mm

F_{mf} ultimate tensile load, N

F_{pf} load at 0,2 % non-proportional elongation for full-size fastener, N

H height of the fundamental triangle of the thread, mm

k height of the head, mm

l nominal length of fastener, mm

L_0 total length of fastener before tensile test, mm

L_1 total length of fastener after fracture, mm

L_2 clamping length before tensile test, mm

l_s length of unthreaded shank, mm

l_t overall length of stud, mm

l_{th} free threaded length of fastener in testing device, mm

M_B breaking torque, Nm

P pitch of the thread, mm

R_{mds} tensile strength for fastener with reduced loadability due to shank design, MPa

R_{mf} tensile strength for full-size fastener, MPa

R_{pf} stress at 0,2 % non-proportional elongation for full-size fastener, MPa

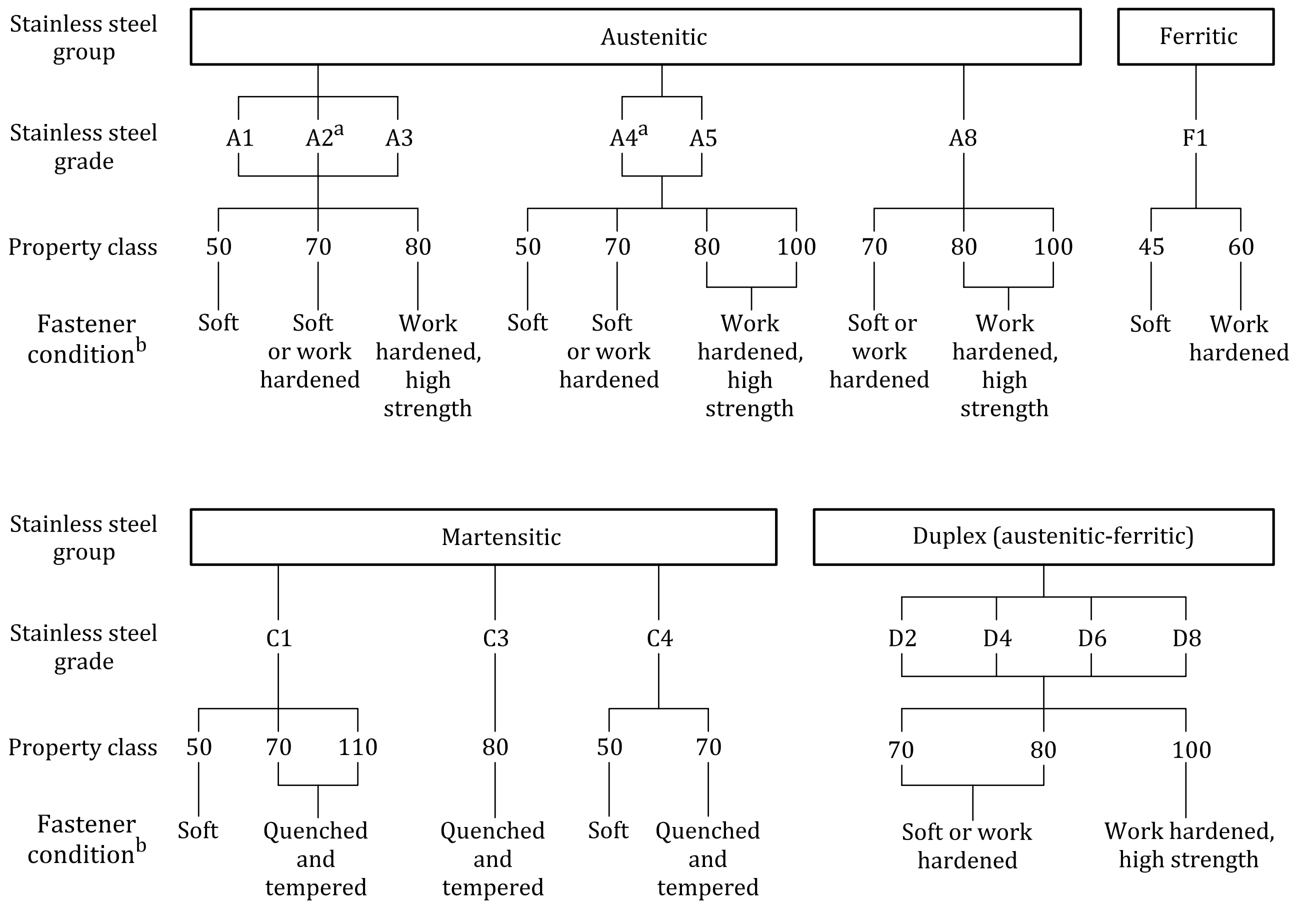
α wedge angle, °

5 Designation system for stainless steel grades and property classes

5.1 General

The standardized combinations of stainless steel grades and property classes are specified in Clause 7, Table 2 or 3.

The designation system for stainless steel grades and property classes for bolts, screws and studs consists of two blocks, separated by a hyphen, as specified in Figure 1. The first block designates the stainless steel grade, and the second block the property class of the fastener.



a For low carbon austenitic stainless steels with carbon content not exceeding 0,030 %, fasteners can additionally be marked or designated with the letter "L" just after the grade. Example: A4L-80.

b For information only.

Figure 1 — Designation system for stainless steel grades and property classes for fasteners

The marking, labelling and designation of fasteners with stainless steel grade and property class shall be as specified in Clause 10. For bolts, screws and studs with reduced loadability which can be tensile tested in the threaded shank, the digit “0” shall precede the property class as specified in 10.1.3. For fasteners with reduced loadability which cannot be tensile tested due to a too short thread length ($b < 3d$), the property class shall not be referenced.

The designation system of this document may be used for sizes outside the diameter limits specified in Clause 1 (i.e. $d < 1{,}6$ mm or $d > 39$ mm), provided that all applicable chemical, mechanical and physical requirements are met.

5.2 Designation of stainless steel grades (first block)

The designation of the stainless steel grade (first block) consists of one letter which specifies the stainless steel group:

— **A** for austenitic,

— **C** for martensitic,

— **F** for ferritic,

— **D** for duplex (austenitic-ferritic), and

— a digit which specifies the range of chemical compositions within this stainless steel group.

The chemical compositions of stainless steel groups and grades classified in Figure 1 are specified in Table 1.

5.3 Designation of property classes (second block)

The designation of the property class (second block) consists of a number corresponding to 1/10 of the minimum tensile strength of the fastener in accordance with Table 2 or 3.

EXAMPLE 1 A2-70 specifies an austenitic stainless steel fastener, work hardened, with a minimum tensile strength of 700 MPa.

EXAMPLE 2 C1-110 specifies a martensitic stainless steel fastener, quenched and tempered, with a minimum tensile strength of 1 100 MPa.

6 Materials

6.1 Chemical composition

Table 1 specifies the limits for chemical composition of the stainless steel grades for fasteners. The chemical composition shall be assessed in accordance with the relevant International Standards.

The final choice of the chemical composition within the specified stainless steel grade is at the discretion of the manufacturer, unless otherwise agreed between the purchaser and the manufacturer.

The stainless steel grade suitable for an application shall be selected in accordance with the specifications defined in ISO 3506-6.

Table 1 — Stainless steel grades — Chemical composition

Stainless steel grade		Chemical composition [a] (cast analysis, mass fraction in %) [b]										Other elements and notes
		C	Si	Mn	P	S	Cr	Mo	Ni	Cu	N	
Austenitic	A1	0,12	1,00	6,5	0,020	0,15 to 0,35	16,0 to 19,0	0,70	5,0 to 10,0	1,75 to 2,25	—	[c,d,e]
	A2	0,10	1,00	2,00	0,050	0,030	15,0 to 20,0	— [f]	8,0 to 19,0	4,0	—	[g,h]
	A3	0,08	1,00	2,00	0,045	0,030	17,0 to 19,0	— [f]	9,0 to 12,0	1,00	—	5C ≤ Ti ≤ 0,80 and/or 10C ≤ Nb ≤ 1,00
	A4	0,08	1,00	2,00	0,045	0,030	16,0 to 18,5	2,00 to 3,00	10,0 to 15,0	4,0	—	[h,i]
	A5	0,08	1,00	2,00	0,045	0,030	16,0 to 18,5	2,00 to 3,00	10,5 to 14,0	1,00	—	5C ≤ Ti ≤ 0,80 and/or 10C ≤ Nb ≤ 1,00 [i]
	A8	0,030	1,00	2,00	0,040	0,030	19,0 to 22,0	6,0 to 7,0	17,5 to 26,0	1,50	—	—
Martensitic	C1	0,09 to 0,15	1,00	1,00	0,050	0,030	11,5 to 14,0	—	1,00	—	—	[i]
	C3	0,17 to 0,25	1,00	1,00	0,040	0,030	16,0 to 18,0	—	1,50 to 2,50	—	—	—
	C4	0,08 to 0,15	1,00	1,50	0,060	0,15 to 0,35	12,0 to 14,0	0,60	1,00	—	—	[c,i]
Ferritic	F1	0,08	1,00	1,00	0,040	0,030	15,0 to 18,0	— [f]	1,00	—	—	[j]
Duplex	D2	0,040	1,00	6,0	0,040	0,030	19,0 to 24,0	0,10 to 1,00	1,50 to 5,5	3,00	0,05 to 0,20	Cr + 3,3Mo +16N ≤ 24,0 [k]
	D4	0,040	1,00	6,0	0,040	0,030	21,0 to 25,0	0,10 to 2,00	1,00 to 5,5	3,00	0,05 to 0,30	24,0 < Cr + 3,3Mo + 16N [k]
	D6	0,030	1,00	2,00	0,040	0,015	21,0 to 23,0	2,50 to 3,5	4,5 to 6,5	—	0,08 to 0,35	—
	D8	0,030	1,00	2,00	0,035	0,015	24,0 to 26,0	3,00 to 4,5	6,0 to 8,0	2,50	0,20 to 0,35	W ≤ 1,00

[a] According to material standards, values are maximum unless otherwise indicated and the number of digits shown is in accordance with usual rules, see e.g. EN 10088 (all parts).

[b] In case of dispute, product analysis applies.

[c] Selenium can be used to replace sulphur, however restrictions may apply to its use.

[d] If the nickel content is below 8,0 %, the minimum manganese content shall be 5,0 %.

[e] There is no minimum limit to the copper content provided that the nickel content is greater than 8,0 %.

[f] Molybdenum may be present at the discretion of the manufacturer. However, if for some applications limiting of the molybdenum content is essential, this shall be stated at the time of ordering by the purchaser.

[g] If the chromium content is below 17,0 %, the minimum nickel content should be 12,0 %.

[h] For austenitic stainless steels having a maximum carbon content of 0,030 %, nitrogen may be present but shall not exceed 0,22 %.

[i] At the discretion of the manufacturer the carbon content may be higher as necessary in order to obtain the specified mechanical properties for larger diameters, but shall not exceed 0,12 % for austenitic steels.

[j] Titanium and/or niobium may be included to improve corrosion resistance.

[k] This formula is used solely for the purpose of classifying duplex steels in accordance with this document (it is not intended to be used as a selection criterion for corrosion resistance).

For the choice of the appropriate stainless steel grade suitable for a specific application, see ISO 3506-6. Examples of stainless steels in accordance with Table 1 are also given in ISO 3506-6.

6.2 Heat treatment for martensitic stainless steel fasteners

Fasteners of grades and property classes C1-70, C3-80 and C4-70 shall be quenched and tempered.

Fasteners of grade and property class C1-110 shall be quenched and tempered, with a minimum tempering temperature of 275 °C.

6.3 Finish

Unless otherwise specified, fasteners in accordance with this document shall be supplied clean and bright.

For maximum corrosion resistance, passivation is recommended. Fasteners that are passivated in accordance with ISO 16048 may additionally be referenced on the label with the letter “P” immediately after the property class symbol (see 10.4).

NOTE 1 Passivated fasteners do not always show a bright surface finish.

Bolts, screws and studs are often used in bolted joints where the preload is achieved by torque tightening. Therefore, lubrication of stainless steel fasteners is recommended in order to avoid galling during tightening.

NOTE 2 Several parameters can increase the risk of galling for stainless steel fasteners in bolted assemblies during tightening such as thread damage, high preload, high tightening speed.

NOTE 3 For the time being, requirements concerning surface discontinuities and torque/clamp force properties are not specified in International Standards for stainless steel fasteners.

A controlled torque/clamp force relationship can be obtained for stainless steel fasteners by means of an adequate finish, either just with a lubricant or with a coating, top coat and/or sealer including lubricant. In this case, the designation and/or labelling should include the letters “Lu” immediately after the symbol of the property class, e.g. A4-80Lu. In conjunction, appropriate measures and means of tightening should be selected in order to achieve the required preload.

When specific requirements are necessary, it shall be agreed between the supplier and the purchaser at the time of the order.

6.4 Corrosion resistance

For corrosion resistance purpose, bolts, screws and studs should be mated with nuts and washers of the same stainless steel grade (e.g. nuts A2 with bolts A2, etc.). Other combinations are possible (e.g. nuts A4 with bolts D4), providing that:

— the component with the lowest corrosion resistance shall always be taken into account,

— the risk of galling should be considered, and

— it is strongly recommended that an experienced fastener metallurgist be consulted.

When using stainless steel fasteners with non-stainless steel parts in bolted joints, e.g. galvanized steels, it is advised that the use of isolation components be considered in order to avoid galvanic corrosion.

7 Mechanical and physical properties

When tested by the methods specified in Clause 9, the bolts, screws and studs of the specified stainless steel grade and property class shall meet, at ambient temperature, all the applicable requirements specified in Tables 2 to 8, regardless of which tests are performed during manufacture or final inspection.

Clause 8 specifies the applicability of test methods for verifying that fasteners of different types and dimensions fulfil the requirements in accordance with Tables 2 to 8.

Even if the material of the fasteners meets all relevant requirements specified in Clause 6, it is possible that certain fasteners would not fulfil the tensile or torsional requirements because of the geometry of their head (with reduced shear area in the head compared to the stress area in the thread, such as countersunk, raised countersunk or low head) or because of the geometry of their shank (reduced shear area in the unthreaded shank compared to the stress area in the thread). For such fasteners with reduced loadability, see 8.2.2 and 10.1.3.

Although a great number of stainless steel grades and property classes are specified in this document, this does not mean that all combinations are appropriate due to the properties of the material in conjunction with the fastener geometry. Nevertheless, some combinations of grades and property classes may not be available on the market. For non-standard fasteners, it is recommended that a fastener expert be consulted.

Table 2 — Mechanical properties for bolts, screws and studs — Austenitic and duplex grades

Stainless steel grade		Property class	Tensile strength [a] R_{mf} min. MPa	Stress at 0,2 % non-proportional elongation [b] R_{pf} min. MPa	Elongation after fracture A min. mm
Austenitic	A1 A2 A3	50	500	210	0,6*d*
		70	700	450	0,4*d*
		80	800	600	0,3*d*
	A4 A5	50	500	210	0,6*d*
		70	700	450	0,4*d*
		80	800	600	0,3*d*
		100	1 000	800	0,2*d*
	A8	70	700	450	0,4*d*
		80	800	600	0,3*d*
		100	1 000	800	0,2*d*
Duplex	D2 D4 D6 D8	70	700	450	0,4*d*
		80	800	600	0,3*d*
		100	1 000	800	0,2*d*

[a] Minimum ultimate tensile loads (F_{mf}) are specified in Table 4 for coarse pitch thread, and in Table 6 for fine pitch thread.

[b] Minimum loads at R_{pf} (F_{pf}) are specified in Table 5 for coarse pitch thread, and in Table 7 for fine pitch thread.

Table 3 — Mechanical properties for bolts, screws and studs — Martensitic and ferritic grades

Stainless steel grade		Property class	Tensile strength [a] R_{mf} min. MPa	Stress at 0,2 % non-proportional elongation [b] R_{pf} min. MPa	Elongation after fracture A min. mm	Hardness min. to max.		
						HV	HRC	HBW
Martensitic	C1	50	500	250	0,2*d*	155 to 220	—	147 to 209
		70	700	410	0,2*d*	220 to 330	20 to 34	209 to 314
		110 [c]	1 100	820	0,2*d*	350 to 440	36 to 45	—
	C3	80	800	640	0,2*d*	240 to 340	21 to 35	228 to 323
	C4	50	500	250	0,2*d*	155 to 220	—	147 to 209
		70	700	410	0,2*d*	220 to 330	20 to 34	209 to 314
Ferritic	F1 [d]	45	450	250	0,2*d*	135 to 220	—	128 to 209
		60	600	410	0,2*d*	180 to 285	—	171 to 271

[a] Minimum ultimate tensile loads (F_{mf}) are specified in Table 4 for coarse pitch thread, and in Table 6 for fine pitch thread.

[b] Minimum loads at R_{pf} (F_{pf}) are specified in Table 5 for coarse pitch thread, and in Table 7 for fine pitch thread.

[c] Hardened and tempered at a minimum tempering temperature of 275 °C.

[d] Only for nominal thread diameters $d \leq 24$ mm.

Table 4 — Minimum ultimate tensile loads — Coarse pitch thread

Thread	Nominal stress area	Minimum ultimate tensile load, F_{mf} [a] N									
		Austenitic and duplex steels				Martensitic steels				Ferritic steels	
d	$A_{s,nom}$ mm²	**50** [b]	**70**	**80**	**100**	**50**	**70**	**80**	**110**	**45**	**60**
M3	5,03	2 520	3 530	4 030	5 040	2 520	3 530	4 030	5 540	2 270	3 020
M3,5	6,78	3 390	4 750	5 430	6 780	3 390	4 750	5 430	7 460	3 050	4 070
M4	8,78	4 390	6 150	7 030	8 780	4 390	6 150	7 030	9 660	3 960	5 270
M5	14,2	7 100	9 930	11 350	14 190	7 100	9 930	11 350	15 610	6 390	8 510
M6	20,1	10 070	14 090	16 100	20 130	10 070	14 090	16 100	22 140	9 060	12 080
M7	28,9	14 430	20 210	23 090	28 860	14 430	20 210	23 090	31 750	12 990	17 320
M8	36,6	18 310	25 630	29 290	36 610	18 310	25 630	29 290	40 270	16 480	21 970
M10	58,0	29 000	40 600	46 400	57 990	29 000	40 600	46 400	63 790	26 100	34 800
M12	84,3	42 140	58 990	67 420	84 270	42 140	58 990	67 420	92 700	37 920	50 560
M14	115	57 720	80 810	92 360	115 500	57 720	80 810	92 360	127 000	51 950	69 270
M16	157	78 340	109 700	125 400	156 700	78 340	109 700	125 400	172 400	70 510	94 010
M18	192	96 240	134 800	154 000	192 500	96 240	134 800	154 000	211 800	86 620	115 500
M20	245	122 400	171 400	195 900	244 800	122 400	171 400	195 900	269 300	110 200	146 900
M22	303	151 700	212 400	242 800	303 400	151 700	212 400	242 800	333 800	136 600	182 100
M24	353	176 300	246 800	282 100	352 600	176 300	246 800	282 100	387 800	158 700	211 600
M27	459	229 800	321 600	367 600	459 500	229 800	321 600	367 600	505 400	—	—
M30	561	280 300	392 500	448 500	560 600	280 300	392 500	448 500	616 700	—	—
M33	694	346 800	485 500	554 900	693 600	346 800	485 500	554 900	763 000	—	—
M36	817	408 400	571 800	653 400	816 800	408 400	571 800	653 400	898 400	—	—
M39	976	487 900	683 100	780 700	975 800	487 900	683 100	780 700	1 073 400	—	—

[a] F_{mf} values have been calculated from the exact figures of $A_{s,nom}$ as specified in 9.1.5 and rounded to the next upper 10 N up to 100 000 N, and to the next 100 N above.

[b] Property class 50 refers to the austenitic grades A1 to A5 only.

Table 5 — Minimum loads at R_{pf} — Coarse pitch thread

Thread *d*	Nominal stress area $A_{s,nom}$ mm²	Minimum load at 0,2 % non-proportional elongation, F_{pf} [a] N									
		Austenitic and duplex steels				Martensitic steels				Ferritic steels	
		50 [b]	**70**	**80**	**100**	**50**	**70**	**80**	**110**	**45**	**60**
M3	5,03	1 060	2 270	3 020	4 030	1 260	2 070	3 220	4 130	1 260	2 070
M3,5	6,78	1 430	3 050	4 070	5 430	1 700	2 780	4 340	5 560	1 700	2 780
M4	8,78	1 850	3 960	5 270	7 030	2 200	3 600	5 620	7 200	2 200	3 600
M5	14,2	2 980	6 390	8 510	11 350	3 550	5 820	9 080	11 630	3 550	5 820
M6	20,1	4 230	9 060	12 080	16 100	5 040	8 260	12 880	16 510	5 040	8 260
M7	28,9	6 070	12 990	17 320	23 090	7 220	11 840	18 480	23 670	7 220	11 840
M8	36,6	7 690	16 480	21 970	29 290	9 160	15 010	23 430	30 020	9 160	15 010
M10	58,0	12 180	26 100	34 800	46 400	14 500	23 780	37 120	47 560	14 500	23 780
M12	84,3	17 700	37 920	50 560	67 420	21 070	34 550	53 940	69 100	21 070	34 550
M14	115	24 250	51 950	69 270	92 360	28 860	47 340	73 890	94 670	28 860	47 340
M16	157	32 910	70 510	94 010	125 400	39 170	64 240	100 300	128 500	39 170	64 240
M18	192	40 420	86 620	115 500	154 000	48 120	78 920	123 200	157 900	48 120	78 920
M20	245	51 410	110 200	146 900	195 900	61 200	100 400	156 700	200 800	61 200	100 400
M22	303	63 720	136 600	182 100	242 800	75 850	124 400	194 200	248 800	75 850	124 400
M24	353	74 030	158 700	211 600	282 100	88 130	144 600	225 700	289 100	88 130	144 600
M27	459	96 480	206 800	275 700	367 600	114 900	188 400	294 100	376 800	—	—
M30	561	117 800	252 300	336 400	448 500	140 200	229 900	358 800	459 700	—	—
M33	694	145 700	312 100	416 200	554 900	173 400	284 400	443 900	568 800	—	—
M36	817	171 600	367 600	490 100	653 400	204 200	334 900	522 800	669 800	—	—
M39	976	205 000	439 100	585 500	780 700	244 000	400 100	624 500	800 200	—	—

[a] F_{pf} values have been calculated from the exact figures of $A_{s,nom}$ as specified in 9.1.5 and rounded to the next upper 10 N up to 100 000 N, and to the next 100 N above.

[b] Property class 50 refers to the austenitic grades A1 to A5 only.

Table 6 — Minimum ultimate tensile loads — Fine pitch thread

Thread	**Nominal stress area**	**Minimum ultimate tensile load, F_{mf} [a]** N									
d×*P*	$A_{s,nom}$	Austenitic and duplex steels				Martensitic steels				Ferritic steels	
	mm²	**50** [b]	**70**	**80**	**100**	**50**	**70**	**80**	**110**	**45**	**60**
M8×1	39,2	19 590	27 420	31 340	39 170	19 590	27 420	31 340	43 090	17 630	23 510
M10×1,25	61,2	30 600	42 840	48 960	61 200	30 600	42 840	48 960	67 320	27 540	36 720
M10×1	64,5	32 250	45 150	51 600	64 500	32 250	45 150	51 600	70 950	29 030	38 700
M12×1,5	88,1	44 070	61 690	70 510	88 130	44 070	61 690	70 510	96 940	39 660	52 880
M12×1,25	92,1	46 040	64 460	73 660	92 080	46 040	64 460	73 660	101 300	41 440	55 250
M14×1,5	125	62 280	87 190	99 640	124 600	62 280	87 190	99 640	137 100	56 050	74 730
M16×1,5	167	83 630	117 100	133 800	167 300	83 630	117 100	133 800	184 000	75 270	100 400
M18×1,5	216	108 200	151 400	173 000	216 300	108 200	151 400	173 000	237 900	97 310	129 800
M20×2	258	129 000	180 600	206 400	258 000	129 000	180 600	206 400	283 800	116 100	154 800
M20×1,5	272	135 800	190 100	217 300	271 600	135 800	190 100	217 300	298 700	122 200	163 000
M22×1,5	333	166 600	233 200	266 500	333 100	166 600	233 200	266 500	366 400	149 900	199 900
M24×2	384	192 300	269 100	307 600	384 500	192 300	269 100	307 600	422 900	173 000	230 700
M27×2	496	247 900	347 100	396 600	495 800	247 900	347 100	396 600	545 400	—	—
M30×2	621	310 700	434 900	497 000	621 300	310 700	434 900	497 000	683 400	—	—
M33×2	761	380 400	532 600	608 700	760 800	380 400	532 600	608 700	836 900	—	—
M36×3	865	432 500	605 500	692 000	865 000	432 500	605 500	692 000	951 500	—	—
M39×3	1030	514 200	719 900	822 800	1 028 400	514 200	719 900	822 800	1 131 300	—	—

[a] F_{mf} have been calculated from the exact figures of $A_{s,nom}$ as specified in 9.1.5 and rounded to the next upper 10 N up to 100 000 N, and to the next 100 N above.

[b] Property class 50 refers to the austenitic grades A1 to A5 only.

Table 7 — Minimum loads at R_{pf} — Fine pitch thread

Thread d×P	**Nominal stress area** $A_{s,nom}$ mm²	**Minimum load at 0,2 % non-proportional elongation, F_{pf}** [a] N									
		Austenitic and duplex steels				Martensitic steels				Ferritic steels	
		50 [b]	**70**	**80**	**100**	**50**	**70**	**80**	**110**	**45**	**60**
M8×1	39,2	8 230	17 630	23 510	31 340	9 800	16 060	25 070	32 120	9 800	16 060
M10×1,25	61,2	12 860	27 540	36 720	48 960	15 300	25 100	39 170	50 190	15 300	25 100
M10×1	64,5	13 550	29 030	38 700	51 600	16 130	26 450	41 280	52 890	16 130	26 450
M12×1,5	88,1	18 510	39 660	52 880	70 510	22 040	36 140	56 410	72 270	22 040	36 140
M12×1,25	92,1	19 340	41 440	55 250	73 660	23 020	37 750	58 930	75 500	23 020	37 750
M14×1,5	125	26 160	56 050	74 730	99 640	31 140	51 070	79 710	102 200	31 140	51 070
M16×1,5	167	35 130	75 270	100 400	133 800	41 820	68 580	107 100	137 200	41 820	68 580
M18×1,5	216	45 410	97 310	129 800	173 000	54 060	88 660	138 400	177 400	54 060	88 660
M20×2	258	54 180	116 100	154 800	206 400	54 180	116 100	154 800	211 600	54 180	116 100
M20×1,5	272	57 020	122 200	163 000	217 300	67 880	111 400	173 800	222 700	67 880	111 400
M22×1,5	333	69 950	149 900	199 900	266 500	83 270	136 600	213 200	273 200	83 270	136 600
M24×2	384	80 730	173 000	230 700	307 600	96 110	157 700	246 100	315 300	96 110	157 700
M27×2	496	104 200	223 100	297 500	396 600	124 000	203 300	317 300	406 600	—	—
M30×2	621	130 500	279 600	372 800	497 000	155 400	254 700	397 600	509 400	—	—
M33×2	761	159 800	342 400	456 500	608 700	190 200	312 000	487 000	623 900	—	—
M36×3	865	181 700	389 300	519 000	692 000	216 300	354 700	553 600	709 300	—	—
M39×3	1030	216 000	462 800	617 100	822 800	257 100	421 700	658 200	843 300	—	—

[a] F_{pf} have been calculated from the exact figures of $A_{s,nom}$ as specified in 9.1.5 and rounded to the next upper 10 N up to 100 000 N, and to the next 100 N above.

[b] Property class 50 refers to the austenitic grades A1 to A5 only.

When tensile test in accordance with Clause 9 is not feasible due to too short length (l < 2,5d or b < 2d), minimum breaking torque is specified in Table 8 as alternative to tensile strength for bolts, screws and studs with full loadability.

If torque testing is required:

— minimum torque values are specified in Table 8 only for austenitic grades of property classes 50, 70 and 80, and fasteners with coarse pitch thread,

— no values are available for austenitic grades of property class 100,

— no values are available for fasteners with fine pitch thread,

— no values are available for martensitic, ferritic and duplex (austenitic-ferritic) steel grades.

In these cases, minimum breaking torques shall be agreed between the manufacturer and the purchaser at the time of the order.

Table 8 — Minimum breaking torque M_B for austenitic grades

Thread d	Minimum breaking torque [a] M_B Nm		
	Property class		
	50	70	80
M1,6	0,15	0,2	0,24
M2	0,3	0,4	0,48
M2,5	0,6	0,9	0,96
M3	1,1	1,6	1,8
M4	2,7	3,8	4,3
M5	5,5	7,8	8,8
M6	9,3	13	15
M8	23	32	37
M10	46	65	74
M12	80	110	130
M16	210	290	330

[a] The drive and/or recess of the fastener are not always able to apply the minimum breaking torque specified in this table; this shall not be the cause for rejection.

8 Applicability of test methods and inspection

8.1 Applicability of test methods

The applicability of the tests specified in Tables 9 and 10 depends on stainless steel grade and fastener type and sizes. However, not all mechanical and physical properties specified in Tables 2 to 8 can be tested on all types or sizes of fasteners, primarily for dimensional and/or loadability reasons.

8.2 Loadability of fasteners

8.2.1 Fasteners with full loadability

A stainless steel bolt or screw with full loadability or a stainless steel stud with full loadability is a finished fastener, standardized or non-standardized which, when tested to fracture:

1) breaks in the free threaded length or in the unthreaded shank;

and

2) meets the minimum ultimate tensile load, F_{mf}, in accordance with Table 4 or 6 as relevant

   and/or

   meets the minimum breaking torque, M_B, in accordance with Table 8 (only for austenitic stainless steel fasteners M1,6 to M16 with coarse pitch thread).

The tests that can be performed for fasteners with full loadability are specified in Table 9 in relation to stainless steel grade and fastener dimensions.

Table 9 — Applicability of tests for fasteners with full loadability

Stainless steel grade	Property and related test method					
	Minimum tensile strength R_{mf}		Stress at 0,2 % non-proportional elongation R_{pf}	Elongation after fracture A	Minimum breaking torque M_B	Hardness
	Tensile test 9.1	Wedge tensile test 9.4	Tensile test 9.1	Tensile test 9.1	Torsional test 9.5	Hardness test 9.6
A1 A2 A3 A4 A5 A8	$d \geq 3$ mm $l \geq 2{,}5d$ $b \geq 2d$	Not relevant	$d \geq 3$ mm $l \geq 2{,}5d$ $b \geq 2d$	$d \geq 3$ mm $l \geq 2{,}5d$ $b \geq 2\,d$	For all lengths when $d < 3$ mm; only for lengths $l < 2{,}5d$ when $d \geq 3$ mm $b \geq 1d + 2P$ No value available for property class 100 or for fine pitch thread	Not applicable
C1 C3 C4	$d \geq 3$ mm $l \geq 2{,}5d$ $b \geq 2d$	$d \geq 3$ mm $l \geq 2{,}5d$ $b \geq 2d$	$d \geq 3$ mm $l \geq 2{,}5d$ $b \geq 2d$	$d \geq 3$ mm $l \geq 2{,}5d$ $b \geq 2d$	No value available	Applicable
F1	$d \geq 3$ mm $l \geq 2{,}5d$ $b \geq 2d$	Not relevant	$d \geq 3$ mm $l \geq 2{,}5d$ $b \geq 2d$	$d \geq 3$ mm $l \geq 2{,}5d$ $b \geq 2d$	No value available	Applicable
D2 D4 D6 D8	$d \geq 3$ mm $l \geq 2{,}5d$ $b \geq 2d$	Not relevant	$d \geq 3$ mm $l \geq 2{,}5d$ $b \geq 2d$	$d \geq 3$ mm $l \geq 2{,}5d$ $b \geq 2d$	No value available	Not applicable
Notes	a,b	b,c	a,b	a,b	c	—

[a] For fully threaded studs, total length $l_t \geq 3{,}5d$.

[b] For $l < 2{,}5d$ (or $l_t < 3{,}5d$ for fully threaded studs), testing and test conditions shall be agreed between the purchaser and the manufacturer.

[c] Only for bolts and screws (not for studs).

8.2.2 Fasteners which have reduced loadability due to their geometry

A stainless steel bolt or screw with reduced loadability or a stainless steel stud with reduced loadability is a finished fastener, standardized or non-standardized, with properties in accordance with its relevant grade and property class as specified in Tables 1 to 3 but which, due to its geometry, does not fulfil the tensile or torsional requirements when tested to fracture.

Basically, there are two geometrical reasons for reduced loadability of fasteners compared with the ultimate tensile load of the thread:

a) the head design of bolts and screws with:

- — low head with or without external driving feature, or
- — low round head or low cylindrical head with internal driving feature, or
- — countersunk head with internal driving feature;

b) the shank diameter of the fasteners which is especially designed for applications where full loadability in accordance with this document is not required or even not desired, e.g. screws with waisted shank.

For stainless steel fasteners with reduced loadability, the material shall be in accordance with Table 1 and the manufacturing process shall be suitable to achieve the mechanical properties specified in Table 2 or 3, even if the fastener can only be tensile tested in its threaded shank; see Table 10.

The tests that can be performed for fasteners with reduced loadability are specified in Table 10 in relation to stainless steel grade and fastener dimensions. Wedge tensile test and torsional test are not applicable.

Table 10 — Applicability of tests for fasteners with reduced loadability

<table>
<tr><th rowspan="3">Stainless steel grade</th><th colspan="5">Property and related test method</th></tr>
<tr><th>Minimum tensile strength
R_{mf}</th><th>Stress at 0,2 % non-proportional elongation
R_{pf}</th><th>Elongation after fracture
A</th><th>Minimum tensile load
F_{mf}</th><th>Hardness</th></tr>
<tr><td>Tensile test
9.1, 9.3</td><td>Tensile test
9.1</td><td>Tensile test
9.1</td><td>Tensile test
9.2</td><td>Hardness test
9.6</td></tr>
<tr><td>**A1 A2 A3
A4 A5 A8**</td><td colspan="3" rowspan="4">$d \geq 3$ mm for all lengths, when $b \geq 3d$ [a]</td><td rowspan="4">$d \geq 3$ mm for all lengths</td><td>Not applicable</td></tr>
<tr><td>**C1 C3 C4**</td><td>Applicable</td></tr>
<tr><td>**F1**</td><td>Applicable</td></tr>
<tr><td>**D2 D4
D6 D8**</td><td>Not applicable</td></tr>
<tr><td colspan="6">[a] A nominal thread length of at least $3d$ is necessary to carry out the tensile test in accordance with Figure 2 d), i.e. $1d$ of free threaded length and additional $1d$ of engaged threads at both ends.</td></tr>
</table>

8.3 Manufacturer's inspection

Fasteners produced in accordance with this document shall be capable of conforming to all applicable requirements specified in Clauses 6 and 7, when using the applicable tests specified in Clause 8 and the test methods specified in Clause 9.

This document does not mandate which of the tests the manufacturer shall perform on each manufacturing lot. It is the responsibility of the manufacturer to apply the suitable methods of their choice, such as in-process control or final inspection, to ensure that the manufactured lot does indeed conform to all of the specified requirements. For additional information, see ISO 16426.

In case of dispute, the test methods in accordance with Clauses 8 and 9 shall apply.

8.4 Supplier's inspection

The supplier may control and/or test the fasteners they provide using the methods of their choice (periodic evaluation of the manufacturer, checking of test results from the manufacturer, tests on the fasteners themselves, etc.), provided the chemical, mechanical and physical properties specified in Clauses 6 and 7 are met.

In case of dispute, the test methods in accordance with Clauses 8 and 9 shall apply.

8.5 Purchaser's inspection

The purchaser may control and/or test the delivered fasteners by using the test methods specified in Clause 9.

In case of dispute, the test methods in accordance with Clauses 8 and 9 shall apply.

8.6 Delivery of test results

If the purchaser requires test results from the supplier, the type of test report shall be agreed upon at the time of order. It shall be established in accordance with ISO 16228, unless otherwise specified. The type of test report (F2.2, F3.1 or F3.2) and any additional or specific test shall also be specified by the purchaser and agreed upon at the time of order.

9 Test methods

9.1 Tensile test for fasteners

9.1.1 General

The purpose of this tensile test is to determine simultaneously or separately:

— the tensile strength, R_{mf}, **and**

— the stress at 0,2 % non-proportional elongation, R_{pf}, **and**

— the elongation after fracture, A.

This tensile test applies to full-size fasteners having the following specifications:

— all stainless steel grades;

— all property classes;

— 3 mm ≤ d ≤ 39 mm;

— bolts, screws and studs (with unthreaded shank) with full loadability, nominal length l ≥ 2,5d and thread length b ≥ 2d;

— unthreaded shank diameter $d_s > d_2$ or $d_s \approx d_2$;

— fully threaded studs with total length ≥ 3,5d.

This tensile test applies also to bolts and screws with reduced loadability due to head design provided that the thread length b ≥ 3d.

The tensile test machine shall be in accordance with ISO 7500-1, class 1 or better. Side thrust on the fastener shall be avoided, e.g. by self-aligning grips.

The grips and adaptors shall be as follows:

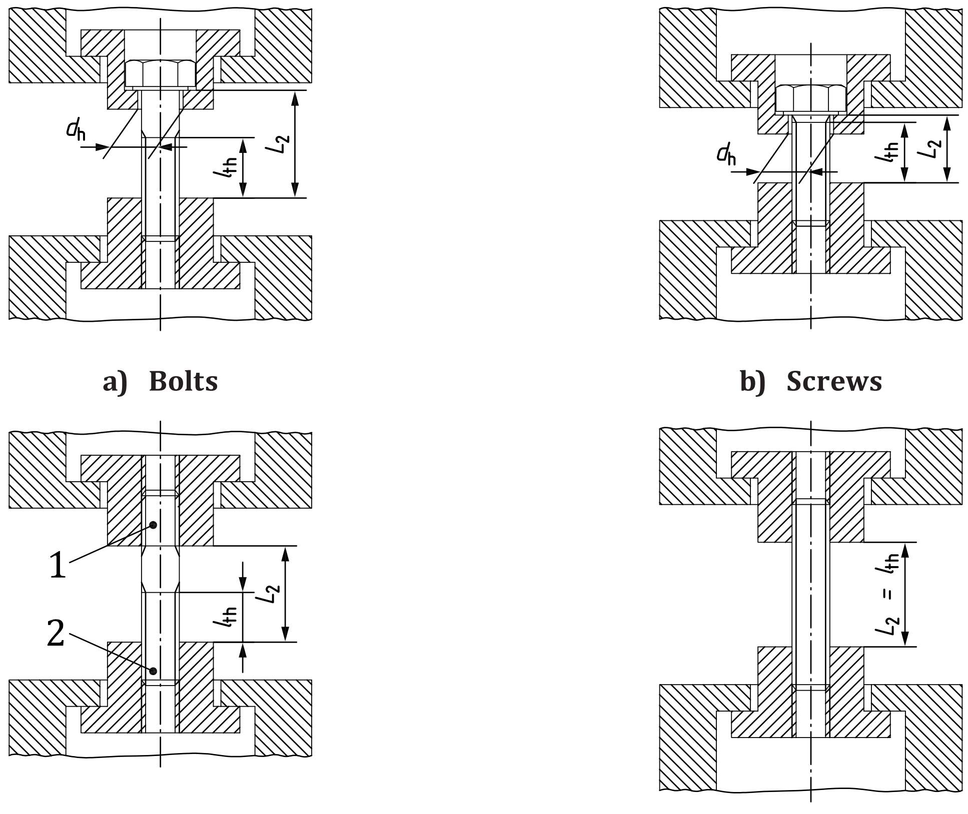
— hardness of 45 HRC minimum;

— hole diameter, d_h, in accordance with Table 12;

— thread tolerance class 5H6G for the threaded adaptors.

The testing device shall be sufficiently rigid to avoid deformation that could influence the determination of the load at 0,2 % non-proportional elongation, F_{pf}, or the elongation after fracture, A.

All length measurements shall be made with an accuracy of 0,05 mm or better.



a) Bolts **b) Screws**

c) Studs with unthreaded shank **d) Fully threaded studs**

Key

1 metal-end of the stud

2 nut-end of the stud

d_h hole diameter

l_{th} free threaded length ≥ 1d

L_2 clamping length

Figure 2 — Example of testing devices for tensile test

Fasteners shall be tested as received.

For fasteners with reduced loadability, this test shall be carried out on the threaded shank when $b \geq 3d$, as shown for fully threaded studs in Figure 2 d). The head or the reduced shank may be removed as relevant.

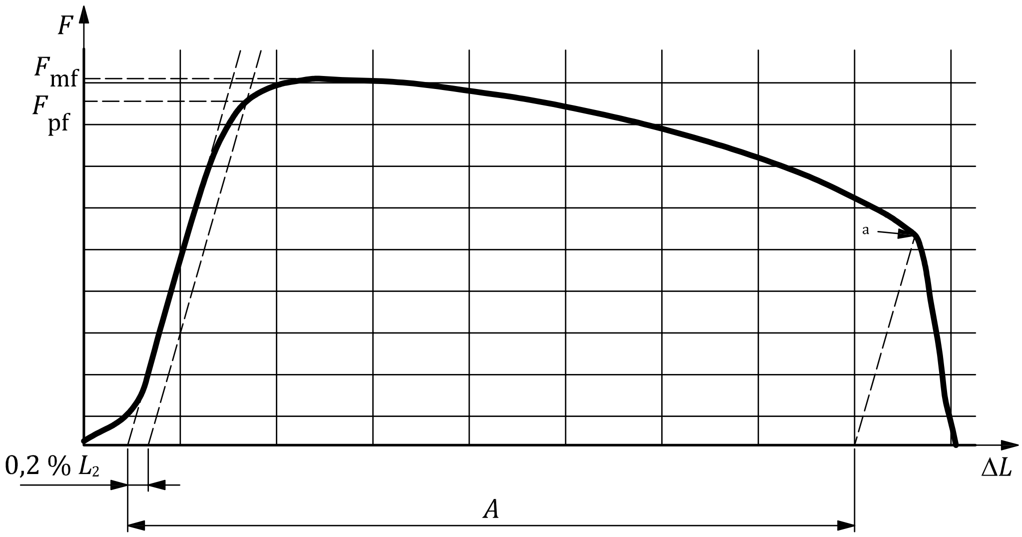
The fastener shall be mounted into adaptors as shown in Figure 2. The length of thread engagement in the threaded adaptor(s) shall be 1d ± 1P. The free threaded length, l_{th}, subjected to the load shall be 1d minimum.

The tensile test shall be carried out in accordance with ISO 6892-1. The speed of testing, as determined with a free-running cross-head, shall not exceed 10 mm/min up to the load F_{pf} and 25 mm/min beyond.

9.1.2 Test procedure for the simultaneous determination of R_{mf}, R_{pf}, and A

The load, F, shall be measured continuously until fracture occurs, either directly by means of an adequate electronic device (e.g. microprocessor), or on the curve of load against displacement (see ISO 6892-1); the curve can be plotted either automatically or graphically.

For acceptable accurate graphical measurement, the scale of the curve shall be such that the slope in the elastic range (straight part of the curve) lies between 30° and 45° against the load axis.



Key

ΔL displacement, mm

F load, N

a Point of fracture.

Figure 3 — Load-displacement curve

The following shall be determined in accordance with Figure 3:

a) The maximum load, F_{mf}.

b) The load at 0,2 % of non-proportional elongation, F_{pf}, directly on the load-displacement curve, as follows:

1) the slope in the elastic range (straight part of the curve) shall be determined;

2) a parallel line shall be drawn at a distance equal to 0,2 % of L_2 on the displacement axis ΔL;

3) the intersection between this line and the curve corresponds to the load F_{pf}.

In case of doubt, the slope in the elastic range shall be determined by drawing a line intersecting the two points of the curve and corresponding to 0,3 $F_{pf,min}$ and 0,6 $F_{pf,min}$ specified in Table 5 or 7.

c) The elongation, A, as follows:

1) a parallel line to the slope in the elastic range (straight part of the curve) shall be drawn through the point of fracture, which has an intersecting point with the displacement axis;

2) the elongation A shall be directly determined on the displacement axis ΔL in accordance with Figure 3.

9.1.3 Reference test procedure for the determination of stress at 0,2 % non-proportional elongation, R_{pf}

The test shall be carried out by measuring the load and elongation of the fastener when subjected to axial tensile load; see Figure 4. When this test is also used for the determination of elongation after fracture A (see 9.1.7), it shall be performed until fracture occurs. The speed of testing, as determined with a free-running cross-head, shall not exceed 10 mm/min up to the load F_{pf} and 25 mm/min beyond.

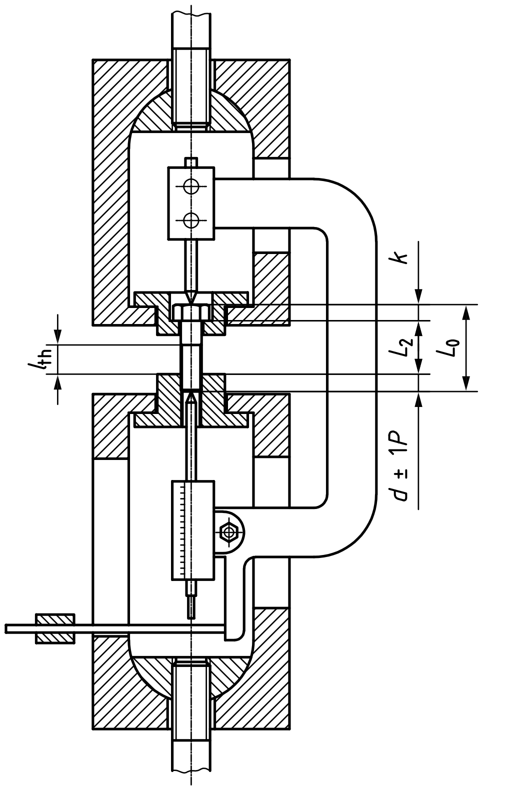
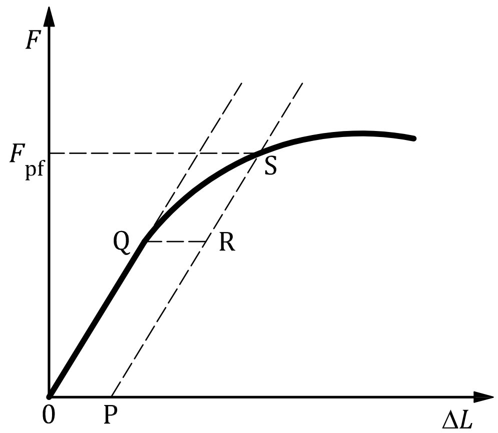


Figure 4 — Example of testing device with an extensometer

The elongation shall be determined between the top of the head and the end of the fastener or between the two ends for studs; see L_0 in Figure 4. When an extensometer is used, it shall be in accordance with ISO 9513, class 2 or better.

The curve of load against elongation shall be drawn as shown in Figure 5.



Key

ΔL elongation, mm

F load, N

Figure 5 — Load-elongation curve for determination of stress at 0,2 % non-proportional elongation, R_{pf}

The clamping length, L_2, shall be calculated as follows:

— for bolts and screws, it is the distance between the bearing surface of the head and the threaded adaptor; see Figures 2 a) and b);

— for studs with unthreaded shank, it is the distance between the two threaded adaptors; see Figure 2 c);

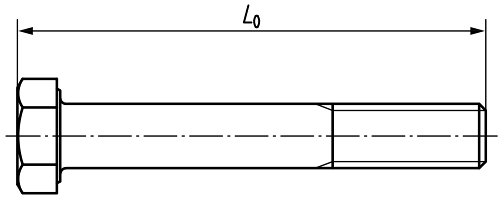
— for fully threaded studs and for fasteners with reduced loadability, it is the distance between the two threaded adaptors; see Figure 2 d).

0,2 % of L_2 shall be applied to scale to the horizontal axis of the load-elongation curve, 0P. The same value shall be plotted horizontally from the straight-line portion of the curve as QR. A line shall be drawn through P and R. The intersection S of this line with the load-elongation curve corresponds to the load F_{pf} on the vertical axis.

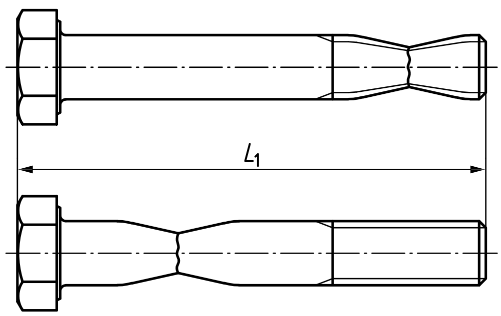
9.1.4 Alternative test procedure for the determination of elongation, *A*

The total length of the fastener, L_0, shall be measured; see Figure 6 a). The fastener shall be mounted in the adaptors in accordance with Figure 2. It shall be axially loaded until fracture occurs. The speed of testing, as determined with a free-running cross-head, shall not exceed 10 mm/min up to the load F_{pf} and 25 mm/min beyond.

After fracture, the two broken pieces shall be fitted together and the length, L_1, shall be measured as shown in Figure 6 b).



a) Before the test



b) After fracture

Figure 6 — Determination of elongation after fracture, *A*

The elongation after fracture, *A*, shall be calculated as follows:

$$A = L_1 - L_0$$

9.1.5 Test results and requirements for tensile strength, R_{mf}

The tensile strength R_{mf}, based on the nominal stress area $A_{s,nom}$ and the ultimate tensile load F_{mf} measured during the test, shall be calculated as follows:

$$R_{mf} = \frac{F_{mf}}{A_{s,nom}}$$

with

$$A_{s,nom} = \frac{\pi}{4}\left(\frac{d_2 + d_3}{2}\right)^2$$

where

d_2 is the basic pitch diameter of external thread; see ISO 724;

d_3 is the minor diameter of external thread.

$$d_3 = d_1 - \frac{H}{6}$$

with

d_1 basic minor diameter of external thread; see ISO 724;

H height of the fundamental triangle of the thread; see ISO 68-1.

Values of $A_{s,nom}$ given in Tables 4 and 6 have been rounded to 3 significant digits.

In order to meet the requirements, the fracture shall occur in the free threaded length or in the unthreaded shank. The fracture shall not occur in the head:

— for bolts with unthreaded shank, the fracture shall not occur in the transition section between the head and the shank;

— for screws threaded to the head, the fracture which causes failure may extend or spread into the transition section between the head and the thread or into the head before separation, provided that it originates in the free threaded length.

R_{mf} shall meet the requirements specified in Table 2 or 3. The minimum ultimate tensile load $F_{mf,min}$ specified in Table 4 or 6 shall also be met.

9.1.6 Test results and requirements for stress at 0,2 % non-proportional elongation, R_{pf}

The stress at 0,2 % non-proportional elongation, R_{pf}, based on the nominal stress area $A_{s,nom}$ and the load at 0,2 % F_{pf} measured during the test, shall be calculated as follows:

$$R_{pf} = \frac{F_{pf}}{A_{s,nom}}$$

Values of $A_{s,nom}$ given in Tables 5 and 7 have been rounded to 3 significant digits.

R_{pf} shall meet the requirements specified in Table 2 or 3. The minimum loads, F_{pf}, specified in Table 5 or 7 shall also be met.

In case of dispute, the reference test method of 9.1.3 performed with the extensometer shall apply for the determination of the stress at 0,2 % non-proportional elongation, R_{pf}.

9.1.7 Test results and requirements for elongation after fracture, *A*

The value for elongation after fracture, *A*, shall meet the requirements specified in Table 2 or 3.

In case of dispute, the reference test method in accordance with 9.1.3 with the extensometer shall apply for the determination of the elongation after fracture, *A*.

9.2 Tensile test for bolts and screws with reduced loadability due to head design

9.2.1 General

The purpose of this tensile test is to determine the ultimate tensile load, F_{mf}, for bolts and screws with reduced loadability, i.e. not expected to break in the threaded or unthreaded shank due to head design; see 8.2.2 and Figure 7.

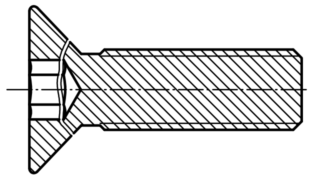


Figure 7 — Example of broken screw with reduced loadability due to head design

Only the ultimate tensile load, F_{mf}, shall be determined in accordance with 9.1. Tensile strength R_{mf}, elongation after fracture, *A*, and stress at 0,2 % non-proportional elongation, R_{pf}, do not apply to bolts and screws with reduced loadability due to head design.

In accordance with 10.1.3, these bolts and screws with reduced loadability that cannot be tensile tested in the threaded shank ($b < 3d$) in accordance with 9.1 shall not reference the property class, but only the stainless steel grade.

For bolts and screws with thread length $b \geq 3d$, the tensile test shall additionally be performed on the threaded shank in accordance with 9.1, and in this case, they are designated and marked with the property class preceded by the digit "zero" to show the reduced loadability, in accordance with 10.1.3.

9.2.2 Test procedure

See 9.1.2.

9.2.3 Test results and requirements for ultimate tensile load, F_{mf}

The maximum load measured during the test shall be equal or above the minimum ultimate tensile load, F_{mf}, specified in the relevant product standard, or shall be agreed between the purchaser and the supplier at the time of the order.

9.3 Tensile test for fasteners with reduced loadability due to shank design

9.3.1 General

The purpose of this tensile test is to determine the tensile strength for bolts, screws and studs with an unthreaded shank diameter $d_s < d_2$ especially designed to break in the unthreaded shank when tested to fracture; see 8.2.2 and Figure 8.

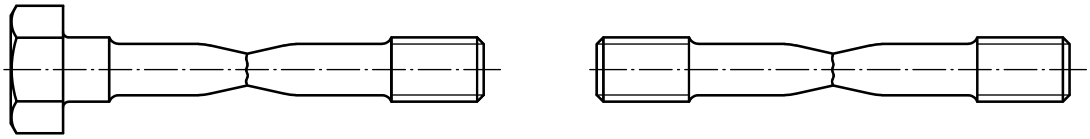


Figure 8 — Examples of fasteners with reduced loadability due to shank design

Only the tensile strength shall be determined in accordance with 9.1. Elongation after fracture, A, stress at 0,2 % non-proportional elongation, R_{pf}, and minimum ultimate tensile loads of Tables 4 and 6 do not apply to fasteners with reduced loadability due to shank design.

NOTE These fasteners are designated and marked in accordance with 10.1.3, with the property class preceded by the digit "zero" to show the reduced loadability.

9.3.2 Test procedure

See 9.1.2.

9.3.3 Test results for tensile strength

The calculation of the tensile strength, R_{mds}, based on the cross-sectional area of the unthreaded shank, A_{ds}, and the ultimate tensile load, F_{mds}, measured during the test, shall be calculated as follows:

$$R_{mds} = \frac{F_{mds}}{A_{ds}}$$

with

$$A_{ds} = \frac{\pi}{4} {d_s}^2$$

The fracture shall occur in the shank, and R_{mds} shall meet the requirements specified in Table 2 or 3 for R_{mf}.

9.4 Wedge tensile test

9.4.1 General

The purpose of this tensile test is to determine simultaneously:

— the tensile strength, R_{mf}, and

— the integrity of the transition section between the head and the unthreaded shank or the thread.

This tensile test applies on full-size bolts and screws having the following specifications:

— martensitic stainless steel grades;

— all property classes;

— bolts and screws (not studs) with full loadability;

— flat bearing surface or flat serrated surface under the head;

— 3 mm ≤ d ≤ 39 mm;

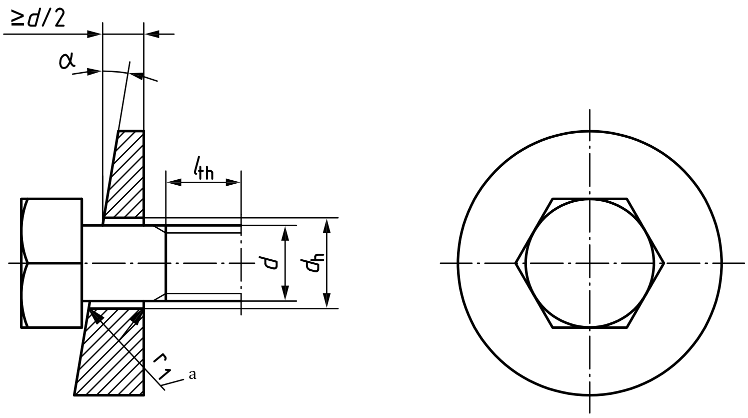
— nominal length l ≥ 2,5d and thread length b ≥ 2d.

The tensile testing machine, grips and adaptors shall as specified in 9.1.1, except for the following:

— tooling features altering the effect of the wedge angle α shall not be used;

— the testing device shall be sufficiently rigid to ensure that bending occurs in the transition section between the head and the unthreaded shank or the thread.

The wedge shall be in accordance with Figure 9, Tables 11 and 12.



a Radius or chamfer of 45° (see Table 12).

Figure 9 — Wedge loading for bolts and screws

Table 11 — Wedge angle α for tensile test under wedge loading

Nominal thread diameter *d* mm	**Bolts and screws with unthreaded shank length** $l_s \geq 2d$	**Screws threaded to the head** **Bolts and screws with unthreaded shank length** $l_s < 2d$
	$\alpha \pm 30'$	
3 ≤ *d* ≤ 20	10°	6°
20 < *d* ≤ 39	6°	4°

Where a bolt or screw with head bearing diameter greater than 1,7*d* fails the wedge tensile test, a new fastener from the same manufacturing lot can be taken and its head machined to 1,7*d* to perform the test.

Table 12 — Hole diameters for adaptors and wedge, and wedge radius or chamfer

Dimensions in millimetres

Nominal thread diameter, d	d_h [a,b] min.	d_h [a,b] max.	r_1 [c] nom.	Nominal thread diameter, d	d_h [a,b] min.	d_h [a,b] max.	r_1 [c] nom.
3	3,4	3,58	0,7	**16**	17,5	17,77	1,3
3,5	3,9	4,08	0,7	**18**	20,0	20,33	1,3
4	4,5	4,68	0,7	**20**	22,0	22,33	1,6
5	5,5	5,68	0,7	**22**	24,0	24,33	1,6
6	6,6	6,82	0,7	**24**	26,0	26,33	1,6
7	7,6	7,82	0,8	**27**	30,0	30,33	1,6
8	9,0	9,22	0,8	**30**	33,0	33,39	1,6
10	11,0	11,27	0,8	**33**	36,0	36,39	1,6
12	13,5	13,77	0,8	**36**	39,0	39,39	1,6
14	15,5	15,77	1,3	**39**	42,0	42,39	1,6

[a] Medium series in accordance with ISO 273.

[b] For square neck bolts, the hole shall be adapted to accommodate the square neck.

[c] The radius or chamfer r_1 is specified for product grades A and B; for product grade C, it should be in accordance with the following formula: $r_c = \frac{d_{a,max} - d_{s,min}}{2} + 0,2$. The tolerance on r_1 and r_c should be ±0,1 mm.

9.4.2 Test procedure

The fastener shall be tested as received.

The wedge shall be placed under the head of the fastener in accordance with Figure 9, and the fastener shall be mounted into adaptors as shown in Figure 2. The threaded length mated with the adapter shall be 1d ± 1P.

The tensile test under wedge loading shall be carried out in accordance with ISO 6892-1. The speed of testing, as determined with a free-running cross-head, shall not exceed 25 mm/min. The tensile test shall be continued until fracture occurs.

The ultimate tensile load, F_{mf}, shall be measured.

9.4.3 Test results and requirements

For test results and requirements, see 9.1.5.

9.5 Torsional test

9.5.1 General

The purpose of this torsional test is to determine the breaking torque, M_B, for small bolts and screws, or for bolts and screws which cannot be tensile tested due to too short length.

This test applies to fasteners having the following specifications:

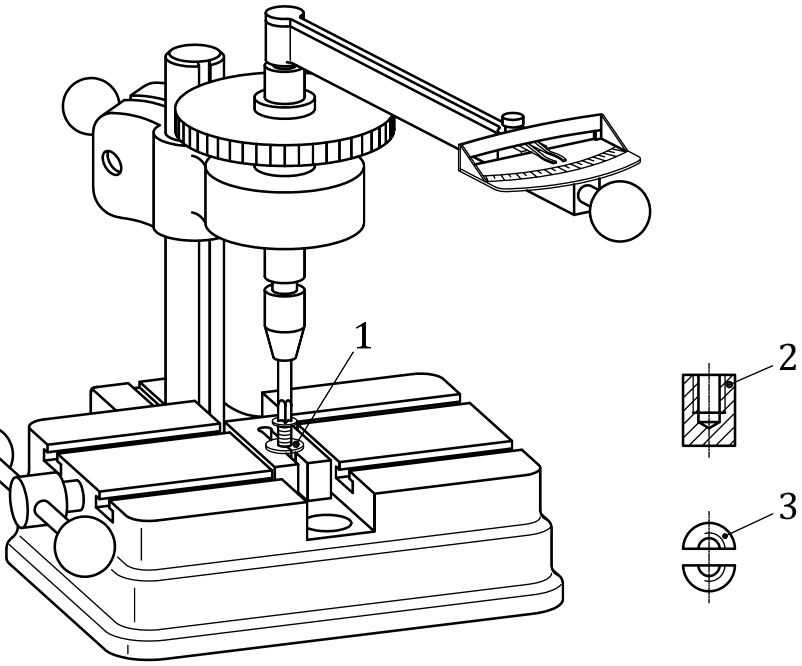
— bolts and screws with full loadability;

— bolts and screws with nominal thread diameter 1,6 mm ≤ d < 3 mm for all lengths, and 3 mm ≤ d ≤ 16 mm for length l < 2,5d;

— thread length b ≥ 1d + 2P.

Minimum breaking torques are specified in Table 8 only for bolts and screws with austenitic stainless steel grade and property classes 50, 70 and 80, with coarse pitch thread. Fasteners with austenitic stainless steel grade and property class 100, other stainless steel grades and fasteners with fine pitch thread can be tested but the minimum breaking torque has to be agreed between the supplier and the purchaser at the time of the order.

For test apparatus, see Figure 10.



Key

1 clamping device (threaded insert or threaded die)

2 mating threaded insert with a blind hole

3 mating split threaded die

Figure 10 — Example of test apparatus for the determination of the breaking torque, M_B

The torque measuring device shall have an accuracy of ±6 % of the values to be measured.

9.5.2 Test procedure

The fastener shall be tested as received. For bolts and screws with recess or internal drive which are too weak for the application of the specified minimum breaking torque, the outside diameter of the head may be machined in order to get a drivable shape (e.g. two across flat surfaces).

The bolt or screw shall be clamped into the clamping device over a threaded length of 1*d* minimum, exclusive of the end or point. At least two full threads shall project above the clamping device.

The clamping device and driving tool shall be aligned with the axis of the fastener.

The torque shall be applied to the bolt or screw in a continuously increasing manner until fracture occurs.

The maximum torque occurring during the test shall be recorded.

9.5.3 Test results and requirements

The fastener shall meet the minimum breaking torque, M_B, specified in Table 8.

NOTE No value is specified in Table 8 for stainless steel groups other than austenitic steels, nor for fasteners with fine pitch thread, property class 100 and fasteners with reduced loadability due to shank design.

For bolts, and screws which can be tensile tested, the tensile test in accordance with 9.1 shall be the reference test.

9.6 Hardness test

9.6.1 General

This test applies to fasteners having the following specifications:

— martensitic and ferritic stainless steel grades;

— all property classes;

— all sizes;

— any shape.

9.6.2 Test procedure

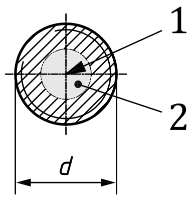
The fastener shall be tested as received.

The hardness test shall be carried out in accordance with ISO 6507-1 (HV), ISO 6508-1 (HRC) or ISO 6506-1 (HBW). The Vickers hardness test shall be performed with a minimum load of 98 N. The Brinell hardness test shall be performed with a load equal to $30D^2$, expressed in newtons.

The hardness shall be determined on a transverse section through the threaded portion. The transverse section shall be taken 1*d* back from the end of the fastener with a suitable process where hardness is not altered, and the surface shall be suitably prepared.

NOTE The term “core hardness” is commonly used for hardness determined by this test method.

Hardness readings shall be performed in the area between the axis and the half-radius position in accordance with Figure 11.



Key

1 axis of the fastener

2 half-radius area (radius of 0,25*d*)

Figure 11 — Half-radius area for hardness determination

Three readings spaced about 120° apart shall be performed when the size of the area allows it. The hardness value shall be the average of the three readings.

9.6.3 Test results and requirements

The hardness value shall be within the limits specified in Table 3.

In case of dispute, the Vickers hardness test with HV10 shall be the reference test method.

10 Fastener marking and labelling

10.1 Fastener marking

10.1.1 General requirements for marking

Marking of the fasteners consists of:

— the stainless steel grade, as specified in Clause 5 (see Figure 1),

— optional additional letter "L", as specified in 10.1.3,

— the hyphen,

— the property class symbol, as specified in 10.1.2 or 10.1.3,

and

— the manufacturer's identification mark, as specified in 10.2.

Fasteners manufactured to the requirements of this document shall be designated in accordance with the designation system specified in Clause 5 and shall be marked in accordance with Clause 10.

The designation system specified in Clause 5 shall only be used and marking shall only be affixed in accordance with Clause 10 when all applicable requirements of this document are met:

— chemical composition as specified in Table 1,

and

— mechanical and physical properties specified in Clauses 6 and 7, when tested in accordance with Clauses 8 and 9.

For fasteners with reduced loadability that cannot be tensile tested in the threaded shank due to its too short length ($b < 3d$), only the stainless steel grade shall be marked and the property class shall not be referenced.

The fastener marking shall be included during the manufacturing process. It shall be indented or embossed. The height of embossed marking on the top of the head shall not be included in the head height dimension.

10.1.2 Marking of property class for fasteners with full loadability

The property class marking symbol for fasteners with full loadability shall be as specified in Table 13.

Table 13 — Property class marking symbol for fasteners with full loadability

Property class	45	50	60	70	80	100	110
Marking symbol	45	50	60	70	80	100	110

10.1.3 Marking of property class for fasteners with reduced loadability

The property class marking symbol for fasteners with reduced loadability that can be tensile tested in accordance with 9.1 shall be as specified in Table 14, with the preceding digit "0".

When reduced loadability applies to fasteners in accordance with a product standard, the marking symbols in accordance with Table 14 shall apply to all sizes specified in the product standard, even if some sizes would fulfil all requirements for full loadability.

Table 14 — Property class marking symbol for fasteners with reduced loadability that can be tensile tested in accordance with 9.1

Property class	45	50	60	70	80	100	110
Marking symbol [a]	045	050	060	070	080	0100	0110

[a] For fasteners with reduced loadability that cannot be tensile tested in the threaded shank due to the length being too short ($b < 3d$), the property class shall not be referenced.

10.1.4 Additional marking

For low-carbon austenitic stainless steels with carbon content not exceeding 0,030 %, fasteners may additionally be marked with the letter "L" after the stainless steel grade and before the hyphen.

EXAMPLE A4L-80.

For fasteners manufactured to a specific order, any additional marking should be applied to both the fastener and the labelling. For fasteners delivered from stock, the additional marking should be applied to the labelling.

10.2 Manufacturer’s identification mark

The manufacturer’s identification mark shall be included during the manufacturing process on all fasteners which are marked with stainless steel grade and property class symbol.

The manufacturer’s identification mark is also recommended on fasteners which are not marked with stainless steel grade and/or the property class symbol.

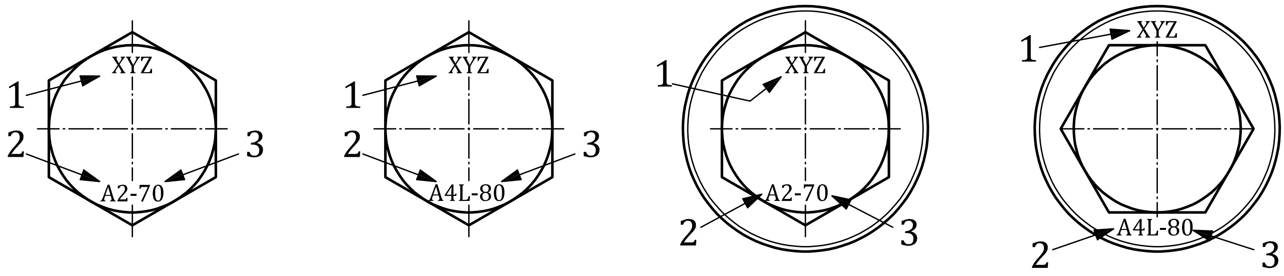
A distributor who distributes fasteners that are marked with their own identification mark shall be considered to be the manufacturer.

10.3 Marking on the fasteners

10.3.1 Hexagon head bolts and screws

All hexagon head bolts and screws of nominal thread diameter $d \geq 5$ mm shall be marked for all stainless steel grades and all property classes, with the stainless steel grade in accordance with Clause 6, with the property class symbol in accordance with Table 13 (fasteners with full loadability) or Table 14 (fasteners with reduced loadability that can be tensile tested with $b \geq 3d$ in accordance with 9.1), and with the manufacturer’s identification mark in accordance with 10.2.

Hexagon head bolts and screws shall be marked preferably on the top of the head by indenting or embossing, or on the side of the head by indenting (see Figure 12). In the case of bolts and screws with flange, marking shall be on the flange when the manufacturing process does not allow marking on the top of the head.



Key

1 manufacturer's identification mark

2 stainless steel grade

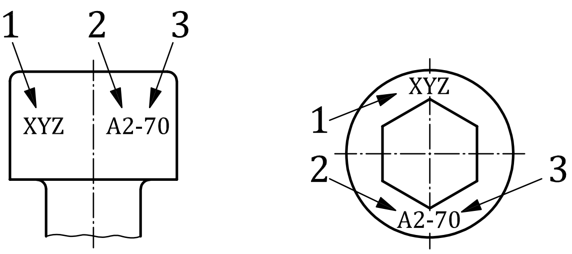
3 property class symbol (full loadability)

Figure 12 — Examples of marking for hexagon head bolts and screws with full loadability

10.3.2 Hexagon socket or hexalobular socket bolts and screws

Hexagon socket bolts and screws and hexalobular socket bolts and screws of nominal thread diameter $d \geq 5$ mm shall be marked for all stainless steel grades and all property classes, with the stainless steel grade in accordance with Clause 6, with the property class symbol in accordance with Table 13 (fasteners with full loadability) or Table 14 (fasteners with reduced loadability that can be tensile tested with $b \geq 3d$ in accordance with 9.1), and with the manufacturer's identification mark in accordance with 10.2.

For cap screws and cheese head bolts and screws, the marking shall be made preferably on the top of the head by indenting or embossing, or on the side of the head by indenting (see Figure 13).



Key

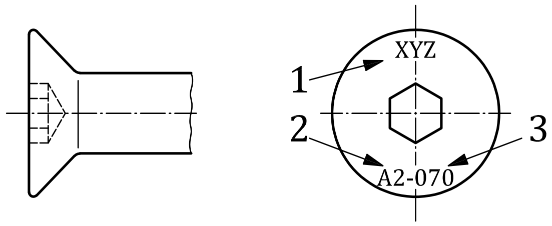
1 manufacturer's identification mark

2 stainless steel grade

3 property class symbol (full loadability)

Figure 13 — Examples of marking for hexagon socket head cap screws with full loadability

An example of marking for fasteners with reduced loadability and $b \geq 3d$, that can be tensile tested in accordance with 9.1, is shown in Figure 14.



Key

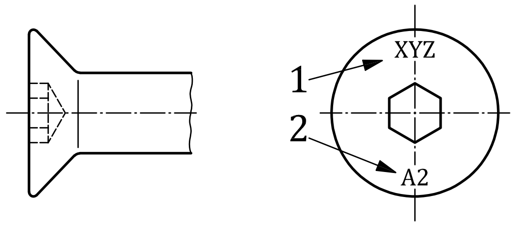
1 manufacturer's identification mark

2 stainless steel grade

3 property class symbol (reduced loadability)

Figure 14 — Example of marking for screws with reduced loadability that can be tensile tested

For bolts and screws with reduced loadability that cannot be tensile tested in the threaded shank due to the length being too short ($b < 3d$), the property class symbol specified in Table 14 shall not be used (see Figure 15).



Key

1 manufacturer's identification mark

2 stainless steel grade (no property class)

Figure 15 — Example of marking for screws with reduced loadability that cannot be tensile tested

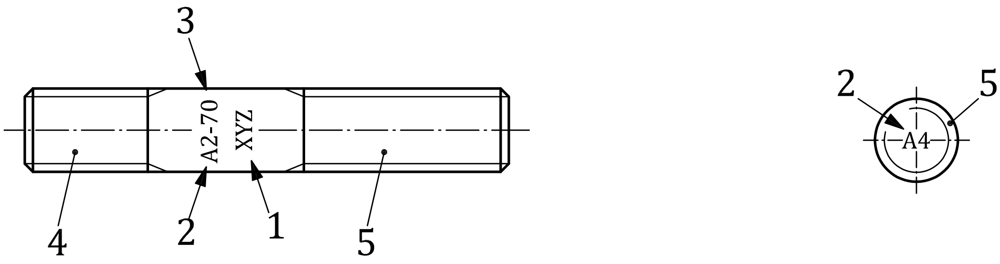
10.3.3 Other types of bolts and screws

Other types of bolts and screws shall be marked in the same way where it is possible to do so, and preferably on the head.

10.3.4 Studs (one-end and double-end studs)

Studs of nominal thread diameter $d \geq 5$ mm should be marked for all stainless steel grades and all property classes, with the stainless steel grade in accordance with Clause 6, with the property class symbol in accordance with Table 13 (studs with full loadability) or Table 14 (studs with reduced loadability, e.g. with waisted shank), and with the manufacturer's identification mark in accordance with 10.2. The marking shall be on the unthreaded shank of the stud; see Figure 16 a).

If marking on the unthreaded shank is not possible, marking of the stud on the nut-end with only the stainless steel grade is permissible; see Figure 16 b).



a) Marking on the unthreaded shank for studs with full loadability

b) Alternative marking on the nut-end for studs

Key

1 manufacturer's identification mark
2 stainless steel grade
3 property class symbol (full loadability)
4 stud metal-end
5 stud nut-end

Figure 16 — Examples of marking for studs

10.3.5 Fully threaded studs

Fully threaded studs may be identified by means of colour marking.

10.3.6 Left-hand thread marking

Bolts and screws with left-hand thread and nominal diameter $d \geq 5$ mm shall additionally be marked with a left pointing arrow, preferably on the top of the head or at the end of the fastener (see Figure 17).

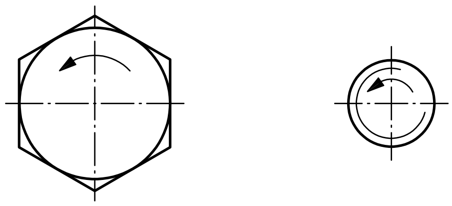


Figure 17 — Examples of marking for left-hand thread

10.4 Marking of the packages (labelling)

All packages for all types of fasteners of all sizes shall be marked through labelling. The labelling shall include:

— the manufacturer's and/or distributor's identification mark and/or name,

— the stainless steel grade,

— the optional letter "L" (immediately after the grade) for low carbon austenitic stainless steel, as specified in 10.1.3,

— the property class symbol (after the hyphen) in accordance with Table 13 for fasteners with full loadability (e.g. 70), or with Table 14 for fasteners with reduced loadability that can be tensile tested in accordance with 9.1 (e.g. 070),

— the optional letter "P" (after the property class) when fasteners have been passivated, as specified in 6.3,

— the optional letters "Lu" (in the last position in the designation) when fasteners have been lubricated, as specified in 6.3,

and

— the manufacturing lot number, as specified in ISO 1891-4.

Annex A
(informative)

Mechanical properties at elevated temperatures — Application at low temperatures

A.1 General

When bolts, screws and studs with ISO metric thread are properly designed and the adequate grade and property class have been selected in accordance with this document, the mating nuts conforming to ISO 3506-2 are designed so that the nut will function at elevated or low temperatures in the bolted joint. Therefore, it is usually sufficient to consider the mechanical properties of bolts, screws and studs only.

NOTE For stainless steel and nickel alloy fasteners intended for high temperature applications, see ISO 3506-5.

A.2 Stress at 0,2 % non-proportional elongation, R_{pf}, at elevated temperatures

Values of stress at 0,2 % non-proportional elongation for fasteners to be used at elevated temperatures (expressed as a percentage of the values of R_{pf} at room temperature) are given in Table A.1.

WARNING — The values given in this annex are for guidance only. Users should understand that the actual chemistry, the load applied to the fastener in the bolted joint and the environment can cause significant variation. If loads are fluctuating, operating periods at elevated temperatures are great and/or the possibility of stress corrosion is high, it is advisable to consult an experienced fastener metallurgist.

Table A.1 — Influence of temperature on R_{pf} for fasteners

Stainless steel grade	**Temperature**			
	+100 °C	+200 °C	+300 °C	+400 °C
	R_{pf} at elevated temperature, in % of the value at room temperature (property classes 70 and 80 only [a,b])			
A2 A3 A4 A5 A8	85	80	75	70
C1	95	90	80	65
C3	90	85	80	60
D2 D4 D6 D8	85	75	[c]	[c]

[a] No data is currently available for property class 100.

[b] For austenitic stainless steel grades and property class 50, the fastener manufacturer should be consulted; however, an estimate may be possible on the basis of EN 10269[15] for material in the solution annealed condition (+AT).

[c] For duplex stainless steels, exposure to temperatures above +250 °C is not advised due to the possibility of initiating 475 °C embrittlement (α+α′ phases). For temperatures of 250 °C to 315 °C inclusive, it is advisable to consult an experienced fastener metallurgist (see also ISO 3506-5 and ISO 3506-6).

A.3 Application at low temperatures

Austenitic stainless steel bolts, screws and studs can be used at low temperatures down to –196 °C.

NOTE –196 °C is the liquid nitrogen temperature.

However, for bolts and screws containing a molybdenum element intended to be used at temperatures below –60 °C, ductility could be reduced, and it is advisable to consult an experienced fastener metallurgist.

Duplex (austenitic-ferritic) stainless steels can be used at sub-zero temperatures. For temperatures below –40 °C, it is advisable to consult an experienced fastener metallurgist.

The acceptance criteria should be agreed between the purchaser and the supplier at the time of the order.

Bibliography

[1] ISO 68-1, *ISO general purpose screw threads — Basic profile — Part 1: Metric screw threads*

[2] ISO 261, *ISO general purpose metric screw threads — General plan*

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

[4] ISO 273, *Fasteners — Clearance holes for bolts and screws*

[5] ISO 724, *ISO general-purpose metric screw threads — Basic dimensions*

[6] ISO 898-1, *Mechanical properties of fasteners made of carbon steel and alloy steel — Part 1: Bolts, screws and studs with specified property classes — Coarse thread and fine pitch thread*

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

[8] ISO 965-2, *ISO general purpose metric screw threads — Tolerances — Part 2: Limits of sizes for general purpose external and internal screw threads — Medium quality*

[9] ISO 3506-2, *Fasteners — Mechanical properties of corrosion-resistant stainless steel fasteners — Part 2: Nuts with specified grades and property classes*

[10] ISO 3506-3, *Mechanical properties of corrosion-resistant stainless steel fasteners — Part 3: Set screws and similar fasteners not under tensile stress*

[11] ISO 3506-5[3)], *Fasteners — Mechanical properties of corrosion-resistant stainless-steel fasteners — Part 5: Special fasteners (also including fasteners from nickel alloys) for high temperature applications*

[12] ISO 16048, *Passivation of corrosion-resistant stainless-steel fasteners*

[13] ISO 16426, *Fasteners — Quality assurance system*

[14] EN 10269, *Steels and nickel alloys for fasteners with specified elevated and/or low temperature properties*

[15] EN 10088 (all parts), *Stainless steels*

3) Under preparation.

ICS 21.060.10
Price based on 37 pages