BS EN ISO 3506-2:2020

BSI Standards Publication

Fasteners — Mechanical properties of corrosion-resistant stainless steel fasteners

Part 2: Nuts with specified grades and property classes

bsi.

National foreword

This British Standard is the UK implementation of EN ISO 3506-2:2020. It is identical to ISO 3506-2:2020. It supersedes BS EN ISO 3506-2:2009, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee FME/9, Fasteners.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Mechanische Verbindungselemente - Mechanische Eigenschaften von Verbindungselementen aus korrosionsbeständigen nichtrostenden Stählen - Teil 2: Muttern mit festgelegten Stahlsorten und Festigkeitsklassen (ISO 3506-2:2020)

This European Standard was approved by CEN on 28 March 2020.

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This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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European foreword

This document (EN ISO 3506-2:2020) has been prepared by Technical Committee ISO/TC 2 "Fasteners" in collaboration with Technical Committee CEN/TC 185 “Fasteners” the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2020, and conflicting national standards shall be withdrawn at the latest by October 2020.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN ISO 3506-2:2009.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Endorsement notice

The text of ISO 3506-2:2020 has been approved by CEN as EN ISO 3506-2:2020 without any modification.

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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 3506-2:2009) 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);

— information for nut styles (see 5.1) has been added;

— design of stainless steel bolt and nut assemblies (see Clause 6), and design principles of stainless steel nuts (see Annex A) have been added;

— finish (see 7.3) has been improved;

— calculated proof load values (see Tables 5 to 8) and rounding rules have been added;

— requirements and guidance for inspection procedures (see Clause 9) have been added;

— thread dimensions of the test mandrel for proof load (see Annex B) have been added;

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

— test methods for proof load and hardness have been improved (see Clause 10);

— nut marking and labelling especially for thin nuts with reduced loadability (see Clause 11) have been added;

— structure and content of this document have been brought in line with ISO 898-2.

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.

INTERNATIONAL STANDARD ISO 3506-2:2020(E)

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

Part 2: Nuts with specified grades and property classes

1 Scope

This document specifies the mechanical and physical properties of nuts, 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 nuts.

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

Nuts 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 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 fastener mechanical properties and clamped parts, and the corrosive service environment of the bolted joint.

NOTE 2 ISO 3506-5[3)] 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 nuts:

— 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 M5 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, including proof load,

— with different nut styles: thin nuts, regular nuts and high nuts,

— with a minimum nut height $m \geq 0{,}45D$,

— with a minimum outside diameter or width across flats $s \geq 1{,}45D$ (see Annex A),

— of any shape, and

— able to mate with bolts, screws and studs with property classes in accordance with ISO 3506-1.

3) Under preparation.

Stainless steel grades and property classes can be used for sizes outside the diameter limits of this document (i.e. for $D < 5$ mm or $D > 39$ mm), provided that all applicable chemical, mechanical and physical requirements are met.

This document does not specify requirements for functional properties such as:

— torque/clamp force properties,

— prevailing torque properties, 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 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*

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

[SOURCE: ISO 3506-1:2020, 3.5]

3.2
austenitic stainless steel
stainless steel (3.1) 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

[SOURCE: ISO 3506-1:2020, 3.6]

3.3
martensitic stainless steel
stainless steel (3.1) 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

[SOURCE: ISO 3506-1:2020, 3.7]

3.4
ferritic stainless steel
stainless steel (3.1) 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

[SOURCE: ISO 3506-1:2020, 3.8]

3.5
duplex stainless steel
stainless steel (3.1) 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

[SOURCE: ISO 3506-1:2020, 3.9]

4 Symbols

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

$A_{s,nom}$	nominal stress area in thread, mm^2
D	nominal thread diameter of the nut, mm
D_2	basic pitch diameter of internal thread, mm
d_h	hole diameter for the grip, mm
F_p	proof load, N
h	thickness of the grip, mm
m	height of the nut, mm
P	pitch of the thread, mm
S_p	stress under proof load, MPa
s	width across flats, mm

5 Designation systems

5.1 Designation of nut styles

This document specifies requirements for three styles of nuts according to their height:

a) nuts with full loadability:

— regular nuts (style 1) with minimum height $0{,}80\ D \leq m_{min} < 0{,}89\ D$, see Annex A,

— high nuts (style 2) with minimum height $m_{min} \geq 0{,}89\ D$, see Annex A;

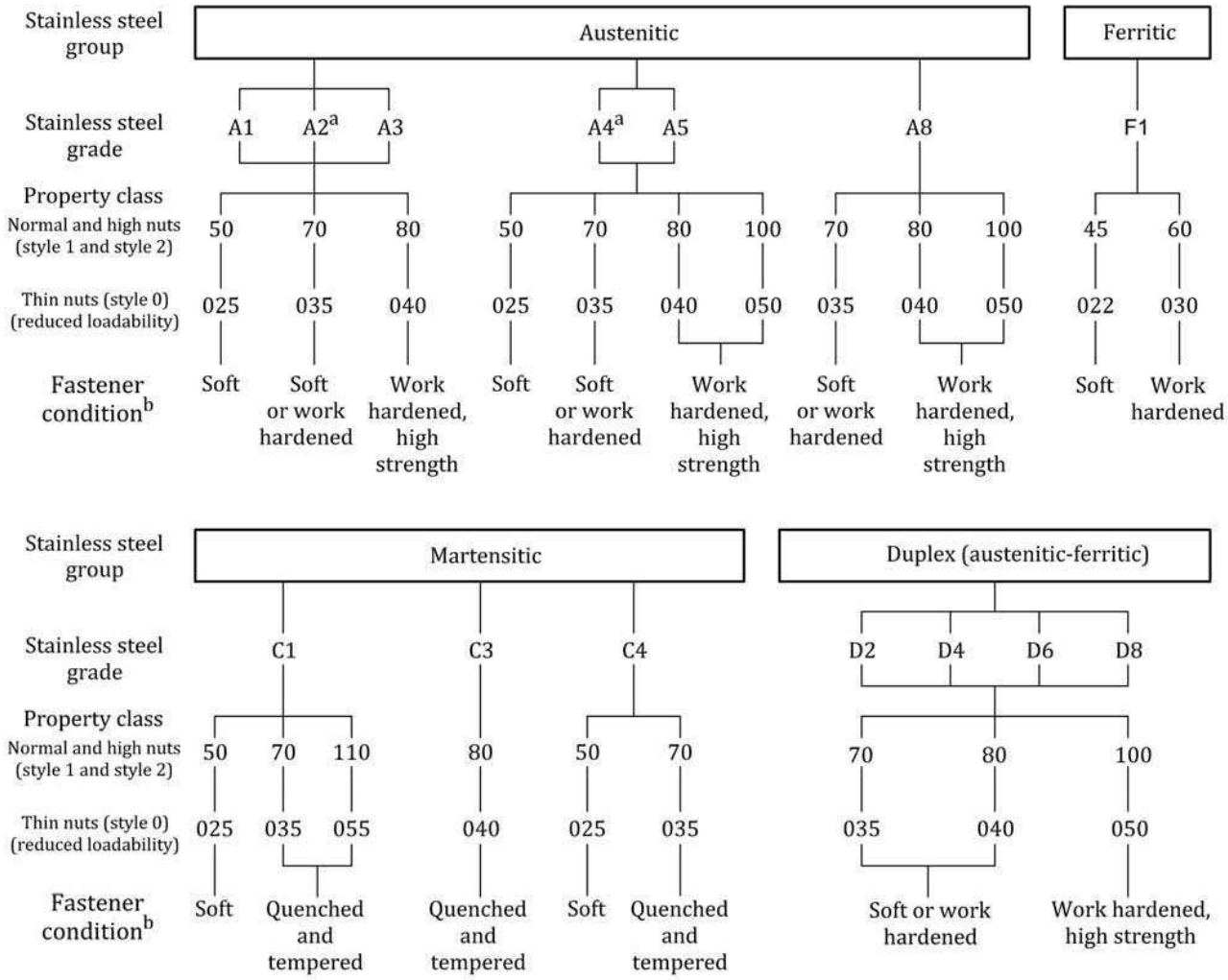
b) nuts with reduced loadability: thin nuts (style 0) with minimum height $0{,}45\ D \leq m_{min} < 0{,}80\ D$.

5.2 Designation system for stainless steel grades and property classes

5.2.1 General

The standardized combinations of stainless steel grades and property classes are specified in Clause 8, Table 3 or 4.

The designation system for stainless steel grades and property classes for nuts 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 nut.



[a] For low carbon austenitic stainless steels with carbon content not exceeding 0,030 %, nuts 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 nuts

The marking, labelling and designation of nuts with stainless steel grade and property class shall be as specified in Clause 11. For thin nuts with reduced loadability, the digit "0" shall precede the property class as specified in 11.3.

The designation system of this document may be used for sizes outside the diameter limits specified in Clause 1 (i.e. $D < 5$ mm or $D > 39$ mm), provided that all applicable chemical, mechanical and physical requirements are met.

5.2.2 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 2.

5.2.3 Designation of property classes (second block) for regular nuts (style 1) and high nuts (style 2)

The designation of the property class (second block) consists of a number corresponding to 1/10 of the stress under proof load of the nut in accordance with Table 3 or 4; it also corresponds to the appropriate stainless steel property class of the bolt, screw and stud with which it should be mated.

EXAMPLE 1 A2-70 specifies an austenitic stainless steel nut, work hardened, with stress under proof load of 700 MPa, for nuts with full loadability ($m \geq 0{,}8D$).

EXAMPLE 2 C1-110 specifies a martensitic stainless steel nut, quenched and tempered, with stress under proof load of 1 100 MPa, for nuts with full loadability ($m \geq 0{,}8D$).

5.2.4 Designation of property classes (second block) for thin nuts (style 0)

The designation of the property class (second block) for thin nuts (style 0) consists of a digit and a number, specified in the following ways:

— the first digit is zero, indicating that the loadability of the thin nuts is reduced in comparison with the loadability of a regular or high nut in accordance with 5.2.3, and therefore thread stripping can occur when overloaded,

— the following number corresponds to 1/10 of the stress under proof load of the nut on a hardened test mandrel in megapascals; it also corresponds to half of the appropriate property class of the stainless steel fastener with which the thin nut should be mated.

EXAMPLE A4-040 specifies an austenitic stainless steel thin nut, with the same material and manufacturing process (work hardened, high strength) as a regular nut A4-80, but with stress under proof load of 400 MPa (reduced loadability) because of its height ($m < 0{,}80\ D$).

6 Design of bolt and nut assemblies

Property class combinations of nuts to bolts, screws and studs shall be in accordance with Table 1.

Table 1 — Property class combination of nuts to bolts, screws and studs

Property class of bolts, screws and studs	Minimum property class of the mating nuts	
	Regular and high nuts (style 1 and style 2)	Thin nuts (style 0)
45	45	022
50	50	025
60	60	030
70	70	035
80	80	040
100	100	050
110	110	055

For full loadability, regular nuts (style 1) and high nuts (style 2) shall be used.

As example, a bolt A4-70 is usually mated with a nut A4-70, however it may be mated with a nut A4-80.

For all-metal prevailing torque nuts, only the same bolt and nut property class shall be combined.

Thin nuts (style 0) have a reduced loadability and are not designed to provide resistance against thread stripping. A thin nut used as jam nut shall be assembled together with a regular nut or a high nut.

For other combinations than those specified in Table 1, it is recommended to check the compatibility of the fasteners before installation in the application.

Explanations of basic design principles of nuts and loadability of bolted assemblies are given in Annex A.

7 Materials

7.1 Chemical composition

Table 2 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 required appropriate stainless steel grade suitable for an application shall be selected in accordance with the specifications defined in ISO 3506-6.

Table 2 — 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 2 are also given in ISO 3506-6.

7.2 Heat treatment for martensitic stainless steel nuts

Regular and high nuts of grades and property classes C1-70, C3-80 and C4-70, and thin nuts of grades and property classes C1-035, C3-040 and C4-035 shall be quenched and tempered.

Regular and high nuts of grade and property class C1-110 and thin nuts of grade and property class C1-055 shall be quenched and tempered, with a minimum tempering temperature of 275 °C.

7.3 Finish

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

For maximum corrosion resistance, passivation is recommended. Nuts 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 11.4).

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

Nuts are often used in bolted joints where the preload is achieved by torque tightening. Therefore, lubrication of stainless steel nuts is strongly recommended in order to avoid galling during tightening.

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

NOTE 3 For the time being, requirements concerning surface discontinuities, torque/clamp force and prevailing torque 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.

7.4 Corrosion resistance

For corrosion resistance purpose, nuts should be mated with bolts, screws, studs 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.

8 Mechanical and physical properties

When tested by the methods specified in Clause 10, the nuts of the specified stainless steel grade and property class shall meet, at ambient temperature, the requirements for the proof load and for the hardness specified in Tables 3 to 8, regardless of which tests are performed during manufacture or final inspection.

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 3 — Mechanical properties for nuts — Austenitic and duplex grades

Stainless steel grade		Regular nuts and high nuts (style 1 and style 2)		Thin nuts (style 0)	
		Property class designation and symbol	Stress under proof load [a] S_p MPa	Property class designation and symbol	Stress under proof load [b] S_p MPa
Austenitic	A1 A2 A3	50	500	025	250
		70	700	035	350
		80	800	040	400
	A4 A5	50	500	025	250
		70	700	035	350
		80	800	040	400
		100	1 000	050	500
	A8	70	700	035	350
		80	800	040	400
		100	1 000	050	500
Duplex	D2 D4 D6 D8	70	700	035	350
		80	800	040	400
		100	1 000	050	500

[a] Proof load values for regular and high nuts (full loadability) are specified in Table 5 for coarse pitch thread, and in Table 6 for fine pitch thread.

[b] Proof load values for thin nuts (reduced loadability) are specified in Table 7 for coarse pitch thread, and in Table 8 for fine pitch thread.

Table 4 — Mechanical properties for nuts — Martensitic and ferritic grades

Stainless steel grade		Regular nuts and high nuts (style 1 and style 2)		Thin nuts (style 0)		All nuts		
		Property class designation and symbol	Stress under proof load [a] S_p MPa	Property class designation and symbol	Stress under proof load [b] S_p MPa	Hardness min. to max. HV	HRC	HBW
Martensitic	C1	50	500	025	250	155 to 220	—	147 to 209
		70	700	035	350	220 to 330	20 to 34	209 to 314
		110 [c]	1 100	055 [c]	550	350 to 440	36 to 45	—
	C3	80	800	040	400	240 to 340	21 to 35	228 to 323
	C4	50	500	025	250	155 to 220	—	147 to 209
		70	700	035	350	220 to 330	20 to 34	209 to 314
Ferritic	F1 [d]	45	450	022	225	135 to 220	—	128 to 209
		60	600	030	300	180 to 285	—	171 to 271

[a] Proof load values for regular and high nuts (full loadability) are specified in Table 5 for coarse pitch thread, and in Table 6 for fine pitch thread.

[b] Proof load values for thin nuts (reduced loadability) are specified in Table 7 for coarse pitch thread, and in Table 8 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 5 — Proof load values for regular and high nuts with coarse pitch thread (full loadability)

Thread D	Nominal stress area $A_{s,nom}$	Proof load, F_{pf} [a] N									
		Austenitic and duplex steels				Martensitic steels				Ferritic steels	
		50 [b]	**70**	**80**	**100**	**50**	**70**	**80**	**110**	**45**	**60**
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] Proof load values have been calculated from the exact figures of $A_{s,nom}$ as specified in ISO 3506-1 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 — Proof load values for regular and high nuts with fine pitch thread (full loadability)

Thread $D \times P$	Nominal stress area $A_{s,nom}$	Minimum ultimate tensile load, F_{mf} [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	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	1 030	514 200	719 900	822 800	1 028 400	514 200	719 900	822 800	1 131 300	—	—

[a] Proof load values have been calculated from the exact figures of $A_{s,nom}$ as specified in ISO 3506-1 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 — Proof load values for thin nuts with coarse pitch thread (reduced loadability)

Thread	Nominal stress area	Proof load, F_{pf} [a] N									
		Austenitic and duplex steels				Martensitic steels				Ferritic steels	
D	$A_{s,nom}$	025 [b]	035	040	050	025	035	040	055	022	030
M5	14,2	3 550	4 970	5 680	7 100	3 550	4 970	5 680	7 810	3 200	4 260
M6	20,1	5 040	7 050	8 050	10 070	5 040	7 050	8 050	11 070	4 530	6 040
M7	28,9	7 220	10 110	11 550	14 430	7 220	10 110	11 550	15 880	6 500	8 660
M8	36,6	9 160	12 820	14 650	18 310	9 160	12 820	14 650	20 140	8 240	10 990
M10	58,0	14 500	20 300	23 200	29 000	14 500	20 300	23 200	31 900	13 050	17 400
M12	84,3	21 070	29 500	33 710	42 140	21 070	29 500	33 710	46 350	18 960	25 280
M14	115	28 860	40 410	46 180	57 720	28 860	40 410	46 180	63 500	25 980	34 640
M16	157	39 170	54 840	62 670	78 340	39 170	54 840	62 670	86 170	35 260	47 010
M18	192	48 120	67 370	76 990	96 240	48 120	67 370	76 990	105 900	43 310	57 750
M20	245	61 200	85 680	97 920	122 400	61 200	85 680	97 920	134 700	55 080	73 440
M22	303	75 850	106 200	121 400	151 700	75 850	106 200	121 400	166 900	68 270	91 020
M24	353	88 130	123 400	141 100	176 300	88 130	123 400	141 100	193 900	79 320	105 800
M27	459	114 900	160 800	183 800	229 800	114 900	160 800	183 800	252 700	—	—
M30	561	140 200	196 300	224 300	280 300	140 200	196 300	224 300	308 400	—	—
M33	694	173 400	242 800	277 500	346 800	173 400	242 800	277 500	381 500	—	—
M36	817	204 200	285 900	326 700	408 400	204 200	285 900	326 700	449 200	—	—
M39	976	244 000	341 600	390 400	487 900	244 000	341 600	390 400	536 700	—	—

[a] Proof load values have been calculated from the exact figures of $A_{s,nom}$ as specified in ISO 3506-1 and rounded to the next upper 10 N up to 100 000 N and to the next 100 N above.

[b] Property class 025 refers to the austenitic grades A1 to A5 only.

Table 8 — Proof load values for thin nuts with fine pitch thread (reduced loadability)

Thread $D \times P$	Nominal stress area $A_{s,nom}$	Proof load, F_{pf} [a] N									
		Austenitic and duplex steels				Martensitic steels				Ferritic steels	
		025 [b]	035	040	050	025	035	040	055	022	030
M8×1	39,2	9 800	13 710	15 670	19 590	9 800	13 710	15 670	21 550	8 820	11 760
M10×1,25	61,2	15 300	21 420	24 480	30 600	15 300	21 420	24 480	33 660	13 770	18 360
M10×1	64,5	16 130	22 580	25 800	32 250	16 130	22 580	25 800	35 480	14 520	19 350
M12×1,5	88,1	22 040	30 850	35 260	44 070	22 040	30 850	35 260	48 470	19 830	26 440
M12×1,25	92,1	23 020	32 230	36 830	46 040	23 020	32 230	36 830	50 640	20 720	27 630
M14×1,5	125	31 140	43 600	49 820	62 280	31 140	43 600	49 820	68 510	28 030	37 370
M16×1,5	167	41 820	58 540	66 900	83 630	41 820	58 540	66 900	91 990	37 640	50 180
M18×1,5	216	54 060	75 690	86 500	108 200	54 060	75 690	86 500	119 000	48 660	64 880
M20×2	258	64 500	90 300	103 200	129 000	64 500	90 300	103 200	141 900	58 050	77 400
M20×1,5	272	67 880	95 030	108 700	135 800	67 880	95 030	108 700	149 400	61 090	81 460
M22×1,5	333	83 270	116 600	133 300	166 600	83 270	116 600	133 300	183 200	74 940	99 920
M24×2	384	96 110	134 600	153 800	192 300	96 110	134 600	153 800	211 500	86 500	115 400
M27×2	496	124 000	173 600	198 300	247 900	124 000	173 600	198 300	272 700	—	—
M30×2	621	155 400	217 500	248 500	310 700	155 400	217 500	248 500	341 700	—	—
M33×2	761	190 200	266 300	304 400	380 400	190 200	266 300	304 400	418 500	—	—
M36×3	865	216 300	302 800	346 000	432 500	216 300	302 800	346 000	475 800	—	—
M39×3	1030	257 100	360 000	411 400	514 200	257 100	360 000	411 400	565 700	—	—

[a] Proof load values have been calculated from the exact figures of $A_{s,nom}$ as specified in ISO 3506-1 and rounded to the next upper 10 N up to 100 000 N and to the next 100 N above.

[b] Property class 025 refers to the austenitic grades A1 to A5 only.

9 Inspection

9.1 Manufacturer's inspection

Nuts produced in accordance with this document shall be capable of conforming to all applicable requirements specified in Clauses 7 and 8, when using the applicable test methods specified in Clause 10.

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 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 Clause 10 shall apply.

9.2 Supplier's inspection

The supplier may control and/or test the nuts they provide using methods of their choice (periodic evaluation of the manufacturer, checking of test results from the manufacturer, tests on the nuts themselves, etc.), provided the chemical, mechanical and physical properties specified in Clauses 7 and 8 are met.

In case of dispute, the test methods in accordance with Clause 10 shall apply.

9.3 Purchaser's inspection

The purchaser may control and/or test the delivered fasteners by using the test methods specified in Clause 10.

In case of dispute, the test methods in accordance with Clause 10 shall apply.

9.4 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.

10 Test methods

10.1 Proof load test

10.1.1 General

The proof load test consists of two main operations, namely:

— application of the specified proof load by means of the test mandrel (see Figures 2 and 3), and

— checking of the damage to the nut thread caused by the proof load, if any.

10.1.2 Applicability

This test applies to nuts having the following specifications:

— all stainless steel grades,

— all property classes,

— nominal diameters 5 mm ≤ D ≤ 39 mm,

— any shape.

10.1.3 Apparatus

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

10.1.4 Testing device

The grips and test mandrel shall be as follows:

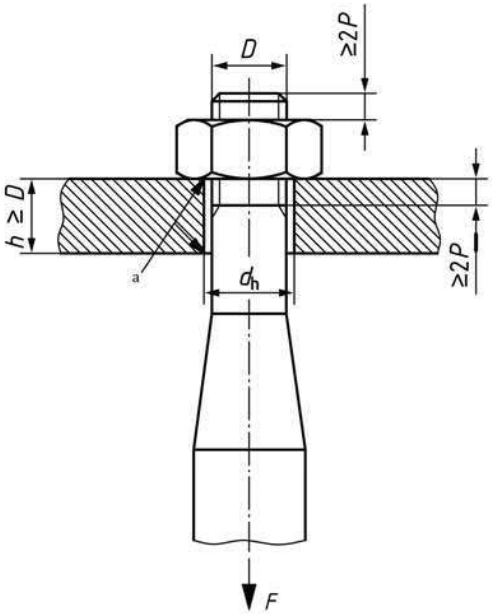
— hardness of the grip: 45 HRC minimum,

— thickness, h, of the grip: 1D minimum,

— hole diameter, d_h, of the grip: in accordance with Table 9,

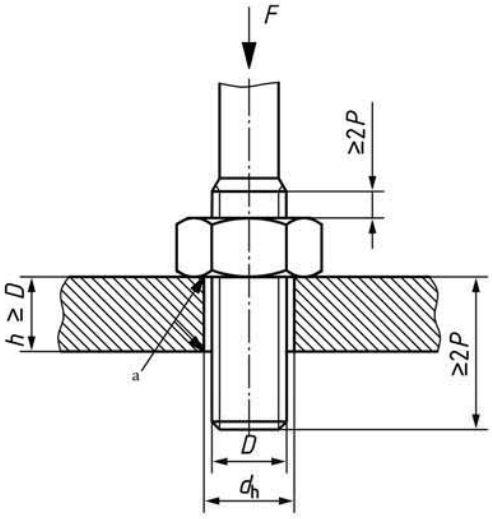
— steel mandrel hardened and tempered: hardness 45 HRC to 50 HRC,

— external thread tolerance class of the test mandrel: the mandrel used shall be threaded to tolerance class 5h6g except that the tolerance of the major diameter shall be the last quarter of the 6g range on the minimum material side; thread dimensions for the test mandrel shall be as specified in Annex B.



a No sharp edge.

Figure 2 — Axial tensile test



a No sharp edge.

Figure 3 — Axial compressive test

Table 9 — Hole diameter for the grip

Dimensions in millimetres

Thread	Hole diameter d_h [a]		Thread	Hole diameter d_h [a]		Thread	Hole diameter d_h [a]	
D	min.	max.	*D*	min.	max.	*D*	min.	max.
5	5,105	5,115	**14**	14,050	14,160	**27**	27,065	27,195
6	6,105	6,115	**16**	16,050	16,160	**30**	30,065	30,195
7	7,040	7,130	**18**	18,050	18,160	**33**	33,080	33,240
8	8,040	8,130	**20**	20,065	20,195	**36**	36,080	36,240
10	10,040	10,130	**22**	22,065	22,195	**39**	39,080	39,240
12	12,050	12,160	**24**	24,065	24,195	—	—	—

[a] $d_h = D$ with tolerance class D11 (see ISO 286-2).

10.1.5 Test procedure

Nuts shall be tested as received.

The threads of the test mandrel shall be checked before each test. If the thread of the mandrel is damaged, it shall not be used within the damaged length or it shall be changed to a conforming mandrel.

The nut to be tested shall be assembled on the test mandrel in accordance with Figure 2 or Figure 3.

The axial tensile test or axial compressive 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 3 mm/min.

The proof load value specified in Tables 5 to 8 shall be applied and shall be maintained for 15 s, and then released. Exceeding the proof load value should be minimized.

The nut shall be removed using the fingers from the test mandrel. It can be necessary to use a manual wrench to start the nut in motion, but the use of such a wrench is permissible only to a half-turn.

The fact that the nut has been removed with the help of a wrench to one half turn maximum shall be noted.

The fact that nut fractures or thread stripping occurs shall be noted.

10.1.6 Addition to test procedure for prevailing torque nuts

Additionally to 10.1.5, the following shall apply for prevailing torque nuts.

The nut to be tested shall be assembled on a steel test bolt or on the test mandrel specified in 10.1.4. When a test bolt is used, it shall have rolled threads, thread tolerance class 6g, and be uncoated. It shall be in accordance with ISO 898-1, and its property class shall be chosen so that its minimum yield strength is above the proof load of the nut to be tested. For reference test purposes, the hardened steel mandrel in accordance with 10.1.4 shall be used.

The maximum prevailing-on torque to assemble the nut through 360° rotation shall be recorded after the first full thread of the test mandrel has passed through the prevailing torque feature.

After releasing the load, the maximum prevailing-off torque occurring during disassembly of the nut after a half-turn to full disengagement, measured with the nut in motion, shall be recorded.

10.1.7 Test results and requirements

The nut shall resist the proof load value specified in Tables 5 to 8 without failure by thread stripping or nut fracture.

For nut without prevailing torque feature, the nut shall be removable using the fingers after the release of the proof load (and, if necessary, after a half-turn maximum with a wrench).

For prevailing torque nuts, the maximum prevailing-off torque occurring during disassembly shall not exceed the recorded maximum prevailing-on torque during assembly.

In case of dispute, the axial tensile test in accordance with Figure 2 shall be the reference method for acceptance.

10.2 Hardness test

10.2.1 General

This test applies to nuts having the following specifications:

— martensitic and ferritic stainless steel grades,

— all property classes,

— all sizes,

— any shape.

10.2.2 Test procedure

Nuts 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.

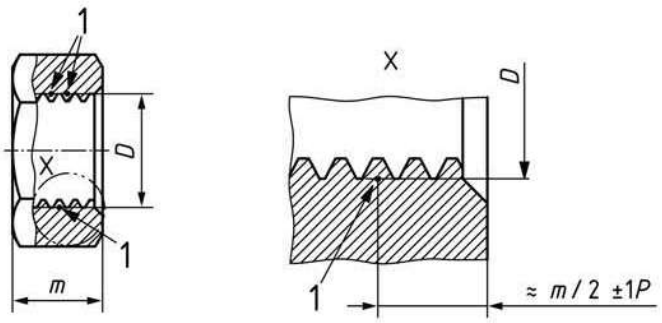
Hardness determined on a surface

For routine inspection, the hardness test shall be carried out on one bearing surface of the nut, after removal of any coating and after suitable preparation of the nut. The hardness value shall be the mean of three readings spaced about 120° apart.

Hardness determined on a longitudinal section (core hardness)

The nut shall be longitudinally sectioned through the nut axis, with a suitable process where hardness is not altered, and the surface shall be suitably prepared.

The hardness shall be determined in accordance with Figure 4, by taking three readings as close as possible to the nominal major diameter of the thread D, at mid-height position ($m/2 \pm 1P$).



Key

1 location of hardness readings

Figure 4 — Location of hardness readings (longitudinal section)

The hardness value shall be the average of the three readings.

10.2.3 Test results and requirements

The hardness value shall be within the limits specified in Table 4.

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

11 Nut marking and labelling

11.1 Nut marking

11.1.1 General requirements for marking

Marking of the nuts consists of:

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

— optional additional letter "L", as specified in 11.1.4,

— the hyphen,

— the property class symbol, as specified in 11.1.2 or 11.1.3,

and

— the manufacturer's identification mark, as specified in 11.2.

Nuts 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 11.

The designation system specified in Clause 5 shall only be used and marking shall only be affixed in accordance with Clause 11 when all applicable requirements of this document are met:

— chemical composition as specified in Table 2,

and

— mechanical and physical properties specified in Clauses 7 and 8, when tested in accordance with Clause 10.

The nut marking shall be included during the manufacturing process. It shall be indented or embossed at the opposite face of the bearing face of the nut. The height of embossed marking on the top of the nut shall not be included in the nut height dimension.

11.1.2 Marking of property class for nuts with full loadability (regular and high nuts)

The property class marking symbol for nuts with full loadability (regular and high nuts) shall be as specified in Table 10.

Table 10 — Property class marking symbol for nuts with full loadability (regular and high nuts)

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

11.1.3 Marking of property class for nuts with reduced loadability (thin nuts)

The property class marking symbol for nuts with reduced loadability (thin nuts) shall be as specified in Table 11, with the preceding digit "0".

When reduced loadability applies to nuts in accordance with a product standard, the marking symbols in accordance with Table 11 shall apply to all sizes specified in the product standard, even if some sizes would fulfil all requirements for full loadability.

Table 11 — Property class marking symbol for nuts with reduced loadability (thin nuts)

Property class	45	50	60	70	80	100	110
Marking symbol	022	025	030	035	040	050	055

11.1.4 Additional marking

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

EXAMPLE A4L-80.

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

11.2 Manufacturer's identification mark

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

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

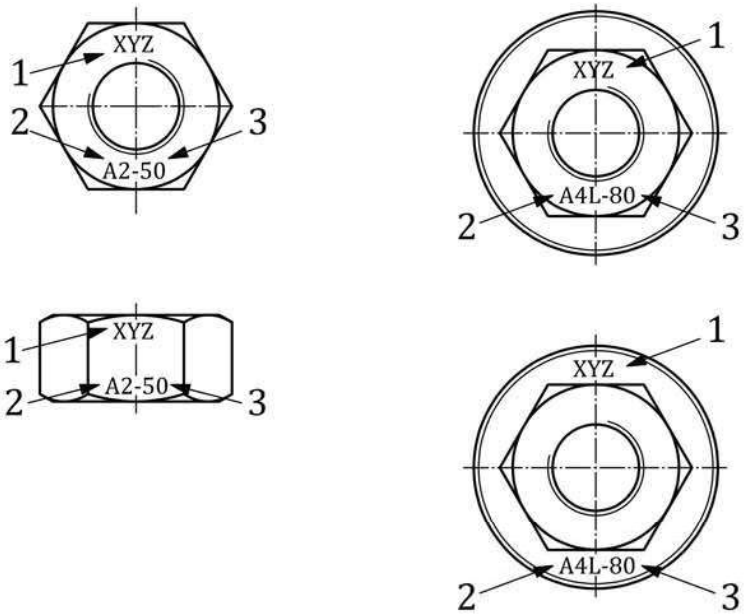
A distributor who distributes nuts that are marked with their own identification mark shall be considered to be the manufacturer.

11.3 Marking on the nuts

11.3.1 Hexagon nuts

All hexagon nuts 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 7, with the property class symbol in accordance with Table 10 or 11, and with the manufacturer's identification mark in accordance with 11.2.

Hexagon nuts shall be marked preferably on the top of the nut by indenting or embossing, or on the side of the nut by indenting (see Figure 5). In the case of nuts with flange, marking shall be on the flange when the manufacturing process does not allow marking on the top of the nut.

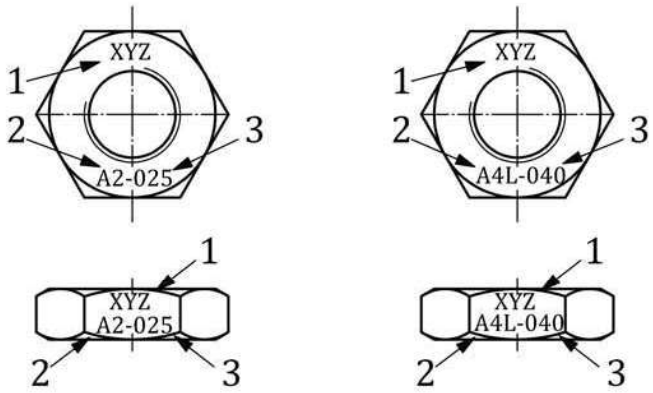


Key

1 manufacturer's identification mark
2 stainless steel grade
3 property class symbol (full loadability)

Figure 5 — Examples of marking for hexagon nuts with full loadability

For nuts with reduced loadability, the property class symbol specified in Table 11 shall be used (see Figure 6).

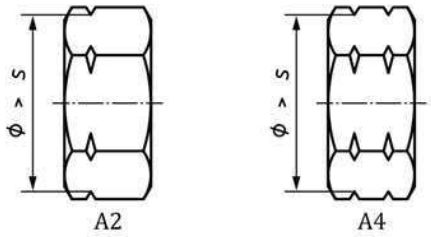


Key

1 manufacturer's identification mark
2 stainless steel grade
3 property class symbol (reduced loadability)

Figure 6 — Examples of marking for hexagon nuts with reduced loadability

For austenitic stainless steel grades A2 and A4 only, the alternative marking shown in Figure 7 can be used; in this case and when no property class is indicated, property class 50 or 025 applies.



Key

s width across flats

Figure 7 — Alternative groove marking (for grades A2 and A4 only)

11.3.2 Other types of nuts

Other types of nuts shall be marked in the same way where it is possible to do so.

11.3.3 Left-hand thread marking

Nuts with left-hand thread and nominal diameter $D \geq 5$ mm shall additionally be marked with a left pointing arrow (see Figure 8). It shall be located preferably on the top of the nut and at the same face as the property class marking.

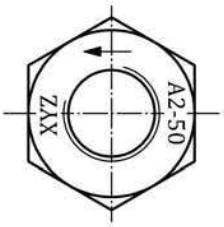


Figure 8 — Example of marking for left-hand thread

11.4 Marking of the packages (labelling)

All packages for all types of nuts 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 11.1.4,

— the property class symbol (after the hyphen) in accordance with Table 10 for nuts with full loadability (e.g. 70), or the property class symbol in accordance with Table 11 for nuts with reduced loadability (e.g. 035),

— the optional letter "P" (after the property class) when nuts have been passivated, as specified in 7.3,

— the optional letters "Lu" (in the last position in the designation) when nuts have been lubricated, as specified in 7.3,

and

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

Annex A
(informative)

Design principles of stainless steel nuts

A.1 Basic design principles of stainless steel nuts

A bolted joint basically consists of two work pieces, which are clamped together using an externally threaded component (bolt, screw or stud) on one side, and an internally threaded component or an internally threaded part or a nut on the other side.

An optimized bolted joint consists of a bolt, screw or stud of a specified property class in accordance with ISO 3506-1 assembled with a regular or high nut of the mating property class in accordance with this document; this bolt and nut assembly is able to provide a preload, using the full strength of the bolt. In the case of over-tightening, the fracture occurs in the loaded part of the bolt, which gives an obvious indication of a tightening failure.

Under tensile load, the fracture mode of bolt and nut assemblies corresponds to the lowest value of the following three loads:

a) thread stripping load in the nut;

b) thread stripping load in the bolt, screw or stud;

c) breaking load in the bolt, screw or stud (bolt breaking is the intended fracture mode of bolt and nut assemblies in case of overloading).

Nuts made of carbon steel and alloy steel have been designed according to Alexander's theory, and nut dimensions have been established, especially minimum height m and width across flats s of hexagon nuts (see ISO 898-2 for more information). Nuts made of stainless steel specified in ISO product standards have the same dimensions as standardized steel nuts, see Table A.1. It has been proven from practical application that this design is also suitable for stainless steel nuts.

Table A.1 — Minimum height of hexagon nuts

Dimensions in millimetres

Thread D	Width across flats s	Minimum height of hexagon nuts			
		Regular nut (style 1)		High nut (style 2)	
		m_{min}	m_{min}/D	m_{min}	m_{min}/D
M5	8	4,40	0,88	4,80	0,96
M6	10	4,90	0,82	5,40	0,90
M7	11	6,14	0,88	6,84	0,98
M8	13	6,44	0,81	7,14	0,90
M10	16	8,04	0,80	8,94	0,89
M12	18	10,37	0,86	11,57	0,96
M14	21	12,10	0,86	13,40	0,96
M16	24	14,10	0,88	15,70	0,98
M18	27	15,10	0,84	16,90	0,94
M20	30	16,90	0,85	19,00	0,95
M22	34	18,10	0,82	20,50	0,93
M24	36	20,20	0,84	22,60	0,94
M27	41	22,50	0,83	25,40	0,94
M30	46	24,30	0,81	27,30	0,91
M33	50	27,40	0,83	30,90	0,94
M36	55	29,40	0,82	33,10	0,92
M39	60	31,80	0,82	35,90	0,92

A.2 Nuts with diameters $D < 5$ mm and $D > 39$ mm

Mechanical properties of bolt and nut assemblies have been optimized for fasteners with nominal diameters from 5 mm to 39 mm inclusive, on the basis of hexagon nut dimensions specified in ISO 4032 (regular nuts, style 1) and ISO 4033 (high nuts, style 2).

Nuts with $D < 5$ mm specified in ISO 4032 have a minimum height, m_{min}, less than $0{,}8D$, which is too low to be in accordance with this design principle. This means that such nuts need a higher strength to avoid the thread stripping fracture mode.

Nuts with $D > 39$ mm specified in ISO 4032 have a minimum height, m_{min}, less than $0{,}8D$, which is also too low to be in accordance with this design principle.

Therefore, mechanical properties for nuts with $D < 5$ mm and $D > 39$ mm are not specified in this document and property classes are not standardized in ISO 4032 and other relevant product standards. The mechanical properties should be by agreement between the purchaser and the supplier.

Annex B
(normative)

Thread dimensions of the test mandrel for proof load

Table B.1 — Thread dimensions of the test mandrel – Coarse pitch thread

Dimensions in millimetres

Nut thread *D*	Mandrel (coarse thread)			
	External thread diameter of the mandrel (lowest quarter of tolerance class 6g)		Pitch diameter of the mandrel (tolerance class 5h)	
	max.	min.	max.	min.
M5	4,864	4,826	4,480	4,405
M6	5,839	5,794	5,350	5,260
M7	6,839	6,794	6,350	6,260
M8	7,813	7,760	7,188	7,093
M10	9,791	9,732	9,026	8,920
M12	11,767	11,701	10,863	10,745
M14	13,752	13,682	12,701	12,576
M16	15,752	15,682	14,701	14,576
M18	17,707	17,623	16,376	16,244
M20	19,707	19,623	18,376	18,244
M22	21,707	21,623	20,376	20,244
M24	23,671	23,577	22,051	21,891
M27	26,671	26,577	25,051	24,891
M30	29,628	29,522	27,727	27,557
M33	32,628	32,522	30,727	30,557
M36	35,584	35,465	33,402	33,222
M39	38,584	38,465	36,402	36,222

Table B.2 — Thread dimensions of the test mandrel — Fine pitch thread

Dimensions in millimetres

Nut thread *D×P*	Mandrel (fine pitch thread)			
	External thread diameter of the mandrel (lowest quarter of tolerance class 6g)		Pitch diameter of the mandrel (tolerance class 5h)	
	max.	min.	max.	min.
M8×1	7,839	7,794	7,350	7,260
M10×1,25	9,813	9,760	9,188	9,093
M10×1	9,839	9,794	9,350	9,260
M12×1,5	11,791	11,732	11,026	10,914
M12×1,25	11,813	11,760	11,188	11,082
M14×1,5	13,791	13,732	13,026	12,911
M16×1,5	15,791	15,732	15,026	14,914
M18×2	17,752	17,682	16,701	16,569
M18×1,5	17,791	17,732	17,026	16,914
M20×2	19,752	19,682	18,701	18,569
M20×1,5	19,791	19,732	19,026	18,914
M22×2	21,752	21,682	20,701	20,569
M22×1,5	21,791	21,732	21,026	20,914
M24×2	23,752	23,682	22,701	22,569
M27×2	26,752	26,682	25,701	25,569
M30×2	29,752	29,682	28,701	28,569
M33×2	32,752	32,682	31,701	31,569
M36×3	35,671	35,577	34,051	33,891
M39×3	38,671	38,577	37,051	36,891

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[11] ISO 4033[7], *Hexagon high nuts (style 2) — Product grades A and B*

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4) Under revision.

5) Under preparation.

6) Under revision.

7) Under revision.