International Standard

ISO 3506-4

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

Part 4: Tapping screws with specified grades and hardness classes

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

Partie 4: Vis à tôle de grades et classes de dureté spécifiés

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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).

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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, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 185 Fasteners, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 3506-4:2009), which has been technically revised.

The main changes are as follows:

— annexes common to several parts of the ISO 3506 series have been withdrawn from this document and are now included in the new ISO 3506-6 which is to be used with this document;

— austenitic stainless steel of grade A8 and duplex (austenitic-ferritic) stainless steels of grades D2 to D8 for hardness classes 20H, 25H and 30H have been added (see Figure 1);

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

— terms and definitions have been added (see Clause 3);

— wording for surface conditions and corrosion resistance have been improved (see 5.3 and 5.4);

— manufacturer's, supplier's and purchaser's inspections have been added (see Clause 7);

— applicability of test methods has been added, and hardness test, torsional test and drive test methods have been improved (see Clause 8);

— marking and labelling have been improved (see Clause 9);

— structure and content of this document have been brought in line with other parts of ISO 3506 published recently.

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 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 process. Austenitic, ferritic 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 and have been increasingly used since the 1980s. This document was revised to reflect their standardization for fasteners.

All duplex stainless steels show improved resistance to stress corrosion cracking compared to the commonly used A2 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.

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

Part 4:
Tapping screws with specified grades and hardness classes

1 Scope

This document specifies the mechanical and physical properties of tapping screws made of corrosion resistant austenitic, martensitic, ferritic and duplex stainless steels, with specified grades and hardness classes.

ISO 3506-6 provides general rules and additional technical information on suitable stainless steels and their properties (detailed properties of stainless steel grades, corrosion behaviour with regards to pitting, crevice and intergranular corrosion, magnetic properties, etc.).

WARNING — Tapping screws conforming to the requirements of this document are tested at the ambient temperature range of 10 °C to 35 °C and are used in applications ranging from –20 °C to +150 °C. It is possible that they do not retain the specified mechanical and physical properties at lower and/or elevated temperatures. Therefore, it is the responsibility of the user to determine the appropriate choices based on service environment conditions of the assembly (see also Clauses 5 and 6).

This document applies to tapping screws with threads ST2,2 to ST8, in accordance with ISO 1478.

This document does not apply to tapping screws with special properties, such as 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 1478, *Tapping screws 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 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method*

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 terminology databases for use in standardization at the following addresses:

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

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

3.1
tapping screw
sheet metal screw
screw with thread in accordance with ISO 1478 which, when driven into a hole, creates its own mating threads in the materials of the parts being assembled (usually thin metal sheets) without deforming its own thread

3.2
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]

3.3
austenitic stainless steel
stainless steel (3.2) 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]

3.4
martensitic stainless steel
stainless steel (3.2) 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]

3.5
ferritic stainless steel
stainless steel (3.2) 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]

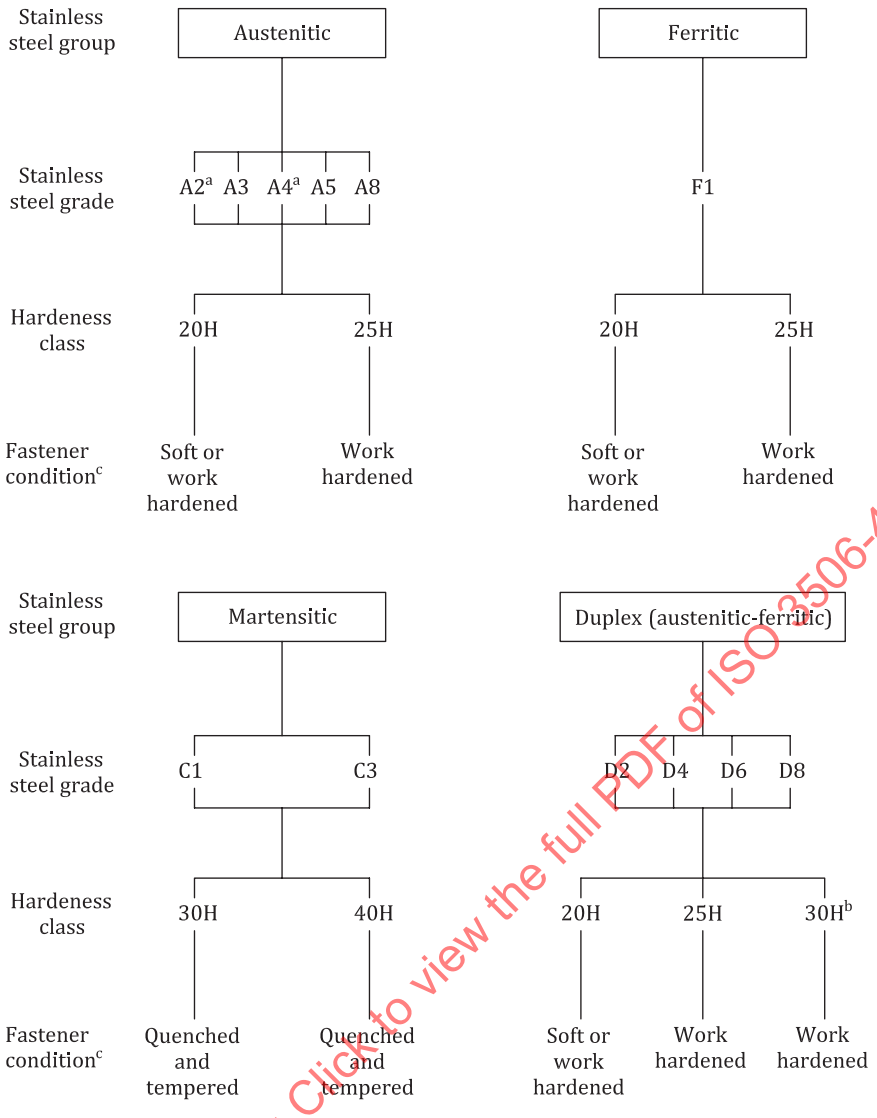
3.6
duplex stainless steel
stainless steel (3.2) with a micro-structure that includes both austenitic and ferritic phases providing excellent resistance to corrosion, containing a higher amount of chromium and a reduced quantity of nickel compared to austenitic steel, with high strength, and with magnetic properties

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

4 Designation system for stainless steel grades and hardness classes

4.1 General

The designation system for stainless steel tapping screws consists of two blocks, separated by a hyphen: the stainless steel grade and the hardness class, as specified in Figure 1.



a For low carbon austenitic stainless steels with carbon content not exceeding 0,030 %, tapping screws can additionally be designated with the letter "L" just after the grade. EXAMPLE: A4L-25H.

b This hardness class requires a prior agreement between the purchaser and the manufacturer.

c For information only.

Figure 1 — Designation system for stainless steel tapping screws

Although a great number of stainless steel grades combined with hardness classes are specified in this document for tapping screws, 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.

The marking, labelling, and designation of tapping screws with stainless steel grade and hardness class shall be as specified in Clause 9.

This designation system may be used for sizes outside the diameter limits specified in this document (i.e. for threads <ST2,2 or >ST8), provided that all applicable chemical, mechanical, and physical requirements are met.

4.2 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.

4.3 Designation of hardness classes (second block)

The designation of the hardness class (second block) consists of two parts, as specified in Table 1:

— the number to the left corresponds to 1/10 of the minimum Vickers hardness, and

— the letter H to the right represents Vickers hardness.

Table 1 — Designation of hardness classes in relation to Vickers hardness

Hardness class		20H	25H	30H	40H
Vickers hardness, HV	min.	200	250	300	400

EXAMPLE 1 A4-25H specifies a tapping screw in austenitic stainless steel of grade A4, work hardened, with a minimum hardness of 250 HV.

EXAMPLE 2 C3-40H specifies a tapping screw in martensitic stainless steel of grade C3, quenched and tempered, with a minimum hardness of 400 HV.

5 Materials

5.1 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 stainless steel grade suitable for an application shall be selected in accordance with ISO 3506-6. ISO 3506-6 also gives examples of stainless steels related to each grade specified in Table 2 (see also Bibliography for additional material information).

For corrosion resistance, see also 5.3 and 5.4.

Table 2 — Stainless steel grades — Chemical composition

Stainless steel grade		Chemical composition[a] (cast analysis, % by mass)[b]										Other elements and notes
		C	Si	Mn	P	S	Cr	Ni	Mo	Cu	N	
Austenitic	A2	0,10	1,00	2,00	0,050	0,030	15,0 to 20,0	8,0 to 19,0	—[c]	4,0	—	[d, e]
	A3	0,08	1,00	2,00	0,045	0,030	17,0 to 19,0	9,0 to 12,0	—[c]	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	10,0 to 15,0	2,00 to 3,00	4,0	—	e, f
	A5	0,08	1,00	2,00	0,045	0,030	16,0 to 18,5	10,5 to 14,0	2,00 to 3,00	1,00	—	5C ≤ Ti ≤ 0,80 and/or 10C ≤ Nb ≤ 1,00 [f]
	A8	0,030	1,00	2,00	0,040	0,030	19,0 to 22,0	17,5 to 26,0	6,0 to 7,0	1,50	—	—
Martensitic	C1	0,09 to 0,15	1,00	1,00	0,050	0,030	11,5 to 14,0	1,00	—	—	—	[f]
	C3	0,17 to 0,25	1,00	1,00	0,040	0,030	16,0 to 18,0	1,50 to 2,50	—	—	—	—
Ferritic	F1	0,08	1,00	1,00	0,040	0,030	15,0 to 18,0	1,00	—[c]	—	—	[g]
Duplex	D2	0,04	1,00	6,0	0,040	0,030	19,0 to 24,0	1,50 to 5,5	0,10 to 1,00	3,00	0,050 to 0,20	Cr + 3,3Mo +16N ≤ 24,0 [h]
	D4	0,04	1,00	6,0	0,040	0,030	21,0 to 25,0	1,00 to 5,5	0,10 to 2,00	3,00	0,050 to 0,30	24,0 < Cr + 3,3Mo + 16N [h]
	D6	0,030	1,00	2,00	0,040	0,015	21,0 to 23,0	4,5 to 6,5	2,50 to 3,5	—	0,080 to 0,35	—
	D8	0,030	1,00	2,00	0,035	0,015	24,0 to 26,0	6,0 to 8,0	3,00 to 4,5	2,50	0,20 to 0,35	W ≤ 1,00

[a] According to material standards, values are maximum unless otherwise specified; the number of digits shown is in accordance with usual rules, see e.g. ISO 6306 or EN 10088-1.

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

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

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

[e] For austenitic stainless steels having a maximum carbon content of 0,030 %, nitrogen may be present but shall not exceed 0,22 % (see ISO 15510).

[f] At the discretion of the manufacturer, the carbon content may be higher as necessary to achieve the specified mechanical, physical and functional properties for larger diameters, but for austenitic steels shall not exceed 0,12 %.

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

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

5.2 Heat treatment for martensitic stainless steel tapping screws

Tapping screws with stainless steel grades C1 and C3 with hardness classes 30H or 40H shall be quenched and tempered. Tapping screws with stainless steel grade and hardness class C1-40H shall be quenched and tempered, with a minimum tempering temperature of 275 °C.

5.3 Surface condition (finish and/or coating)

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

For maximum corrosion resistance, an additional passivation process may be performed, e.g. in accordance with ISO 16048. Additional passivation, if any, shall be required by the purchaser at the time of the order. Tapping screws that are passivated in accordance with ISO 16048 may additionally be referenced on the label with the letter "P" just after the hardness class (see 9.3).

NOTE Tapping screws with additional passivation do not always show a bright surface aspect.

An additional lubrication may be performed in order to minimize friction between the tapping screw and the assembled parts during tightening. Additional lubrication, if any, shall be required by the purchaser at the time of the order. In this case, the designation should include the letters “Lu” last after the hardness class, e.g. A2-25H Lu.

Any other specific requirement shall be agreed between the purchaser and the supplier at the time of the order.

5.4 Corrosion resistance

The stainless steel grade suitable for an application shall be selected in accordance with ISO 3506-6, by taking into account the corrosion resistance in the expected corrosive service environment.

Details on the different types of corrosion (stress corrosion cracking, pitting and crevice corrosion, intergranular corrosion) are given in ISO 3506-6, which also gives information on materials for particular environments (e.g. for indoor swimming pools).

Galvanic corrosion (also called contact corrosion) should be considered when designing a joint where materials with different electrical potentials are assembled (stainless steel fasteners and assembled parts), if the joint is exposed to a wet or humid atmosphere and/or to an environment where condensation may occur.

In case of stainless steel tapping screws being in contact other stainless steel parts, the tapping screws shall match the corrosion resistance of the material in contact with (e.g. tapping screw D4 in contact with sheet of grade 1.4404). When in contact with non-stainless steel parts, e.g. galvanized steels, the use of isolation components is advised to avoid galvanic corrosion.

For further information about the risk of corrosion, consulting an experienced materials specialist is recommended.

5.5 Magnetic properties

Details on magnetic properties are given in ISO 3506-6.

Austenitic stainless steels in the annealed state are usually non-magnetic. However, some residual magnetism can occur as a result of work hardening during the fastener manufacture.

6 Requirements for mechanical, physical and functional properties

6.1 General

The manufacturer shall ensure the fasteners conformity with the mechanical, physical and functional properties specified in this document.

When tested by the methods specified in Clause 8, the tapping screws of the specified stainless steel grade and hardness class shall meet, at ambient temperature, all the applicable requirements specified in 6.2 to 6.5, regardless of which tests are performed during manufacture or final inspection.

The applicability of test methods is specified in 8.1.

6.2 Surface hardness for martensitic grades

Tapping screws with martensitic stainless steel grades shall meet the surface hardness requirements specified in Table 3 when tested in accordance with 8.2.2.

Table 3 — Surface hardness requirements for martensitic grades

Stainless steel grade	Hardness class	Surface hardness, HV 0,3 min.
C1, C3	30H	300
	40H	400

6.3 Core hardness

Tapping screws with austenitic, ferritic, and duplex stainless steel grades shall meet the core hardness requirements specified in Table 4 when tested in accordance with 8.2.3. In case of dispute, the requirements for functional properties in accordance with 6.4 shall be used to determine product acceptance.

Table 4 — Core hardness

Stainless steel grade	Hardness class	Core hardness, HV[a] min.
A2, A3, A4, A5, A8	20H	200
	25H	250
F1	20H	200
	25H	250
D2, D4, D6, D8	20H	200
	25H	250
	30H	300

[a] HV 5 shall be used for threads ≤ST3,9; HV 10 shall be used for threads >ST3,9.

6.4 Thread forming ability

Tapping screws shall form mating threads without deforming their own thread, when driven into a test plate in accordance with 8.3.

6.5 Torsional strength

Tapping screws shall have a torsional strength such that the torque necessary to cause failure, when tested in accordance with 8.4, shall meet the minimum torque values specified in Table 5 for the applicable hardness class.

Table 5 — Minimum breaking torque

Thread	Minimum breaking torque, $M_{B,min}$ Nm			
	Hardness class			
	20H	25H	30H	40H
ST2,2	0,38	0,48	0,54	0,60
ST2,6	0,64	0,80	0,90	1,00
ST2,9	1,00	1,20	1,40	1,50
ST3,3	1,30	1,60	1,80	2,0
ST3,5	1,70	2,2	2,4	2,7
ST3,9	2,3	2,9	3,3	3,6
ST4,2	2,8	3,5	3,9	4,4
ST4,8	4,4	5,5	6,2	6,9

Table 5 *(continued)*

Thread	Minimum breaking torque, $M_{B,min}$ Nm			
	Hardness class			
	20H	25H	30H	40H
ST5,5	6,9	8,7	9,7	10,8
ST6,3	11,4	14,2	15,9	17,7
ST8	23,5	29,4	32,9	36,5

7 Inspection

7.1 Manufacturer's inspection

Tapping screws produced in accordance with this document shall meet all applicable requirements specified in Clauses 5 and 6, when using the applicable test methods specified in Clause 8.

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 specified requirements. For additional information, see ISO 16426.

In case of dispute, the test methods in accordance with Clause 8 shall apply.

7.2 Supplier's inspection

The supplier may control and/or test the tapping screws they provide using the methods of their choice (periodic evaluation of the manufacturer, checking of test results from the manufacturer, tests on the tapping screws themselves, etc.), provided the chemical, mechanical, physical and functional properties specified in Clauses 5 and 6 are met.

In case of dispute, the test methods in accordance with Clause 8 shall apply.

7.3 Purchaser's inspection

The purchaser may control and/or test the delivered tapping screws by using the test methods specified in Clause 8.

In case of dispute, the test methods in accordance with Clause 8 shall apply.

7.4 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. The test report 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.

8 Test methods

8.1 General

The applicability of the tests specified in Clause 8 depends on stainless steel grade and tapping screw type and size. Primarily for dimensional reasons, not all mechanical and physical properties can be tested on all types or sizes.

Tapping screws shall be tested in the as-received condition.

8.2 Hardness test

8.2.1 General

The hardness tests apply to all tapping screws specified in this document (i.e. all hardness classes, all sizes and of any shape).

8.2.2 Surface hardness test

This test applies to tapping screws of martensitic stainless steel grades only.

The surface hardness test shall be carried out in accordance with ISO 6507-1, using a Vickers indenter with a test force of 2,942 N (HV 0,3). The indentation of the pyramid shall be made on a flat surface, preferably on the screw head.

Three surface hardness readings shall be performed either on the same screws or on three screws from the same manufacturing lot.

8.2.3 Core hardness test

This test applies to tapping screws of austenitic, ferritic and duplex stainless steel grades.

Vickers hardness test to determine core hardness shall be carried out in accordance with ISO 6507-1:

— with a test force of 49,03 N (HV 5) for threads ≤ST3,9 and a test force of 98,07 N (HV 10) for threads >ST3,9,

— in the area of the fully formed thread

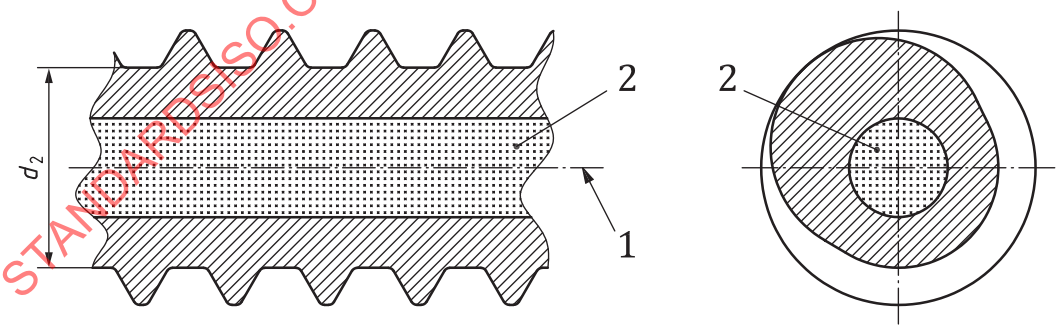
— at a distance sufficiently behind the thread end,

— between the axis and the half-radius position, in accordance with Figure 2,

— either on a longitudinal section through the screw axis or on (a) transverse section(s).

The section(s) shall be made with a suitable process where hardness is not altered, and the surface shall be suitably prepared.

The core hardness shall be determined in accordance with Figure 2 by taking three readings in the area between the axis and the half-radius position.



Key

1 axis of the screw

2 half-radius area (radius of $0{,}25 d_{2,\min}$ as specified in ISO 1478)

Figure 2 — Half-radius area for core hardness determination

8.2.4 Test results and requirements

All surface hardness readings shall be within the limits specified in Table 3.

All core hardness readings shall be within the limits specified in Table 4.

8.3 Drive test

The purpose of the drive test is to evaluate the thread forming ability of the tapping screw by driving it into a test plate. This test applies to all tapping screws specified in this document (i.e. all stainless steel grades, all hardness classes, all sizes and of any shape).

The test plate shall be in accordance with the following requirements:

— for hardness classes 20H and 25H, an aluminium alloy material shall be used, with hardness of 80 HV 30 to 120 HV 30 determined in accordance with ISO 6507-1;

— for hardness classes 30H and 40H, a low-carbon steel material with a carbon content not exceeding 0,23 % shall be used, with hardness of 130 HV 30 to 170 HV 30 determined in accordance with ISO 6507-1;

— thickness in accordance with Table 6;

— hole diameter in accordance with Table 6; the hole shall be drilled, or punched and redrilled, or reamed.

The tapping screws shall be driven into the test plate until at least one fully formed thread has completely protruded from the test plate.

Table 6 — Test plate dimensions

Thread	Test plate thickness mm		Hole diameter mm	
	min.	max.	min.	max.
ST2,2	1,17	1,30	1,905	1,955
ST2,6	1,17	1,30	2,185	2,235
ST2,9	1,17	1,30	2,415	2,465
ST3,3	1,17	1,30	2,680	2,730
ST3,5	1,85	2,06	2,920	2,970
ST3,9	1,85	2,06	3,240	3,290
ST4,2	1,85	2,06	3,430	3,480
ST4,8	3,10	3,23	4,015	4,065
ST5,5	3,10	3,23	4,735	4,785
ST6,3	4,67	5,05	5,475	5,525
ST8	4,67	5,05	6,885	6,935

The drive test result shall be in accordance with 6.4.

8.4 Torsional test

The purpose of the torsional test is to determine the breaking torque, M_B. This test applies to all tapping screws specified in this document (i.e. all stainless steel grades, all hardness classes and all sizes), when the shape of head and recess size allows it.

The tapping screw shall be clamped in a mating, split, threaded die or other similar device so that the clamped portion of the screw is not damaged. At least two fully formed threads shall project above the clamping device. At least two fully formed threads exclusive of the screw end shall be held within the clamping device. A threaded insert with a blind hole may be used in place of the clamping device (see Figure 3) provided the hole depth is such as to ensure that breakage occurs beyond the screw end.

The clamping device and driving tool shall be aligned with the axis of the screw. A calibrated torque measuring device with an accuracy of ±4 % of the minimum breaking torque of the screw to be tested