SLOVENSKI STANDARD
oSIST prEN ISO 3506-5:2023

01-september-2023

Vezni elementi - Mehanske lastnosti veznih elementov iz korozijsko odpornega nerjavnega jekla - 5. del: Posebni vezni elementi (vključno z veznimi elementi iz nikljevih zlitin) za uporabo pri visokih temperaturah (ISO 3506-5:2022)

Fasteners - Mechanical properties of corrosion-resistant stainless steel fasteners - Part 5: Special fasteners (also including fasteners from nickel alloys) for high temperature applications (ISO 3506-5:2022)

Verbindungselemente - Mechanische Eigenschaften von Verbindungselementen aus nichtrostenden Stählen - Teil 5: Spezielle Verbindungselemente (einschließlich Verbindungselemente aus Nickellegierungen) für Hochtemperaturanwendungen (ISO 3506-5:2022)

Fixations - Caractéristiques mécaniques des fixations en acier inoxydable résistant à la corrosion - Partie 5: Fixations spéciales (incluant également les fixations en alliages de nickel) pour utilisation à hautes températures (ISO 3506-5:2022)

Ta slovenski standard je istoveten z: **prEN ISO 3506-5**

ICS:

21.060.99	Drugi vezni elementi	Other fasteners

oSIST prEN ISO 3506-5:2023 **en,fr,de**

INTERNATIONAL STANDARD

ISO 3506-5

First edition
2022-04

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

Part 5: Special fasteners (also including fasteners from nickel alloys) for high temperature applications

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

Partie 5: Fixations spéciales (incluant également les fixations en alliages de nickel) pour utilisation à hautes températures

Reference number
ISO 3506-5:2022(E)

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Published in Switzerland

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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.*

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: 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*

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

The properties of stainless steel and nickel alloy fasteners for high temperature applications result from the chemical composition of the material, from the heat treatment process and from the manufacturing process of the fasteners. Static or dynamic properties at room temperature like tensile strength, hardness or fatigue resistance are not sufficient enough to design fasteners for high temperature applications properly.

In fact, at high temperatures e.g. above 300 °C, additional phenomena occur, for instance:

— decrease in tensile properties and hardness,

— hot oxidation and scaling,

— stress relaxation,

— creep.

All these phenomena significantly affect the durability and service life of fasteners. Therefore:

— a proper choice of material grade is essential to avoid heavy hot oxidation,

— qualification of fasteners through dedicated tests should be performed.

Different tests are currently available to assess the behaviour of machined and standardized samples (see for example ASTM E292 or ASTM E328). In addition to these tests, this document specifies test methods on finished fasteners: these are useful when requiring results as representative as possible of the actual service conditions.

All fastener categories included in this document are heat-treated (see Clause 6). Heat treatment processing is crucial to reach mechanical properties and suitable microstructure that are essential to stand phenomena described above and to get adequate durability for the fasteners and the assembled bolted joints.

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.

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

Part 5: Special fasteners (also including fasteners from nickel alloys) for high temperature applications

1 Scope

This document specifies the mechanical and physical properties of bolts, screws, studs and nuts, with coarse pitch thread and fine pitch thread, made of corrosion-resistant stainless steels (i.e. martensitic stainless steels and precipitation hardening austenitic stainless steels) and nickel alloys, intended for use at high temperatures up to 800 °C.

Tests in accordance with Clause 9 are performed at the ambient temperature range of 10 °C to 35 °C, and other tests can be performed at higher temperatures, see Clause 10.

NOTE Fasteners specified in this document are also suitable when used at low temperatures, typically down to -50 °C. For more information, see ISO 3506-6.

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

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

This document applies to fasteners:

— 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 M3 to M39, and fine pitch thread M8×1 to M39×3,

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

— of any shape but with full loadability.

Stainless steel and nickel alloy fastener symbols can be used for sizes outside the diameter limits of this document (i.e. for bolts, screws and studs with $d < 3$ mm or $d > 39$ mm and for nuts with $D < 5$ mm or $D > 39$ mm), provided that all applicable chemical, mechanical and physical requirements are met.

Fasteners with reduced loadability (i.e. thin nuts and bolts, screws and studs with head or unthreaded shank weaker than the threaded shank) are not dealt with in this document.

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

— torque/clamp force properties,

— shear strength,

— fatigue resistance,

— weldability,

or

— properties of bolted joints and fasteners in high temperature environment (see test methods at high temperature for fasteners in Clause 10).

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 3506-1, *Fasteners — Mechanical properties of corrosion-resistant stainless steel fasteners — Part 1: Bolts, screws and studs with specified grades and property classes*

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

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*

EN 10319-2, *Metallic materials — Tensile stress relaxation testing — Part 2: Procedure for bolted joint models*

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
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
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]

3.3
precipitation hardening austenitic stainless steel
austenitic stainless steel that can be hardened through precipitation of intermetallic phases from its supersaturated metallic matrix

3.4
nickel alloy
alloy whose main constituent is nickel

3.5
soaking time
time that the entire part being heat-treated (throughout its cross-sections) remains at the specified set temperature

3.6
stainless steel bolt and screw with full loadability
nickel alloy 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

[SOURCE: ISO 3506-1:2020, 3.1 modified]

3.7
stainless steel stud with full loadability
nickel alloy 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

[SOURCE: ISO 3506-1:2020, 3.2 modified]

3.8
stainless steel nut with full loadability
nickel alloy nut with full loadability
regular nut or high nut fulfilling the requirements for proof load and with minimum height $m_{min} \geq 0{,}80D$ or $m_{th,design,min} \geq 0{,}73D$

Note 1 to entry: The limits for the minimum height $m_{min} \geq 0{,}80D$ (for standard nuts) or $m_{th,design,min} \geq 0{,}73D$ (for other nuts) are explained in 6.4.

3.9
resistance to high temperature environment
extent to which a fastener retains required functional properties (e.g. resistance against oxidation, relaxation, creep) during exposure to a specified temperature for a specified duration and/or to temperature cycles

3.10
creep
time-dependent strain that occurs after the application of a force which is thereafter maintained constant

3.11
relaxation
time-dependent stress loss for a constant strain

4 Symbols

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

A	Total elongation after fracture for full-size fastener, mm
A_T	Total elongation after fracture for full-size fastener at high temperature, mm
$A_{s,nom}$	Nominal stress area in thread, mm^2
b	Thread length, mm
d, D	Nominal thread diameter, mm
d_1	Basic minor diameter of external thread, mm
d_2	Basic pitch diameter of external thread, mm
D_2	Basic pitch diameter of internal thread, mm
d_3	Minor diameter of external thread (for nominal stress area calculation), mm
d_h	Hole diameter of the grip in tensile testing device, mm
d_s	Diameter of unthreaded shank, mm
F_{mf}	Ultimate tensile load for full-size fastener, N
$F_{mf,T}$	Ultimate tensile load for full-size fastener at high temperature, N
$F_{n,T}$	Ultimate stripping load at high temperature for the nut, N
F_P	Proof load for nut, N
F_{pf}	Load at 0,2 % non-proportional elongation for full-size fastener, N
$F_{pf,T}$	Load at 0,2 % non-proportional elongation for full-size fastener at high temperature, N
h	Thickness of the nut grip in tensile testing device, mm
H	Height of the fundamental triangle of the thread, 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_t	Overall length of stud, mm
l_{th}	Free threaded length of fastener in testing device, mm
m	Height of the nut, mm
$m_{th,design}$	Design thread height of the nut, mm
P	Pitch of the thread, mm
R_{mf}	Tensile strength for full-size fastener, MPa

$R_{mf,T}$ Tensile strength for full-size fastener at high temperature, MPa

$R_{n,T}$ Ultimate nut strength at stripping load at high temperature, MPa

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

$R_{pf,T}$ Stress at 0,2 % non-proportional elongation for full-size fastener at high temperature, MPa

S_P Stress under proof load for nuts, MPa

5 Designation system for fasteners made from stainless steels and nickel alloys

All stainless steels and nickel alloys specified in this document belong to one of the three following categories:

— **martensitic stainless steels** (3.2): CH0, CH1, CH2, V, VH, and VW,

— **precipitation hardening austenitic stainless steels** (3.3): SD,

— **nickel alloys** (3.4): SB and 718.

The chemical composition and heat treatment of fasteners for these three material categories are specified in Clause 6.

The marking, labelling and designation with the fastener symbols of Clause 6 shall be as specified in Clause 11.

6 Materials and manufacture

6.1 Chemical composition

Tables 1 to 3 specify the limits for chemical composition of the stainless steels and nickel alloys 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 fastener symbol is at the discretion of the manufacturer, unless otherwise agreed between the purchaser and the manufacturer.

The stainless steel or nickel alloy grade suitable for an application shall be selected in accordance with the specifications defined in ISO 3506-6 (see also Bibliography for additional material information).

Table 1 — Chemical composition for martensitic stainless steel fasteners

Fastener symbol	Material reference	Chemical composition Mass fraction, % (maximum values unless stated otherwise)									
		C	Si	Mn	P	S	Cr	Mo	Ni	N	Other elements
CH0	4021-420-00-I [a]	0,16 to 0,25	1,00	1,50	0,040	0,030 [c]	12,0 to 14,0	—	—	—	—
	1.4021 [b]										
CH1	4028-420-00-I [a]	0,26 to 0,35	1,00	1,50	0,040	0,030 [c]	12,0 to 14,0	—	—	—	—
	1.4028 [b]										
CH2	4057-431-00-X [a]	0,12 to 0,22	1,00	1,50	0,040	0,030 [c]	15,0 to 17,0	—	1,50 to 2,50	—	—
	1.4057 [b]										
V or **VH** [d]	4923-422-77-E [a]	0,18 to 0,24	0,50	0,40 to 0,90	0,025	0,015	11,0 to 12,5	0,80 to 1,20	0,30 to 0,80	—	V: 0,25 to 0,35
	1.4923 [e]										
VW	1.4913 [e]	0,17 to 0,23	0,50	0,40 to 0,90	0,025	0,015	10,0 to 11,5	0,50 to 0,80	0,20 to 0,60	0,05 to 0,10	V: 0,10 to 0,30 Nb: 0,25 to 0,55 B ≤ 0,0015 Al ≤ 0,020

[a] Material reference given for information according to ISO 15510.

[b] Material reference given for information according to EN 10088-3.

[c] For machinability, a controlled sulfur mass fraction of 0,015 % to 0,030 % is recommended.

[d] Symbol V for stress at 0,2 % non-proportional elongation $R_{pf} \geq 600$ MPa, and symbol VH for $R_{pf} \geq 700$ MPa, in accordance with Table 7.

[e] Material reference given for information according to EN 10269.

Table 2 — Chemical composition for precipitation hardening austenitic stainless steel fasteners

Fastener symbol	Material reference	Chemical composition Mass fraction, % (maximum values unless stated otherwise)									
		C	Si	Mn	P	S	Cr	Mo	Ni	Ti	Other elements
SD [a]	4980-662-86-X [b]	0,080 [e]	1,00	2,00	0,040	0,030	13,5 to 16,0	1,00 to 1,50	24,0 to 27,0	1,90 to 2,35	Al ≤ 0,35 V: 0,10 to 0,50 B: 0,0010 to 0,010
	Alloy 660 UNS S66286 [c]										
	1.4980 [d]	0,030 to 0,080	1,00	1,00 to 2,00	0,025	0,015	13,5 to 16,0	1,00 to 1,50	24,0 to 27,0	1,90 to 2,30	Al ≤ 0,35 V: 0,10 to 0,50 B: 0,0030 to 0,010

[a] Secondary melting (for instance Electro-Slag Remelting) of the raw material is recommended due to the beneficial effect on the functional properties of the finished fasteners. The melting process is left to the choice of the fastener manufacturer, unless otherwise agreed.

[b] Material reference given for information according to ISO 15510.

[c] Material reference given for information according to ASTM A453/A453M.

[d] Material reference given for information according to EN 10269.

[e] A minimum carbon content may be required for specific applications.

Table 3 — Chemical composition for nickel alloy fasteners

Fastener symbol	Material reference	Chemical composition Mass fraction, % (maximum values unless stated otherwise)									
		C	Si	Mn	P	S	Cr	Mo	Ni	Ti	Other elements
SB [a]	Alloy 80A UNS N07080 [b]	0,10 [c]	1,00	1,00	—	0,015	18,0 to 21,0	—	Re-minder	1,80 to 2,70	Al: 0,50 to 1,80 Fe ≤ 3,00
	2.4952 [d]	0,040 to 0,10	1,00	1,00	0,020	0,015	18,0 to 21,0	—	≥ 65	1,80 to 2,70	Al: 1,00 to 1,80 Fe ≤ 1,50 Co ≤ 1,00 Cu ≤ 0,20 B ≤ 0,0080
718 [a]	Alloy 718 UNS N07718 [e]	0,080 [c]	0,35	0,35	0,015	0,015	17,0 to 21,0	2,80 to 3,30	50 to 55	0,65 to 1,15	Nb + Ta: 4,75 to 5,50 Al: 0,20 to 0,80 Co ≤ 1,00 Cu ≤ 0,30 B ≤ 0,0060
	2.4668 [f]	0,020 to 0,080	0,35	0,35	0,015	0,015	17,0 to 21,0	2,80 to 3,30	50 to 55	0,60 to 1,20	Nb + Ta: 4,7 to 5,5 Al: 0,30 to 0,70 Co ≤ 1,00 Cu ≤ 0,30 B ≤ 0,0020 to 0,0060

[a] Secondary melting (for instance Electro-Slag Remelting) of the raw material is recommended due to the beneficial effect on the functional properties of the finished fasteners. The melting process is left to the choice of the fastener manufacturer, unless otherwise agreed.

[b] Material references given for information according to ASTM B637.

[c] A minimum carbon content may be required for specific applications.

[d] Material references given for information according to EN 10269.

[e] Material references given for information according to ASTM A1014.

[f] Material references given for information according to EN 10302.

6.2 Heat treatment for fasteners

Fasteners shall be heat treated in order to meet the mechanical and physical properties specified in Clause 7.

Heat treatment requirements are specified in Table 4. The minimum tempering temperature for martensitic stainless steels shall be selected in accordance with Table 4, by taking into account the mechanical and physical properties required in Table 7 as well as the temperature at which the fasteners are intended to be used.

The process steps shall be as follows:

— for SD, SB and 718, solution annealing (AT) shall be carried out. In addition, it is strongly recommended to perform AT after the manufacture of the fasteners; however, for externally threaded fasteners with tensile strength R_{mf} above or equal to 1 100 MPa, AT could be performed on the raw material (before manufacturing the fasteners) subject to prior agreement between the purchaser and the manufacturer at the time of order;

— for cold and hot forged fasteners, heat treatment shall be performed after the manufacture of the fasteners;