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

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

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

Partie 6: Règles générales pour la sélection des aciers inoxydables et des alliages de nickel pour les fixations

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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

When revising ISO 3506-1 and ISO 3506-2, annexes common to several parts have been withdrawn and included in this document in order to avoid uncessery repetition and to ease further revision of parts as necessary (these annexes have also been technically revised). This document replaces:

— ISO 3506-1:2009, Annexes B, C, D, E, G and H, and

— ISO 3506-2:2009, Annexes A, B, C, D, F and G.

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*

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

2) Under preparation.

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

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

1 Scope

This document specifies general rules and provides technical information on stainless steels and their properties, which are relevant when using other parts of the ISO 3506 series. It includes specifications for corrosion-resistant stainless steels and nickel alloys, which are suitable for the manufacture of fasteners.

It applies to austenitic, martensitic, ferritic and duplex (austenitic-ferritic) stainless steel grades and nickel alloys for fasteners, and is intended to be used together with the relevant parts of the ISO 3506 series.

Common designations of stainless steels and nickel alloys used for fasteners are given in Annex A.

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

3 Terms and definitions

For the purpose of this document, terms and definitions specified in ISO 3506-1, ISO 3506-2 and ISO 3506-5 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) Under preparation.

4 Groups and grades of stainless steels

4.1 General

The ISO 3506 series deals with stainless steel grades of the following groups:

— austenitic steel A1 to A5 and A8,

— martensitic steel C1, C3 and C4,

— ferritic steel F1,

— duplex (austenitic-ferritic) steel D2, D4, D6 and D8.

Stainless steels cover a great variety of materials providing different corrosion resistant properties and different functional properties. A specific fastener manufactured from stainless steel shall be carefully chosen by taking into account all the conditions in the expected environment of the bolted joint.

The condition of the surface of the fasteners (passivated, surface roughness, etc.) can influence the capacity of the fastener to resist corrosion.

In special cases, it is advised to consult an experienced fastener manufacturer and/or stainless steel metallurgist in order to make the appropriate choice for a given application.

Corrosion depends on several factors related to the fasteners themselves, the design of the bolted joint, service environment, surface and material conditions, mechanical stresses, temperature and corrosion caused by contact between dissimilar metals (known as galvanic corrosion or contact corrosion), etc.

NOTE When combining different stainless steel grades, the corrosion resistance of the assembly depends on the lowest corrosion resistance grade.

When stainless steel fasteners are intended to be used in a high or low temperature environment:

— austenitic stainless steels are suitable for service environment typically down to –196 °C[4] and up to +300 °C;

— martensitic stainless steels are suitable for service environment typically down to −40 °C and up to +230 °C;

— ferritic stainless steels are suitable for service environment typically down to −20 °C and up to +250 °C;

— duplex stainless steels are suitable for service environment typically down to −40 °C and up to +280 °C.

4.2 Stainless steel group A (austenitic structure)

4.2.1 General

Several grades of austenitic stainless steels (A1 to A5 and A8) are included in the ISO 3506 series. They are generally classified as chromium-nickel austenitic grades (A1 to A3) and chromium-nickel-molybdenum austenitic grades (A4 to A8).

Austenitic stainless steels cannot be hardened by quenching; the mechanical properties of the fasteners are usually achieved by work hardening. Copper may be added in order to enhance the plasticity of the austenitic matrix (see chemical compositions specified in ISO 3506-1 and ISO 3506-2).

Stainless steel grades A2 and A4 with carbon content lower than 0,030 % may be identified by adding the letter L to the grade, i.e. A2L and A4L, respectively. Stainless steel grades A2 and A4 with carbon

4) –196 °C is a limit for testability corresponding to liquid nitrogen at a normal atmosphere pressure.

content above 0,030 % and/or exposed to high temperatures (either during the manufacturing process, welding process or in the service environment) can have a higher susceptibility to intergranular corrosion; see Clause 8. In these cases, the purchaser may choose stainless steel grades A2L or A4L, or stabilized stainless steels A3 or A5 including titanium or niobium. A8 is a highly alloyed austenitic stainless steel with corrosion resistance much higher than A1 to A5.

Austenitic steels in the annealed state are usually non-magnetic; however, cold working occurring during the fastener manufacture can create some residual magnetism; see Clause 10. Where low magnetic permeability is an important consideration, the advice of a stainless steel expert should be sought.

4.2.2 Grade A1

Stainless steels of grade A1 are specially designed for machining. Due to high sulfur content, this grade has lower resistance to corrosion than corresponding stainless steels with normal sulfur content. This grade is neither suitable for use in non-oxidizing acids and agents, nor in an environment with chloride (e.g. in swimming pools using chloride as a cleaning agent, or marine environments).

4.2.3 Grade A2

Stainless steels of grade A2 are the most frequently used stainless steel. This grade is not suitable for use in non-oxidizing acids and agents, or in an environment with chloride (e.g. in swimming pools using chloride as a cleaning agent, or marine environments).

4.2.4 Grade A3

Stainless steels of grade A3 have properties similar to grade A2, but with increased resistance to temperature (typically up to 350 °C). They are stabilized by addition of titanium or niobium that combines with carbon and nitrogen. This grade is neither suitable for use in non-oxidizing acids and agents, nor in an environment with chloride (e.g. in swimming pools using chloride as a cleaning agent, or marine environments).

4.2.5 Grade A4

Stainless steels of grade A4, often known as “acid proof steels”, are molybdenum alloyed which gives a considerably better resistance to corrosion. This grade may be used in some environments where chloride is present; however, it is still not suitable in swimming pools using chloride as a cleaning agent, or many marine environments.

4.2.6 Grade A5

Stainless steels of grade A5 are stabilized stainless steels with properties of grade A4, but with increased resistance to temperature (typically up to 350 °C). Stainless steels of grade A5 have properties similar to grade A4 and are resistant to many acids. They are stabilized by addition of titanium or niobium that combines with carbon and nitrogen. This grade may be used in some environments where chloride is present; however, it is still not suitable in swimming pools using chloride as a cleaning agent, or many marine environments.

4.2.7 Grade A8

Stainless steels of grade A8 are known as “6 % Mo” stainless steels. They have a high level of resistance to all forms of corrosion including pitting, crevice and stress corrosion cracking. They are suitable for use in swimming pools using chloride as a cleaning agent. However, there can be specific requirements and/or regulations for buildings and construction. Grade A8 is also suitable for applications in marine environments.

4.3 Stainless steel group C (martensitic structure)

4.3.1 General

Three grades of martensitic stainless steels (C1, C3 and C4) are included in the ISO 3506 series. They can be hardened by quenching and tempering. Mechanical properties increase when the carbon content rises, inducing the necessary rise of chromium content in order to achieve a suitable corrosion resistance.

Martensitic grades C1, C3 and C4 normally have a lower corrosion resistance than austenitic grades. However, other martensitic steels with improved corrosion resistance (see Table A.2) can also be used for special fasteners.

Caution should be taken when using martensitic stainless steels at sub-zero temperatures due to their poor impact strength and ductility.

Martensitic steel grades are always highly magnetic.

4.3.2 Grade C1

Stainless steels of grade C1 have limited resistance to corrosion.

4.3.3 Grade C3

Stainless steels of grade C3 have limited resistance to corrosion, though better resistance than C1.

4.3.4 Grade C4

Stainless steels of grade C4 are similar to grade C1 but with a lower resistance to corrosion due to their sulfur content. They are primarily intended for machining.

4.4 Stainless steel group F (ferritic structure) — Grade F1

One single ferritic stainless steel grade F1 is included in the ISO 3506 series. The steels within F1 can be hardened by work hardening (cold working); however, the cold working effect has a lower efficiency than for austenitic stainless steels. F1 steels are always magnetic.

When lower corrosion resistance than provided by grades A2 or A3 is suitable for the planned application, stainless steel grade F1 can be a good economical compromise. However, grade F1 should not be used at temperatures lower than –20 °C because ferritic stainless steels have poor impact strength and ductility.

4.5 Stainless steel group D (austenitic-ferritic structure)

4.5.1 General

Duplex stainless steel is a mixture of ferrite and austenite grains with a ferrite content typically 40 % to 60 % by volume.

In the solution annealed condition, the strength of duplex stainless steels is significantly higher than the strength of austenitic stainless steels and can be further increased by cold working, but ductility could then be lower.

Four grades of duplex stainless steels (D2, D4, D6 and D8) are included in the ISO 3506 series: the higher the digit in the grade, the better the corrosion resistance. Families of duplex stainless steel are usually described as follows:

— “lean-duplex” (D2 and D4) with lower alloying content (specifically nickel and molybdenum);

— “standard-duplex” (D6);

— “super-duplex” (D8) with higher alloying content.

Duplex stainless steels have much improved resistance to stress corrosion cracking when compared to austenitic stainless steels A1 to A5.

It is not recommended to use duplex stainless steels for application outside the temperature range of −40 °C to +280 °C.

4.5.2 Grades D2 and D4

D2 and D4 are “lean-duplex” characterized by their molybdenum content below 2 %, and even below 1 %.

With respect to pitting and crevice corrosion, D2 has at least an equivalent corrosion resistance compared to A2, and D4 has at least an equivalent corrosion resistance compared to A4.

4.5.3 Grades D6 and D8

D6 is a “standard-duplex” with molybdenum content above 2,5 %, which has improved corrosion resistance when compared to A1 to A5 and D4, particularly with respect to pitting and crevice corrosion.

D8 is a “super-duplex” and has a corrosion resistance comparable to A8.

4.6 Stainless steels and nickel alloys for elevated and high temperatures

Elevated temperatures refer to the temperature range of 300 °C to 550°C, and high temperatures refer to temperatures above 550 °C:

— for high temperature applications, fasteners require a sufficient resistance to oxidation and high temperature corrosion, as well as long-term creep resistance at the service temperature;

— for elevated temperature applications, time-dependent properties are generally not considered to be critical.

Stainless steels and nickel alloys for elevated and high temperature applications are dealt with in ISO 3506-5.

5 Chemical composition specifications for stainless steels and nickel alloys

Chemical composition for stainless steel fasteners is specified in ISO 3506-1 for bolts, screws and studs, ISO 3506-2 for nuts, ISO 3506-3 for set screws, ISO 3506-4 for tapping screws and ISO 3506-5 for special fasteners for high temperature applications. Tables 1 to 3 give the most widely used standardized materials, included in ISO 15510, EN 10269 and/or DIN 267-13.