SLOVENSKI STANDARD
SIST EN 12502-4:2005

01-marec-2005

Protikorozijska zaġļ ita kovinskih materialov - Navodilo za ocenjevanje verjetnosti nastanka korozije v porazdeljeni vodi in skladiġļ nih sistemih - 4. del: Vplivni dejavniki za nerjavna jekla

Protection of metallic materials against corrosion - Guidance on the assessment of corrosion likelihood in water distribution and storage systems - Part 4: Influencing factors for stainless steels

Korrosionsschutz metallischer Werkstoffe - Hinweise zur Abschätzung der Korrosionswahrscheinlichkeit in Wasserverteilungs- und speichersystemen - Teil 4: Einflussfaktoren für nichtrostende Stähle

Protection des matériaux métalliques contre la corrosion - Recommandations pour l'évaluation du risque de corrosion dans les installations de distribution et de stockage d'eau - Partie 4 : Facteurs a considérer pour les aciers inoxydables

Ta slovenski standard je istoveten z: EN 12502-4:2004

ICS:

23.040.99	Drugi sestavni deli za cevovode	Other pipeline components
77.060	Korozija kovin	Corrosion of metals
91.140.60	Sistemi za oskrbo z vodo	Water supply systems

SIST EN 12502-4:2005 **en**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 12502-4

December 2004

ICS 77.060; 23.040.99; 91.140.60

English version

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This European Standard was approved by CEN on 22 November 2004.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

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 Central Secretariat has the same status as the official versions.

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Ref. No. EN 12502-4:2004: E

Contents

Foreword

This document (EN 12502-4:2004) has been prepared by Technical Committee CEN/TC 262 “Metallic and other inorganic coatings”, 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 June 2005, and conflicting national standards shall be withdrawn at the latest by June 2005.

This standard is in five parts:

Part 1: *General*;

*Part 2: Influencing factors for copper and copper alloy*s;

Part 3: Influencing factors for hot dip galvanized ferrous materials;

Part 4: Influencing factors for stainless steels;

Part 5: Influencing factors for cast iron, unalloyed and low alloyed steels.

Together these five parts constitute a package of inter-related European Standards with a common date of withdrawal (dow) of 2005-06.

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

Introduction

This document mainly results from investigations into and experience gained of the corrosion of stainless steel materials used as tubes, fittings or vessels in drinking water distribution systems in buildings. However, it can be applied analogously to other supply water systems.

The corrosion resistance of products made of stainless steel immersed in waters exists because of the presence of a very thin passive layer. Stainless steels in water systems are, in general, resistant to corrosion, although there are certain conditions under which they can sustain corrosion damage.

As a result of the complex interactions between the various influencing factors, the extent of corrosion can only be expressed in terms of likelihood. This document is a guidance document and does not set explicit rules for the use of stainless steels in water systems. It can be used to minimize the likelihood of corrosion damages occurring by:

— assisting in designing, installing and operating systems from an anti-corrosion point of view;

— evaluating the need for additional corrosion protection methods for a new or existing system;

— assisting in failure analysis, when failures occur in order to prevent repeat failures occurring.

However, a corrosion expert, or at least a person with technical training and experience in the corrosion field, is required to give an accurate assessment of corrosion likelihood or failure analysis.

NOTE Stainless steels are used for domestic pipework, in the food industry and, more importantly, in the chemical industry covering a variety of aggressive environments and service conditions. This explains the existence of a significant number of steel grades each with specific corrosion resistance and also specific mechanical properties.

1 Scope

This document gives a review of influencing factors of the corrosion likelihood of stainless steels used as tubes, tanks and equipment in water distribution and storage systems as defined in EN 12502-1.

2 Normative references

The following referenced documents are indispensable for the application 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.

EN ISO 8044:1999, *Corrosion of metals and alloys — Basic terms and definitions (ISO 8044:1999)*.

EN 12502-1:2004, *Protection of metallic materials against corrosion — Guidance on the assessment of corrosion likelihood in water distribution and storage systems — Part 1: General*.

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 8044:1999 and EN 12502-1:2004 apply.

4 Materials

For the purpose of this document, the term “stainless steel” includes all martensitic, ferritic, austenitic-ferritic and austenitic steels conforming to the requirements of EN 10088-1 [2], EN 10088-2 [3] and EN 10088-3 [4].

Examples of steel grades that are used or that can be considered as candidate materials for supply water installations are listed in EN 10312 [5].

This document also applies to stainless casting alloys, which are commonly used for the production of valves and fittings and which are of the same composition type as the steels listed in EN 10088, Parts 1 to 3. The casting alloys can be considered as equivalent to their wrought counter parts, provided that no sensitization of the material remains after manufacturing (to be checked by testing the resistance against intergranular corrosion).

5 Types of corrosion

5.1 General

The most common types of corrosion are described in EN 12502-1:2004, Clause 4.

The rate of uniform corrosion of stainless steels in water distribution and storage systems is negligible because of their passive state.

Under the conditions prevailing in water systems stainless steels are usually the more noble materials and hence are not endangered by bimetallic corrosion.

The likelihood of intergranular corrosion is negligible in the systems under consideration.

Discoloration of the material’s surface resulting from deposition of foreign corrosion products is not indicative of corrosion of the stainless steel.

In some cases, however, the passive layer of these materials can be locally destroyed. This can result in localized corrosion attack, which can lead to failure because of corrosion damage.

The types of corrosion considered for stainless steels comprise the following:

— pitting corrosion;

— crevice corrosion;

— stress corrosion;

— knife-line corrosion;

— corrosion fatigue.

For each type of corrosion, the following influencing factors (described in EN 12502-1:2004, Table 1 and Clause 5) are considered:

— characteristics of the metallic material;

— characteristics of the water;

— design and construction;

— pressure testing and commissioning;

— operating conditions.

5.2 Pitting corrosion

5.2.1 General

Pitting corrosion occurs only when the potential is more noble than a critical value, which is referred to as pitting initiation potential. The pitting initiation potential depends on parameters related to both the material and the water composition. Pitting corrosion can occur only if the redox-potential of the water is more positive than the pitting initiation potential.

5.2.2 Influence of the characteristics of the metallic material

The likelihood of pitting corrosion in stainless steels decreases with increasing chromium, molybdenum and nitrogen contents. It is increased for sulfur-enriched stainless steels (e.g. free-cutting stainless steels used for valves and fittings).

Clean metal surfaces exhibit the smallest likelihood of pitting corrosion.

Mechanical damage to the surface of finished products, e.g. by scratching or coarse grinding, results in an increased susceptibility of stainless steels to pitting corrosion and stress corrosion cracking.

Metallic particles of unalloyed and low-alloy steels can become embedded in the stainless steel surface during machining or handling. They can act as small anodes of corrosion cells, the cathode of which is the stainless steel. In the course of the dissolution of the anodes, the local concentration of chloride ions will be increased by ion migration, and therefore the likelihood of pitting corrosion increases. Furthermore, the corrosion likelihood can also be increased by the iron (III)-bearing corrosion products formed during the dissolution of the anodes, because these corrosion products are more effective oxidizing agents than the dissolved oxygen and favour the conditions necessary for the occurrence of pitting corrosion.

Sensitization can also lead to an increase in the likelihood of pitting corrosion. Incorrect heat treatment or welding procedures, where the material remains for a prolonged period of time in the temperature range of

500 °C to 800 °C leads to precipitation of chromium-rich carbides at the grain boundaries and consequent depletion of chromium in the vicinity of the boundaries. This change in the material is referred to as sensitization.

Sensitization can be revealed by testing in accordance with EN ISO 3651-2 [6]. Materials in the as-fabricated condition should be resistant to this test. Sensitization during fabrication and welding, especially with wall thicknesses greater than 6 mm, can be avoided by following the recommendations from the material's manufacturer.

5.2.3 Influence of the characteristics of the water

The likelihood of pitting corrosion of stainless steels increases as the chloride ion concentration in the water increases, if the other service conditions remain constant.

The likelihood of pitting corrosion (within the limits of supply water) is either decreased or the pitting corrosion is not influenced by the presence of other anions.

The likelihood for pitting corrosion of non-molybdenum-bearing ferritic and austenitic stainless steels in cold water becomes high when the chloride ion concentration exceeds about 6 mmol/l. For hot water the limiting chloride ion concentration for these alloys is lower, possibly less than 1,5 mmol/l depending on other factors discussed in 5.1 to 5.6.

5.2.4 Influence of design and construction

The likelihood of pitting corrosion and crevice corrosion is increased by welding defects such as filler metal sagging, incomplete root pass, edge misalignment, open pores, weld metal splashing, slag residuals on both base and weld materials.

During the welding process, oxide films and scales can be formed that highly increase the likelihood of pitting corrosion. This can be avoided by gas-shielded welding methods, where attention is paid to proper supply and guidance of shielding and purging gas.

Oxide films that exhibit colours darker than that of straw strongly increase the likelihood of pitting corrosion. Removal of oxide films can be achieved by pickling (with pickling agents free from hydrochloric acid), fine grinding or shot peening, e.g. with glass beads. Under critical conditions (e.g. depending on material and water composition and temperature) even straw-coloured oxide films increase the likelihood of pitting corrosion.

A special problem arises during alignment of tubes by tack welding prior to final welding. This usually cannot be done with proper gas shielding, thus creating critical sites for pitting corrosion. This effect can only be avoided by pickling the system after welding.

The risk of sensitization can be minimized by avoiding any excessive heat input during welding and heating of material, e.g. in order to facilitate bending of pipes, unless it is followed by a full annealing of the material.

5.2.5 Influence of pressure testing and commissioning

If pressure testing is not carried out according to the recommendations given in EN 12502-1:2004, 5.5, so that residual water is left in the system after draining, the likelihood for pitting corrosion is increased. This is the result of evaporation of water leading to an increase in chloride concentration.

Because the initiation of pitting corrosion depends on the potential, the likelihood of corrosion of stainless steels increases as the redox potential of the water shifts to more noble values, e.g. as a result of the oxidizing disinfection of new pipe systems. If any installed equipment is to be treated with oxidizing disinfectants for a limited period of time, there will be no additional corrosion risk if the recommendations given in appropriate standards are followed.