



SLOVENSKI STANDARD

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Protection of metallic materials against corrosion - Guidance on the assessment of corrosion likelihood in closed water circulation systems

Korrosionsschutz metallischer Werkstoffe - Leitfaden für die Ermittlung der Korrosionswahrscheinlichkeit in geschlossenen Wasser-Zirkulationssystemen

Protection des matériaux métalliques contre la corrosion - Recommandations pour l'évaluation du risque de corrosion dans les systèmes fermés à recirculation d'eau

Ta slovenski standard je istoveten z: EN 14868:2005

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EUROPEAN STANDARD

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Protection of metallic materials against corrosion - Guidance on the assessment of corrosion likelihood in closed water circulation systems

Protection des matériaux métalliques contre la corrosion -
Recommandations pour l'évaluation du risque de corrosion
dans les systèmes fermés à recirculation d'eau

Korrosionsschutz metallischer Werkstoffe - Leitfaden für
die Ermittlung der Korrosionswahrscheinlichkeit in
geschlossenen Wasser-Zirkulationssystemen

This European Standard was approved by CEN on 8 July 2005.

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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Contents	page
Foreword	3
Introduction	4
1 Scope	5
2 Normative references	5
3 Terms and definitions	5
4 Symbols and abbreviations	6
5 Types of corrosion	6
6 Role of oxygen	7
7 Microbial corrosion	8
8 Corrosion damage in Case I conditions	8
9 Corrosion damages in Case II systems	11
10 Corrosion protection methods	15
Annex A (informative) Important corrosion reactions in the systems under consideration	19
Bibliography	22

SIST EN 14868:2005

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Foreword

This European Standard (EN 14868:2005) 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 February 2006, and conflicting national standards shall be withdrawn at the latest by February 2006.

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.

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Introduction

This European Standard results mainly from investigations into and experience gained on the corrosion of metallic materials normally present in water circulation systems in buildings (unalloyed and low alloyed steels, cast iron, aluminium, copper and copper alloys, stainless steels).

Because of the complex interactions between the various influencing factors, which can alter during service life due either to normal operation changes in service conditions or accidental events, the extent of corrosion can only be expressed in terms of likelihood. This European Standard therefore is a guidance document and does not set explicit rules for the use of metallic materials in water systems.

A correct evaluation of the corrosion likelihood therefore needs a corrosion expert (or at least a person with technical training in the corrosion field) and knowledge of the technology and operating conditions of the system considered.

Though incidences of severe damage because of corrosion (and/or scaling) are generally rare, certain basic precautions should be taken in order to maintain a long-term, trouble-free service. This European Standard should therefore be considered as a guidance document. On the basis of the information provided herein, decisions can be made during design, installation and service life to minimize the likelihood of corrosion damage occurring.

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1 Scope

This European Standard gives a review of influencing factors on the corrosion likelihood of metallic components (pipes, tanks, vessels, heat exchangers, pumps etc.) in water circulation systems in buildings.

The water circulation systems considered are:

- heating systems (up to 110 °C service water temperature);
- cooling and chilling systems;

which are filled with potable water or water of similar composition according to the Directive 98/83/EC.

NOTE 1 Sanitary hot water systems with a re-circulation loop are not considered in this European Standard as they are not really closed system, because the water is continually renewed. The corrosion likelihood of these systems is discussed in EN 12502 Parts 1 to 5 [1], [2], [3], [4], [5].

NOTE 2 Cooling systems with open atmospheric towers are not considered in this European Standard because fresh water is generally added to the system periodically to compensate for losses by evaporation or blow-down.

NOTE 3 Heating systems in buildings, connected to district heating systems without an intervening heat exchanger, are not considered in this European Standard. However, local heating systems, where several buildings are heated by one boiler plant, are included.

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2 Normative references

The following referenced documents are indispensable for the application of this European Standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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*

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

3 Terms and definitions

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

3.1

ferrous materials

cast iron, unalloyed and low alloyed steel (excluding stainless steel)

3.2

sludge formation

build-up of non-adherent particulate corrosion products which can be suspended and/or deposited in the system

3.3

scaling

formation of relatively thick layers of calcium carbonate and/or corrosion products, especially on heat transfer surfaces

EN 14868:2005 (E)**4 Symbols and abbreviations**

- $c(\text{Cl}^-)$ Concentration of chloride ions in mmol l^{-1}
 $c(\text{HCO}_3^-)$ Concentration of hydrogen carbonate ions in mmol l^{-1}
 $c(\text{SO}_4^{2-})$ Concentration of sulphate ions in mmol l^{-1}
 $c(\text{NO}_3^-)$ Concentration of nitrate ions in mmol l^{-1}

5 Types of corrosion

When evaluating the corrosion likelihood in water circulation systems almost all types of corrosion should be taken into consideration.

The following types of corrosion can occur in the systems under consideration:

- uniform corrosion;
- localised corrosion:
 - pitting corrosion;
 - bimetallic corrosion;
 - crevice corrosion;
 - deposit corrosion;
 - water-line corrosion;
 - selective corrosion (de-alloying);
 - erosion corrosion;
 - cavitation corrosion;
 - stress corrosion cracking;
 - microbial corrosion.

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These types of corrosion can lead to different kinds of corrosion damage:

- leakage;
- constriction of flow;
- reduction of efficiency;
- boiler noise;
- seizure of movable components and other detrimental effects.

6 Role of oxygen

6.1 General

In the systems under consideration, the corrosion processes are mainly determined by the extent of oxygen ingress into the system. Generally, oxygen reduction is the driving force for anodic metal dissolution reactions. If the ingress of oxygen can be prevented, the rate of corrosion will be minimised to the extent that corrosion damages will normally not occur.

Oxygen can enter the system in different ways:

- as dissolved oxygen in the filling and any make-up water;
- from the atmosphere into the water within an open expansion vessel or some so-called de-aeration units and with some kinds of pressurisation systems (e.g. compressor or pump pressurisation systems);
- from the atmosphere in the case of negative pressure (e.g. through gaskets, O-rings on valves or some automatic air vents);
- from the atmosphere by diffusion through organic materials (e.g. plastic pipes without barrier, rubber hoses or rubber membranes of air-filled expansion vessels and some so-called de-aeration systems);
- as dissolved oxygen in drinking water in the case of defective secondary heat exchangers for domestic hot water, where the pressure in the domestic hot water is greater than in the primary heating water;
- from air pockets remaining in the system after refilling during maintenance or modification.

Corrosion becomes negligible after consumption of the oxygen initially present in the filling water provided that the water is not renewed and no air entry is possible. The main concern with a closed system is therefore to maintain water and air tightness. However, in some systems, especially large complex ones, maintaining complete air tightness can be impractical.

6.2 Influence of design and operating conditions on oxygen ingress

With respect to oxygen ingress, two cases should be considered:

- **Case I:** systems with no significant oxygen ingress;
- **Case II:** systems with continuous or intermittent oxygen ingress.

Case I is defined by the fact that practically no oxygen ingress is possible during service. Oxygen dissolved in the initial fill water is quickly used up in forming corrosion products, which in most cases does not lead to impairment of the system.

Case II is characterised by the fact that oxygen ingress is possible during service either occasionally, regularly or continuously.

Systems designed to represent Case I can become Case II during service depending on operating conditions.

Examples of Case I are as follows:

- a. Systems with a closed expansion vessel, which are correctly designed, installed and maintained.
- b. Open vented heating systems under conditions where only negligible amounts of oxygen are introduced into the circulating water.

EN 14868:2005 (E)

Examples of Case II are as follows:

- c. Open vented systems where during service the re-circulating water is regularly enriched with oxygen.
- d. Systems with closed expansion vessels in situations where:
 - volume of the expansion vessel is too small;
 - gas pressure within the dry expansion vessel is not correctly adjusted to match the water pressure;
 - gas pressure decreases during service;
 - water volume decreases because of water loss (e.g. from valves and pumps).

Such circumstances can result in negative pressure in the system during cooling phases (e.g. overnight), leading to oxygen ingress through O-rings or gaskets and automatic air vents.

- e. Systems with continuous oxygen ingress by diffusion through the walls of organic materials, e.g. plastic pipes, rubber hoses.

NOTE Refilling of a system does not normally lead to significant oxygen ingress. However, if the circulation water is regularly renewed because of losses in the system and excessive amounts of fresh water are added (more than 2 times initial fill volume) oxygen ingress will almost certainly lead to significant impairment of the system.

7 Microbial corrosion

Micro-organisms (algae, yeasts, fungi, bacteria etc.) can exist in debris left in the system after construction or can enter the system with the initial filling water or via open header tank during operation. In Case II systems, this can lead to bio-fouling problems and can also give rise to microbial corrosion irrespective of metallic materials used in the system.

Although corrosion is favoured at moderate temperatures, not even the high temperatures in heat exchangers are always sufficient to kill all micro-organisms and some bacteria are thermophiles. Favourable conditions (nutrients, inorganic ions and organic contaminants, possibly also from some water treatment additives) favour growth of microbiological organisms. Bacterial growth is also favoured by stagnant conditions, especially under deposits, in dead legs or crevices formed during manufacturing operations. Their metabolism produces organic acids, which promote initiation and acceleration of localised corrosion cells. The most well known case is anaerobic bacteria, especially sulphate reducing bacteria, developing under deposits.

In addition, in Case II systems, aerobic bacteria in the bulk water can oxidize ferrous (Fe^{2+}) to ferric (Fe^{3+}) ions leading to an enhanced uniform corrosion.

8 Corrosion damage in Case I conditions**8.1 Ferrous materials****8.1.1 Leakage**

Leakage caused by corrosion generally does not occur under Case I conditions.

8.1.2 Constriction of flow

In the normal course of events, corrosion of iron does not lead to sludge formation to the extent that it constricts flow. However, in special cases, where the ratio of water volume to surface area of iron is very high (i.e. with large buffering vessels or large surfaces of non-oxygen consuming materials such as plastic or

stainless steel) the oxygen content of filling water can give rise to the build-up of non-adherent sludge composed of corrosion products (see 9.1.2).

8.1.3 Reduction of efficiency

In systems containing waters of relatively low pH (< about 8) increased concentration of iron(II) ions can lead to enhanced formation of magnetite (Fe_3O_4) according to equation (A.5), Annex A.1, on the hot walls of heat transfer surfaces. This scale, which can be associated with lime scale, reduces boiler efficiency irrespective of the boiler material. However, in the majority of systems the pH of the re-circulating water rises quickly above 8,0 and this corrosion damage does not occur.

The deposition of iron corrosion products on the inside surfaces of plastic pipes, formed according to (A.4), Annex A.1, can also lead to the reduction of heat transfer efficiency by decreasing water flow.

8.1.4 Boiler noise

On directly heated heat transfer surfaces, unevenly distributed scale (e.g. iron oxides and calcium carbonate) can lead to boiler noise because of nucleate boiling, particularly in the case of small, high efficiency heat exchangers.

8.2 Copper and copper alloys

8.2.1 Leakage

Generally no leakage caused by pitting corrosion happens with copper and copper alloys.

Leakage caused by stress corrosion cracking of brass can occur when a critical level of tensile stress together with a sufficient concentration of nitrite and/or ammonia is present. Critical tensile stresses can be induced during construction, for example by over-tightening threads or use of male tapered threads with female parallel threads. Nitrites and/or ammonia are normally not present in potable water in concentrations sufficient to induce stress corrosion. However, nitrates in water are reduced in oxygen-free conditions in re-circulating systems and in critical areas, for example in crevices or under deposits.

8.2.2 Constriction of flow

There is generally no constriction of flow caused by corrosion of copper and copper alloys under Case I conditions.

8.2.3 Reduction of efficiency

There is generally no reduction of efficiency caused by corrosion of copper and copper alloys under Case I conditions.

Nevertheless, corrosion of other materials in the system can lead to a reduction of efficiency, see 8.1.3 and 8.3.3.

8.2.4 Boiler noise

There is generally no boiler noise caused by corrosion of copper and copper alloys under Case I conditions.

Nevertheless, corrosion of other materials in the system can lead to boiler noise, see 8.1.4 and 8.3.4.