BS 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

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ICS 77.060; 23.040.99; 91.140.60

British Standards

National foreword

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Contents

Foreword

This document (EN 12502-1:2004) 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of an identical text or by endorsement, at the latest by June 2005, and conflicting national standards shall be withdrawn at the latest by June 2005.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 alloys;

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

The water distribution and storage systems under consideration consist of a variety of metals and alloys in pipework and in other components, i.e. pumps, valves and heat exchangers. Corrosion on the water-side of these systems generally leads to a build-up of surface corrosion product layers, which, depending on the circumstances, can or cannot be protective. In some cases, corrosion leads to the impairment of the function of the system, i.e. corrosion damage.

This impairment can manifest itself in:

— perforation (leakage);

— blockage of system components;

— detrimental changes of water composition.

The type and rate of corrosion for any particular alloy system can depend on:

— characteristics of the metallic material;

— characteristics of the water;

— design and construction;

— pressure testing and commissioning;

— operating conditions.

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 therefore is a guidance document and does not set explicit rules for the use of metallic materials 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 a correct assessment of corrosion likelihood or failure analysis.

1 Scope

This document gives guidance for the assessment of the corrosion likelihood of metallic materials in water distribution and storage systems, as a result of corrosion on the water-side.

NOTE This document lists the different types of corrosion and describes in general terms the factors influencing corrosion likelihood.

Water distribution and storage systems considered in this document are used for waters intended for human consumption according to EC directive 98/83/EEC and for waters of similar chemical composition.

This document does not cover systems that convey the following types of water.

- sea water;
- brackish water;
- geothermal water;
- sewage water;
- swimming pool water;
- open cooling tower water;
- recirculating heating and cooling water;
- demineralized water.

Parts 2 to 5 of this document cover the factors influencing the corrosion likelihood for copper and copper alloys, hot-dip galvanized ferrous materials, stainless steels and cast iron, unalloyed and low alloyed steels in detail.

This document does not cover lead.

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)*.

3 Terms and definitions

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions and those given in EN ISO 8044 apply.

3.1.1
water system
system, including every metallic and non-metallic component (e.g. pipes, valves, fittings), constituting the water distribution and storage system, which can be in contact with the water

3.1.2
uniform corrosion attack
corrosion effect caused by uniform corrosion

3.1.3
pitting attack
corrosion effect caused by pitting corrosion

4 Types of corrosion

When assessing the corrosion likelihood for a given system, all types of corrosion are to be taken into consideration.

The following types of corrosion can occur in water distribution and storage systems, depending on the corrosion system:

- uniform corrosion;
- localized corrosion:
  - pitting corrosion;
  - crevice corrosion;
  - selective corrosion;
  - knife-line corrosion;
  - bimetallic corrosion;
  - erosion corrosion;
  - stress corrosion;
  - corrosion fatigue.

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

- wall perforation;
- blockage of system components;
- detrimental changes of water composition.

5 Factors influencing corrosion likelihood

5.1 General

Table 1 lists the factors that can influence the corrosion likelihood of a particular metallic material in a water distribution and storage system, not in order of importance.

In order to minimize corrosion damage, special care should be taken during design, construction, pressure testing, commissioning and operation of a water distribution and storage system.

The behaviour of some metallic materials depends on the initial stage of formation of protective layers. When protective layers are formed under suitable conditions, subsequent adverse variations of the quality of water and/or service conditions have, in general, a reduced influence.

Table 1 — Factors influencing the corrosion likelihood

Characteristics of the metallic material	Characteristics of the water	Design and construction	Pressure testing and commissioning	Operating conditions
— Chemical composition/ Microstructure — Surface condition	— Physico-chemical composition (see Table 2) — Solid particles	— Geometry — Multi-metal systems — Joints — Tensile stress	— Flushing — Draining — Disinfection/ Rinsing	— Temperature/ Temperature variations — Flow conditions — Disinfection

5.2 Characteristics of the metallic material

5.2.1 Chemical composition/Microstructure

The effect of chemical composition and microstructure on the corrosion likelihood for various metals is more or less dependent on the type of alloy. For some metals, a small change in the alloy composition has no significant effect, whereas for others a small change markedly alters the corrosion likelihood.

NOTE Detailed information is given in Parts 2 to 5 of this document.

5.2.2 Surface conditions

Surface conditions (e.g. roughness, cleanliness, contamination with deposits) can influence the corrosion likelihood, especially with respect to the initial formation of corrosion cells.

5.3 Characteristics of the water

Table 2 lists some of the principal physical and chemical parameters of water that can influence corrosion in a water distribution and storage system.

Table 2 — Physical and chemical characteristics of the water

Characteristics	Unit
Temperature	°C
pH	
Conductivity at 20 ºC	µS/cm
Total hardness (concentration of soluble Ca + Mg components)	mmol/l
Calcium hardness (concentration of soluble Ca components)	mmol/l
Alkalinity (by titration down to pH 4,2)	mmol/l
Acidity (by titration up to pH 8,2)	mmol/l
Dissolved oxygen	mmol/l
Chloride ions	mmol/l
Nitrate ions	mmol/l
Sulphate ions	mmol/l
Phosphorous compounds	mmol/l
Silicon compounds	mmol/l
Total organic carbon	mg/l

The concentration of dissolved oxygen in the water is considered in these once-through systems to be at, or close to, saturation level. Therefore, anodic metal dissolution reactions can always be driven by the cathodic reduction of oxygen.

Although drinking water conforming to EC Directive 98/83/EEC has strict limits placed on the maximum concentrations of dissolved species and pH range, the chemical composition of the water within this range can still significantly influence corrosion likelihood.

The concentration and, more significantly the ratio of the concentration of different anions in the water are of vital importance for the corrosivity of water.

Certain inorganic and organic species naturally occurring in water, e.g. phosphates and silicates, can inhibit corrosion reactions by assisting in the formation of protective layers. Assessment of corrosion likelihood will be more difficult if the composition of the water varies with time. Therefore, not only the composition, but also the range of variation should be known. If different waters are present, the most unfavourable scenario should be assumed.

5.4 Design and construction

5.4.1 Geometry

The geometry of a water system determines to a large degree the flow characteristics of the water it conveys.

The presence of crevices in a system can create a special risk for the occurrence of crevice corrosion.

The presence of dead legs creates stagnant conditions giving rise to the possibility of pitting corrosion beneath deposits that can be increased by microbial activity.

The risk of locally high fluid velocities is increased at sharp bends, T-pieces, sharp reductions or enlargements of cross-sections. This can give rise to erosion corrosion.

5.4.2 Multi-metal systems

Direct electrical contact between dissimilar metals gives rise to the possibility of bimetallic corrosion, in which the corrosion rate of the less noble metal is increased.

In general, the corrosion likelihood for bimetallic corrosion decreases with:

- decreasing difference in the corrosion potential of the metals;
- increasing anodic and/or cathodic polarization resistance;
- decreasing conductivity of the water;
- increasing contact resistance between the different metals;
- increasing ratio of area of anode to cathode;
- formation of protective layers on the cathode.

The corrosion likelihood is generally high where a small anode area is in electrical contact with a large cathode area.

Bimetallic corrosion can occur even without direct joining of two dissimilar metals, when dissolved ions from the more noble metal electro-deposit on the less noble metal resulting in an increased localized cathodic activity.

5.4.3 Joints

The type of jointing can have a great influence on corrosion likelihood, especially in view of the formation of crevices, combination of different metals and changes of the microstructure and surfaces because of the influence of on-site welding and brazing, in the heat-affected zone.

5.4.4 Tensile stresses

Tensile stresses deriving from manufacture and/or installation can lead to stress corrosion cracking. For water distribution and storage systems under consideration in this document, this effect is sometimes observed with brass and certain stainless steels.

In addition, stresses can be generated by the movements produced in pipework by variations in the water temperature in parts of the system, particularly where the structure is rigidly fixed into the building. Such effects can lead to corrosion fatigue.

5.5 Pressure testing and commissioning

When pressure testing is done using water, the systems are sometimes drained leaving partially filled areas with 3-phase boundaries between metal, water and air. This can cause serious corrosion close to the waterline. Even systems that are considered to be fully drained could have small pools of water in horizontal pipework and on upward-facing surfaces.

Therefore, the systems should remain completely filled with water after pressure testing or pressure testing with dry air should be performed according to the relevant regulations.

Commissioning of a water distribution and storage system involves cleaning by thorough flushing. The object of cleaning is to remove extraneous matter such as sand and dirt, which can find its way into pipework on installation, as well as excess flux from soldering and brazing operations.

Dirt particles and deposits can give rise to localized corrosion cells in stagnant conditions.

5.6 Operating conditions

5.6.1 Temperature

The water temperature has different influences on different metals and on corrosion types. Furthermore, the temperature has different influences depending on water composition.

The temperature determines the possible type of pitting for copper and hot dip galvanized ferrous materials. One type only occurs in cold water, another type only in heated water.

If a water system is subjected to large temperature variations, it is also possible that corrosion products could spall off because of differential coefficients of expansion. This could lead to blockages in components downstream.

5.6.2 Flow conditions

The corrosion likelihood is influenced mainly by the flow regime and the velocity (or, more precisely, by the Reynold's Number) of water flow. Between the two boundary cases of water flow conditions (full flow and water stagnation), a wide range of water flow conditions is possible in the same system.

Long stagnant periods facilitate the stabilization of local corrosion cells and the onset of pitting attack. In addition, very low flow rates can allow deposits to settle out in the system or existing deposits cannot be dislodged by such low rates, thereby creating the likelihood of pitting corrosion under deposits.

Locally high fluid velocities, depending on geometry, can cause erosion corrosion by removing protective surface films.

6 Assessment of corrosion likelihood

In order to assess the corrosion likelihood of a specific metallic material in a water distribution and storage system, all the influencing factors, listed in Table 1, and their possible interactions should be taken into consideration. This assessment should be carried out separately for all types of corrosion relevant to the specific corrosion system. Because of the complexity of the influencing factors and of their interaction in most cases only a qualitative assessment is possible.

Bibliography

[1] EUROPEAN COMMUNITIES. Directive 98/83/EEC of the European Community and the Council of 3 November 1998 on the quality of water intended for human consumption. (O.J. EC L 330, 05.12.1998, p. 32-54).

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