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Korozija kovin in zlitin - Smernice za ovrednotenje jamičaste korozije

Corrosion of metals and alloys -- Guidelines for the evaluation of pitting corrosion

Corrosion des métaux et alliages -- Lignes directrices pour l’évaluation de la corrosion par piqûres

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Corrosion of metals and alloys — Guidelines for the evaluation of pitting corrosion

Corrosion des métaux et alliages — Lignes directrices pour l'évaluation de la corrosion par piqûres

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Foreword

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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).

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This document was prepared by Technical Committee ISO/TC 156, *Corrosion of metals and alloys*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 262, *Metallic and other inorganic coatings, including for corrosion protection and corrosion testing of metals and alloys*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 11463:1995), which has been technically revised. The main changes compared with the previous edition are as follows:

— modern surface analysis and characterization techniques for ex situ examination have been included.

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

It is important to be able to determine the extent of pitting and its characteristics, either in a service application, where it is necessary to estimate the remaining life in a metal structure, or in laboratory test programmes that are used to select pitting-resistant materials for a particular service. Corrosion pits can also act as the precursor to other damage modes such as stress corrosion cracking and corrosion fatigue.

The application of the materials to be tested will determine the minimum pit size to be evaluated and whether total area covered, average pit depth, maximum pit depth or another criterion is the most important to measure.

Corrosion of metals and alloys — Guidelines for the evaluation of pitting corrosion

1 Scope

This document gives guidelines for the selection of procedures that can be used in the identification and examination of corrosion pits and in the evaluation of pitting corrosion and pit growth rate.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

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/

4 Identification and examination of pits

4.1 Preliminary low magnification visual inspection

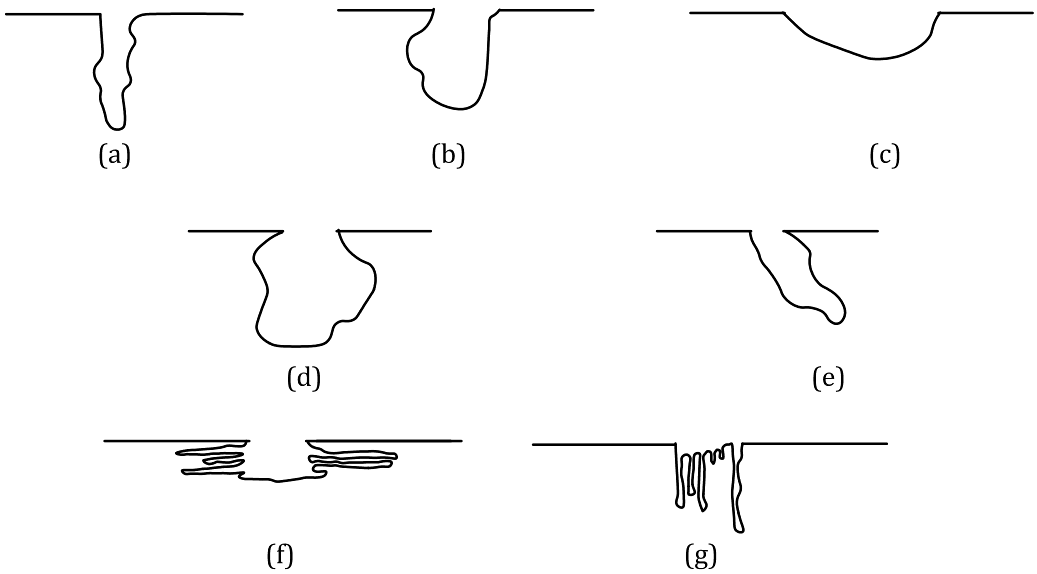
4.1.1 A visual examination of the corroded metal surface with or without the use of a low-power magnifying glass may be used to determine the extent of corrosion and the apparent location of pits. It is often advisable to photograph the corroded surface so that it can be compared with the clean surface after the removal of corrosion products or with a fresh unused piece of material.

4.1.2 If the metal specimen has been exposed to an unknown environment, the composition of the corrosion products may be of value in determining the cause of corrosion. Recommended procedures for the removal of particulate corrosion products should be followed and the material removed should be preserved for future identification.

4.1.3 To expose the pits fully, it is recommended that cleaning procedures should be used to remove the corrosion products. Rinsing with water followed by light mechanical cleaning can be sufficient for lightly adhered corrosion products. Chemical cleaning is required for more adherent products. ISO 8407[1] provides a range of chemical cleaning processes. Preliminary testing should be undertaken to ensure that attack of the base metal is avoided.

4.2 Optical microscopic examination of pit size and shape

4.2.1 Examine the cleaned metal surface to determine the approximate size and distribution of pits. Follow this procedure by a more detailed examination through a microscope using a low magnification (approximately × 20). Pits can have various sizes and shapes. A visual examination of the metal surface can show a round, elongated or irregular opening, but it seldom provides an accurate indication of the extent of corrosion beneath the surface. Thus, it is often necessary to cross-section the pit to determine its actual shape. Several common variations in the cross-sectioned shape of pits are shown in Figure 1.



Key

(a) narrow, deep

(b) elliptical

(c) wide, shallow

(d) sub-surface

(e) undercutting

(f) microstructural orientation (horizontal)

(g) microstructural orientation (vertical)

Figure 1 — Variations in the cross-sectional shape of pits

4.2.2 It is difficult to determine pit density by counting pits through a microscope eyepiece, but the task can be made easier by the use of a plastic grid. Place the grid, containing 3 mm to 6 mm squares, on the metal surface. Count and record the number of pits in each square and move across the grid in a systematic manner until all the surface has been covered. This approach minimizes eyestrain because the eyes can be taken from the field of view without fear of losing the area of interest. Enlarged photographs of the area of interest may also be used to reduce eyestrain. An alternative approach is to mount the specimen on an x-y stage and measure both the number and spatial distribution of pits. When coupled with optical depth measurement, where applicable, the number, depth and spatial distribution of pits can be determined.

4.2.3 Advanced optical microscopy techniques, such as infinite focus microscopy and confocal laser microscopy may be used to obtain three-dimensional images of the pit surface, within the constraints of optical observations [most relevant to Figure 1 a) to c) but not applicable to undercut]. Such measurements can be used to view the surface features and quantify surface roughness, pit depth, surface profile, etc.

4.2.4 To carry out a metallographic examination, select and cut out a representative portion of the metal surface containing the pits and prepare a metallographic specimen. If corrosion products are to be examined in cross-section, it may be necessary to fix the surface in a mounting compound before cutting. Examine microscopically to determine whether there is a relation between pits and inclusions or microstructure, or whether the cavities are true pits or might have resulted from metal loss caused by intergranular corrosion, dealloying, etc.

4.3 In situ non-destructive inspection

4.3.1 General

Several techniques have been developed to assist in the detection of cracks or cavities in a metal surface without destroying the material (see Reference [2]). These methods are less effective for locating and defining the shape of pits than some of those described previously, but they merit consideration because they are often used in situ, and thus they are more applicable to field applications.

4.3.2 Radiographic

Radiation, such as X-rays, passes through the object. The intensity of the emergent rays decreases with increasing thickness of the material. Imperfections can be detected if they cause a change in the absorption of X-rays. Detectors or films are used to provide an image of interior imperfections. The metal thickness that can be inspected is dependent on the available energy output. Pits must be as large as 0,5 % of the metal thickness to be detected and care should be taken to ensure that pits are not confused with pre-existing pores.

4.3.3 Electromagnetic

4.3.3.1 Eddy currents may be used to detect defects or irregularities in the structure of electrically conductive materials. When a specimen is exposed to a varying magnetic field, produced by connecting an alternating current to a coil, eddy currents are induced in the specimen and they in turn produce a magnetic field of their own. Materials with defects will produce a magnetic field that is different from that of a reference material without defects, and an appropriate detection instrument is required to determine these differences.

4.3.3.2 The induction of a magnetic field in ferromagnetic materials is another approach that is used. Discontinuities that are transverse to the direction of the magnetic field cause a leakage field to form above the surface of the part. Ferromagnetic particles are placed on the surface to detect the leakage field and to outline the size and shape of the discontinuities. Rather small imperfections can be detected by this method. However, the method is limited by the required directionality of defects to the magnetic field, by the possible need for demagnetization of the material, and by the limited shapes of parts that can be examined.

4.3.4 Ultrasonics

In the use of ultrasonics, pulses of sound energy are transmitted through a couplant, such as oil or water, on to the metal surface where waves are generated. The reflected echoes are converted to electrical signals that can be interpreted to show the location of flaws or pits. Both contact and immersion methods are used and various techniques can be applied. The test should be carried out from the non-pitted face. The test is affected by the morphology of the pits, the ultrasonic technique selected and the performance of the probe and flaw detector. Information about the size and location of flaws can be established. However, the capability of the technique for the pitting expected should be assessed and reference standards produced for comparison. Operators should be trained in the application of the technique and the interpretation of the results.

4.3.5 Penetrants

Defects opening to the surface can be detected by the application of a penetrating liquid that subsequently exudes from the surface after the excess penetrant has been removed. Defects are located by spraying the surface with a developer that reacts with a dye in the penetrant, or the penetrant may contain a fluorescent material that is viewed under ultraviolet light. The size of the defect is shown by the intensity of the colour and the rate of bleed-out. This technique provides only an approximation of the depth and size of pits.

