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# SLOVENSKI STANDARD
# SIST ISO 11463:1999

**01-oktober-1999**

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**Korozija kovin in zlitin ï  Vrednotenje jamiļ aste korozije**

Corrosion of metals and alloys -- Evaluation of pitting corrosion

Corrosion des métaux et alliages -- Évaluation de la corrosion par piqûres



**Ta slovenski standard je istoveten z: ISO 11463:1995**



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**ICS:**

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| 77.060 | Korozija kovin | Corrosion of metals |

**SIST ISO 11463:1999** **en**

# INTERNATIONAL STANDARD

# ISO 11463

First edition
1995-12-15

# Corrosion of metals and alloys — Evaluation of pitting corrosion



*Corrosion des métaux et alliages — Évaluation de la corrosion par piqûres*



Reference number
ISO 11463:1995(E)

## 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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 11463 was prepared by Technical Committee ISO/TC 156, *Corrosion of metals and alloys*.



Annexes A and B of this International Standard are for information only.





International Organization for Standardization
Case Postale 56 • CH-1211 Genève 20 • Switzerland

Printed in Switzerland

## Introduction

It is important to be able to determine the extent of pitting, 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 (see [1] in annex B).

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.

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# Corrosion of metals and alloys — Evaluation of pitting corrosion

## 1 Scope

This International Standard gives guidance on the selection of procedures that can be used in the identification and examination of pits and in the evaluation of pitting corrosion.

## 2 Normative reference



The following standard contains provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.



ISO 8407:1991, *Corrosion of metals and alloys - Removal of corrosion products from corrosion test specimens.*

## 3 Identification and examination of pits

### 3.1 Visual inspection

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.

**3.1.1** 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 in the removal of particulate corrosion products should be followed and reserved for future identification.

**3.1.2** To expose the pits fully, it is recommended that cleaning procedures should be used to remove the corrosion products and avoid solutions that attack the base metal excessively (see ISO 8407). It may be advisable during cleaning to probe the pits with a pointed tool to determine the extent of undercutting or subsurface corrosion (see figure 1). However, scrubbing with a stiff-bristle brush will often enlarge the pit openings sufficiently by removal of corrosion products or undercut metal to make the pits easier to evaluate.

**3.1.3** 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 low magnification (approximately × 20).

**3.1.4** Determine the size, shape and density of pits.

**3.1.4.1** Pits may have various sizes and shapes. A visual examination of the metal surface may show a round, elongated or irregular opening, but it seldom provides an accurate indication of corrosion beneath the surface. Thus it is often necessary to cross-section the pit to see its actual shape and to determine its true depth. Several variations in the cross-sectioned shape of pits are shown in figure 1.

**3.1.4.2** It is difficult to determine pit density by counting pits through a microscope eyepiece, but the task may 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 eye-strain 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 eye-strain.

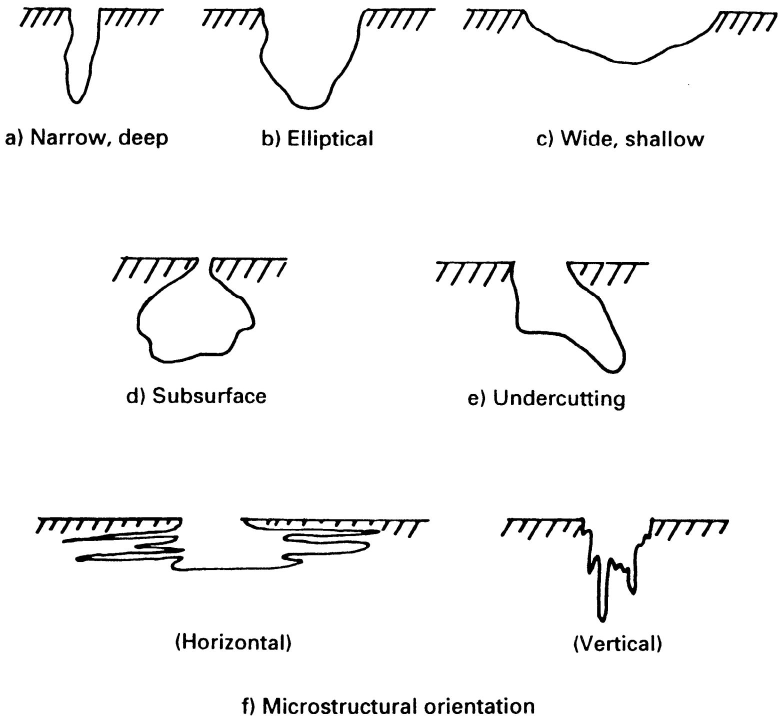


**Figure 1 — Variations in the cross-sectional shape of pits**



**3.1.5** 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 in accordance with recommended procedures. 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.

## 3.2 Non-destructive inspection

A number of techniques has been developed to assist in the detection of cracks or cavities in a metal surface without destroying the material. See [1] in annex B. These methods are less effective for locating and defining the shape of pits than some of those previously described, but they merit consideration because they are often used *in situ*, and thus are more applicable to field applications.

### 3.2.1 Radiographic

Radiation, such as X-rays, passes through the object. The intensity of the emergent rays varies with the thickness of the material. Imperfections may 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. Pores or pits must be as large as 0,5 % of the metal thickness to be detected. This technique has only slight application to pitting detection, but it might be useful for comparing specimens before and after corrosion to determine whether pitting has occurred and whether it is associated with previous porosity. It may also be useful to determine the extent of subsurface and undercutting pitting (see figure 1).

### 3.2.2 Electromagnetic

**3.2.2.1** 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.

**3.2.2.2** 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 shape of parts that can be examined.

### 3.2.3 Sonics

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. The test shall be carried out from the non-pitted face. The test has good sensitivity, although it is unlikely to detect pits of less than 1 mm diameter or within 1 mm of a non-pitted face, and provides instantaneous information about the size and location of flaws. However, reference standards are required for comparison and training is needed to interpret the results properly.

### 3.2.4 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 ultra-violet 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.

### 3.2.5 Replication

Images of a pitted surface can be created by applying a material to the surface which conforms to the shape of the pits and can be removed without damaging its shape. This method will not work however, for pits of subsurface or undercut type. The removed material contains a replica of the original surface which, in some cases, is easier to analyze than the original. Replication is particularly useful for analysis of very small pits.

## 4 Extent of pitting

### 4.1 Mass loss

Metal mass loss is not ordinarily recommended for use as a measure of the extent of pitting unless general corrosion is slight and pitting is fairly severe. If uniform corrosion is significant, the contribution of pitting to total metal loss is small, and pitting damage cannot be determined accurately from mass loss. In any case, mass loss can only provide information about total metal loss due to pitting but nothing about density of pits and depth of penetration. However, mass loss should not be neglected in every case because it may be of value; for example, mass loss along with a visual comparison of pitted surfaces may be adequate to evaluate the pitting resistance of alloys in laboratory tests. Mass loss may also be useful to detect the existence of subsurface metal loss.

### 4.2 Pit depth measurement

#### 4.2.1 Metallography

Pit depth may be determined by sectioning vertically through a preselected pit, mounting the cross-sectioned pit metallographically and polishing the surface. A better or alternative way is to section slightly away from the pit and slowly grind until the pit is in the cross-section. Sectioning through a pit can be difficult and one may miss the deepest portion. The depth of the pit is measured on the flat, polished surface by the use of a microscope with a calibrated eyepiece. The method is very accurate, but it requires good operator skill and good judment in the selection of the pit and good technique in cutting through the pit. Its limitations are that it is time-consuming, the deepest pit may not have been selected and the pit may not have been sectioned at the deepest point of penetration. The method, however, is the only suitable for the evaluation of the pit shape as in figure 1.

#### 4.2.2 Machining

See [2] and [3] in annex B.

**4.2.2.1** This method requires a sample that is fairly regular in shape, and it usually involves the destruction of the specimen. Measure the thickness of the specimen between two areas that have not been affected by general corrosion. Select a portion of the surface on one side of the specimen that is relatively unaffected; then machine the opposite surface where the pits are located on a precision lathe, grinder or mill until all signs of corrosion have disappeared. Some difficulty from galling and smearing may be encountered with soft metals and pits may be obliterated. Conversely, inclusions may be removed from the metal thus confusing examination. Measure the thickness of the specimen between the unaffected surface and subtract from the original thickness to give the maximum depth of pitting. Repeat this procedure on the unmachined surface unless the thickness has been reduced by 50 % or more during the machining of the first side.

**4.2.2.2** This method is equally suitable for determining the number of pits with specific depths. Count the visible pits then machine away the surface of the metal in measured stages and count the number of visible pits remaining at each stage. Subtract the number of pits at each stage from the count at the previous stage to obtain the number of pits at each depth of cut. Count at the previous stage to obtain the number of pits at each depth of cut.

#### 4.2.3 Micrometer or depth gauge

**4.2.3.1** This method is based on the use of a pointed needle attached to a micrometer or calibrated depth gauge to penetrate the pit cavity. Remove surrounding corrosion products or debris thoroughly then zero the instrument on an unaffected area at the lip of the pit.