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**Corrosion of metals and alloys - Guidelines for the evaluation of
pitting corrosion
(English Translation)**

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1 Scope

This document provides guidelines for selecting procedures for identifying and observing pits, evaluating pitting corrosion and pit growth rates.

This document is applicable to the evaluation of pitting corrosion in metals and alloys after pitting has occurred.

2 Normative references

This document has no normative references.

3 Terms and definitions

This document has no terms and definitions that need to be defined.

4.1 Preliminary low-magnification visual inspection

4.1.1

The corroded metal surface can be visually inspected, with or without a low- magnification magnifying glass, to determine the extent of corrosion and the apparent location of pits. It is usually recommended to photograph the corroded surface for comparison with a clean surface after removing corrosion products or with a new, unused sample.

4.1.2

If the metal specimen is exposed to an unknown environment, the composition of the corrosion products may be valuable in determining the cause of corrosion. It is recommended to follow the recommended procedure for removing particulate corrosion products; these removed products should be preserved for future identification.

4.1.3

To fully expose the pits, a cleaning procedure should be used to remove corrosion products. For lightly adhering corrosion products, rinsing with water followed by light mechanical cleaning is sufficient. For more strongly adhering products, chemical cleaning is required. GB/T 16545[1] provides a series of chemical cleaning processes.

To ensure that the base material is not corroded, preliminary tests should be conducted.

4.2.1 Observe the cleaned metal surface to determine the approximate size and

distribution of the pits. Then, use a low-magnification microscope (approximately 20x) for more detailed observation. Pits may have various sizes and shapes. Visual inspection of the metal surface can reveal circular, elongated, or irregular openings; however, it is rarely possible to accurately observe the extent of corrosion below the surface of the pits. Therefore, cross-sectional analysis of the pits is usually required to determine their actual shape. Figure 1 shows several common cross-sectional shapes of pits.

f) Microstructure orientation - Horizontal type g) Microstructure orientation - Vertical type

Figure 1 -- Different cross-sectional shapes of pits

4.2.2 Counting the number of pits with a microscope to determine the pit density is difficult. However, using a plastic grid makes it easier. Place a grid with square meshes of 3 mm ~ 6

mm side length on the metal surface; record the number of pits in each square mesh. Then move the grid sequentially until the entire surface has been observed.

This method reduces eye strain, because the field of view can be observed without worrying about missing significant areas. Magnifying significant areas also reduces eye strain. Another method is to mount the specimen on an x-y stage; measure the number and spatial distribution of the pits. Combined with optical depth measurement where applicable, this can determine the number, depth, spatial distribution of the pits.

4.2.3 In situations where optical observation is limited, advanced optical microscopy techniques such as infinite-focus microscopes and laser confocal microscopes can be used, to obtain three-dimensional images of the pit surface. This is most suitable for

Figures 1a) ~ 1c), but not for undercut types. This measurement can be used to observe surface features and quantify surface roughness, pit depth, surface profile.

4.2.4 For metallographic observation, a representative metal surface containing pits

shall be selected to prepare metallographic specimens. If observing corrosion products along the cross-section, the surface can be fixed with an embedding compound before sectioning, if necessary. Microscopic observation can determine whether the pits are related to inclusions or microstructure, or determine whether these pits are true pits or metal loss caused by intergranular corrosion or dealloying corrosion.

4.3.1 Overview

Many techniques have been developed to detect cracks or voids on metal surfaces without damaging the material (see reference [2]). Compared to the methods mentioned earlier, these methods are less effective in locating and determining the shape of the pits, but they are more suitable for on-site applications because they are often used for in-situ measurements.

4.3.2 Radiography

Radiation such as X-rays can penetrate objects. The intensity of the transmitted radiation varies with the thickness of the material. Defects can be detected if they cause a change in X-ray absorption. Detectors or films can be used to provide the morphology of internal defects. The detection of metal thickness mainly depends on the effective energy output. The pits shall be deep enough to be 0.5% of the metal thickness to be detected; care should be taken to ensure that the pits are not confused with pre-existing voids.

4.3.3 Electromagnetic methods

4.3.3.1

Eddy currents can be used to detect structural defects and irregularities in conductive materials. When a specimen is exposed to a changing magnetic field generated by a coil carrying alternating current, eddy currents are induced in the specimen, which in turn generate their own magnetic field. The magnetic field generated by defective material differs from that of a defect-free reference material, meanwhile appropriate detection instruments are needed to determine these differences.

4.3.3.2

Magnetic induction in ferromagnetic materials is another applicable method.

Discontinuities in the magnetic field across the cross-section lead to the formation of a leakage magnetic field on the surface of the material. Ferromagnetic powder is placed

Non-contact methods record the same type of information, typically using laser-based optical methods such as infinite focus microscopy, which do not require direct physical contact with the sample surface. These techniques derive 3D surface profiles by accumulating images at different optical focal planes. Using white light interferometry, which compares the phase difference between light reflected from the sample surface and light reflected from a reference mirror, 3D surface profiles can be obtained by recording surface morphology path length differences. Laser confocal microscopy can also provide similar information.

The disadvantage of these techniques is that they can only characterize information that is optically detectable, which are mainly suitable for the types of pits shown in Figures

1a) ~ 1c) (see also 4.2.3).

5.1 Weight loss

Weight loss measurement is generally not recommended for measuring pitting severity, unless uniform corrosion is very slight and pitting is quite severe. If uniform corrosion is significant, meanwhile pitting has little effect on the weight loss of the metal, then pitting damage cannot be accurately assessed by weight loss methods. In any case, weight loss only provides the total metal loss due to pitting, but does not provide information on pit density and depth. However, weight loss shall not be ignored in any case, as it can be very valuable. For example, weight loss combined with observation of the pitted surface is sufficient to evaluate the pitting resistance of an alloy in laboratory tests. Weight loss may also help to detect metal loss existing below the surface.