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Corrosion of metals and alloys — Method for determination of the uniform corrosion rate of stainless steels and nickel based alloys in liquids

Corrosion des métaux et alliages — Méthode pour la détermination du taux de corrosion uniforme des aciers inoxydables et des alliages à base de nickel dans les liquides

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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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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 156, *Corrosion of metals and alloys*.

Introduction

Stainless steel and nickel based alloys generally show good corrosion resistance but uniform corrosion can occur in acidic and alkaline solutions. The uniform corrosion rate in aqueous solutions is usually considered to be a fairly stable process as long as the corrosive environment is constant with respect to chemical composition, temperature, and flow conditions. The uniform corrosion resistance of stainless steels and nickel based alloys is thus often determined by short-term laboratory coupons immersion tests carried out under controlled conditions. However, in real applications, some variation in service conditions can occur which might cause a temporary activation of the stainless steel or nickel based alloy surface. Temperature variations, fluctuation in the access of air or other oxidants, contact to less noble materials, e.g. mild steel, or to certain cleaning agents are all factors which under certain circumstances could cause activation.

One important property to investigate is therefore the ability for the material to passivate after activation and accordingly, this method includes activation of the specimens. The corrosion rate determined by this test can be used as a basis for material selection and to estimate the lifetime of the material.

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Corrosion of metals and alloys — Method for determination of the uniform corrosion rate of stainless steels and nickel based alloys in liquids

1 Scope

This International Standard specifies the measurements of the corrosion rate of uniform corrosion for stainless steels and nickel based alloys in the intended liquids and the ability for the material to passivate after activation.

This method is intended to be used for estimation of the uniform corrosion rate in liquids, under atmospheric conditions, for the chemical industry under specific environmental conditions and not as a qualification test. It can also be used to determine iso-corrosion diagrams and at which temperature the corrosion rate exceeds 0,1 mm/a.

This International Standard is not intended for excessive corrosion rates above 1 mm/a since an even higher corrosion rate indicates that the stainless steel is not suitable in the application.

This International Standard is not intended to be used for solutions containing halides, especially chlorides, since these might cause localized corrosion.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applied. For undated references, the latest edition of the referenced document applies.

ISO 3696, *Water for analytical laboratory use — Specification and test methods*

ISO 8044, *Corrosion of metals and alloys — Basic terms and definitions*

ISO 17864, *Corrosion of metals and alloys — Determination of the critical pitting temperature under potientiostatic control*

3 Terms and definitions

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

4 Principle

4.1 This method involves immersion of the material in the intended liquid after the required temperature has been reached. Mass measurements are carried out before and after each of three sequential periods, 24 h, 72 h, and 72 h of immersion.

Period 1: 24 h of immersion in the liquid. When exposed to acid, the passive layer will change composition during this period. In addition, contaminations on the specimens will be removed during this period. For this reason, the first period is normally not accounted for when evaluating the corrosion rate.

Period 2: 72 h of immersion in the liquid. This period determines the corrosion rate.

Period 3: 72 h of immersion in the liquid with activation of the specimens. This period determines the corrosion rate of a specimen with an active surface and the ability to repassivate in the specific liquid.

4.2   The weight, before and after each period, is measured, the mass loss during each period is calculated, and the average corrosion rate is determined for periods 2 and 3.

4.3   In the beginning of the third period, the specimens shall be activated, according to the procedure described in 8.5, to investigate whether the material has the ability to repassivate in the specific conditions.

4.4   Activation by a potentiostat or zinc shall be used, except in strongly oxidising solutions, such as nitric acids or ferrous sulfate where a hydrochloric acid solution shall be used.

4.5   The test involves immersion of specimens in a test liquid, which is in open air. This implies that the oxygen in the aerated liquid can maintain the passive layer and the result shall therefore not be compared with results obtained in deaerated liquid.

5   Equipment

5.1   **Vessel, flask, or beaker** of inert material to the test liquid.

5.2   **Specimen holder** of inert material to the test liquid shall be used.

5.3   **Temperature controller** with an accuracy of ±1 °C.

5.4   **In case of using potentiostatic activation, a potentiostat and a reference electrode is required.** The potentiostat shall be capable of controlling the electrode potential to within ±1 mV of a present value. If the liquid in the test vessel is heated, the reference electrode shall be maintained at ambient temperature external to the test vessel via a Luggin capillary probe (see ISO 17864) or electrode shall be suitable for higher temperatures and values shall be referred to as values at ambient temperature.

5.5   **Laboratory balance.** The laboratory balance shall be able to measure with accuracy of 0,000 1 g or better.

6   Test solutions

6.1   Test solutions can be laboratory prepared or process solution. If the solution is prepared in the laboratory, it shall be made from reagent-grade chemicals and high-purity water.

6.2   Precautions shall be taken according to the chemical safety data sheet of the solution.

6.3   It is necessary to be sure that the solution does not react with the vessel.

If the solution contains hydroxides (e.g. NaOH) or fluorides (e.g. HF and wet phosphoric acid, WPA), the equipment shall be made of a resistant polymer material.

6.4   If hydrochloric acid-solution is used for activation of the specimens, it shall be prepared by mixing 1 part of HCl, mass fraction 37 % by weight HCl, with 2 parts high-purity water with a conductivity less than 1 µS/cm (ISO 3696, grade 2).

7   Specimens

7.1   At least two specimens for each of the materials shall be tested in each environmental condition. Both welded and non-welded specimens can be used.

If materials of different alloy composition are tested in the same liquid, it should be verified that this does not influence the result.

7.2   The surface area of each specimen shall be at least 20 cm^2 and influence from edges surfaces shall be minimized by minimizing the area of the edges as far as possible. The specimen's dimensions shall be measured with an accuracy of 0,1 mm and the area shall be calculated. The specimen shall be orientated so the majority of the test area is representative of the surface of interest.

7.3   The edges shall be ground down to a surface finish of at least P 120 grit paper. All the other surfaces shall represent the surface of interest. The specimens shall be left in air, at a temperature higher than the dew point temperature for at least 24 h before testing, to be able to form a stable passive film.

NOTE   Wet grinding is preferred but dry grinding can also be used if care is taken to avoid overheating of the surface.

7.4   If welded specimens are used, the weld shall preferably be located in the middle of the specimens. Post weld cleaning shall be selected to be representative for the application of interest.

NOTE   Surface preparation such as blasting or too rough grinding surfaces might affect the result.

7.5   The specimens shall be cleaned immediately prior to immersion by degreasing, rinsing in high-purity water followed by ethanol or a similar solvent, and air drying. After degreasing, care shall be taken not to contaminate the test surface of the specimens.

8   Procedure

8.1   The specimens shall be weighed preferably at room temperature with an accuracy of 0,000 1 g or better. The weight prior to this testing shall be registered as m_i. Weighing prior to and after testing shall be conducted at the same temperature.

8.2   Examples of the experimental equipment are shown in Figures 1 and 2. In Figure 1, the equipment consists of a flask, a specimen holder, a reflux condenser, a stirrer, and a temperature controller. In Figure 2, the specimens are mounted on a specimen holder of glass and placed in the liquid. Covers of the beakers are used to avoid evaporation.

8.3   The test solutions temperature shall be constant during the test with an accuracy of ±1 °C. Stirring shall be used if corrosion products are formed in the liquid.

NOTE   Slight stirring is used to avoid corrosion products on the specimens and temperature gradients in the liquid.