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ISO 7441

Second edition
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Corrosion of metals and alloys — Determination of bimetallic corrosion in atmospheric exposure corrosion tests

Corrosion des métaux et alliages — Détermination de la corrosion bimétallique par des essais d'exposition de corrosion atmosphérique

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Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
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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. www.iso.org/directives

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

This second edition cancels and replaces the first edition (ISO 7441:1984), which has been technically revised.

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Introduction

Bimetallic corrosion occurs when a metal in electrical contact with a more noble metal corrodes at a higher rate than it would in the same environment but without this contact.

Bimetallic corrosion in the atmosphere, in contrast to that in electrolytes, is characterized by a large potential drop between the anode and the cathode. Therefore, bimetallic corrosion is usually limited to a distance within about 0,5 cm from the point of contact[1].

The determination of bimetallic corrosion in atmospheric exposure tests can be made with several methods, each with its own advantages. Three standardized tests are compared and described in this International Standard:

— rectangular plates;

— washers;

— wire on bolt.

The standard starts with an overview and comparison of the three methods, with the purpose of aiding the selection of an appropriate test method. Test procedures for the rectangular plate and washer test are included in this standard since no independent standard describes these methods while those who wish to use the wire on bolt test need to consult ASTM G116 for a complete description of the method.

The standard describes how to derive the bimetallic effect, which is a relative measure of the bimetallic corrosion of a metal compared to the corrosion of the same metal but without the bimetallic effect. A high galvanic effect does not necessarily mean that the bimetallic corrosion rate is high. Therefore, valuable complementary information is the classification of the corrosivity of the test site according to ISO 9223[2].

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Corrosion of metals and alloys — Determination of bimetallic corrosion in atmospheric exposure corrosion tests

1 Scope

This International Standard specifies and compares methods for the determination of bimetallic corrosion of metals and coated metals in atmospheric exposure corrosion tests.

NOTE In the text of this International Standard, the term "metal" is used for both metals and alloys, and the term "coated metal" for metals and alloys with metallic and non-metallic inorganic coatings.

The methods are intended for the determination of the amount and type of corrosion effect, arising in natural atmospheres, caused by contact with different metals.

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 applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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ISO 1456, *Metallic and other inorganic coatings — Electrodeposited coatings of nickel, nickel plus chromium, copper plus nickel and of copper plus nickel plus chromium*

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ISO 2081, *Metallic and other inorganic coatings — Electroplated coatings of zinc with supplementary treatments on iron or steel*

ISO 7599, *Anodizing of aluminium and its alloys — General specifications for anodic oxidation coatings on aluminium*

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

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

ISO 8407, *Corrosion of metals and alloys — Removal of corrosion products from corrosion test specimens*

ISO 8565, *Metals and alloys — Atmospheric corrosion testing — General requirements*

ISO 15510, *Stainless steels — Chemical composition*

ASTM G116, *Standard Practice for Conducting Wire-on-Bolt Test for Atmospheric Galvanic Corrosion*

3 Terms and definitions

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

3.1
test specimens
specimens that are exposed for evaluation of bimetallic corrosion caused by contact with different materials

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3.2
reference specimens
specimens prepared, exposed and evaluated in the same configuration and design as the test specimens but not subject to bimetallic corrosion, for example by being in contact with an inert non-conductive material or the same material, instead of the different material

3.3
standard specimens
specimens used to determine the corrosivity of the test environment in absence of bimetallic corrosion

3.4
control specimens
specimens prepared and evaluated in the same way as test specimens but, instead of being exposed in the test environment, stored under controlled conditions which prevent corrosion

4 Overview and comparison of methods

The determination of bimetallic corrosion in atmospheric exposure tests can be made with several methods. Three of these methods are compared and described in this International Standard:

— rectangular plates;

— washers;

— wire on bolt.

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An overview and comparison of methods are shown in Table 1. Each configuration has its own advantages and the selection of method shall be based on the needs of the test programme. The main advantage with rectangular plate test is the possibility of evaluating the mechanical properties. The washer test is the only method where it is not necessary to know in advance which material is the anode. The short exposure time is the main advantage of the wire on bolt test.

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Table 1 — Comparison of rectangular plates, washers and wire on bolt for conducting test assessing bimetallic corrosion in the atmosphere

Effect	Rectangular plates	Washers	Wire on bolt
Sensitivity (exposure time)	≥ 1 year	≥ 1 year	> 90 days[a]
Material limitation	None	None	Wire anode
Anode/cathode	Necessary to know in advance which material is the anode	Not necessary to know in advance which material is the anode	Necessary to know in advance which material is the anode
Evaluation method(s)	Mass loss Mechanical properties	Mass loss	Mass loss
Mechanical	Can be difficult to maintain electrical contact between panels throughout the exposure test.	Can be difficult to maintain electrical contact between panels throughout the exposure test.	Can be difficult to maintain enough wire tension without causing wire fracture
Crevice corrosion	Crevice corrosion can be a problem	Crevice corrosion can be a problem	Lower risk that crevice corrosion will be a problem

[a] A shorter duration of exposure is permissible under certain conditions, see Clause 6.

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5 Preparation of specimens

5.1 Types of specimens

5.1.1 General

When determining the risk of bimetallic corrosion, depending on the particular test, the specimens will not only suffer from increased corrosion due to bimetallic effects. For example, in the wire on bolt test the wire tension may influence the outcome of the test depending on the particular application. Therefore, several types of specimens (test specimens, reference specimens, standard specimens and control specimens) as defined in Clause 3 are needed depending on the purpose of the test programme.

NOTE Comparison of effects of test and reference specimens gives the *relative* risk of bimetallic corrosion but reference specimens are generally not suitable for evaluation of the *absolute* corrosion attack when there is no risk of bimetallic corrosion due to the particular design of the specimens. For evaluation of the absolute attack standard specimens are more suitable. Flat or irregularly shaped specimens can be used, as described in ISO 8565, depending on the intended use of the tested material. For example, hanging wires can be used as standard specimens for the wire on bolt test but flat panels can also be used if they are easily obtained and more closely resembles the shape of the intended use.

Control specimens shall be used if evaluation of mechanical properties is part of the test programme.

Unless otherwise stated, the material, dimensions, direction of cutting, method of surface treatment and other parameters of anodic plates of test specimens, reference specimens and control specimens shall be the same.

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5.1.2 Rectangular plates

The test specimens shall be as shown in Figure 1 or Figure 2.

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NOTE 1 The configuration shown in Figure 1 cannot be used for evaluation based on mass loss. The configuration shown in Figure 2 cannot be used for evaluation based on mechanical properties.

Anodic plates shall have a thickness of 1 mm to 6 mm and their length shall be suitable for tensile testing in accordance with ISO 6892-1.

Cathodic plates shall have thickness of 1 mm to 6 mm. In the case of precious metals, cathodic plates can consist of a foil covering a plate of inert material, such as plastic material. In this case, the foil and inert material assembly shall have a thickness of 1 mm to 6 mm.

If it is not known which of the metals constituting the test specimen is nobler, each metal shall be tested in one complete set of specimens as the anode, and in the other, as the cathode.

The surfaces of specimens shall be free from visible defects, such as non-uniformity of rolling, scale, exfoliation, cracks, pores, blisters, scratches and dents. If there are no visual surface defects, as detected with the naked eye, specimens shall be tested with the surface in the condition as delivered or after treatment, as recommended for the articles concerned. If defects are removed by mechanical means, the surface roughness of specimens, including cut edges, shall at least be better than 2,5 µm, a surface roughness of 0,4 µm to 0,5 µm is recommended.

The surface conditions, including cut edges, of coated metallic plates shall be in accordance with ISO 1456, ISO 2081 or ISO 7599 or other appropriate international, national or regional standards depending on the specific coatings in question.

If a metal is tested in contact with a coated metal, damage to, or absence of, the coating is permissible only on the cut edges of anodic plates.

Washers and sleeves shall be used to insulate bolts from the metallic plates. The contact between two plates of metal shall be achieved by pressure. Ceramics or other insulating materials which are not susceptible to creep or degradations over extended periods of time are recommended as washer materials. Sleeves of polyethylene or polypropylene are recommended.

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The bolts shall be tightened firmly until good electrical contact is achieved between the plates. Insufficient torque will cause too high a resistance between the washers, and too much torque will crack the bushing. The torque applied while tightening the bolts shall be the same for all specimens, a value of about (1,0 ± 0,1) N m^{-1} being typical. Otherwise, a good rule of thumb is to tighten until all components are in contact and then tighten an additional one quarter turn. After assembly, the electrical insulation (>10 kΩ) of the bolt from the washers and the electrical contact (<1 Ω) between the plates shall be verified with a resistance meter.

These electrical resistance checks should be repeated if assemblies are dry in connection with site visits. If the resistance increases or if there are other indications of relaxation, the bolts should be re-tightened without disturbing the assemblies. The reason for loss of contact could be that solid corrosion products accumulate between the washers pushing them apart. Another reason could be the relaxation of the non-metallic components caused by long term stress leading to creep.

Metallic bolts and washers shall be made of stainless steel of grade 1.4301/X5CrNi18-10/304 or higher chromium grades, see ISO 15510.

Specimens shall be examined for conformity to the requirements above by visual inspection and appropriate measurements.

Immediately before testing, the surfaces of the specimens and other parts of the assemblies shall be degreased using organic solvents, for example ethanol, white spirit.

After degreasing, the specimens shall be handled only by the cut edges and when wearing cotton or rubber gloves.

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After degreasing, test specimens and reference specimens, the corrosion behaviour of which is to be determined by mass loss, shall be kept in desiccators containing a desiccant (for example silica gel) for not less than 24 hours.

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In preparing specimens a thin layer of an organic coating, glue, varnish or lacquer, such as cellulose acetate dissolved in acetone, is recommended to prevent crevice corrosion. This coating shall be applied to the degreased surface of the anodic plate in such a way as to seal completely the gap between the anode and cathode plates without projecting beyond the cathode plate. The dry coating thickness shall not exceed 10 µm. This coating shall not cover the area adjacent to bolt holes, in order to allow contact between the metallic plates when they are assembled.

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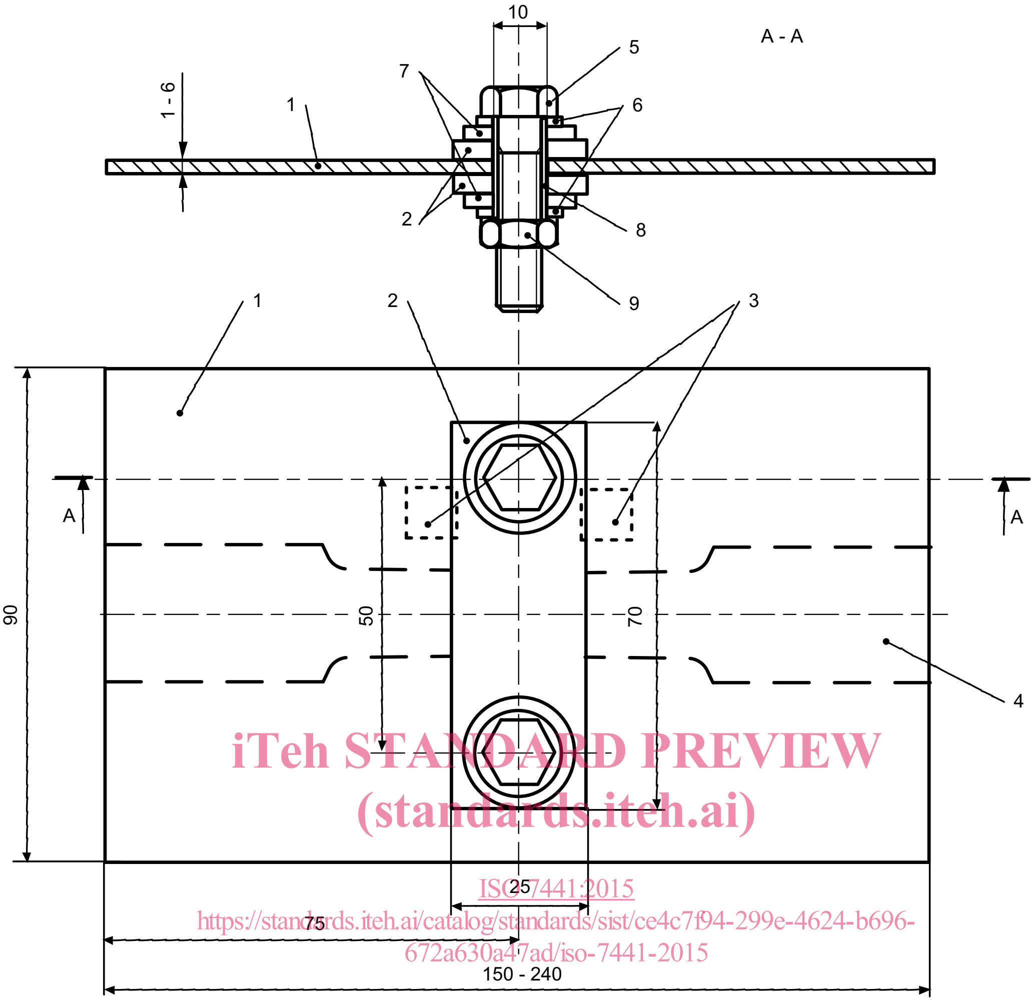
Dimensions in millimetres



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Key

1 anodic plate
2 cathodic plate
3 microsections
4 tensile test specimen
5 bolt 8 mm × 40 mm
6 washer, thickness 1 mm, diameter 16 mm
7 insulating washer, thickness 1 mm to 3 mm, diameter 18 to 20 mm
8 insulating sleeve
9 nut

Figure 1 — Example of test specimen used for evaluations based on criteria other than mass loss

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