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Second edition
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Corrosion of metals and alloys — Accelerated testing involving cyclic exposure to salt mist, dry and wet conditions

Corrosion des métaux et alliages — Essais accélérés comprenant des expositions cycliques à des conditions de brouillard salin, de séchage et d'humidité

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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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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 156, *Corrosion of metals and alloys.*

This second edition cancels and replaces the first edition (ISO 14993:2001), which has been technically revised. The main technical changes are as follows:

- the document has been harmonized with ISO 9227;
- the terms and definitions clause has been added;
- the allowed range of mass loss of steel reference specimen has been changed.

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

Corrosion of metallic materials with or without corrosion protection is influenced by many environmental factors, the importance of which may vary depending on the type of metallic material and the type of environment. It is impossible, therefore, to design accelerated laboratory corrosion tests in such a way that all environmental factors influencing resistance to corrosion are taken into account. Laboratory tests are, therefore, designed to simulate the effects of the most important factors that enhance the corrosion of metallic materials.

The accelerated corrosion test method described in this document is designed to simulate and enhance the environmental influence on a metallic material of exposure to an outdoor climate, where exposure to salt-contaminated conditions occurs and may promote corrosion.

The test method involves cyclic exposure of test specimens to a mist of salt solution, to drying conditions and to periods of high humidity. However, the method is mainly intended for comparative testing and the results obtained do not permit far-reaching conclusions on the corrosion resistance of the tested metallic material under the whole range of environmental conditions within which it may be used. Nevertheless, the method provides valuable information on the performance of materials exposed to salt-contaminated environments similar to those used in the test.

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Corrosion of metals and alloys — Accelerated testing involving cyclic exposure to salt mist, dry and wet conditions

WARNING — This document may involve hazardous materials, operations and equipment. It does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this document to establish appropriate safety and health practices.

1 Scope

This document specifies the apparatus and test procedure to be used in conducting accelerated corrosion tests for the comparative evaluation of metallic materials with or without permanent corrosion protection or temporary corrosion protection in salt-contaminated outdoor environments. The test involves cyclic exposure of the specimens to neutral salt mist, “dry” and “wet” conditions. The type of test specimen and the exposure period are not specified.

The particular advantages of this test over common accelerated tests such as the neutral salt spray (NSS) test lie in its ability to better reproduce the corrosion that occurs in outdoor salt-contaminated environments.

This document is applicable to

- metals and their alloys,
- metallic coatings (anodic and cathodic),
- conversion coatings,
- anodic oxide coatings, and
- organic coatings on metallic materials.

NOTE Methods of test for coatings to determine their resistance, in the presence of scribe marks through to the substrate, to various cyclic corrosion conditions which include the condensation of water on the test specimens during periods of humidity are given in ISO 11997-1.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1514, *Paints and varnishes — Standard panels for testing*

ISO 2808, *Paints and varnishes — Determination of film thickness*

ISO 4623-2:2016, *Paints and varnishes — Determination of resistance to filiform corrosion — Part 2: Aluminium substrates*

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

ISO 17872, *Paints and varnishes — Guidelines for the introduction of scribe marks through coatings on metallic panels for corrosion testing*

3 Terms and definitions

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

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/

3.1
reference material
material with known test performance

3.2
reference specimen
portion of the *reference material* (3.1) that is to be exposed with the intention to check the reproducibility and repeatability of the test results for the test cabinet in use

3.3
test specimen
specific portion of the samples upon which the testing is to be performed

3.4
substitute specimen
specimen made of inert materials (such as plastic or glass) used for the substitute of a *test specimen* (3.3)

4 Test solution

4.1 General

Instructions for the preparation and use of a neutral sodium chloride solution are given in 4.2 and 4.3.

4.2 Preparation of the sodium chloride solution

Dissolve a sufficient mass of sodium chloride in distilled or deionized water with a conductivity no higher than 20 µS/cm at 25 °C ± 2 °C to produce a concentration of 50 g/l ± 5 g/l. The sodium chloride concentration of the sprayed solution collected shall be 50 g/l ± 5 g/l. The specific gravity range for a 50 g/l ± 5 g/l solution is 1,029 to 1,036 at 25 °C.

The sodium chloride shall not contain a mass fraction of the heavy metals of copper (Cu), nickel (Ni) and lead (Pb) in total more than 0,005 %. It shall not contain a mass fraction of sodium iodide more than 0,1 % and a mass fraction of total impurities more than 0,5 %, calculated for dry salt.

NOTE Sodium chloride with anti-caking agents can act as corrosion inhibitors or accelerators. A useful sodium chloride salt grade is a grade named Ph. Eur/USP or JIS, ACS.

4.3 pH adjustment

Adjust the pH of the salt solution so that the pH of the sprayed solution collected within the test cabinet is 6,5 to 7,2 at 25 °C ± 2 °C. Check the pH using electrometric measurement. Measurements of pH shall be done using electrode suitable for measuring in weakly buffered sodium chloride solutions in deionized water. Make any necessary corrections by adding hydrochloric acid, sodium hydroxide or sodium bicarbonate solution of analytical grade.

NOTE Possible changes in pH can result from loss of carbon dioxide from the solution when it is sprayed. Such changes can be avoided by reducing the carbon dioxide content of the solution by, for example, heating it to a temperature greater than 35 °C before it is placed in the apparatus, or by making the solution from freshly boiled water.

5 Apparatus

5.1 Component protection

All components in contact with the salt mist spray or the test solution shall be made of, or lined with, materials which are resistant to corrosion by the test solution and which do not influence the corrosivity of the sprayed test solution.

The supports for the test specimen shall be constructed such that different substrate types do not influence each other. It shall also be constructed so that the supports themselves do not influence the test specimens.

5.2 Exposure equipment

5.2.1 Test cabinet, that meets the conditions of homogeneity and distribution of the spray. Due to the limited capacity of test cabinets smaller than 0,4 m^3, the effect of the loading of the test cabinet on the distribution of the spray and temperature shall be carefully considered. The solution shall not be sprayed directly onto test specimens but rather spread throughout the test cabinet so that it falls naturally down on them. The upper parts of the test cabinet shall be designed so that drops of sprayed solution formed on its surface do not fall on the specimens being tested.

The size and shape of the test cabinet shall be such that during periods of exposure to salt mist spray, the collection rate of solution in the test cabinet is within the limits specified in 8.2.

NOTE A schematic diagram of one possible design of test cabinet and associated apparatus for salt mist cyclic corrosion testing is shown in Annex A.

5.2.2 Humidity and temperature control system, that maintains the test cabinet and its contents at the specified temperature and humidity (see 8.1). The temperature shall be measured at a position at least 100 mm from walls and radiant heat sources.

5.2.3 Spraying device, for spraying the salt solution during periods of exposure to salt mist spray comprising a supply of air at controlled pressure, a reservoir containing the solution to be sprayed and one or more atomizers.

The compressed air supplied to the atomizers shall be passed through a filter to remove all traces of oil or solid matter and shall be at an overpressure of 70 kPa to 170 kPa. The pressure is typically 98 kPa ± 10 kPa but can vary depending on the type of test cabinet and atomizer used.

5.2.4 Air saturator, consisting of a saturation tower containing hot water at a temperature higher than that of the test cabinet. In order to prevent evaporation of water from the sprayed droplets, the air shall be humidified before entering the atomizer, by passage through this tower.

During periods of exposure to the salt mist, the appropriate temperature depends on the pressure used and on the type of atomizer nozzle and shall be adjusted so that the rate of collection of spray in the test cabinet and the concentration of the collected spray are kept to within the specified limits (see 8.2). The level of water shall be maintained automatically to ensure adequate humidification.

The atomizers shall be made of inert material, e.g. glass or plastic materials. Baffles may be used to prevent direct impact of spray on the test specimens and the use of adjustable baffles is helpful in obtaining constant distribution of spray within the test cabinet. The level of the salt solution in the supply tank shall be maintained automatically to ensure constant spray delivery throughout the test.

5.2.5 Collecting devices, at least two, consisting of clean funnels with a collecting area of approximately 80 cm^2 made of glass or other chemically inert material, with the stems inserted into graduated cylinders or other similar containers. The purpose of the collecting devices is to confirm that the collection rate is within specified limits (see 8.2). They shall be placed in the zone of the test cabinet where the test specimens are placed, one close to the spray inlet and one remote from an inlet and in such a way that only spray, and not the liquid falling from specimens or from parts of the test cabinet, is collected.

5.2.6 Air dryer, comprising a heating device and fan to supply dried air of the specified humidity during “dry” periods (see Table 1).

5.2.7 Exhaust system, by which air is exhausted from the test cabinet. It shall not be influenced by the back pressure of the atmosphere when the air is released at a point outside the building.

6 Test specimens

6.1 The number and type of test specimens, their shape and their dimensions, shall be selected in accordance with the specification for the material or product being tested. When not specified, these parameters shall be mutually agreed between the interested parties. Unless otherwise specified or agreed, test specimens with an organic coating to be tested shall be made from burnished steel conforming with ISO 1514, and of approximate dimensions 150 mm × 100 mm × 1 mm. Annex C describes how test specimens with organic coatings shall be prepared for testing. Annex D gives supplementary information that shall be supplied, as appropriate, for testing test specimens with organic coatings.

6.2 The test specimens shall be thoroughly cleaned before testing, if not otherwise specified. The cleaning method employed shall depend on the nature of the material, its surface and the contaminants and shall not include the use of any abrasives or solvents which may attack the surface of the specimens.

Care shall be taken that test specimens are not re-contaminated after cleaning by careless handling.

6.3 If the test specimens are cut from a larger coated sample, cutting shall be carried out in such a way that the coating is not damaged in the area adjacent to the cut. Unless otherwise specified, the cut edges shall be adequately protected by coating them with a suitable material, which remains stable under the conditions of the test, such as paint, wax or adhesive tape.

7 Arrangement of the test specimens

7.1 The test specimens shall be placed in the test cabinet so that they are not in the direct path of spray from the atomizer.

7.2 If the test cabinet is not full of test specimens, it is recommended to fill it with inert flat substitute specimens of the same size as a reference specimen, in order to ensure uniformity of the spray. The material used shall be plastics, glass, or other inert insulating materials, which would not influence corrosion of the test specimens being tested.

7.3 The angle at which the surfaces of the test specimens are exposed in the test cabinet is very important. The specimen shall, in principle, be flat and placed in the test cabinet facing upwards at an angle as close as possible to 20° to the vertical. This angle shall, in all cases, be within limits 15° to 25°. In the case of irregular surfaces, e.g. entire components, these limits shall be adhered to as closely as possible.

7.4 The test specimens shall be arranged so that they do not come into contact with the test cabinet and so that the surfaces to be tested are exposed to free circulation of spray. The specimens may be placed at different levels within the test cabinet, as long as the solution does not drip from specimens or their supports at one level onto other specimens placed below. However, for a new examination, or for tests with a total duration exceeding 96 h, location permutation of specimens is permitted. In this case, the number and frequency of the permutations are left to the operator and shall be indicated in the test report.

7.5 The supports for the test specimens shall be made of inert non-metallic material, such as glass, plastic or suitably coated wood. If it is necessary to suspend specimens, the material used shall not be metallic but shall be synthetic fibre, cotton thread or another inert insulating material.

8 Operating conditions

8.1 The test conditions are summarized in Table 1.

Table 1 — Test conditions

1	**Salt mist conditions**	
	1) Temperature	35 °C ± 1 °C
	2) Salt solution	pH 6,5 to 7,2, salt concentration 50 g/l ± 5 g/l as described in Clause 4
2	**“Dry” conditions**	
	(The air is purged under dry conditions.)	
	1) Temperature	60 °C ± 1 °C
	2) Relative humidity	< 30 %
3	**“Wet” conditions**	
	(Condensation on the test specimens shall not occur under wet conditions.)	
	1) Temperature	50 °C ± 1 °C
	2) Relative humidity	> 95 %
4	**Period and content of a single exposure cycle**	Total period 8 h, as follows: Salt mist spray 2 h “Dry” conditions 4 h “Wet” conditions 2 h (These times include the time for reaching the specified temperature for each condition.)
5	**Time to reach the specified condition** (i.e. period taken for temperature and humidity to reach the specified values once the test condition has begun)	Mist to “Dry” < 30 min “Dry” to “Wet” < 15 min “Wet” to Mist < 30 min (Mist conditions are attained almost instantaneously once this condition begins.)
6	**Angle** at which test specimens are supported	20° ± 5° to the vertical

NOTE The ± tolerances given are the allowable operational fluctuations, which are defined as the positive and negative deviations from the setting of the sensor at the operational control set point during equilibrium conditions. This does not mean that the set value may vary by plus/minus the amount indicated from the given value.

8.2 The test shall not be started until it has been confirmed, with the test cabinet filled to a similar extent as during the test, that, when the apparatus is operated in the salt mist condition, the collection rate of solution measured over a period of 24 h of continuous spraying is within the range 1 ml/h to 2 ml/h for a horizontal collecting area of 80 cm^2 and that other conditions are as specified. In particular, the solution collected in each of the collecting devices shall have a sodium chloride concentration of 50 g/l ± 5 g/l and a pH value in the range 6,5 to 7,2.

8.3 A test solution that has been sprayed shall not be re-used.

8.4 During the salt mist conditions of the test, the change from the set pressure shall be within ± 0,002 5 MPa.