
Corrosion tests in artificial atmospheres — Salt spray tests

*Essais de corrosion en atmosphères artificielles — Essais aux
brouillards salins*

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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.

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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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 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 the following URL: www.iso.org/iso/foreword.html.

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

This fourth edition cancels and replaces the third edition (ISO 9227:2012), which has been technically revised. The main technical changes are as follows:

- new definitions for reference material, reference specimen, test specimen and substitute specimen have been implemented;
- checking of the test apparatus during test operation has been made possible;
- [Clause 4](#) has been added, with some of its text moved from the scope;
- [Clause 7](#) has been summarized.

Introduction

There is seldom a direct relation between resistance to the action of salt spray and resistance to corrosion in other media, because several factors influencing the progress of corrosion, such as the formation of protective films, vary greatly with the conditions encountered. Therefore, the test results should not be regarded as a direct guide to the corrosion resistance of the tested metallic materials in all environments where these materials might be used. Also, the performance of different materials during the test should not be taken as a direct guide to the corrosion resistance of these materials in service.

Nevertheless, the method described gives a means of checking that the comparative quality of a metallic material, with or without corrosion protection, is maintained.

Different metallic substrates (metals) cannot be tested in direct comparison in accordance to their corrosion resistances in salt spray tests. Comparative testing is only applicable for the same kind of substrate.

Salt spray tests are generally suitable as corrosion protection tests for rapid analysis for discontinuities, pores and damage in organic and inorganic coatings. In addition, for quality control purposes, comparison can be made between specimens coated with the same coating. As comparative tests, however, salt spray tests are only suitable if the coatings are sufficiently similar in nature.

It is often not possible to use results gained from salt spray testing as a comparative guide to the long-term behaviour of different coating systems, since the corrosion stress during these tests differs significantly from the corrosion stresses encountered in practice.

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Corrosion tests in artificial atmospheres — Salt spray tests

1 Scope

This document specifies the apparatus, the reagents and the procedure to be used in conducting the neutral salt spray (NSS), acetic acid salt spray (AASS) and copper-accelerated acetic acid salt spray (CASS) tests for assessment of the corrosion resistance of metallic materials, with or without permanent or temporary corrosion protection.

It also describes the method employed to evaluate the corrosivity of the test cabinet environment.

It does not specify the dimensions or types of test specimens, the exposure period to be used for a particular product, or the interpretation of results. Such details are provided in the appropriate product specifications.

The salt spray tests are particularly useful for detecting discontinuities, such as pores and other defects, in certain metallic, organic, anodic oxide and conversion coatings.

The neutral salt spray (NSS) test particularly applies to

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

The acetic acid salt spray (AASS) test is especially useful for testing decorative coatings of copper + nickel + chromium, or nickel + chromium. It has also been found suitable for testing anodic and organic coatings on aluminium.

The copper-accelerated acetic acid salt spray (CASS) test is useful for testing decorative coatings of copper + nickel + chromium, or nickel + chromium. It has also been found suitable for testing anodic and organic coatings on aluminium.

The salt spray methods are all suitable for checking that the quality of a metallic material, with or without corrosion protection, is maintained. They are not intended to be used for comparative testing as a means of ranking different materials relative to each other with respect to corrosion resistance or as means of predicting long-term corrosion resistance of the tested material.

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 3574, *Cold-reduced carbon steel sheet of commercial and drawing qualities*

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

ISO 4628-1, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 1: General introduction and designation system*

ISO 4628-2, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 2: Assessment of degree of blistering*

ISO 4628-3, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 3: Assessment of degree of rusting*

ISO 4628-4, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 4: Assessment of degree of cracking*

ISO 4628-5, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 5: Assessment of degree of flaking*

ISO 4628-8, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 8: Assessment of degree of delamination and corrosion around a scribe or other artificial defect*

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 8993, *Anodizing of aluminium and its alloys — Rating system for the evaluation of pitting corrosion — Chart method*

ISO 10289, *Methods for corrosion testing of metallic and other inorganic coatings on metallic substrates — Rating of test specimens and manufactured articles subjected to corrosion tests*

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:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

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 Principle

The neutral salt spray (NSS) test is the test method in which a neutral 5 % sodium chloride solution is atomized under a controlled environment.

The acetic acid salt spray (AASS) test is the test method in which an acidified 5 % sodium chloride solution with the addition of glacial acetic acid is atomized under a controlled environment.

The copper-accelerated acetic acid salt spray (CASS) test is the test method in which an acidified 5 % sodium chloride solution with the addition of copper chloride and glacial acetic acid is atomized under a controlled environment.

5 Test solutions

5.1 Preparation of the sodium chloride solution

Dissolve a sufficient mass of sodium chloride in distilled or deionized water with a conductivity not higher than $20 \mu\text{S}/\text{cm}$ at $25 \text{ }^{\circ}\text{C} \pm 2 \text{ }^{\circ}\text{C}$ to produce a concentration of $50 \text{ g/l} \pm 5 \text{ g/l}$. The sodium chloride concentration of the sprayed solution collected shall be $50 \text{ g/l} \pm 5 \text{ g/l}$. The specific gravity range for a $50 \text{ g/l} \pm 5 \text{ g/l}$ solution is 1,029 to 1,036 at $25 \text{ }^{\circ}\text{C}$.

The sodium chloride shall not contain a mass fraction of the heavy metals 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 HS ACS.

5.2 pH adjustment

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5.2.1 pH of the salt solution

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Adjust the pH of the salt solution to the desired value on the basis of the pH of the sprayed solution collected.

5.2.2 Neutral salt spray (NSS) test

Adjust the pH of the salt solution (5.1) so that the pH of the sprayed solution collected within the test cabinet (6.2) is 6,5 to 7,2 at $25 \text{ }^{\circ}\text{C} \pm 2 \text{ }^{\circ}\text{C}$. Check the pH using electrometric measurement. Measurements of pH shall be done using electrodes 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 in 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 above $35 \text{ }^{\circ}\text{C}$ before it is placed in the apparatus, or by making the solution using freshly boiled water.

5.2.3 Acetic acid salt spray (AASS) test

Add a sufficient amount of glacial acetic acid to the salt solution (5.1) to ensure that the pH of samples of sprayed solution collected in the test cabinet (6.2) is between 3,1 and 3,3 at $25 \text{ }^{\circ}\text{C} \pm 2 \text{ }^{\circ}\text{C}$. If the pH of the solution initially prepared is 3,0 to 3,1, the pH of the sprayed solution is likely to be within the specified limits. Check the pH using electrometric measurement. Measurements of pH shall be done using electrodes suitable for measuring in weakly buffered sodium chloride solutions in deionized water. Make any necessary corrections by adding glacial acetic acid, sodium hydroxide, or sodium bicarbonate of analytical grade.

5.2.4 Copper-accelerated acetic acid salt spray (CASS) test

Dissolve a sufficient mass of copper(II) chloride dihydrate ($\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$) in the salt solution (5.1) to produce a concentration of $0,26 \text{ g/l} \pm 0,02 \text{ g/l}$ [equivalent to $(0,205 \pm 0,015) \text{ g}$ of CuCl_2 per litre].

Adjust the pH using the procedures described in 5.2.3.

5.3 Filtration

If necessary, filter the solution before placing it in the reservoir of the apparatus, to remove any solid matter which might block the apertures of the spraying device.

6 Apparatus

6.1 Component protection

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

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.

6.2 Spray cabinet

The cabinet shall be such that the conditions of homogeneity and distribution of the spray are met. Due to the limited capacity of cabinets smaller than $0,4 \text{ m}^3$, the effect of the loading of the 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 cabinet so that it falls naturally down to them. The upper parts of the cabinet shall be designed so that drops of sprayed solution formed on its surface do not fall on the test specimens being tested.

The size and shape of the cabinet shall be such that the collection rate of solution in the cabinet is within the limits measured as specified in 10.3.

Preference shall be given to apparatus that has a means for properly dealing with fog after the test, prior to releasing it from the building for environmental conservation, and for drawing water prior to discharging it to the drainage system.

NOTE A schematic diagram of one possible design of spray cabinet is shown in Annex A (see Figure A.1 and Figure A.2).

6.3 Heater and temperature control

An appropriate system maintains the cabinet and its contents at the specified temperature (see 10.1). The temperature shall be measured at least 100 mm from walls and radiant heat sources.

6.4 Spraying device

The device for spraying the salt solution comprises a supply of clean air, of controlled pressure and humidity, a reservoir to contain 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 the atomizing pressure shall be at an overpressure of 70 kPa^1 to 170 kPa . The pressure is typically $98 \text{ kPa} \pm 10 \text{ kPa}$ but can vary depending on the type of cabinet and atomizer used.

1) $1 \text{ kPa} = 1 \text{ kN/m}^2 = 0,01 \text{ atm} = 0,01 \text{ bar} = 0,145 \text{ psi}$.

In order to prevent the evaporation of water from the sprayed droplets (aerosol), the air shall be humidified before entering the atomizer by passing through a suitable humidifier. The humidified air shall be saturated such that the concentration of the fallout solution falls within the specifications of 5.1. The humidified air shall also be heated such that when mixed with the salt solution, there is no significant disturbance of the temperature in the cabinet. The appropriate temperature depends on the pressure used and on the type of atomizer nozzle. Temperature, pressure or humidification, or a combination thereof, shall be adjusted so that the rate of collection of the spray in the cabinet and the concentration of the collected spray are kept within the specified limits (see 10.3). A commonly used humidifier is the saturation tower, where temperature and pressure are controllable. Table 1 gives guiding values on temperature and pressure combinations for the saturation tower.

Table 1 — Guiding values for the temperature of the hot water in the saturation tower

Atomizing overpressure kPa	Guiding values for the temperature, in °C, of the hot water in the saturation tower when performing the different salt spray test	
	Neutral salt spray (NSS) and acetic acid salt spray (AASS)	Copper-accelerated acetic acid salt spray (CASS)
70	45	61
84	46	63
98	48	64
112	49	66
126	50	67
140	52	69
160	53	70
170	54	71

The atomizers shall be made of inert material. Baffles may be used to prevent direct impact of the spray on the test specimens, and the use of adjustable baffles is helpful in obtaining uniform distribution of the spray within the cabinet. For this purpose, a dispersion tower equipped with an atomizer may also be helpful.

The salt solution supplied to the nozzle shall be kept stable to ensure a continuous and uniform fall out as described in 10.3. A stable level of spraying can be achieved by either controlling the level of salt solution in the reservoir or restricting the flow of salt solution to the nozzle such that a continuous spray is achieved.

Distilled or deionized water with a conductivity not higher than 20 µS/cm at 25 °C ± 2 °C shall be used for humidification of spray air.

6.5 Collecting devices

At least two collecting devices shall be used to check the homogeneity of the spraying of the cabinet. Suitable funnels shall be made of chemically inert material, with the stems inserted into graduated cylinders or other similar containers and have a diameter of 100 mm, which corresponds to a collecting area of approximately 80 cm². The collecting devices shall be placed in the zone of the cabinet where the test specimens are placed, one close to an inlet of spray and one remote from an inlet. They shall be placed so that only mist, and not liquid falling from specimens or from parts of the cabinet, is collected.

6.6 Re-use

If the cabinet has been used once for an AASS or CASS test, or has been used for any other purpose with a solution differing from that specified for the NSS test, it shall not be used for the NSS test until a thorough cleaning procedure has been completed and the pH of collected solution has been verified