

Redline version
compares Second edition to
First edition



**Corrosion of metals and alloys —
Corrosion in artificial atmosphere —
Accelerated corrosion test involving
exposure under controlled conditions
of humidity cycling and intermittent
spraying of a salt solution**

*Corrosion des métaux et alliages — Corrosion en atmosphère
artificielle — Essai de corrosion accélérée comprenant des
expositions sous conditions contrôlées à des cycles d'humidité et à des
vaporisations intermittentes de solution saline*





Reference number
ISO 16701:redline:2015(E)

© ISO 2015

IMPORTANT — PLEASE NOTE

This is a mark-up copy and uses the following colour coding:

- | | |
|---|---|
| Text example 1 | — indicates added text (in green) |
| Text example 2 | — indicates removed text (in red) |
|  | — indicates added graphic figure |
|  | — indicates removed graphic figure |
| 1.x ... | — Heading numbers containg modifications are highlighted in yellow in the Table of Contents |

All changes in this document have yet to reach consensus by vote and as such should only be used internally for review purposes.

DISCLAIMER

This Redline version provides you with a quick and easy way to compare the main changes between this edition of the standard and its previous edition. It doesn't capture all single changes such as punctuation but highlights the modifications providing customers with the most valuable information. Therefore it is important to note that this Redline version is not the official ISO standard and that the users must consult with the clean version of the standard, which is the official standard, for implementation purposes.



COPYRIGHT PROTECTED DOCUMENT

© ISO 2015, Published in Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

Contents

Page

Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Reagent	2
4 Apparatus	3
4.1 Climate chamber	3
4.2 Spraying device	3
4.3 System for forced drying	3
5 Test objects	4
6 Procedure	4
6.1 Arrangement of the test objects	4
6.2 Exposure conditions of test cycle	5
6.3 Duration of test	8
6.4 Treatment of test objects after test	8
7 Evaluation of results	8
8 Test report	9
Annex A (informative) Recommended periods of testing	10
Annex B (informative) Suitable design of test apparatus with spraying device	12
Annex C (informative) Method for evaluation of corrosivity of test	15
Bibliography	17

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.

~~International Standards are~~ 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 ~~rules given in~~ editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

~~The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.~~

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 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](#)

~~ISO 16701 was prepared by Technical Committee~~ 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 16701:2003), of which it constitutes a minor revision.

Introduction

As an alternative to the continuous salt spray test methods of **Atmospheric corrosion of metallic materials, with or without corrosion protection** [ISO 9227](#)^[3], intermittent salt spray test methods may be used. The results of such tests provide a better correlation with the effects of exposure in environments where there is a significant influence of chloride ions, such as from a marine source or road de-icing salt is influenced by many environmental factors, the importance of which might vary with the type of metallic material and with the type of environment. It is therefore not possible to design a laboratory corrosion test in such a way that the full complexity of real in-service conditions are taken into account. Acceleration (forced conditions) as such can also have a negative impact on the correlation to field performance. Nevertheless, tests with humidity cycling and only intermittent exposure to salt solution will generally provide a better correlation to field performance than tests using continuous salt spray.

Accelerated corrosion tests to simulate atmospheric corrosion in such environments should include cyclic exposure to the following conditions:

- a) A wet phase, during which the test object is repeatedly subjected first to a spray of aqueous salt-containing solution then to a wet stand-by period during which residual wetness remains on the test object. This sequence provides a prolonged period of continuous exposure to wetness, extending over several hours.
- b) A phase of controlled cyclic humidity conditions, where the test object is subjected to an environment which alternates between high humidity and comparative dryness.

These two phases should be cycled for an appropriate number of times.

The test method described in this International Standard conforms with these requirements, as follows:

In the first (wet) phase of exposure, the test objects are sprayed for 15 min with a 1 % (mass fraction) aqueous solution of sodium chloride acidified to pH 4,2, to simulate the rather acidic precipitation present in industrialized areas, followed by a 1 h 45 min period of wet stand-by. This sequence is repeated three times to give a total of 6 h exposure to wetness. The whole of this first phase of the test cycle is repeated twice a week. If spraying is carried out more frequently or a more concentrated solution of sodium chloride is used during this phase, phenomena may appear that are seldom experienced in the field, e.g. severe diffusion blocking by red rust or excessive dissolution of zinc.

The major part of the test cycle, however, consists of humidity cycling between the two levels of 95 % RH and 50 % RH at a constant temperature of 35 °C. To simulate the wet phase of humidity cycling, the humidity level has been set close to the condensation limit, but at a level at which test conditions can be satisfactorily controlled. Introducing 100 % humidity conditions, inevitably results in loss of control of the amount of salt deposited on a test object.

The test method described in this International Standard 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 relative performance of materials exposed to salt-contaminated environments similar to those used in the test. See **This International Standard was developed in the automotive context, where the major contributor to corrosion is the use of winter time de-icing road salt in cool/cold temperate areas around the world, here as sodium chloride compounds acting in cyclic humidity conditions. The test procedure is moderately forced by humidity and salt and intended to be applicable for quality assurance of the metals and corrosion protections typically encountered in motor vehicles. The method can have relevance also in other areas of application, provided representing similar climatic conditions with an influence of sodium chloride compounds.**

iTeh STANDARD PREVIEW
(standards.iteh.ai)

Full standard:
<https://standards.iteh.ai/catalog/standards/sist/66836e9-e437-45aa-9a8b-9d65ae6348c7/iso-16701-2015>

Corrosion of metals and alloys — Corrosion in artificial atmosphere — Accelerated corrosion test involving exposure under controlled conditions of humidity cycling and intermittent spraying of a salt solution

1 Scope

This International Standard defines an accelerated corrosion test method, specifies the test method, the reagents, and the procedure to be used in assessing the corrosion resistance of metals in environments where there is a significant influence of chloride ions, mainly as sodium chloride from a marine source or road de-icing salt, an accelerated atmospheric corrosion test constituting a 6 h exposure to a slightly acidified solution of 1 % NaCl twice weekly, followed by a condition of controlled humidity cycling between 95 % RH and 50 % RH at a constant temperature of 35 °C.

This International Standard specifies the test apparatus and test procedure, does not specify the dimensions of the test specimens, the exposure period to be used in conducting the accelerated corrosion test to simulate, in a very controlled way, atmospheric corrosion conditions for a particular product, or the interpretation of the results. Such details are provided in the appropriate product specifications.

In this International Standard, the term “metal” includes metallic materials with or without corrosion protection.

The accelerated laboratory corrosion test applies to

- metals and their alloys;
- metallic coatings (anodic and/or cathodic);
- chemical conversion coatings; and
- organic coatings on metals and metallic materials.

The method is especially suitable for comparative testing in the optimization of surface treatment systems.

NOTE 1 If testing low-alloy stainless steels, especially austenitic grades, according to this International Standard, there is a risk of receiving exaggerated pitting, not representative for most service environments.

NOTE 2 This International Standard is not suitable for testing of wax and oil based rust protection agents, due to the constantly elevated temperature condition of the test.

2 Normative references

The following referenced documents, in whole or in part, are normatively referenced in this document and are indispensable for the application 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 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 4628-4, *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 8407, *Corrosion of metals and alloys — Removal of corrosion products from corrosion test specimens*

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*

3 Reagent

A salt solution, prepared by dissolving a sufficient mass of sodium chloride in distilled or deionized water to a concentration of $10 \text{ g l}^{-1} \pm 1 \text{ g l}^{-1}$. The distilled or deionized water used shall have a conductivity not higher than 2 mS m^{-1} at $25 \text{ °C} \pm 2 \text{ °C}$.

The maximum permissible amounts of impurities in the sodium chloride are given in [Table 1](#).

Table 1 — Maximum permissible amounts of impurities in the sodium chloride as calculated for dry salt

Impurity	Maximum mass-fraction of impurity %	Note
Copper (calculated for dry salt)	0,001	Determined by atomic absorption spectro-photometry or other method with similar accuracy
Nickel (calculated for dry salt)	0,001	
Sodium iodide	0,1	
Total	0,5	

Table 1 — Maximum permissible amounts of impurities in the sodium chloride as calculated for dry salt

Impurity	Maximum mass fraction of impurity %	Note
Copper (calculated for dry salt)	0,001	Determined by atomic absorption spectro-photometry or other method with similar accuracy
Nickel (calculated for dry salt)	0,001	
Sodium iodide	0,1	
Total	0,5	

Check the pH of the salt solution by using potentiometric measurement at $25 \text{ °C} \pm 2 \text{ °C}$. Finely adjust the pH of the salt solution to a value of $4,2 \pm 0,1$ by standard addition of a diluted sulphuric acid solution (e.g. 1 ml of $0,05 \text{ mol/L H}_2\text{SO}_4$ is added to 1 l of salt solution).

4 Apparatus

4.1 Climate chamber

The climate chamber shall be designed so that the following test conditions can be obtained, controlled and monitored during the test.

An instantaneous maximum deviation from set relative humidity value of $\pm 4\%$ in the range from 50 % to 95 % at 35 °C, which corresponds to a temperature accuracy requirement of $\pm 0,8\text{ °C}$ at that temperature. For the mean value in relative humidity during a period of constant climatic conditions 7 h to 8 h an accuracy of $\pm 2\%$ shall apply, corresponding to temperature accuracy requirement of in this case $\pm 0,4\text{ °C}$.

~~NOTE To meet the temperature and humidity accuracy requirements, the climate chamber should be equipped with means for efficient circulation of air to provide for small temperature and humidity variations in the chamber. Sufficient insulation of the chamber walls and lids are required in order to avoid excessive condensation on these surfaces.~~

To meet the temperature and humidity accuracy requirements, the climate chamber should be equipped with means for efficient circulation of air to provide for small temperature and humidity variations in the chamber. Sufficient insulation of the chamber walls and lids are required in order to avoid excessive condensation on these surfaces.

The climate chamber shall also be designed so that the relative humidity ~~may~~ can be changed linearly with respect to time from 95 % to 50 % within 2 h and back from 50 % to 95 % also within 2 h. [Figure B.1](#) shows a suitable design of climate chamber.

The humidity and temperature levels of the climate chamber during a test cycle shall be continuously monitored or regularly checked so that it can be confirmed that the relative humidity versus time for a complete test cycle is within the specified ranges at 95 % RH and 50 % RH. For measurement of the relative humidity use a hygrometer designed for measurements at high humidity levels, e.g. a high-quality combined temperature and capacitance humidity sensor or a gold mirror dewpoint meter. For measurement of temperature preferably use Pt 100 sensors.

4.2 Spraying device

The spraying device for salt solution installed in the climate chamber shall be capable of producing a finely distributed uniform vertical downward flow of mist or small droplets falling on the test objects at a linear flow rate of $15\text{ mm h}^{-1} \pm 5\text{ mm h}^{-1}$.

If a graduated glass cylinder with a collecting area of 80 cm^2 is used to check whether this flow rate is within the specified range, the collection rate of salt solution shall be $120\text{ ml h}^{-1} \pm 40\text{ ml h}^{-1}$.

The device for salt spraying is preferably made of a number of nozzles mounted in series on a rail or tube. A spray pattern in the form of a fan, partly overlapping, is then obtained. The spraying device shall be made of, or lined with, materials resistant to corrosion by the salt solution and which do not influence the corrosivity of the sprayed salt solution. The use of molybdenum-alloyed stainless steel or plastic is recommended. [Figure B.2](#) shows a suitable design of spraying device.

Salt solution that has already been sprayed shall not be re-used.

4.3 System for forced drying

The climate chamber shall be equipped with a system for forced ~~air flow~~ airflow drying, as after spraying/wet stand-by all test objects should be dried from excessive macro wetness and climate control shall be made possible to regain within a reasonable time.

Forced drying is preferably arranged by supercooling and reheating an internal circulating flow. Alternatively, drying ~~may~~ can be arranged by letting a forced flow of pre-heated ambient air ventilate the chamber. For a climate chamber of the volume 1 m^3 to 2 m^3 an ~~air flow~~ airflow rate of 50 ls^{-1} to 100 ls^{-1}

is recommended. The forced ~~air flow~~airflow shall not be pre-heated to such temperature levels that the maximum chamber temperature of 35 °C is exceeded.

NOTE Pre-heating of the forced ~~air flow~~airflow to a temperature of 40 °C has been found suitable from practical experience.

5 Test objects

5.1 The number and type of test objects, their shape and their dimensions shall be selected according to the specification for the material or product being tested. When not specified accordingly, these details shall be mutually agreed between the interested parties.

5.2 For each series of test objects, data records shall be kept and include the following information.

- a) Specification of material to be tested, e.g. for surface-treated materials: type of base material, its pretreatment, type of coating, method of application, and dry film thickness.
- b) If the test specimen is subjected to intentional damage in the coating, the shape and the location of the damage should be described, as well as how the damage was achieved. The orientation of the damage during testing should also be specified.

If the test objects are cut from a larger coated article, 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, stable under the conditions of the test, such as paint, wax or adhesive tape.

- c) Information on cleaning procedure to be used prior to testing.
- d) Information on reference material or materials with which the test specimen is to be compared.
- e) How the test object is to be examined and which properties are to be assessed, see [Clause 7](#).

~~If the test objects are cut from a larger coated article, 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, stable under the conditions of the test, such as paint, wax or adhesive tape.~~

- ~~c) Information on cleaning procedure to be used prior to testing.~~
- ~~d) Information on reference material or materials with which the test specimen is to be compared.~~
- ~~e) How the test object is to be examined and which properties are to be assessed, see e.g. [Clause 7](#).~~

6 Procedure

6.1 Arrangement of the test objects

The test objects shall be placed in the ~~cabinet~~chamber on stands with their test surface facing upwards. The angle at which the surface of the test specimens is exposed in the ~~cabinet~~chamber is important. For flat test objects the angle at which the test surface is inclined shall preferably be $20^\circ \pm 5^\circ$ to the vertical. In the case of irregular surfaces, e.g. entire components, this angle shall be adhered to as closely as possible.

The stands with the test objects shall be placed on the same level of the climate chamber. The stands shall be made of inert non-metallic material, such as glass, plastic or suitably coated wood. If it is necessary to suspend the test object, the material used shall on no account be metallic but shall be synthetic fibre, cotton thread, or other inert insulating material.