

---

**Korozija kovin in zlitin - Korozija v umetni atmosferi - Preskus pospešene korozije z izpostavljanjem nadzorovanim pogojem izmeničnega vlaženja in vmesnim pršenjem slanice (ISO/DIS 16701:2023)**

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 (ISO/DIS 16701:2023)

Korrosion von Metallen und Legierungen - Korrosion in künstlicher Atmosphäre - Beschleunigte Korrosionsprüfungen unter zyklischer Einwirkung von Luftfeuchte und intermittierendem Versprühen einer Salzlösung unter kontrollierten Bedingungen (ISO/DIS 16701:2023)

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 (ISO/DIS 16701:2023)

**Ta slovenski standard je istoveten z: prEN ISO 16701**

**ICS:**

77.060

Korozija kovin

Corrosion of metals

**oSIST prEN ISO 16701:2023**

**en,fr,de**



# DRAFT INTERNATIONAL STANDARD

## ISO/DIS 16701

ISO/TC 156

Secretariat: SAC

Voting begins on:  
2023-09-04Voting terminates on:  
2023-11-27

---

---

## 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*

ICS: 77.060

iTeh Standards  
(<https://standards.iteh.ai>)  
Document Preview

[oSIST prEN ISO 16701:2023](https://standards.iteh.ai/catalog/standards/sist/259d482d-4635-4a34-aa36-58db7ef7cf13/osist-pren-iso-16701-2023)

<https://standards.iteh.ai/catalog/standards/sist/259d482d-4635-4a34-aa36-58db7ef7cf13/osist-pren-iso-16701-2023>

This document is circulated as received from the committee secretariat.

THIS DOCUMENT IS A DRAFT CIRCULATED FOR COMMENT AND APPROVAL. IT IS THEREFORE SUBJECT TO CHANGE AND MAY NOT BE REFERRED TO AS AN INTERNATIONAL STANDARD UNTIL PUBLISHED AS SUCH.

IN ADDITION TO THEIR EVALUATION AS BEING ACCEPTABLE FOR INDUSTRIAL, TECHNOLOGICAL, COMMERCIAL AND USER PURPOSES, DRAFT INTERNATIONAL STANDARDS MAY ON OCCASION HAVE TO BE CONSIDERED IN THE LIGHT OF THEIR POTENTIAL TO BECOME STANDARDS TO WHICH REFERENCE MAY BE MADE IN NATIONAL REGULATIONS.

RECIPIENTS OF THIS DRAFT ARE INVITED TO SUBMIT, WITH THEIR COMMENTS, NOTIFICATION OF ANY RELEVANT PATENT RIGHTS OF WHICH THEY ARE AWARE AND TO PROVIDE SUPPORTING DOCUMENTATION.

**ISO/CEN PARALLEL PROCESSING**



Reference number  
ISO/DIS 16701:2023(E)

© ISO 2023

iTeh Standards  
(<https://standards.iteh.ai>)  
Document Preview

[oSIST prEN ISO 16701:2023](https://standards.iteh.ai/catalog/standards/sist/259d482d-4635-4a34-aa36-58db7ef7cf13/osist-pren-iso-16701-2023)

<https://standards.iteh.ai/catalog/standards/sist/259d482d-4635-4a34-aa36-58db7ef7cf13/osist-pren-iso-16701-2023>



**COPYRIGHT PROTECTED DOCUMENT**

© ISO 2023

All rights reserved. Unless otherwise specified, or required in the context of its implementation, 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  
CP 401 • Ch. de Blandonnet 8  
CH-1214 Vernier, Geneva  
Phone: +41 22 749 01 11  
Email: [copyright@iso.org](mailto:copyright@iso.org)  
Website: [www.iso.org](http://www.iso.org)

Published in Switzerland

# Contents

	Page
<b>Foreword</b> .....	<b>v</b>
<b>Introduction</b> .....	<b>vi</b>
<b>1 Scope</b> .....	<b>1</b>
<b>2 Normative references</b> .....	<b>1</b>
<b>3 Terms and definitions</b> .....	<b>1</b>
<b>4 Apparatus</b> .....	<b>2</b>
4.1 Basic properties of the climate test chamber.....	3
4.2 Supporting requisites and accessories.....	3
<b>5 Test method</b> .....	<b>4</b>
5.1 Test exposure conditions.....	4
5.2 Requirements on salt solution.....	10
5.3 Precipitation rate of salt solution.....	10
5.4 Start and end time of test.....	11
5.5 Duration of test.....	11
<b>6 Test object conditions</b> .....	<b>11</b>
6.1 Requirements on geometry and distribution.....	11
6.1.1 Test object orientation.....	11
6.1.2 Distribution of test objects.....	11
6.1.3 Mass and total exposed surface of test objects.....	11
6.1.4 Test object support.....	12
6.1.5 Test object exposure to salt spray.....	12
6.2 Test object preparation.....	12
6.2.1 Painted and scribed panels.....	12
6.2.2 Other test object geometries.....	13
6.2.3 Additional test conditions.....	13
<b>7 Requirements on quality control and calibration</b> .....	<b>13</b>
7.1 Overview.....	13
7.2 Climate control and calibration procedures.....	14
7.2.1 Definition of a climate deviation.....	14
7.2.2 Control procedure for basic compliance of test chamber.....	14
7.3 Control of salt solution precipitation.....	16
7.3.1 Spray rack according to the example in <a href="#">Annex B</a> .....	16
7.3.2 Other configurations for salt solution downfall.....	17
7.3.3 Visual control of spray patterns.....	18
7.4 Recommended schedule for quality control.....	18
7.4.1 Control before test start.....	18
7.4.2 Workday inspection.....	18
7.4.3 Weekly inspection.....	18
7.4.4 6-month controls.....	18
7.4.5 Annual calibration and verification.....	19
7.5 Deviation handling.....	19
7.5.1 General.....	19
7.5.2 Test interruption.....	19
<b>8 Evaluation of results</b> .....	<b>19</b>
<b>9 Test report</b> .....	<b>20</b>
<b>Annex A (normative) Requirements on test equipment</b> .....	<b>21</b>
<b>Annex B (informative) Application of salt containing solution</b> .....	<b>25</b>
<b>Annex C (informative) Guidelines on devices for independent, stand-alone temperature and humidity monitoring</b> .....	<b>26</b>

## ISO/DIS 16701:2023(E)

<b>Annex D (normative) Temperature/humidity control procedures</b> .....	<b>27</b>
<b>Annex E (informative) Guiding information about the test method</b> .....	<b>31</b>
<b>Bibliography</b> .....	<b>39</b>

# iTeh Standards (<https://standards.iteh.ai>) Document Preview

[oSIST prEN ISO 16701:2023](https://standards.iteh.ai/catalog/standards/sist/259d482d-4635-4a34-aa36-58db7ef7cf13/osist-pren-iso-16701-2023)

<https://standards.iteh.ai/catalog/standards/sist/259d482d-4635-4a34-aa36-58db7ef7cf13/osist-pren-iso-16701-2023>

## 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](http://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](http://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 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](http://www.iso.org/iso/foreword.html).

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

This third edition is a complete technical revision of the second edition (ISO 16701:2015), which it replaces.

The main changes are as follows:

- The test cycle has been revised with the same intended acceptance criteria to improve field correlation and reproducibility, when performed in various exposure chambers
- An alternative cycle with alternating temperature in the climate cycling (constant dew point instead of constant temperature) is introduced. It is a modification of the so called ACT1 (originally Volvo Standard 423-0014), however within the same scope and intended acceptance criteria.
- Extensive requirements and guidelines on quality assurance of test equipment and control procedures have been incorporated, mainly as normative and informative annexes.

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](http://www.iso.org/members.html).

## ISO/DIS 16701:2023(E)

### Introduction

Atmospheric corrosion of metallic materials, with or without corrosion protection, is influenced by many environmental factors, the importance of which may 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 complexity and variations of real in-service conditions are fully represented. Acceleration (forced conditions) as such may also have a negative impact on the correlation to field performance. Nevertheless, tests with humidity cycling and only intermittent exposure to a salt solution will provide a better correlation to field performance than tests using continuous salt spray.

This document was developed in the automotive context, where the major contributor to corrosion is the use of wintertime de-icing road salt in cool/cold temperate areas around the world, here represented by sodium chloride depositions 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<sup>[1]</sup> to<sup>[4]</sup>. The method may have relevance also in other areas of application, provided representing similar climatic conditions with an influence of sodium chloride depositions<sup>[5]</sup><sup>[6]</sup>.

## iTeh Standards (<https://standards.iteh.ai>) Document Preview

[oSIST prEN ISO 16701:2023](https://standards.iteh.ai/catalog/standards/sist/259d482d-4635-4a34-aa36-58db7ef7cf13/osist-pren-iso-16701-2023)

<https://standards.iteh.ai/catalog/standards/sist/259d482d-4635-4a34-aa36-58db7ef7cf13/osist-pren-iso-16701-2023>



# 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 document defines a laboratory accelerated corrosion test method in two closely related variants. They are used in assessing the corrosion resistance of metals in environments where there is a significant influence of chloride ions, mainly as sodium chloride from e.g., winter road de-icing salt. The test variants contain humidity dynamics in proportions found in outdoor environments affected by corrosion and are balanced to receive realistic proportions of corrosion rates between various commonly occurring materials, coatings and engineering designs. 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 in which it may be used. Nevertheless, the method provides information on the relative corrosion resistance of a material exposed to a salt-contaminated environment with varying humidity conditions. The two accelerated laboratory corrosion test variants are applicable to:

- metals and their alloys (ferrous and non-ferrous);
- metallic coatings;
- chemical conversion coatings;
- organic coating on metals;
- a combination of materials and coatings that include galvanic interactions and/or crevice conditions.

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

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

NOTE 3 This document does not specify the dimensions of the tests specimens, the exposure period to be used for a particular product, or the interpretation of the results. Such details are provided in the appropriate product specifications.

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

ISO 9227, *Corrosion tests in artificial atmospheres — Salt spray tests*

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

## ISO/DIS 16701:2023(E)

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

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

### 3.1

#### **step**

individual test climate operation, such as a linear climate ramp between two temperatures/humidities, constant conditions during a defined time period or spraying with salt solution

### 3.2

#### **sequence**

a series of *steps* (3.1), here in 12 h and 24 h schemes

Note 1 to entry: Sequences can be handled as subroutines when programming the test

### 3.3

#### **sub-cycle**

*sequence* (3.2) when run in a repeated mode

### 3.4

#### **test cycle**

full weekly (168 h) series of different *sub-cycles* (3.3), to be repeated for a stipulated number of weeks

### 3.5

#### **test area**

area within a test chamber (usually horizontal and designed as a structure open to air circulation) onto which test objects and their possible fixtures are supported

### 3.6

#### **approved test area**

part of the test area where the test conditions are fulfilled regarding climate and downfall of salt solution

### 3.7

#### **test space**

volume defined by the *test area* (3.5) times the permissible height to which the test object may extend without compromising the stipulated uniformity of the test conditions

### 3.8

#### **approved test space**

*approved test area* (3.6) times the height where the test conditions are fulfilled regarding climate and downfall of salt solution

### 3.9

#### **Tolerance span**

The tolerance spans for set temperature and relative humidity define the permissible deviation ranges for the achieved momentaneous value relative the programmed set value at any time increment

## 4 Apparatus

The climate test chamber shall offer a design so that the requirements on the test conditions in [Clause 5](#) can be obtained and controlled within the permissible range according to the procedures in [Clause 7](#). The chamber test area and test space where these conditions are fulfilled are hence defined as the approved test area and approved test space, respectively. Normative requirements and guidelines on the test chamber design, applicable for manufacturing and at purchasing, are found in [Annex A](#), including an exemplifying guiding illustration.

#### 4.1 Basic properties of the climate test chamber

For a fully automated procedure, the chamber shall be equipped with a spray device capable of producing a uniformly distributed spray of salt solution falling onto the test objects at a rate defined in 5.3. This can be performed by installing a swaying rail or tube equipped with flat-spraying nozzles as depicted in Annex B. Other technical solutions are permissible, provided meeting the downfall requirements.

#### 4.2 Supporting requisites and accessories

The following requisites and accessories are necessary to perform the test method:

- Compressed, oil-free, clean air for humidification (if supplied by spray humidifiers), for cleaning salt solution from spray nozzles and as a source for the renewal of chamber air. The supplier of the equipment shall stipulate the specific requirements of the compressed air supply and may additionally include special requirements, such as that it should meet ISO 8573-1, class 4 or better<sup>[7]</sup>.
- A low-conductivity water supply for humidification or evaporative spray humidifiers and for the preparation of salt solutions. The requirement on water quality for the equipment shall be set by the supplier of the equipment. From corrosion testing standpoint it is sufficient to be below 20 µS/cm. If the humidification of the test chamber is supplied by high-pressure nozzle(s), the acceptable conductivity of the water can be as low as 5 µS/cm to secure the long-term performance of nozzles and heaters;
- A tank for preparation and storage of salt solution or, alternatively, a system for direct on-line mixing of water, saturated NaCl solution and, if applicable, diluted sulphuric acid to be contained within the stipulated concentration and tolerances;
- A conductivity meter with built-in temperature compensation for preparation and control of the salt solution;
- A standard pH-meter, with a glass-electrode for weak electrolytes, to be regularly calibrated at pH = 7 and pH = 4;
- Sodium chloride according to the specification in ISO 9227, or a vacuum salt of min 99,9 % purity without sodium iodide addition and supplied as grain salt. Food-grade concentrations of added anti-caking agents are then permissible. [prEN ISO 16701:2023](https://standards.iteh.ai/catalog/standards/sist/259d482d-4635-4a34-aa36-58db7ef7cf13/osist-pren-iso-16701-2023)
- Sulphuric acid of reagent grade;  
 WARNING — Sulfuric Acid (CAS no. 7664-93-9<sup>1)</sup>) solution causes severe skin burns and eye damage. Refer to Safety Data Sheet for details. Handling of sulfuric acid solution shall be restricted to skilled personnel or conducted under their control.  
 For accuracy, safety and convenience it is recommended to use commercially available ampoules of diluted sulfuric acid (titration reagent, e.g. "Titrisol"<sup>2)</sup>) as source for the preparation of the solution. One litre of a 0,5 M sulphuric acid solution prepared this way is sufficient for the acidification of 10 m<sup>3</sup> of ready salt solution. In the unlikely need to adjust up the pH of the ready salt solution, then use diluted sodium hydroxide. For safety reasons it is recommended to prepare the solution from commercially available titration ampoules. A 0,01 M solution is convenient.
- A device for independent monitoring of temperature and relative humidity shall be accessible according to the options given in Annex C. This instrument shall on stipulated intervals be used for independent monitoring and calibration of the climate in the test space of the exposure chamber (Annex D);

1) CAS Registry Number® is a trademark of American Chemical Society. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

2) Titrisol® is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named

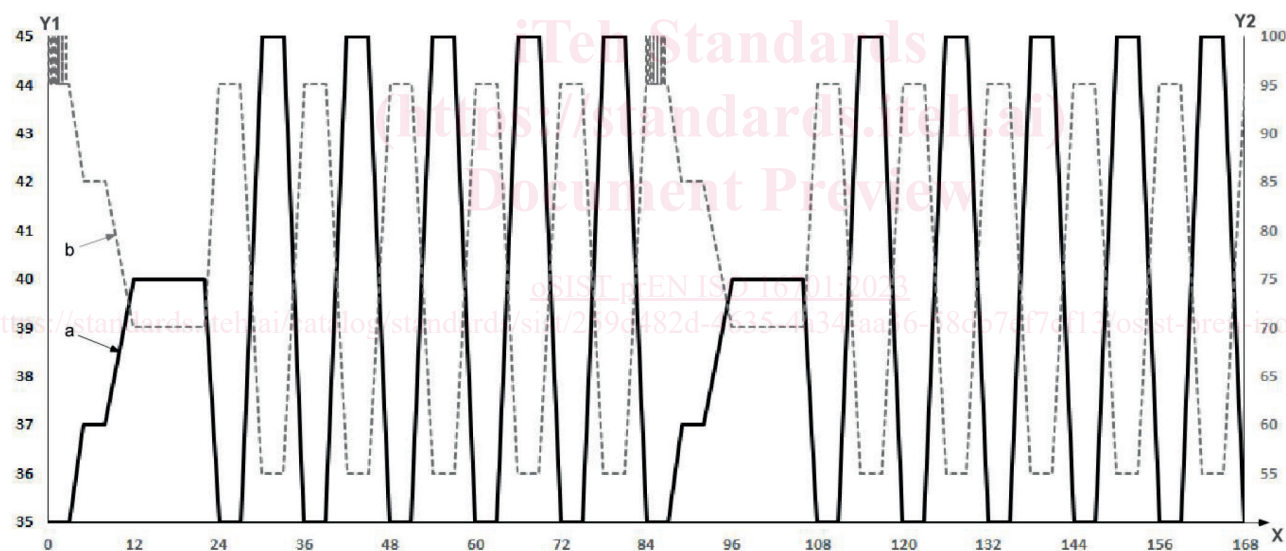
## ISO/DIS 16701:2023(E)

- Racks of inert material for support and aligned fixation of test object, which must not hamper a free airflow around the test objects, nor collect standing wetness. Further requirements are found in [Clause 6](#);
- Funnels, beakers/measuring glasses and a balance with at least 0,1 g accuracy for monitoring and calibration of salt solution downfall throughout the test plane of the exposure chamber.

## 5 Test method

### 5.1 Test exposure conditions

There are two variants of the test procedure, here denoted A and B. [Figure 1](#) shows overviews of the weekly patterns of temperature and relative humidity for the variants. In variant A the humidity cycling is run with a counter temperature cycling to receive approximately constant absolute humidity/dew point. This is in line with outdoor day and night conditions. Variant B runs with constant temperature during the humidity cycling and is recommended when heavy test objects are exposed. In both test variants a sequence of intermittent spray with salt solution followed by a slow gradual drying-up for several hours is applied twice weekly (see [Figure 2](#)). This 24-h sequence is identical for variant A and B, except for the last 2 h, connecting to a series of repeated 12-h climate cycles, different for variants A and B (see [Figure 3](#)), followed by a new 24-h sequence with spray, and so on. A chosen one-week (168 h) cycle is then repeated for a stipulated number of weeks (typically six weeks) to form a complete atmospheric corrosion test. The background and rationales behind the two test variants and guidelines when to use which are found in [Annex E](#). [Tables 1](#) and [2](#) list the detailed exposure conditions step by step for each test variant independently.



a) Weekly overview of Test variant A