
**Corrosion of metals and alloys —
Accelerated cyclic test with exposure
to acidified salt spray, dry and wet
conditions**

Corrosion des métaux et alliages — Essais cycliques accélérés avec exposition au brouillard salin acidifié, en conditions «sèches» et en conditions «humides»

STANDARDSISO.COM : Click to view the full PDF of ISO 16151:2018



STANDARDSISO.COM : Click to view the full PDF of ISO 16151:2018



COPYRIGHT PROTECTED DOCUMENT

© ISO 2018

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
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	2
4 Test solution	2
4.1 General	2
4.2 Method A	2
4.2.1 Neutral sodium chloride solution	2
4.2.2 Preparation of the acidified-salt solution	2
4.3 Method B	3
4.3.1 Preparation of the mixed salt solution	3
4.3.2 Preparation of the acidic solution	3
4.3.3 Preparation of the acidified-salt solution	3
5 Apparatus	3
6 Test specimens	5
7 Arrangement of the test specimen	5
8 Operating condition	6
9 Continuity of tests	8
10 Duration of the tests	8
11 Treatment of test specimens after test	8
11.1 General	8
11.2 Non-organic coated test specimens: metallic and/or inorganic coated	8
11.3 Organic coated test specimens	8
11.3.1 Scribed organic coated test specimens	8
11.3.2 Organic coated but not scribed test specimens	9
12 Evaluation of results	9
13 Test report	9
Annex A (informative) Relationship between amounts of acidic stock solution added to mixed salt solution and pH of the resulting acidified-salt solution	11
Annex B (informative) Typical apparatus for accelerated cyclic tests with exposure to acidified salt spray, dry and wet conditions	12
Annex C (informative) Method for evaluation of the corrosivity of the apparatus	14
Annex D (normative) Preparation of test specimens with organic coatings for testing	16
Annex E (normative) Required supplementary information for testing test specimens with organic coatings	17
Bibliography	18

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 second edition cancels and replaces the first edition (ISO 16151:2005), which has been technically revised. The main technical changes are as follows:

- harmonization with ISO 9227;
- terms and definitions clause has been added.

Introduction

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 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, which enhance the corrosion of metallic materials.

The accelerated corrosion-test methods described in this document are designed to simulate and enhance the environmental influence on a metallic material to outdoor climates, where exposure to acid rain and to salt-contaminated conditions occur and may promote corrosion. It has been prepared by reference to technical papers and reports (see the Bibliography).

The test methods involve cyclic exposure of test specimens to a mist of acidified salt solution, to drying conditions, and to periods of high humidity. However, the methods are 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 in which they may be used. Nevertheless, the methods provide valuable information on the relative performance of materials exposed to salt and/or acid rain environments similar to those employed in the test.

STANDARDSISO.COM : Click to view the full PDF of ISO 16151:2018

Corrosion of metals and alloys — Accelerated cyclic test with exposure to acidified salt spray, 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 two accelerated corrosion-test procedures, Methods A and B, for the comparative evaluation of metallic materials with or without permanent corrosion protection or temporary corrosion protection in outdoor salt and/or acid rain environments. It also specifies the apparatus used. The two tests involve cyclic exposure of the specimens to acidified salt spray, “dry” and “wet” conditions.

The particular advantages of the two tests over conventional accelerated tests, such as the neutral salt spray (NSS) test as specified in ISO 9227 lie in their better ability to reproduce the corrosion that occurs in outdoor salt and/or acid rain environments. They are also useful for evaluating cosmetic corrosion.

Method A is applicable to

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

Method B is applicable to

- steel coated with anodic coatings, and
- steel coated with anodic coatings covered with conversion coatings.

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 <http://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 the solutions used in Methods A and B are given in 4.2 and 4.3.

4.2 Method A

4.2.1 Neutral sodium chloride solution

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

4.2.2 Preparation of the acidified-salt solution

The pH of the solution shall be adjusted to a value of $3,5 \pm 0,1$ at $25^\circ\text{C} \pm 2^\circ\text{C}$, by adding the following reagents to 10 l of the prepared neutral sodium chloride solution in 4.2.1 as follows:

- 12 ml of nitric acid (HNO_3 , $\rho = 1,42 \text{ g/ml}$);
- 17,3 ml of sulfuric acid (H_2SO_4 , $\rho = 1,84 \text{ g/ml}$);
- a sufficient quantity of 10 % mass fraction of sodium hydroxide (NaOH) solution, to adjust the pH of the solution to $3,5 \pm 0,1$ (about 300 ml will be required).

4.3 Method B

4.3.1 Preparation of the mixed salt solution

The reagent shown in [Table 1](#) shall be dissolved 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 stock solution with a concentration of $36,0 \text{ g/l} \pm 3,6 \text{ g/l}$. It shall be diluted by 1:6 to produce a mixed salt solution with a concentration of $6,0 \text{ g/l} \pm 0,6 \text{ g/l}$.

Table 1 — Composition and concentration of a stock solution for a mixed salt solution

Reagent	Concentration g/l
NaCl	24,53
MgCl ₂	5,20
Na ₂ SO ₄	4,09
CaCl ₂	1,16
KCl	0,695
NaHCO ₃	0,201
KBr	0,101
H ₃ BO ₃	0,027
SrCl ₂	0,025
NaF	0,003
WARNING — Handling of SrCl ₂ and NaF can be hazardous and shall be restricted to skilled chemists or conducted under their control.	
NOTE The composition of the stock solution is the same as typical synthetic ocean water shown in ISO 11130.	

4.3.2 Preparation of the acidic solution

To prepare the acidic solution, 16,2 g of concentrated nitric acid (HNO₃, $\rho = 1,40 \text{ g/ml}$, with a mass fraction of HNO₃ equal to 0,65) and 42,5 g of sulfuric acid (H₂SO₄, $\rho = 1,84 \text{ g/ml}$, with a mass fraction of H₂SO₄ equal to 0,96) shall be dissolved in water and diluted to a total volume of 1 l to make 1 N acid solution with respect to nitric acid and sulfuric acid at an equivalent ratio of $[\text{NO}_3^-]/[\text{SO}_4^{2-}]$ of 0,4.

4.3.3 Preparation of the acidified-salt solution

The prepared acidic solution from [4.3.2](#) shall be added to the mixed salt solution from [4.3.1](#) to adjust the pH to $2,5 \pm 0,1$ at $25 \text{ }^{\circ}\text{C} \pm 2 \text{ }^{\circ}\text{C}$.

NOTE The relationship between the amount of mixed acidic solution from [4.3.2](#) and the pH of the acidified-salt solution is shown in [Annex A](#). This solution, with pH value near to 2,5, would have a no-buffering action.

5 Apparatus

5.1 Component protection.

All components in contact with the 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 Test cabinet.

The test cabinet shall be such that the conditions of homogeneity and distribution of the spray are met. Due to the limited capacity of test cabinets smaller than 0,4 m³. 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 rate of collection 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 accelerated cyclic tests with exposure to acidified salt spray, "dry" and "wet" conditions is shown in [Annex B](#).

5.3 Humidity and temperature control.

The temperature and humidity control system of the test cabinet shall be capable of achieving the test condition transition times listed in [8.1](#) when the test cabinet is filled with flat substitute specimens having a dimension of 150 mm × 70 mm × 1 mm.

5.4 Spraying device.

The device for spraying the acidified-salt solution shall comprise a supply of clean air, of controlled pressure and humidity, 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 the atomizing pressure 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.

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

5.5 Air saturator.

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

During periods of exposure to the acidified-salt solution 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 within the specified limits (see [8.2](#)). The level of water shall be maintained automatically to ensure adequate humidification.

5.6 Collecting devices.

At least two suitable collecting devices shall be available, consisting of clean funnels with a collecting area of approximately 80 cm², 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, at least one close to the spray inlet and one remote from the 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.

5.7 Air dryer.

A heating device and fan shall supply dried air of the specified humidity during "dry" periods (see [8.1](#)).

5.8 Exhaust system.

The system by which air is exhausted from the test cabinet shall not be influenced by the back pressure of the atmosphere when the air is released at a point outside the building. It is preferred that the apparatus has a means to properly treat the fog prior to releasing it outside the building (see [Annex B](#)).

5.9 Drain system.

An appropriate system to treat the drain water shall be provided, so that the solution is not directly discharged into the drainage system (see [Annex B](#)).

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 D](#) describes how test specimens with organic coatings shall be prepared for testing. [Annex E](#) 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 specimen

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, for example 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 downward falling 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 specimens placed below them. 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, plastics or other 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 condition

8.1 The test conditions used shall be in accordance with those given in [Table 2](#) for Method A and [Table 3](#) for Method B.

Table 2 — Test conditions in Method A

1	Acidified salt mist conditions 1) Temperature 2) Acidified-salt solution	35 °C ± 1 °C pH 3,5 ± 0,1, salt concentration 50 g/l ± 5 g/l as described in 4.2
2	“Dry” conditions 1) Temperature 2) Relative humidity	60 °C ± 1 °C < 30 %
3	“Wet” conditions 1) Temperature 2) Relative humidity	50 °C ± 1 °C > 95 %
4	Length and composition of a single exposure cycle	Total period 8 h: Acidified salt mist 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 conditions (i.e. time taken for temperature and humidity to reach the specified values once the test conditions have been changed)	“Mist” to “Dry” < 30 min “Dry” to “Wet” < 15 min “Wet” to “Mist” < 30 min (“Mist” conditions shall be attained almost instantaneously after changing to these conditions)
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.

Table 3 — Test condition in Method B

1	Acidified salt mist conditions 1) Temperature 2) Acidified-salt solution	35 °C ± 1 °C pH 2,5 ± 0,1, salt concentration 6,0 g/l ± 0,6 g/l as described in 4.3
2	“Dry” conditions 1) Temperature 2) Relative humidity	60 °C ± 1 °C < 30 %
3	“Wet” conditions 1) Temperature 2) Relative humidity	40 °C ± 1 °C (85 ± 5) %
4	Length and composition of a single exposure cycle	Total period 8 h: Acidified salt mist 1 h “Dry” conditions 4 h “Wet” conditions 3 h (These times include the time for reaching the specified temperature for each condition)
5	Time to reach the specified conditions (i.e. time taken for temperature and humidity to reach the specified values once the test conditions have been changed)	“Mist” to “Dry” < 30 min “Dry” to “Wet” < 15 min “Wet” to “Mist” < 30 min (“Mist” conditions shall be attained almost instantaneously after changing to these conditions)
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 In Method A, 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 acidified salt mist condition, the collection rate of solution measured over a period of 24 h of continuous spraying is within the range 1,5 ml/h ± 0,5 ml/h for a horizontal collecting area of 80 cm² 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 in the range 3,4 to 3,6.

In Method B, 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 continuously operated in the acidified salt mist condition, the collection rate of solution measured over a period of 24 h of continuous spraying is within the range 1,5 ml/h ± 0,2 ml/h for a horizontal collecting area of 80 cm² and that other conditions are as specified. In particular, the solution collected in the collecting devices shall have a salt concentration of 6,0 g/l ± 0,6 g/l and a pH in the range 2,4 to 2,6.

NOTE In Method B, as the test period for the acidified-salt solution mist in the accelerated cycle is only 1 h and the corrosion resistance of steels is so sensitive to salt concentration, it is necessary to control the collection of solution more strictly.

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

8.4 During the test, changes of test cabinet pressure shall be avoided.

8.5 To check the reproducibility of the test results, the corrosivity of the apparatus shall be verified at regular intervals. A suitable method for the evaluation of the corrosivity of the apparatus by use of reference specimens is described in [Annex C](#).

8.6 During operation, the solution tank shall be covered by a lid to prevent dust or other contaminants from influencing the solution and to prevent the concentration of sodium chloride and the pH from fluctuating.

9 Continuity of tests

Tests shall preferably be continued without interruption throughout the test duration. When it is necessary to interrupt the operation for the removal of specimens for inspection, the period of interruption shall be minimized. In case of interruption for a longer period, its cause, duration and treatment used shall be stated to the test report.

10 Duration of the tests

The period of test shall be as designated by the specification covering the material or product being tested. When not specified, the period shall be agreed by the interested parties.

Recommended periods of test are as follows:

- a) for Method A: 3 cycles (24 h), 6 cycles (48 h), 12 cycles (96 h), 30 cycles (240 h), 45 cycles (360 h), 60 cycles (480 h), 90 cycles (720 h), 180 cycles (1 440 h);
- b) for Method B: 12 cycles (96 h), 24 cycles (192 h), 36 cycles (288 h), 60 cycles (480 h), 96 cycles (768 h), 192 cycles (1 536 h).

11 Treatment of test specimens after test

11.1 General

How to treat test specimens after testing shall be included in the test specification or material specification given by the customer. It shall be agreed with the test parties before starting the test.

11.2 Non-organic coated test specimens: metallic and/or inorganic coated

At the end of the test period, remove the test specimens from the test cabinet and allow them to dry for 0,5 h to 1 h before rinsing, in order to reduce the risk of removing corrosion products. Before they are examined, carefully remove the residues of spray solution from their surfaces. A suitable method is to rinse the test specimens gently in clean running tap water, at a temperature not exceeding 40 °C, and then to dry them immediately in a stream of air, at an overpressure not exceeding 200 kPa and at a distance of approximately 300 mm.

NOTE ISO 8407 can be used for treatment of the specimen after the test.

11.3 Organic coated test specimens

11.3.1 Scribed organic coated test specimens

Clean the surface of the organic coated test specimens under running tap water directly after removing the test specimens out of the test cabinet. A soft sponge may be used to remove dirt and salt rests out

of the scribed area but not to remove evaluable corrosion phenomena. Remove the delaminated area around the scribe by one of the following methods.

- a) Using a knife. Carefully remove the loose coating using a knife blade held at an angle, positioning the blade at the interface between the coating and the substrate and forcing the coating away from the substrate.
- b) Using an adhesive tape.

NOTE Removing the organic coating (paint coating) depends on the kind of coating (paint) and its behaviour in wet conditions. If agreed by the interested parties, let the test specimens dry in room atmosphere for 24 h and then treat them as described under a) and b).

11.3.2 Organic coated but not scribed test specimens

Coated but not scribed test specimens shall be cleaned under running tap water so that corrosion products and/or corrosion phenomena which have to be evaluated are not influenced by cleaning.

12 Evaluation of results

Many different criteria for the evaluation of the test results may be applied to meet particular requirements, for example:

- a) appearance after the test;
- b) appearance after removing superficial corrosion products;
- c) number and distribution of corrosion defects, i.e. pits, cracks, blisters, rusting or creep from scribes in the case of organic coatings be assessed by methods described in ISO 8993 or ISO 10289 and, for organic coatings in ISO 4628-1, ISO 4628-2, ISO 4628-3, ISO 4628-4, ISO 4628-5 and ISO 4628-8 (see [Annex E](#));
- d) the time elapsed before the appearance of the first signs of corrosion;
- e) changes in mass (in accordance with ISO 8407);
- f) alteration revealed by micrographic examination;
- g) changes in mechanical or electrical properties.

NOTE It is good engineering practice to define the appropriate criteria in the specification for a coating or a product to be tested.

13 Test report

The test report shall provide the following information:

- a) reference to this document, i.e. ISO 16151:2018;
- b) type and purity of salt and water used;
- c) description of the test equipment;
- d) description of the material or product tested;
- e) dimensions and shape of the test specimen, and the nature and area of the surface tested;
- f) details of the preparation of the test specimen, including any cleaning treatment applied before testing and any protection given to edges or other special areas;
- g) known characteristics of any coating, with an indication of the surface, if required;

- h) number of test specimens subjected to the test representing each material or product;
- i) angle at which the tested surfaces were inclined;
- j) temperature and relative humidity in each of the acidified-salt solution mist, “dry” and “wet” conditions during the test;
- k) the time taken to undergo the transitions from “mist” condition to “dry”, “dry” to “wet”, and “wet” to “mist” conditions during the test;
- l) mist collection rate, salt concentration, and pH of the solution collected during the pre-test;
- m) the frequency and duration of any interruptions;
- n) the number of cycles or the duration of the test;
- o) the frequency and number of test specimen location permutation, if required;
- p) the method used to clean the test specimens after testing and, where appropriate, an indication of the mass loss resulting from the cleaning operation and the method used for correcting for this mass loss;
- q) test results (see [Clause 12](#));
- r) if necessary, photographic records and/or descriptions of the appearance of tested specimens;
- s) any deviation from test procedure;
- t) any unusual features observed;
- u) the date of the test.

Annex A

(informative)

Relationship between amounts of acidic stock solution added to mixed salt solution and pH of the resulting acidified-salt solution

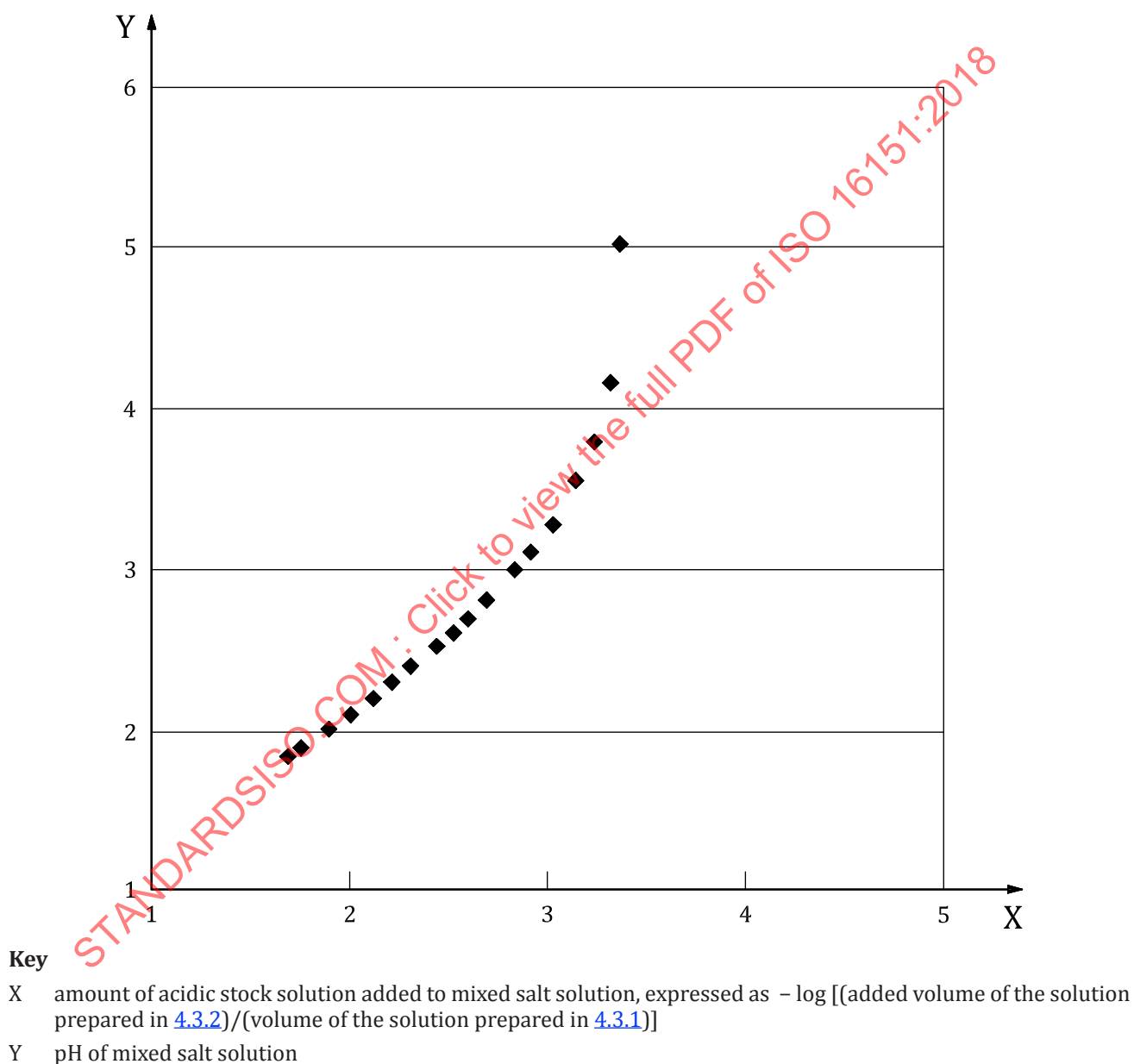
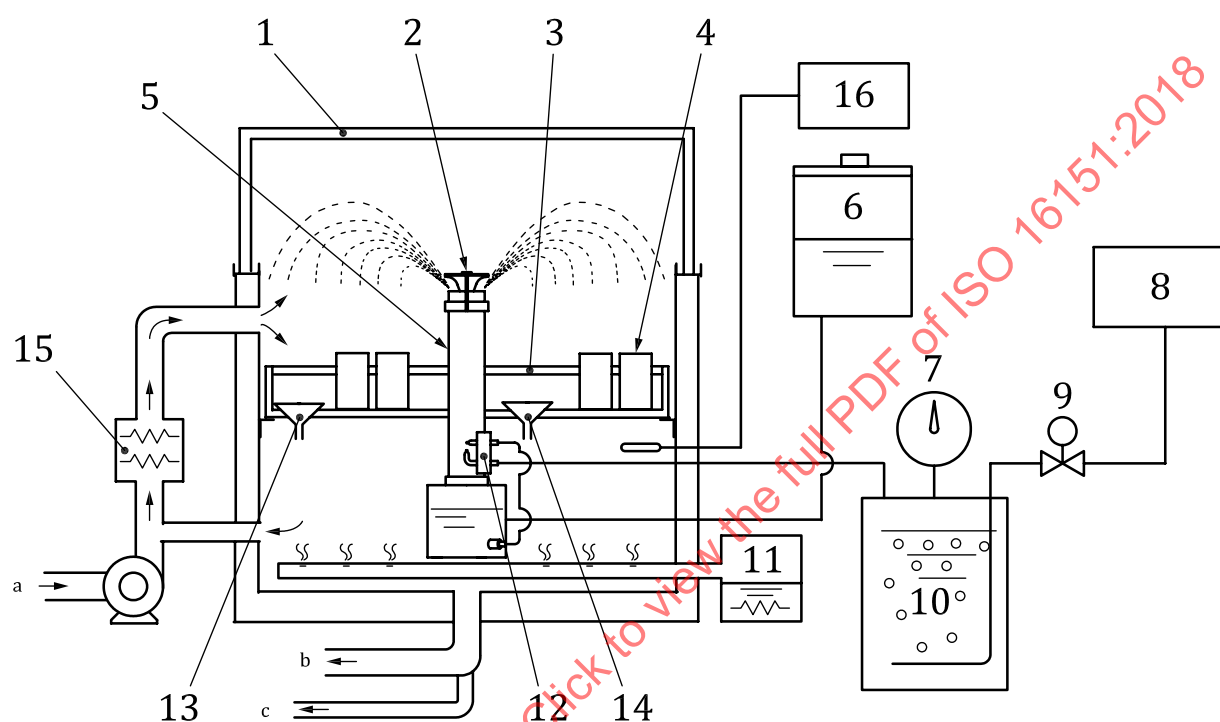


Figure A.1 — Relationship between amounts of acidic stock solution added to mixed salt solution and pH of the resulting acidified-salt solution

Annex B (informative)

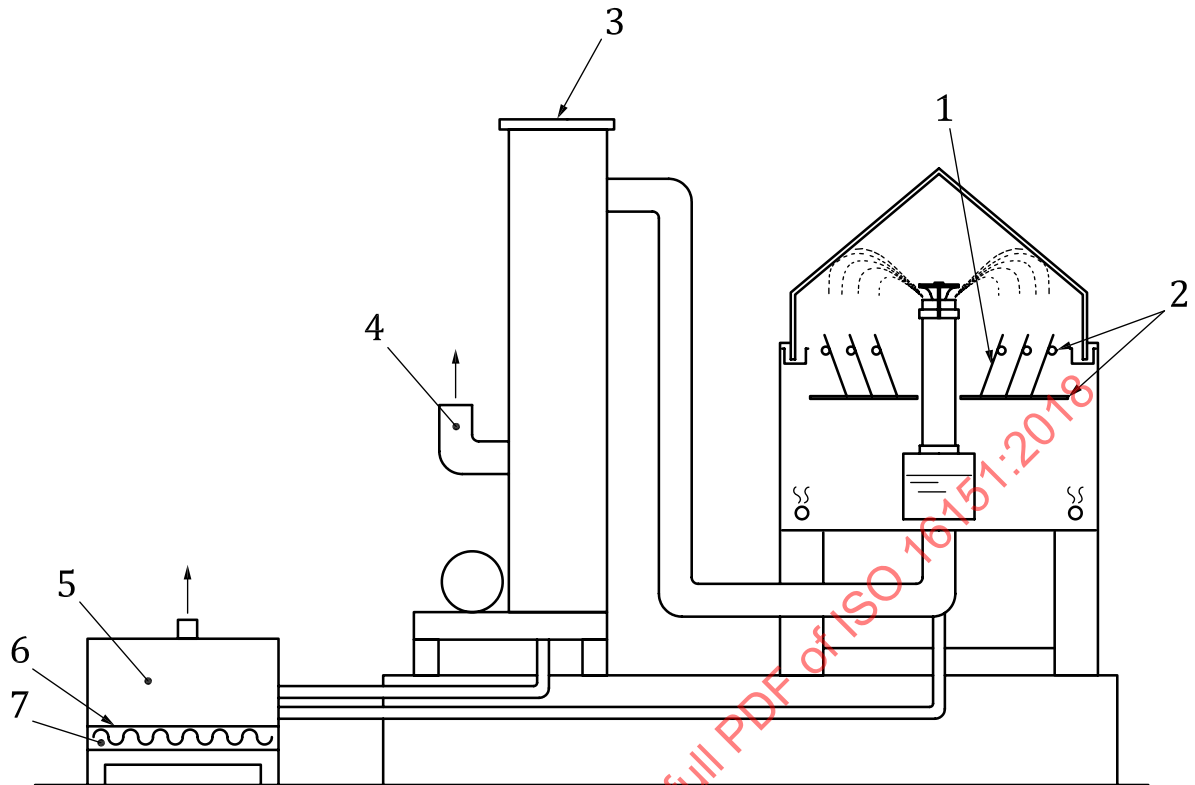
Typical apparatus for accelerated cyclic tests with exposure to acidified salt spray, dry and wet conditions



Key

- | | |
|--------------------------|--|
| 1 cover | 11 humidifier |
| 2 adjustable baffle | 12 atomizer |
| 3 test specimen supports | 13 collecting device (remote from an inlet of spray) |
| 4 test specimen | 14 collecting device (close to an inlet of spray) |
| 5 mist-dispersion tower | 15 air dryer |
| 6 solution tank | 16 temperature controls |
| 7 pressure gauge | a air-inlet port |
| 8 compressed air | b air-outlet port |
| 9 solenoid valve | c water |
| 10 air saturator | |

Figure B.1 — Typical apparatus for accelerated cyclic tests (front view)

**Key**

- 1 test specimen
- 2 test specimen support
- 3 exhaust air treatment unit
- 4 air-outlet port
- 5 drain-treatment unit
- 6 salt tray
- 7 heating elements

Figure B.2 — Typical apparatus for accelerated cyclic tests (side view)

Annex C **(informative)**

Method for evaluation of the corrosivity of the apparatus

C.1 Reference specimens

To verify the corrosivity of the apparatus, at least four reference specimens made of steel should be used.

The reference specimen should be made of CR 4 grade steel according to ISO 3574, with a surface free from pores, slight marks and scribes, and with a mat finish (arithmetical mean deviation of the profile $Ra = 0,8 \mu\text{m} \pm 0,3 \mu\text{m}$). The reference specimen made of steel should have a dimension of $1,0 \text{ mm} \pm 0,2 \text{ mm}$ thickness and $150 \text{ mm} \times 70 \text{ mm}$. Cut these reference specimens from cold-rolled plates or strips.

As a complement to the reference specimens made of steel, at least four reference specimens of zinc with an impurity level of less than 0,1 %, in mass fraction, may be used. The reference specimens made of zinc should have dimensions of $50 \text{ mm} \times 100 \text{ mm} \times 1 \text{ mm}$.

The reference specimens should be carefully cleaned immediately before testing. Cleaning should eliminate all those traces (dirt, oil or other foreign matter) which could influence the test results.

Thoroughly clean the reference specimens with an appropriate organic solvent (such as a hydrocarbon with a boiling point between 60°C and 120°C) using a clean soft brush or soft cloth, non-woven lint free cloth, that does not leave any remains or an ultrasonic cleaning device. Carry out the cleaning in a vessel full of solvent. After cleaning, rinse the reference specimens with fresh solvent and then dry them.

Determine the mass of the reference specimens to $\pm 1 \text{ mg}$. Protect one face of the reference specimens with a removable coating, for example an adhesive plastic film. The edges of the reference specimens may be protected by the adhesive tape as well.

C.2 Arrangement of the reference specimens

Four reference specimens should be positioned in four quadrants (if six specimens are available, place them in six different positions including four quadrants) in the zone of the test cabinet where the test specimens are placed, with the unprotected face upwards, and at an angle of $20^\circ \pm 5^\circ$ to the vertical.

The supports of the reference specimens should be made of, or coated with, inert material, such as plastics. The lower edge of the reference specimens should be in level with the top of the salt spray collector.

The apparatus should be verified during the testing of test specimens. If this is the case, great care should be taken that the specimens do not affect each other. Otherwise, the test cabinet should be filled with substitute specimens to maintain the homogeneity of the test cabinet. The verification procedure should be performed using the same settings as for the test runs.

C.3 Duration of tests

The test duration should be 48 h (6 exposure cycles) for Method A and 96 h (12 exposure cycles) for Method B.