

English Version

**Paints and varnishes - Determination of resistance to  
cyclic corrosion conditions - Part 1: Wet (salt  
fog)/dry/humid (ISO 11997-1:2017)**

Peintures et vernis - Détermination de la résistance  
aux conditions de corrosion cyclique - Partie 1:  
Brouillard salin/sécheresse/humidité (ISO 11997-  
1:2017)

Beschichtungsstoffe - Bestimmung der Beständigkeit  
bei zyklischen Korrosionsbedingungen - Teil 1: Nass  
(Salzsprühnebel)/trocken/Feuchte (ISO 11997-  
1:2017)

This European Standard was approved by CEN on 12 July 2017.

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EUROPEAN COMMITTEE FOR STANDARDIZATION  
COMITÉ EUROPÉEN DE NORMALISATION  
EUROPÄISCHES KOMITEE FÜR NORMUNG

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## European foreword

This document (EN ISO 11997-1:2017) has been prepared by Technical Committee ISO/TC 35 “Paints and varnishes” in collaboration with Technical Committee CEN/TC 139 “Paints and varnishes” the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2018, and conflicting national standards shall be withdrawn at the latest by March 2018.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN ISO 11997-1:2006.

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### Endorsement notice

The text of ISO 11997-1:2017 has been approved by CEN as EN ISO 11997-1:2017 without any modification.

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

This document was prepared by Technical Committee ISO/TC 35, *Paints and varnishes*, Subcommittee SC 9, *General test methods for paints and varnishes*.

This third edition cancels and replaces the second edition (ISO 11997-1:2005), which has been technically revised.

The main changes compared to the previous edition are as follows:

- the time for no drops of moisture are visible on the panels (see 6.4) has been changed;
- a reference to ISO 4628-8 for assessment of degree of delamination and corrosion around a scribe or other artificial defect has been added;
- a reference to ISO 4620-10 for assessment of degree of filiform corrosion has been added;
- the supplementary test conditions previously in Annex A have been integrated in the test report;
- the numbering and order of annexes has been changed;
- the adjustment procedure for the pH of the salt solution in Annex A to Annex D has been implemented from ISO 9227;
- the text has been harmonized with the latest edition of ISO 9227 where possible.

A list of all parts in the ISO 11997 series can be found on the ISO website.

# Introduction

Coatings of paints, varnishes and similar materials are exposed to one of four cycles of wet and dry conditions specified in this document (see [Annex A](#) to [Annex D](#)), using specified salt solutions in a cabinet in order to simulate, in the laboratory, processes occurring in aggressive outdoor conditions, such as marine environments. Generally, correlation between such outdoor weathering and laboratory testing cannot be expected because of the large number of factors influencing the breakdown process. Correlation can only be expected if the effect on the coating of important parameters (e.g. the nature of the pollutant, the spectral distribution of the incident irradiance in the relevant photochemical region, the temperature of the specimen, the type and cycle of wetting and relative humidity) is known. In contrast to outdoor weathering, laboratory testing in a cabinet is performed with a reduced number of variables which can be controlled, and therefore the effects are more reproducible. The method described may also give a means of checking that the quality of a paint or paint system is being maintained.

The method has been found to be useful in comparing the cyclic salt spray resistance of different coatings. It is most useful in providing relevant ratings for a series of coated panels exhibiting significant differences in cyclic salt spray resistance.

The test cycles included in this document have been used successfully, with documented evidence, in the industry for the assessment of performance. The cycles can be summarized as follows.

- **Cycle A (see [Annex A](#)):** This cycle is specified in Japanese Automobile Standards JASO M 609-91 and JASO M610-92.
- **Cycle B (see [Annex B](#)):** This is based on the VDA 621-415 cycle and is widely used in Europe. It has also been shown to give good correlation with natural weathering for thermosetting paints in vehicle corrosion.
- **Cycle C (see [Annex C](#)):** This cycle was developed in the UK for use with water-soluble and latex paint systems and has been shown to give good correlation with natural weathering.
- **Cycle D (see [Annex D](#)):** This cycle is specified in Japanese Standard JIS K 5621-2003.

It is intended that other cycles will be added at later revisions of this document, as they are developed for evaluating other paint types.

ISO 11997-2 describes a method for determining the cyclic corrosion resistance of paints which includes UV exposure as part of the cycle. It has been found to give good correlation with natural weathering for industrial maintenance coatings.



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# Paints and varnishes — Determination of resistance to cyclic corrosion conditions —

## Part 1: Wet (salt fog)/dry/humid

### 1 Scope

This document specifies a method for the determination of the resistance of coatings to one of four defined cycles of wet (salt fog)/dry/humid conditions using specified solutions.

### 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 1513, *Paints and varnishes — Examination and preparation of test samples*

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

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

ISO 3270, *Paints and varnishes and their raw materials — Temperatures and humidities for conditioning and testing*

ISO 3696, *Water for analytical laboratory use — Specification and test methods*

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 4628-10, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 10: Assessment of degree of filiform corrosion*

ISO 15528, *Paints, varnishes and raw materials for paints and varnishes — Sampling*

### 3 Terms and definitions

No terms and definitions are listed in this document.

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>

### 4 Principle

A coated test panel is exposed to a cyclic wet (salt fog), drying and humidity test schedule and the effects of exposure are evaluated by criteria agreed in advance between the interested parties, these criteria usually being of a subjective nature.

### 5 Salt fog test solution

Prepare the salt fog test solution by dissolving the salt or salts as given in [Annexes A, B, C](#) and [D](#) in water conforming to at least grade 2 of ISO 3696 to produce the required concentration.

The salts shall be of analytical grade and contain a mass fraction of the heavy metals of copper (Cu), nickel (Ni) and lead (Pb) in total less 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 1 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.

If the pH of the solution is outside the required range (see [Annexes A, B, C](#) and [D](#)), the presence of undesirable impurities in the salt or the water or both shall be investigated. 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. Any necessary corrections shall be made by adding hydrochloric acid, sodium hydrogen carbonate or analytical-grade sodium hydroxide, of appropriate concentrations.

NOTE 2 Attention is drawn to the possible changes in pH resulting from loss of carbon dioxide from the solution when it is sprayed or from dissolution of carbon dioxide from the ambient atmosphere. Such changes can be avoided by reducing the carbon dioxide content of the solution by, for example, heating it to a temperature above 35 °C before it is placed in the cabinet or making the solution from freshly boiled water.

Filter the solution before placing it in the reservoir of the cabinet in order to remove any solid matter which might block the apertures of the spraying device.

### 6 Apparatus

Ordinary laboratory apparatus and glassware, together with the following.

**6.1 Spray cabinet**, made of, or lined with, material resistant to corrosion by the sprayed solution and having a roof which prevents condensed moisture dripping onto the test specimens. Due to the limited capacity of cabinets smaller than 0,4 m<sup>3</sup>, 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 on them.

The size and shape of the cabinet shall be such that the salt fog deposition rate is within the limits given in [Annexes A, B, C and D](#).

NOTE Cabinets with a volume greater than 2 m<sup>3</sup> will be difficult to operate unless careful consideration is given to their design and construction.

Factors to be taken into consideration in the design and construction of the cabinet are given in [Annex E](#).

If the cabinet has been used for a spray test, or for any other purpose, using a solution differing from that specified for the current test cycle, it shall be thoroughly cleaned before use.

**6.2 Hot-air blowers**, capable of maintaining the cabinet and its contents at the specified temperatures and achieving the required heating rates (see [Annexes A, B, C and D](#)). The temperature shall be controlled by a thermostat element placed within the cabinet at least 100 mm from the walls of the cabinet.

**6.3 Means for spraying the salt solution**, comprising a supply of clean compressed air at a controlled pressure, a reservoir to contain the solution to be sprayed and one or more atomizers made of material resistant to the solution. The compressed-air supply to each atomizer shall be passed through a filter to remove all traces of oil or solid matter, shall be at a suitable pressure depending upon the type of atomizer nozzle and shall be adjusted so that the rate of collection of spray in the cabinet and the concentration of the collected spray are kept within the specified limits (see [Annexes A, B, C and D](#)).

The reservoir containing the solution to be sprayed shall be a tank made of material resistant to the solution and shall be provided with means of maintaining a constant flow of solution to the atomizers.

The atomizers shall be made of inert material, for example glass or plastic.

NOTE Baffles can be used to prevent direct impingement of spray on the test specimens, and the use of adjustable baffles is helpful in obtaining uniform distribution of spray throughout the cabinet.

**6.4 Drying-air supply**, of 20 % to 30 % relative humidity for cycles A and D (see [Annexes A and D](#)) and of (50 ± 20) % relative humidity for cycles B and C (see [Annexes B and C](#)). The air shall be passed through a filter to remove all traces of oil or solid matter and shall have a flow rate sufficient to ensure that no drops of moisture are visible on the panels after the drying time specified for cycles A and D and after 45 min to 75 min after the start of the dry phase for cycle C. The panels shall not be dried by heaters inside the cabinet walls.

NOTE It is common practice to vent the cabinet to the atmosphere outside the laboratory.

**6.5 Collecting devices**, at least two, of chemically inert material (see Note). The collecting devices shall be placed in the zone of the cabinet where the test panels are placed, one close to the spray atomizer(s) and one remote from the spray atomizer(s). They shall be placed so that only spray and not liquid falling from test panels or from parts of the cabinet is collected. If two or more atomizers are used, the number of collecting devices shall be at least twice the number of atomizers.

NOTE Glass funnels with the stems inserted into graduated cylinders have been found to be suitable collecting devices. Funnels with a diameter of 100 mm have a collecting area of approximately 80 cm<sup>2</sup>.

**6.6 Test panel racks**, made of inert non-metallic material such as glass, plastic or suitably coated wood. Exceptionally, test panels may be suspended. In this case, the material used shall be synthetic fibre, cotton thread or other inert insulating material; on no account shall metallic material be used. All racks shall be placed at the same level in the cabinet so that the solution cannot drip from panels or racks at one level onto other panels placed below.

**6.7 Control equipment**, for providing wet (salt fog)/dry/humid cycles for the times and temperatures specified in [Annexes A, B, C and D](#).

## 7 Sampling

Take a representative sample of the product to be tested (or of each product in the case of a multi-coat system) as described in ISO 15528.

Examine and prepare each sample for testing as described in ISO 1513.

## 8 Test panels

Unless otherwise specified or agreed, the test panels shall be of burnished steel complying with ISO 1514 and of minimum dimensions 100 mm × 70 mm × 0,3 mm.

Unless otherwise specified, prepare each test panel in accordance with ISO 1514 and then coat it by the specified method with the product or system under test.

Unless otherwise specified, the back and edges of the panel shall be coated with the product or system under test.

If the coating on the back and edges of the panel differs from that of the product under test, it shall have a corrosion resistance greater than that of the product under test.

Dry (or stove) and age (if applicable) each coated test panel for the specified time under the specified conditions, and then, unless otherwise specified, condition them at a temperature and relative humidity as defined in ISO 3270 for at least 16 h, with free circulation of air and without exposing them to direct sunlight. The test procedure shall then be carried out as soon as possible.

Determine the thickness, in micrometres, of the dried coating by one of the non-destructive procedures described in ISO 2808.

Unless otherwise specified, make a straight scribe with a minimum width of 0,2 mm through the coating to the substrate as follows.

To make the scribe, use a single-blade cutting tool. The scribe shall have an upwards-broadening cross-section, which shows a width of 0,2 mm to 1,0 mm of the metallic substrate, as shown in ISO 17872:2007, Figure 2 a). Remove any loose debris from the vicinity of the scribe.

Do not cut the scribe with a knife.

For aluminium panels, make two scribes which are perpendicular to, but do not intersect, each other. One scribe shall be parallel to the rolling direction and the other at right angles to it.

All scribes shall be at least 20 mm from each other and from any edge of the test panel, unless agreed otherwise.

Two parallel scribes may also be applied. Unless agreed otherwise, locate the scribes parallel to the longer edge of the test panel.

Care needs to be taken in the production of the scribe to ensure uniformity of results.

## 9 Method of exposure of test panels

Place the panels in the cabinet in such a way that they are not in the path of spray from the atomizer.

Place the panels facing upwards at an angle of  $(20 \pm 5)^\circ$  to the vertical.

The angle at which each panel is exposed in the cabinet is very important.

It is sometimes necessary to expose painted components of different shapes. When such tests are conducted, it is of particular importance to expose the shaped components at the angle at which they are normally used. While satisfying this restriction, the component shall also be placed so as to minimize the disruption of flow. Furthermore, other test panels and components cannot be tested at the same time if the shape of the painted component interferes with the general direction of flow.

The degree of film breakdown may vary with different test specimen orientations and due consideration shall be given to this when interpreting the results.

Arrange the panels so that they do not come into contact with one another or with the cabinet and so that the surfaces to be tested are exposed to the spray only where it is settling freely.

It is recommended that the positions of the test panels be repositioned on a daily basis to ensure positional effects within the cabinet do not interfere with the degradation process.

## 10 Operating conditions

Set the cabinet to run on the required spray cycle only and fill to a similar extent as during the test. Determine the salt fog deposition rate. The average rate of collection of solution in each collecting device (6.5) measured over a minimum period of 24 h shall be as given in the appropriate annex (see [Annex A](#), [B](#), [C](#) or [D](#)) for a horizontal collecting area of 80 cm<sup>2</sup>. This gives a more accurate assessment of the deposition rate, as the water will evaporate away from the collection devices during the drying cycles.

The solution collected shall have the concentration given in the appropriate annex (see [Annex A](#), [B](#), [C](#) or [D](#)).

Operate the cabinet to the required cycle (see [Annex A](#), [B](#), [C](#) or [D](#)) unless otherwise specified, repeating the cycle for the required time.

Do not re-use test solution which has already been sprayed.

## 11 Procedure

Carry out the determination in duplicate, unless otherwise agreed.

Set up the cabinet as described in [Clause 10](#) and allow equilibrium to be established.

Arrange the test panels in the cabinet (6.1) as described in [Clause 9](#).

It is recommended that a control specimen of a paint with known durability be included with each series of test panels and that duplicates be exposed in different parts of the chamber.

Close the cabinet and start the flow of the salt solution through the atomizers. Run the cycle continuously throughout the prescribed test period, except for a short daily interruption (see [Clause 12](#)) to inspect, re-arrange or remove test panels, to check the atomizers, to check and replenish the solution in the reservoir and to make any necessary recordings.

## 12 Examination of test panels

Make a periodic examination in accordance with the criteria agreed in advance between the interested parties.

Examine the panels as quickly as possible, taking care not to damage the surfaces under test. Do not turn off the cabinet for more than 30 min in any 24 h period. Examine the panels during a dry phase. If this is not possible for any reason, turn off the cabinet but do not allow the panels to dry and restart the cabinet as soon as possible.

At the end of the specified test period, remove the panels from the cabinet and rinse with clean water to remove residues of salt solution from the surface. Immediately examine the test surfaces for signs of deterioration in accordance with ISO 4628-1, ISO 4628-2, ISO 4628-3, ISO 4628-4, ISO 4628-5, ISO 4628-8 and ISO 4628-10.

If required, keep the panels in a standard atmosphere as defined in ISO 3270 for the specified period and re-examine the test surfaces for deterioration.

If it is required to examine the substrate for signs of attack, remove the coating by means of a non-corrosive paint remover unless otherwise specified.

## 13 Precision

The concept of precision is not applicable to this document because of the subjective nature of the assessment (see [Clause 4](#)). Precision depends upon a number of factors, including the following:

- the evaluation method (i.e. ISO 4628-1, ISO 4628-2, ISO 4628-3, ISO 4628-4, ISO 4628-5, ISO 4628-8 and ISO 4628-10);
- the preparation of the test panels;
- the thickness of the coating;
- the drying and conditioning of the test panels;
- the preparation of the scribe(s).

## 14 Test report

The test report shall contain at least the following information:

- a) all information necessary to identify the product tested;
- b) a reference to this document (i.e. ISO 11997-1);
- c) the cycle used;
- d) the details of the preparation of the test panels, including
  - 1) the material, the thickness and the surface preparation of the substrate (see [8.1](#) and [8.2](#)),
  - 2) the method of application of the coating material to the substrate, including the duration and conditions of drying between coats in the case of a multi-coat system including details on sealing of the edges and backs of the test panels (if required) (see [8.2](#)),
  - 3) the duration and conditions of drying (or stoving) and ageing (if applicable) of the coating before testing (see [8.3](#)),
  - 4) the thickness, in micrometres, of the dry coating and the method of measurement used in ISO 2808, and whether it is a single coating or a multi-coat system (see [8.4](#)),
  - 5) whether a scribe is to be made before exposure and, if so, the type of scribing tool, the position of each scribe and any other required information (see [8.5](#));
- e) the duration of the test (see [Clause 10](#) or corresponding [Annex A](#), [B](#), [C](#) or [D](#));

- f) whether the position of the panels was changed (see [Clause 9](#));
- g) how inspection of the test coating is to be made and what characteristics are to be considered in evaluating its resistance to wet (salt fog)/dry/humid (see [Clause 12](#));
- h) the results of the test in terms of the stated requirements (see [Clause 12](#));
- i) any deviation from the test procedure described;
- j) any unusual features (anomalies) observed during the test;
- k) the date of the test.

# Annex A (normative)

## Cycle A

### A.1 Preparation of salt solution

Prepare the spray solution as described in [Clause 5](#) by dissolving sodium chloride in water to give a concentration of  $(50 \pm 5)$  g/l.

### A.2 Collection of salt solution

Adjust the pH of the salt solution (see [A.1](#)) so that the pH of the sprayed solution collected within the test cabinet is 6,5 to 7,2 at  $(25 \pm 2)$  °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. The salt fog deposition shall be 1 ml/h to 2 ml/h when the salt fog is collected over a 24 h period of time (see [Clause 10](#)).

### A.3 Cycle

Set up the cabinet to perform the cycle specified in [Table A.1](#).

**Table A.1 — Test parameters for cycle A**

Step	Time h	Temperature °C	Condition	Notes
1	2	35 ± 2	Salt spray	—
2	4	60 ± 2	Dry: 20 % to 30 % RH	—
3	2	50 ± 2	Wet: 95 % RH or over	—
4	Go back to step 1.			This makes a total cycle time of 8 h from step 1 to step 3.
	Transition time (i.e. time allowed to reach the temperature and relative humidity specified for a condition after changing to that condition):			From salt spray to dry: within 30 min From dry to wet: within 15 min From wet to salt spray: within 30 min The effect of the salt spray will, in principle, be instantaneous. For details of drying-air flow, see <a href="#">6.4</a> .
Set points and operational fluctuations can be listed either independently of each other or in the format: set point ± operational fluctuations. The set point is the target condition for the sensor when used at the operational control point as programmed by the user. Operational fluctuations are deviations from the indicated set point at the control point indicated by the readout of the calibrated control sensor during equilibrium operation and do not include measurement uncertainty. At the operational control point, the operational fluctuation shall not exceed the listed value at equilibrium. When a standard calls for a particular set point, the user programmes that exact number. The operational fluctuations specified for that set point do not imply that the user is allowed to programme a set point higher or lower than the exact set point specified.				

Unless otherwise agreed, repeat the test cycle for 30 cycles (240 h), 60 cycles (480 h), 90 cycles (720 h) or 180 cycles (1 440 h).

## Annex B (normative)

### Cycle B

#### B.1 Preparation of salt solution

Prepare the spray solution as described in [Clause 5](#) by dissolving sodium chloride in water to give a concentration of  $(50 \pm 5)$  g/l.

#### B.2 Collection of salt solution

Adjust the pH of the salt solution (see [B.1](#)) so that the pH of the sprayed solution collected within the test cabinet is 6,5 to 7,2 at  $(25 \pm 2)$  °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. The salt fog deposition shall be 1 ml/h to 2 ml/h when the salt fog is collected over a 24 h period of time (see [Clause 10](#)).

#### B.3 Cycle

Set up the cabinet to perform the cycle specified in [Table B.1](#).

**Table B.1 — Test parameters for cycle B**

Step	Time h	Temperature °C	Condition	Notes
1	24	$35 \pm 2$	Salt fog	—
2	8	$40 \pm 2$	100 % RH	Water condensing on test panels
3	16	$23 \pm 2$	$(50 \pm 20)$ % RH	—
4	8	$40 \pm 2$	100 % RH	Water condensing on test panels
5	16	$23 \pm 2$	$(50 \pm 20)$ % RH	—
6	8	$40 \pm 2$	100 % RH	Water condensing on test panels
7	16	$23 \pm 2$	$(50 \pm 20)$ % RH	—
8	8	$40 \pm 2$	100 % RH	Water condensing on test panels
9	16	$23 \pm 2$	$(50 \pm 20)$ % RH	—
10	48	$23 \pm 2$	$(50 \pm 20)$ % RH	—
11	Go back to step 1.			This makes the total cycle time 7 days from step 1 to step 10.

Set points and operational fluctuations can be listed either independently of each other or in the format: set point  $\pm$  operational fluctuations. The set point is the target condition for the sensor when used at the operational control point as programmed by the user. Operational fluctuations are deviations from the indicated set point at the control point indicated by the readout of the calibrated control sensor during equilibrium operation and do not include measurement uncertainty. At the operational control point, the operational fluctuation shall not exceed the listed value at equilibrium. When a standard calls for a particular set point, the user programmes that exact number. The operational fluctuations specified for that set point do not imply that the user is allowed to programme a set point higher or lower than the exact set point specified.

Unless otherwise agreed, repeat the test cycle for five cycles (840 h).

## Annex C (normative)

### Cycle C

#### C.1 Preparation of salt solution

Prepare the spray solution as described in [Clause 5](#) by dissolving sodium chloride and ammonium sulfate in water to give concentrations of  $(0,31 \pm 0,01)$  g/l (sodium chloride) and  $(4,10 \pm 0,01)$  g/l (ammonium sulfate).

#### C.2 Collection of salt solution

Adjust the pH of the salt solution (see [C.1](#)) so that the pH of the sprayed solution collected within the test cabinet is 6,5 to 7,2 at  $(25 \pm 2)$  °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. The salt fog deposition shall be 2 ml/h to 4 ml/h when the salt fog is collected over a 24 h period of time (see [Clause 10](#)).

#### C.3 Cycle

Set up the cabinet to perform the cycle specified in [Table C.1](#).

**Table C.1 — Test parameters for cycle C**

Step	Time min	Temperature °C	Condition	Notes
1	210	$30 \pm 2$	Salt fog	—
2	210	$40 \pm 2$	Dry	Drying-air purge (see <a href="#">6.4</a> )
3	1 470	$40 \pm 2$	$(75 \pm 15)$ % RH	One method of achieving this condition is to alternate the dry and humid cycles for suitable (short) time periods to keep the RH between the limits specified.
4	102	$30 \pm 2$	Dry	Drying-air purge (see <a href="#">6.4</a> )
5	210	$30 \pm 2$	Salt fog	—
6	378	$30 \pm 2$	95 % to 100 % RH	Water condensing on test panel
7	180	$35 \pm 2$	Dry	Drying-air purge (see <a href="#">6.4</a> )
8	120	$25 \pm 2$	Dry	—
9	Go back to step 1.			This makes the total cycle time 48 h from step 1 to step 8.

Set points and operational fluctuations can be listed either independently of each other or in the format: set point  $\pm$  operational fluctuations. The set point is the target condition for the sensor when used at the operational control point as programmed by the user. Operational fluctuations are deviations from the indicated set point at the control point indicated by the readout of the calibrated control sensor during equilibrium operation and do not include measurement uncertainty. At the operational control point, the operational fluctuation shall not exceed the listed value at equilibrium. When a standard calls for a particular set point, the user programmes that exact number. The operational fluctuations specified for that set point do not imply that the user is allowed to programme a set point higher or lower than the exact set point specified.

Unless otherwise agreed, repeat the test cycle for 21 cycles (1 008 h).

## Annex D (normative)

### Cycle D

#### D.1 Preparation of salt solution

Prepare the spray solution as described in [Clause 5](#) by dissolving sodium chloride in water to give a concentration of  $(50 \pm 10)$  g/l.

#### D.2 Collection of salt solution

Adjust the pH of the salt solution (see [D.1](#)) so that the pH of the sprayed solution collected within the test cabinet is 6,5 to 7,2 at  $(25 \pm 2)$  °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. The salt fog deposition shall be 1 ml/h to 2 ml/h when the salt fog is collected over a 24 h period of time (see [Clause 10](#)).

#### D.3 Cycle

Set up the cabinet to perform the cycle specified in [Table D.1](#).

**Table D.1 — Test parameters for cycle D**

Step	Time h	Temperature °C	Condition	Notes
1	0,5	$30 \pm 2$	Salt spray	—
2	1,5	$30 \pm 2$	Wet: $(95 \pm 3)$ % RH	—
3	2	$50 \pm 2$	Hot dry	—
4	2	$30 \pm 2$	Warm dry	—
5	Go back to step 1.			This makes a total cycle time of 6 h from step 1 to step 4.
	Transition time (i.e. time allowed to reach the temperature and relative humidity specified for a condition after changing to that condition):			From salt spray to wet: within 10 min From wet to hot dry: within 15 min From hot dry to warm dry: within 30 min From warm dry to salt spray: instantaneous

Set points and operational fluctuations can be listed either independently of each other or in the format: set point  $\pm$  operational fluctuations. The set point is the target condition for the sensor when used at the operational control point as programmed by the user. Operational fluctuations are deviations from the indicated set point at the control point indicated by the readout of the calibrated control sensor during equilibrium operation and do not include measurement uncertainty. At the operational control point, the operational fluctuation shall not exceed the listed value at equilibrium. When a standard calls for a particular set point, the user programmes that exact number. The operational fluctuations specified for that set point do not imply that the user is allowed to programme a set point higher or lower than the exact set point specified.

Unless otherwise agreed, repeat the test cycle for 28 cycles (168 h).

## **Annex E**

(informative)

### **Factors to be considered in the design and construction of salt spray cabinets**

The following factors should be considered in the design and construction of the cabinet (see [6.1](#)):

- a) the number and the positioning of the atomizers and baffles required to produce an even spray distribution within the limits specified in [Annex A](#), [B](#), [C](#) or [D](#);
- b) the number of collecting devices required to monitor the spray as required in [6.5](#);
- c) the heating, insulation and means of temperature control required to produce a uniform temperature within the cabinet at all positions where test specimens are exposed;
- d) the design of the ceiling (e.g. a false ceiling) needed to prevent drops of solution falling onto the test panels as required in [6.1](#).

## Bibliography

- [1] ISO 9227, *Corrosion tests in artificial atmospheres — Salt spray tests*
- [2] JASO M 609-91, *Corrosion test method for automotive materials*
- [3] JASO M 610-92, *Cosmetic corrosion test method for automotive parts*
- [4] JIS K 5621-2003, *Anticorrosive paint for general use*
- [5] VDA 621-415, *A popular standard for testing corrosion properties of vehicle paints*



