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

**Part 3:
Testing of coating systems on
materials and components in
automotive construction**

*Peintures et vernis — Détermination de la résistance aux conditions
cycliques de corrosion —*

*Partie 3: Essais de systèmes de revêtements sur matériaux et
composants en construction automobile*



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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation 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.

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

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

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.

Introduction

This document was prepared on the basis of SEP 1850^[9] and VDA 233-102^[10].

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

Part 3:

Testing of coating systems on materials and components in automotive construction

1 Scope

This document specifies a method based on a cyclic corrosion test for testing the corrosion protection of automobiles using coating systems on aluminium, steel or galvanized steel.

The test method uses corrosive conditions (temperature and humidity ramps and salt spray) to create realistic corrosion patterns. These corrosion patterns are typical for automobiles, and they are comparable in the case of sufficiently similar protective coating systems. In particular, the accelerated test investigates the delamination/corrosion creep that results from defined artificial damage to a coating. Investigations of surface and edge corrosion or investigations of adhesive specimens or components are also covered. This cyclic corrosion test is also suitable for testing corrosion in flanged areas or near gaps.

This document was developed for the assessment of coated substrates (test specimens, bodywork and mounted parts) in the automotive industry. Other applications, such as components with unpainted metallic coatings, were not part of the scope of the standardization work. This document was originally developed for coating systems on aluminium, steel or galvanized steel but it can also be used for the assessment of the corrosion resistance of coating systems on other metals and their alloys.

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 2409, *Paints and varnishes — Cross-cut test*

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

ISO 4618, *Paints and varnishes — Terms and definitions*

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 9227:2017, *Corrosion tests in artificial atmospheres — Salt spray tests*

ISO 17872, *Paints and varnishes — Guidelines for the introduction of scribe marks through coatings on metallic panels for corrosion testing*

ISO 20567-1, *Paints and varnishes — Determination of stone-chip resistance of coatings — Part 1: Multi-impact testing*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4618 apply.

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/>

4 Principle

WARNING — This document may involve hazardous materials, operations and equipment. This document does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this document to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

The test specimens are tested in a cyclic test that involves salt spray, humidity ramps and temperature ramps. In this way, realistic corrosion patterns are created for coated substrates of steel, galvanized steel and aluminium. The results of the tests are assessed based on subjective criteria that are agreed beforehand between the contractual partners.

5 Apparatus and test equipment

The typical laboratory and glass or plastics apparatus, together with the following.

5.1 Corrosion test chamber

All parts of the test chamber that come into contact with salt spray, condensate or test solutions shall be made of a material that is resistant to attack by the test solutions and does not itself affect the action of the test solutions or the salt spray/condensate on the test specimens.

The test may be carried out in separate chambers as long as the climatic conditions for the cycles are met. Chambers that can perform all conditions are available and recommended.

Test chambers shall consist of a cooling unit, heating, pressure equalization as well as the necessary measurement and control equipment to set and maintain the climate data described in Annex B (temperature ± 2 °C, relative humidity ± 5 %) as measured at a reference point in the closed chamber at defined temperature/relative humidity values. When passing through temperature ramps in phases with constant relative humidity, deviations in relative humidity of -8 % to $+5$ % are permitted.

The test chamber shall be designed in such a way that no drops fall from the ceiling or side walls onto the test specimens positioned below them. A test solution that has already been sprayed shall not be returned to the storage container.

The usable space for the test and/or the space for positioning the test specimens and test specimen holders is only that part of the test chamber that is outside of the direct spray jet. In this space, it is possible to demonstrate that there is a uniform distribution of the spray jet in accordance with 5.4.

The holders for the test specimens are to be produced from a durable, non-metallic non-conductive material. The holder should be designed as such that the gathering of test solution on the holder is prevented as much as possible. No conductive bridge is allowed between test specimens. If it is necessary to hang up test specimens, the material used shall be a durable, non-metallic and non-conductive material. The connection points on the test specimen should be at least 20 mm to the left or right from the scribe.

5.2 Spray nozzle(s)

Nozzles that are suitable for the temperature range of the test and that fulfil the conditions in 5.4 are used to generate the spray. Nozzles that use compressed air (see 5.5) to atomize the droplets shall be used. It is necessary to set the flow rate to be constant so that it is within the limits specified in 5.4. It is to be noted that the spray jet shall not point directly at the test specimens to be tested. The number and arrangement of the spray nozzles are to be selected in such a way that the specifications in 5.4 for the usable space are fulfilled.

The spray nozzles shall be made from a durable material such as glass or plastic.

5.3 Test solution

The initial solution in the storage container is a preparation of NaCl in distilled, demineralized or deionized water with a maximum conductivity of 20 $\mu\text{S}/\text{cm}$ at $(25 \pm 2)^\circ\text{C}$ in accordance with ISO 9227 but having a NaCl concentration of 10 g/l. The purity of sodium chloride shall be as specified in ISO 9227.

This solution is to be used in such a way that the sodium chloride concentration of the sprayed and collected test solution is (10 ± 1) g/l, as this can deviate from the prepared solution depending on the chamber. The density of a corresponding solution is $(1,005 \pm 0,000 5)$ g/cm³ at 25 °C. The pH value (6,5 to 7,2) is to be maintained. Use hydrochloric acid or sodium hydroxide to adjust the pH if necessary.

WARNING — Hydrochloric acid (CAS No. 7647-01-0) solution is toxic, corrosive, irritating and very toxic to aquatic life. Refer to Safety Data Sheet for details. Handling of hydrochloric acid solution shall be restricted to skilled personnel or conducted under their control. Care shall be taken in the disposal of this solution.

WARNING — Sodium hydroxide (CAS No. 1310-73-2) solution is toxic, corrosive and irritating. Refer to Safety Data Sheet for details. Handling of sodium hydroxide solution shall be restricted to skilled personnel or conducted under their control. Care shall be taken in the disposal of this solution.

5.4 Quantity and distribution of the spray

The quantity of test solution to be sprayed over a defined period of time in accordance with 5.3 is selected in such a way that $(3,0 \pm 1,0)$ ml/h of sprayed solution is collected on average in each of the collecting devices that are used. The collected quantity in the test chamber should be controlled when the chamber is loaded with specimens in a manner similar to the test procedure. A period of at least 16 h of constant salt spray operation is recommended before the test and during regular checks of the salt spray phase.

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Glass or plastic funnels with a diameter of 100 mm which are fitted into a measuring cylinder made of glass or plastic using a plug are examples of suitable collecting devices.

NOTE Funnels made of glass or plastic that have their pipe sections inside measuring cylinders have proven themselves to be suitable collecting devices. Funnels with a diameter of 100 mm have a collection area of approximately 80 cm².

To demonstrate the uniform distribution of the spray, at least two of the collecting devices – depending on the size of the chamber – shall be placed in the zone where the test specimens are usually placed.

In the case of very large chambers (walk-in chambers), at least one collection device is to be used for every 4 m² of positioning area.

For calibration purposes and for the verification of the uniform distribution of the spray, follow the procedure specified in ISO 9227:2017, 6.5.

5.5 Compressed air

The compressed air used to generate the salt spray shall be free of oil and solid contaminants. It shall be at a suitable pressure depending upon the type of spray nozzle and adjusted so that the collection rate of sprayed solution in the chamber and the concentration of sprayed solution collected are kept within the specified limits.

NOTE Humidification of the spray air can be necessary to prevent evaporation of the spray during the test. Saturation towers as described in ISO 9227 represent one common method to humidify the air.

5.6 Mass-loss coupons to demonstrate constant test conditions.

To test the apparatus, use at least three mass-loss coupons with dimensions of 150 mm × 70 mm and a thickness of (0,9 ± 0,2) mm, made of CR4 steel in accordance with ISO 3574 with practically fault-free surfaces (roughness Ra = 0,9 µm to 1,4 µm).

At least five mass-loss coupons should be used when the test chamber is being commissioned.

5.7 Balance, accurate to at least 0,001 g.

6 Test specimen preparation

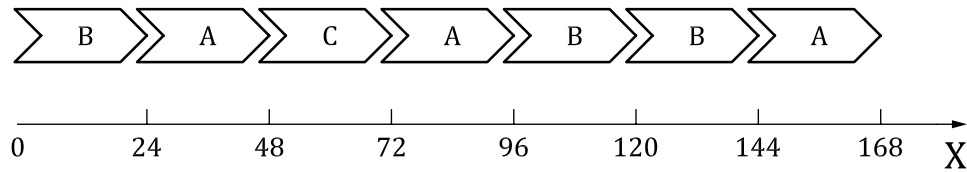
If not otherwise specified, apply an artificial defect (prior damage) to the coating, for example:

- scribe in accordance with ISO 17872;
- stone impact in accordance with ISO 20567-1;
- cross cut in accordance with ISO 2409.

7 Procedure

7.1 Test conditions – Test procedure

The test duration is six test cycles (6 weeks), if not otherwise agreed. A test cycle lasts 7 days. It consists of daily cycles A, B and C, the sequence of which is specified as shown in [Figure 1](#).



Key

- X test time, in hours
- A, B, C daily cycle

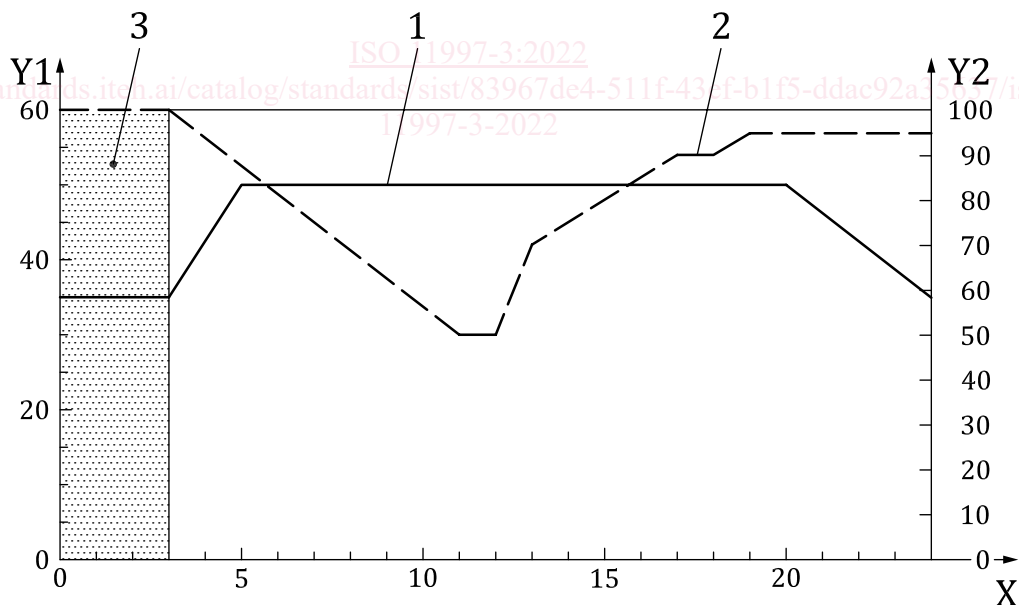
Figure 1 — Test cycle with sequence of daily cycles A, B and C

The daily cycles are characterized by the following features:

- daily cycle A, in accordance with [Figure 2](#) and [Table B.1](#), with a salt spray phase of 3 h (10 g/l NaCl solution);
- daily cycle B, in accordance with [Figure 3](#) and [Table B.2](#), with an assessment phase;
- daily cycle C, in accordance with [Figure 4](#) and [Table B.3](#), with a low-temperature phase.

NOTE The ramps specified in this document are based on the current status of the control technology for the chambers. They are intended to ensure that the temperature and relative humidity loadings necessary for the corrosion processes can be achieved. An example for the programming of the chambers is given in [Table C.1](#).

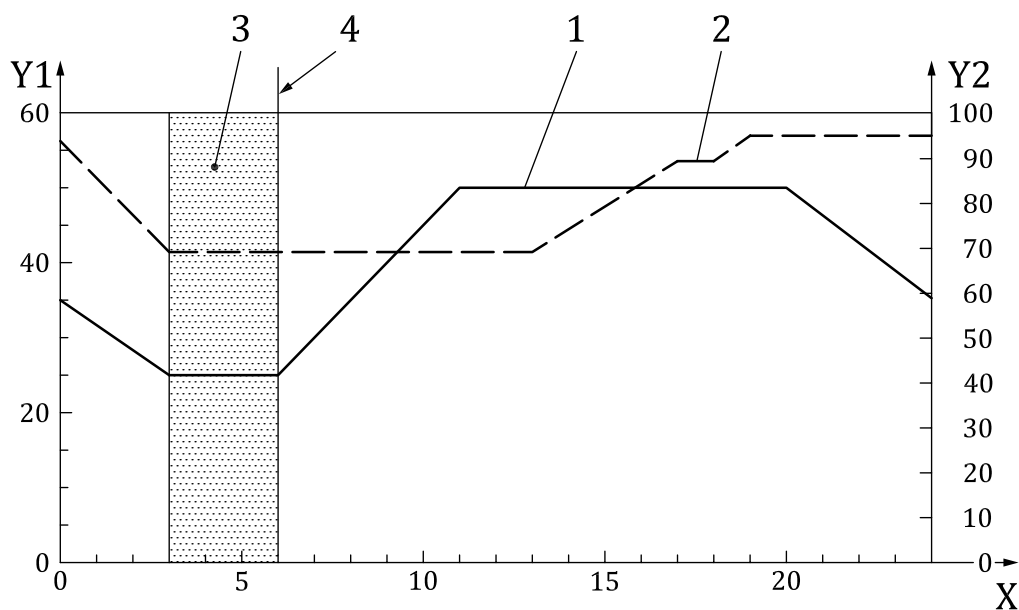
The positioning of test specimens in the test chamber (or the removal of test specimens) is carried out solely during the first daily cycle B of the assessment phase during the fourth, fifth and sixth hours after the start of daily cycle B – see [Figure 3](#).



Key

- X time, in hours
- Y1 temperature, in degrees Celsius (°C)
- Y2 relative humidity, in percent (%)
- 1 temperature
- 2 relative humidity
- 3 salt spray phase (10 g/l NaCl solution)

Figure 2 — Daily cycle A with a salt spray phase of 3 h (10 g/l NaCl solution)



Key

- X time, in hours
- Y1 temperature, in degrees Celsius (°C)
- Y2 relative humidity, in percent (%)
- 1 temperature
- 2 relative humidity
- 3 assessment phase
- 4 start of test after first placing test specimens in the chamber

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<https://standards.itech.ai> **Figure 3 — Daily cycle B with assessment phase** [1f5-ddac92a35637/iso-11997-3-2022](https://standards.itech.ai/standards/11997-3-2022)