
Paints and varnishes — Artificial weathering including acidic deposition

*Peintures et vernis — Vieillissement artificiel comportant un dépôt
acide*

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

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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).

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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. (standards.itech.ai)

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This second edition cancels and replaces the first edition (ISO 15110:2013), which has been technically revised. The main changes compared to the previous edition are as follows:

- the scope has been restricted to paints and varnishes;
- the black panel thermometer has been added for fluorescent UV lamps, since it gives equivalent results to BST UV-F devices;
- exposure with uncontrolled humidity has been included as a new type U ADF test, since it has been shown that control of humidity does not affect type of pinpoint damage resulting from this test.

Introduction

This document specifies a method of simulating the damaging effect of outdoor weathering with relevance to acidic atmospheric precipitation on painted products. The mechanisms differ from those of harmful gases, which essentially constitute the initial products of acidic precipitation.

Arising from changing industrial air pollution and additionally diffused by the stochastic wind and cloud distribution, acidic precipitation occurs sporadically. Thus, especially regarding acidic precipitation, outdoor weathering effects vary enormously within different years. Therefore, it is practically impossible to obtain reliable outdoor exposure results from just one season. These fluctuations can be avoided through the use of a laboratory test where all weathering parameters, including the acidic deposition, can be controlled.

The method is based on VDI Guideline VDI 3958-12[9].

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Paints and varnishes — Artificial weathering including acidic deposition

1 Scope

This document specifies a so-called acid dew and fog test (ADF test) as an accelerated laboratory test method for simulating, by the use of artificial acidic precipitation, the damaging effects of acidic atmospheric precipitation in association with UV radiation, neutral condensed precipitation, and changing temperature and humidity. This test method is intended to be used in evaluating, on the basis of relative performance rankings, the suitability of painted materials for use in outdoor environments with acidic precipitation. It is not intended to generate the same extent of damage or the same damage pattern as in outdoor weathering, but rather to give a ranking which is similar to that which would be obtained in outdoor weathering. The method produces damage which is more homogeneous, allows fewer specimens to be exposed (and hence more rapid testing) and enables evaluation of the exposed specimens to be carried out using methods which are more objective than visual assessment.

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 16474-1, *Paints and varnishes — Methods of exposure to laboratory light sources — Part 1: General guidance*

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ISO 16474-2:2013, *Paints and varnishes — Methods of exposure to laboratory light sources — Part 2: Xenon-arc lamps*

ISO 16474-3:2013, *Paints and varnishes — Methods of exposure to laboratory light sources — Part 3: Fluorescent UV lamps*

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

The combined action of solar UV radiation, heat, humidity, wetting and acidic deposition is simulated in weathering devices similar to those described in ISO 4892-2 and ISO 16474-2 for xenon-arc lamps and in ISO 4892-3 and ISO 16474-3 for fluorescent UV lamps.

Included in the artificial exposure is an acidic exposure, which is accomplished by a once-per-day spraying of acid. The aim of this test is not to reproduce the visual damage patterns which result from outdoor exposures, which show a very widespread distribution that is hard to evaluate. Rather, the aim is to reproduce the same ranking which would be obtained with an outdoor exposure, by causing damage by the same mechanisms but creating a homogeneous distribution on a smaller scale that can be evaluated in an objective way.

Accelerated weathering is achieved by the serial arrangement of the worst conceivable combinations of environmental conditions for the object under test (referred to hereafter as the “worst-case scenario”). This is accomplished by reproducing these environmental conditions in a more compressed sequence than would be the case outdoors and by including artificial acidic precipitation. However, the values of the environmental conditions used do not significantly exceed those encountered in practice outdoors.

5 Apparatus

5.1 General

For this test, weathering devices as specified in either ISO 16474-2 or ISO 16474-3 shall be used. The test chamber, as well as the specimen holders, shall be made of acid- and UV-resistant materials.

5.2 Laboratory radiation sources

5.2.1 Fluorescent UV lamp apparatus, in accordance with that specified for ISO 16474-3:2013, method A, using type 1A lamps.

For a fluorescent UV lamp apparatus giving the spectral distribution specified for ISO 16474-3:2013, method A, a UV irradiance of: $E_{UV} = (45 \pm 5) \text{ W}\cdot\text{m}^{-2}$, constant over time and uniformly applied to the specimens in the weathering device, shall be achieved in the spectral range 290 nm to 400 nm; or $E_{\lambda} = (0,76 \pm 0,08) \text{ W}\cdot\text{m}^{-2}\cdot\text{nm}^{-1}$ at 340 nm.

5.2.2 Xenon-arc lamp apparatus, in accordance with that specified for ISO 16474-2:2013, method A.

Irradiance uniformity shall be in accordance with the requirements specified in ISO 16474-1. For a xenon-arc lamp apparatus, equipped with daylight filters, giving the spectral distribution specified for ISO 16474-2:2013, method A, the UV irradiance shall be $E_{UV} = (60 \pm 5) \text{ W}\cdot\text{m}^{-2}$ in the spectral range 300 nm to 400 nm.

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5.3 Test chamber.

The design of the test chamber may vary, but it shall be constructed from inert material, meeting the requirements of ISO 16474-1 and ISO 16474-2 or ISO 16474-3, respectively. For xenon-arc lamp apparatuses, the test chamber shall provide for control of both black standard temperature and chamber air temperature, meeting the requirements of ISO 16474-1. For fluorescent UV apparatuses, the test chamber shall provide for control of either black standard temperature, black panel temperature, or chamber air temperature, meeting the requirements of ISO 16474-1. When specified herein, humidity control shall also meet the requirements of ISO 16474-1. Devices shall also produce water spray. Water used for the water spray shall meet the purity requirements of ISO 16474-1. The weathering device shall be capable of completing the change from each climatic phase to the next during the ADF test within 30 min.

5.4 Wetting system.

The test chamber shall be equipped with a means of introducing an intermittent spray of water onto the front of the test specimens, under specified conditions. The spray system shall be made from corrosion-resistant materials that do not contaminate the water employed.

The water spray system in xenon-arc lamp instruments shall be as specified in ISO 16474-2.

5.5 Specimen holders.

The specimen holders shall be made from inert materials that will not affect the test results, for example non-oxidizing alloys of aluminium, or stainless steel. Brass, steel or copper shall not be used.

5.6 Black standard or black panel thermometer.

The black standard thermometer or black panel thermometer (for fluorescent UV apparatuses) used shall comply with the requirements for these devices that are given in ISO 16474-1.

5.7 Humidity sensor.

If required, use a hygrometer for measuring the relative humidity.

5.8 Acid spray device.

A manually operated atomizer or an automatic spraying device may be used.

5.9 Radiometer.

When a radiometer is used, it shall comply with the requirements of ISO 16474-1.

6 Solutions for artificial acidic deposition

Prepare an acid mixture with a pH of 1,5 at (25 ± 2) °C by dissolving 10,6 g of H₂SO₄, 3,18 g of HNO₃ and 1,80 g of HCl in 10 l of distilled or deionized water (this gives a mass ratio of 1,0:0,3:0,17). These quantities refer to acids with a calculated concentration of 100 %. Depending on the mass concentrations of the acids available, larger quantities of acid might have to be weighed out (e.g. if 36 % HCl is used, the quantity will have to be $1,8/0,36 = 5,0$ g). Analytical-grade acids shall be used.

Then prepare a solution with a pH of 2,5 by diluting the pH 1,5 solution with distilled or deionized water by a volume ratio of 1:10.

The pH 2,5 solution is the recommended solution. However, the more aggressive pH 1,5 solution may be used if agreed upon by the interested parties. If the pH 1,5 solution is used, this shall be mentioned in the test report.

Before starting the exposure, check the pH-value of the solution using, for instance, pH test strips. If it deviates by more than pH 0,3 from the theoretical value, replace the solution.

To avoid changes in the pH-value of the solution, store it in an airtight container.

Acid spraying may be carried out either manually or automatically (see 9.3).

7 Test specimens

7.1 General

All specimens shall be permanently marked.

NOTE The specimens will be delivered by a customer or specifically prepared for this test or taken from a building component. Guidelines for preparation are given in ISO 1514. Guidelines for sampling are given in ISO 15528.

7.2 Specimen size

The specimen size shall be such that the condition of the specimens can be unambiguously ascertained before and after the ADF test.

Due to the homogeneity of the damage on exposed specimens, only relatively small areas need to be evaluated. The minimum exposed surface area shall be 30 cm², with the shortest edge at least 50 mm in length. This reduces local variation in the acid deposition (e.g. due to the spraying procedure or edge effects).

7.3 Corrosion of the substrates

If possible, the substrate used should be the same as that to which the coating material will be applied in practice. It shall be made, as far as possible (see below), from inert material.

If the possibility of corrosion or delamination at the edges cannot be excluded, suitable edge protection should preferably be provided. Also, exposed edges and substrate surfaces that might react with acidic precipitation (e.g. those made of non-stainless steels, aluminium, copper, zinc or concrete) should be suitably protected.

7.4 Reference specimens

The use of reference specimens is recommended for assessing the repeatability. Reference specimens of the same type of material as employed in previous test series should be used.

If possible, these reference specimens should be made of materials which do not change with time (i.e. do not age) under normal storage conditions.

8 Designation of test type

Exposures carried out under conditions corresponding to the subtropical climate of Jacksonville in Florida (i.e. those of type J as defined in [Table 1](#)) are designated:

ISO 15110, ADF-J test

Exposures carried out under conditions corresponding to a moderate climate like that of central Europe (i.e. those of type M as defined in [Table 2](#)) are designated:

ISO 15110, ADF-M test

Exposures carried out without humidity control (i.e. those of type U as defined in [Table 3](#)) are designated:

ISO 15110, ADF-U test

9 Procedure

9.1 General

The ADF test may be performed in weathering devices as described in ISO 16474-1, ISO 16474-2 or ISO 16474-3.

If damage occurs unexpectedly fast, it is recommended that a check be carried out to determine if the damage really results from the synergistic action of the acid and the weathering, by performing separate acid and weathering exposures. For the acid-free weathering exposure, the same weathering conditions should preferably be used. For the pure acid exposure, ISO 2812-5 or ISO 175 could be used.

NOTE 1 Testing in different types of weathering device can lead to different results.

NOTE 2 To differentiate between the special action of the acidic deposition and that of usual weathering effects, it can be useful to expose a second set of specimens to the same weathering exposure in parallel, but without acidic deposition.

The specimens may be mounted either in an open frame or on a solid backing.

NOTE 3 If backing is used, the presence of a space between the backing and the test specimens can affect the results.

During the dry periods, specimens shall be exposed to varying relative humidity as specified in [Table 1](#) or [Table 2](#). During the rain period, specimens shall be sprayed with water in the way specified in [Table 1](#), [Table 2](#), or [Table 3](#).

9.2 Wetting and relative humidity

The water spray system in fluorescent UV lamp devices shall permit a constant rain flux density of 2 l to 5 l of water per square metre of specimen surface per second to be produced continuously with time.

The spray shall be uniformly distributed over the specimens.

If the water is recycled, the quantity of circulating water used for the ADF test shall not be less than 50 l. Because of the uptake of the acids washed off the specimens and possible contamination from the specimen material, the spray water, if recycled, shall be replaced when it reaches pH 4,5 and at the latest after one operating week (168 h).

The water sprayed onto the specimen surfaces shall have a conductivity below 5 $\mu\text{S}/\text{cm}$, contain less than 1 $\mu\text{g}/\text{g}$ dissolved solids and leave no observable stains or deposits on the specimens. Care shall be taken to keep silica levels below 0,2 $\mu\text{g}/\text{g}$. A combination of deionization and reverse osmosis may be used to produce water of the desired quality.

For those tests that require relative humidity, the humidity sensor shall be in accordance with ISO 16474-1.

NOTE The air humidity can have an influence on the effect of the acidic precipitation, as it influences evaporation and hence the concentration of the acid on the specimens.

9.3 Acid spraying

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An atomizer similar to that used with perfume bottles may be used to apply acid spray to the specimens manually. This allows the amount of acid to be controlled by visually checking the spray pattern.

If an automatic spraying device is used, the device shall control the amount sprayed on to the specimens as well as the droplet size, which shall be sufficiently small.

9.4 Weathering cycles

The 24 h weathering cycle recommended for the ADF test (the ADF cycle) exposes the specimens to continuous UV radiation and changing climatic conditions. This cycle is shown in [Table 1](#) for a Jacksonville, Florida, climate, in [Table 2](#) for a moderate climate with a lower relative humidity, and [Table 3](#) for a cycle without humidity control

The first step in the ADF cycle, the spraying of the specimen surface with the artificial acidic precipitation, is performed on five consecutive days of each week, followed by two 1-day cycles without acid spraying.

To protect the chamber materials, the specimens should preferably be sprayed outside the test chamber.

After spraying, the specimens shall be returned to the test chamber. The time required for spraying and the necessary handling of the specimens shall not exceed 5 min. The test chamber of the weathering device shall remain set to the climatic test conditions and shall only be opened for the maximum time necessary for specimen removal and replacement.

The quantity of acidic solution applied shall be such that the surface becomes uniformly wet, but not so much that the solution runs off the specimen surface, even when oriented in its recommended vertical position.

It is recommended that, for a particular spraying device, the tester should regularly check the quantity of acidic solution sprayed on to unit area of the specimen surface (e.g. by measurement of the mass increase).