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**Paints and varnishes — Artificial  
weathering including acidic deposition**

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

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 15110 was prepared by Technical Committee ISO/TC 35, *Paints and varnishes*, Subcommittee SC 9, *General test methods for paints and varnishes*.

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## Introduction

This International Standard specifies a method of simulating the damaging effect of outdoor weathering with relevance to acidic atmospheric precipitation on polymeric products. In addition to the classical environmental variables of temperature and humidity, acidic atmospheric precipitation can also have a significant effect on the photochemical ageing of polymers, e.g. by attacking the stabilizers. 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.<sup>[9]</sup>

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# Paints and varnishes — Artificial weathering including acidic deposition

## 1 Scope

This International Standard 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 polymeric 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, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 4892-1, *Plastics — Methods of exposure to laboratory light sources — Part 1: General guidance*

ISO 4892-2:2006, *Plastics — Methods of exposure to laboratory light sources — Part 2: Xenon-arc lamps*  
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ISO 4892-3:2006, *Plastics — Methods of exposure to laboratory light sources — Part 3: Fluorescent UV lamps*

## 3 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.

## 4 Apparatus

### 4.1 General

For this test, weathering devices as specified in either ISO 4892-2 or ISO 4892-3 shall be used. The test chamber, as well as the specimen holders, shall be made of acid- and UV-resistant materials.

### 4.2 Laboratory radiation sources

#### 4.2.1 Fluorescent UV lamp apparatus

Fluorescent UV lamp apparatus shall be in accordance with that specified for ISO 4892-3:2006, method A, using type 1A lamps. For a fluorescent UV lamp apparatus giving the spectral distribution specified for ISO 4892-3:2006, method A, a UV irradiance of  $E_{UV} = (45 \pm 5) \text{ W/m}^2$ , 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.

#### 4.2.2 Xenon arc lamp apparatus

Xenon-arc lamp apparatus shall be in accordance with that specified for ISO 4892-2:2006, method A. Irradiance uniformity shall be in accordance with the requirements specified in ISO 4892-1. For a xenon-arc lamp apparatus, equipped with daylight filters, giving the spectral distribution specified for ISO 4892-2:2006, method A, the UV irradiance shall be  $E_{UV} = (60 \pm 5) \text{ W/m}^2$  in the spectral range 300 nm to 400 nm.

### 4.3 Test chamber

The design of the test chamber may vary, but it shall be constructed from inert material, meeting the requirements of ISO 4892-1 and ISO 4892-2 or ISO 4892-3, respectively. The test chamber shall provide for control of temperature or black standard temperature and for humidity control that meets the requirements of ISO 4892-1. Devices shall also be provided to produce water spray. Water used for the water spray shall meet the requirements of ISO 4892-1. The weathering device shall be capable of completing the change from each climatic phase to the next during the ADF test within 30 min.

### 4.4 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 4892-2.

### 4.5 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.

### 4.6 Black-standard thermometer

The black-standard thermometer used shall comply with the requirements for these devices that are given in ISO 4892-1.

### 4.7 Humidity sensor

Use a hygrometer for measuring the relative humidity.

### 4.8 Acid spray device

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



## 4.9 Radiometer

When a radiometer is used, it shall comply with the requirements of ISO 4892-1.

## 5 Solutions for artificial acidic deposition

Prepare an acid mixture with a pH of 1,5 at  $(25 \pm 2)$  °C by dissolving 10,6 g of H<sub>2</sub>SO<sub>4</sub>, 3,18 g of HNO<sub>3</sub> and 1,80 g of HCl in 10 l of demineralized 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 demineralized 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 8.3).

## 6 Test specimens

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### 6.1 General

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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.

### 6.2 Specimen size

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

For vertically exposed specimens, due to the homogeneity of the damage, only relatively small areas need to be evaluated. The minimum exposed surface area shall be 30 cm<sup>2</sup>, with the shortest edge at least 50 mm in length to reduce local variation in the acid deposition due e.g. to the spraying procedure or edge effects.

### 6.3 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.

## 6.4 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 a materials which do not change with time (i.e. do not age) under normal storage conditions.

## 7 Designation of type of test

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:

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## 8 Procedure

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### 8.1 General

The ADF test may be performed in weathering devices as described in ISO 4892-1, ISO 4892-2 or ISO 4892-3.

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 might affect the results, particularly with transparent specimens.

During the dry periods, specimens shall be exposed to varying relative humidities 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](#) or [Table 2](#).

### 8.2 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 1 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.

Tests carried out in accordance with this International Standard require the relative humidity to be controlled during the dry periods. The location of the sensor used to measure the humidity shall be in accordance with ISO 4892-1.

**NOTE** The air humidity will have a significant influence on the photodegradation of many polymers and on the effect of the acidic precipitation, as it influences evaporation and hence the concentration of the acid on the specimens.

### 8.3 Acid spraying

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.

### 8.4 Weathering cycles (standards.iteh.ai)

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 and in [Table 2](#) for a moderate climate with a lower relative humidity.

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).

The various steps in the ADF cycle are shown in [Table 1](#) and [Table 2](#), respectively.

The following symbols are used:

BST	Black-standard temperature
RH	relative humidity in the chamber
$E_{\text{UV}}$	UV irradiance in the range up to 400 nm
$E_{\lambda}$	spectral irradiance