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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

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

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].

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*

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 ± 5) 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; or E_{λ} = (0,76 ± 0,08) W·m^{-2}·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 ± 5) W·m^{-2} in the spectral range 300 nm to 400 nm.

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 H_2SO_4, 3,18 g of HNO_3 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 cm^2, 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 µS/cm, contain less than 1 µg/g dissolved solids and leave no observable stains or deposits on the specimens. Care shall be taken to keep silica levels below 0,2 µg/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

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).

The various steps in the ADF cycle are shown in Table 1, Table 2, and Table 3, respectively.

The following symbols are used:

BPT	black panel thermometer
BST	black standard thermometer
CAT	chamber air temperature
RH	relative humidity in the chamber
E_{UV}	UV irradiance in the range up to 400 nm
E_λ	spectral irradiance

Since in fluorescent UV lamp devices, the difference between black standard temperature, black panel temperature, and the chamber air temperature is less than 2 °C, the temperature may be controlled either using BST, BPT, or CAT.

Table 1 — Test conditions used for the daily cycle in the type J ADF test
(where "J" stands for the subtropical climate of Jacksonville in Florida)

Step		Duration	Fluorescent UV lamp apparatus	Xenon-arc lamp apparatus
1	Acid spraying	< 5 min	30 g to 40 g of acid solution per m^2 of specimen surface preferably outside the test chamber	
2a	First dry period	9 h	BST, BPT, or CAT = (35 ± 2) °C, RH = (75 ± 8) %, E_{UV} = (45 ± 5) $W·m^{-2}$ or E_λ = (0,76 ± 0,08) $W·m^{-2}·nm^{-1}$ at 340 nm	BST = (55 ± 2) °C, RH = (90 ± 10) %, E_{UV} = (60 ± 5) $W·m^{-2}$
2b	First dry period continued	5 h	BST, BPT, or CAT = (60 ± 2) °C, RH = (40 ± 5) %, E_{UV} = (45 ± 5) $W·m^{-2}$ or E_λ = (0,76 ± 0,08) $W·m^{-2}·nm^{-1}$ at 340 nm	BST = (75 ± 2) °C, RH = (90 ± 10) %; E_{UV} = (60 ± 5) $W·m^{-2}$
3	Rain period	4 h	Continuous spraying of the specimen surface with distilled or deionized water, BST, BPT, or CAT = (35 ± 3) °C	Continuous spraying of the specimen surface with distilled or deionized water, CAT = (35 ± 3) °C
4	Second dry period	6 h	BST, BPT, or CAT = (60 ± 2) °C, RH = (40 ± 5) %, E_{UV} = (45 ± 5) $W·m^{-2}$ or E_λ = (0,76 ± 0,08) $W·m^{-2}·nm^{-1}$ at 340 nm	BST = (75 ± 2) °C, RH = (90 ± 10) %, E_{UV} = (60 ± 5) $W·m^{-2}$

Table 2 — Test conditions used for the daily cycle in the type M ADF test
(where "M" stands for a moderate climate like that of central Europe)

Step		Duration	Fluorescent UV lamp apparatus	Xenon-arc lamp apparatus
1	Acid spraying	< 5 min	30 g to 40 g of acid solution per m^2 of specimen surface, preferably sprayed on outside the test chamber	
2a	First dry period	9 h	BST, BPT, or CAT = (35 ± 2) °C, RH = (30 ± 5) %, E_{UV} = (45 ± 5) $W \cdot m^{-2}$ or E_λ = (0,76 ± 0,08) $W \cdot m^{-2} \cdot nm^{-1}$ at 340 nm	BST = (55 ± 2) °C, RH = (50 ± 10) %, E_{UV} = (60 ± 5) $W \cdot m^{-2}$
2b	First dry period continued	5 h	BST, BPT, or CAT = (60 ± 2) °C, RH < 10 %, E_{UV} = (45 ± 5) $W \cdot m^{-2}$ or E_λ = (0,76 ± 0,08) $W \cdot m^{-2} \cdot nm^{-1}$ at 340 nm	BST = (75 ± 2) °C, RH < 20 %, E_{UV} = (60 ± 5) $W \cdot m^{-2}$
3	Rain period	4 h	Continuous spraying of the specimen surface with distilled or deionized water. BST, BPT, or CAT = (35 ± 3) °C	Continuous spraying of the specimen surface with distilled or deionized water. CAT = (35 ± 3) °C
4	Second dry period	6 h	BST, BPT, or CAT = (60 ± 2) °C, RH < 10 %, E_{UV} = (45 ± 5) $W \cdot m^{-2}$ or E_λ = (0,76 ± 0,08) $W \cdot m^{-2} \cdot nm^{-1}$ at 340 nm	BST = (75 ± 2) °C, RH < 20 %, E_{UV} = (60 ± 5) $W \cdot m^{-2}$

Table 3 — Test conditions used for the daily cycle in the type U ADF test
(where "U" stands for uncontrolled humidity)

Step		Duration	Fluorescent UV lamp apparatus	Xenon-arc lamp apparatus
1	Acid spraying	< 5 min	30 g to 40 g of acid solution per m^2 of specimen surface, preferably sprayed on outside the test chamber	
2a	First dry period	9 h	BST, BPT, or CAT = (35 ± 2) °C, RH = not controlled E_{UV} = (45 ± 5) $W \cdot m^{-2}$ or E_λ = (0,76 ± 0,08) $W \cdot m^{-2} \cdot nm^{-1}$ at 340 nm	BST = (55 ± 2) °C, RH = not controlled E_{UV} = (60 ± 5) $W \cdot m^{2}$ or E_λ = (0,51 ± 0,02) $W \cdot m^{-2} \cdot nm^{-1}$ at 340 nm
2b	First dry period continued	5 h	BST, BPT, or CAT = (60 ± 2) °C, RH = not controlled E_{UV} = (45 ± 5) $W \cdot m^{-2}$ or E_λ = (0,76 ± 0,08) $W \cdot m^{-2} \cdot nm^{-1}$ at 340 nm	BST = (75 ± 2) °C, RH = not controlled E_{UV} = (60 ± 5) $W \cdot m^{-2}$ or E_λ = (0,51 ± 0,02) $W \cdot m^{-2} \cdot nm^{-1}$ at 340 nm
3	Rain period	4 h	Continuous spraying of the specimen surface with distilled or deionized water. BST, BPT, or CAT = (35 ± 3) °C	Continuous spraying of the specimen surface with distilled or deionized water. CAT = (35 ± 3) °C
4	Second dry period	6 h	BST, BPT, or CAT = (60 ± 2) °C, RH = not controlled E_{UV} = (45 ± 5) $W \cdot m^{-2}$ or E_λ = (0,76 ± 0,08) $W \cdot m^{-2} \cdot nm^{-1}$ at 340 nm	BST = (75 ± 2) °C, RH = not controlled E_{UV} = (60 ± 5) $W \cdot m^{-2}$ or E_λ = (0,51 ± 0,02) $W \cdot m^{-2} \cdot nm^{-1}$ at 340 nm

9.5 Test duration

For ADF tests of all types, a test duration of 4 weeks is recommended.

NOTE This corresponds to 20 cycles with acid spray.

Longer exposures might be necessary if the differences in a measured property between the specimens in a set of specimens are smaller than the uncertainty of measurement of the property.

The exposure shall be terminated after the second dry period (step 4), as the measurement of properties might depend on the water content (e.g. gloss measurement). Particular care shall be taken that no acid remains on the specimen surfaces.

Interruptions to the test procedure are permissible, in which case the specimens shall be stored under standard climatic conditions until resumption of the test. If a break of longer than 20 min occurs during the first dry phase, the acid left on the specimens shall be removed by thorough rinsing with distilled or deionized water. In such cases, the test shall be resumed by re-spraying the specimens with the acidic solution. Each interruption shall be documented in detail.

9.6 Further weathering of specimens

Especially if stabilizers based on sterically hindered amines are involved in reactions with the acid during the exposure, some painted plastics might develop an increased sensitivity to ageing. Therefore, subsequent exposures can lead to more marked property changes than usual.

Care shall be taken if ADF-weathered specimens have to be stored for a long period of time, as any acid remaining on the specimens can continue to cause damage during storage.

10 Assessment of results

Since acidic atmospheric precipitation occurs sporadically and randomly in terms of frequency and acidity, the lifetime of identical products in outdoor use in such an environment can vary enormously. A rough estimate of a product's service life on the basis of the results of method A of ISO 16474-2:2013 or ISO 16474-3:2013 and the usually only very imprecise information on the degree of aggressiveness from acidic atmospheric precipitation in the envisaged area of use is only possible if suitable repeated outdoor weathering tests have been carried out in sufficient numbers on the same object.

NOTE 1 A duration of 28 d was chosen for the ADF-J test, using a solution of pH 2,5, in order to simulate the damage caused by a 98 d outdoor exposure in Jacksonville for a specific set of 20 coatings (see also Annex A).

However, method A of ISO 16474-2:2013 and ISO 16474-3:2013 is useful for comparing different products in terms of their suitability for use in an acid-charged environment. Therefore, it makes little sense to define the test duration as the degree of aggressiveness.

It shall be agreed between the interested parties which properties of the coating are to be measured before, during and after the exposure, and which standards are to be used for this purpose.

NOTE 2 Suitable methods are given in e.g. ISO 2813, ISO 3668, ISO 4628-1 to ISO 4628-8 and ISO 4628-10, ISO 11664-1 to ISO 11664–5 and ISO 13803.

11 Precision

11.1 General

Repeatability data are available only for the ADF test in fluorescent UV lamp devices.

Data on the reproducibility are not available.

11.2 Repeatability

Major sources of variation in the results of the ADF test are:

a) fluctuations in the composition and acidity of the artificial acidic deposition solution (weighing, volume measurement, pH measurement during its preparation);

b) fluctuations in the quantity of acid sprayed on to the specimen surface (due to wear of the spraying device and, in the case of a manual spraying device, differences in the execution of the spraying process);

c) non-adherence to the climatic conditions (particularly temperature, humidity, and the duration of the joint action of acid and UV radiation).

The repeatability was determined using a fluorescent UV lamp apparatus, with relative humidity control in five tests on four selected automotive finishes, repeated at intervals of up to three years. During this period, new batches of the artificial acidic deposition solution were prepared several times and the person performing the spraying process and operating the weathering device changed. The variations ascertained in loss of gloss and increase in haze were of a statistical nature and were within the range of the results of the individual measurements distributed in each case over the specimen surface. Absolute variations in loss of gloss of 4 gloss units (with a standard deviation, σ, of ±1,4 %) and an increase in haze of ±10 haze units (with a standard deviation, σ, of ±8 haze units) can be expected.

Repeatability data for the ADF test using xenon-arc apparatus are not available.

12 Test report

The test report shall contain at least the following information:

a) a reference to this document, i.e. ISO 15110;

b) the type of exposure conditions used (type J, M or U);

c) all information necessary for identification of the coating material tested;

d) a description of the test apparatus and the light source, including:

  1) the type of test apparatus and light source,

  2) the type of thermometer used (BST or BPT),

  3) a description of the filters used,

  4) the irradiance at the surface of the specimens (including that of the band pass filter with which the radiation was measured), as well as a description of the radiation-measuring instrument used,

  5) the duration of use of the filters and light source, in hours, before the beginning of the exposure;

e) the type of instrument used to measure the air humidity, if controlled;

f) a description of the procedure used to mount the specimens on the exposure frame, including a description of all materials used to support the specimens and the orientation (i.e. vertical, horizontal, or at some other angle);

g) in the case of transparent materials, the type of backing used for the specimens;

h) the type (manual or automatic) of spraying device used and its location (inside or outside the test chamber);

i) the procedure used to change of the positions of the specimens in the test chamber, if applicable;

j) the result of the assessment of the specimens, including:

  1) the method used to measure each of the properties determined,

  2) the results of the determinations on the test specimens,

  3) the results of determinations on any control specimens,

  4) the results of determinations on any unexposed reference specimens,

  5) the UV radiant exposure, in joules per square metre, and wavelength range in which the above measurements were made;

k) details of any deviations from the specified exposure conditions;

l) details of any unusual features (anomalies) observed during the test;

m) the dates of the beginning and end of the test.

Annex A
(informative)

Background information

A.1 Acidic precipitation — Outdoor conditions

The term “acidic precipitation” describes the deposition of pollution on surfaces that, in its aqueous form (rain, dew, fog, snow, frost or hail) exhibits an acidity more severe than pH 5,6 and that, in the form of aerosols or dusts, contains free acids[1]. Acidic precipitation forms when certain air pollutants combine with oxygen, water or dust particles in the atmosphere. The main focus is on sulfur dioxide, a by-product of the combustion of fossil fuel, which forms sulfuric acid (H_2SO_4) after oxidation and contributes to about 60 % to 70 % of the acidity of precipitation. Other frequently encountered components of acidic precipitation are nitric acid (HNO_3) and hydrochloric acid (HCl). From mean values derived from the mixing ratios of the above-mentioned acids recorded in major industrial regions and frequently used internationally for test purposes[2][3][4], the following mass ratio is derived:

$$H_2SO_4:HNO_3:HCl = 1:0{,}3:0{,}17$$

Taking into account the recorded frequency of the acidity of aqueous acidic precipitation observed outdoors, the following rough ranking of categories of acidic exposure situations is obtained:

— Dew: up to pH 1,5

— Fog: up to pH 2,5

— Rain: up to pH 3,5

In outdoor exposures as well as in the ADF test, the special properties of sulfuric acid are crucial for the so-called worst-case scenario. Sulfuric acid does not evaporate in the climatic environmental conditions to be expected outdoors. Due to water evaporation, acidic precipitation deposited on the surface of an object in rain-free environmental conditions might become concentrated into sulfuric acid with a mass fraction of 50 % to 60 %, particularly if exposed to bright sunlight. Because of their generally higher acidity, the most serious surface damage is expected from exposure to acid dew or fog precipitation. The ADF test therefore chiefly simulates the effect of fog and dew precipitation in joint action with the relevant climatic conditions. Because of the similar mechanisms involved, the ADF test may also be used without modification to simulate the effect of dusts and aerosols containing acids. The worst-case outdoor weather scenario has proven to be the combination of deposited dew or fog droplets with sunlight.

A.2 Experience with the ADF test

Extensive experimental tests have shown that temperature and humidity can have a considerable effect on the ranking with respect to damage. For the ADF test, the temperature and humidity values have been optimized to fit the average ranking for three summer seasons of outdoor exposure in Jacksonville (for the type J test) and for six years in central Europe (for the type M test).

The ADF-J test using a solution of pH 2,5 was assessed by testing 16 modern automotive finishes (base-coat/clearcoat systems with a black basecoat) of different types and from different manufacturers in comparison with a conventional 14-week outdoor weathering test in Jacksonville, Florida. The result achieved after 28 days with the ADF test in terms of the ranking correlates with the mean result from three outdoor weathering tests conducted at the same time of year (end of May to the beginning of September) in 1999 to 2001 with a Pearson ranking correlation coefficient of 0,9. The reference criterion was the increase in haze.