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Paints and varnishes – Methods of exposure to laboratory light sources – Part 3: Fluorescent UV lamps (ISO 16474-3:2021); English version EN ISO 16474-3:2021, English translation of DIN EN ISO 16474-3:2021-04

Beschichtungsstoffe –
Künstliches Bestrahlen oder Bewittern in Geräten –
Teil 3: UV-Leuchtstofflampen (ISO 16474-3:2021);
Englische Fassung EN ISO 16474-3:2021,
Englische Übersetzung von DIN EN ISO 16474-3:2021-04

Peintures et vernis –
Méthodes d'exposition à des sources lumineuses de laboratoire –
Partie 3: Lampes fluorescentes UV (ISO 16474-3:2021);
Version anglaise EN ISO 16474-3:2021,
Traduction anglaise de DIN EN ISO 16474-3:2021-04

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In case of doubt, the German-language original shall be considered authoritative.

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National foreword

This document (EN ISO 16474-3:2021) has been prepared by Technical Committee ISO/TC 35 “Paints and varnishes” in collaboration with Technical Committee CEN/TC 139 “Paints and varnishes” (Secretariat: DIN, Germany).

The responsible German body involved in its preparation was *DIN-Normenausschuss Beschichtungsstoffe und Beschichtungen* (DIN Standards Committee Coatings and Coating Materials), Working Committee NA 002-00-07 AA “General test methods for coating materials and coatings”.

The DIN documents corresponding to the documents referred to in this document are as follows:

ISO 1514	DIN EN ISO 1514
ISO 2808	DIN EN ISO 2808
ISO 2813	DIN EN ISO 2813
ISO 3668	DIN EN ISO 3668
ISO 4618	DIN EN ISO 4618
ISO 4892-3	DIN EN ISO 4892-3
ISO 13076	DIN EN ISO 13076
ISO 16474-1:2013	DIN EN ISO 16474-1:2014-03
ISO 16474-2:2013	DIN EN ISO 16474-2:2014-03
ISO 18314-1	DIN EN ISO 18314-1

For current information on this document, please go to DIN’s website (www.din.de) and search for the document number in question.

Amendments

This standard differs from DIN EN ISO 16474-3:2014-03 as follows:

a) in 7.2, the difference between the temperature of a black panel sensor and a black standard sensor has been corrected;

b) in Table 4, a change has been made so that the black-panel temperature is not controlled during water spray;

c) the text has been editorially revised and normative references have been updated.

Previous editions

DIN EN ISO 11507: 2002-01, 2007-05
DIN EN ISO 16474-3: 2014-03

National Annex NA
(informative)

Bibliography

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

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

DIN EN ISO 2813, *Paints and varnishes — Determination of gloss reading at 20°, 60° and 85°*

DIN EN ISO 3668, *Paints and varnishes — Visual comparison of the colour of paints*

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

DIN EN ISO 4892-3, *Plastics — Methods of exposure to laboratory light sources — Part 3: Fluorescent UV lamps*

DIN EN ISO 13076, *Paints and varnishes — Lighting and procedure for visual assessments of coatings*

DIN EN ISO 16474-1:2014-03, *Paints and varnishes — Methods of exposure to laboratory light sources — Part 1: General guidance (ISO 16474-1:2013)*

DIN EN ISO 16474-2:2014-03, *Paints and varnishes — Methods of exposure to laboratory light sources — Part 2: Xenon-arc lamps (ISO 16474-2:2013)*

DIN EN ISO 18314-1, *Analytical colorimetry — Part 1: Practical colour measurement*

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN ISO 16474-3

January 2021

ICS 87.040

Supersedes EN ISO 16474-3:2013

English Version

Paints and varnishes - Methods of exposure to laboratory light sources - Part 3: Fluorescent UV lamps (ISO 16474-3:2021)

Peintures et vernis -
Méthodes d'exposition à des sources lumineuses de laboratoire -
Partie 3: Lampes fluorescentes UV
(ISO 16474-3:2021)

Beschichtungsstoffe -
Künstliches Bestrahlen oder Bewittern in Geräten -
Teil 3: UV-Leuchtstofflampen
(ISO 16474-3:2021)

This European Standard was approved by CEN on 17 October 2020.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

Ref. No. EN ISO 16474-3:2021 E

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European foreword

This document (EN ISO 16474-3:2021) 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 July 2021, and conflicting national standards shall be withdrawn at the latest by July 2021.

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 16474-3:2013.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Endorsement notice

The text of ISO 16474-3:2021 has been approved by CEN as EN ISO 16474-3:2021 without any modification.

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*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 139, *Paints and varnishes,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 16474-3:2013) which has been technically revised. The main changes compared to the previous edition are as follows:

— in 7.2 the difference between the temperature of a black panel sensor and a black standard sensor has been corrected;

— in Table 4 it has been changed that the black-panel temperature is not controlled during water spray;

— the text has been editorially revised and the normative references have been updated.

A list of all parts in the ISO 16474 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

Coatings of paints, varnishes and similar materials (subsequently referred to simply as coatings) are exposed to laboratory light sources, in order to simulate in the laboratory the ageing processes which occur during natural weathering or behind window glass.

1 Scope

This document specifies methods for exposing coatings to fluorescent UV lamps, heat and water in apparatus designed to reproduce the weathering effects that occur when materials are exposed in actual end-use environments to daylight, or to daylight through window glass.

The coatings are exposed to different types of fluorescent UV lamps under controlled environmental conditions (temperature, humidity and/or water). Different types of fluorescent UV lamp can be used to meet all the requirements for testing different materials.

Specimen preparation and evaluation of the results are covered in other ISO documents for specific materials.

General guidance is given in ISO 16474-1.

NOTE Fluorescent UV lamp exposures for plastics are described in ISO 4892-3.

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

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

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

ISO 9370, *Plastics — Instrumental determination of radiant exposure in weathering tests — General guidance and basic test method*

ISO 16474-1:2013, *Paints and varnishes — Methods of exposure to laboratory light sources — Part 1: General guidance*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
radiant exposure
H
amount of radiant energy to which a test panel has been exposed

Note 1 to entry: Radiant exposure is given by the equation:

$$H = \int E \cdot \mathrm{d}t$$

where

H is the radiant exposure, in joules per square metre (J/m^2);

E is the irradiance, in watts per square metre (W/m^2);

t is the exposure time, in seconds (s).

Note 2 to entry: If the irradiance E is constant throughout the whole exposure time, the radiant exposure H is given simply by the product of E and t.

4 Principle

4.1 Fluorescent UV lamps, when properly maintained, can be used to simulate the spectral irradiance of daylight in the ultraviolet (UV) region of the spectrum.

4.2 Specimens are exposed to various levels of UV radiation, heat and moisture (see 4.4) under controlled environmental conditions.

4.3 The exposure conditions may be varied by selection of:

a) the type of fluorescent lamp (spectral power distribution);

b) the irradiance level;

c) the temperature during the UV exposure;

d) the relative humidity of the chamber air during the light and dark exposures, when test conditions requiring control of humidity are used;

NOTE Commercial fluorescent UV lamp devices generally do not provide means of relative humidity control.

e) the type of wetting (see 4.4);

f) the wetting temperature and cycle;

g) the timing of the UV/dark cycle.

4.4 Wetting is usually produced by condensation of water vapour onto the exposed specimen surface or by spraying the test specimens with demineralized/deionized water.

4.5 The procedure(s) may include measurement of the irradiance and the radiant exposure in the plane of the specimen.

4.6 It is recommended that a similar material of known performance (a control) be exposed simultaneously with the test specimens to provide a standard for comparative purposes.

4.7 Intercomparison of results obtained from specimens exposed in different apparatus or to different types of lamp should not be made unless an appropriate statistical relationship has been established between the different types of equipment for the material to be tested.

5 Apparatus

5.1 Laboratory light source

5.1.1 Fluorescent UV lamps are fluorescent lamps in which radiant emission in the ultraviolet region of the spectrum, i.e. below 400 nm, makes up at least 80 % of the total light output. There are three types of fluorescent UV lamp used in this document:

— The spectral distribution of radiation for typical fluorescent lamps is described in Annex A. Type 1A (UVA-340) fluorescent UV lamp: These lamps have a radiant emission below 300 nm of less than 1 % of the total light output and a peak emission at 343 nm. They are more commonly identified as UVA-340 for simulation of daylight from 300 nm to 340 nm (see Table 1, Spectral pass-band column). Figure A.1 is a graph of spectral irradiance from 250 nm to 400 nm of a typical type 1A (UVA-340) fluorescent UV lamp compared to daylight.

— Type 1B (UVA-351) fluorescent UV lamp: These lamps have a radiant emission below 310 nm of less than 1 % of the total light output and a peak emission at 353 nm. They are more commonly identified as UVA-351 for simulation of the UV portion of daylight behind window glass (see Table 2). Figure A.2 is a graph of spectral irradiance from 250 nm to 400 nm of a typical type 1B (UVA-351) fluorescent UV lamp compared to daylight filtered by window glass.

— Type 2 (UVB-313) fluorescent UV lamp: These lamps have a radiant emission below 300 nm of more than 10 % of the total light output, and a peak emission at 313 nm. They are more commonly identified as UVB-313 (see Table 3). Figure A.3 is a graph of the spectral irradiance from 250 nm to 400 nm of two typical type 2 (UVB-313) fluorescent UV lamps compared to daylight. Type 2 (UVB-313) fluorescent UV lamps may be used only by agreement between the parties concerned. Such agreement shall be stated in the test report.

NOTE 1 Type 2 (UVB-313) fluorescent UV lamps have a spectral distribution of radiation which peaks near the 313 nm mercury line and might emit radiation down to $\lambda = 254$ nm, which can initiate ageing processes that never occur in end-use environments.

NOTE 2 The solar spectral irradiance for a number of different atmospheric conditions is described in CIE 85[7]. The benchmark daylight value used in this document is from CIE 85:1989, Table 4[7].

5.1.2 Unless otherwise specified, type 1A (UVA-340) fluorescent UV lamps or corresponding type 1A fluorescent UV lamp combinations shall be used to simulate the UV part of daylight (see Table 4, method A). Unless otherwise specified, type 1B (UVA-351) fluorescent UV lamps shall be used to simulate the UV part of daylight through window glass (see Table 4, method B).

5.1.3 Fluorescent UV lamps age significantly with extended use. If an automatic irradiance control system is not used, follow the apparatus manufacturer's instructions on the procedure necessary to maintain the desired irradiance.

5.1.4 Irradiance uniformity shall be in accordance with the requirements specified in ISO 16474-1. Requirements for periodic repositioning of specimens when irradiance within the exposure area is less than 90 % of the peak irradiance are described in ISO 16474-1.

Table 1 — Relative ultraviolet spectral irradiance for type 1A (UVA-340) fluorescent UV lamps for daylight UV (method A)[a, b]

Spectral passband	Minimum[c]	CIE 85:1989, Table 4[d, e]	Maximum[c]
(λ = wavelength in nm)	%	%	%
$\lambda < 290$	—	0	0,1
$290 \leq \lambda \leq 320$	5,9	5,4	9,3
$320 < \lambda \leq 360$	60,9	38,2	65,5
$360 < \lambda \leq 400$	26,5	56,4	32,8

[a] This table gives the relative values for irradiance in the given passband, expressed as a percentage of the total irradiance between 290 nm and 400 nm. To determine whether a specific type 1A (UVA-340) fluorescent UV lamp meets the requirements of this table, the spectral irradiance from 250 nm to 400 nm shall be measured. Typically, this is done in 2 nm increments. The total irradiance in each passband is then summed and divided by the total irradiance between 290 nm and 400 nm.

[b] The minimum and maximum limits for type 1A (UVA-340) fluorescent UV lamps in this table are based on more than 60 spectral irradiance measurements with type 1A (UVA-340) fluorescent UV lamps from different production lots and of various ages[8]. The spectral irradiance data are for lamps within the ageing recommendations of the apparatus manufacturer. As more spectral irradiance data become available, minor changes in the limits are possible. The minimum and maximum limits are at least three sigma from the mean for all the measurements. The range of the relative irradiance of fluorescent UV lamp combinations is determined by radiation measurements at about 50 locations within the exposure area recommended by the apparatus manufacturer.

[c] The minimum and maximum columns will not necessarily sum to 100 % because they represent the minima and maxima for the measurement data used. For any individual spectral irradiance distribution, the percentages calculated for the passbands in this table will sum up to 100 %. For any individual type 1A (UVA-340) fluorescent UV lamp, the calculated percentage in each passband shall fall within the minimum and maximum limits given. Test results can be expected to differ between exposures using type 1A (UVA-340) fluorescent UV lamps in which the spectral irradiance differs by as much as that allowed by the tolerances. Contact the manufacturer of the fluorescent UV apparatus for specific spectral irradiance data for the type 1A (UVA-340) fluorescent UV lamp used.

[d] The data from CIE 85:1989, Table 4[7], is the global solar irradiance on a horizontal surface for an air mass of 1,0, an ozone column of 0,34 cm at standard temperature and pressure (STP), 1,42 cm of precipitable water vapour and a spectral optical depth of aerosol extinction of 0,1 at 500 nm. These data are provided for reference purposes only and are intended to serve as a target.

[e] For the solar spectrum represented by CIE 85:1989, Table 4[7], the UV irradiance (290 nm to 400 nm) is 11 % and the visible irradiance (400 nm to 800 nm) is 89 %, expressed as a percentage of the total irradiance from 290 nm to 800 nm. Because the primary emission of fluorescent UV lamps is concentrated in the 300 nm to 400 nm passband, there are limited data available for the visible light emission of fluorescent UV lamps. The percentages of UV irradiance and visible irradiance on specimens exposed in fluorescent UV apparatus might vary due to the number of specimens being exposed and their reflectance properties.

Table 2 — Relative ultraviolet spectral irradiance for type 1B (UVA-351) fluorescent UV lamps for daylight behind window glass (method B)[a, b]

Spectral passband	Minimum[c]	CIE 85:1989, Table 4, plus effect of window glass[d, e]	Maximum[c]
(λ = wavelength in nm)	%	%	%
$\lambda < 300$	—	0	0,2
$300 \leq \lambda \leq 320$	1,1	≤1	3,3
$320 < \lambda \leq 360$	60,5	33,1	66,8
$360 < \lambda \leq 400$	30,0	66,0	38,0

a This table gives the relative values for irradiance in the given passband, expressed as a percentage of the total irradiance between 290 nm and 400 nm. To determine whether a specific type 1B (UVA-351) fluorescent UV lamp meets the requirements of this table, the spectral irradiance from 250 nm to 400 nm shall be measured. Typically, this is done in 2 nm increments. The total irradiance in each passband is then summed and divided by the total irradiance between 290 nm and 400 nm.

b The minimum and maximum limits given in this table are based on 21 spectral irradiance measurements with type 1B (UVA-351) fluorescent UV lamps from different production lots and of various ages[8]. The spectral irradiance data are for lamps within the ageing recommendations of the apparatus manufacturer. As more spectral irradiance data become available, minor changes in the limits are possible. The minimum and maximum limits are at least three sigma from the mean for all the measurements.

c The minimum and maximum columns will not necessarily sum to 100 % because they represent the minima and maxima for the measurement data used. For any individual spectral irradiance distribution, the percentages calculated for the passbands in this table will sum to 100 %. For any individual type 1B (UVA-351) fluorescent UV lamp, the calculated percentage in each passband shall fall within the minimum and maximum limits given. Test results can be expected to differ between exposures using type 1B (UVA-351) fluorescent UV lamps in which the spectral irradiance differs by as much as that allowed by the tolerances. Contact the manufacturer of the fluorescent UV apparatus for specific spectral irradiance data for the type 1B (UVA-351) fluorescent UV lamp used.

d The data from CIE 85:1989, Table 4[7], plus the effect of window glass was determined by multiplying the CIE 85:1989, Table 4[7] data by the spectral transmittance of typical 3-mm-thick window glass (see ISO 16474-2:2013, Annex A). These data are provided for reference purposes only and are intended to serve as a target.

e For the solar spectrum represented by CIE 85:1989, Table 4[7], plus window glass data, the UV irradiance from 300 nm to 400 nm is typically about 9 % and the visible irradiance (400 nm to 800 nm) is typically about 91 %, expressed as a percentage of the total irradiance from 300 nm to 800 nm. Because the primary emission of fluorescent UV lamps is concentrated in the 300 nm to 400 nm passband, there are limited data available for the visible light emission of fluorescent UV lamps. The percentages of UV irradiance and visible irradiance on specimens exposed in fluorescent UV apparatus might vary due to the number of specimens being exposed and their reflectance properties.

Table 3 — Relative ultraviolet spectral irradiance for type 2 (UVB-313) fluorescent UV lamps (method C)[a, b]

Spectral passband	Minimum[c]	CIE 85:1989, Table 4[d, e]	Maximum[c]
(λ = wavelength in nm)	%	%	%
$\lambda < 290$	1,3	0	5,4
$290 \leq \lambda \leq 320$	47,8	5,4	65,9
$320 < \lambda \leq 360$	26,9	38,2	43,9
$360 < \lambda \leq 400$	1,7	56,4	7,2

[a] This table gives the relative values for irradiance in the given passband, expressed as a percentage of the total irradiance between 250 nm and 400 nm. To determine whether a specific type 2 (UVB-313) fluorescent UV lamp meets the requirements of this table, the spectral irradiance from 250 nm to 400 nm shall be measured. Typically, this is done in 2 nm increments. The total irradiance in each passband is then summed and divided by the total irradiance between 250 nm and 400 nm.

[b] The minimum and maximum limits given in this table are based on 44 spectral irradiance measurements with type 2 (UVB-313) fluorescent UV lamps from different production lots and of various ages[8]. The spectral irradiance data are for lamps within the ageing recommendations of the apparatus manufacturer. As more spectral irradiance data become available, minor changes in the limits are possible. The minimum and maximum limits are at least three sigma from the mean for all the measurements.

[c] The minimum and maximum columns will not necessarily sum to 100 % because they represent the minima and maxima for the measurement data used. For any individual spectral irradiance distribution, the percentages calculated for the passbands in this table will sum to 100 %. For any individual type 2 (UVB-313) fluorescent UV lamp, the calculated percentage in each passband shall fall within the minimum and maximum limits given. Test results can be expected to differ between exposures using type 2 (UVB-313) fluorescent UV lamps in which the spectral irradiance differs by as much as that allowed by the tolerances. Contact the manufacturer of the fluorescent UV apparatus for specific spectral irradiance data for the type 2 lamp used.

[d] The data from CIE 85:1989, Table 4[7], is the global solar irradiance on a horizontal surface for an air mass of 1,0, an ozone column of 0,34 cm at standard temperature and pressure (STP), 1,42 cm of precipitable water vapour and a spectral optical depth of aerosol extinction of 0,1 at 500 nm. These data are provided for reference purposes only.

[e] For the solar spectrum represented by CIE 85:1989, Table 4[7], the UV irradiance (290 nm to 400 nm) is 11 % and the visible irradiance (400 nm to 800 nm) is 89 %, expressed as a percentage of the total irradiance from 290 nm to 800 nm. Because the primary emission of fluorescent UV lamps is concentrated in the 300 nm to 400 nm passband, there are limited data available for the visible light emission of fluorescent UV lamps. The percentages of UV irradiance and visible irradiance on specimens exposed in fluorescent UV apparatus might vary due to the number of specimens being exposed and their reflectance properties.

5.2 Test chamber

The design of the exposure chamber may vary, but it shall be constructed from inert material and provide uniform irradiance in conformance with ISO 16474-1, with means for controlling the temperature. When required, provision shall be made for the formation of condensate or for spraying water onto the exposed faces of the specimens, or for controlling the humidity in the exposure chamber.

5.3 Radiometer

The use of a radiometer for irradiance control is recommended. If a radiometer is used, it shall conform to the requirements given in ISO 16474-1 and ISO 9370. If an automatic irradiance control system is not used, follow the apparatus manufacturer's instructions on the procedure necessary to maintain the desired irradiance.

5.4 Black-standard/black-panel thermometer

The black-standard or black-panel thermometer used shall conform to the requirements for these devices that are given in ISO 16474-1.

5.5 Wetting and humidity

5.5.1 General

Specimens may be exposed to moisture in the form of condensation or water spray. Specific test conditions describing the use of condensation or water spray are described in Table 4. If condensation or water spray is utilized, the specific procedures and exposure conditions used shall be included in the test report.

Table 4 describes various test conditions where relative humidity is not controlled.

NOTE The duration of the condensation or water spray period, or the relative humidity of the air, might have a significant influence on the photo-degradation of coatings.

5.5.2 Spray and condensation system

The test chamber shall be equipped with a means of producing intermittent condensation on, or directing intermittent water spray onto, the front of the test specimens, under specified conditions. The condensate or spray shall be uniformly distributed over the specimens. The spray system shall be made from corrosion resistant materials that do not contaminate the water employed.

When using condensation to wet the test panels, the design of the rack shall be such that, when the panels are mounted in place, there will be sufficient free access of air to cool the back of each panel and produce condensation on the front.

For insulated materials on the back, quickly check the specimens during the condensation period to verify that visible condensation is occurring on the specimens. Perform this visual check once per week at least one hour after the start of condensation.

The spray water quality shall be in accordance to ISO 16474-1. Condensate may be produced from tap water or deionized water.

5.6 Specimen holders

Specimen holders shall be made from inert materials that will not affect the results of the exposure. The behaviour of specimens can be affected by the presence of backing and by the backing material used. The use of backing shall therefore be by mutual agreement between the interested parties.

5.7 Apparatus to assess changes in properties

The apparatus required depends on the properties chosen for monitoring after artificial weathering, e.g. gloss meter in accordance with ISO 2813 when test in gloss, illumination in accordance with ISO 13076 for visual assessments, illumination in accordance with ISO 3668 for visual colour comparison or colorimeter for colour measurements in accordance with ISO 18314-1.

Refer to ISO 16474-1:2013, 8.3.

6 Test specimens (panels)

6.1 General

Refer to ISO 16474-1.

The substrate used for the preparation of the test panels shall be that usually used in practice (e.g. plaster, wood, metal or plastic material).

When using condensation to wet the test panels, the maximum test-panel thickness shall be such that condensation occurs on the front of the panel.

6.2 Preparation and coating

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 agreed, coat only the front of each test panel with the coating material or coating system to be tested. If necessary, coat the backs and edges of the test panels with a protective paint.

6.3 Drying and conditioning

Dry (or stove) and age (if applicable) each coated test panel for the specified time and under the specified conditions.

6.4 Thickness of coating

Determine the thickness, in micrometres (µm), of the dried coating by one of the non-destructive procedures specified in ISO 2808.

6.5 Number of test panels

Refer to ISO 16474-1.

7 Test conditions

7.1 General

Locate the apparatus in a draft-free but ventilated environment maintained at a temperature of (24 ± 5) °C.

7.2 Radiation

Unless otherwise specified, control the UV irradiance at the levels indicated in Table 4. Other irradiance levels may be used when agreed upon by all interested parties. The irradiance and wavelength passband in which it was measured shall be included in the test report.

The use of a radiometer to monitor irradiance and exposure is optional. If a radiometer is used, it shall conform to ISO 16474-1.

7.3 Temperature

Fluorescent UV lamps emit relatively little visible and infrared radiation when compared to solar radiation, xenon-arc sources and carbon-arc sources. Unlike solar radiation, in fluorescent UV apparatus, heating of the specimen surface is primarily by convection of heated air across the panel. Therefore, additional measurement of white-standard temperature or white-panel temperature as recommended in ISO 16474-1 is not necessary. In instruments with sample wetting by condensation and sample cooling by an air flow on the back of each sample, the surface temperature can be highly dependent on the sample's thermal conductivity and thickness.

NOTE 1 In test equipment using air cooling on the back side of the sample panels, there can be a significant difference in the surface temperature between black-panel and black-standard sensors.

Table 4 specifies black-panel temperatures. Black-standard thermometers may be used in place of black-panel thermometers for instruments without sample wetting by condensation and without sample cooling by an air flow on the back of each panel.

NOTE 2 The surface temperature of the specimens is a crucial exposure parameter. Generally, degradation processes run faster with increasing temperature. The specimen temperature permissible for accelerated exposure depends on the material under test and on the ageing criterion under consideration.

Other temperatures may be selected when agreed upon by all interested parties but shall be stated in the test report.

The temperature requirements apply to the equilibrium conditions of the exposure period. If the exposure period duration is not sufficient to reach temperature equilibrium, the maximum temperature attained during that exposure period shall be established and reported.

7.4 Relative humidity of chamber air

Exposures may be conducted with the relative humidity allowed to float without control or with the relative humidity controlled at a specified level.

7.5 Condensation and spray cycles

The condensation or spray cycle shall be as agreed between the interested parties but should preferably be the one in Table 4.

In cases where specimen thickness or low thermal conductivity does not allow condensation, use method A, cycle No. 2 or method C, cycle No 5 (Table 4).

7.6 Complex cycles with dark periods

More complex exposure cycles as listed in Table 4 may be used.

Such programmes shall be given, with full details of the conditions, in the test report.

7.7 Sets of exposure conditions

Four sets of exposure conditions are listed in Table 4 as exposure including condensation (method A, cycle No. 1 and method C, cycle No. 4) and exposure including water spray (method A, cycle No. 2 and method C, cycle No. 5). One set of conditions with no condensation or spray is listed in Table 4 (method B, cycle 3).

Table 4 — Exposure cycles

<table>
<tr><td colspan="6">Method A: artificial weathering</td></tr>
<tr><th>Cycle No.</th><th>Exposure period</th><th>Lamp type</th><th>Irradiance</th><th>Black-panel temperature
°C</th><th>Relative humidity
%</th></tr>
<tr><td rowspan="2">1</td><td>4 h dry</td><td rowspan="2">UVA-340</td><td>0,83 W/m²/nm
at 340 nm</td><td>60 ± 3</td><td>not controlled</td></tr>
<tr><td>4 h condensation</td><td>UV radiation off</td><td>50 ± 3</td><td>not controlled</td></tr>
<tr><td rowspan="2">2</td><td>5 h dry</td><td rowspan="2">UVA-340</td><td>0,83 W/m²/nm
at 340 nm</td><td>50 ± 3</td><td>not controlled</td></tr>
<tr><td>1 h water spray</td><td>UV radiation off</td><td>not controlled</td><td>not controlled</td></tr>
<tr><td colspan="4">Method B: daylight behind window glass</td><td></td><td></td></tr>
<tr><td>3</td><td>24 h dry
(no moisture)</td><td>UVA-351</td><td>0,76 W/m²/nm
at 340nm</td><td>50 ± 3</td><td>not controlled</td></tr>
<tr><td colspan="6">Method C: Type 2 UVB-313 lamps</td></tr>
<tr><td rowspan="2">4</td><td>4 h dry</td><td rowspan="2">UVB-313</td><td>0,71 W/m²/nm
at 310 nm</td><td>60 ± 3</td><td>not controlled</td></tr>
<tr><td>4 h condensation</td><td>UV radiation off</td><td>50 ± 3</td><td>not controlled</td></tr>
<tr><td rowspan="2">5</td><td>5 h dry</td><td rowspan="2">UVB-313</td><td>0,71 W/m²/nm
at 310 nm</td><td>50 ± 3</td><td>not controlled</td></tr>
<tr><td>1 h water spray</td><td>UV radiation off</td><td>not controlled</td><td>not controlled</td></tr>
<tr><td colspan="6">NOTE 1 Higher-irradiance tests can be conducted if agreed upon by all interested parties. If high-irradiance conditions are used, lamp life might be significantly shortened.

NOTE 2 The ±3 °C variation shown for the black-panel temperature is the allowable fluctuation of the indicated black-panel temperature around the given black-panel temperature set point under equilibrium conditions. This does not mean that the set point can vary by ±3 °C from the given value.

NOTE 3 With the use of the UVB-313 fluorescent UV lamp, the degradation of the coating can be un-realistic because of significant un-natural radiation below 290 nm.</td></tr>
</table>

8 Procedure and mounting of the test specimens

8.1 General

Follow the recommendation given in ISO 16474-1.

8.2 Exposure

Before placing the specimens in the test chamber, be sure that the apparatus is operating under the desired conditions (see Clause 7). Programme the selected test conditions to operate continuously throughout the entire exposure period selected. The test conditions selected shall be agreed between all parties concerned and within the capabilities of the apparatus used. Maintain these conditions throughout the exposure. Interruptions to service the apparatus and to inspect specimens shall be minimized.

Expose the test specimens and, if required, the irradiance-measuring device for the specified period of exposure. Repositioning of the specimens during exposure is desirable and might be necessary to ensure uniformity of all exposure stresses. Follow the guidance in ISO 16474-1.

If it is necessary to remove a test specimen for a periodic inspection, care shall be taken not to handle or disturb the test surface. After inspection, the test specimen shall be returned to its holder or to the test chamber with its test surface in the same orientation as before.

8.3 Measurement of radiant exposure

If used, mount the radiometer so that it indicates the irradiance at the exposed surface of the test specimen.

When radiant exposure is measured, express the exposure interval in terms of the incident radiant energy per unit area of the exposure plane in joules per square metre per nanometre ($J \cdot m^{-2}\ nm^{-1}$) for the wavelength selected (e.g. 340 nm).

8.4 Determination of changes in properties after exposure

Refer to ISO 16474-1.

9 Test report

Refer to ISO 16474-1.

Annex A
(informative)

Spectral distribution of radiation for typical fluorescent UV lamps

A.1 General

A variety of fluorescent UV lamps may be used for the purposes of exposure. The lamps described in this annex are representative of their type. Other lamps, or combinations of lamps, may also be used. The particular application determines which lamp should be used. The lamps discussed in this annex differ in the total amount of UV energy emitted and in their wavelength spectrum. Differences in lamp energy or spectrum might cause significant differences in the results of exposure. Consequently, it is extremely important to report the lamp type in the exposure report.

A.2 Representative spectral irradiance data

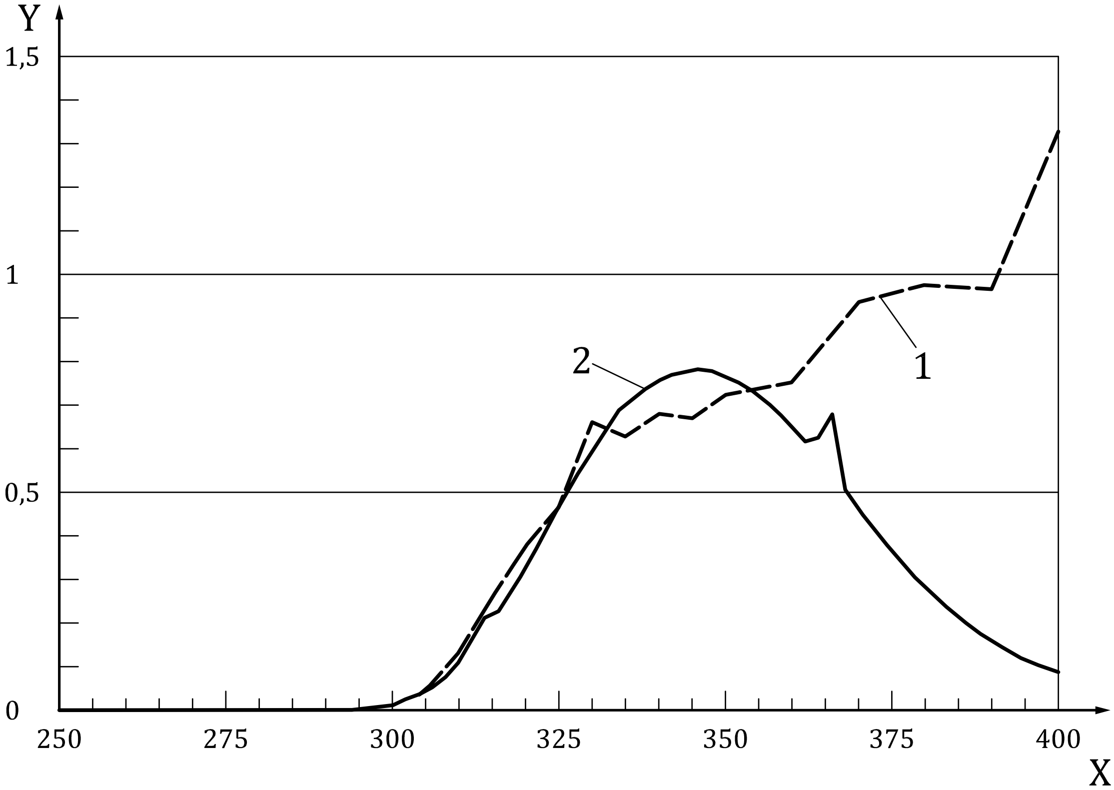
A.2.1 Type 1A (UVA-340) and type 1B (UVA-351) fluorescent UV lamps

A.2.1.1 Figure A.1 and Figure A.2 show representative spectral distributions for type 1A (UVA-340) and type 1B (UVA-351) fluorescent UV lamps.

For non-irradiance-controlled test apparatus, actual irradiance levels will vary depending on the type and/or manufacturer of the lamp used, the age of the lamps, the distance to the lamp array and the air temperature within the exposure chamber. For test apparatus with feedback loop irradiance control, the light intensity may be programmed at various levels within a selected range.

A.2.1.2 For most applications, the wavelength spectrum of type 1A (UVA-340) fluorescent UV lamps is recommended. Figure A.1 illustrates the spectral irradiance for a type 1A (UVA-340) fluorescent UV lamp compared to daylight as specified in CIE 85:1989, Table 4.

A.2.1.3 Type 1B (UVA-351) lamps are mostly used for behind-window-glass simulations. Figure A.2 illustrates the spectral irradiance for a typical type 1B (UVA-351) fluorescent UV lamp compared to daylight behind window glass as specified in CIE 85:1989, Table 4. Note that type 1A (UVA-340) and type 1B (UVA-351) fluorescent UV lamps have different spectral irradiance distributions and can produce very different results.



Key

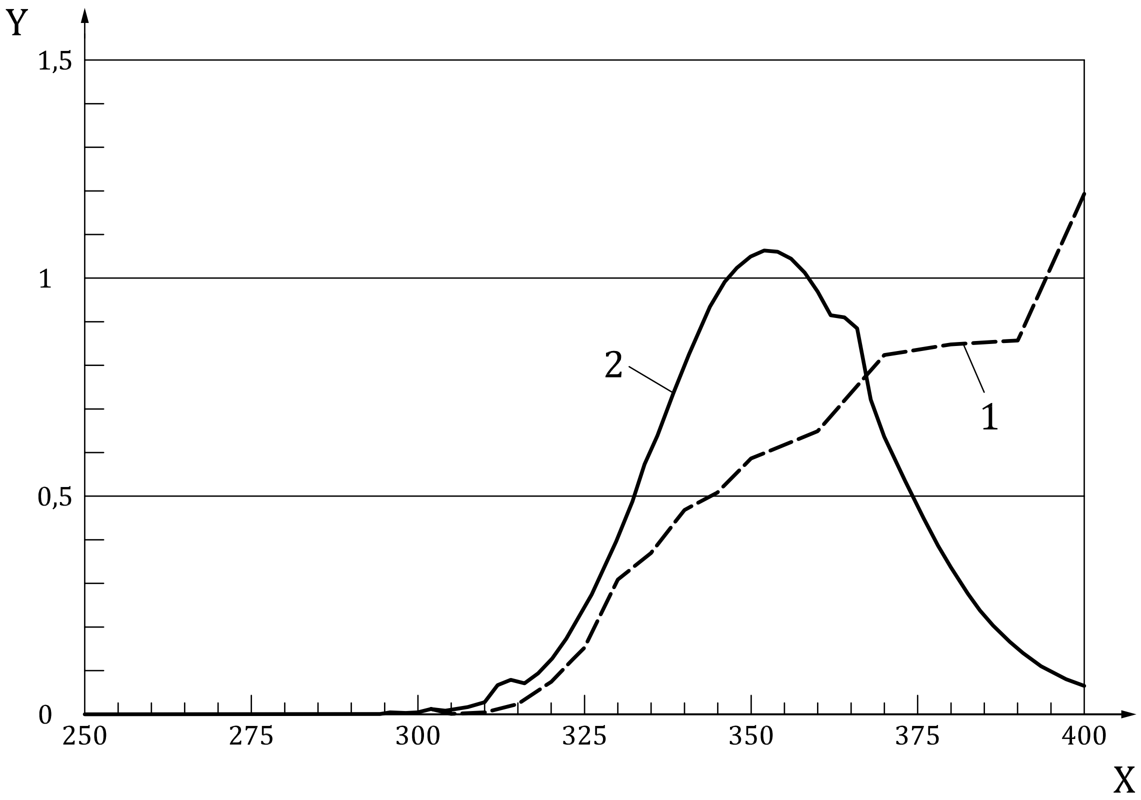
X wavelength, λ (nm)

Y spectral irradiance, E_λ (W · m^{-2}·nm^{-1})

1 CIE 85:1989, Table 4, daylight

2 spectral irradiance for a typical type 1A (UVA-340) lamp

Figure A.1 — Spectral irradiance for a typical type 1A (UVA-340) fluorescent UV lamp compared to CIE 85:1989, Table 4, daylight



Key

X wavelength, λ (nm)

Y spectral irradiance, E_λ ($W \cdot m^{-2} \cdot nm^{-1}$)

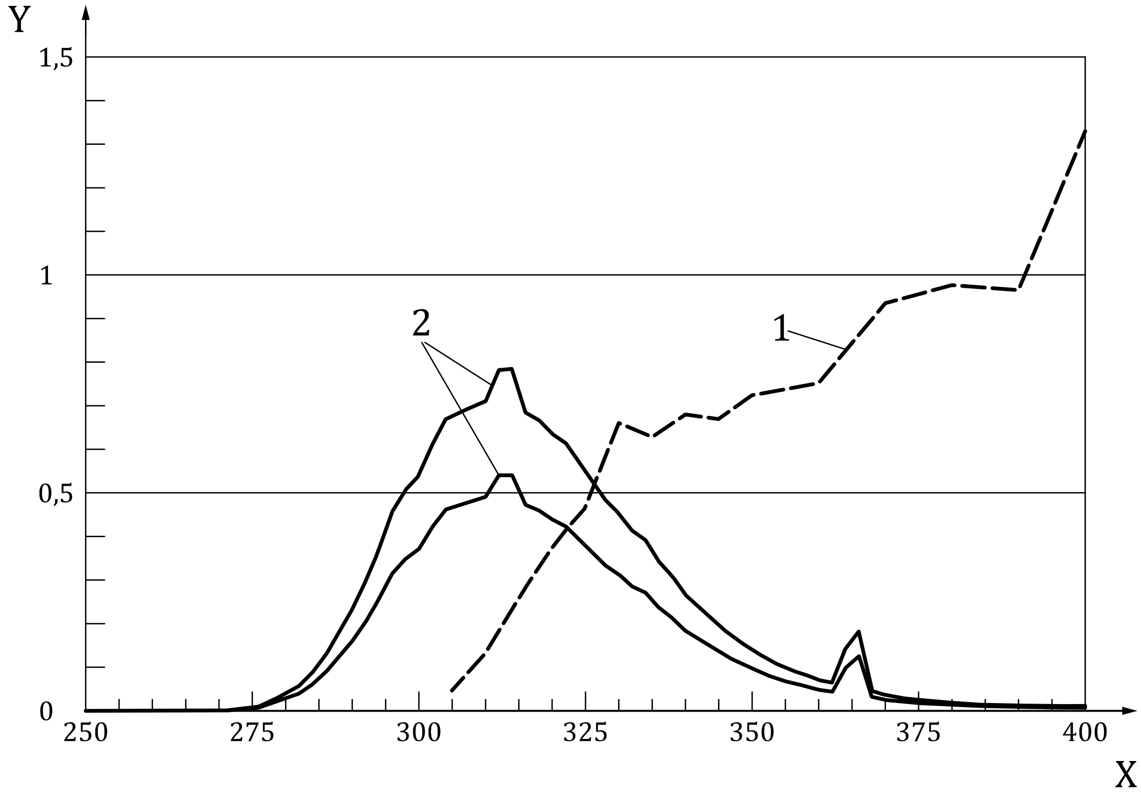
1 CIE 85:1989, Table 4, daylight through typical window glass

2 spectral irradiance for a typical type 1B (UVA-351) fluorescent UV lamp

Figure A.2 — Spectral irradiance for a typical type 1B (UVA-351) fluorescent UV lamp compared to CIE 85:1989, Table 4, daylight through typical window glass

A.2.2 Type 2 (UVB-313) fluorescent UV lamps

Figure A.3 illustrates the spectral irradiance of two commonly used type 2 (UVB-313) fluorescent UV lamps compared to daylight. These lamps have a peak emission at 313 nm.



Key

X wavelength, λ (nm)

Y spectral irradiance, E_λ (W · m^{-2} · nm^{-1})

1 CIE 85:1989, Table 4, daylight

2 spectral irradiance for typical type 2 (UVB-313) fluorescent UV lamps

Figure A.3 — Spectral irradiance for typical type 2 (UVB-313) fluorescent UV lamps compared to CIE 85:1989, Table 4, daylight

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

[6] ISO 18314-1, *Analytical colorimetry — Part 1: Practical colour measurement*

[7] CIE 85:1989, *Solar spectral irradiance*

[8] ASTM G154, *Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials*