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**Paints and varnishes — Methods of
exposure to laboratory light sources —**

**Part 3:
Fluorescent UV lamps**

*Peintures et vernis — Méthodes d'exposition à des sources lumineuses
de laboratoire —*

Partie 3: Lampes fluorescentes UV



Reference number
ISO 16474-3:2013(E)

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Foreword

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

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

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

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

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: [Foreword - Supplementary information](#)

The committee responsible for this document is ISO/TC 35, *Paints and varnishes*, Subcommittee SC 9, *General test methods for paints and varnishes*.

This first edition of ISO 16474-3, together with ISO 16474-1 cancels and replaces ISO 11507:2007, which has been technically revised.

ISO 16474 consists of the following parts, under the general title *Paints and varnishes — Methods of exposure to laboratory light sources*:

- Part 1: *General guidance*
- Part 2: *Xenon-arc lamps*
- Part 3: *Fluorescent UV lamps*
- Part 4: *Open-flame carbon-arc lamps*

This corrected version of ISO 16474-3:2013 incorporates the following corrections.

- In 7.4, "method B" has been replaced by "method A, cycle No. 2".
- In 7.6, "(method A)" has been replaced by "(method A, cycle No. 1)" and "(method B)" has been replaced by "(method A, cycle No. 2)".

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.

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Paints and varnishes — Methods of exposure to laboratory light sources —

Part 3: Fluorescent UV lamps

1 Scope

This part of ISO 16474 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 may 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, 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 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, *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.

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 $H = \int E \cdot dt$

where

H is the radiant exposure, in joules per square metre;

E is the irradiance, in watts per square metre;

t is the exposure time, in seconds

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 mostly 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 part of ISO 16474:

- 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, have an emission peak at 343 nm, and are more commonly identified as UVA-340 for simulation of daylight from 300 nm to 340 nm (see [Table 1](#), column [A.1](#)). [Figure A.1](#) is a graph of spectral irradiance from 250 nm to 400 nm of a typical type 1A (UVA-340) fluorescent 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, have a peak emission at 353 nm, and 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 are more commonly identified as UVB-313 and have a radiant emission below 300 nm that is more than 10 % of the total output and a peak emission at 313 nm (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 lamps compared to daylight. Type 2 (UVB-313) 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) 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 No. 85.[2] The benchmark daylight used in this part of ISO 16474 is from CIE No. 85:1989, Table 4.

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) lamps shall be used to simulate the UV part of daylight through window glass (see [Table 4](#), method B).

5.1.3 Fluorescent 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 lamps for daylight UV (method A) a, b

Spectral pass-band	Minimum ^c	CIE No. 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 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) 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) lamps in this table are based on more than 60 spectral irradiance measurements with type 1A (UVA-340) lamps from different production lots and of various ages.^[3] 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 pass-bands in this table will sum to 100 %. For any individual type 1A (UVA-340) fluorescent lamp, the calculated percentage in each pass-band shall fall within the minimum and maximum limits given. Test results can be expected to differ between exposures using type 1A (UVA-340) 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) lamp used.

^d The data from CIE No. 85:1989, Table 4, is the global solar irradiance on a horizontal surface for an air mass of 1,0, an ozone column of 0,34 cm at 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 No. 85:1989, Table 4, 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 pass-band, 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) lamps for daylight behind window glass (method B) a, b

Spectral pass-band	Minimum ^c	CIE No. 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 irradiance in the given pass-band, expressed as a percentage of the total irradiance between 290 nm and 400 nm. To determine whether a specific type 1B (UVA-351) 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 pass-band 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) lamps from different production lots and of various ages.^[3] 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 pass-bands in this table will sum to 100 %. For any individual type 1B (UVA-351) fluorescent lamp, the calculated percentage in each pass-band shall fall within the minimum and maximum limits given. Test results can be expected to differ between exposures using type 1B (UVA-351) 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) lamp used.

d The data from CIE No. 85:1989, Table 4, plus the effect of window glass was determined by multiplying the CIE No. 85:1989, Table 4 data by the spectral transmittance of typical 3-mm-thick window glass (see ISO 16474-2, 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 No. 85:1989, Table 4, 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) lamps (method C) a, b

Spectral passband	Minimum ^c	CIE No. 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 irradiance in the given pass-band, expressed as a percentage of the total irradiance between 250 nm and 400 nm. To determine whether a specific type 2 (UVB-313) 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 pass-band 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) lamps from different production lots and of various ages.^[3] 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 pass-bands in this table will sum to 100 %. For any individual type 2 (UVB-313) fluorescent lamp, the calculated percentage in each pass-band shall fall within the minimum and maximum limits given. Test results can be expected to differ between exposures using type 2 (UVB-313) 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 No. 85:1989, Table 4, is the global solar irradiance on a horizontal surface for an air mass of 1,0, an ozone column of 0,34 cm at 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 No. 85:1989, Table 4, 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 pass-band, 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 comply with 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.

NOTE 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 deionised 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 by the International Standards relating to the determination of the properties chosen for monitoring shall be used.

Refer to ISO 16474-1.

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, 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

Locate the apparatus in a draft-free but ventilated environment maintained at a temperature of $(24 \pm 5) ^\circ\text{C}$.

7.1 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.

7.2 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, the difference between the temperature of a black-panel thermometer, a black-standard thermometer, the specimen surface and the air in the test chamber is typically $< 2 ^\circ\text{C}$. Additional measurement of white-standard temperature or white panel temperature as recommended in ISO 16474-1 is not necessary.

For reference purposes, [Table 4](#) specifies black-panel temperatures. black-standard thermometers may be used in place of black-panel thermometers.

NOTE 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.

If condensation periods are used, the temperature requirements apply to the equilibrium conditions of the condensation period. If water spray periods are used, the temperature requirements apply to the end of the dry period. If the temperature does not attain equilibrium during a short cycle, the specified

temperature shall be established without water spray and the maximum temperature attained during the dry cycle shall be reported.

7.3 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.

[Table 4](#) describes the exposure cycles.

7.4 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 ([Table 4](#)).

7.5 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.

7.6 Sets of exposure conditions

Two sets of exposure conditions are listed in [Table 4](#) as exposure including condensation (method A, cycle No. 1) and exposure including water spray (method A, cycle No. 2).

Table 4 — Exposure cycles

Method A: artificial weathering					
Cycle No	Exposure period	Lamp type	Irradiance	Black-panel temperature	Relative humidity
				°C	%
1	4 h dry	UVA-340	0,83 W/m ² /nm at 340 nm	60 ± 3	not controlled
	4 h condensation		UV radiation off	50 ± 3	not controlled
2	5 h dry	UVA-340	0,83 W/m ² /nm at 340 nm	50 ± 3	not controlled
	1 h water spray		UV radiation off	25 ± 3	not controlled
Method B: daylight behind window glass					
3	24 h dry (no moisture)	UVA-351	0,76 W/m ² /nm at 340nm	50 ± 3	not controlled
Method C: Type 2 UVB-313 lamps					
4	4 h dry	UVB-313	0,71 W/m ² /nm at 310 nm	60 ± 3	not controlled
	4 h condensation		UV lamps off	50 ± 3	not controlled
5	5 h dry	UVB-313	0,71 W/m ² /nm at 310 nm	50 ± 3	not controlled
	1 h water spray		UV lamps off	25 ± 3	not controlled
NOTE 1 Higher-irradiance tests may 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-standard temperature set point under equilibrium conditions. This does not mean that the set point may vary by ± 3 °C from the given value.					
NOTE 3 With the use of the UVB-313 fluorescent lamp, the degradation of the coating can be un-realistic because of significant un-natural radiation below 290 nm.					

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 [$\text{J} \cdot \text{m}^{-2} \cdot \text{nm}^{-1}$] 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

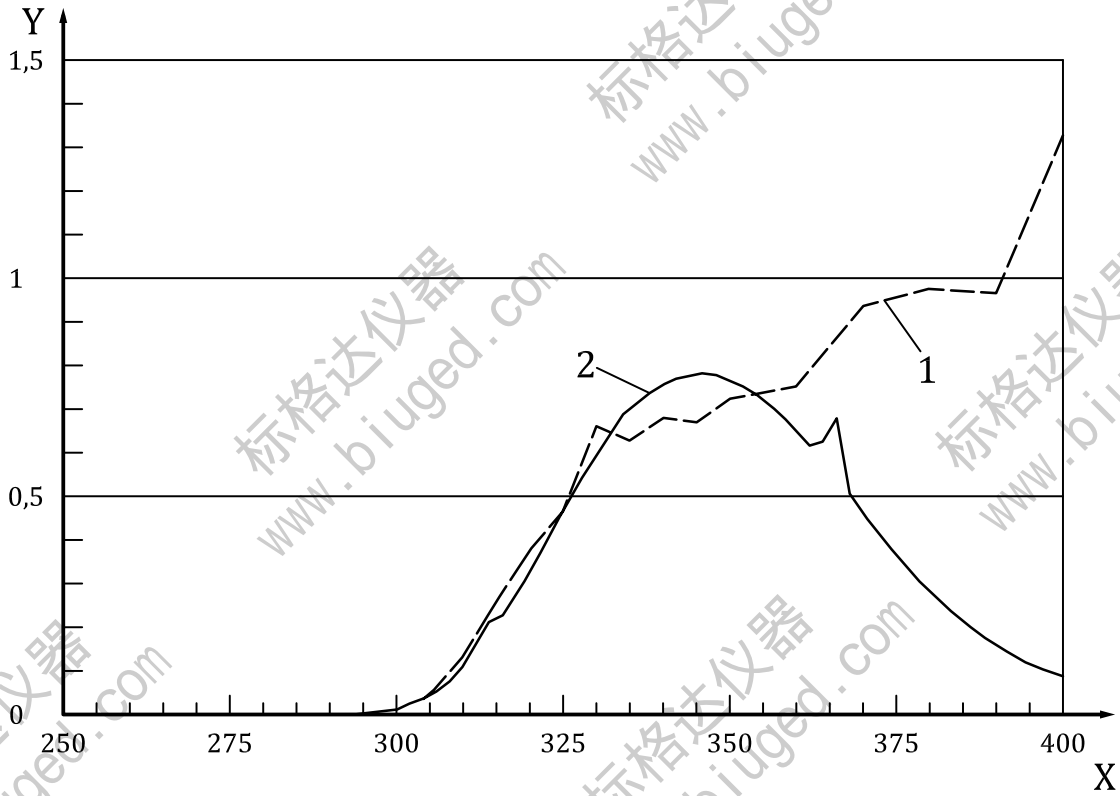
A.2.1 Type 1A (UVA-340) and type 1B (UVA-351) lamps

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) 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.

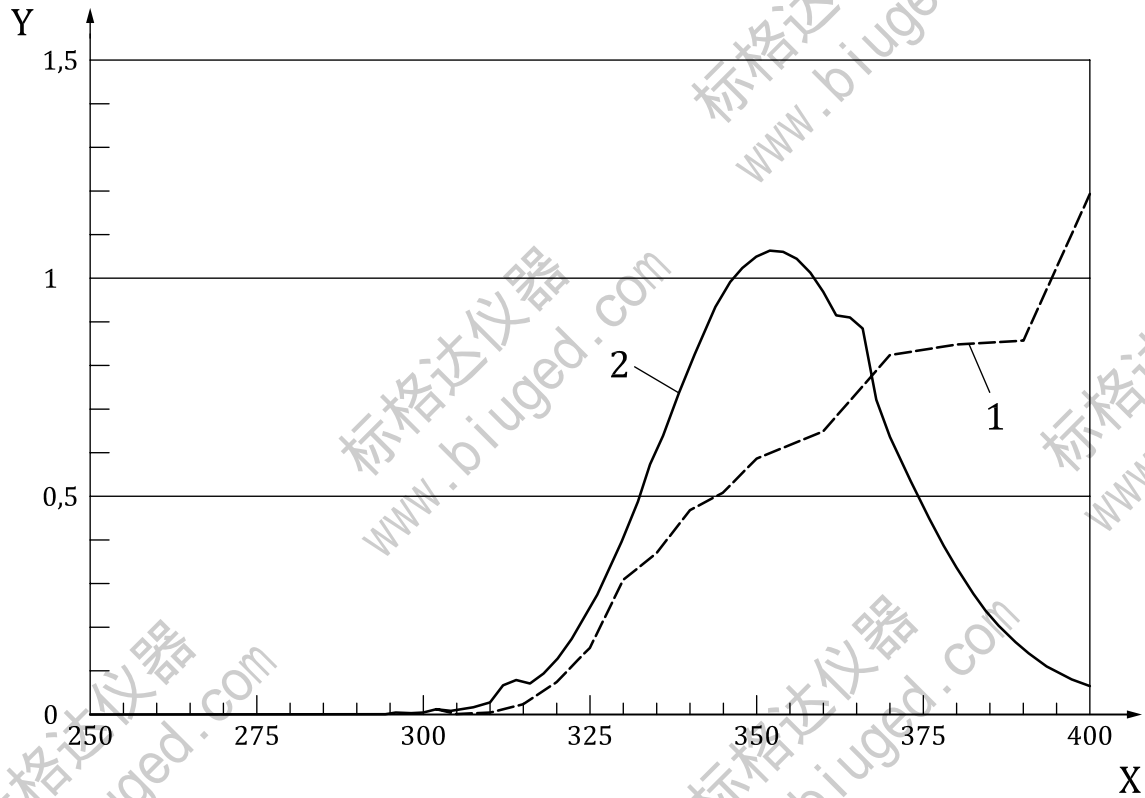
A.2.1.2 For most applications, the wavelength spectrum of type 1A (UVA-340) lamps is recommended. [Figure A.1](#) illustrates the spectral distribution for a type 1A (UVA-340) lamp compared to CIE No. 85:1989, Table 4, daylight.

A.2.1.3 Type 1B (UVA-351) lamps are mostly used for behind-window-glass simulations. Spectral irradiance for a typical type 1B (UVA-351) lamp is compared to CIE No. 85:1989, Table 4 daylight behind window glass is shown in [Figure A.2](#). Note that type 1A (UVA-340) and type 1B (UVA-351) lamps have different spectral irradiance distributions and can produce very different results.

**Key**

- 1 CIE No. 85:1989, Table 4, daylight
- 2 spectral irradiance for a typical type 1A (UVA-340) lamp
- X wavelength, λ (nm)
- Y spectral irradiance, E_λ ($W \cdot m^{-2} \cdot nm^{-1}$)

Figure A.1 — Spectral irradiance for a typical type 1A (UVA-340) lamp compared to CIE No. 85:1989, Table 4, daylight

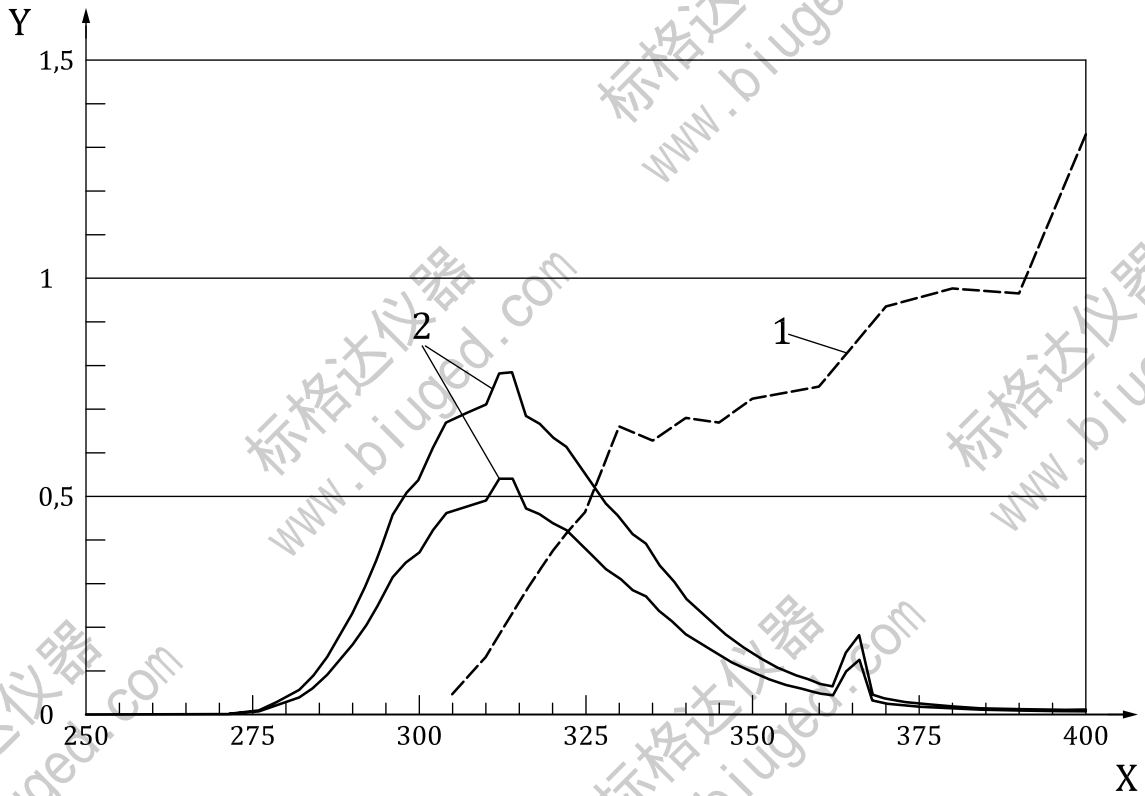


- Key**
- 1 CIE No. 85:1989, Table 4, daylight through typical window glass
 - 2 spectral irradiance for a typical type 1B (UVA-351) lamp
 - X wavelength, λ (nm)
 - Y spectral irradiance, E_{λ} ($W \cdot m^{-2} \cdot nm^{-1}$)

Figure A.2 — Spectral irradiance for typical type 1B (UVA-351) lamp compared to CIE No. 85:1989, Table 4, daylight through typical window glass

A.2.2 Type 2 (UVB-313) lamps

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



Key

- 1 CIE No. 85:1989, Table 4, daylight
- 2 spectral irradiance for typical type 2 (UVB-313) lamps
- X wavelength, λ (nm)
- Y spectral irradiance, E_{λ} ($W \cdot m^{-2} \cdot nm^{-1}$)

Figure A.3 — Spectral irradiance for typical type 2 (UVB-313) lamps compared to CIE No. 85:1989, Table 4, daylight

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- [1] ISO 4892-3:2006, *Plastics — Methods of exposure to laboratory light sources — Part 3: Fluorescent UV lamps*
- [2] CIE No. 85:1989, *Solar spectral irradiance*
- [3] ASTM G 154, *Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials*

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