# INTERNATIONAL STANDARD

# ISO 4892-3

Second edition
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## Plastics — Methods of exposure to laboratory light sources —

## Part 3: Fluorescent UV lamps

*Plastiques — Méthodes d'exposition à des sources lumineuses de laboratoire —*

*Partie 3: Lampes fluorescentes UV*

Reference number
ISO 4892-3:2006(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.

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

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 4892-3 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 6, *Ageing, chemical and environmental resistance*.

This second edition cancels and replaces the first edition (ISO 4892-3:1994), which has been technically revised.

ISO 4892 consists of the following parts, under the general title *Plastics — 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*

# Plastics — Methods of exposure to laboratory light sources —

## Part 3:
## Fluorescent UV lamps

## 1 Scope

This part of ISO 4892 specifies methods for exposing specimens to fluorescent UV radiation, 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 specimens are exposed to 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 4892-1.

NOTE Fluorescent UV lamp exposures for paints, varnishes and other coatings are described in ISO 11507[4].

## 2 Normative references

The following referenced documents are indispensable for the application 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 4582, *Plastics — Determination of changes in colour and variations in properties after exposure to daylight under glass, natural weathering or laboratory light sources*

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

## 3 Principle

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

**3.2** Specimens are exposed to various levels of UV radiation, heat and moisture (see 3.4) under controlled environmental conditions.

**3.3** The exposure conditions may be varied by selection of:

a) The type of fluorescent lamp.

b) The irradiance level.

c) The temperature during the light 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 devices usually do not provide means of relative humidity control.

e) The type of wetting (see 3.4).

f) The wetting temperature and cycle.

g) The timing of the light/dark cycle.

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

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

**3.6** 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.

**3.7** 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.

## 4 Apparatus

### 4.1 Laboratory light source

**4.1.1** 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 4892:

— **Type 1A (UVA-340) fluorescent UV lamp**: These lamps have a radiant emission below 300 nm of less than 2 % 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 of Annex A is a graph of spectral irradiance from 250 nm to 400 nm of a typical type 1A (UVA-340) fluorescent lamp compared to daylight. If specified and agreed upon by all parties, a combination of fluorescent UVA lamps may also be used (see Table 1, column A.2). When combinations of lamps with different spectral emissions are used, provision shall be made to ensure the uniformity of the spectral irradiance at the surface of the specimens, e.g. by continuous repositioning of the specimens around the lamp array.

— **Type 1B (UVA-351) fluorescent UV lamp**: These lamps have a radiant emission below 300 nm of less than 2 % 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 of Annex A 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 of Annex A 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 may 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 Publication No. 85[1]. The benchmark daylight used in this part of ISO 4892 is from Table 4 in CIE Publication No. 85:1989.

**4.1.2** 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).

**4.1.3** 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.

**4.1.4** Irradiance uniformity shall be in accordance with the requirements specified in ISO 4892-1. Requirements for periodic repositioning of specimens when irradiance within the exposure area is less than 90 % of the peak irradiance are described in ISO 4892-1.

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

| Spectral passband ($\lambda$ = wavelength in nm) | Type 1A (UVA-340) lamp A.1 | | | Type 1A lamp combination A.2 | | |
|---|---|---|---|---|---|---|
| | Minimum [c] % | CIE No. 85:1989, Table 4 [d,e] % | Maximum [c] % | Minimum [c] % | CIE No. 85:1989, Table 4 [d,e] % | Maximum [c] % |
| $\lambda < 290$ | | 0 | 0,01 | | 0 | 0 |
| $290 \leqslant \lambda \leqslant 320$ | 5,9 | 5,4 | 9,3 | 4 | 5,4 | 7 |
| $320 < \lambda \leqslant 360$ | 60,9 | 38,2 | 65,5 | 48 | 38,2 | 56 |
| $360 < \lambda \leqslant 400$ | 26,5 | 56,4 | 32,8 | 38 | 56,4 | 46 |

[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 [2]. 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 to 100 %. For any individual type 1A (UVA-340) fluorescent 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) 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 Table 4 in CIE Publication No. 85:1989 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 Table 4 in CIE No. 85:1989, 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 may 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 passband ($\lambda$ = wavelength in nm) | Minimum [c] % | CIE No. 85:1989, Table 4, plus effect of window glass [d,e] % | Maximum [c] % |
|---|---|---|---|
| $\lambda < 300$ | | 0 | 0,2 |
| $300 \leqslant \lambda \leqslant 320$ | 1,1 | $\leqslant$ 1 | 3,3 |
| $320 < \lambda \leqslant 360$ | 60,5 | 33,1 | 66,8 |
| $360 < \lambda \leqslant 400$ | 30,0 | 66,0 | 38,0 |

[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 1B (UVA-351) lamp meets the requirements of this table, the spectral irradiance from 250 nm to 400 nm shall be measured. 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) lamps from different production lots and of various ages [2]. 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 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) 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 Table 4 in CIE No. 85:1989 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 11341 [3]). These data are provided for reference purposes only and are intended to serve as a target.

[e] For the 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 may 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 ($\lambda$ = wavelength in nm) | Minimum [c] % | CIE No. 85:1989, Table 4 [d, e] % | Maximum [c] % |
|---|---|---|---|
| $\lambda < 290$ | 1,3 | 0 | 5,4 |
| $290 \leqslant \lambda \leqslant 320$ | 47,8 | 5,4 | 65,9 |
| $320 < \lambda \leqslant 360$ | 26,9 | 38,2 | 43,9 |
| $360 < \lambda \leqslant 400$ | 1,7 | 56,4 | 7,2 |

[a] This table gives the 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) lamp meets the requirements of this table, the spectral irradiance from 250 nm to 400 nm shall be measured. 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) lamps from different production lots and of various ages [2]. 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 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) 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 Table 4 in CIE Publication No. 85:1989 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 Table 4 in CIE No. 85:1989, 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 may vary due to the number of specimens being exposed and their reflectance properties.

## 4.2 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 4892-1, 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.

## 4.3 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 4892-1. If an automatic irradiance control system is not used, follow the apparatus manufacturer's instructions on the procedure necessary to maintain the desired irradiance.

## 4.4 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 4892-1.

## 4.5 Wetting and humidity

### 4.5.1 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 controlled and where humidity control is not required.

NOTE The duration of the condensation or water spray period, or the relative humidity of the air, may have a significant influence on the photodegradation of polymers.

#### 4.5.2 Relative humidity control equipment

The relative humidity may be controlled during the exposure. For tests where relative humidity control is required, the locations of the sensors used to measure the humidity shall conform to the requirements given in ISO 4892-1. For tests where relative humidity is controlled, the equipment shall be able to maintain the humidity at the desired value to within ± 10 % RH.

#### 4.5.3 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.

Water sprayed on specimen surfaces shall have a conductivity below 5 μS/cm, contain less than 1 ppm of dissolved solids and leave no observable stains or deposits on the specimens. Care shall be taken to keep silica levels below 0,2 ppm. A combination of deionization and reverse osmosis can be used to produce water of the desired quality.

### 4.6 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.

### 4.7 Apparatus to assess changes in properties

The apparatus required by the International Standards relating to the determination of the properties chosen for monitoring (see also ISO 4582) shall be used.

## 5 Test specimens

Refer to ISO 4892-1.

## 6 Test conditions

### 6.1 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.

### 6.2 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 °C. Additional measurement of white-standard temperature or white-panel temperature as recommended in ISO 4892-1 is not necessary.

For reference purposes, Table 4 specifies black-standard temperatures. Black-panel thermometers may be used in place of black-standard 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.

## 6.3 Relative humidity of chamber air

Exposures can 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.

## 6.4 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.

## 6.5 Cycles with dark periods

The conditions of cycles No. 3 and 4 are valid for continuous presence of radiant energy from the source. More complex cycles may be used. These could include dark periods that might include high humidity and/or formation of condensate on the specimen surface.

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

## 6.6 Sets of exposure conditions

Various sets of exposure conditions are listed in Table 4 as “exposure cycles” for artificial weathering (method A), for daylight behind window glass (method B) and for type 2 (UVB-313) lamps (method C).

**Table 4 — Exposure cycles**

| Cycle No. | Exposure period | Lamp type | Irradiance | Black-standard temperature | Relative humidity (%) |
|---|---|---|---|---|---|
| **Method A:** | **Artificial weathering** | | | | |
| 1 | 8 h dry | Type 1A (UVA-340) | 0,76 W·m$^{-2}$·nm$^{-1}$ at 340 nm | 60 °C ± 3 °C | Not controlled |
| | 4 h condensation | | Light off | 50 °C ± 3 °C | |
| 2 | 8 h dry | Type 1A (UVA-340) | 0,76 W·m$^{-2}$·nm$^{-1}$ at 340 nm | 50 °C ± 3 °C | Not controlled |
| | 0,25 h water spray | | | Not controlled | Not controlled |
| | 3,75 h condensation | | Light off | 50 °C ± 3 °C | Not controlled |
| 3 | 5 h dry | Type 1A lamp combination | Continuously 45 W·m$^{-2}$ (290 nm to 400 nm) | 50 °C ± 3 °C | < 15 |
| | 1 h water spray | | | 25 °C ± 3 °C | Not controlled |
| 4 | 5 h dry | Type 1A lamp combination | Continuously 45 W·m$^{-2}$ (290 nm to 400 nm) | 70 °C ± 3 °C | < 15 |
| | 1 h water spray | | | 25 °C ± 3 °C | Not controlled |
| **Method B:** | **Daylight behind window glass** | | | | |
| 5 | 24 h dry (no moisture) | Type 1B (UVA-351) | 0,76 W·m$^{-2}$·nm$^{-1}$ at 340 nm | 50 °C ± 3 °C | Not controlled |
| **Method C:** | **Type 2 UVB-313 lamps** | | | | |
| 6 | 8 h dry | Type 2 (UVB-313) | 0,48 W·m$^{-2}$·nm$^{-1}$ at 310 nm | 70 °C ± 3 °C | Not controlled |
| | 4 h condensation | | Light off | 50 °C ± 3 °C | |

NOTE 1 Higher-irradiance tests may be conducted if agreed upon by all interested parties. When high-irradiance conditions are used, lamp life may be significantly shortened.

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

# 7 Procedure

## 7.1 General

It is recommended that at least three replicates of each material evaluated be exposed in each test to allow statistical evaluation of the results.

## 7.2 Mounting the test specimens

Attach the specimens to the specimen holders in the apparatus in such a manner that the specimens are not subject to any applied stress. Identify each test specimen by suitable indelible marking, avoiding areas to be used for subsequent testing. As a check, a plan of the test-specimen positions may be made.

If desired, in the case of specimens used to determine change in colour and appearance, a portion of each test specimen may be shielded by an opaque cover throughout the test. This gives an unexposed area adjacent to the exposed area for comparison. This is useful for checking the progress of the exposure, but the data reported shall always be based on a comparison with file specimens stored in the dark.

Fill all spaces in the exposure area in order to ensure uniform exposure conditions. Use blank panels if necessary.

### 7.3 Exposure

Before placing the specimens in the test chamber, be sure that the apparatus is operating under the desired conditions (see Clause 6). 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 may be necessary to ensure uniformity of all exposure stresses. Follow the guidance in ISO 4892-1.

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.

### 7.4 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 exposures are used, express the exposure interval in terms of the incident radiant energy per unit area of the exposure plane in joules per square metre ($J/m^2$) in the wavelength band from 290 nm to 400 nm or joules per square metre per nanometre [$J/(m^2 \cdot nm)$] for the wavelength selected (e.g. 340 nm).

### 7.5 Determination of changes in properties after exposure

These shall be determined as specified in ISO 4582.

## 8 Exposure report

Refer to ISO 4892-1.

# Annex A
(informative)

# Spectral distribution of radiation for typical fluorescent UV lamps

## A.1 General

A variety of fluorescent UV lamps can 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 may 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

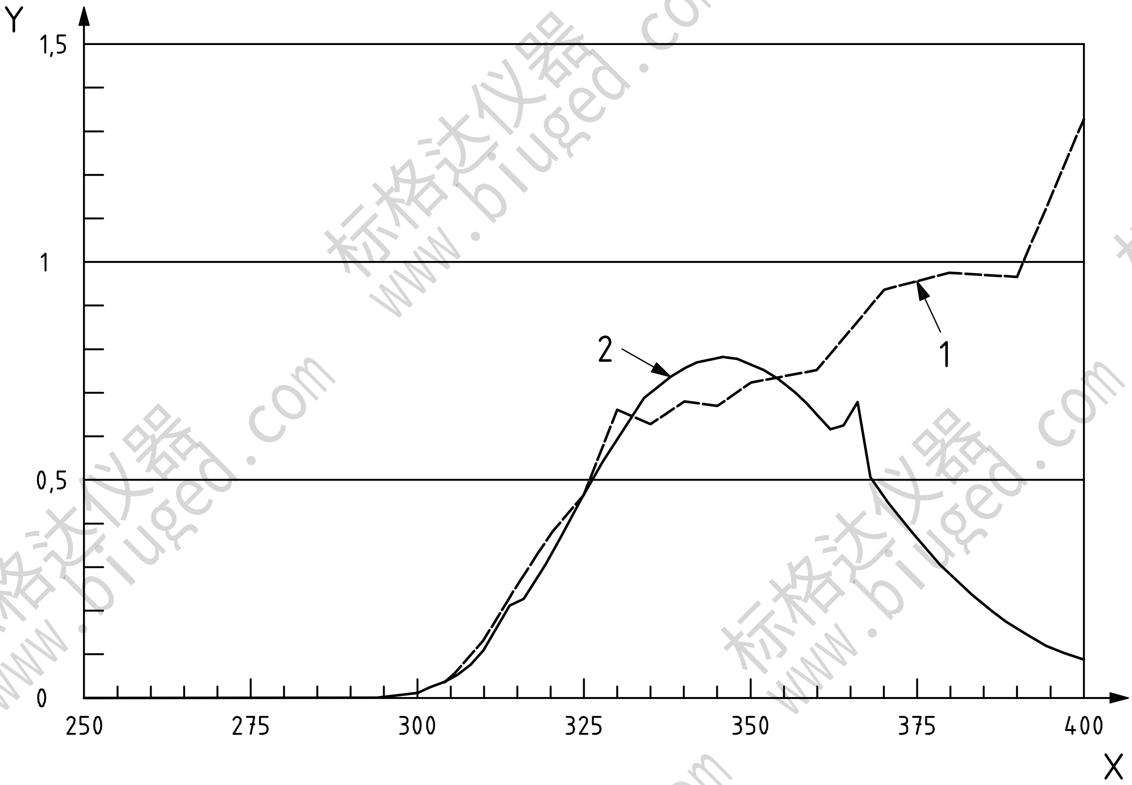
### A.2.1 Type 1A (UVA-340) and type 1B (UVA-351) lamps

**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 can 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**

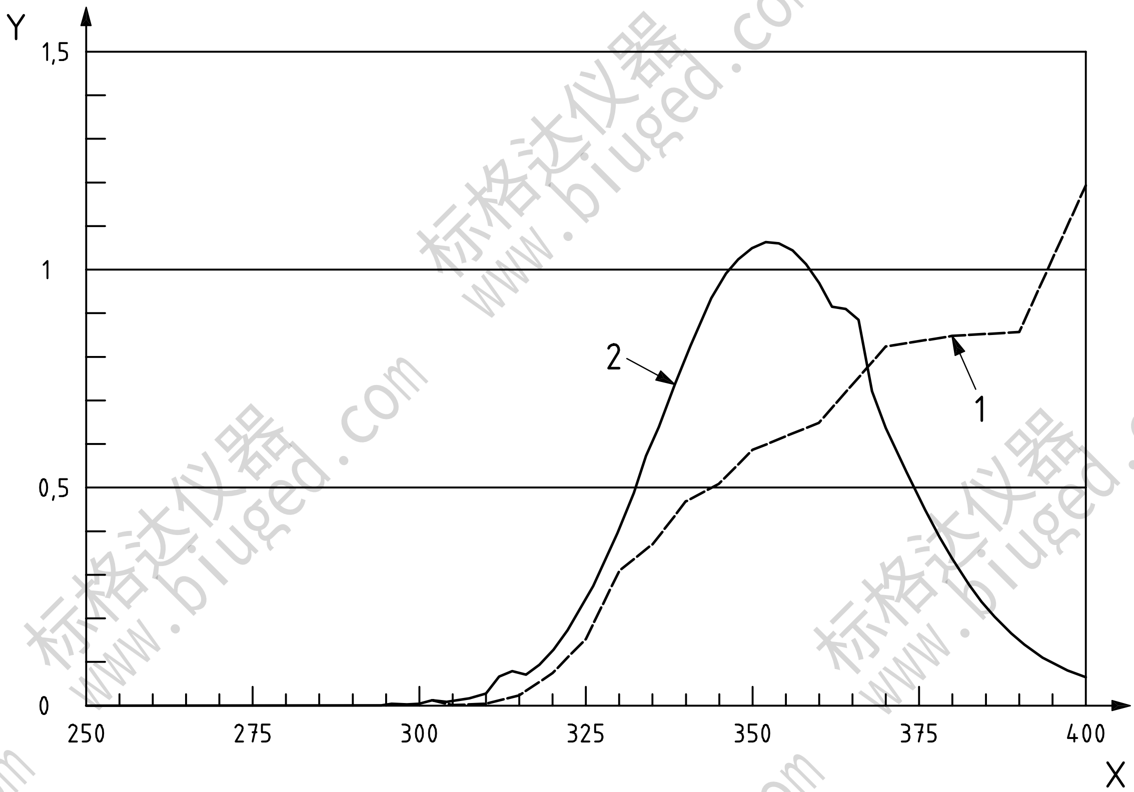
1 CIE No. 85:1989 Table 4 daylight

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

X wavelength, $\lambda$ (nm)

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

**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

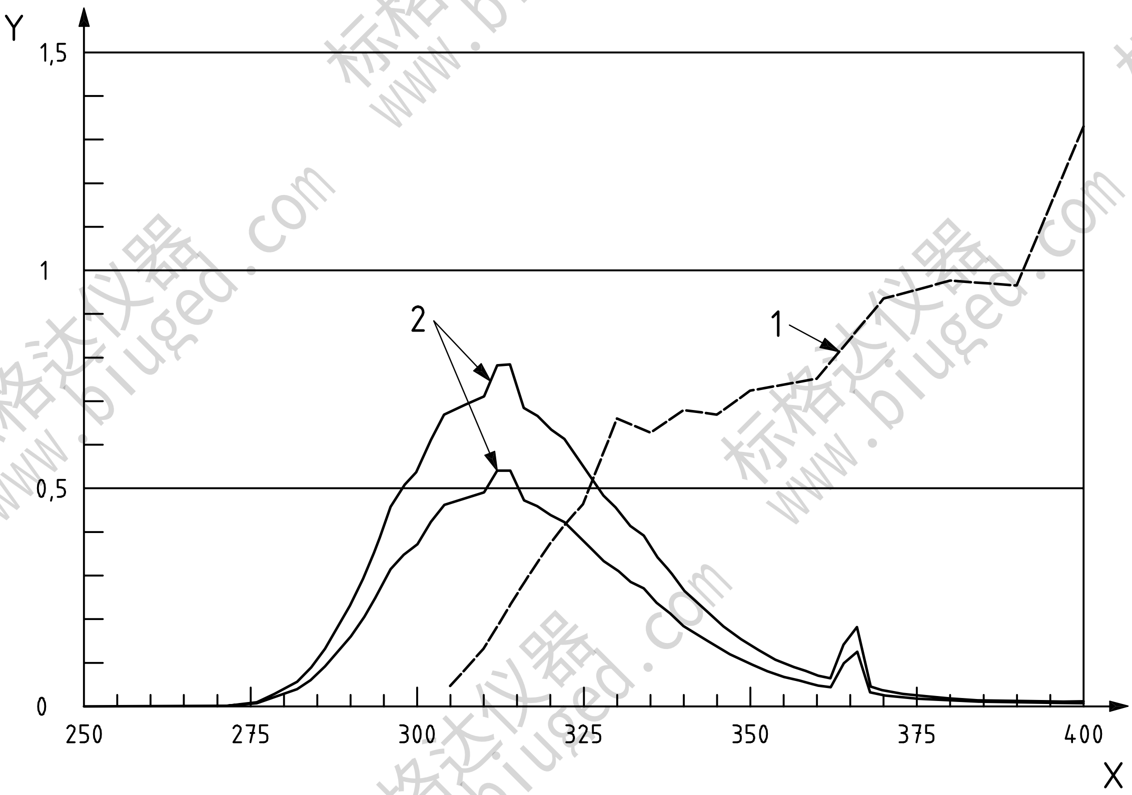
X wavelength, $\lambda$ (nm)

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

**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 (UVA-313) lamps

X wavelength, $\lambda$ (nm)

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

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

# Bibliography


[1] CIE Publication No. 85:1989, *Solar spectral irradiance*

[2] ASTM G 154, *Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials*

[3] ISO 11341, *Paints and varnishes — Artificial weathering and exposure to artificial radiation — Exposure to filtered xenon-arc radiation*

[4] ISO 11507, *Paints and varnishes — Exposure of coatings to artificial weathering — Exposure to fluorescent UV and water*

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