INTERNATIONAL STANDARD

ISO 4892-3

Fourth edition
2016-02-15

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 4892-3:2016(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).

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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 61, *Plastics*, Subcommittee SC 6, *Ageing, chemical and environmental resistance*.

This fourth edition cancels and replaces the third edition (ISO 4892-3:2013), of which it constitutes a minor revision with the following change:

— in A.2.3, further information on lamp combination is added.

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 simulate the weathering effects that occur when materials are exposed in actual end-use environments to global solar radiation, or to solar radiation 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 can be used to meet all the requirements for testing different materials.

Specimen preparation and evaluation of the results are covered in other International Standards 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.

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 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 following the manufacturer's recommendations for lamp maintenance and/or rotation, may be used to simulate the spectral irradiance of global solar radiation in the short wavelength 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 the following:

a) type of fluorescent UV lamp;

b) irradiance level;

c) temperature during the UV exposure;

d) type of wetting (see 3.4);

e) wetting temperature and cycle;

f) timing of the UV/dark cycle.

3.4 Wetting is usually produced by condensation of water vapour on to 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 types of 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.

— **UVA-340 (type 1A) 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 global solar radiation from 300 nm to 340 nm (see Table 1). Figure A.1 is a graph of spectral irradiance from 250 nm to 400 nm of a typical UVA-340 (type 1A) fluorescent lamp compared to global solar radiation.

— **UVA-351 (type 1B) 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 solar radiation behind window glass (see Table 2). Figure A.2 is a graph of spectral irradiance from 250 nm to 400 nm of a typical UVA-351 (type 1B) fluorescent UV lamp compared to global solar radiation filtered by window glass.

— **UVB-313 (type 2) 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 UVB-313 (type 2) fluorescent lamps compared to global solar radiation. UVB-313 (type 2) lamps may be used only by agreement between the parties concerned. Such agreement shall be stated in the test report.

— **Four different UV lamps used as one combination**: these four different UV lamps are used together as one combination with a suited filter. See Figure A.4 in A.2.3.

NOTE 1 UVB-313 (type 2) lamps have a spectral distribution of radiation, which peaks near the 313 nm mercury line and can emit radiation down to λ = 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. The benchmark global solar radiation used in this part of ISO 4892 is from CIE Publication No. 85:1989, Table 4.

4.1.2 Unless otherwise specified, UVA-340 (type 1A) fluorescent UV lamps shall be used to simulate the UV part of global solar radiation (see Table 4, method A). Unless otherwise specified, UVA-351 (type 1B) lamps shall be used to simulate the UV part of solar radiation through window glass (see Table 4, method B). The four-lamp UV combination may be used (see A.2.3) and shall be stated in the test report.

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 UVA-340 (type 1A) lamps for global solar UV radiation (method A)[a,b]

Spectral passband [λ = wavelength in nanometres (nm)]	**Minimum**[c] %	**CIE No. 85:1989, Table 4**[d,e] %	**Maximum**[c] %
$\lambda < 290$	—	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 or not a specific UVA-340 (type 1A) 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 UVA-340 (type 1A) lamps in this table are based on more than 60 spectral irradiance measurements with UVA-340 (type 1A) lamps from different production lots and of various ages.[3] The spectral irradiance data are for lamps within the ageing recommendations of the manufacturer of the apparatus. As more spectral irradiance data become available, minor changes in the limits are possible. The minimum and maximum limits are at least three sigmas 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 UVA-340 (type 1A) 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 UVA-340 (type 1A) 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 UVA-340 (type 1A) lamp used.

[d] The data from Table 4 of CIE Publication No. 85:1989 are 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 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 UVA-351 (type 1B) lamps for solar radiation behind window glass (method B)[a,b]

Spectral passband [λ = wavelength in nanometres (nm)]	**Minimum**[c] %	**CIE No. 85:1989, Table 4, plus effect of window glass**[d,e] %	**Maximum**[c] %
λ < 300	—	0	0,2
300 ≤ λ ≤ 320	1,1	≤1	3,3
320 < λ ≤ 360	60,5	33,1	66,8
360 < λ ≤ 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 UVA-351 (type 1B) 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 UVA-351 (type 1B) lamps from different production lots and of various ages. The spectral irradiance data are for lamps within the ageing recommendations of the manufacturer of the apparatus. As more spectral irradiance data become available, minor changes in the limits are possible. The minimum and maximum limits are at least three sigmas 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 UVA-351 (type 1B) 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 UVA-351 (type 1B) 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 UVA-351 (type 1B) lamp used.

[d] The data from CIE No. 85:1989, Table 4, plus the effect of window glass were determined by multiplying the data from CIE No. 85:1989, Table 4 by the spectral transmittance of typical 3 mm-thick window glass (see ISO 11341). 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 UVB-313 (type 2) lamps (method C)[a,b]

Spectral passband [λ = wavelength in nanometres (nm)]	**Minimum**[c] %	**CIE No. 85:1989, Table 4**[d,e] %	**Maximum**[c] %
$\lambda < 290$	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 passband, expressed as a percentage of the total irradiance between 250 nm and 400 nm. To determine whether a specific UVB-313 (type 2) 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 UVB-313 (type 2) lamps from different production lots and of various ages.[3] The spectral irradiance data are for lamps within the ageing recommendations of the manufacturer of the apparatus. As more spectral irradiance data become available, minor changes in the limits are possible. The minimum and maximum limits are at least three sigmas 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 UVB-313 (type 2) 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 UVB-313 (type 2) 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 Publication No. 85:1989, Table 4 are 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 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 on to the exposed faces of the specimens.

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-panel/black-standard thermometer

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

4.5 Wetting

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.

NOTE The duration of the condensation or water spray period can have a significant influence on the photodegradation of polymers.

4.5.2 Spray and condensation system

The test chamber shall be equipped with a means of producing intermittent condensation on, or directing intermittent water spray on to 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.

Check the specimens in the test chamber during the condensation period at least 1 h after the start of the condensation cycle to verify that the condensation is visibly forming on the specimens. Then, perform this visual check at least once per week.

NOTE 1 If condensation is not evident on the specimen, the most likely cause involves the following:

a) inadequate room air cooling,

b) laboratory temperature that is too high,

c) condensation temperature that is set too low or set too close to the room temperature,

d) thick specimens of insulating material that might be preventing the room air cooling necessary for condensation. For example, a 25 mm specimen can exhibit poor condensation with a condensation set point of 40 °C and a laboratory temperature of 30 °C, or

e) improper mounting that is allowing vapour to escape from the chamber.

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

NOTE 2 The spray water temperature might have a significant effect on the test results.

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 ISO 4582) shall be used.

5 Test specimens

Test specimens are specified in ISO 4892-1.

1) 1 mg/l is the equivalent of 1 ppm; ppm is a deprecated unit.

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 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-panel temperatures. Black-standard thermometers may be used in place of black-panel thermometers, when agreed upon by all interested parties.

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 Condensation and spray cycles

The condensation or spray cycle shall be as agreed between the interested parties and should be one of the cycles in Table 4.

Full details of the conditions shall be given in the test report.

6.4 Cycles with dark periods

The conditions of most cycles in Table 4 include dark periods that might include high humidity and/or formation of condensate on the specimen surface. More complex cycles may be used.

Full details of the conditions shall be given in the test report.

6.5 Sets of exposure conditions

Various sets of exposure conditions are listed in Table 4 as “exposure cycles” (method A) for artificial accelerated weathering with UVA-340 lamps, (method B) for UV solar radiation behind window glass with UVA-351 lamps and (method C) for artificial accelerated weathering with UVB-313 lamps.

Table 4 — Exposure cycles

Cycle No.	Exposure period	Lamp type	Irradiance	Black-panel temperature
Method A: Artificial accelerated weathering with UVA-340 lamps				
1	8 h dry 4 h condensation	UVA-340 (type 1A)	0,76 W·m^{-2} × nm^{-1} at 340 nm UV lamps off	60 °C ± 3 °C 50 °C ± 3 °C
2	8 h dry 0,25 h water spray 3,75 h condensation	UVA-340 (type 1A)	0,76 W·m^{-2} × nm^{-1} at 340 nm UV lamps off UV lamps off	50 °C ± 3 °C Not controlled 50 °C ± 3 °C
3	5 h dry 1 h water spray	UVA-340 (type 1A)	0,83 W·m^{-2} × nm^{-1} at 340 nm UV lamps off	50 °C ± 3 °C Not controlled
4	5 h dry 1 h water spray	UVA-340 (type 1A)	0,83 W·m^{-2}·nm^{-1} at 340 nm UV lamps off	70 °C ± 3 °C Not controlled
Method B: Artificial accelerated weathering with UVA-351 lamps				
5	24 h dry (no moisture)	UVA-351 (type 1B)	0,76 W·m^{-2} × nm^{-1} at 340 nm	50 °C ± 3 °C
Method C: Artificial accelerated weathering with UVB-313 lamps				
6	8 h dry 4 h condensation	UVB-313 (type 2)	0,48 W·m^{-2} × nm^{-1} at 310 nm UV lamps off	70 °C ± 3 °C 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-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 Black-panel temperature during the water spray cycle is not controlled but should not exceed 30 °C. Spray water temperature might have a significant effect on the test result.

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 subjected 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.

UV radiometers may be calibrated for either narrow band (e.g. at 340 nm) or broad band (e.g. 290 nm to 400 nm) measurements.

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). Common SI units 1 J = 1 Ws.

7.5 Determination of changes in properties after exposure

These shall be determined as specified in ISO 4582.

8 Exposure report

The exposure report shall be in accordance with ISO 4892-1.

Annex A
(informative)

Relative irradiance of 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 types (type 1A, 1B or 2); these are commonly available from manufacturers plainly labelled as either UVA-340, UVA-351 or UVB-313. Other lamps may also be used. The particular application determines which lamp should be used. The lamps discussed in this Annex differ in the absolute spectral emission of UV radiation emitted and in their wavelength spectrum. Differences in lamp irradiance values or spectrum might cause significant differences in the results of exposure. Consequently, it is extremely important to report the irradiance value and lamp type in the exposure report.

A.2 Relative spectral irradiance data

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

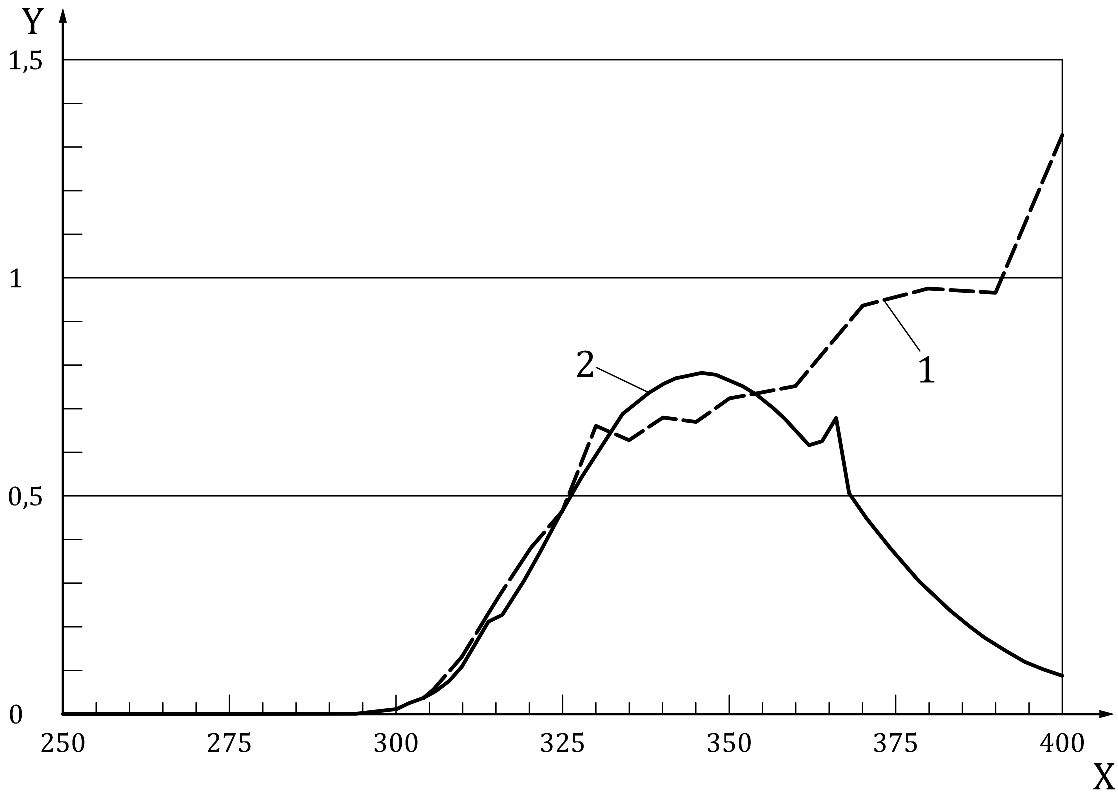
A.2.1.1 Figure A.1 shows the relative spectral irradiance for UVA-340 (type 1A) lamps and Figure A.2 shows the relative spectral irradiance for UVA-351 (type 1B) lamps.

For non-irradiance-controlled test apparatus, actual irradiance levels 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 irradiance can be programmed at various levels within a selected range.

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

A.2.1.3 UVA-351 (type 1B) lamps are mostly used for behind-window-glass simulations. Spectral irradiance for a typical UVA-351 (type 1B) lamp is compared to CIE No. 85:1989, Table 4, solar radiation behind window glass is shown in Figure A.2.

NOTE UVA-340 (type 1A) and UVA-351 (type 1B) lamps have different spectral irradiance distributions and can produce very different results.



Key

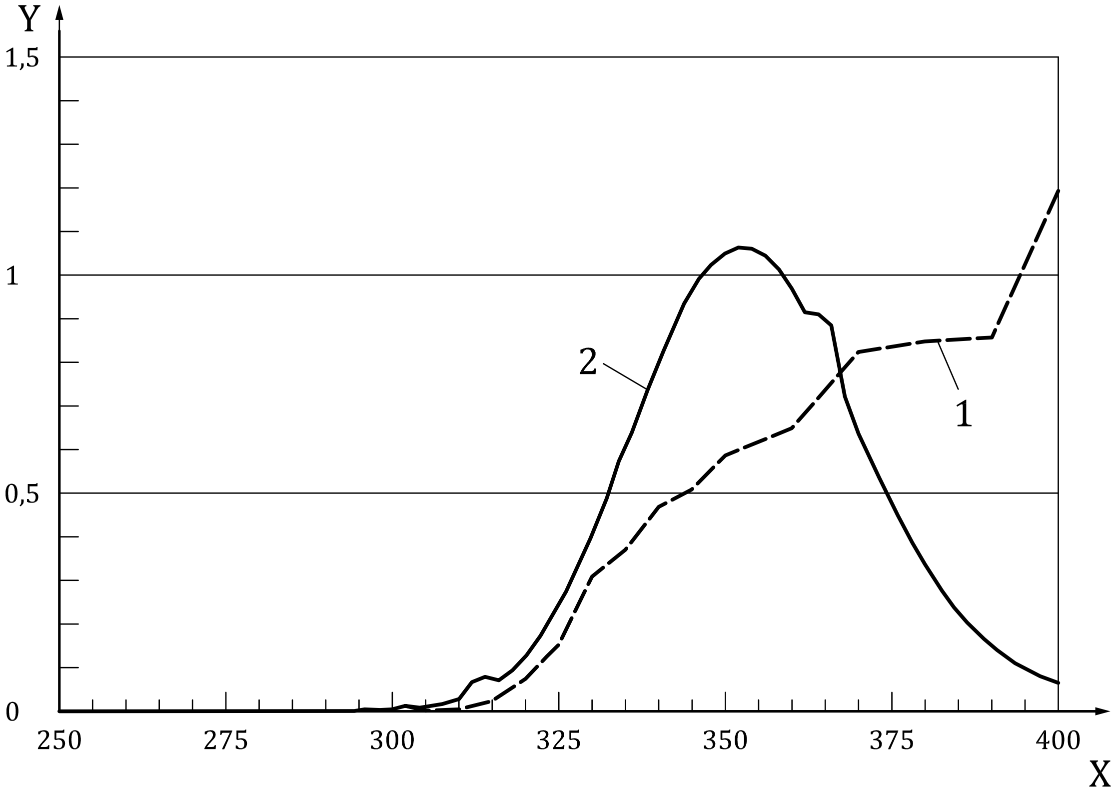
X wavelength, λ (nm)

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

1 CIE No. 85:1989, Table 4, global solar radiation

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

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



Key

X wavelength, λ (nm)

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

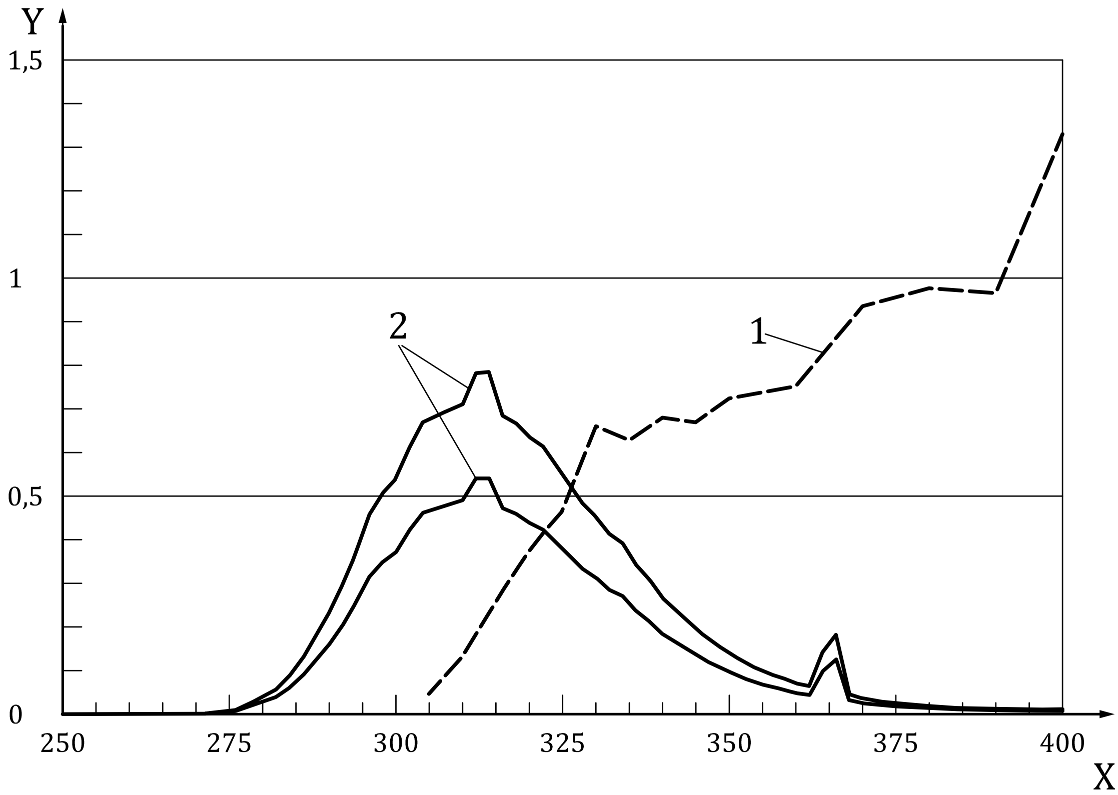
1 CIE No. 85:1989, Table 4, solar radiation through typical window glass

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

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

A.2.2 UVB-313 (type 2) lamps

Figure A.3 illustrates the spectral irradiance of two commonly used UVB-313 (type 2) lamps compared to global solar radiation. 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 No. 85:1989, Table 4, global solar radiation

2 the upper spectral irradiance for typical UVB 313 (type 2) lamps; the lower curve shows a FS40 lamp

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

A.2.3 Four different lamp types used as one combination

To simulate the sharp cut off of the global solar radiation at about 300 nm and the relative spectral irradiance up to about to 350 nm, the UVA-340 (type 1A) lamp is the best radiation source, see Figure A.1. However, the spectral range above 350 nm can be intensified by a combination of fluorescent lamps with different appropriate phosphors up to 420 nm. A sufficient number of lamps (more than a dozen) therefore should be mounted in a closely spaced arrangement. By suitable positioning of the different lamp types, a homogeneous radiation field can be achieved. Additionally, a filter pane with diffusing areas can improve homogeneity. By vertical lamp arrangement, heat dissipation is intensified.

Figure A.4 illustrates a spectral distribution which can be achieved by combining the following four UV lamp types with their peak wavelengths at 313 nm, 340 nm, 365 nm and 420 nm, with a suited cut on filter (see Figure A.4). This spectrum is useful as some polymeric materials may be partly sensitive to long-wave UV and blue radiation.

Table A.1 — Relative ultraviolet spectral irradiance for UVA lamp combination for global solar UV radiation[a]

Spectral passband [λ = wavelength in nanometres (nm)]	**Minimum**[b] %	**CIE No. 85:1989, Table 4**[c,d] %	**Maximum**[b] %
$\lambda < 290$	–	0	0
$290 \leq \lambda \leq 320$	4	5,4	7
$320 < \lambda \leq 360$	48	38,2	56
$360 < \lambda \leq 400$	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 or not a specific UVA-340 (type 1A) 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 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 UVA-340 (type 1A) 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 UVA-340 (type 1A) 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 UVA-340 (type 1A) lamp used.

[c] The data from CIE Publication No. 85:1989, Table 4 are 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.

[d] For the solar spectrum represented by of 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 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.

The following are typical cycles.

a) Typical cycle:

   1) 5 h dry with 1 h water spray (lamps on during water spray);

   2) using four different lamps as one combination at irradiance value 45 $W \cdot m^{-2} \times nm^{-1}$ (290 nm to 400 nm);

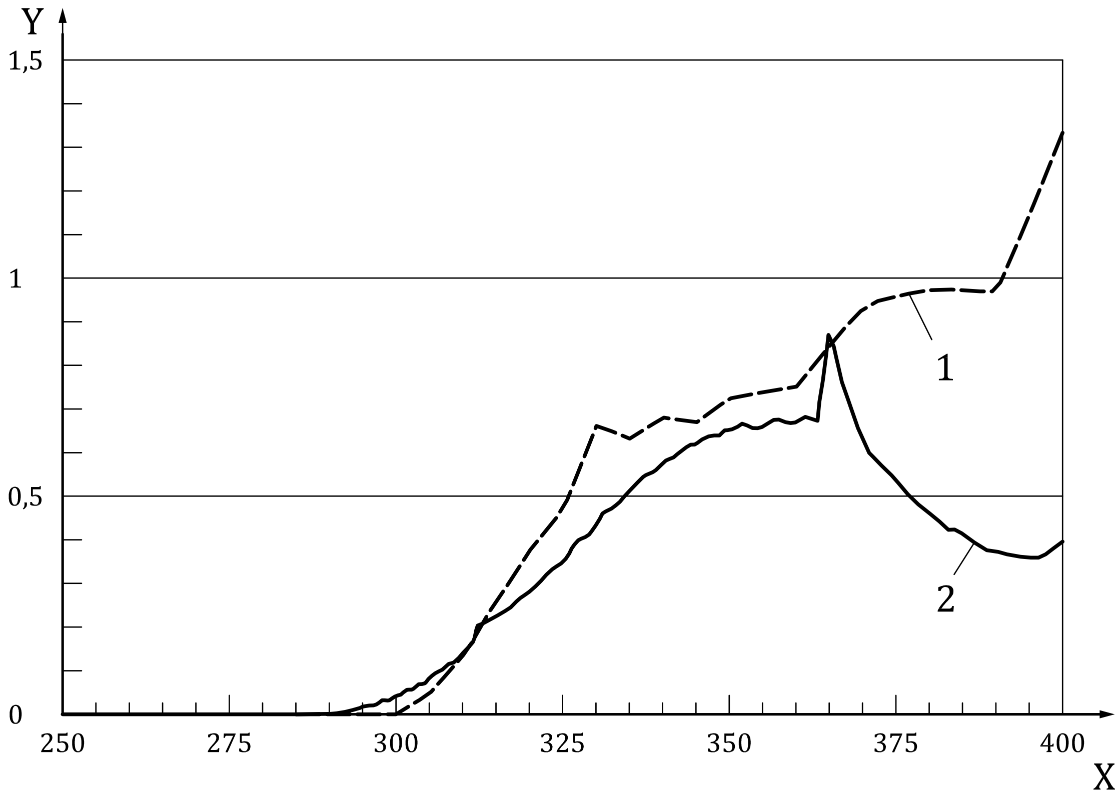
   3) black-panel temperature 50 °C ± 3 °C and RH value <15 %.

b) Typical cycle:

   1) 5 h dry with 1 h water spray (lamps on during water spray);

   2) using four different lamps as one combination at irradiance value 45 $W \cdot m^{-2} \times nm^{-1}$ (290 nm to 400 nm);

   3) black-panel temperature 70 °C ± 3 °C and RH value <15 %.



Key

X wavelength, λ (nm)

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

1 CIE No. 85:1989, Table 4, global solar radiation

2 a spectral irradiance for a lamp combination with 340 nm, 313 nm, 365 nm and 420 nm peak wavelengths with suited filter

Figure A.4 — Spectral irradiance of four (4) typical lamp types to achieve spectral distribution of the lamp combination, as an example

Bibliography

[1] ISO 11341[2)], *Paints and varnishes — Artificial weathering and exposure to artificial radiation — Exposure to filtered xenon-arc radiation*

[2] ISO 11507[3)], *Paints and varnishes — Exposure of coatings to artificial weathering — Exposure to fluorescent UV lamps and water*

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

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

2) Withdrawn. Replaced by ISO 16474-1:2013.

3) Withdrawn. Replaced by ISO 16474-1:2013.

ICS 83.080.01
Price based on 16 pages