



**International
Standard**

ISO 4892-3

**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

**Fifth edition
2024-10**

STANDARDSISO.COM : Click to view the full PDF of ISO 4892-3:2024



COPYRIGHT PROTECTED DOCUMENT

© ISO 2024

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword	iv
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Principle	1
5 Apparatus	2
5.1 Laboratory light source	2
5.2 Test chamber	5
5.3 Radiometer	6
5.4 Control of temperature	6
5.5 Wetting	6
5.5.1 General	6
5.5.2 Condensation and water spray system	7
5.6 Control of humidity	7
5.7 Specimen holders	7
5.8 Apparatus to assess changes in properties	7
6 Test specimens	8
7 Test conditions	8
7.1 Radiation	8
7.2 Temperature	8
7.3 Condensation and spray cycles	8
7.4 Cycles with dark periods	8
7.5 Sets of exposure conditions	8
8 Procedure	10
8.1 General	10
8.2 Mounting the test specimens	10
8.3 Exposure	10
8.4 Measurement of radiant exposure	11
8.5 Determination of changes in properties after exposure	11
9 Test report	11
Annex A (normative) Relative irradiance of typical fluorescent UV lamps	12
Annex B (informative) Condensation type device	16
Annex C (informative) Climatic chamber type device	17
Annex D (informative) Alternative test cycles	18
Bibliography	19

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).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 6, *Ageing, chemical and environmental resistance*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 249, *Plastics*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This fifth edition cancels and replaces the fourth edition (ISO 4892-3:2016), which has been technically revised.

The main changes are as follows:

- clarification that two fundamentally different types of test chambers exist added (e.g. in [5.2](#), [5.4](#), new Annexes);
- [Table 4](#) has been split into two separate tables for the different types of test chambers, [Table 4](#) applies to condensation type devices and [Table 5](#) to climatic chamber type devices;
- new [Annex B](#) "Condensation type device", [Annex C](#) "Climatic chamber type device" and [Annex D](#) "Alternative test cycles" have been added;
- reference to CIE 85 has been updated to CIE 241;
- combination of different UV fluorescent lamps have been deleted;
- mandatory [Clause 3](#) "Terms and definitions" has been added and subsequent clauses have been renumbered;
- lamp type designations 1A, 1B, 2 have been deleted.

A list of all parts in the ISO 4892 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Plastics — Methods of exposure to laboratory light sources —

Part 3: Fluorescent UV lamps

1 Scope

This document specifies methods for exposing plastic specimens to fluorescent UV lamp radiation, heat and water in apparatus designed to simulate the weathering effects that occur when plastic materials are exposed in actual end-use environments to global solar radiation, or to window-glass filtered solar radiation.

Fluorescent UV lamp exposures for paints, varnishes and other coatings are described in ISO 16474-3.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 4582, *Plastics — Determination of changes in colour and variations in properties after exposure to glass-filtered radiation, natural weathering or laboratory radiation sources*

ISO 4892-1, *Plastics — 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 4892-1 apply.

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

4 Principle

4.1 General guidance is given in ISO 4892-1. Following the manufacturer's recommendations for lamp maintenance and/or rotation, fluorescent UV lamps are used to simulate the spectral irradiance of global solar radiation in the short wavelength 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.

NOTE Specimen preparation and evaluation of the results are covered in other International Standards for specific materials.

4.3 The exposure conditions are 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 [4.4](#));
- e) wetting temperature and cycle;
- f) timing of the UV/dark cycle.

4.4 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.

4.5 The procedure(s) can 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 types of apparatus as per [Annex B](#) and [Annex C](#) or to different types of lamps 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. The UV fluorescent lamps used shall conform with the requirements of [Annex A](#). There are three types of fluorescent UV lamp used in this document.

- **UVA-340 fluorescent UV lamp:** these lamps have a radiant emission below 300 nm of less than 1 % of the total radiation 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 360 nm (see [Table 1](#)). [Figure A.1](#) is a graph of spectral irradiance from 250 nm to 400 nm of a typical UVA-340 fluorescent lamp compared to global solar radiation.
- **UVA-351 fluorescent UV lamp:** these lamps have a radiant emission below 310 nm of less than 1 % of the total radiation output, have a peak emission at 353 nm, and are more commonly identified as UVA-351 for simulation of the UV portion of window-glass filtered solar radiation (see [Table 2](#)). [Figure A.2](#) is a graph of spectral irradiance from 250 nm to 400 nm of a typical UVA-351 fluorescent UV lamp compared to window-glass filtered global solar radiation.
- **UVB-313 fluorescent UV lamp:** these lamps have a radiant emission below 300 nm that is more than 10 % of the total radiation output, have a peak emission at 313 nm, and are more commonly identified as UVB-313 (see [Table 3](#)). [Figure A.3](#) is a graph of the spectral irradiance from 250 nm to 400 nm of two typical UVB-313 fluorescent lamps compared to global solar radiation. UVB-313 lamps may be used only by agreement between the parties concerned. Such agreement shall be stated in the test report.

NOTE 1 UVB-313 lamps have a spectral distribution of radiation that peaks near the 313 nm mercury line and emits radiation below $\lambda = 295$ nm, which can initiate ageing processes that never occur in natural environments.

NOTE 2 The solar spectral irradiance for a number of different atmospheric conditions is described in CIE Publication No. 241. The benchmark global solar radiation used in this document is from CIE Publication No. 241, CIE-H1.

Different lamp types shall not be mixed.

5.1.2 Unless otherwise specified, UVA-340 fluorescent UV lamps shall be used to simulate the UV part of global solar radiation (see [Tables 4](#) and [5](#), method A). Unless otherwise specified, UVA-351 lamps shall be used to simulate the UV part of window-glass filtered solar radiation (see [Tables 4](#) and [5](#), method B). Refer to [Table 4](#) for condensation type devices and [Table 5](#) for climatic chamber type devices.

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 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 lamps for global solar UV radiation (method A)^{a,b}

Spectral passband [λ = wavelength in nanometres (nm)]	Minimum ^c %	CIE 241, CIE-H1 ^{d,e} %	Maximum ^c %
$\lambda < 290$	—	0	0,1
$290 \leq \lambda \leq 320$	5,9	5,9	9,3
$320 < \lambda \leq 360$	60,9	40,4	65,5
$360 < \lambda \leq 400$	26,5	53,8	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 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 lamps in this table are based on more than 60 spectral irradiance measurements with UVA-340 lamps from different production lots and of various ages^[1]. 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 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 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 lamp used.

^d The data from CIE 241, CIE-H1 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 241, CIE-H1, 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.

Table 2 — Relative ultraviolet spectral irradiance for UVA-351 lamps for window-glass filtered solar radiation (method B)^{a,b}

Spectral passband [λ = wavelength in nanometres (nm)]	Minimum^c %	CIE 241, CIE-H1, plus effect of window glass^{d,e} %	Maximum^c %
$\lambda < 300$	—	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 passband, expressed as a percentage of the total irradiance between 290 nm and 400 nm. To determine whether a specific 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 UVA-351 lamps from different production lots and of various ages.^[4] 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 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 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-351 lamp used.

^d The data from CIE 241, CIE-H1, plus the effect of window glass were determined by multiplying the data from CIE 241, CIE-H1 by the spectral transmittance of typical 3 mm-thick window glass (see ISO 16474-2). These data are provided for reference purposes only and are intended to serve as a target.

^e For the CIE 241, CIE-H1, 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.

Table 3 — Relative ultraviolet spectral irradiance for UVB-313 lamps (method C)^{a,b}

Spectral passband [λ = wavelength in nanometres (nm)]	Minimum^c %	CIE 241, CIE-H1^{d,e} %	Maximum^c %
$\lambda < 270$	-	0	0
$270 \leq \lambda < 290$	1,3	0	5,4
$290 \leq \lambda \leq 320$	47,8	5,9	65,9
$320 < \lambda \leq 360$	26,9	40,4	43,9
$360 < \lambda \leq 400$	1,7	53,8	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 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 lamps from different production lots and of various ages.^[1] 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 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 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 UVB-313 lamp used.

^d The data from CIE 241, CIE-H1 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 241, CIE-H1, 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.

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 4892-1, with means for controlling the temperature. When required, provision shall be made for controlling the relative air humidity and for the formation of condensate or for spraying water on to the exposed faces of the specimens.

There are two fundamentally different types of test chambers where specimens can be exposed to fluorescent UV lamps, designated as condensation type device (see also [Annex B](#)) and climatic chamber type device (see also [Annex C](#)).

- In a condensation type chamber, the specimens form an integral part of the chamber wall. The cooling of the specimen back side by external air allows continuous condensation on the exposed specimen surface during a condensation step. The heated water bath creates a high humidity level during the whole test time. Temperature control in a condensation type chamber requires a black-panel thermometer or black-standard thermometer.

NOTE Specimen wetting in condensation type devices is typically achieved by condensation but can also be achieved by water spray if the chamber is equipped with water spray nozzles. These two methods of wetting are different physical phenomena.

- The climatic chamber type device consists of an insulated climate chamber equipped with fluorescent UV lamps. Wetting of the specimen requires water spray. Temperature control in a climatic chamber type device can be best carried out by measuring the chamber air temperature.

Therefore, not all sets of exposure conditions given in [Table 4](#) and [Table 5](#) can be performed in both types of devices. All exposure cycles comprising a condensation step (Cycles 1, 2, 6 and 7) strictly require a condensation type device. All exposure cycles that do not have a condensation step (Cycles 3, 4, and 5) can be performed in both test chamber types. Cycles 2, 3 and 4 require a test chamber equipped with water spray nozzles.

The type of device (condensation type or climatic chamber type device) shall be included in the test report.

5.3 Radiometer

The use of an integrated (or on-board) radiometer for irradiance control is recommended. If a radiometer is used, it shall conform to the requirements given in ISO 4892-1.

NOTE 1 For test apparatus with feedback loop irradiance control, the irradiance can be programmed at various levels within a selected range. Irradiance measurements made with radiometers calibrated using different light sources than the type being measured can be subject to significant errors. This can occur even when the two light sources have relatively small differences in spectra.

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

NOTE 2 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.

5.4 Control of temperature

5.4.1 In condensation type devices, the temperature shall be controlled by means of black surface thermometers, of which the black-panel thermometer is the most widely used type. For 3D-samples or specimens with very little thermal conductivity the sample surface temperature might be significantly higher. In this case, the temperature of the test chamber can still be controlled by a black-panel thermometer but the sample surface temperature might be better represented by a black-panel thermometer with an insulation added on the back side or by a black-standard thermometer.

NOTE 1 Due to the different thermal conductivity, a black-panel thermometer will read significantly different temperatures in a condensation type device than a black-panel thermometer with insulation or a black-standard thermometer.

Black-panel and black-standard thermometers are described in ISO 4892-1. The combination of a black-panel thermometer with added insulation can give the same temperature reading than a black-standard thermometer but does not fall under this definition.

Thermometers which differ in construction, e.g. a black-panel thermometer with insulation, are permitted, as long as the temperature reading of the alternate construction is within $\pm 1,0$ °C of a black-standard thermometer at all steady state temperature and irradiance settings of the cycle being performed and the time needed to reach steady state is within 90 % to 110 % of the time needed by a black-standard thermometer to reach steady state.

NOTE 2 In cases where a black-panel with insulation is used which does not meet the definition of a black-standard, consult the apparatus manufacturer for information on its performance.

5.4.2 In climatic chamber type devices, the temperature shall be controlled by chamber air temperature.

5.4.3 The type of thermometer used (black-surface thermometer or chamber air thermometer) shall be included in the test report.

5.5 Wetting

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](#) for condensation type devices and

[Table 5](#) for climatic chamber type devices. 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.

5.5.2 Condensation and water spray system

For all exposure cycles comprising a condensation step, the test chamber shall be equipped with a means of producing intermittent condensation on the test specimens. For all exposure cycles comprising a water spray step, the test chamber shall be equipped with spray nozzles for directing intermittent water spray on to the front of the test specimens. 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 after 2 hours of the condensation cycle, 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 $\mu\text{S}\cdot\text{cm}^{-1}$, contain less than 1 $\text{mg}\cdot\text{l}^{-1}$ (1 $\text{ppm}^{1)}$ of dissolved solids and leave no observable stains or deposits on the specimens. Care shall be taken to keep silica levels below 0,2 $\text{mg}\cdot\text{l}^{-1}$ (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.

5.6 Control of humidity

The climatic chamber type device shall be equipped with humidity control.

5.7 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.

In general, backing is not recommended in condensation type devices.

5.8 Apparatus to assess changes in properties

If an International Standard related to the determination of the properties chosen for monitoring the changes in properties exists (see, in particular, ISO 4582), the apparatus specified by the International Standard concerned shall be used.

1) 1 $\text{mg}\cdot\text{l}^{-1}$ is the equivalent of 1 ppm; ppm is a deprecated unit.

6 Test specimens

Test specimens are specified in ISO 4892-1.

7 Test conditions

7.1 Radiation

Unless otherwise specified, control the UV irradiance at the levels indicated in [Table 4](#) for condensation type devices and [Table 5](#) for climatic chamber type devices. Other irradiance levels may be used when agreed upon by all interested parties. Commonly-used conversions between narrowband and broadband irradiance values are given in [Annex A](#). The irradiance and wavelength passband in which it was measured shall be included in the test report.

7.2 Temperature

Fluorescent UV lamps emit relatively little visible and infrared radiation and heating of the specimen surface is primarily by convection of heated air across the panel. Unless otherwise specified, control the temperature at the levels indicated in [Table 4](#) for condensation type devices and [Table 5](#) for climatic chamber type devices, respectively. For reference purposes, [Table 4](#) specifies black-panel temperatures. In climatic chamber type devices, the air chamber temperature shall be controlled.

Black-standard thermometers or other black surface thermometers as described in [5.4](#) may be used in place of black-panel thermometers, when agreed upon by all interested parties.

NOTE 1 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.

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.

NOTE 2 For specimens with low glass transition temperature, test cycles with lower temperature can be considered.

7.3 Condensation and spray cycles

The condensation or spray cycle shall be as agreed between the interested parties. Full details of the conditions shall be given in the test report.

7.4 Cycles with dark periods

The conditions of most cycles in [Table 4](#) for condensation type devices include dark periods that might include high humidity and/or formation of continuous condensation on the specimen surface. More complex cycles may be used.

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

7.5 Sets of exposure conditions

Various sets of exposure conditions are listed in [Table 4](#) for condensation type devices, and [Table 5](#) for climatic chamber type devices, as "exposure cycles" for artificial accelerated weathering with UVA-340 lamps (Method A), window-glass filtered UV solar radiation with UVA-351 lamps (Method B), and artificial accelerated weathering with UVB-313 lamps (Method C).

Table 4 — Exposure cycles for condensation type devices

Cycle No.	Lamp type	Exposure period	Irradiance ^{a, b}	Black-panel temperature ^{c, d}
Method A: Artificial accelerated weathering with UVA-340 lamps				
1	UVA-340	8 h dry 4 h condensation	(0,76 ± 0,02) W·m ⁻² ·nm ⁻¹ at 340 nm UV lamps off	60 °C ± 3 °C 50 °C ± 3 °C
2	UVA-340	8 h dry 0,25 h water spray 3,75 h condensation	(0,76 ± 0,02) 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	UVA-340	5 h dry 1 h water spray	(0,83 ± 0,02) W·m ⁻² ·nm ⁻¹ at 340 nm UV lamps off	50 °C ± 3 °C Not controlled
4	UVA-340	5 h dry 1 h water spray	(0,83 ± 0,02) W·m ⁻² ·nm ⁻¹ at 340 nm UV lamps off	70 °C ± 3 °C Not controlled
Method B: Artificial accelerated irradiation with UVA-351 lamps				
5	UVA-351	24 h dry (no moisture)	(0,76 ± 0,02) W·m ⁻² ·nm ⁻¹ at 340 nm	50 °C ± 3 °C
Method C: Artificial accelerated weathering with UVB-313 lamps				
6	UVB-313	8 h dry 4 h condensation	(0,48 ± 0,02) W·m ⁻² ·nm ⁻¹ at 310 nm UV lamps off	70 °C ± 3 °C 50 °C ± 3 °C
7	UVB-313	8 h dry 4 h condensation	(0,71 ± 0,02) W·m ⁻² ·nm ⁻¹ at 310 nm UV lamps off	60 °C ± 3 °C 50 °C ± 3 °C
NOTE 1 The ±3 °C variation shown for the black-panel temperature is the allowable operational 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 2 The operational fluctuations do not take into consideration measurement or calibration uncertainty. ^a For reference purposes, this table specifies irradiance at 340 nm control point. A conversion to broadband irradiance is given in Annex A. ^b Higher-irradiance tests may be conducted if agreed upon by all interested parties. When high-irradiance conditions are used, lamp life can be significantly shortened. Also, there might be no correlation to other test methods or natural weathering test results. Some proposed cycles with higher irradiance are given in Annex D. ^c For reference purposes, this table specifies black-panel temperatures. ^d 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.				

Table 5 — Exposure cycles for climatic chamber type devices

Cycle No.	Lamp type	Exposure period	Irradiance ^{a, b}	Air temperature ^c	Humidity
Method A: Artificial accelerated weathering with UVA-340 lamps					
3*	UVA-340	5 h dry 1 h water spray	continuous UV irradiance (45 ± 5) W·m ⁻²	50 °C ± 3 °C Not controlled	20 %RH ± 10 %RH Not controlled
4*	UVA-340	5 h dry 1 h water spray	continuous UV irradiance (45 ± 5) W·m ⁻²	70 °C ± 3 °C Not controlled	5 %RH ± 3 %RH Not controlled
Method B: Artificial accelerated irradiation with UVA-351 lamps					
5*	UVA-351	24 h dry (no moisture)	continuous UV irradiance (43 ± 5) W·m ⁻²	50 °C ± 3 °C	20 %RH ± 10 %RH
NOTE 1 The ±3 °C variation shown is the allowable operational fluctuation of the indicated chamber air temperature around the temperature set point under equilibrium conditions. This does not mean that the set point can vary by ±3 °C from the given value. NOTE 2 The operational fluctuations do not take into consideration measurement or calibration uncertainty. ^a For reference purposes, this table specifies broadband irradiance (295 nm - 400 nm). A conversion to 340 nm control point is given in Annex A. ^b Higher-irradiance tests may be conducted if agreed upon by all interested parties. When high-irradiance conditions are used, lamp life can be significantly shortened. Also, there might be no correlation to other test methods or natural weathering test results. ^c Chamber air temperature during the water spray cycle is not controlled but the temperature of the sprayed water should not exceed 30 °C. Spray water temperature might have a significant effect on the test result. If the spray water is circulated with the help of a water tank, temperature can be adjusted by means of a suited heating or cooling system within the water tank. Recording the water temperature is a best practise. * The test cycles are the equivalent to the corresponding cycles in Table 4 with the difference that there is no dark phase in the climatic chamber type device (UV lamps are switched on during the whole test cycle).					

8 Procedure

8.1 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.

8.2 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.

For condensation type devices, fill all spaces in the exposure area in order to ensure uniform exposure conditions. Use blank panels if necessary. Inappropriate sample mounting can result in condensed water droplets above the exposure area of the test device.

8.3 Exposure

Before placing the specimens in the test chamber, be sure that the apparatus is operating under the desired conditions (see [Clause 7](#)). Program 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.

It is recommended to plan the exposure in a manner that any sampling (periodic or final) takes place at the end of a dry phase and that the samples are allowed to dry off and acclimate before evaluations. 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.

8.4 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. A conversion is given in [Annex A](#).

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 ($\text{J}\cdot\text{m}^{-2}$) in the wavelength band from 290 nm to 400 nm or joules per square metre per nanometre [$\text{J}\cdot\text{m}^{-2}\cdot\text{nm}^{-1}$] for the wavelength selected (e.g. 340 nm). Common SI units $1 \text{ J} = 1 \text{ W}\cdot\text{s}$.

8.5 Determination of changes in properties after exposure

These shall be determined as specified in ISO 4582 insofar as possible. Other properties may be used if agreed upon by all interested parties.

9 Test report

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

Annex A
(normative)

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; these are commonly available from manufacturers plainly labelled as either UVA-340, UVA-351 or UVB-313. Other lamps may also be used if they fulfil the requirements in [Tables 1, 2](#) or [3](#), respectively. The particular application determines which lamp should be used. The lamps discussed in this annex differ in the relative and 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 test report. [Table A.1](#) provides a representative conversion for narrowband control point to broadband control point for three types of lamps.

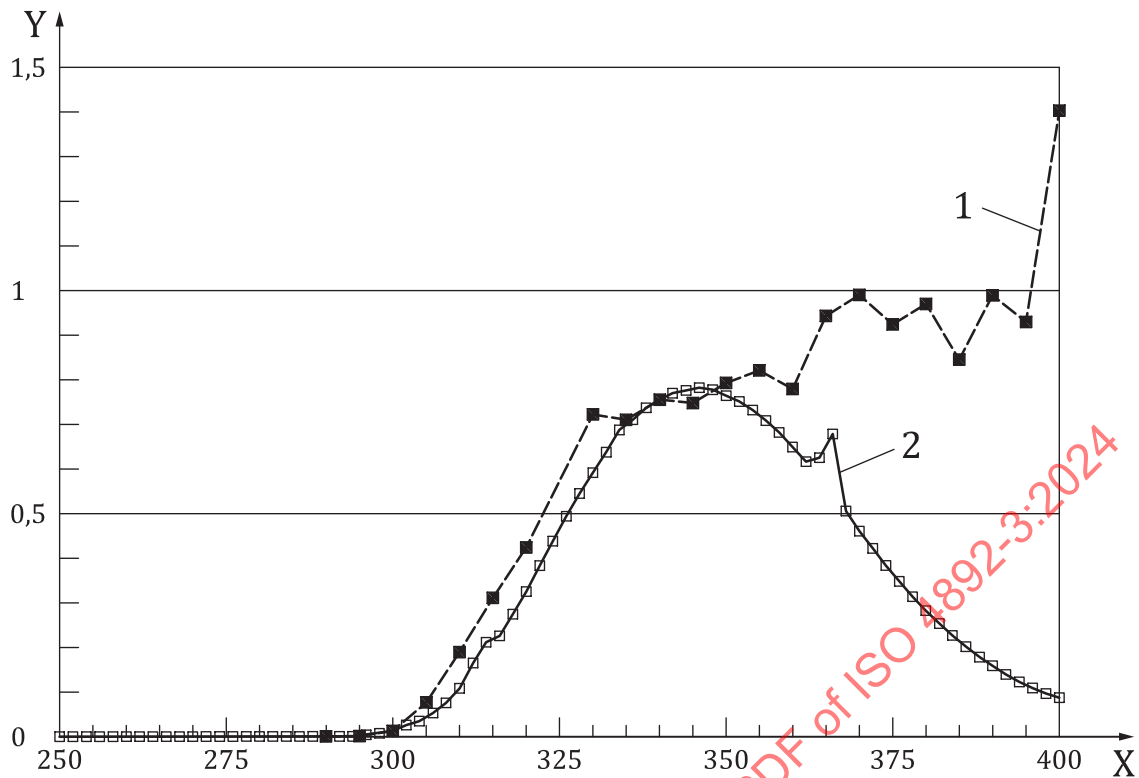
Table A.1 — Irradiance conversion for the different lamp types

Lamp type	Narrowband irradiance $E_{e\lambda}$ $W \cdot m^{-2} \cdot nm^{-1}$	Estimated broadband UV irradiance E_{UV} $W \cdot m^{-2}$
UVA-340	0,76 @ 340 nm	40 - 45 (295 nm - 400 nm)
UVA-351	0,76 @ 340 nm	41 - 46 (295 nm - 400 nm)
UVB-313	0,71 @ 310 nm	30 - 37 (250 nm - 400 nm)

A.2 Spectral irradiance data of UV fluorescent lamps

A.2.1 UVA-340 lamps

For most applications, the wavelength spectrum of UVA-340 lamps is recommended. [Figure A.1](#) illustrates the spectral distribution for a UVA-340 lamp compared to CIE 241, CIE-H1, global solar radiation.

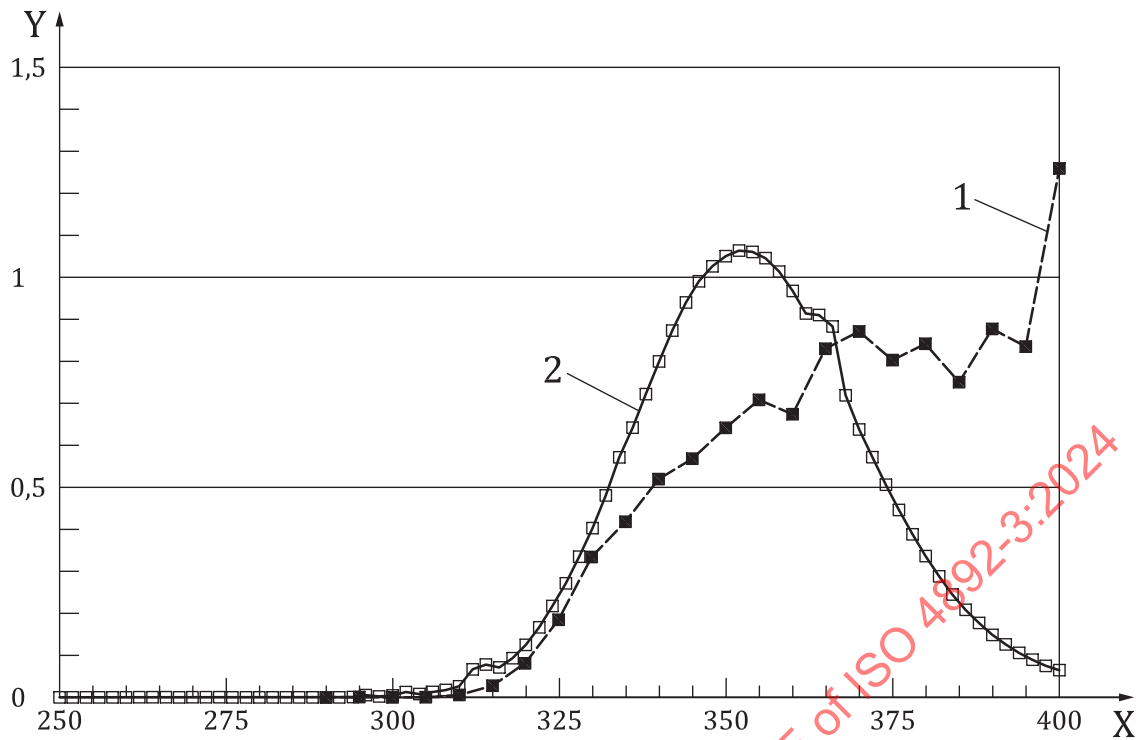
**Key**

- X wavelength, λ (nm)
 Y spectral irradiance, E_λ ($\text{W} \cdot \text{m}^{-2} \cdot \text{nm}^{-1}$)
 1 CIE 241, CIE-H1, global solar radiation (5 nm resolution)
 2 spectral irradiance for typical UVA-340 lamp

Figure A.1 — Spectral irradiance for a typical UVA-340 lamp compared to CIE 241, CIE-H1 (5 nm resolution), global solar radiation

A.2.2 UVA-351 lamps

UVA-351 lamps are mostly used for the simulation of window-glass filtered radiation. Spectral irradiance for a typical UVA-351 lamp compared to CIE 241, CIE-H1, global solar radiation, filtered through window glass is shown in [Figure A.2](#).

**Key**X wavelength, λ (nm)Y spectral irradiance, E_λ ($\text{W} \cdot \text{m}^{-2} \cdot \text{nm}^{-1}$)

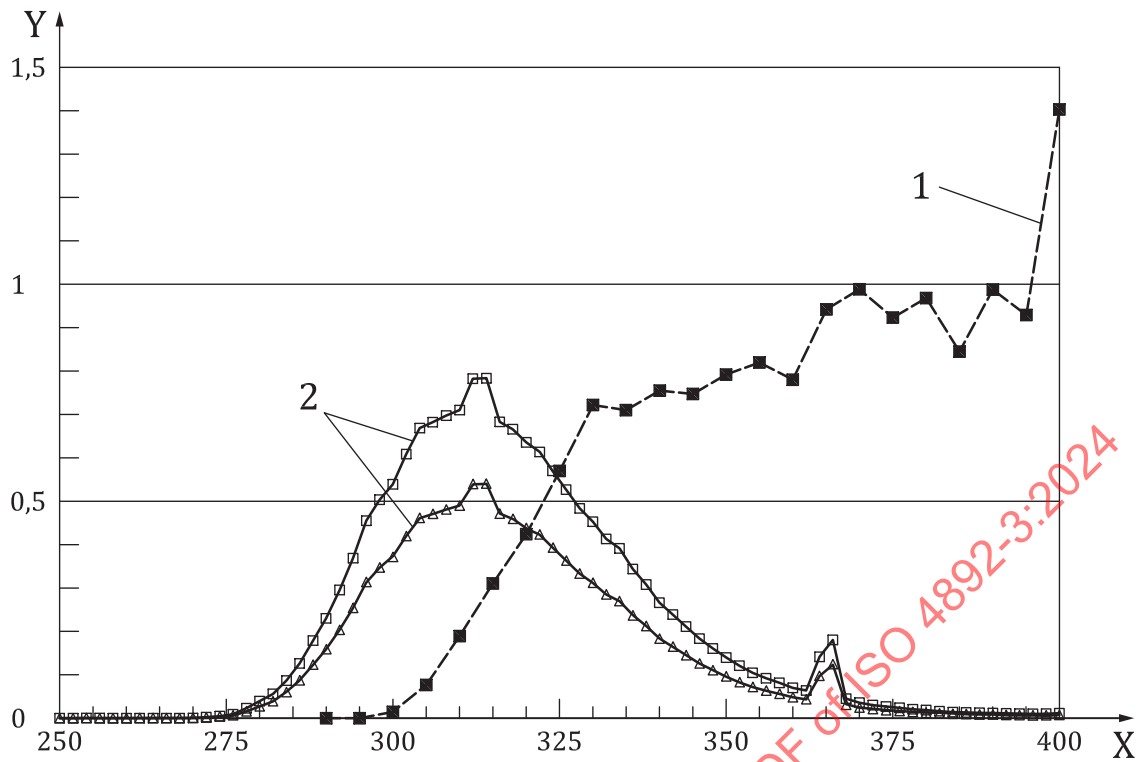
1 CIE 241, CIE-H1, global solar radiation (5 nm resolution), filtered through window-glass

2 spectral irradiance for a typical UVA-351 lamp

Figure A.2 — Spectral irradiance for typical UVA-351 lamp compared to CIE 241, CIE-H1 (5 nm resolution), global solar radiation, filtered through window-glass

A.2.3 UVB-313 lamps

UVB-313 lamps have a peak emission at 313 nm. [Figure A.3](#) illustrates the spectral irradiance of two commonly used UVB-313 lamps compared to CIE 241, CIE-H1, global solar radiation.



Key

X wavelength, λ (nm)

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

1 CIE 241, CIE-H1, global solar radiation (5 nm resolution)

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

Figure A.3 — Spectral irradiance for typical UVB-313 lamps compared to CIE 241, CIE-H1 (5 nm resolution), global solar radiation