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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

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Foreword

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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).

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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 λ = 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
$290 \le \lambda \le 320$	5,9	5,9	9,3
$320 < \lambda \le 360$	60,9	40,4	65,5
$360 < \lambda \le 400$	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] %
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 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.[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-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 ±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