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INTERNATIONAL STANDARD

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Environmental testing –
Part 2-5: Tests – Test Sa: Simulated solar radiation at ground level and guidance for solar radiation testing and weathering

IEC 60068-2-5:2018-04 RLV(en)

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Part 2-5: Tests – Test Sa: Simulated solar radiation at ground level and guidance for solar radiation testing and weathering

INTERNATIONAL
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ENVIRONMENTAL TESTING –

Part 2-5: Tests – Test S~~a~~: Simulated solar radiation at ground level and guidance for solar radiation testing and weathering

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International Standard IEC 60068-2-5 has been prepared by IEC technical committee 104: Environmental conditions, classification and methods of test.

This third edition cancels and replaces the second edition of published in 2010. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) the title of this document has been modified;
b) the current thermal effect test method, specified as "Test method Sa" has been retained and the weathering test method specified as "Test method Sb" has been added.

The text of this International Standard is based on the following documents:

CDV	Report on voting
104/735/CDV	104/789/RVC

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60068 series, published under the general title *Environmental testing*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

This part of IEC 60068 describes methods of simulation designed to examine the effect of solar radiation on equipment and components at the surface of the earth. The main characteristics of the environment to be simulated are the spectral ~~energy distribution of the sun~~ irradiance of solar radiation, as observed at the earth's surface, and the intensity of received energy, in combination with controlled temperature conditions. However, ~~it may be necessary to consider~~ the combination of solar radiation with other environments, for example temperature, humidity, water spray (to simulate wetting) and air velocity, should be considered. Two different methods are described, one aiming at the thermal effects, a second aiming at the weathering effects.

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ENVIRONMENTAL TESTING –

Part 2-5: Tests – Test S~~a~~: Simulated solar radiation at ground level and guidance for solar radiation testing and weathering

1 Scope ~~and object~~

This part of IEC 60068-2 ~~provides guidance~~ specifies the methods for testing equipment or components under simulated solar radiation conditions.

This document is applicable to the equipment and components at the surface of the earth.

The purpose of testing is to investigate to what extent the equipment or components are affected by simulated solar radiation in the presence of moisture to reproduce the weathering effects (temperature, humidity and/or wetting) that occur when they are exposed in actual end-use environments to daylight or to daylight filtered through window glass. This document specifies two test methods, test method Sa: thermal effect test, and test method Sb: weathering test.

~~The method of combined tests detects electrical, mechanical or other physical variations.~~

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.

IEC 60068-1, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-1, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

~~IEC 60068-2-78, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*~~

~~CIE 20:1972, *Recommendation for the integrated irradiance and the spectral distribution of simulated solar radiation for testing purposes*~~

~~CIE 85:1985, *Solar spectral irradiance*~~

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60068-1 and the following apply.

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

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

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~~**3.1**~~
~~**air mass**~~
~~path length that light from a celestial object takes through the earth's atmosphere relative to the length where air mass = 1~~

~~NOTE The air mass is 1/sin (gamma), where gamma is the elevation angle of the sun.~~

3.1
black standard temperature
~~BST~~
insulated black panel temperature
characteristic value of the test specimen's(s') surface temperature measured by an insulated black panel thermometer, consisting of a black painted stainless steel panel and a resistance temperature sensor embedded in insulating material (white PVDF, polyvinylidene difluoride) attached

Note 1 to entry: ~~Black standard temperature as measured by a black standard thermometer~~ More details are described in ISO 4892-1.

Note 2 to entry: It is designed to approximate the maximum surface temperature of any material with thermal insulating properties and for control in weathering test apparatus.

3.2
black panel temperature
uninsulated black panel temperature
characteristic value of the test specimen's(s') surface temperature measured by an uninsulated black panel thermometer, consisting of a black painted stainless steel panel and a resistance temperature sensor attached

Note 1 to entry: ~~Black panel temperature as measured by a black panel thermometer~~ More details are described in ISO 4892-1.

Note 2 to entry: It is designed to approximate the maximum surface temperature of any material and for control in weathering test apparatus.

~~**3.4**~~
~~**solar constant**~~
~~rate at which solar energy, at all wavelengths, is received per unit area at the top level of earth's atmosphere~~

~~NOTE The value of the solar constant is E_0 = 1 367 W/m^2.~~

~~**3.5**~~
~~**optical depth**~~
~~measure of how much light is absorbed in travelling through a medium~~

~~NOTE A completely transparent medium has an optical depth of zero.~~

4 General remarks

4.1 Overview

The effect of solar radiation on the test specimen(s) will depend on the level of irradiance, the spectral ~~distribution~~ irradiance, the location, the time of day and the sensitivity of the material of the test specimen(s).

4.2 Irradiance of solar radiation

~~The irradiance by the sun on a plane perpendicular to the incident radiation outside the earth's atmosphere at the mean earth-sun distance is known as the solar constant E_0.~~

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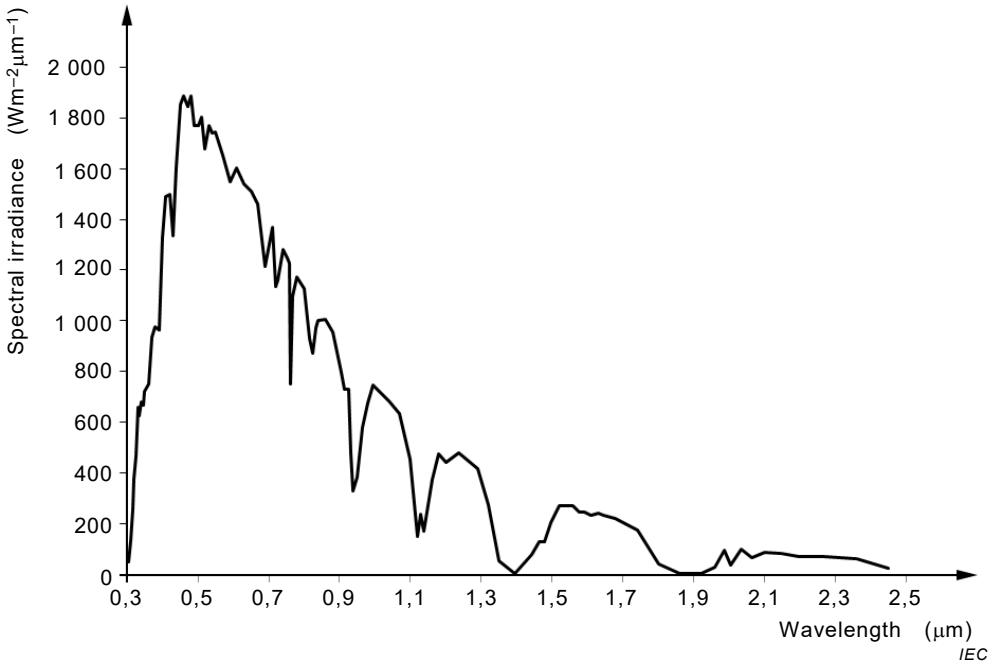
The irradiance at ~~the surface of the earth~~ sea level is influenced by the solar constant and the attenuation and scattering of solar radiation in the atmosphere. For test purposes, CIE 85:1989, Table 4 gives a value of 1 090 W/m^2 for the global solar radiation at the surface of the earth from the sun at zenith; this value is based on a solar constant E_0 = 1 367 W/m^2.

4.3 Spectral ~~distribution~~ irradiance of solar radiation

The standard spectral ~~distribution~~ irradiance of the global solar radiation specified for this test, in accordance with the recommendations of CIE 85:1989, Table 4 (see Annex A), is given in Figure 1 and in Table 1.



~~NOTE Optical depth of aerosol extinction 0,1 (solid line) and 0,27 (dashes), respectively.~~

Figure 1 – Global solar spectral irradiance at ~~the earth´s surface for relative air mass 1~~ sea level

Table 1 – Spectral ~~energy distribution~~ irradiance

Spectral region	Ultra-violet B[a]	Ultra-violet A	Visible	Infra-red	Total radiation
Bandwidth	300 nm to 320 nm	320 nm to 400 nm	400 nm to 800 nm	800 nm to 2 450 nm	300 nm to 2 450 nm
Irradiance	4,06 W/m^2	70,5 W/m^2	604,2 W/m^2	411,2 W/m^2	1 090 W/m^2
~~Approximate~~ Proportion of total radiation	0,4 %	6,4 %	55,4 %	37,8 %	100 %

NOTE This table is a condensed version of CIE 85:1989, Table 4.

[a] Radiation shorter than 300 nm reaching the earth's surface is insignificant

4.4 Radiation source

If the source of radiation used for the test does not meet the standard spectral distribution given in Table 1, the exact spectral absorption data of the material and the exact spectral irradiance of the alternative radiation source in the range from 300 nm to about 3 000 nm and for the solid angle of 2π sr above the specimen surface shall be known or measured.

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Detail of a radiation source is described in Annex B.

5 Test method Sa: thermal effect test

5.1 Conditioning

5.1.1 General

During the entire test, the irradiation, the temperature within the chamber, the humidity and any other specified environmental conditions shall be maintained at the levels appropriate to the particular test procedure specified in the relevant specification. The relevant specification shall state which preconditioning requirements are to be applied.

Detail of instrumentation is described in Annex D.

5.1.2 Temperature

The temperature within the chamber during irradiation and darkness periods shall be controlled in accordance with the procedure ~~(A, B or C)~~ (Sa 1, Sa 2 or Sa 3) specified. ~~During irradiation, the temperature within the chamber shall rise or fall by 1 K/min and be maintained at one of the preferred values given in IEC 60068-2-1, IEC 60068-2-2 or the relevant specification.~~

NOTE Additionally, an insulated black ~~standard~~ panel thermometer or an uninsulated black panel thermometer can be used to measure the maximum surface temperature. This temperature can be influenced by ventilation.

5.1.3 Humidity

Different humidity conditions, particularly condensation, can markedly affect photochemical degradation of materials, paints, plastics, etc. If ~~required~~ applicable, the values given in IEC 60068-2-78 ~~shall be preferred~~ should be used.

The relevant specification shall state the humidity and whether it is to be maintained during

a) the irradiation periods only;

b) the periods of darkness only;

c) the whole test duration.

5.1.4 Ozone and other ~~contaminating~~ contamination gases

Ozone, generated by short wavelength ultra-violet test sources, will normally be excluded from the test chamber by the radiation filter(s) used to correct the spectral energy distribution. As ozone and other contaminating gases can significantly affect the degradation processes of certain materials, it is important to exclude these gases from the test chamber, unless otherwise required by the relevant specification.

5.1.5 Surface contamination

Dust and other surface contamination may significantly change the absorption characteristics of irradiated surfaces. Unless otherwise required, specimens should be tested in a clean condition. However, if effects of surface contamination are to be assessed, the relevant specification should include the necessary information on preparation of surfaces, etc.

5.1.6 Mounting of test specimen(s)

The specimen(s) to be tested shall be placed either on raised support, on a turntable or a specified substrate of known thermal conductivity and thermal capacity within the chamber as stated in the relevant specification, and so spaced from other specimen(s) as to avoid

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shielding from the source of radiation or re-radiated heat. Temperature sensors should be attached to specimen(s) as required.

5.1.7 Test facility

It shall be ensured that the optical parts of the test facility, lamps, reflectors and filters, etc. are clean.

The level of irradiation over the specified measurement plane shall be measured immediately prior to each test.

Any ancillary environmental conditions, for example ambient temperature, humidity and other parameters if specified, should be monitored continuously during the test.

5.1.8 Test apparatus

The chamber in which the tests are to be carried out shall be provided with means for obtaining, over the ~~prescribed~~ specified irradiation measurement plane, an irradiance of 1 090 (1 ± 10 %) W/m^2 with the spectral distribution given in Table 1. The value of 1 090 W/m^2 shall include any radiation reflected from the test chamber and received by the specimen(s) under test. It should not include long-wave infra-red radiation emitted by the test chamber. The minimum and maximum levels of the relative spectral irradiance are given in Table 2.

Table 2 – Minimum and maximum levels of the relative spectral irradiance

Spectral region	Ultra-violet B	Ultra-violet A	Visible	Infra-red	Total radiation
Bandwidth	300 nm to 320 nm	320 nm to 400 nm	400 nm to 800 nm	800 nm to 2 450 nm	300 nm to 2 450 nm
Proportion of total radiation (%)	0,4	6,4	55,4	37,8	100,0
Minimum level (%)	0,3	4,2	43,8	33,7	–
Maximum level (%)	0,7	7,4	57,0	50,5	–

Means shall also be provided whereby the specified conditions of temperature, air flow and humidity can be maintained within the chamber.

The temperature within the chamber shall be measured (with adequate shielding from radiated heat) at a point or points in a horizontal plane 0 mm to 50 mm below the ~~prescribed~~ specified irradiation measurement plane, at half the distance between the specimen under test and the wall of the chamber, or at 1 m from the specimen, whichever is the lesser.

5.2 Initial measurements

The specimen(s) shall be submitted to the visual, dimensional and functional checks ~~prescribed~~ specified by the relevant specification.

5.3 Testing

5.3.1 General

During exposure, the temperature within the chamber shall rise or fall by 1 K/min and be maintained at one of the preferred values given in IEC 60068-2-1 or IEC 60068-2-2 or the relevant specification.

In procedure ~~A~~ Sa 1, the temperature within the chamber shall start to rise 2 h before the irradiation period starts.

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During the darkness period in procedures ~~A and B~~ Sa 1 and Sa 2, the temperature within the chamber shall fall ~~approximately~~ with average rate of 1 K/min and be maintained at +25 °C, unless otherwise specified. ~~If the required temperature is lower than 25 °C, the temperature shall be maintained at the required temperature.~~

The requirements for irradiation, temperature and time relationships are given in Figure 2. Throughout the specified test duration, the temperature within the chamber shall be maintained within ±2 ~~°C~~ K of that shown for the appropriate procedure.

The level of irradiance ~~should~~ shall be 1 090 (1 ± 10 %) W/m^2 or specified in the relevant specification. Acceleration of the test by increasing the irradiation above this level is not recommended. The total daily irradiation approximating the most severe natural conditions is simulated by procedure ~~A~~ Sa 1 with a duration of exposure to the standard irradiation conditions of 8 h per day. Thus, exposure for periods in excess of 8 h will effect acceleration over natural conditions. However, continuous exposure of 24 h per day (procedure ~~C~~ Sa 3) ~~might~~ could mask any degradation effects of cyclic thermal stressing, and this procedure is therefore not generally recommended in this instance.

The specimen shall be exposed, for the duration called for in the relevant specification, to one of the test procedures outlined in 5.3.2, 5.3.3 and 5.3.4 (see Figure 2).

5.3.2 Procedure ~~A~~ Sa 1 – 24 h cycle, 8 h irradiation and 16 h darkness, repeated as required

This gives a total irradiation of ~~8,96~~ 8,72 kWh/m^2 per diurnal cycle, which approximates to the most severe natural conditions. Procedure ~~A~~ Sa 1 ~~should be~~ is specified where the principal interest is in thermal effects.

5.3.3 Procedure ~~B~~ Sa 2 – 24 h cycle, 20 h irradiation and 4 h darkness, repeated as required

This gives a total irradiation of ~~22,4~~ 21,8 kWh/m^2 per diurnal cycle and is applicable where the principal interest is in degradation effects.

5.3.4 Procedure ~~C~~ Sa 3 – Continuous irradiation as required

Procedure Sa3 is a simplified test, applicable where cyclic thermal stressing is unimportant and photochemical effects only are to be assessed. This procedure is also applicable for the assessment of heating effects on specimens with low thermal capacity.

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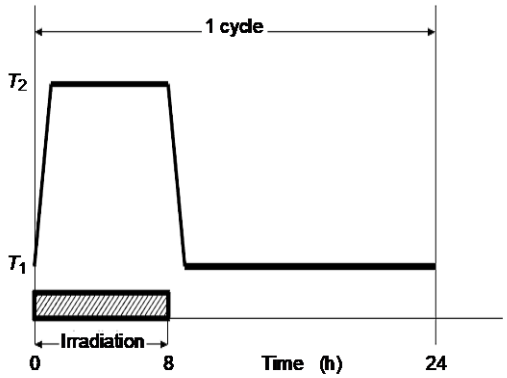
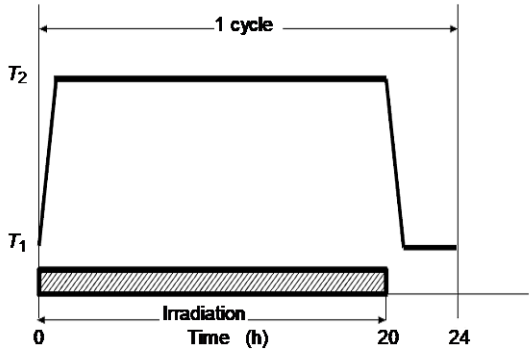
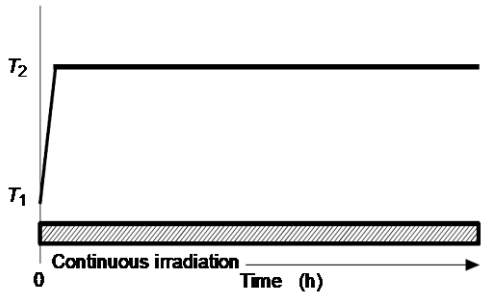
Procedure A



Procedure B



Procedure C



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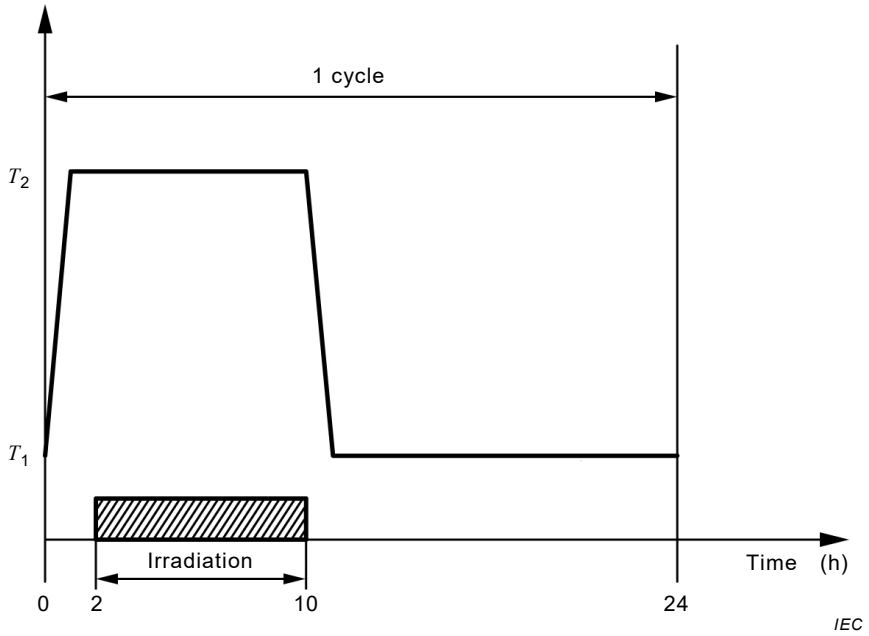
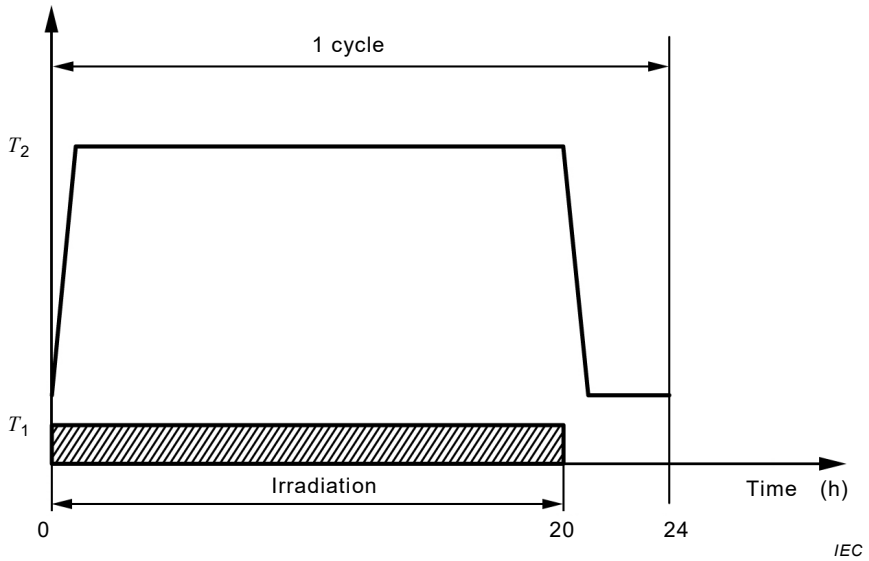


a) Procedure Sa 1



b) Procedure Sa 2

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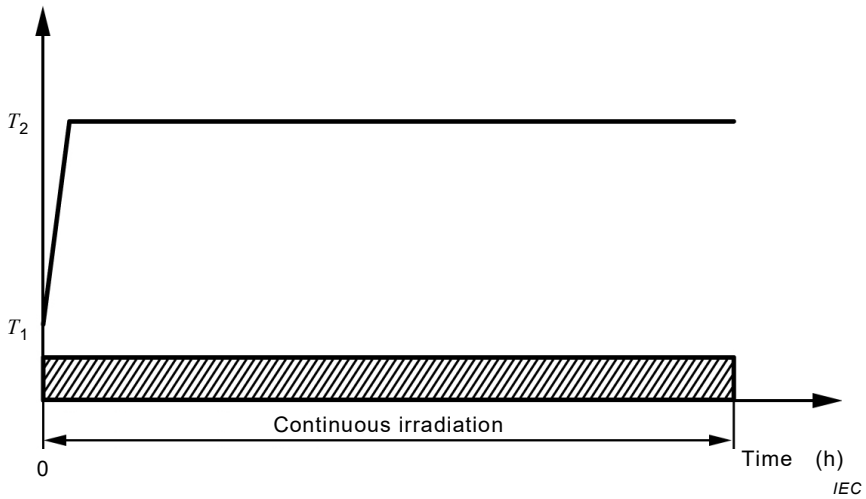

c) Procedure Sa 3

Key

T_1 lower temperature (25 °C if not otherwise specified)

T_2 upper temperature (40 °C if not otherwise specified)

Figure 2 – Test procedures ~~A, B and C~~ Sa 1, Sa 2 and Sa 3

5.4 Final measurements

The specimen shall be submitted to the visual, dimensional and functional checks ~~prescribed~~ specified by the relevant specification.

6 Test method Sb: Weathering test with or without wetting

6.1 Test apparatus

6.1.1 Laboratory radiation source

6.1.1.1 Xenon arc lamp

The radiation source shall comprise one or more quartz-jacketed xenon-arc lamps that emit radiation from below 270 nm in the ultraviolet through the visible spectrum and into the infrared. In order to simulate solar radiation, filters shall be used to remove short-wavelength UV radiation (Table 3). For tests intended to simulate solar radiation through window glass, filters to minimize irradiance at wavelengths shorter than 310 nm shall be used (Table 4). In addition, filters to remove infrared radiation may be used to prevent unrealistic heating of the test specimen(s), which can cause thermal degradation not experienced during outdoor exposures.

6.1.1.2 Spectral irradiance of xenon-arc lamp(s) with daylight filters

Filters are used to filter xenon-arc emissions in order to simulate solar radiation (CIE 85:1989, Table 4). The minimum and maximum levels of the relative spectral irradiance in the UV wavelength range are given in Table 3.

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Table 3 – Relative spectral irradiance of xenon-arc lamp(s) with daylight filters

Spectral passband (λ = wavelength in nm)	Minimum %	CIE 85:1989, Table 4 %	Maximum %
λ < 290	–	–	0,15
290 ≤ λ ≤ 320	2,6	5,4	7,9
320 < λ ≤ 360	28,2	38,2	39,8
360 < λ ≤ 400	54,2	56,4	67,5
NOTE More details regarding this table are given in ISO 4892-2.			

6.1.1.3 Spectral irradiance of xenon-arc lamp(s) with window glass filters

Filters are used to filter the xenon-arc lamp emissions in order to simulate solar radiation which has passed through a window glass. The minimum and maximum levels of the relative spectral irradiance in the UV region are given in Table 4.

Table 4 – Relative spectral irradiance for xenon-arc lamp(s) with window glass filters

Spectral passband (λ = wavelength in nm)	Minimum %	CIE 85:1989, Table 4, plus effect of window glass %	Maximum %
λ < 300	–	–	0,29
300 ≤ λ ≤ 320	0,1	≤ 1	2,8
320 < λ ≤ 360	23,8	33,1	35,5
360 < λ ≤ 400	62,4	66,0	76,2
NOTE More details regarding this table are given in ISO 4892-2.			

6.1.1.4 Uniformity of irradiance

The exposure area shall be designed such that the irradiance at any location used for test specimen(s) exposure is at least 70 % of the maximum irradiance measured in this area. If the minimum irradiance at any position in the area used for test specimen(s) exposure is between 70 % and 90 % of the maximum irradiance, the test specimen(s) shall be periodically repositioned to reduce the variability in radiant exposure. The repositioning procedure and schedule shall be agreed upon by all interested parties.

NOTE Procedures for measuring irradiance uniformity by the device manufacturers are given in ISO 4892-1.

6.1.2 Test chamber

A laboratory radiation source(s) is used to provide irradiance for the test specimen(s). The test chamber shall be water-resistant and means shall also be provided whereby the specified conditions of temperature, air flow and humidity can be maintained within it.

Typical apparatus are shown in Annex C.

6.1.3 Temperature

The temperature-sensing element shall be shielded from the radiation source and water spray. The chamber air temperature measured at this position may not be the same as the chamber air temperature near the surface of the exposed test specimen(s).

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