IEC 60068-2-5

Edition 2.0 2010-04

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

Essais d'environnement –
Partie 2-5: Essais – Essai Sa: Rayonnement solaire simulé au niveau du sol et guide pour les essais de rayonnement solaire

IEC 60068-2-5:2010

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ENVIRONMENTAL TESTING –

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

FOREWORD

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

This second edition cancels and replaces the first edition of IEC 60068-2-5, published in 1975, and IEC 60068-2-9, published in 1975, and constitutes a technical revision.

The main changes with respect to the previous edition are listed below:

This second edition of IEC 60068-2-5 will make the reading much easier, partly because it includes guidance for solar radiation testing, previously published in a separate publication, IEC 60068-2-9, and partly because it now allows the use of all lamps specified in CIE 85 and published in 1985 by the International commission on Illumination.

The text of this standard is based on the following documents:

FDIS	Report on voting
104/500/FDIS	104/515/RVD

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

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

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

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

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- withdrawn,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

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, 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 a combination of solar radiation with other environments, e.g. temperature, humidity, air velocity, etc.

ENVIRONMENTAL TESTING –

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

1 Scope and object

This part of IEC 60068 provides guidance for testing equipment or components under solar radiation conditions.

The purpose of testing is to investigate to what extent the equipment or components are affected by solar radiation.

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

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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 85:1985, *Solar spectral irradiance*

3 Terms and definitions

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

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

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

3.2
black standard temperature
BST
characteristic value of the specimen surface temperature

NOTE Black standard temperature as measured by a black standard thermometer (see ISO 4892-1).

3.3
black panel temperature
characteristic value of the specimen surface temperature

NOTE Black panel temperature as measured by a black panel thermometer (see ISO 4892-1).

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 radiation on the specimen will depend on the level of irradiance, the spectral distribution, the location, the time of day and the sensitivity of the material of the specimen.

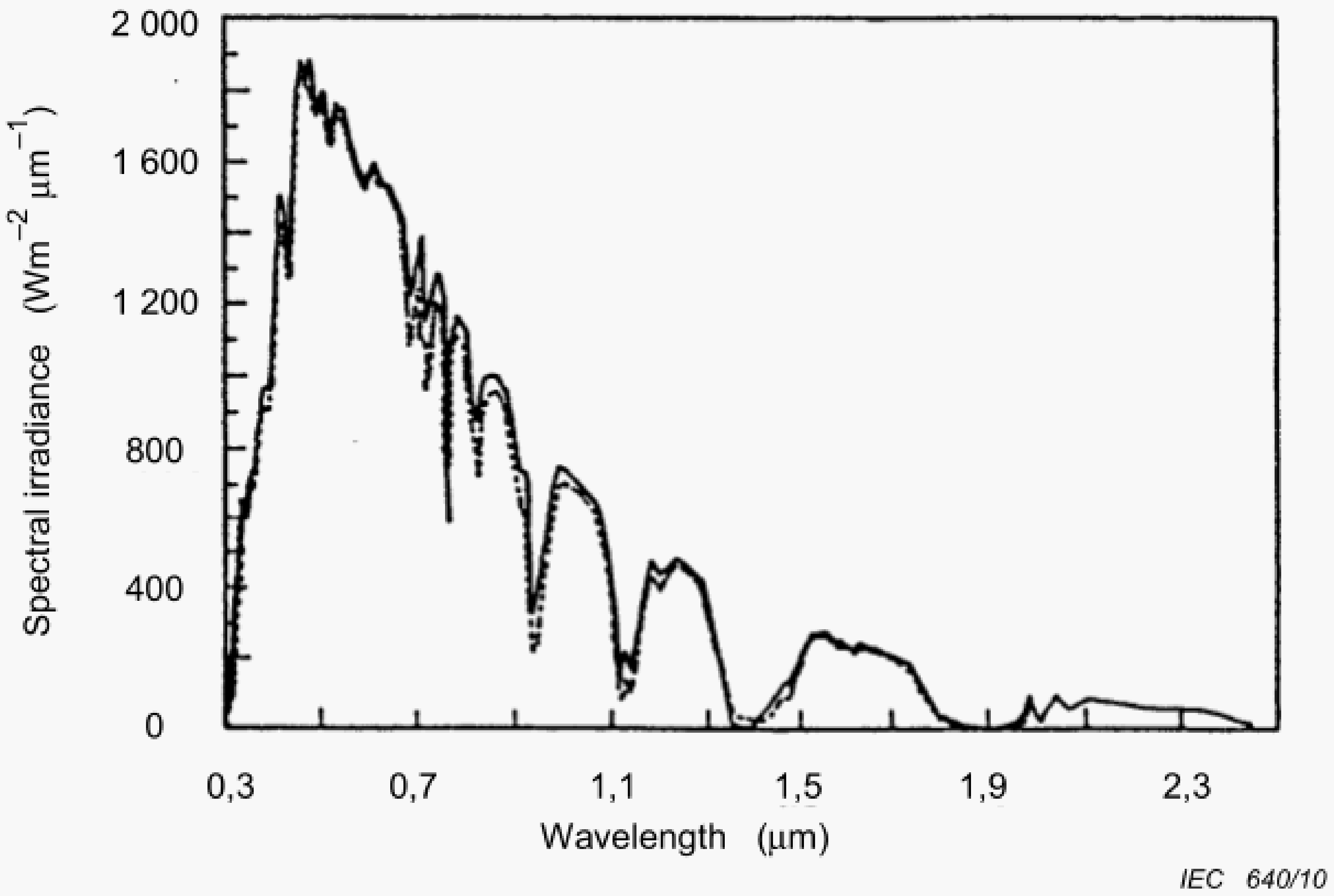
4.2 Irradiance

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.

The irradiance at the surface of the earth is influenced by the solar constant and the attenuation and scattering of radiation in the atmosphere. For test purposes, CIE 85 gives a value of 1 120 W/m^2 for the global radiation at the surface of the earth from sun at zenith; value based on a solar constant E_0 = 1 367 W/m^2 .

4.3 Spectral distribution

The standard spectral distribution of the global radiation specified for this test, in accordance with the recommendations of the CIE 85, 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

Table 1 – Spectral energy distribution and permitted tolerances

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
Irradiance	4,06 W/m^2	70,5 W/m^2	604,2 W/m^2	186 W/m^2	1 090 W/m^2
Proportion of total radiation	0,4 %	6,4 %	55,4 %	37,8 %	100 %
* Radiation shorter than 300 nm reaching the earth's surface is insignificant.					

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.

5 Conditioning

5.1 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.

5.2 Temperature

The temperature within the chamber during irradiation and darkness periods shall be controlled in accordance with the procedure (A, B or C) 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, a black standard thermometer can be used to control the maximum surface temperature. By ventilation, this temperature can be influenced.

5.3 Humidity

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

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.

5.4 Ozone and other contaminating gases

Ozone, generated by short wavelength ultra-violet of 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.

5.5 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.

5.6 Mounting of specimen

The specimen 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 specimens as to avoid shielding from the source of radiation or re-radiated heat. Temperature sensors should be attached to specimen as required.

5.7 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, e.g. ambient temperature, humidity and other parameters if specified, should be monitored continuously throughout the test.

5.8 Test apparatus

The chamber in which the tests are to be carried out shall be provided with means for obtaining, over the prescribed irradiation measurement plane, an irradiance of 1 120 W/m^2 ± 10 % with the spectral distribution given in Table 1. The value of 1 120 W/m^2 shall include any radiation reflected from the test chamber and received by the specimen under test. It should not include long-wave infra-red radiation emitted by the test chamber.

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 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.

6 Initial measurement

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

7 Testing

7.1 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, the temperature within the chamber shall start to rise 2 h before the irradiation period starts.

During the darkness period in procedures A and B, the temperature within the chamber shall fall approximately with 1 K/min and be maintained at +25 °C. 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 of that shown for the appropriate procedure.

The level of irradiance should be 1 120 W/m^2 ± 10 % 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 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, might 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 following test procedures (see Figure 2).

7.2 Procedure A – 24 h cycle, 8 h irradiation and 16 h darkness, repeated as required

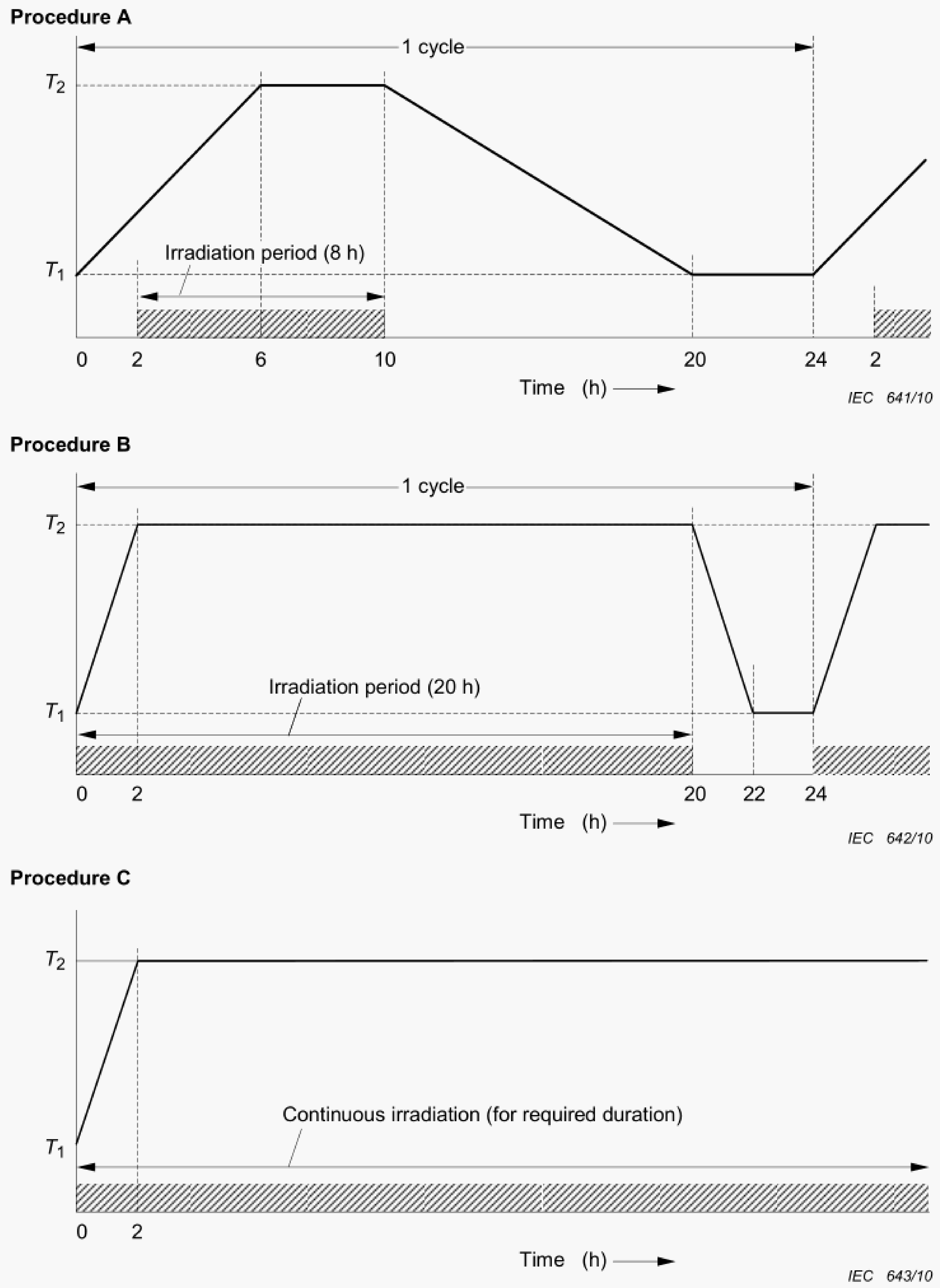
This gives a total irradiation of 8,96 kWh/m^2 per diurnal cycle, which approximates to the most severe natural conditions. Procedure A should be specified where the principal interest is in thermal effects.

7.3 Procedure B – 24 h cycle, 20 h irradiation and 4 h darkness, repeated as required

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

7.4 Procedure C – Continuous irradiation as required

A simplified test, applicable where cyclic thermal stressing is unimportant and photochemical effects only are to be assessed. Also for the assessment of heating effects on specimens with low thermal capacity.



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

8 Final measurements

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

9 Information to be given in the relevant specification

The relevant specification shall contain the following details as far as they are applicable:

a) exposure time to radiation;

b) black standard temperature;

c) power of radiation;

d) duration of the test;

e) state of operation;

f) preconditioning;

g) number of specimens;

h) humidity if relevant;

i) type and scope of initial measurement;

j) test procedure;

k) temperature during the test;

l) period of operation;

m) type and scope of intermediate measurement;

n) recovery;

o) type and scope of final measurement;

p) criteria for evaluation;

q) type and scope of test report;

r) description of specimen support used for testing.

10 Information to be given in the test report

When this test is included in the relevant specification, the following details shall be given, where applicable:

a) Test laboratory	(name and address and details of accreditation – if any)
b) Test dates	(dates when test was run)
c) Customer	(name and address)
d) Type of test	(procedure A, B, C)
e) Required values	(temperature, humidity, radiation, etc.)
f) Purpose of test	(development, qualification, etc.)
g) Test standard, edition	(IEC 60068-2-5, edition used)
h) Relevant laboratory test procedure	(code and issue)
i) Test specimen description	(drawing, photo, quantity build status, etc.)
j) Test chamber	(manufacturer, model number, unique id, etc.)
k) Performance of test apparatus	(set point temperature control, etc.)
l) Uncertainties of measurement system	(uncertainties data)
m) Calibration data	(last and next due date)
n) Initial, intermediate and final measurements	(Initial, intermediate and final measurements)
o) Required severities	(from relevant specification)
p) Test severities	(measuring points, data, etc.)
q) Performance of test specimens	(results of functional tests, etc.)
r) Observations during testing and actions taken	(any pertinent observations)
s) Summary of test	(test summary)
t) Distribution	(distribution list)

Annex A
(informative)

Interpretation of results

A.1 Compliance with specification

The relevant specification should indicate the permitted changes in the external condition and/or performance of the specimen(s) under test after exposure to the required level of irradiation for specified durations. In addition to such requirements, the following aspects of interpretation may be considered.

A.2 Short-term effects

Primarily, heating effects are concerned. Short-term effects to be looked for will mainly be in the nature of local overheating.

A.3 Long-term effects

The purpose of carrying out long-term tests is to determine the pattern of deterioration with the two objectives of seeing whether there is an initial rapid change and of assessing the useful life of the item under test.

A.4 Thermal effects

The maximum surface and internal temperatures attained by a specimen or equipment will depend on

a) temperature of ambient air,
b) intensity of radiation,
c) air velocity,
d) duration of exposure,
e) the thermal properties of the object itself, e.g. surface reflectance, sizes and shape, thermal conductance and specific heat.

Equipment can attain temperatures in excess of 80 °C if fully exposed to solar radiation in an ambient temperature as low as 35 °C to 40 °C. The surface reflectance of an object affects its temperature rise from solar heating to a major extent; changing the finish from, for example, a dark colour to a gloss white, will effect a considerable reduction in temperature. Conversely, a pristine finish designed to reduce temperature can be expected to deteriorate in time, resulting in an increase in temperature.

Most materials are selective reflectors, i.e. their spectral reflectance factor changes with wavelength. For instance, paints, in general, are poor infra-red reflectors although they may be very efficient in the visible region. Furthermore, the spectral reflectance factor of many materials change sharply once visible (producing a colour sensation to the human eye) and when in the near infra-red zone. It is important, therefore, that the spectral energy distribution of the radiation source(s) used in any simulated test should closely duplicate that of natural solar radiation, or that appropriate adjustment of the irradiance is made so that the same heating effect is obtained.

A.5 Degradation of materials

The combined effects of solar radiation, atmospheric gases, temperature and humidity changes, etc. are often collectively termed “weathering” and result in the “ageing” and ultimate destruction of most organic materials (e.g. plastics, rubbers, paints, timber, etc.).

Many materials which give satisfactory service in temperate regions have been found to be completely unsuitable for use under the more adverse conditions of the tropics. Typical defects are the rapid deterioration and breakdown of paints, the cracking and disintegration of cable sheathing and the fading of pigments.

The breakdown of a material under weathering usually results not from a single reaction, but from several individual reactions of different types occurring simultaneously, often with interacting effects. Although solar radiation, principally the ultra-violet – resulting in photo-degradation – is often the major factor, its effects can seldom be separated in practice from those of other weathering factors. An example is the effect of ultra-violet radiation on polyvinyl chloride, where the apparent effects of ultra-violet radiation alone is small but its susceptibility to thermal breakdown, in which oxygen probably plays a major role, is markedly increased.

Unfortunately, artificial tests occasionally produce abnormal defects which do not occur under natural weathering. This can often be attributed to one or more of the following causes:

a) many laboratory sources of ultra-violet radiation differ considerably from natural solar radiation in spectral energy distribution;
b) when the intensity of ultra-violet radiation, temperature, humidity, etc. are increased to obtain an accelerated effect, the rates of the individual reactions which occur under normal exposure conditions are not necessarily increased to the same extent;
c) the artificial tests, in general, do not simulate all the natural weathering factors.

Annex B
(informative)

Radiation source

B.1 General

The radiation source may comprise one or more lamps and their associated optical components, e.g. reflectors, filters, etc., to provide the required spectral distribution and irradiance.

Depending on place, time, irradiance, spectral distribution and power of radiation, different lamps with different filters can be used.

B.2 Filters

The choice of filters depends on the source, the equipment and spectral distribution. The present preference is therefore for glass filters to be used, although fundamentally a glass is not as accurately reproducible as a chemical solution. Some trial and error may be necessary to compensate for different optical densities by using different plate thicknesses. Glass filters are proprietary articles and manufacturers should be consulted concerning the choice of filters suitable for particular purposes. The choice will depend on the source and its method of use.

Some glass infra-red filters may be prone to rapid changes in spectral characteristics when exposed to excessive ultra-violet radiation. This deterioration may be largely prevented by interposing the ultra-violet filter between the source and the infra-red filter. Interference type filters, which function by reflecting instead of absorbing the unwanted radiation, thus resulting in reduced heating of the glass, are generally more stable than absorption filters.

B.3 Uniformity of irradiance

Owing to the distance of the sun from the earth, solar radiation appears at the earth's surface as an essentially parallel beam. Artificial sources are relatively close to the working surface and means of directing and focusing the beam shall be provided with the aim of providing a uniform irradiance at the measurement plane within specification limits (i.e. 1 120 W/m^2 ± 10 %). Uniform irradiation is more readily achieved with a long-arc lamp mounted in a parabolic “trough” type reflector. By employing very elaborate mounting techniques, it is possible to irradiate, with some degree of uniformity, a large surface by a number of lamps. It is also possible using a turntable.

It is generally advisable to locate radiation source(s) outside the test chamber. This avoids possible degradation of the optical components, e.g. by high humidity conditions and contamination of test specimens by ozone generated by some types of lamps. In this case, the spectral transmittance of the window material shall be taken into account.

Precise collimation of the radiation beam is not normally necessary except for testing special equipment such as solar cells, solar tracking devices, etc.

Annex C
(informative)

Instrumentation

C.1 General

Test apparatus as described in the ISO 4892 series shall be used for the tests specified in this part of IEC 60068.

C.2 Measurement of irradiance

The type of instrument considered most suitable for monitoring irradiance is a pyranometer as used for measuring combined solar and sky radiation on a horizontal plane.

Two types are suitable for measuring radiation from a simulated solar source. Each depends for its operation on thermo junctions.

The measurement instruments described in ISO 9370 are recommended for the purpose of monitoring the irradiance from laboratory light sources.

Neither of these instruments is significantly affected by long-wave infra-red radiation emitted by the specimen or the test chamber.

C.3 Measurement of spectral distribution

Total intensity checks are readily made, but detailed checks on spectral characteristics are more difficult. Major spectral changes can be checked by inexpensive routine measurements, using a pyranometer in conjunction with selective filters. For checking the detail distribution characteristics of the facility, it would be necessary to employ sophisticated spectroradiometric instrumentation.

Changes in the spectral characteristics of lamps, reflectors and filters may occur over a period of time which could result in the spectral distribution being seriously outside the permitted tolerances. Manufacturing tolerances may mean that lamp replacement could result in unacceptable changes in the level of irradiation compared with that initially set up. Regular monitoring is therefore essential, but monitoring of the detail spectral distribution within the test facility may not be possible while a specimen is undergoing test.

C.4 Measurement of temperature

Because of the high level of radiation, it is essential that temperature sensors are adequately shielded from radiant heating effects. This applies both to measuring air temperatures within the test chamber and also to monitoring specimen/equipment temperatures.

When monitoring equipment temperatures, sensors, e.g. thermocouples, should be located on the inside surface of the external case and not be attached to the outside surfaces. Temperature-indicating paints and waxes are unsuitable for monitoring the temperature of irradiated surfaces of specimens, as their absorption characteristics will not be the same as those of the specimens.

The maximum temperature on the surface of the specimen is determined by a black standard thermometer.

Table C.1 – Detailed spectral distribution of global radiation for calculation purposes

Spectral region	**Bandwidth** µm	**Irradiance** W/m^2	**Irradiance** %
Ultra-violet B*	0,28 to 0,32	5	0,4
Ultra-violet A	0,32 to 0,36 0,36 to 0,40	27 36	2,4 3,2
Visible	0,40 to 0,44 0,44 to 0,48 0,48 to 0,52	56 73 71	5,0 6,5 6,4
	0,52 to 0,56 0,56 to 0,64	65 121	5,8 10,8
	0,64 to 0,68 0,68 to 0,72 0,72 to 0,78	55 52 67	4,9 4,6 6,0
Infra-red	0,78 to 1,0 1,0 to 1,2 1,2 to 1,4 1,4 to 1,6 1,6 to 1,8 1,8 to 2,0 2,0 to 2,5 2,5 to 3,0	176 108 65 44 29 20 35 15 _____ 1 120 _____	15,7 9,7 5,8 3,9 2,6 1,8 3,1 1,4 _____ 100,0 _____
* Radiation shorter than 0,30 µm reaching the earth's surface is insignificant.			

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ISO 4892-4, *Plastics – Methods of exposure to laboratory light sources – Part 4: Open-flame carbon-arc lamps*

ISO 9370, *Plastics – Instrumental determination of radiant exposure in weathering tests – General guidance and basic test method*

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