

Environmental testing —

Part 2: Tests — Guidance for solar radiation testing

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Summary of pages

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CENELEC

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Foreword

The text of the International Standard IEC 60068-2-9:1975 and its amendment 1:1984, prepared by IEC TC 50 (transformed into IEC TC 104 "Environmental conditions, classification and methods of test), was approved by CENELEC as HD 323.2.9 S2 on 1985-12-03.

This Harmonization Document was submitted to the formal vote for conversion into a European Standard and was approved by CENELEC as EN 60068-2-9 on 1999-10-01.

The following date was fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2000-10-01

Annexes designated "normative" are part of the body of the standard.
In this standard, annex ZA is normative.
Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60068-2-9:1975 and its amendment 1:1984 was approved by CENELEC as a European Standard without any modification.

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BASIC ENVIRONMENTAL TESTING PROCEDURES –

Part 2: Tests – Guidance for solar radiation testing

Warning note

Intending users of solar radiation tests are directed to the health hazards associated with tests of this nature and should therefore read clause 9 of this publication and take particular note of its contents.

1 Introduction

This publication 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 combination of solar radiation – including sky radiation – with other environments, e.g. temperature, humidity, air velocity, etc.

2 Irradiance and spectral distribution of test source

The effect of radiation on the specimen(s) will depend on the level of irradiance and its spectral distribution.

2.1 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 [12].*

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 Publication No. 20 gives a value of 1,120 W/m² for the global (total) radiation at the surface of the earth from sun and sky, with the sun at zenith; value based on a solar constant $E_0 = 1,35$ kW/m² [22].

2.2 Spectral distribution

The standard spectral distribution of the global radiation specified for this test, in accordance with the recommendations of the CIE [22], is given in table I of Test Sa of IEC 60068-2-5. Where only the thermal effects of solar radiation are of interest, then the use of tungsten filament lamps may be permitted. However, it must be clearly understood that the spectral distribution of tungsten filament lamps differs markedly from that of natural solar radiation (see figure 2) and the irradiance shall be adjusted in accordance with 2.3 below.

* All the numbers in square brackets [] refer to the Bibliography.

2.3 Irradiance to be used with other spectral distribution

If the source of radiation used for the test does not meet the standard spectral distribution given in table I of Test Sa, e.g. where tungsten filament lamps are used (permissible if the test is solely to assess thermal effects), the irradiance shall be adjusted so that the heating effect is the same as if the test specimen(s) were irradiated by the global radiation of sun and sky. Therefore, the absorbed radiation from the test source shall be the same as for the global radiation of sun and sky, i.e.:

$$E_{\text{ex}} = 1,120 \frac{a_{\text{es}}}{a_{\text{ex}}} \text{ kW/m}^2$$

where:

E_{ex} = irradiance from the test source

a_{ex} = absorptance factor of the specimen for the radiation from the test source

a_{es} = absorptance factor of the specimen for the global radiation of sun and sky

(See also annex A.)

3 Test procedure and duration

3.1 Consideration must be given to the duration of exposure and whether it should be continuous or intermittent. Three possible procedures are specified:

Procedure A

A 24 h cycle, with 8 h irradiation and 16 h darkness, repeated as required. (This gives a total irradiation of 8,96 kWh/m² per diurnal cycle, which approximates to the most severe natural conditions. Procedure A should be specified where the principal interest is in thermal effects.)

Procedure B

A 24 h cycle, with 20 h irradiation and 4 h darkness, repeated as required. (This gives a total irradiation of 22,4 kWh/m² per diurnal cycle and is applicable where the principal interest is in degradation effects.)

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.)

3.2 The level of irradiance, as prescribed in Test Sa, is 1,120 kW/m² ± 10 %. Acceleration of the test by increasing the irradiation above this level is not recommended. As stated above, 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.

3.3 The duration called for will depend on the object of the test. Where the interest is in heating effects only, then three cycles should be adequate (except for large equipment which may require longer to attain maximum internal temperatures). A much longer test duration is necessary if degradation effects are to be assessed.

4 Other environmental factors to be considered

4.1 Temperature within the enclosure

The temperature within the enclosure during irradiation and darkness periods shall be controlled in accordance with the procedure (A, B or C) specified. The relevant specification shall state whether +40 °C or +55 °C is to be attained during irradiation, depending on the intended usage of the equipment or component.

4.2 Humidity

Different humidity conditions, particularly condensation, can markedly affect photochemical degradation of materials, paints, plastics, etc., but requirements are so varied that no attempt has been made here to give guidance on this matter. Individual requirements should be clearly stated in the relevant specification, e. g. a 4 h period of damp heat (40 ± 2 °C and 93 % R.H. ± 3 %) could be specified at the beginning of a test in accordance with Procedure B.

4.3 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.

4.4 Ozone and other contaminating gases

Ozone, generated by short wavelength ultra-violet of test sources, will normally be excluded from the test enclosure 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 enclosure, unless otherwise required by the relevant specification (see also 9.3).

4.5 Air velocity

Attention is drawn to the possible cooling effects of air flow over the specimens. This can also result in misleading errors in open-type thermopiles used to monitor radiation intensity. An air flow of as little as 1 m per second can effect a reduction in temperature rise of over 20 %. It is essential, therefore, to control and measure the rate of air flow, which should be as low as possible, consistent with achieving satisfactory control of temperature (and humidity, where applicable). Adjustment of the temperature within the enclosure by suitable heating and cooling of the walls of the enclosure eliminates the need for high air velocities.

However, in practice high solar radiation conditions are rarely accompanied by complete absence of wind. It may be necessary, therefore, to assess the effect of different air velocities over an equipment or component under test. The relevant specification should state any special requirements in this respect.

4.6 Substrate, mounting attitude, etc.

As the thermal properties of the substrate and method of mounting can significantly affect the temperature rise of the test specimen(s), these factors must be carefully considered, so that the heat transfer is representative of typical use. The specimen(s) will probably be required to be mounted either on raised supports or on a substrate of specified properties, e.g. a layer of concrete of specified thickness or a sand bed of certain conductivity, etc. Full details of the substrate, method of mounting and attitude of the specimen(s) should be given in the relevant specification (see also annex B).

5 Radiation source

5.1 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.

The high-pressure xenon arc lamp with filters can provide the best match [1]. Mercury vapour and xenon mercury lamps have considerable deficiencies in matching which could lead to error [2]. The carbon arc, with specially doped electrodes, has been widely used but presents difficulties as regards stability and maintenance and is therefore not generally favoured. Tungsten filament lamps may be used if only thermal effects are of interest, but are almost completely deficient in ultra-violet and therefore cannot be used where photochemical effects are to be assessed.

Characteristics of these lamps, features of filters, optical arrangements, etc., are covered in the following subclauses. Further information can also be found in reference [2] of the Bibliography.

5.2 Xenon lamps

The configuration and size of the lamp(s) used will depend on the test required. A typical spectral distribution from a xenon arc is given in figure 1. However, the radiation direct from the hot electrodes shall also be considered. This effect is proportionally much greater with short arcs than with long arcs and may considerably influence the spectral match, since radiation from the electrodes has a higher proportion of infra-red than that from the arc. The relative spectral distribution of the xenon arc radiation has been found to be substantially independent of lamp power [3]. However, variation of lamp power will change the temperature of the electrodes and hence the spectral distribution of their radiation. With long-arc lamps, it is relatively simple to mask off the electrode radiation. The form of construction of the short-arc lamp leads to considerably wider manufacturing tolerances than those of the long arc, a point of particular importance when replacement becomes necessary.

Routine replacement of either type of lamp will be needed, since the emission will change continuously with life and there may be quite wide variations of the life characteristic from lamp to lamp. Despite these variations in intensity, the relative spectral distribution of the arc radiation should remain practically unchanged, because xenon is pure elemental gas.