

# Basic environmental testing procedures —

## Part 2.2 Guidance —

### Test Sa: Guidance for solar radiation testing

(This Part should be read in conjunction with Part 1.1 General)

Amendments issued since publication

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# Contents

|                                                                                                                                                     | Page |
|-----------------------------------------------------------------------------------------------------------------------------------------------------|------|
| National foreword                                                                                                                                   | ii   |
| 1 Introduction                                                                                                                                      | 1    |
| 2 Irradiance and spectral distribution of test source                                                                                               | 1    |
| 3 Test procedure and duration                                                                                                                       | 1    |
| 4 Other environmental factors to be considered                                                                                                      | 2    |
| 5 Radiation source                                                                                                                                  | 2    |
| 6 Instrumentation                                                                                                                                   | 4    |
| 7 Preparation of test facilities and specimens                                                                                                      | 5    |
| 8 Interpretation of results                                                                                                                         | 6    |
| 9 Hazards and personnel safety                                                                                                                      | 7    |
| Bibliography                                                                                                                                        | 9    |
| Appendix A Calculation of adjustment to irradiance                                                                                                  | 13   |
| Appendix B Heat transfer through substrate                                                                                                          | 14   |
| Figure 1 — Radiation from a typical high-pressure xenon arc lamp compared with solar radiation spectral energy curves for air masses 0–1 and 2 [18] | 11   |
| Figure 2 — Radiation from a tungsten lamp compared with solar radiation spectral energy curves for air masses 0–1 and 2 [18]                        | 12   |
| Table A.I — Detailed spectral distribution of global radiation for calculation purposes                                                             | 14   |
| Table II — Thermal conductivities of common materials                                                                                               | 15   |

# National foreword

This British Standard has been prepared under the direction of the General Electrotechnical Engineering Standards Committee. It is identical with IEC Publication 68-2-9:1975 “*Basic environmental testing procedures. Part 2: Tests — Test Sa: Guidance for solar radiation testing*”.

**Terminology and conventions.** The text of the IEC Publication has been accepted as suitable for publication, without deviation, as a British Standard. Certain terminology and conventions are used, however, that are not strictly appropriate in a British Standard, and attention is therefore drawn to the following.

Wherever the word “publication”, relating to this document, appears, it should be interpreted as “British Standard”.

The comma has been used in the tables and figures as a decimal marker. In British Standards it is current practice to use a full point (a full stop on the baseline) as a decimal marker.

Wherever page numbers are quoted in connection with references to figures or bibliography in this publication, they are IEC page numbers.

### Cross-references

| International standard | Corresponding British Standard                                                                                                                                                                                                                                             |
|------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| IEC 68-2-5             | BS 2011 Environmental testing<br>Part 2.1 Sa:1977 Test Sa. Simulated solar radiation at ground level<br>(Identical)                                                                                                                                                        |
| ISO 105                | BS 1006 Methods of test for colour fastness of textiles and leather<br>(Technically equivalent)                                                                                                                                                                            |
| ISO 4892               | BS 2782 Methods of testing plastics<br>Part 5 Optical and colour properties, weathering<br>Method 540B:1982 Methods of exposure to laboratory light sources, (xenon arc lamp, enclosed carbon arc lamp, open-flame carbon arc lamp, fluorescent tube lamps)<br>(Identical) |

The Technical Committee has reviewed the provisions of IEC 27-1, to which reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

**Compliance with a British Standard does not of itself confer immunity from legal obligations.**

### Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 15 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

**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].<sup>1)</sup>

The irradiance at the surface of the earth is influenced by the solar constant and the attenuation and scattering of radiation in the atmosphere. CIE Publication No. 20 gives a value of 1 120 W/m<sup>2</sup> 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  $E_0 = 1.35 \text{ kW/m}^2$  [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 Publication 68-2-5. 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 Sub-clause 2.3 below.

### 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.:

$$E_{\text{ex}} = 1.120 \frac{\alpha_{\text{es}}}{\alpha_{\text{ex}}} \text{ kW/m}^2$$

where:

$E_{\text{ex}}$  = irradiance from the test source

$\alpha_{\text{ex}}$  = absorptance factor of the specimen for the radiation from the test source

$\alpha_{\text{es}}$  = absorptance factor of the specimen for the global radiation of sun and sky

(See also Appendix 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/m<sup>2</sup> 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/m<sup>2</sup> 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).

<sup>1)</sup> All the numbers in square brackets [ ] refer to the Bibliography, pages 9 and 10.

**3.2** The level of irradiance, as prescribed in Test Sa, is  $1.120 \text{ kW/m}^2 \pm 10 \%$ . 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  $+40^\circ\text{C}$  or  $+55^\circ\text{C}$  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 ( $40 \pm 2^\circ\text{C}$  and  $93\% \text{ R.H.} \pm 3\%$ ) 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 Sub-clause 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 Appendix 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.