INTERNATIONAL STANDARD

ISO 4892-4

Second edition
2004-09-01

Plastics — Methods of exposure to laboratory light sources —

Part 4: Open-flame carbon-arc lamps

Plastiques — Méthodes d'exposition à des sources lumineuses de laboratoire —

Partie 4: Lampes à arc au carbone

Reference number
ISO 4892-4:2004(E)

PDF created with pdfFactory trial version www.pdffactory.com

Contents

Page

1 Scope 1
2 Normative references 1
3 Principle 1
4 Apparatus 2
5 Test specimens 5
6 Test conditions 5
7 Procedure 6
8 Exposure report 7

PDF created with pdfFactory trial version www.pdffactory.com

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 4892-4 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 6, *Ageing, chemical and environmental resistance*.

This second edition cancels and replaces the first edition (ISO 4892-4:1994), which has been technically revised.

ISO 4892 consists of the following parts, under the general title *Plastics — Methods of exposure to laboratory light sources*:

— *Part 1: General guidance*

— *Part 2: Xenon-arc sources*

— *Part 3: Fluorescent UV lamps*

— *Part 4: Open-flame carbon-arc lamps*

PDF created with pdfFactory trial version www.pdffactory.com

Plastics — Methods of exposure to laboratory light sources —

Part 4:
Open-flame carbon-arc lamps

1 Scope

This part of ISO 4892 specifies methods for exposing specimens to open-flame carbon-arc lamps in the presence of moisture to reproduce the weathering effects that occur when materials are exposed in actual end-use environments in daylight or daylight filtered through window glass.

The specimens are exposed to filtered open-flame carbon-arc light under controlled environmental conditions (temperature, moisture). Various filters are described.

Specimen preparation and evaluation of the results are covered in other International Standards for specific materials.

General guidance is given in ISO 4892-1.

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.

ISO 4582, *Plastics — Determination of changes in colour and variations in properties after exposure to daylight under glass, natural weathering or laboratory light sources*

ISO 4892-1:1999, *Plastics — Methods of exposure to laboratory light sources — Part 1: General guidance*

CIE Publication No. 85:1989, *Solar spectral irradiance*

3 Principle

3.1 Specimens of the materials to be tested are exposed to glass-filtered open-flame carbon-arc light, to heat and to moisture continuously or in repetitive cycles.

3.2 The exposure conditions may be varied by selection of:

a) the light filter;

b) the type of exposure to moisture/humidity;

c) the length of exposure to light and moisture/humidity;

d) the temperature of the exposure;

e) the relative lengths of the light and dark periods.

The effect of moisture is usually produced by controlling the humidity of the air or by spraying the test specimens with demineralized/deionized water or by condensation of water vapour onto the surfaces of the specimens.

PDF created with pdfFactory trial version www.pdffactory.com

3.3 The procedure may include measurements of the irradiance and radiant exposure at the surface of the specimens.

3.4 It is recommended that a similar material of known behaviour (a control) be exposed simultaneously with the test specimens to provide a reference standard for comparative purposes.

3.5 Intercomparison of results obtained from specimens exposed in different apparatus should not be made unless an appropriate statistical relationship has been established between the devices for the particular material tested.

4 Apparatus

4.1 Laboratory light source

4.1.1 Open-flame carbon-arc light sources typically use three or four pairs of carbon rods which contain a mixture of rare-earth metal salts and have a surface coating of a metal such as copper. An electric current is passed between the carbon rods which burn, giving off ultraviolet, visible and infrared radiation. The pairs of carbon rods are burned in sequence, with one pair burning at any one time. Use the carbon rods recommended by the manufacturer of the apparatus. The radiation reaching the specimens passes through glass filters. Three types of glass filter are used in practice. Tables 1 and 2 show the typical relative spectral power distribution for open-flame carbon-arc lamps with daylight and window-glass filters, respectively. When extended-UV filters are used, the relative spectral power distribution shall meet the requirements of Table 3.

4.1.2 Spectral irradiance of open-flame carbon-arc lamps with daylight filters (type 1): The data in Table 1 are typical of an open-flame carbon-arc lamp with glass filters used to simulate daylight (see CIE Publication No. 85:1989, Table 4).

Table 1 — Typical ultraviolet spectral power distribution for open-flame carbon-arc lamps with daylight filters (type 1)[a,b]

Spectral passband (λ = wavelength in nm)	Typical distribution for open-flame carbon-arc lamp with daylight filters[c] %	CIE No. 85:1989, Table 4[d,e] %
$\lambda < 290$	0,05	
$290 \leqslant \lambda \leqslant 320$	2,9	5,4
$320 < \lambda \leqslant 360$	20,5	38,2
$360 < \lambda \leqslant 400$	76,6	56,4

[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 the relative spectral power distribution for a specific daylight filter or set of filters for an open-flame carbon-arc lamp, the spectral power distribution must be measured from 250 nm to 400 nm. 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 table gives typical data for an open-flame carbon-arc lamp with borosilicate-glass daylight filters. There is currently not enough data available to develop a specification for the open-flame carbon-arc lamp with a daylight filter.

[c] For any individual spectral power distribution, the calculated percentages for the passbands in this table will sum to 100 %.

[d] The data from Table 4 in CIE Publication No. 85:1989 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 comparison purposes only.

[e] For the solar spectrum represented by Table 4 in CIE No. 85:1989, 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.

PDF created with pdfFactory trial version www.pdffactory.com

Table 2 — Typical ultraviolet spectral power distribution for open-flame carbon-arc lamps with window-glass filters (type 2)[a,b]

Spectral passband (λ = wavelength in nm)	Typical distribution for open-flame carbon-arc lamp with window-glass filters[c] %	CIE No. 85:1989, Table 4 plus effect of window glass[d,e] %
$\lambda < 300$	0,0	
$300 \leqslant \lambda \leqslant 320$	0,3	$\leqslant 1$
$320 < \lambda \leqslant 360$	18,7	33,1
$360 < \lambda \leqslant 400$	81,0	66,0

[a] This table gives the typical irradiance in the given passband, expressed as a percentage of the total irradiance between 290 nm and 400 nm. To determine the irradiance in each passband for an open-flame carbon-arc lamp with a specific set of window-glass filters, the spectral power distribution must be measured from 250 nm to 400 nm. 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 table gives typical data for an open-flame carbon-arc lamp with window-glass filters. There is currently not enough data available to develop a specification for the spectral power distribution.

[c] For any individual spectral power distribution, the calculated percentages for the passbands in this table will sum to 100 %. Contact the manufacturer of the carbon-arc apparatus for the spectral power distribution data for the particular carbon arcs and window-glass filters used.

[d] The data from Table 4 in CIE No. 85:1989 plus the effect of window glass was determined by multiplying the CIE No. 85:1989, Table 4, data by the upper and lower transmission ranges typical for window glass used in the USA and Europe. These data are provided for comparison purposes only.

[e] For the CIE No. 85:1989 plus window glass data, the UV irradiance between 300 nm and 400 nm ranges from 7,7 % to 10,6 % and the visible radiation ranges from 89,4 % to 92,3 %, expressed as a percentage of the total irradiance between 300 nm and 800 nm.

Table 3 — Ultraviolet spectral power distribution for open-flame carbon-arc lamps with extended-UV filters (type 3)[a,b]

Spectral passband (λ = wavelength in nm)	Minimum[c] %	Maximum[c] %	CIE No. 85:1989, Table 4[d,e] %
$\lambda < 290$		4,9	
$290 \leqslant \lambda \leqslant 320$	2,3	6,7	5,4
$320 < \lambda \leqslant 360$	16,4	24,3	38,2
$360 < \lambda \leqslant 400$	68,1	80,1	56,4

[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 filter or set of filters for an open-flame carbon-arc lamp meets the requirements of this table, the spectral power distribution must be measured from 250 nm to 400 nm. Typically, this is done in 2 nm increments. The total irradiance in each wavelength passband is then summed and divided by the total irradiance from 250 nm to 400 nm.

[b] The minimum and maximum limits in this table are based on 24 spectral power distribution measurements with open-flame carbon-arc lamps with filters from different production lots and of various ages, used in accordance with the recommendations of the manufacturer. The minimum and maximum limits are at least three sigma from the mean for all the measurements. Open-flame carbon-arc lamps emit significant amounts of short-wavelength UV radiation between 250 nm and 280 nm. The intensity of this short-wavelength UV radiation varies with the age and initial transmission properties of the extended-UV filters used, as well as the composition of the carbon rods. The composition of the carbon rods may vary between production lots and between manufacturers.

[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 power distribution, the percentages calculated for the passbands in this table will sum to 100 %. For any individual open-flame carbon-arc lamp with extended-UV filters, the calculated percentage in each passband shall fall within the minimum and maximum limits given. Test results can be expected to differ if obtained using open-flame carbon-arc apparatus in which the spectral power distributions differed by as much as that allowed by the tolerances. Contact the manufacturer of the carbon-arc apparatus for specific spectral power distribution data for the carbon-arc lamp and filters used.

[d] The data from Table 4 in CIE Publication No. 85:1989 is 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 comparison purposes only.

[e] For the solar spectrum represented by Table 4 in CIE No. 85:1989, 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 between 290 nm and 800 nm.

PDF created with pdfFactory trial version www.pdffactory.com

4.1.3 Spectral irradiance of open-flame carbon-arc lamps with window-glass filters (type 2): The data in Table 2 are typical of an open-flame carbon-arc lamp with window-glass filters.

4.1.4 Spectral irradiance of open-flame carbon-arc lamps with extended-UV filters (type 3): The data in Table 3 are required for an open-flame carbon-arc lamp with extended-UV filters. A typical example of a suitable type 3 filter is that commonly known as Corex 7058[1)].

4.1.5 The following factors can affect the spectral power distribution of open-flame carbon-arc lamps.

a) Differences in the composition and thickness of the filters can have large effects on the amount of short-wavelength UV radiation transmitted.

b) The ageing of filters on exposure to the carbon-arc radiation can cause a significant reduction in the short-wavelength UV transmitted by the filter, resulting in a reduction in the short-wavelength UV in the filtered radiation. Ageing of the filters can be influenced by the composition of the glass.

c) Accumulation of dirt or other residues on the filter can affect the filter transmission properties.

d) Differences in the composition of the metallic salts used in the carbon rods can affect the spectral power distribution.

4.2 Test chamber

The test chamber contains a specimen frame, with provision for passing air over the specimens for temperature control.

The frame rotates about the central axis of the carbon-arc holder. A typical frame diameter is 96 cm. Other frame diameters may be used if mutually agreed upon by all interested parties. The specimens shall be mounted directly on the frame or mounted in holders attached to the frame. The frame may be vertical or inclined.

The upper and lower carbon rods, as well as the filters, shall be installed in accordance with the instructions of the manufacturer of the apparatus.

The apparatus shall be fitted with equipment for programming exposure cycles within the operational limits of the apparatus.

4.3 Radiometer

When a radiometer is used, it shall comply with the requirements outlined in ISO 4892-1:1999, Subclause 5.1.7.

4.4 Thermometer

The black-standard or black-panel thermometer used shall comply with the requirements for these devices given in ISO 4892-1.

4.5 Moisture

4.5.1 General

The test specimens shall be exposed to moisture in the form of water spray, condensation or high humidity.

1) Corex 7058 is an example of a suitable product available commercially. This information is given for the convenience of users of this part of ISO 4892 and does not constitute an endorsement by ISO of this product.

PDF created with pdfFactory trial version www.pdffactory.com

4.5.2 Relative-humidity control equipment

The test chamber shall be equipped with means to control the relative humidity. If required, the humidity of the air passing over the test specimens shall be controlled at an agreed value and measured by suitable instruments inserted into the test chamber and shielded from the lamp radiation.

4.5.3 Spray system

The test chamber shall be equipped with a means of directing an intermittent water spray onto the fronts or backs of the test specimens under specified conditions. The spray shall be uniformly distributed over the specimens. The spray system shall be made from corrosion-resistant materials that do not contaminate the water employed.

Distilled or demineralized water (with a conductivity below 5 μS/cm) may be used. The water shall leave no observable stains or deposits and the solids content should therefore preferably be less than 1 μg/g. In addition to distillation, a combination of deionization and reverse osmosis can be used to produce water of the required quality.

A spray system designed to cool the specimen by spraying the back surface of the specimen or the specimen backing may be required when the exposure programme specifies periods of condensation.

4.6 Specimen holders

Specimen holders may be in the form of an open frame, leaving the back of the specimen exposed, or they may provide the specimen with a solid backing. They shall be made from inert materials that will not affect the test results, for example non-oxidizing alloys of aluminium or stainless steel. Brass, steel or copper shall not be used in the vicinity of the test specimens. The backing used may affect the results, as may any space between the backing and the test specimen, particularly with transparent specimens, and shall be agreed on between the interested parties.

4.7 Apparatus to assess changes in properties

The apparatus required by the International Standards relating to the determination to the properties chosen for monitoring (see also ISO 4582) shall be used.

5 Test specimens

Refer to ISO 4892-1.

It is recommended that at least three test specimens of each material to be evaluated be exposed in each test to allow statistical evaluation of the results.

6 Test conditions

6.1 Temperature

6.1.1 Black-standard/black-panel temperature

For referee purposes, it is recommended that black-standard temperatures be used. However, black-panel temperatures are widely used for open-flame carbon-arc lamp apparatus. In the case of the black-panel temperature, 63 °C ± 3 °C is typically used. If a black-panel thermometer is used, then the type of thermometer, the way in which it is mounted on the specimen holder and the selected temperature of operation shall be stated in the exposure report. If a water spray is used, the temperature requirement applies to the end of the dry period.

PDF created with pdfFactory trial version www.pdffactory.com

NOTE For a black-panel thermometer, the temperature indicated is typically 3 °C to 12 °C lower than that for a black standard thermometer under typical exposure conditions.

6.1.2 Chamber air temperature

If required, the chamber air temperature may also be controlled. If so, use 40 °C ± 3 °C unless otherwise specified.

6.2 Relative humidity of air

Unless otherwise specified, the relative humidity shall be (50 ± 5) %.

NOTE The relative humidity of the air as measured in the test chamber is not necessarily equivalent to the moisture content of the air very close to the specimen surface owing to the differences in temperature of test specimens of different colours and thicknesses.

6.3 Spray cycle

The spray cycle used shall be as agreed between the interested parties, but should preferably be one of following.

Spray cycle 1	duration of spraying period: 18 min ± 0,5 min
	dry interval between spraying periods: 102 min ± 0,5 min
Spray cycle 2	duration of spraying period: 12 min ± 0.5 min
	dry interval between spraying periods: 48 min ± 0,5 min

6.4 Cycles with dark periods

The conditions in 6.1 to 6.3 are valid for continuous presence of radiant energy from the source. More complex cycles may be programmed including dark periods that allow high relative humidities and the formation of condensate at elevated chamber temperatures.

Such programmes shall be given, with full details of the conditions, in the exposure report.

7 Procedure

7.1 Mounting the test specimens

Attach the specimens to the specimen holders in the equipment in such a manner that the specimens are not subject to any applied stress. Identify each test specimen by suitable indelible marking, avoiding areas to be used for subsequent testing. As a check, a plan of the test-specimen positions may be made.

If desired, in the case of specimens used to determine change in colour and appearance, a portion of each test specimen may be shielded by an opaque cover throughout the test. This gives a masked area adjacent to the exposed area for comparison. This is useful for checking the progress of the exposure, but the data reported shall always be based on a comparison with unexposed specimens stored separately in the dark.

7.2 Exposure

7.2.1 Before placing the specimens in the test chamber, be sure the apparatus is operating under the specified conditions (see Clause 6). Maintain these conditions throughout the exposure.

7.2.2 Mount the specimens on the specimen frame both above and below the horizontal centerline of the source of radiation. To ensure uniform irradiation over the whole of the specimen surface, specimens shall be

PDF created with pdfFactory trial version www.pdffactory.com

repositioned vertically in a sequence which will ensure that each specimen has equivalent exposure periods in each location. When the exposure interval does not exceed 24 h, place the specimens in holders located in the upper half of the specimen frame. For exposure intervals not exceeding 100 h, daily rotation of the specimens is recommended. Other methods of achieving uniform radiant exposure may be employed if mutually agreed on by the interested parties.

7.2.3 Replace filter after 2 000 h of use, or when pronounced discoloration of milkiness develops, whichever occurs first. Clean the filters, at intervals recommended by the manufacturer, with a clean, dry, non-abrasive cloth or towel, or with a solution of detergent in water followed by rinsing with clean water. It is recommended that filters be replaced on a rotating schedule in order to provide more uniformity over long periods of exposure. In such cases, replace the filters sequentially, in pairs, every 500 h. Monitor the age and position of the filter panes so that the oldest pair is removed each time.

7.3 Measurement of radiant exposure

If used, mount the radiometer so that it indicates the irradiance at the exposed surface of the test specimens.

The exposure interval shall be expressed in terms of the incident radiant energy per unit area of the exposure plane, in joules per square metre, for the passband selected.

It is recommended that the length of the exposure, in hours, be measured when a radiometer is not used.

7.4 Determination of changes in properties after exposure

These shall be determined as specified in ISO 4582.

8 Exposure report

Refer to ISO 4892-1.

PDF created with pdfFactory trial version www.pdffactory.com