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METHOD OF TEST FOR
PAINTS AND VARNISHES
PART 28 : EXPOSURE TO LABORATORY LIGHT SOURCES
SECTION 1 : GENERAL GUIDANCE

SRI LANKA STANDARDS INSTITUTION

Sri Lanka Standard
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SLS 1256 : Part 28 : Section 1 : 2016
ISO 16474-1 : 2013
(Superseding SLS 1256 : Part 28 : 2009)

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Sri Lanka Standards are subject to periodical revision in order to accommodate the progress made by industry. Suggestions for improvement will be recorded and brought to the notice of the Committees to which the revisions are entrusted.

This standard does not purport to include all the necessary provisions of a contract.

Sri Lanka Standard
METHOD OF TEST FOR PAINTS AND VARNISHES
PART 28: EXPOSURE TO LABORATORY LIGHT SOURCES
SECTION 1: GENERAL GUIDANCE

NATIONAL FOREWORD

This Sri Lanka Standard was approved by the Sectoral Committee on Chemical and Polymer Technology and authorized for adoption and publication as a Sri Lanka Standard by the Council of the Sri Lanka Standards Institution on 2016-10-27.

This Standard supersedes SLS 1256: Part 28: 2009 Artificial weathering and exposure to artificial radiation- Exposure to filtered xenon arc radiation which was an adoption of ISO 11341: 2004. The text of ISO 11341: 2004 has been technically revised and replaced by ISO 16474-1 and ISO 16474-2. This Standard series of SLS 1256 : Part 28 is published to adopt ISO 16474: 2013 part 1 to part 4: Paints and varnishes – Methods of exposure to laboratory light sources which consists of four sub sections:

SLS 1256: Part 28: Section 1- General guidance
SLS 1256: Part 28: Section 2- Xenon arc lamps
SLS 1256: Part 28: Section 3- Fluorescent UV lamps
SLS 1256: Part 28: Section 4- Open flame carbon arc lamps

The text of the International Standard ISO 16474-1: 2013 Paints and varnishes – Methods of exposure to laboratory light sources- Part 1: General guidance has been accepted for adoption as **SLS 1256: Part 28: Section 1: 2016.**

This Sri Lanka standard is identical with ISO 16474-1: 2013 Paints and varnishes – Methods of exposure to laboratory light sources- Part 1: General guidance published by the International Organization for Standardization (ISO).

TERMINOLOGY AND CONVENTIONS

The text of the International Standard has been accepted as suitable for publication, without deviation, as a Sri Lanka Standard. However, certain terminology and conventions are not identical with those used in Sri Lanka Standards. Attention is therefore drawn to the following:

a) Wherever the words “International Standard” appear referring to a particular Standards they should be interpreted as “Sri Lanka Standard”.

b) The comma has been used throughout as a decimal marker. In Sri Lanka Standards it is the current practice to use the full point at the base as the decimal marker.

c) Wherever page numbers are quoted, they are ISO page numbers.

Cross References

International Standard	Corresponding Sri Lanka Standard
ISO 1513, Paints and varnishes – Examination and preparation of test samples	No corresponding Sri Lanka Standard
ISO 1514, Paints and varnishes — Standard panels for testing	No corresponding Sri Lanka Standard
ISO 2808, Paints and varnishes — Determination of film thickness	SLS 1256 : Part 15 Determination of film thickness (First Revision)
ISO 3270, Paints and varnishes and their raw materials — Temperatures and humidities for conditioning and testing	No corresponding Sri Lanka Standard
ISO 9370, Plastics — Instrumental determination of radiant exposure in weathering tests — General guidance and basic test method	No corresponding Sri Lanka Standard
ISO 16474-2, Paints and varnishes — Methods of exposure to laboratory light sources — Part 2: Xenon-arc lamps	No corresponding Sri Lanka Standard
ISO 16474-3, Paints and varnishes — Methods of exposure to laboratory light sources — Part 3: Fluorescent UV lamps	No corresponding Sri Lanka Standard
ISO 16474-4, Paints and varnishes — Methods of exposure to laboratory light sources — Part 4: Open-flame carbon-arc lamps	No corresponding Sri Lanka Standard
ISO 4618, Paints and varnishes – Terms and definitions	No corresponding Sri Lanka Standard
ISO 15528, Paints, varnishes and raw materials for paints and varnishes — Sampling	SLS 523 Methods of sampling for paints, varnishes and raw materials for paints and varnishes

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Paints and varnishes — Methods of exposure to laboratory light sources —

Part 1:
General guidance

Peintures et vernis — Méthodes d'exposition à des sources lumineuses de laboratoire —

Partie 1: Lignes directrices générales

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Contents

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received. www.iso.org/patents

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 35, *Paints and varnishes*, Subcommittee SC 9, *General test methods for paints and varnishes*.

This first edition of ISO 16474-1, together with ISO 16474-2, cancels and replaces ISO 11341:2004, which has been technically revised. This first edition of ISO 16474-1, together with ISO 16474-3, cancels and replaces ISO 11507:2007, which has been technically revised.

ISO 16474 consists of the following parts, under the general title *Paints and varnishes — Methods of exposure to laboratory light sources*:

— *Part 1: General guidance*

— *Part 2: Xenon-arc lamps*

— *Part 3: Fluorescent UV lamps*

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

Introduction

Coatings from paints, varnishes and similar materials are often used outdoors or in indoor locations where they are exposed to solar radiation or to solar radiation behind glass for long periods. It is therefore very important to determine the effects of solar radiation, heat, moisture and other climatic stresses on the colour and other properties of polymers. Outdoor exposures to solar radiation and to solar radiation filtered by window glass are described in ISO 2810[9]. However, it is often necessary to determine more rapidly the effects of light, heat and moisture on the physical, chemical and optical properties of coatings with artificial accelerated weathering or artificial accelerated irradiation exposures that use specific laboratory light sources. Exposures in these laboratory devices are conducted under more controlled conditions than found in natural environments and are intended to accelerate polymer degradation and product failures. Relating results from accelerated weathering or artificial accelerated irradiation exposures to those obtained in actual-use conditions is difficult because of variability in both types of exposure and because laboratory tests often do not reproduce all the exposure stresses experienced by coatings exposed in actual-use conditions. In addition, the increase in rate of degradation by the accelerated test compared with natural exposure conditions varies with the type of material and its formulation. No single laboratory exposure test can be specified as a total simulation of actual-use exposures. The relative durability of materials in actual-use exposures can be very different depending on the location of the exposure because of differences in solar radiation, time of wetness, temperature, pollutants and other factors. Therefore, even if results from specific accelerated weathering or artificial accelerated irradiation exposures are found to be useful for comparing the relative durability of materials exposed in a particular outdoor location or in particular actual-use conditions, it cannot be assumed that they will be useful for determining the relative durability of materials exposed in a different outdoor location or in different actual-use conditions.

Paints and varnishes — Methods of exposure to laboratory light sources —

Part 1:
General guidance

1 Scope

1.1 This part of ISO 16474 provides information and general guidance relevant to the selection and operation of the methods of exposure described in detail in subsequent parts. It also describes general performance requirements for devices used for exposing paints and varnishes to laboratory light sources. Information about such performance requirements is provided for producers of artificial accelerated weathering or artificial accelerated irradiation devices.

1.2 This part of ISO 16474 also provides information on the interpretation of data from artificial accelerated weathering or artificial accelerated irradiation exposures.

2 Normative references

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

ISO 1513, *Paints and varnishes — Examination and preparation of test samples*

ISO 1514, *Paints and varnishes — Standard panels for testing*

ISO 2808, *Paints and varnishes — Determination of film thickness*

ISO 3270, *Paints and varnishes and their raw materials — Temperatures and humidities for conditioning and testing*

ISO 4618, *Paints and varnishes — Terms and definitions*

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

ISO 15528, *Paints, varnishes and raw materials for paints and varnishes — Sampling*

ISO 16474-2, *Paints and varnishes — Methods of exposure to laboratory light sources — Part 2: Xenon-arc lamps*

ISO 16474-3, *Paints and varnishes — Methods of exposure to laboratory light sources — Part 3: Fluorescent UV lamps*

ISO 16474-4, *Paints and varnishes — Methods of exposure to laboratory light sources — Part 4: Open-flame carbon-arc lamps*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4618 and the following apply.

3.1
artificial accelerated irradiation
exposure of a material to a laboratory radiation source intended to simulate window-glass-filtered solar radiation or radiation from interior lighting sources and where specimens are subjected to relatively small changes in temperature and relative humidity in an attempt to produce more rapidly the same changes that occur when the material is used in an indoor environment

Note 1 to entry: These exposures are commonly referred to as fading or light fastness tests.

3.2
artificial accelerated weathering
exposure of a material in a laboratory weathering device to conditions which may be cyclic and intensified compared with those encountered in outdoor or in-service exposure

Note 1 to entry: This involves a laboratory radiation source, heat and moisture (in the form of relative humidity and/or water spray, condensation or immersion) in an attempt to produce more rapidly the same changes that occur in long-term outdoor exposure.

Note 2 to entry: The device may include means for control and/or monitoring of the light source and other weathering parameters. It may also include exposure to special conditions, such as acid spray to simulate the effect of industrial gases.

3.3
control material
material which is of similar composition and construction to the test material and which is exposed at the same time for comparison with the test material

Note 1 to entry: An example of the use of a control material would be when a formulation different from one currently being used is being evaluated. In that case, the control would be the coating made with the original formulation.

3.4
file specimen
portion of the material to be tested which is stored under conditions in which it is stable and which is used for comparison between the exposed and unexposed states

3.5
reference material
material of known performance

3.6
reference specimen
portion of the reference material that is to be exposed

4 Principle

4.1 General

Specimens of the samples to be tested are exposed to laboratory light sources under controlled environmental conditions. The methods described include the requirements which have to be met for the measurement of the irradiance and radiant exposure in the plane of the specimen, the temperature of specified white and black sensors, the chamber air temperature and the relative humidity.

4.2 Significance

4.2.1 When conducting exposures in devices that use laboratory light sources, it is important to consider how well the accelerated-test conditions simulate the actual-use environment for the paint or varnish being tested. In addition, it is essential to consider the effects of variability in both the accelerated test and actual exposures when setting up exposure experiments and when interpreting the results from artificial accelerated weathering or artificial accelerated irradiation exposures.

4.2.2 No laboratory exposure test can be specified as a total simulation of actual-use conditions. Results obtained from artificial accelerated weathering or artificial accelerated irradiation exposures can be considered as representative of actual-use exposures only when the degree of rank correlation has been established for the specific materials being tested and when the type and mechanism of degradation are the same. The relative durability of materials in actual-use conditions can be very different in different locations because of differences in solar radiation, time of wetness, relative humidity, temperature, pollutants and other factors. Therefore, even if results from a specific exposure test conducted in accordance with any of the parts of this International Standard are found to be useful for comparing the relative durability of materials exposed in a particular environment, it cannot be assumed that they will be useful for determining the relative durability of the same materials in a different environment.

4.2.3 Even though it is very tempting, it is invalid to assign to all materials a "general acceleration factor" relating "*x*" hours or megajoules of radiant exposure in an artificial accelerated weathering or artificial accelerated irradiation exposure to "*y*" months or years of actual exposure. Such acceleration factors are invalid for the following reasons:

a) acceleration factors are material-dependent and can be significantly different for each material and for different formulations of the same material;

b) variability in the rate of degradation in both actual-use and artificial accelerated weathering or artificial accelerated irradiation exposures can have a significant effect on the calculated acceleration factor;

c) acceleration factors calculated based on the ratio of irradiance between a laboratory light source and solar radiation (even when identical pass-bands are used) do not take into consideration the effects of temperature, moisture and differences in spectral power distribution between the laboratory light source and solar radiation.

NOTE Acceleration factors determined for a specific formulation of a material are valid, but only if they are based on data from a sufficient number of separate outdoor or indoor environmental tests and artificial accelerated weathering or artificial accelerated irradiation exposures so that results used to relate times to failure in each exposure can be analysed using statistical methods. An example of a statistical analysis using multiple laboratory and actual exposures to calculate an acceleration factor is described by J.A. Simms[1].

4.2.4 There are a number of factors that might decrease the degree of correlation between accelerated tests using laboratory light sources and exterior exposures (more specific information on how each factor can alter the stability ranking of materials is given in Annex B):

a) differences in the spectral irradiance of the laboratory light source and solar radiation;

b) irradiance levels higher than those experienced in actual-use conditions;

c) exposure cycles that use continuous exposure to light from a laboratory light source without any dark periods;

d) specimen temperatures higher than those in actual conditions;

e) exposure conditions that produce unrealistic temperature differences between light- and dark-coloured specimens;

f) exposure conditions that produce very frequent cycling between high and low specimen temperatures, or that produce unrealistic thermal shock;

g) unrealistic levels of moisture in the accelerated test compared to actual-use conditions;

h) the absence of biological agents, pollutants or acidic precipitation or condensation.

4.3 Use of accelerated tests with laboratory light sources

4.3.1 Results from artificial accelerated weathering or artificial accelerated irradiation exposures conducted in accordance with any of the parts of this International Standard are best used to compare the relative performance of materials. Comparisons between materials can only be made when the materials are tested at the same time in the same exposure device. Results can be expressed by comparing the exposure time or radiant exposure necessary to reduce the level of a characteristic property to some specified level. A common application of this is a test conducted to establish that the level of quality of different batches does not vary from that of a control of known performance.

4.3.1.1 It is strongly recommended that at least one control be exposed with each test for the purpose of comparing the performance of the test materials to that of the control. The control material should be of similar composition and construction and be chosen so that its failure modes are the same as that of the material being tested. It is preferable to use two controls, one with relatively good durability and one with relatively poor durability.

4.3.1.2 Sufficient replicates of each control and each test material being evaluated are necessary in order to allow statistical evaluation of the results. Unless otherwise specified, use a minimum of three replicates for all test and control materials. When material properties are measured using destructive tests, a separate set of specimens is needed for each exposure period.

4.3.2 In some specification tests, test materials are exposed at the same time as a weathering reference material (e.g. blue wool test fabric). The property or properties of the test material are measured after a defined property of the reference material reaches a specified level. If the reference material differs in composition from the test material, it might not be sensitive to exposure stresses that produce failure in the test material or it might be very sensitive to an exposure stress that has very little effect on the test material. The variability in results for the reference material might be very different from that for the test material. All these differences between the reference material and the test material can produce misleading results when the reference material is used as a control or to determine the length of the exposure period.

NOTE 1 Definitions of control and reference materials that are appropriate to weathering tests are given in Clause 3.

NOTE 2 Weathering reference materials can also be used to monitor the consistency of the operating conditions in an exposure test. Information about the selection and characterization of reference materials used for this purpose can be found in ASTM G 156[2]. ISO/TR 19032[3] describes a procedure which uses the change in the carbonyl index of a specific polyethylene weathering reference material to monitor conditions in both natural weathering and artificial accelerated weathering exposures.

4.3.3 In some specification tests, properties of test specimens are evaluated after a specific exposure time or radiant exposure using a test cycle with a prescribed set of conditions. Results from any accelerated exposure test conducted in accordance with any of the parts of this International Standard should not be used to make a “pass/fail” decision for materials, based on the level of a specific property after a specific exposure time or radiant exposure, unless the combined reproducibility of the effects of a particular exposure cycle and property measurement method has been established.

5 Requirements for laboratory exposure devices

Laboratory exposure devices shall be equipped with facilities to provide specimens with irradiance (5.1), temperature (5.2), humidity and wetting (5.3).

5.1 Irradiance

5.1.1 Laboratory light sources are used to provide irradiance for the test specimens. In ISO 16474-2 a xenon-arc lamp is used to provide the irradiance for the specimens, in ISO 16474-3 a fluorescent UV lamp, and in ISO 16474-4 an open-flame carbon-arc lamp.

5.1.2 The exposure device shall provide for placement of specimens and any designated sensing devices in positions that allow uniform irradiance from the light source.

NOTE The spectral irradiance produced in an artificial accelerated weathering device is very important. Ideally, the relative spectral irradiance produced by the device should be a very close match to that of solar radiation, especially in the short-wavelength UV region. Annex C provides information about a benchmark solar spectrum that can be used for comparing the spectral irradiance produced in the artificial accelerated exposure to that for solar radiation. Subsequent parts of this International Standard contain specific requirements for the relative spectral irradiance produced in the devices described in those parts.

5.1.3 Exposure devices shall be designed such that the irradiance at any location in the area used for specimen exposures is at least 70 % of the maximum irradiance measured in this area. Procedures for measuring irradiance uniformity by the device manufacturers are given in Annex A.

NOTE The irradiance uniformity in exposure devices depends on several factors, such as deposits that can develop on the optical system and chamber walls. In addition, irradiance uniformity can be affected by the type of specimen and the number of specimens being exposed. The irradiance uniformity as guaranteed by the manufacturer is valid for new equipment and well-defined measuring conditions.

5.1.4 Depending on the specific sensitivity of the material periodic repositioning of the specimens is good practice in order to be sure that the variability in exposure stresses experienced during the exposure period is kept to the minimum. If the irradiance at any position in the area used for specimen exposure is between 70 % and 90 % of the maximum irradiance, specimens shall be periodically repositioned to reduce the variability in radiant exposure.

NOTE Random placement of replicate specimens is also good practice to reduce the effect of any variability in the conditions within the exposure area.

5.1.5 Follow the device manufacturer's instructions for lamp and filter replacement and for pre-ageing of lamps and/or filters.

5.1.6 A radiometer that complies with the requirements outlined in ISO 9370 may be used to measure the irradiance E or spectral irradiance E_λ and the radiant exposure H or spectral radiant exposure H_λ in the plane of the specimen surface.

5.1.6.1 If used, the radiometer shall be mounted so that it receives the same radiation as the specimen surface. If it is not positioned in the specimen plane, it shall have a sufficiently wide field of view and be calibrated for irradiance at the specimen distance.

5.1.6.2 The field radiometer shall be calibrated in the emission region of the light source used with a reference radiometer. The radiometer shall be calibrated using a light source filter combination of the same type that will be used for testing or an appropriate spectral mismatch factor has been taken into account. The calibration shall be checked in accordance with the radiation measuring instrument manufacturer's instructions.

For fluorescent UV lamps, it has been shown that the field radiometers have to be calibrated with lamps that have a spectral power distribution which is identical to that of the lamps that will be used for testing.

NOTE Refer to ISO 9370 for definitions of field and reference radiometers.

5.1.6.3 When measured, the irradiance in the wavelength range agreed upon by all interested parties shall be reported. Some types of device provide for measuring irradiance in a specific wavelength range (e.g. 300 nm to 400 nm or 300 nm to 800 nm) or in a narrow pass-band that is centred around a single wavelength (e.g. 340 nm).

5.2 Temperature

5.2.1 The surface temperature of exposed materials depends primarily on the amount of radiation absorbed, the emissivity of the specimen, the amount of thermal conduction within the specimen and the amount of heat transmission between the specimen and the air or between the specimen and the specimen holder. Since it is not practical to monitor the surface temperature of individual test specimens, a specified black surface sensor is used to measure and control the temperature within the exposure chamber. The black surface temperature sensor shall be mounted within the specimen exposure area so that it receives the same radiation and experiences the same cooling conditions as a flat test panel surface.

5.2.2 Two types of black surface temperature sensor may be used: a black-standard thermometer (BST) and a black-panel thermometer (BPT).

5.2.2.1 *Black-standard thermometers*, consisting of a plane (flat) stainless-steel plate with a thickness of 0,5 mm to 1,2 mm. A typical length and width is about 70 mm by 40 mm. The surface of this plate facing the light source shall be coated with a black layer which has good resistance to ageing. The coated black plate shall reflect no more than 10 % of all incident flux up to 2 500 nm. A thermally sensitive element such as a platinum resistance sensor shall be attached to the centre of the plate, in good thermal contact with the plate, on the side opposite the radiation source. This side of the metal plate shall be attached to a 5 mm thick baseplate made of unfilled poly(vinylidene fluoride) fluoride (PVDF). A small space sufficient to hold the platinum resistance sensor shall be machined in the PVDF baseplate. The distance between the sensor and this recess in the PVDF plate shall be about 1 mm. The length and width of the PVDF plate shall be sufficient so that no metal-to-metal thermal contact exists between the black-coated metal plate and the mounting holder into which it is fitted. The metal mounts of the holder of the insulated black panel shall be at least 4 mm from the edges of the metal plate. Black-standard thermometers which differ in construction from that specified above are permitted as long as the temperature indicated by the alternative construction is within ± 1,0 °C of that of the specified construction at all steady-state temperature and irradiance settings the exposure device is capable of attaining. In addition, the time needed for an alternative black-standard thermometer to reach the steady-state shall be within 10 % of the time needed for the specified black-standard thermometer to reach the steady-state.

NOTE Black-standard thermometers are sometimes referred to as insulated black-panel thermometers.

5.2.2.2 *Black-panel thermometers,* consisting of a plane (flat) metal plate that is resistant to corrosion. Typical dimensions are about 150 mm long, 70 mm wide and 1 mm thick. The surface of this plate that faces the light source shall be coated with a black layer which has good resistance to ageing. The coated black plate shall reflect no more than 10 % of all incident flux up to 2 500 nm. A thermally sensitive element shall be firmly attached to the centre of the exposed surface. This thermally sensitive element may be a black-coated stem-type bimetallic dial sensor, a resistance-based sensor, a thermistor or a thermocouple. The back side of the metal panel shall be open to the atmosphere.

NOTE Black-panel thermometers are sometimes referred to as uninsulated black-panel thermometers.

5.2.2.3 Unless otherwise specified, temperatures shall be measured using either of the thermometer designs described above. If other means are used to measure the temperature of black or white panels, the exact construction of the black or white panel shall be included in the test report.

5.2.3 The temperature indicated by the black-panel or black-standard thermometer depends on the irradiance produced by the laboratory light source and the temperature and speed of the air moving in the exposure chamber. Black-panel temperatures generally correspond to those for dark coatings on metal panels without thermal insulation on the rear side. Black-standard thermometer temperatures generally correspond to those for the exposed surface of dark samples with poor thermal conductivity. At conditions used in typical exposures, the temperature indicated by a black-standard thermometer will be 3 °C to 12 °C higher than that indicated by a black-panel thermometer. The actual difference between a black-panel temperature and a temperature measured with a black-standard thermometer should, however, preferably be determined for each exposure condition. Because black-standard thermometers are insulated, their response time for temperature changes is slightly slower than for a black-panel thermometer.

5.2.4 At low irradiance levels, the difference between the temperature indicated by a black-panel or black-standard thermometer and the real specimen temperature can be small. When light sources that emit very little infrared radiation are used, there will generally be only very small differences in the temperatures indicated by the two types of black panel or between light- and dark-coloured specimens.

5.2.5 In order to evaluate the range of surface temperatures of the exposed specimens and to better control the irradiance or the conditions in the exposure chamber, the use of a white-panel or white-standard thermometer, in addition to the black-panel or black-standard thermometer, is recommended. The white-panel or white-standard thermometer shall be constructed in the same way as the corresponding black-panel or black-standard thermometer, except for the use of a white coating with a good resistance to ageing. The reflectance of the white coating shall be at least 60 % between 450 nm and 800 nm and at least 30 % between 800 nm and 1 500 nm.

5.2.6 Manufacturers of exposure devices shall ensure that devices designed to meet the requirements of this part of ISO 16474 are able to meet the following requirements for control of the temperature of the black or white temperature sensor at the position where it is intended to operate (see Table 1). These requirements apply to equilibrium conditions.

Table 1 — Requirements for set-point temperature of the black or white temperature sensor at the position where it is intended to operate

Set-point temperature	Allowable deviation of the sensor temperature at the position in which sensor operates
≤ 70 °C	±3 °C
≥ 70 °C	±4 °C

5.2.7 Manufacturers of exposure devices shall ensure that devices designed to meet the requirements of this part of ISO 16474 are able to meet the following requirements for control of the temperature of a black or white temperature sensor at any position within the allowed exposure area (see Table 2). These requirements apply to equilibrium conditions.

Table 2 — Requirements for set-point temperature of the black or white temperature sensor at any position within the allowed exposure area

Set-point temperature	Allowable deviation of the sensor temperature when sensor placed anywhere in the exposure area
≤ 70 °C	±5 °C
≥ 70 °C	±7 °C

NOTE For some materials, differences in the degradation rate can occur between devices operating within the allowable temperature ranges. Periodic repositioning of specimens or random positioning of replicate specimens during exposure will reduce the variability caused by differences in temperature within the exposure area.

5.2.8 The test report shall indicate whether a black-standard or black-panel thermometer was used and whether a white-standard or white panel thermometer was used.

NOTE Different temperatures may be indicated by a single type of black-standard or black-panel thermometer, depending on the specific design of the device supplied by different manufacturers.

5.2.9 If the exposure chamber air temperature is measured, the temperature-sensing element shall be shielded from the light source and water spray. The chamber air temperature measured at this position might not be the same as the chamber air temperature near the surface of the exposed specimens. Manufacturers of devices that control chamber air temperature shall ensure that their equipment is able to maintain the measured chamber air temperature within ± 3 °C of the set point under equilibrium conditions for set points up to 70 °C and within ± 4 °C of the set point for set points greater than 70 °C.

5.2.10 Calibrate the temperature sensor used to measure the chamber air temperature in accordance with the sensor manufacturer's instructions at least annually.

5.3 Humidity and wetting

5.3.1 Moisture

The presence of moisture on the exposed face of the specimen, particularly long wet periods and the cyclic change between wet and dry periods, might have a significant effect in accelerated laboratory exposure tests. Any device operated in accordance with any of the parts of this International Standard which attempts to simulate the effects of moisture shall have means for providing moisture to specimens using one or more of the following methods:

a) humidification of the chamber air;

b) formation of condensation;

c) water spray;

d) immersion.

5.3.2 Water purity

5.3.2.1 Water purity for xenon lamp and carbon arc instruments

The purity of the water used for spraying the specimens is very important. Without proper treatment to remove cations, anions, organic compounds and, in particular, silica, exposed specimens will develop spots or stains that do not occur in exterior exposures. Unless otherwise specified, water used for specimen spray shall contain a maximum solids content of 1 µg/g of water and a maximum silica content of 0,2 µg/g of water. Distillation, or a combination of deionization and reverse osmosis, can effectively produce water of the desired purity. If the water used for specimen spray contains more than 1 µg/g of solids content, the solids and silica content levels shall be reported. Recirculation of water used for specimen spray is not recommended and shall not be done unless the recirculated water meets the purity requirements listed above.

5.3.2.2 Water purity for UV fluorescent lamp instruments

The purity of the water used for spraying for UV fluorescent lamps is not as critical as for xenon. Therefore, the test panels shall be sprayed using water that has been purified so as to have < 2,0 µg/g dissolved solids content and < 0,5 µg/g suspended silica content.

5.3.3 Contamination

If specimens are found to have deposits or stains after exposure, the water purity shall be checked to determine whether it meets the purity requirements specified in 5.3.2. On some occasions, exposed specimens can be contaminated by deposits from bacteria that can grow in the purified water used for specimen spray. If bacterial contamination is detected, the entire system used for specimen water spray shall be flushed with a chlorinating solution such as sodium hypochlorite and thoroughly rinsed prior to resuming exposures.

5.3.4 Silica content

Although conductivity does not always correlate with silica content, it is recommended that the conductivity of the water used for specimen spray be continuously monitored and that exposures be stopped whenever the conductivity is above 5 µS/cm.

5.3.5 Fabrication of the components

All components of the specimen spray unit shall be fabricated from stainless steel or some other material that does not contaminate the water with materials that could absorb UV radiation or form unrealistic deposits on test specimens.

5.3.6 Humidity

In devices where the humidity within the exposure chamber is controlled, sensors used to measure humidity shall be placed within the chamber air-flow and shielded from direct radiation and water spray. When humidity is controlled, the measured relative humidity shall be maintained within ± 10 % of the set point humidity.

The humidity sensors shall be calibrated at least annually in accordance with the exposure device manufacturer's instructions.

5.3.7 Wetting

Any device that introduces periods of wetting of the exposed specimens by any method shall have means to programme the periods with and without wetting.

5.4 Other requirements for the exposure device

5.4.1 Although various designs of exposure device are used in practice, each device shall meet the following requirements.

5.4.1.1 Any device intended to simulate the effects of light and dark cycles shall have an electronic controller or mechanical device to programme periods with or without light.

5.4.1.2 Manufacturers shall ensure that devices that provide periods during which the exposure conditions are different have means to time each period. The length of each exposure period shall be controlled to within ± 10 % of the shortest period used. It is desirable to use timers that are as accurate and have as high a repeatability as possible. Optionally, a means to record the length of each test period may also be provided.

5.4.2 To fulfil the requirements of particular test procedures, the device might need to provide means to register or record the following operating parameters:

a) the line voltage;

b) the lamp wattage;

c) the lamp current;

d) the spectral irradiance (or the integrated spectral irradiance) within the passband used and the radiant exposure.

6 Test specimens — Preparation, replicates, storage and conditioning

6.1 Handling of test specimens

The handling of the test specimens can have a significant impact on the usability of the test result.

6.2 Form, shape, preparation

6.2.1 Form, shape and preparation of test panels have a significant impact on the durability.

6.2.2 The methods used for the preparation of test panels can have a significant impact on their apparent durability. Therefore, the method used for test panel preparation shall be agreed upon by the interested parties. It should preferably be closely related to the method normally used to process the material in typical applications. A complete description of the method used for the preparation of test specimens shall be included in the test report.

6.2.3 The substrate used for the preparation of the test panels shall be that usually used in practice (e.g. plasterboard, wood, metal, plastics materials) and the method of application and drying of the coating shall be that normally used in practice to give a coating of the usual thickness.

Unless otherwise agreed or specified, standard panels conforming to the requirements of ISO 1514 shall be used as substrate for the test coating.

NOTE Preferably, flat test panels of dimensions appropriate to the holders in the test chamber should be used.

6.2.4 Unless otherwise agreed, only the front sides of the test panels shall be coated with the material or coating system to be tested. The rear sides and edges of the test panels shall be coated, if necessary, with a coating suitable to protect the substrate from deterioration during the period of the test.

6.2.5 Stoving paints shall be dried under the same conditions as laid down for their normal use. In the case of air-drying paints, the coated test panels shall be stored horizontally and allowed to dry at a temperature of (23 ± 2) °C and a relative humidity of (50 ± 5) %, in accordance with the requirements of ISO 3270. The duration of drying and subsequent storage shall be as specified.

6.2.6 All the test panels shall be permanently marked in a suitable way. The thickness of the test coating shall be determined in accordance with ISO 2808.

6.3 Number of test specimens

In the case of testing carried out over a series of different test periods, an adequate number of test panels shall be prepared for each coating material.

6.3.1 If the test method used for property measurement does not specify the number of test specimens to be exposed, it is recommended that a minimum of three replicate specimens of each material be prepared for each exposure stage.

6.3.2 Control materials of known durability should preferably be included with each exposure test. lt is recommended that control materials known to have relatively poor and relatively good durability be used. Before any laboratory to laboratory comparisons are made, it is necessary for all the interested parties to agree on the control materials to be used. The number of specimens of the control material should preferably be the same as that used for test materials.

6.4 Storage and conditioning

6.4.1 If required, at least one additional test panel for each coating shall be prepared and stored at a temperature of 18 °C to 28 °C in the dark for use as a file specimen.

NOTE Such coated panels can change their properties during storage.

6.4.2 Coatings such as alkyd paints which are sensitive to storage in the dark shall be stored under conditions agreed between the interested parties.

6.4.3 Some materials will change colour during storage in the dark, particularly after exposure. It is essential that colour measurement or visual comparison be carried out as soon as possible after exposure once the exposed surface has dried.

NOTE In some cases, additional evaluation of colour change after a conditioning period such as 24 h will be very helpful in determining whether the colour is stable after the specimens have been removed from the exposure chamber.

7 Test conditions and procedure

7.1 Set points for exposure conditions

The conditions and procedures for the artificial accelerated weathering or artificial accelerated irradiation exposure depend upon the particular method selected. Refer directly to the appropriate part (ISO 16474-2 or ISO 16474-3) of this International Standard or to any other relevant standard. For each exposure test, specific set points for important parameters such as irradiance, temperature and humidity are used. Typically, these parameters are measured and controlled at a single position within the test chamber that is known as the control point. Table 3 lists the maximum allowable deviation from the set point when the exposure device is operating at equilibrium conditions.

Table 3 — Maximum allowable deviation from exposure condition set points

Set-point parameter	Maximum allowable deviation of the measurement from the set point at equilibrium
Irradiance measured at a single wavelength[a]	±0,02 W/(m^2 · nm)
Irradiance measured over a broad passband[a]	±5 W/m^2
Irradiance measured over a wide passband[a]	±75 W/m^2
Temperature of black-standard thermometer	±3 °C for set points up to 70 °C ±4 °C for set points greater than 70 °C
Temperature of black-panel thermometer	±3 °C for set points up to 70 °C ±4 °C for set points greater than 70 °C
Temperature of chamber air (when controlled)	±3 °C for set points up to 70 °C ±4 °C for set points greater than 70 °C
Relative humidity (when controlled)	±10 %
Full width at half maximum (FWHM), nm	—

[a] Terms see ISO 9370.

NOTE A single-point measurement does not mean conditions throughout the exposure chamber are the same. It does not mean two tests run in similar exposure devices will produce the same results. Exposure devices that control temperature by means of a black-standard thermometer or black-panel thermometer will not produce the same results as exposure devices that control the air temperature.

7.2 Property measurements on test specimens

7.2.1 It shall be agreed between the interested parties which properties of the coating shall be determined prior to, during and after the exposure, using the appropriate standards.

NOTE Suitable methods include those given in ISO 2813, ISO 3668, ISO 11664-4, ISO 4628-1 to ISO 4628-8 and ISO 4628-10.

7.2.2 For intermediate examinations, the test panels shall not be washed or polished, unless agreed between the interested parties. For the final examination of the coating, it shall be agreed between the interested parties whether the surface on which the determination is made shall be unwashed, washed or polished.

7.2.3 The individual values of the properties determined shall be presented in such a way that the intermediate results and progressive changes in properties can be clearly seen. If required, the results shall also be presented in the form of a comparison with the values of the properties of unexposed file specimens or control specimens exposed at the same time. For multi-stage tests, the results of intermediate examinations and those of the final examination shall be presented in the form of tables, or graphically, as a function of the radiant exposure.

8 Periods of exposure and evaluation of test results

8.1 General

The repeatability and reproducibility of results obtained in exposures conducted in accordance with any of the parts of this International Standard will vary with the materials being tested, the material property being measured and the specific test conditions and cycles that are used.

8.2 Sampling

Take a representative sample of the product to be tested (or of each product in the case of a multi-coat system), as described in ISO 15528.

Examine and prepare each sample for testing, as described in ISO 1513.

8.3 Determination of changes in properties after exposure

If required, these shall be determined as specified in ISO 2813[10], ISO 3668[11], ISO 4628-1[12], ISO 4628-2[13], ISO 4628-3[14], ISO 4628-4[15], ISO 4628-5[16], ISO 4628-6[17], ISO 4628-7[18], ISO 4628-8[19], ISO 4628-10[20], ISO 11664-4[21].

8.4 Use of control materials

8.4.1 In most cases, periodic evaluation of test and control specimens is necessary to evaluate the direction of property change as a function of exposure. The time or radiant exposure necessary to produce a defined change in a material property can be used to evaluate or rank the durability of materials. This method is preferred over evaluating materials after an arbitrary time or radiant exposure.

8.4.2 Exposure to an arbitrary time or radiant exposure may be used for the purpose of a specific test if agreed upon by all parties or if required for conformance to a specification. Two criteria are critical when selecting the single time or radiant exposure used:

a) when control materials of minimum acceptable performance are used, statistical analysis of the results after exposure shall show that the test material is equivalent to or better than the control material;

b) a substantial change in the property of interest shall be produced in the least stable material being evaluated.

NOTE An exposure time that produces a significant change in one type of material cannot be assumed to be applicable to other materials.

8.4.3 Use appropriate statistical analysis when comparing the results given by test and control materials. Test and control materials can be considered different when the results of the statistical analysis are significant to at least the 90 % confidence level.

8.5 Use of results in specifications

8.5.1 If a standard or specification for general use requires a definite property level after a specific time or radiant exposure in an exposure test conducted in accordance with any of the parts of this International

Standard, the specified property level shall be based on results obtained in an interlaboratory trial that takes into consideration the variability due to the exposure and the test method used to measure the property of interest. The interlaboratory trial shall be carried out in accordance with the relevant International Standard for conducting interlaboratory exposures and shall include a statistically representative sample of all laboratories or organizations which would normally conduct the exposure and property measurement.

8.5.2 If a standard or specification for use between two or three parties requires a definite property level after a specific time or radiant exposure in an exposure test conducted in accordance with any of the parts of this International Standard, the specified property level shall be based on statistical analysis of results from at least two separate, independent exposures in each laboratory. The design of the experiment used to determine the specification shall take into consideration the variability due to the exposure and the test method used to measure the property of interest.

8.5.3 When reproducibility in results from an exposure test conducted in accordance with any of the parts of this International Standard have not been established through interlaboratory testing, performance requirements for materials shall be specified in terms of comparison (i.e. rank) with a control material. Specimens of the control material shall be exposed simultaneously with the test specimen(s) in the same device. The specific control material used shall be agreed upon by the interested parties.

9 Test report

The test report shall contain the following information:

9.1 Specimen description

a) a full description of the specimens and their origin;

b) compound details, cure time and temperature where appropriate;

c) a complete description of the method used for preparation of the test specimens;

d) substrate material, substrate thickness and surface preparation of the substrate;

e) method of application of the test coating to the substrate;

f) duration and conditions of drying (or stoving) and ageing (if applicable) of the coating before testing;

g) duration of conditioning of the test panels before starting the test (in the event of other tests having been performed beforehand on the same test panels);

h) thickness, in micrometres, of the dry coating and method of measurement in accordance with ISO 2808, and whether it is a single coating or a multi-coat system;

i) any agreement on deviation from the test method;

j) any particular test requirements and the agreed limit of colour change for the assessment of colour fastness to light.

NOTE If exposure tests are conducted by a contracting agency, specimens are usually identified by code-number. In such cases, it is the responsibility of the originating laboratory to provide the complete specimen description when reporting the results of the exposure test.

9.2 Description of exposure test conducted in accordance with ISO 16474-2, ISO 16474-3 or ISO 16474-4, including:

a) a description of the exposure device and radiation (light) source, including:

    1) the type of device and radiation (light) source,

   2) a description of the filters used,
   3) if required, the irradiance at the specimen surface (including the passband in which the radiation was measured),
   4) the number of hours that the filters and the radiation (light) source had been used prior to beginning the exposure;

b) the type of black and/or white temperature sensor used and the exact position of the sensor if it was not located in the test specimen exposure area;

c) for black or white temperature sensors, a description of how these sensors are mounted in the specimen exposure area;

d) if required, the type of instrument used to measure the humidity;

e) if required, the method used for controlling uniformity;

f) a complete description of the exposure cycle used, including the following information for each light and dark period:
   1) the set point for the black- and/or white-panel temperature sensor used and the maximum allowable deviation from the set point if different from that in Table 3,
   2) the set point for the relative humidity and the maximum allowable deviation from the set point if different from that in Table 3,
   3) for tests which include a water spray period, report the duration of the water spray and whether the water was sprayed on the exposed face, the back or both surfaces of the specimens (if the total solids of the water used for the spray was greater than 1 µg/g, report the total solids and the silica content),
   4) for tests where water is condensed on the specimens, report the set point for the length of the condensation period,
   5) the length of each light and dark period;

g) a description of the method used to mount the specimens in the exposure frame, including a description of any material used as backing for the test specimens;

h) the procedure for test specimen repositioning, if used;

i) a description of the radiometer used for measuring the radiant exposure, if used,

j) any unusual observations (anomalies) observed during the test.

9.3 Test results

a) a complete description of the test procedure used for measurement of any properties reported;

b) the results shall include:
   1) the results from property measurements on the test specimens,
   2) the results from property measurements on control specimens,
   3) the results from property measurements on unexposed file specimens, if determined,
   4) the exposure period (either the time, in hours, or the radiant exposure, in J/m^2, and the passband in which it was measured).

9.4 The date(s) of the exposure test.

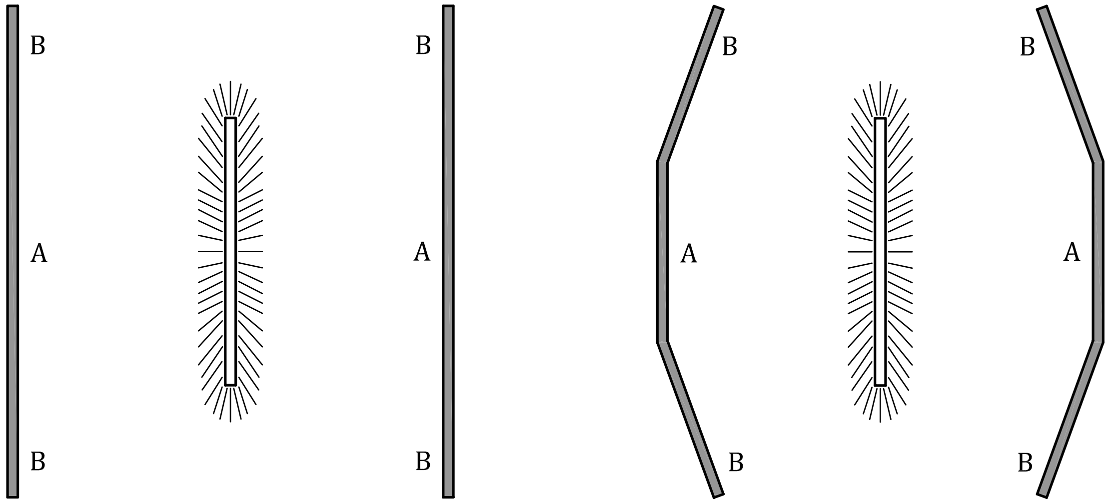
Annex A
(informative)

Procedure for measuring the irradiance uniformity in the specimen exposure area

A.1 This annex provides information for those who use this part of ISO 16474 as the basis for conducting an exposure to a laboratory light source and requirements for manufacturers of devices that expose materials to laboratory light sources.

A.2 In devices that use a rack to hold the specimens and rotate them around a light source [shown at the centre of Figures A.1a) and A.1b)], measure the irradiance at a position in the specimen rack that is closest to the light source (position A in Figure A.1) and at two positions within the specimen rack that are farthest from the light source (position B in Figure A.1). Measurements made with a radiometer that is placed on the rack as it rotates around the light source will give the most realistic indication of irradiance uniformity. The relationship between the irradiance at position B relative to the irradiance at position A shall be as follows:

$$E_{\mathrm{B}} \geq 0{,}7 E_{\mathrm{A}} \tag{A.1}$$

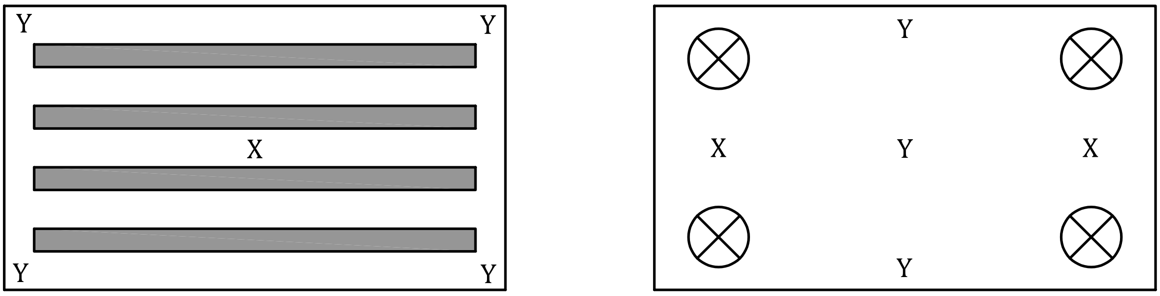


a) Flat specimen rack **b) Canted specimen rack**

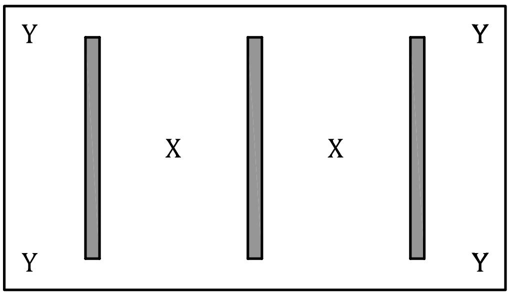
Figure A.1 — Determining irradiance uniformity in devices using a rotating specimen rack

A.3 In devices where specimens are positioned in a flat plane in front of a light source, measure the irradiance at a position in the specimen plane that is closest to the light source (position X in Figure A.2) and in two opposite corners of the plane where test specimens are placed (position Y in Figure A.2). The relationship between the irradiance at position Y relative to the irradiance at position X shall be as follows:

$$E_{\mathrm{Y}} \geq 0{,}7 E_{\mathrm{X}} \tag{A.2}$$



a) Flat specimen plane with fluorescent lamps b) Flat specimen plane with multiple point sources



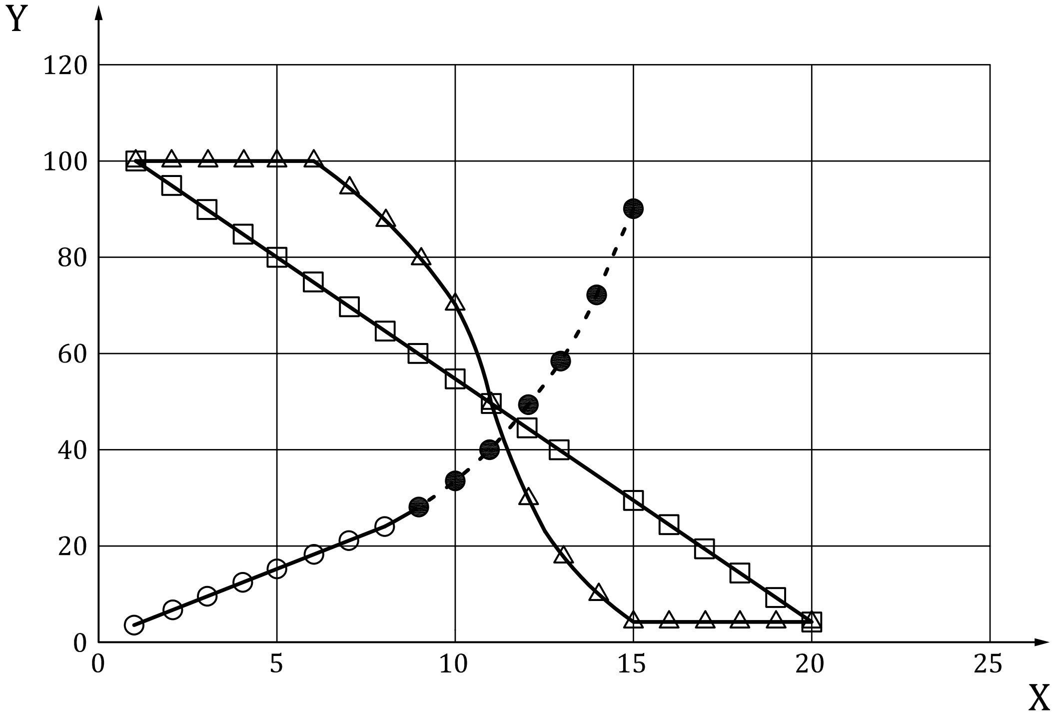
c) Flat specimen plane with multiple line sources

Figure A.2 — Determining irradiance uniformity in devices using a flat specimen plane

A.4 If the design of the device is such that the maximum irradiance might not be at the centre of the exposure area or such that the minimum irradiance might not be at the position farthest from the centre, the actual maximum irradiance shall be used for E_A or E_X and the actual minimum irradiance shall be used for E_B or E_Y in Formulae (A.1) and (A.2). Additional measurements of the irradiance at other positions within the exposure area may also be made. In all cases, however, the irradiance measured at these positions shall be at least 70 % of the maximum irradiance. Unless otherwise specified, at least four measurements shall be made at the periphery of the proposed exposure area (e.g. near the corners of flat specimen planes where fluorescent lamps or line sources are used as the light sources). For more precise definition of the allowed exposure area where $E_X \geq E_Y$ or $E_B \geq E_A$, many more than four measurements near the periphery of the exposure area will be necessary.

A.5 As an alternative to irradiance measurements, the uniformity of the irradiance may be determined by use of reference materials if the ageing of these materials is independent of the effects of heat or moisture or if the effects of heat and moisture are known. The change in the characteristic property of the reference material shall be a known function of the radiant exposure (preferably linear) and should preferably not show an induction time with little change in the property as a function of radiant exposure. Figure A.3 is a typical plot showing the characteristic property of reference materials as a function of radiant exposure or exposure time. The preferred reference material is that which shows a completely linear response throughout the exposure period. Materials that show an induction period followed by a period of rapid change are not recommended for use as reference materials. Materials that show a linear response followed by a period where response is not linear shall only be used for exposure periods during which they exhibit a linear response. Expose reference material specimens at the centre of the exposure area and at positions farthest from the centre. All specimens shall be exposed at the same time. Expose the reference specimens until there is a measurable change in the characteristic property being monitored. The change in the measured property of the reference material at positions farthest from the centre shall be at least 70 % of the change measured for the specimen exposed at the centre.

NOTE Actual measurements of irradiance are preferred over the use of reference materials because differences in property change between reference material specimens exposed at the extremes of the exposure area and those exposed at the centre might be significantly affected by differences in temperature and/or moisture conditions as well as differences in irradiance.



Key

X radiant exposure or exposure time (arbitrary units)

Y characteristic property (arbitrary units)

Figure A.3 — Typical behaviour of the characteristic property as a function of exposure for a reference material showing linear change (square symbols), for a reference material showing an induction time before the property starts to change (triangular symbols) and for a reference material showing a period of linear change (empty circles) followed by a region of nonlinear change (black-filled circles)

Annex B
(informative)

Factors that decrease the degree of correlation between artificial accelerated weathering or artificial accelerated irradiation exposures and actual-use exposures

B.1 Differences between the spectral distribution of the laboratory light source and that of solar radiation

Shorter-than-normal wavelengths are sometimes used to obtain faster failure rates in artificial accelerated weathering or artificial accelerated irradiation exposures. For outdoor exposures, the cut-on for short wavelength UV radiation is generally considered to be about 300 nm. Exposures to UV radiation of wavelengths less than 300 nm might produce degradation reactions that do not occur when the material is used outdoors. If a laboratory light source used in an artificial accelerated weathering or irradiation exposure produces UV radiation of wavelengths shorter than that found in the actual-use conditions, the mechanism of degradation and the stability ranking of the materials tested can be dramatically different in the accelerated test.

If radiation in a specific region of the spectrum is known to produce the type of degradation of interest in the materials being tested, it might not be necessary to simulate solar radiation over the entire spectrum. However, laboratory light sources that have a very strong emission in a narrow band relative to the rest of the UV or visible spectrum can cause a particular reaction to be favoured relative to others that might be very important. This type of light source might also not produce changes caused in exposures to solar radiation. Exposures to light sources which only produce UV radiation might not produce the colour fade caused by visible radiation and might cause polymer yellowing that is more pronounced than that produced in exposures to solar radiation.

B.2 Light intensities higher than those experienced in actual-use conditions

Light intensities higher than those experienced in actual-use conditions are typically used in exposures to laboratory light sources in order to accelerate degradation. There are two main reasons why the use of abnormally high irradiance can change the mechanism of material degradation relative to the conditions found in an actual-use environment (polymers show a broad range of responses to irradiance and these differences can alter the stability ranking of materials when results from artificially accelerated tests are compared to those from in-service exposures).

a) In exterior exposures, polymers in an excited state caused by absorption of a high-energy photon will typically decay to the ground state before absorbing another high-energy photon. However, in exposures to laboratory light sources producing an abnormally high light flux, the rate of photon absorption is so high that the material will often absorb a high-energy photon when it is still in an excited state.[4]

b) Free radicals are often formed in materials exposed to UV light. Reactions leading to degradation occur when the free radicals interact with the material. Free radicals can also recombine with other free radicals in reactions that do not lead to degradation. The high concentration of free radicals formed under high irradiance conditions results in a greater percentage of recombination due to the close proximity of the free radicals. In this case, degradation is not a linear function of irradiance.[5]

Furthermore, oxygen diffusion can sometimes become rate-limiting in polymer oxidation processes where abnormally high irradiance (or abnormally high specimen temperatures) are used for test acceleration.[6] This can produce differences in the mechanism of degradation reactions and might cause an abnormal ratio of surface to bulk oxidation, which could result in unnatural colour shifts or physical-property changes.

B.3 Continuous exposure to light with no dark periods

Continuous exposure to light from laboratory light sources is often used in order to achieve accelerated degradation relative to actual-use conditions. However, continuous exposure to light might eliminate critical dark reactions that occur in outdoor exposures or indoor-use conditions where there are regular periods without light.

B.4 Specimen temperatures that are abnormally high relative to actual-use

Temperatures higher than those experienced in actual-use conditions are often used to obtain faster degradation in artificial accelerated weathering or artificial accelerated irradiation exposures. Some coatings are much more susceptible to degradation due to thermal effects than others. Exposures at abnormally high temperatures might make a temperature-sensitive material appear to be less durable than a less temperature-sensitive material. In addition, exposures of coatings at temperatures above their glass-transition temperature can dramatically alter the mechanism of degradation and the stability ranking compared to exposures conducted at a temperature below the glass-transition temperature. The black standard temperature used in an artificial accelerated weathering or artificial accelerated irradiation exposure should be maintained in a reasonable range, which is usually no higher than the maximum observed for the black panel in actual-use conditions.

B.5 Exposure conditions that produce unrealistically large temperature differences between light- and dark-coloured specimens

Some laboratory light sources produce large amounts of infrared radiation. In order to prevent overheating of the specimens, the infrared radiation can be reduced by using infrared-absorbing or -reflecting filters, or by passing large amounts of air through the exposure chamber to cool the specimens. If measures to control the amount of infrared radiation reaching the specimens being exposed are not sufficient, the temperature differences between light- and dark-coloured specimens of the same material can be much larger than would be seen in natural exposures.

Some laboratory light sources produce very little visible and infrared radiation. When these types of laboratory light source are used, the temperature difference between dark- and light-coloured specimens might be much less than that found in outdoor exposures.

B.6 Temperature-cycling conditions that are different from those found in actual-use conditions

Abnormally high temperature-cycling frequencies can produce mechanically induced cracking or other types of degradation not seen in exposures under actual-use conditions. Exposure devices which spray specimens with water when the light source is on can produce an abnormally rapid change in temperature that might also produce cracking not produced in the actual-use environment.

B.7 Unrealistic levels of moisture in the accelerated test compared to those found in actual-use conditions

Moisture is very important in producing degradation of many polymers. If the amount of moisture, or the way in which specimens are exposed to the effects of moisture in an artificial accelerated weathering or artificial accelerated irradiation exposure, differs from that in the actual-use environment, the mechanism and rate of degradation might be very different. This can have a significant effect on the stability ranking of the materials.

B.8 Absence of biological agents and pollutants

Coating materials exposed in warm, wet locations are often subject to significant growth of biological agents such as fungi, bacteria and algae. Pollutants and acidic precipitation present in some exterior environments might have a significant effect on the mechanism and rate of degradation of some plastics. If these effects are not included in an artificial accelerated weathering or artificial accelerated irradiation exposure, the mechanism and stability ranking of the materials might be significantly different from that found in exterior exposures.

Annex C
(informative)

Solar spectral irradiance standard

C.1 The solar spectrum defined in CIE No. 85:1989, Table 4[22] is often used as a benchmark for comparing solar radiation to the radiation produced in artificial accelerated weathering or artificial accelerated irradiation exposures. In CIE 85:1989, Table 4, the global solar irradiance in the 300 nm to 2 450 nm band is given as 1 090 W/m^2 for a relative air mass of 1, with 1,42 cm of precipitable water and 0,34 cm of ozone (measured at a pressure of 1 atmosphere and a temperature of 0 °C). Table C.1 shows a broadband condensed spectral irradiance for global solar radiation at these atmospheric conditions in the UV, visible and infrared regions of the spectrum. This represents the maximum global solar irradiance that would be experienced by materials exposed on a horizontal surface at the Equator near noon on a clear day at the spring or autumn equinox.

Table C.1 — Spectral global irradiance (condensed from CIE No. 85:1989, Table 4)

Wavelength	**Irradiance**	**Percent of total**	**Percent of UV and visible**
nm	W · m^{-2}	300 nm to 2 450 nm	300 nm to 800 nm
300 to 320	4,1	0,4	0,6
320 to 360	28,5	2,6	4,2
360 to 400	42,0	3,9	6,2
300 to 400	74,6	6,8	11,0
400 to 800	604,2	55,4	89,0
300 to 800	678,8	62,2	100,0
800 to 2 450	411,6	37,8	—
300 to 2 450	1090,4	100,0	—

C.2 Direct radiation from xenon burner and some fluorescent lamps and some other light sources used for artificial accelerated weathering or artificial accelerated irradiation exposures, such as mercury lamps or metal halide lamps, contains considerable amounts of short-wavelength UV radiation not present in solar radiation. With proper selection of filters for these light sources, much of the short-wavelength light can be eliminated. However, some filters allow a small, but significant, amount of this short-wavelength (less than 300 nm) radiation through. Fluorescent lamps may be selected to have a spectral output corresponding to a particular UV region of solar radiation. The xenon arc, when appropriately filtered, produces radiation with a spectral power distribution that is a good simulation of average solar radiation throughout the UV and visible region.

C.3 CIE Publication No. 85:1989 provides data on spectral solar irradiance for typical atmospheric conditions and this data can be used as a basis for comparing laboratory light sources with daylight. The data used for filtered xenon-arc radiation are given in CIE No. 85:1989, Table 4. However, CIE85, which was published in 1989 has several disadvantages: Global solar spectral energy distribution starts at 305 nm, the increments are rather rough and the calculation code is no longer available. Therefore, efforts have been underway for several years to revise CIE85. The basis for this revision is newer measurements and improved calculation models (SMARTS2 model[7]). CIE85 (Table 4) can continue to be employed as a reference when recalculated with the SMARTS2 model[8].

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[13] ISO 4628-2, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 2: Assessment of degree of blistering*

[14] ISO 4628-3, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 3: Assessment of degree of rusting*

[15] ISO 4628-4, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 4: Assessment of degree of cracking*

[16] ISO 4628-5, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 5: Assessment of degree of flaking*

[17] ISO 4628-6, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 6: Assessment of degree of chalking by tape method*

[18] ISO 4628-7, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 7: Assessment of degree of chalking by velvet method*

[19] ISO 4628-8, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 8: Assessment of degree of delamination and corrosion around a scribe or other artificial defect*

[20] ISO 4628-10, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 10: Assessment of degree of filiform corrosion*

[21] ISO 11664-4, *Colorimetry — Part 4: CIE 1976 L*a*b* Colour space*

[22] CIE No. 85:1989, *Solar spectral irradiance*

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