BS EN ISO 877-1:2010

BSI Standards Publication

Plastics — Methods of exposure to solar radiation

Part 1: General guidance (ISO 877-1:2009)

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National foreword

This British Standard is the UK implementation of EN ISO 877-1:2010. It is identical to ISO 877-1:2009. Together with BS EN ISO 877-2:2010 and BS EN ISO 877-3:2010, it supersedes BS EN ISO 877:1997 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PRI/21, Testing of plastics.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Foreword

The text of ISO 877-1:2009 has been prepared by Technical Committee ISO/TC 61 "Plastics" of the International Organization for Standardization (ISO) and has been taken over as EN ISO 877-1:2010 by Technical Committee CEN/TC 249 "Plastics" the secretariat of which is held by NBN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2011, and conflicting national standards shall be withdrawn at the latest by June 2011.

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

This document supersedes EN ISO 877:1996.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Endorsement notice

The text of ISO 877-1:2009 has been approved by CEN as a EN ISO 877-1:2010 without any modification.

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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 877-1 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 6, *Ageing, chemical and environmental resistance*.

Together with the other parts (see below), it cancels and replaces ISO 877:1994, which has been technically revised.

ISO 877 consists of the following parts, under the general title *Plastics — Methods of exposure to solar radiation*:

— *Part 1: General guidance*

— *Part 2: Direct weathering and exposure behind window glass*

— *Part 3: Intensified weathering using concentrated solar radiation*

Introduction

Outdoor-exposure tests of the type specified in the three parts of this International Standard are needed to evaluate the performance of plastics when exposed to solar radiation. The results of such tests should be regarded only as an indication of the effect of exposure to direct weathering (ISO 877-2:2009, method A) or to indirect weathering using glass-filtered solar radiation (ISO 877-2:2009, method B) or to intensified solar radiation (ISO 877-3) by the methods described. Results from tests conducted in accordance with any of the parts of this International Standard will show some variability when comparing results from repeat exposures conducted at the same location at a different time. This is much more important for materials that show significant change after a year or less of exposure. In general, results from repeat exposures at the same location are necessary to determine the range of performance of a material subjected to exposure to solar radiation as specified in this International Standard. Since the type of climate can have a significant effect on the rate and type of degradation, results from exposures conducted in different types of climate are necessary to fully characterize the outdoor durability of a material. For solar-concentrating exposures conducted in accordance with ISO 877-3, exposure duration is defined in terms of the total solar UV radiant exposure because of the annual and seasonal variations in solar ultraviolet radiation.

Fresnel-reflecting concentrators of the type described in ISO 877-3, which employ solar radiation as the source of ultraviolet radiation, are utilized to provide accelerated outdoor-exposure testing of many plastics materials.

A system of classifying and characterizing climates in different parts of the world is given in Annex A.

The test method chosen is usually that designed to expose the material to the most severe conditions associated with any particular climate. It should, therefore, be borne in mind that the severity of exposure in actual use is, in most cases, likely to be less than that specified in this International Standard, and allowance should be made accordingly when interpreting the results. For example, vertical exposure at 90° from the horizontal is considerably less severe in its effects on plastics than near-horizontal exposure, particularly in tropical regions, where the sun is most powerful at high zenith angles.

Polar-facing surfaces are much less likely to be degraded than equator-facing surfaces because they are less exposed to solar radiation. However, the fact that they may remain wet for longer periods may be of significance for materials affected by moisture or for materials that are susceptible to microbial growth.

Plastics — Methods of exposure to solar radiation —

Part 1:
General guidance

1 Scope

This part of ISO 877 provides information and general guidance on the selection and use of the methods of exposure to solar radiation described in detail in subsequent parts of ISO 877. These methods of exposure to solar radiation are applicable to plastics materials of all kinds as well as to products and portions of products.

It also specifies methods for determining radiant exposure.

It does not include direct weathering using black-box test fixtures, which simulate higher end-use temperatures in some applications.

NOTE ASTM G 7 [1] and ASTM D 4141 [2] describe black-box exposure tests.

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 291, *Plastics — Standard atmospheres for conditioning and testing*

ISO 472, *Plastics — Vocabulary*

ISO 877-2:2009, *Plastics — Methods of exposure to solar radiation — Part 2: Direct weathering and exposure behind window glass*

ISO 877-3, *Plastics — Methods of exposure to solar radiation — Part 3: Intensified weathering using concentrated solar radiation*

ISO 2818, *Plastics — Preparation of test specimens by machining*

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

ISO 9370:—1), *Plastics — Instrumental determination of radiant exposure in weathering tests — General guidance and basic test method*

1) To be published. (Revision of ISO 9370:1997)

ASTM G 179, *Standard Specification for Metal Black Panel and White Panel Temperature Devices for Natural Weathering Tests*

ASTM G 183, *Standard Practice for Field Use of Pyranometers, Pyrheliometers and UV Radiometers*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 472 and ISO 9370 apply.

NOTE ASTM G 113 [3] defines terms used for artificially accelerated and natural weathering exposures. Submission of these definitions has been proposed for inclusion in ISO 472 and/or ISO 9370, or ISO 877, as appropriate.

4 Principle

Specimens or, if required, sheets or other shapes from which specimens can be cut, are exposed to natural solar radiation (ISO 877-2:2009, method A), or to window-glass-filtered solar radiation (ISO 877-2:2009, method B) or to intensified solar radiation using a Fresnel-reflecting concentrator (ISO 877-3). After the prescribed exposure period, the specimens are removed from exposure and, if a characterization is required, tested for changes in optical, mechanical or other properties of interest. The exposure stage may be a given period of time or may be expressed in terms of a given total radiant exposure or UV radiant exposure. The latter is preferred whenever the main objective of the exposure is to determine resistance to solar radiation, since it minimizes the effect of variations in spectral irradiance with climate, location and time.

Instrumental means of measuring irradiance, and means for integration to give the radiant exposure over a period of time, are preferred.

NOTE 1 Physical standards that change in colour, or another property, upon exposure to solar radiation have been used to determine radiant exposures. Determinations of radiant exposure using these procedures are less reliable indicators than determination of radiant exposure by actual measurement of solar radiation.

When comparing the results of exposure using ISO 877-2:2009, method A or B, with ISO 877-3, differences in specimen temperatures, ultraviolet radiant exposure levels and moisture deposition should be taken into account. Additionally, when comparing ISO 877-2:2009, method B, to ISO 877-3, the glass or other transparent material used as the filter must be identical. Comparison of results from ISO 877-3 to those from ISO 877-2:2009, method A or B, must be based on equal radiant exposure levels

The climatic conditions during the test may be monitored and reported with the other conditions of exposure.

It is recommended that a similar material of known behaviour be exposed simultaneously with the experimental material as a control.

Unless otherwise specified, test pieces for the determination of change in colour and change in mechanical properties are exposed in an unstrained state.

ISO 877-2:2009, method B, excludes the effects of wind and rain. The devices used for ISO 877-3 are typically equipped to provide moisture in the form of water spray.

Exposures in hot and wet and in hot and dry climates are often used to benchmark the outdoor durability of materials such as plastics. Information on climate classification can be found in Annex A.

NOTE 2 More detailed information about the effects of different climates and different exposure parameters on the variability of results from outdoor exposures can be found in ASTM G 141 [4].

5 Apparatus

5.1 General requirements

Exposure equipment consisting essentially of an appropriate test rack shall be used. The rack, specimen holders and other fixtures shall be made from inert materials that will not affect the test results. Noncorrosive aluminium alloy, stainless steel and ceramics have been found to be suitable. Untreated wood may be used, but may be subject to rot at locations high in moisture. Wood treated with preservatives, copper or its alloys, zinc or its alloys, iron or non-galvanized steel shall not be used. Materials with different thermal properties may affect the surface temperature and therefore the test results. Copper or its alloys, zinc or its alloys, iron or steels other than stainless steels, galvanized or plated metals or timbers other than those above should preferably not be used in the vicinity of the test specimens.

If backing is necessary to support the test specimens or to simulate special end-use conditions, such backing shall be of inert material. Test specimens that require support to prevent sagging of the specimen but do not require backing to elevate the temperature, or require no “solid” backing, should preferably be supported with fine-strand wire netting or slit-expanded aluminium or stainless-steel backing. Use 16-gauge to 18-gauge metal with approximately 12 mm to 13 mm openings. It is recommended that the surface area of the wire netting be 60 % to 70 % open.

For tests on finished products, it is recommended that, wherever possible, the fixtures closely simulate those used in practice.

ISO 877-2 gives specific requirements for rack design for outdoor exposures, and ISO 877-3 gives specific requirements for the solar concentrator.

5.2 Apparatus for measurement of climatic factors

5.2.1 Apparatus for measurement of radiant exposure

5.2.1.1 General

All radiometers used to measure radiant exposure shall meet the requirements of ISO 9370 and shall be calibrated at least annually, the calibration being traceable to national/international radiometric references. Listed below are examples of instruments used to measure radiant exposure.

5.2.1.2 Pyranometers

A pyranometer is a radiometer used to measure global solar radiation if mounted horizontally, or hemispherical radiation if mounted at an angle. Pyranometers shall meet or exceed the requirements for a second-class pyranometer as specified in ISO 9370. In addition, pyranometers shall be calibrated at least annually, more frequently if specified, using the calibration requirements given in ISO 9370.

5.2.1.3 Pyrheliometers

A pyrheliometer is a radiometer used to measure the direct component of solar irradiance on a surface normal to the sun’s rays. Pyrheliometers shall meet or exceed the requirements for a first-class pyrheliometer as specified in ISO 9370. In addition, pyrheliometers shall be calibrated at least annually, using the calibration requirements given in ISO 9370.

5.2.1.4 Total-ultraviolet radiometers

When used to define exposure stages, total-ultraviolet radiometers shall have a passband that maximizes the acceptance of radiation within the 290 nm to 400 nm wavelength region, and they shall be cosine-corrected to include ultraviolet sky radiation. Total-ultraviolet radiometers shall be calibrated at least annually, more frequently if specified, and their calibration shall be traceable to national/international radiometric references.

NOTE Traditionally, UV radiometers measuring from 295 nm to 385 nm have been used. Use of radiometers with different wavelength measurement range (for example, those that respond to 400 nm) can result in recorded UV radiant exposures that are up to 25 % to 30 % higher than the UV radiant exposure determined with radiometers that only measure up to 385 nm. See Annex A of ISO 9370:— for more information about the differences in measured total solar UV radiation between total ultraviolet radiometers that have differences in long wavelength UV response.

5.2.1.5 Narrow-band ultraviolet radiometers (NBUVRs)

When used to define exposure stages, NBUVRs shall be cosine-corrected if used in conjunction with either natural fixed angles or glass-filtered exposures. The acceptance angle of NBUVRs shall exceed the mirror system's effective field of view if used in conjunction with devices used for intensified solar radiation exposures in accordance with ISO 877-3. In either case, they shall be calibrated at least every six months, more often if required to ensure stability of their instrument constants.

5.2.2 Other climate-measuring instruments

Instrumentation used for the measurement of air temperature, specimen temperature, relative humidity, rainfall, wet time, sunshine hours, black- or white-standard temperature, and black- or white-panel temperature shall be appropriate to the exposure method used and shall be agreed upon between the interested parties. Unless otherwise specified, if measurement of black- or white-panel temperature is required, the panels shall be constructed, calibrated and maintained in accordance with ASTM G 179. Unless otherwise specified, if measurement of black- or white-standard temperature is required, the panels shall be constructed and maintained in accordance with ISO 4892-1.

NOTE 1 Time-of-wetness measurements are typically made using methods that employ galvanic cells or other electrical means. ASTM G 84 [5] describes a procedure for measuring time of wetness with a small galvanic-cell device. Use of this sensor for measurement of time of wetness has been discontinued by several major suppliers of equipment for outdoor weathering tests because of inconsistent results.

NOTE 2 At the time of publication, there is no acceptable standardized calibration technique for black- or white-standard thermometers used outdoors.

NOTE 3 Either a black-standard thermometer or a black-panel thermometer may be used. If a black-standard thermometer is used, the temperature indicated will be higher than that indicated by a black-panel thermometer under typical exposure conditions.

6 Test specimens

6.1 Form, shape and preparation

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

The dimensions of the test specimens are normally those specified in the appropriate test method for the property or properties to be measured after exposure. When the behaviour of a specific type of article is to be determined, the article itself should be exposed whenever possible.

If the material to be tested is an extrusion- or moulded-grade polymer in the form of granules, chips, pellets or some other raw state, specimens to be exposed shall be cut from a sheet produced from the material in the raw state by an appropriate method. The exact shape and dimensions of the specimens will be determined by the specific test procedure used for measurement of the property or properties of interest. The procedures used to machine or cut individual test specimens from a larger sheet or article may affect the results of the property measurement, and hence the apparent durability of the specimens. For preparation of test specimens, the procedures described in ISO 293, ISO 294-1, ISO 294-2 and ISO 294-3, ISO 295, ISO 2557-1 and ISO 3167 have been found to be satisfactory.

In some cases, individual specimens used for property measurement may need to be cut from a larger specimen which has been exposed. For example, materials that delaminate at the edges may be exposed in the form of larger sheets from which individual test specimens are cut after exposure. The effects of any cutting or machining operation on the properties of individual test specimens are usually much larger when the test specimens are cut from a large piece after exposure. This is especially true for materials that embrittle on exposure. Follow the procedures described in ISO 2818 for preparation of test specimens by machining. Do not cut specimens from larger specimens that have been exposed unless this preparation procedure is required in the specification or standard being followed.

When test specimens are cut from an exposed sheet or larger article, they should preferably be taken from an area that is at least 20 mm from the fixture holding the material or from the exposed specimen edges. In no circumstances shall any material from the exposed face be removed during test specimen preparation.

When comparing materials in an exposure test, use test specimens that are similar in dimensions and exposed area.

Label test and control specimens using marking that is permanent during the exposure and does not affect the measurement of the desired properties. Guidance is given in ASTM G 147 [6].

Do not touch the exposed surface of specimens or the optical components of the exposure apparatus with bare skin because oils that are deposited may act as UV absorbers or contain contaminants that affect specimen degradation.

6.2 Number of test specimens

The number of test specimens for each set of test conditions or for each exposure period shall be that specified in the appropriate test method for the property or properties to be measured after exposure. For the determination of mechanical properties, however, it is recommended that the number of test specimens exposed be twice that required by the relevant International Standard (due to the large standard deviation known to occur in measuring the mechanical properties of “weathered” materials).

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.

When destructive tests are used to determine the properties being measured, the total number of test specimens required will be determined by the number of exposure periods used and whether unexposed file specimens are tested at the same time as exposed specimens.

Control materials of known durability should preferably be included with each exposure test. It is recommended that control materials known to have relatively poor and relatively good durability be used. The number of specimens of the control material should preferably be the same as that used for test materials.

When making site-to-site comparisons, it is necessary for all the interested parties to agree on the materials to be used for the comparison.

6.3 Conditioning and storage

If test and/or reference specimens are cut or machined from larger pieces, they shall be conditioned, after preparation, in accordance with ISO 291. In some circumstances, it may be necessary to precondition the sheets prior to cutting or machining to facilitate specimen preparation.

When using tests to characterize the mechanical properties of the materials being exposed, specimens shall be appropriately conditioned before all property measurements. Use the conditions described in ISO 291, where appropriate. The properties of some plastics are very sensitive to moisture content, and the duration of conditioning may need to be longer than that specified in ISO 291, particularly where specimens have been exposed to climatic extremes.

File specimens shall be stored in the dark under normal laboratory conditions, preferably in one of the standard atmospheres given in ISO 291.

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

If agreed upon between the interested parties, the specimens can be stored at lower temperatures to avoid such dark reactions. Evaluation of specimens at several intervals after exposure will provide information on any colour or other property changes that occur once specimens are removed from exposure.

7 Conditions of exposure of the test specimens

7.1 Classes of climate

There are a number of different climates in which plastics may be used. Climates are generally divided into six classes and into several types within each class. Annex A provides a description of a commonly used climate classification system. Significant differences in rate and/or type of degradation may be expected when plastics are exposed in the different types of climate. Exposure of plastics in hot/wet and hot/dry climates with high levels of solar radiation are often conducted to obtain the fastest indications of durability.

7.2 Types of exposure used for specimens

Unless otherwise specified, test specimens shall be exposed in an unstrained state. If specimens are exposed with an applied strain, the exact procedure used for strain application shall be included with the test report.

Two types of exposure are commonly used for plastics:

a) Open exposures — Specimens are attached to the test rack or to a frame in such a manner that there is a free flow of air against the front and back of the specimen. In these exposures, specimens are subjected to the effects of weather on all sides. If specimens require additional support to prevent distortion or deformation during exposure, they may be placed against a wire mesh.

b) Backed exposures — Specimens are attached to a solid backing for exposure. When these exposures are used, the backing material shall be a sheet of plywood. The thickness of the plywood and type of coating used shall be agreed upon by all interested parties and shall be reported. Maximum specimen temperatures will be higher when backed exposures are used.

When the type of exposure is not specified, open exposures shall be used. The specific test conditions will depend upon the particular method selected. Refer directly to the appropriate part of this International Standard.

NOTE The backing or general support may significantly affect the temperature of the exposed test specimen since the backing influences the thermal insulation provided to the unexposed side of the specimen. If specimens are attached to a small section of backing material, the maximum temperature may be lower than if the specimen were attached to a large sheet of the backing material.

In cases where the intended use of the material renders it necessary to consider exposure in direct contact with specific backing materials, the test may be modified to take account of this.

8 Exposure stages

8.1 General considerations

The amount of change in a material will vary between repeat exposures conducted to the same exposure stage at the same site. Results from several exposures conducted at different times at the same site are necessary to provide an indication of the typical amount of change produced when conducting exposures to a specified stage at a particular location. The amount of change in a material exposed to the same exposure stage may also vary between locations with similar climates. The amount of change in a material will typically show large differences between sites with different climates. Results from exposures conducted in several different climates are needed to fully characterize the durability of a plastic material or product.

The exposure stages at which changes in properties of the test specimen are determined are specified by one of the following procedures.

8.2 Duration of exposure

Exposure stages may be specified in terms of total time in days, weeks, months or years.

8.3 Solar radiant exposure

8.3.1 Importance

Since the amount of solar radiation is one of the most important factors in the deterioration of plastics during weathering exposure, stages may be defined in terms of radiant exposure received by the specimens. It is recommended that total solar radiation or total solar ultraviolet radiation be measured and reported for each exposure stage, even if total solar radiant exposure is not used to define the exposure stage.

8.3.2 Instrumental measurement of solar radiant exposure

8.3.2.1 General

Measurement of solar radiation used to determine total solar radiant exposure, broadband solar ultraviolet radiant exposure or solar ultraviolet radiant exposure in a narrow passband shall be conducted in accordance with ISO 9370 and ASTM G 183.

8.3.2.2 Total solar radiant exposure

Total solar radiant exposure is expressed in MJ/m^2 and includes radiation from UV, visible and infrared wavelengths.

8.3.2.3 Radiant exposure within specified wavelength ranges

Total solar radiant exposures include all of the infrared portion of solar radiation in addition to ultraviolet and visible wavelengths. Since the infrared radiation has no direct photochemical effect on the weathering of plastics (although it may affect the temperature of exposed specimens), it may be useful to confine solar radiation measurements to the UV wavelength region that is photochemically active.

Solar ultraviolet radiation may be measured using a broadband radiometer that typically measures in the UV region between 290 nm and 400 nm (J/m^2). Alternatively, exposure stages may be defined in terms of ultraviolet radiation determined in a narrow passband [e.g. 340 nm, $J/(m^2 \cdot nm)$].

NOTE One of the most widely used broadband UV radiometers measures wavelengths from 295 nm to 385 nm. Others measure in a slightly different passband, which will result in a different measurement of total solar ultraviolet radiation. ISO 9370 gives more detailed information about these differences.

Solar UV radiant exposures shall be expressed in terms of J/m^2 and shall include the passband in which the ultraviolet radiation was measured.

9 Procedure

9.1 Mounting of test specimens

Attach the test specimens to the test rack, or in suitable holders, using inert mounting or clamping materials which will depend on the type of exposure described in 7.2. Ensure that sufficient space exists between the points of attachment to the test rack or frame so that the exposed area is of sufficient dimensions for the required optical or mechanical tests to be carried out. Ensure that specimens required for mechanical tests are mounted properly with respect, for example, to notches and fillets. Ensure that the method of mounting does not impose significant stress on the specimens.

It is recommended that a plan, diagram or photograph of the mounting positions be prepared and retained for future reference.

If required, a portion of each test specimen may be covered by an opaque, weather-resistant mask during the exposure to provide an unexposed, masked area adjacent to the exposed area for comparison. This procedure is useful for checking the progress of the exposure, but the data reported shall always be based on the comparison with unexposed file specimens in storage in order to provide an unambiguous determination of the colour change produced by the exposure.

Details of the mounting of specimens for the methods given in ISO 877-2 and ISO 877-3 are specified in the relevant document.

NOTE It is useful to expose control materials of known performance at the same time as the test materials so that the performance of the test materials can be ranked against the performance of materials of known durability.

9.2 Mounting of reference materials

If reference materials are used, they shall, unless otherwise specified, be mounted in the same way as the test specimens for which they are to be used as a reference. Mount reference materials as close as possible to the test specimens.

NOTE Historically, the dyed blue wool references developed for the testing of textiles for colour fastness have been used in the testing of plastics. It is well recognized that this method has severe limitations when used to define exposure stages for plastics.

9.3 Climatic observations

If required, maintain a record of all climatic conditions and changes that may affect the results of the exposure (see 10.3).

9.4 Exposure of test specimens

Unless otherwise specified, do not wash test specimens during exposure. If washing is required, use distilled water or water of equivalent purity and take care not to damage the weathered surface by abrasion or otherwise.

Perform regular inspections and maintenance of the site for the purpose of refixing loose test specimens, recording the general condition of the test specimens and repairing damage to or deterioration of equipment, particularly after storms.

Details of the exposure of specimens in the methods given in ISO 877-2 and ISO 877-3 are specified in the relevant document.

9.5 Determination of changes in properties, if required

Expose test specimens for the required duration and then remove them from the test fixture to determine changes in appearance, colour, gloss or other physical properties in accordance with ISO 4582 or another relevant standard.

Perform the test(s) as soon as possible after exposure, consistent with the period required for conditioning, and record the interval between the end of the exposure and the commencement of testing.

Consider whether the value of an exposure/test programme would be increased by adjusting subsequent specimen withdrawal times based on results from prior exposures of the same or similar materials.

10 Expression of results

10.1 Determination of changes in properties

If the changes in a property or properties of interest are required, they should preferably be expressed in accordance with ISO procedures and test methods (see ISO 4582).

10.2 Levels (values) of exposure stages

The exposure stages shall be expressed in at least one of the following ways (see Clause 8):

a) as the total solar ultraviolet radiant exposure, expressed in megajoules per square metre;

b) as the total solar radiant exposure, expressed in megajoules per square metre;

c) if required, as the radiant exposure within specified wavelength ranges, expressed in joules per square metre;

d) as the elapsed time (in weeks, months or years, as appropriate).

For the determination of exposure levels when using Fresnel-reflecting concentrators, refer to ISO 877-3.

10.3 Climatic conditions

A number of different climatic observations may be used to describe the conditions during the exposure. A partial list of these observations is as follows:

a) Temperature

— monthly mean of daily maxima;

— monthly mean of daily minima;

— monthly mean of daily mean temperature;

— monthly maximum and minimum.

b) Relative humidity

— monthly mean of daily maxima;

— monthly mean of daily minima;

— monthly mean of daily mean relative humidity;

— monthly range.

c) Precipitation

— monthly total amount of rainfall, in millimetres.

d) Time of wetness

— monthly total time of wetness, in hours.

e) Other observations

Other observations, such as wind speed and direction, incidence and nature of any atmospheric pollution, total ultraviolet radiant exposure (if measured) and any special local features, may also be recorded.

11 Test report

The test report shall contain the following information:

a) sample details, as supplied by the person or body requesting the test:

   1) a full description of the sample and its origin,

   2) compounding details, including cure time and temperature where appropriate;

b) the method of preparation of the test specimens;

c) the method of exposure used (ISO 877-2:2009, method A or B, or ISO 877-3);

d) details of the exposure:

   1) the exposure aspect (e.g. tilt and azimuth orientation),

   2) the location and, if required, additional details about the exposure site, such as latitude, longitude and altitude.

   3) if required, the climate class and type (refer to Annex A for more detailed information),

   4) the nature of the masking, backing support and attachments, if used,

   5) the procedure used to determine the exposure stages, as required by the person or body requesting the test,

   6) if required, the total solar radiant exposure, measured in accordance with ISO 9370,

   7) if required, details of water spray cycles and the procedures used for temperature and/or irradiance control (these are applicable to ISO 877-3 only, which provides detailed information about reporting this information),

   8) details of specimen washing, if any;

e) the test results:

   1) the exposure stages used, the corresponding intervals between removal of the specimens from exposure and any property measurements that were conducted and, if specimens were re-exposed, the total time between removal from exposure and when the specimens were returned to exposure,

   2) climatic data,

   3) the results, presented as required by ISO 4582;

f) the date(s) of testing.

Annex A
(informative)

Classification of climates

The most widely recognized system for defining and classifying the various types of climate is based on the work of German climatologist Wladimir Köppen who introduced this climate classification system in 1928 and published modifications and improvements until he died in 1940. Köppen's classification system was originally developed for vegetation and has been modified by several researchers, but the most common modification in use today was developed by Glenn Trewartha of the University of Wisconsin in the USA. A full description of Trewartha's modification of Köppen's climate classification is described in Reference [7]. In this system, climates are classified into six basic types. Within each of the basic types, there are several different subtypes based on temperature and precipitation. These are described in Table A.1

Table A.1 — Climate classification and description

Climate type	Name of climate type	Climate subtype	Name of climate/subclimate	General description	Average temperature
A	Tropical humid	Af	Tropical wet	No dry season	>17 °C all year
		Am	Tropical monsoonal	Short dry season; heavy monsoon rains in other months	
		Aw	Tropical savanna	Winter dry season	
B	Dry	BWh	Subtropical desert	Low-latitude desert	Not applicable (for type B climates, evaporation exceeds precipitation). The temperature of type B climates is indicated by the third letter. An "h" is used for climates where the coldest month has an average temperature greater than 0 °C. A "k" indicates that at least one month has an average temperature of less than 0 °C.
		BSh	Subtropical steppe	Low-latitude dry	
		BWk	Mid-latitude desert	Mid-latitude desert	
		BSk	Mid-latitude steppe	Mid-latitude dry	
C	Mild mid-latitude	Csa	Mediterranean	Mild with dry, hot summer	>9 °C for 8-12 months of year
		Csb	Mediterranean	Mild with dry, warm summer	
		Cfa	Humid subtropical	Mild with no dry season, hot summer	
		Cwa	Humid subtropical	Mild with dry winter, hot summer	
		Cfb	Marine west coast	Mild with no dry season, warm summer	
		Cfc	Marine west coast	Mild with no dry season, cool summer	
D	Severe mid-latitude	Dfa	Humid continental	Humid with severe winter, no dry season, hot summer	>9 °C for 4-7 months of year
		Dfb	Humid continental	Humid with severe winter, no dry season, warm summer	
		Dwa	Humid continental	Humid with severe, dry winter, hot summer	
		Dwb	Humid continental	Humid with severe, dry winter, warm summer	
		Dfc	Subarctic	Severe winter, no dry season, cool summer	>9 °C for 1-3 months of year
		Dfd	Subarctic	Severe, very cold winter, no dry season, cool summer	
		Dwc	Subarctic	Severe, dry winter, cool summer	
		Dwd	Subarctic	Severe, very cold and dry winter, cool summer	
E	Polar	ET	Tundra	Polar tundra, no true summer	No month with average temperature >9 °C
		EF	Ice cap	Perennial ice	
H	Undifferentiated highlands	H	Undifferentiated highlands	High altitude	Not applicable

NOTE The climate classification for two benchmark climates used for exposure tests on plastics are Aw for South Florida and BWh for the mid-Arizona desert.

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