INTERNATIONAL STANDARD

ISO 877-1

First edition
2009-06-01

Plastics — Methods of exposure to solar radiation —

Part 1: General guidance

Plastiques — Méthodes d'exposition au rayonnement solaire —

Partie 1: Lignes directrices générales

Reference number
ISO 877-1:2009(E)

Contents

Page

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.