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Plastics — Methods of exposure to solar radiation —

Part 3: Intensified weathering using concentrated solar radiation

Plastiques — Méthodes d'exposition au rayonnement solaire —

Partie 3: Exposition intensifiée par rayonnement solaire concentré

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Foreword

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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 (see 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 (see 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 voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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

This second edition cancels and replaces the first edition (ISO 877-3:2009), which has been technically revised.

A list of all the parts in the ISO 877 series can be found on the ISO website.

Introduction

The International Organization for Standardization (ISO) draws attention to the fact that it is claimed that compliance with this document may involve the use of patents concerning temperature control described in 7.3

ISO takes no position concerning the evidence, validity and scope of this patent right.

The holder of this patent right has assured ISO that he/she is willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of this patent right is registered with ISO. Information may be obtained from:

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Plastics — Methods of exposure to solar radiation —

Part 3:
Intensified weathering using concentrated solar radiation

1 Scope

This document specifies a method for exposing plastics to concentrated solar radiation using reflecting concentrators to accelerate the weathering processes. The purpose is to assess property changes produced after specified stages of such exposures. The reflecting concentrators used in these exposures are sometimes referred to as "Fresnel reflectors" because in cross-section the array of mirrors used to concentrate the solar radiation resembles the cross-section of a Fresnel lens.

General guidance concerning the scope of the ISO 877 series is given in ISO 877-1.

NOTE Additional information about solar concentrating exposures, including a partial list of standards in which they are specified, is given in the Bibliography.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 877-1, *Plastics — Methods of exposure to solar radiation — Part 1: General guidance*

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

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

ASTM G90, *Standard Practice for Performing Accelerated Outdoor Weathering of Nonmetallic Materials Using Concentrated Natural Sunlight*

ASTM G179, *Standard Specification for Metal Black Panel and White Panel Temperature Devices for Natural Weathering Tests*

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

4 Principle

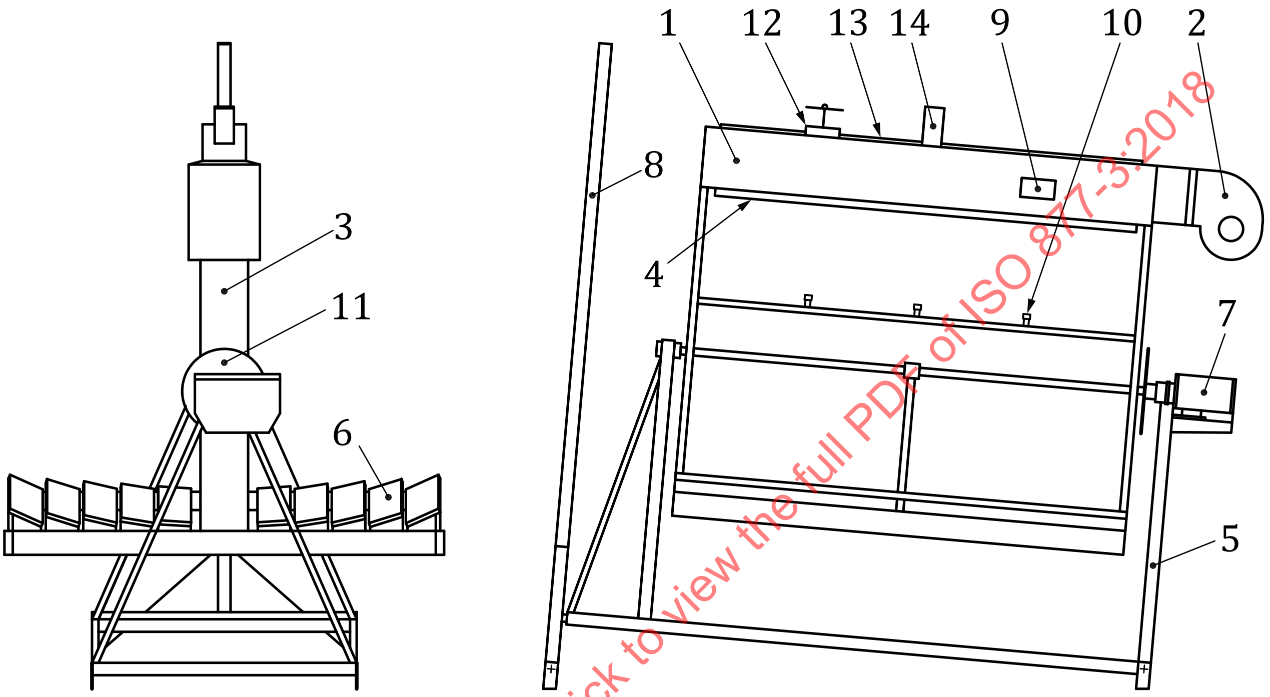
This document describes a method for performing accelerated weathering on plastics using intensified solar radiation. General guidance is given in ISO 877-1.

5 Apparatus

5.1 General requirements

Refer to ISO 877-1 for general requirements.

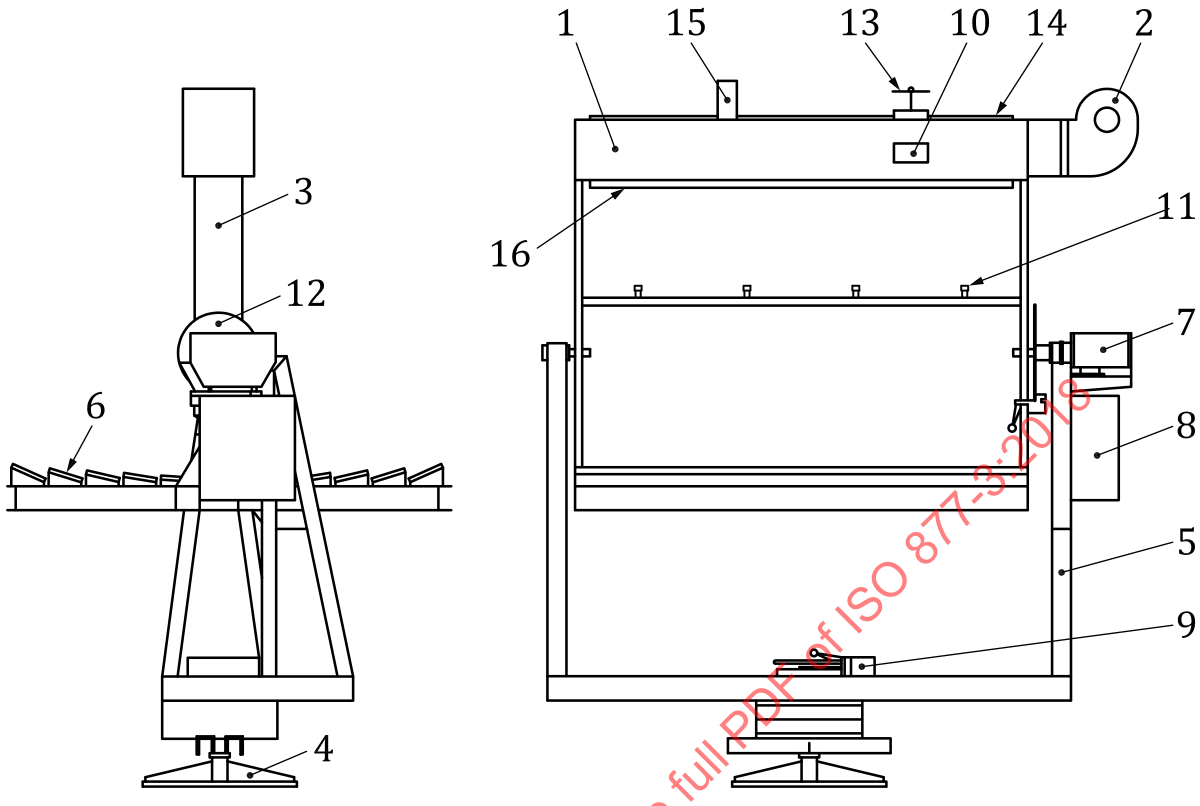
All requirements for the solar concentrating device, operation of the device and measurement of the solar radiation within the specimen exposure area shall be in accordance with ASTM G90. See Figures 1 and 2 for schematic diagrams of the two types of test apparatus.



Key

1	air plenum	6	mirror	11	clutch disc for elevation drive
2	air blower	7	gear box	12	solar cells with shadow hat
3	rotor assembly	8	mast for manual elevation adjustment	13	specimen protection door
4	air deflector	9	air flow switch	14	door release mechanism
5	A-frame assembly	10	water spray nozzles		

Figure 1 — Schematic diagram of test apparatus with single-axis tracking and manual elevation adjustment



Key

1	air plenum	7	gear box for elevation drive	13	solar cells with shadow hat
2	air blower	8	control box	14	specimen protection door
3	rotor assembly	9	gear box for azimuth drive	15	door release mechanism
4	turntable assembly	10	air flow switch	16	air deflector
5	A-frame assembly	11	water spray nozzles		
6	mirror	12	clutch disc for elevation drive		

Figure 2 — Schematic diagram of test apparatus with dual-axis tracking

5.2 Apparatus for measurement of climatic factors

Refer to ISO 877-1.

6 Test specimens

Refer to ISO 877-1.

NOTE When irregularly shaped specimens are used, air flow and specimen cooling can be adversely affected. In addition, irradiance will not be uniform on all surfaces of a shaped specimen.

7 Exposure conditions

7.1 Orientation of mirrors

For specific information on the orientation of the mirrors, refer to ASTM G90.

7.2 Exposure site

Fresnel-reflecting solar concentrating devices operate most effectively at locations that receive at least 3 500 h of sunshine per year and where the average daytime relative humidity is less than 30 %. ASTM G90 provides requirements for the exposure site's average ratio of direct solar radiation to global normal solar radiation.

NOTE In regions that receive 3 500 h of solar radiation and where the average daytime relative humidity is less than 30 %, the average ratio of direct solar radiation to global normal solar radiation is at least 0,75. Areas that meet these criteria have a minimum diffuse component of solar radiation (sky radiation). The use of reflecting solar concentrator devices in regions of moderate to high diffuse solar irradiance will substantially reduce the amount of UV radiation at the specimen target board. Moderate to high levels of humidity and urban aerosols result in scattering of the direct component of solar radiation so that ultraviolet radiation is scattered into the hemispherical sky dome and is not available to be focused by the mirrors on to the specimen target board. This is shown in Figure 3. In addition, the use of reflecting solar concentrator devices in regions of moderate to high diffuse solar irradiance can give different stability rankings for materials compared to exposures conducted in accordance with ISO 877-2 because of the differences in UV radiation.

7.3 Temperature control

Solar concentrating devices are equipped with a blower to cool the specimens. Specimen temperatures for most materials are typically 10 °C higher than the maximum temperature which would be reached if an identical specimen was exposed directly to solar radiation (without concentration) at normal incidence at the same time.

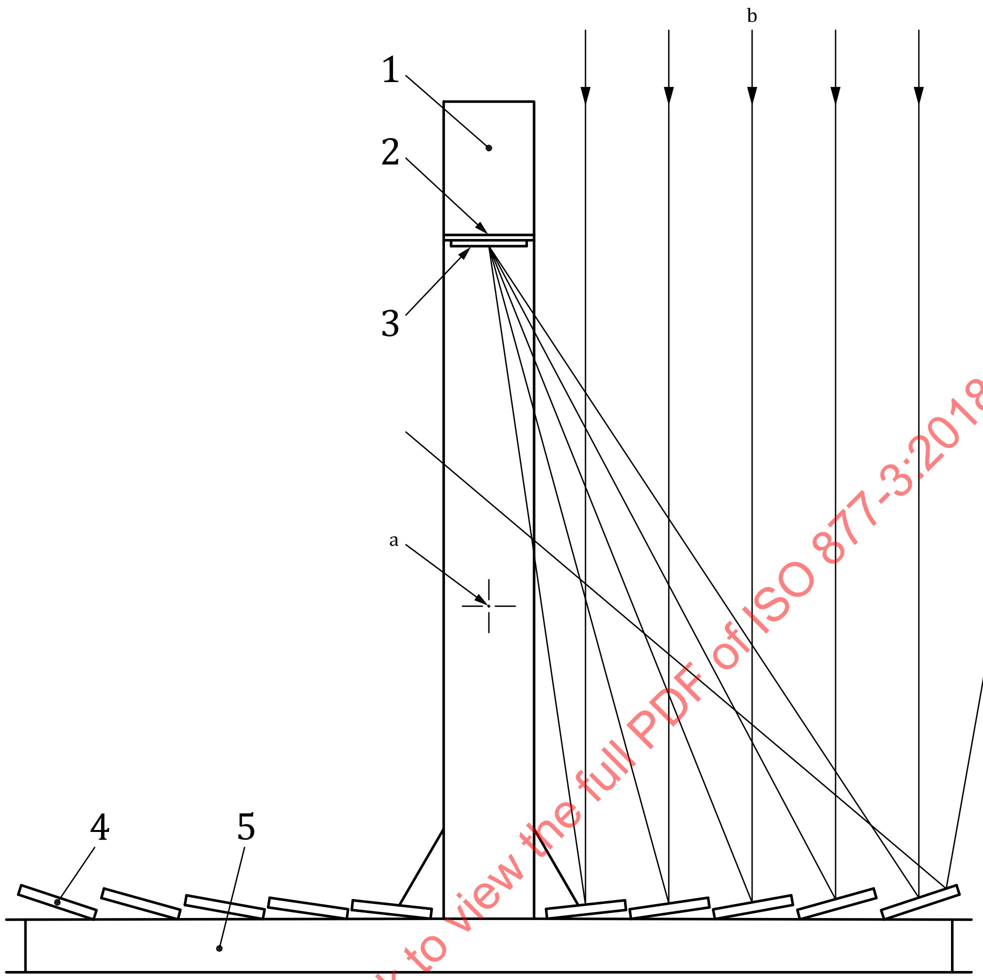
If more precise control of specimen temperature is required, the temperature of a black or white panel, the temperature of a black or white standard thermometer, the temperature of a particular specimen, the air temperature or the temperature indicated by a remote sensor may be monitored and used as an input to control the specimen temperature. If used, report the controlled temperature and any observed deviations in the test report.

Use of this method of temperature control may produce results that are not equivalent to typical solar concentrating exposures and may require longer radiant exposures to produce the same amount of degradation.

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 G179. 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 If a black-standard temperature is used, the temperature indicated will be higher than that indicated by a black-panel thermometer under typical exposure conditions.

Temperatures during the night-time are typically not controlled. If agreed upon by the interested parties, heat sources placed behind the specimens may be used to control night-time temperatures. If so, the method used to control night-time temperatures shall be included in the test report.



Key

1 air plenum (end view)
2 specimen target board
3 test specimen
4 flat mirror
5 mirror bed
a Centre of gravity and rotation.
b Direct component of solar radiation.
c Diffuse component of solar radiation (sky radiation).

Figure 3 — Reflecting mechanism in a solar concentrating device

7.4 Irradiance level

Measurement of total solar radiation and solar ultraviolet radiation for the determination of radiant exposure using solar concentrating exposures is described in ASTM G90. The irradiance may be varied by changing the number of mirrors used in the device. This will also change the specimen temperature. Any modifications to the exposure conditions to modify the irradiance in the exposure area, as well as the method used to calculate or measure the modified irradiance level, shall be completely described in the test report.

These modifications will change the time necessary to produce the same radiant exposure in devices using all mirrors, and may not produce an equivalent result for the same radiant exposure.

8 Exposure stages

8.1 General

Since the amount of solar radiation is one of the most important factors in the deterioration of plastics during weathering exposure, exposure stages shall, unless otherwise specified, be defined in terms of total solar radiant exposure, solar UV radiant exposure or solar UV radiant exposure in a narrow passband.

8.2 Solar radiant exposure

8.2.1 Guidance for selection of the exposure stage

For guidance in selecting the exposure stage, Table 1 shows the average annual total solar radiation and solar ultraviolet radiation for sites in southern Florida and in the central Arizona desert. This data may be used as an "equivalent standard year" for setting desired exposure stages (e.g. an exposure stage of 305 MJ/m^2 total solar UV from 295 nm to 385 nm could be used to simulate a one-year latitude-angle exposure in southern Florida conducted in accordance with ISO 877-2:2009, method A).

Table 1 — Average annual total solar and total solar ultraviolet radiation for exposures conducted at a tilt angle equal to the latitude angle in southern Florida and the central Arizona desert

Location	Average annual radiant exposure at tilt angle equal to site latitude	
	Total solar radiation MJ/m^2	Solar UV radiation (295 nm to 385 nm) MJ/m^2
Southern Florida	6 310	305
Central Arizona	8 240	340

NOTE Traditionally, UV radiometers measuring from 295 nm to 385 nm have been used. The use of radiometers with a different measurement response (for example, radiometers that measure 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 ISO 9370:2017, Annex A for more information about the differences in measured total solar UV radiation between total ultraviolet radiometers that have differences in long-wavelength UV measurement cut-off.

The degree of acceleration for exposures conducted in accordance with this document is dependent on both the material formulation and the time of year. The ultraviolet content of terrestrial solar radiation is time-of-year dependent. Therefore, exposures started in the fall or winter months will take longer to accumulate the specified radiant exposure than exposures started in the spring or summer.

8.2.2 Instrumental measurement of solar radiant exposure

Refer to ISO 877-1 for general guidance.

8.2.2.1 Total solar radiant exposure

Refer to ASTM G90.

8.2.2.2 Radiant exposure in specified wavelength intervals

Refer to ASTM G90.

9 Procedure

9.1 Mounting of test specimens

For general information regarding the mounting of the test specimens, refer to ISO 877-1. Orient specimens so that the surfaces to be exposed face the mirrors of the solar concentrating device.

Mount the test specimens in a suitable test frame such that a minimum of any test specimen is covered by the clamping fixture used.

For unbacked exposures, mount the framed specimens approximately 5 mm off the target board, with the test surfaces facing the mirrors. Position the specimens such that clearance is maintained between the air-delivery slot and the frame. Adjust the machine's air deflector to provide a clearance of from 10 mm to 14 mm between the exposed surfaces of the specimens and the air deflector lip.

For insulated, backed exposures, mount specimens in specimen holders with the specimens backed with an insulating, water-resistant material (such as 12-mm-thick exterior plywood).

For solar concentrating exposures, the total specimen thickness (including any backing material) shall be limited to ensure adequate cooling. The maximum thickness of the specimen or specimen plus backing material shall therefore be 13 mm.

9.2 Mounting of reference materials (if used)

Refer to ISO 877-1. The same requirements as described in 9.1 apply to the mounting of specimens of reference materials.

9.3 Climatic observations

Refer to ISO 877-1.

9.4 Exposure of test specimens

9.4.1 General

Conduct all exposures and maintain the solar concentrating device in accordance with ASTM G90.

9.4.2 Exposure cycles

Select the exposure cycle according to the amount of water spray desired from the cycles described in Table 2.

9.4.3 Testing under glass

When cycle 3 is used for testing specimens behind glass, the characteristics of the glass used shall be as given in ISO 877-2. In addition, when under-glass exposures are used, the air flow across the specimen exposure area shall be set as high as possible in order to prevent unrealistic temperatures of the specimens exposed behind the glass. Finally, the transmission of the glass used shall be included in the test report.

Table 2 — Water spray cycles used with Fresnel-reflecting concentrators

Cycle No.	Description
1	8 min spray, 52 min dry (during irradiation) plus three night-time sprays of 8 min duration (at 21:00 h, 24:00 h and 03:00 h)
2	3 min spray, 12 min dry (from 19:00 h to 05:00 h only, i.e. no daytime spray)
3	No spray
Other	Other spray cycles may be used as agreed upon between the interested parties

NOTE Typical uses of the cycles are as follows:

— cycle No. 1: testing most plastics specimens;

— cycle No. 2: testing plastics specimens having an initially high gloss, such as automotive lens materials, transparent sheet, etc.;

— cycle No. 3: testing under glass, testing plastics-laminated glass, fade-only tests and testing inner covers of solar hot-water collectors.

10 Expression of results

10.1 Determination of changes in properties

Changes in the properties of interest should preferably be determined in accordance with ISO procedures and test methods (see ISO 4582).

10.2 Climatic conditions and observations

10.2.1 General

The general description of the climate at the exposure site by class, type and special conditions shall be supplemented by the following detailed observations.

10.2.2 Temperature

Refer to ISO 877-1.

10.2.3 Relative humidity

Refer to ISO 877-1.

10.2.4 Levels (values) of exposure stages

For determining exposure levels, compute the solar radiant exposure H_S, total solar UV radiant exposure, or UV radiant exposure in a narrow passband, in joules per square metre, of the test specimens using the following equation:

$$H_s = M\rho_s \sum_{1}^{N} H_d$$

where