TECHNICAL SPECIFICATION

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Plastics — Method of controlled acceleration of laboratory weathering by increased irradiance

Plastiques — Méthode d'accélération contrôlée du vieillissement en laboratoire par irradiance accrue

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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).

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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 61, *Plastics*, Subcommittee SC 6, *Ageing, chemical and environmental resistance*.

Introduction

A realization of the acceleration of laboratory weathering under controlled conditions is an essential requirement for delivering reliable and fast prediction of material durability. In this connection, the correlation to real use aging behaviour is being checked constantly.

The fundamental parameters of a weathering test are simulated solar radiation, heat and moisture. The induced change in the material properties, among other things, is determined by the irradiance level and relative spectral irradiance of simulated solar radiation incident on the material surface during the test, the surface temperature, and the level of moisture. An increase in some well-known weather parameters, continuously monitored outdoors, offers opportunities to speed up the weathering process outdoors and in the laboratory. Since 1967, acceleration of outdoor weathering with instruments for intensified weathering using concentrated solar radiation (according to ISO 877-3) became a common practice. By concentrating the natural solar radiation with Fresnel mirrors, irradiances of five to six times higher than the maximum natural level has been reached. Already in 1996, a screening procedure with very high irradiances for dyed textiles were developed which enabled the reduction of the test duration for lightfastness grades from five days to seven days to two and a half days.[5]

However, the applicability of an increased irradiance for deterministic acceleration of weathering without a specific knowledge of material properties requires that the degradation of material (at constant temperature and moisture conditions) has to be dependent on the applied radiant exposure only, irrespective of the irradiance level and resulting exposure duration used during the test. For some materials fulfilling this criterion, the acceleration of weathering has been demonstrated successfully.[6][7][8][9] This criterion is not always fulfilled since an increase in the irradiance might not always produce the expected increase in the weathering acceleration due to possible and a priory unknown to the operator nonlinear dependence of the photochemical processes on the irradiance level. Moreover, the overall material degradation might be strongly affected by the other weather parameters which can be modified due to the increased irradiance.

There are limitations in using increased irradiances. Therefore, the applicability and the limits of this weathering acceleration approach are determined by the properties of the specific material and have to be investigated systematically in each particular case. In this respect, it is of essential importance to validate an appropriate test procedure under controlled conditions in laboratory with an artificial radiation source which can provide high irradiances above the natural level with the relative spectral irradiance closely mimicking the natural solar radiation. Simultaneously, the temperature of the sample specimen surface and of the chamber air is kept constant in a wide range of irradiance level. In addition, the usual wetting and rain option have to be available.

Plastics — Method of controlled acceleration of laboratory weathering by increased irradiance

1 Scope

This Technical Specification specifies a test method which allows predicting the aging rate of material specimens, e.g. plastics, under interest independent of the aging mechanisms as a function of radiant exposure. The UV irradiance of a simulated solar radiation (with a laboratory radiation source) will be extended above the normal maximum level on earth surface while keeping all relevant temperature parameters fixed.

NOTE For translucent plastics, the surface temperatures are below the white standard temperature. In addition, the maximum temperature is not on the irradiated surface, it is somewhere inside the plastic material.

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

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

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

ISO 10640, *Plastics — Methodology for assessing polymer photo ageing by FT-IR and UV-visible spectrometry*

ISO/TR 17801, *Plastics — Standard table for reference global solar spectral irradiance at sea level — Horizontal, relative air mass 1*

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

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
radiant exposure
H
radiant energy per unit

Note 1 to entry: Radiant exposure is given by the following formula:

$$H = \int E \times dt$$

where

E is the irradiance, in watts per square metre ($W \times m^{-2}$);

t is the exposure time, in seconds (s).

Note 2 to entry: H is therefore expressed in joules per square metre ($J \times m^{-2}$).

3.2
solar radiation
global solar radiation
solar radiant flux, both direct and diffuse, received on a horizontal plane unit area from a solid angle of 2π steradians

[SOURCE: ISO/TR 17801, 3.1, modified — irradiance has been replaced by radiation]

Note 1 to entry: In this Technical Specification, “solar radiation” always means “global solar radiation”.

4 Symbols and abbreviated terms

CHT	chamber air temperature (ambient air temperature)
BST	black-standard thermometer (insulated surface temperature sensor)
BPT	black-panel thermometer (uninsulated surface temperature sensor)
WST	white standard thermometer (insulated surface temperature sensor)
WPT	white panel thermometer (uninsulated surface temperature sensor)

5 Principle

A xenon or fluorescent UV radiation source (other radiation sources are possible), fitted with filters (if necessary), is used to simulate preferably the relative spectral irradiance of solar radiation according to CIE Publication No. 85:1989, Table 4 or solar radiation filtered by window glass. A standard test method (e.g. ISO 4892-2, ISO 4892-3) or a differing/non-standardized weathering test method shall be conducted as a basis for further investigations. The base level test shall use weathering parameters (irradiance, temperatures, relative humidity) which are not above a maximum natural level (e.g. irradiance in the wavelength range 300 nm to 400 nm smaller than 66 W/m^2). As a second step, the irradiance is increased step by step above the natural level. While the irradiance is increased above the maximum level (at least three levels) or decreased, all other test parameters (relative spectral irradiance, chamber air temperature, relative humidity) shall be kept constant (unchanged). If used, the influence of a spray/dry cycle shall be carefully considered. The test results (e.g. colour change, carbonyl formation) shall be plotted as a function of the radiant exposure.

6 Apparatus

6.1 General

The equipment comprises a climate chamber with a chamber air temperature and relative humidity measurement device. In the climate chamber, included is a radiation source. The radiation source may generate UV, visible radiation, and infrared radiation similar to solar radiation with appropriate filter systems. A cooling system for the laboratory simulated solar radiation source and a fixture for the specimens are included in the chamber as well.

6.2 Test chamber

The design of the test chamber may vary, but it shall be constructed from inert material. In case of radiation sources including VIS and IR, it shall be equipped with a blower which generates a defined airflow to be directed across the specimens. In addition to the controlled lamp wattage, the test chamber shall provide for control of chamber air temperature radiation shielded. For exposures that require control of humidity, the test chamber shall include humidity-control facilities that meet the requirements of ISO 4892-1.

NOTE If the lamp system (one or more lamps) is centrally positioned in the chamber, the effect of any eccentricity of the lamp(s) on the uniformity of exposure may be reduced by using a rotating frame carrying the specimens or by repositioning or rotating the lamps.

Should any ozone be generated from operation of the lamp(s), the lamp(s) shall be isolated from the test specimens and operating personnel. If the ozone is in an air stream, it shall be vented directly to the outside of the building.

6.3 Laboratory radiation source

6.3.1 General

The laboratory solar radiation sources (e.g. xenon arc lamp, fluorescent UV lamp) may emit radiation from below 270 nm in the ultraviolet through the visible spectrum and into the infrared. In order to simulate solar radiation with lamps which emit the full spectrum of solar radiation (UV, VIS, and IR radiation), filters shall be used to remove short wavelength UV radiation. In addition, filters to remove infrared radiation may be used to prevent unrealistic heating of the test specimens.

NOTE 1 Solar spectral irradiance for a number of different atmospheric conditions is described in CIE Publication No. 85. The benchmark solar radiation used in this Technical Specification is that defined in CIE No. 85:1989, Table 4. A recalculated Table 4 is available in ISO/TR 17801 (better wavelength resolution).

NOTE 2 If laboratory radiation sources are used which emit serious amounts in the IR and VIS range, surface temperatures are affected by surface heating. Then, actions to adjust specimen surface temperatures have to be taken.

6.3.2 Spectral irradiance

Filters are used to filter xenon-arc or other laboratory radiation sources in order to simulate solar radiation (CIE Publication No. 85:1989, Table 4). The minimum and maximum levels of the relative spectral irradiance are given in the used standard applications (e.g. ISO 4892-2, ISO 4892-3).

During the test, the relative spectral irradiance shall not be changed considerably. An evaluation method shall be used to compare the relative spectral irradiance at different irradiance levels.

NOTE 1 The deviation of the relative spectral irradiance at the lowest level from the highest level can be calculated according to ISO/TR 18486.

NOTE 2 The following wavelength ranges are recommended for the comparison of the relative spectral irradiance: 290 nm to 320 nm, 320 nm to 340 nm, 340 nm to 360 nm, and 360 nm to 400 nm.

NOTE 3 Xenon arc and fluorescent UV lamps can run at variable wattages (which the lamp is specified for) without a significant change of the relative spectral irradiance.

NOTE 4 For natural and artificial sun radiation, the irradiance of 60 W/m^2 in the wavelength range of 300 nm to 400 nm or 0,51 W/($m^2 \times nm^{-1}$) at 340 nm indicates the one sun level. This does not mean that higher irradiances can appear (66 W/m^2 at 300 nm to 400 nm or 0,8 W/m^2 at 340 nm acc. new calculation of CIE 85, Table 4).

6.3.3 Irradiance uniformity

The irradiance at any position in the area used for specimen exposure shall be at least 90 % of the maximum irradiance.

For some materials of high reflectivity, high sensitivity to irradiance and temperature, periodic repositioning of specimens is recommended to ensure uniformity of exposures, even when the irradiance uniformity in the exposure area is within the limits.