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Plastics — Methods of exposure to laboratory light sources —

Part 1:
General guidance and requirements

Plastiques — Méthodes d'exposition à des sources lumineuses de laboratoire —

Partie 1: Lignes directrices générales et exigences

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Foreword

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This document was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 6, *Ageing, chemical and environmental resistance*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 249, *Plastics*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This fourth edition cancels and replaces the third edition (ISO 4892-1:2016), which has been technically revised.

The main changes are as follows:

— the definition of file specimen (see 3.2) and weathering reference material (see 3.5) have been clarified and Notes to entry have been added;

— definition and Notes to entry of artificial accelerated weathering (see 3.3) and artificial accelerated irradiation (see 3.4) have been clarified;

— new terms, definitions and Notes to entry have been added for black-panel thermometer (see 3.7), black-standard thermometer (see 3.8), white-panel thermometer (see 3.9), and white-standard thermometer (see 3.10);

— reference to ISO/TR 18486 has been added under 4.2.4;

— calibration requirements have been clarified in 5.1.7, 5.2.8, 5.2.9, 5.3.6;

— requirements regarding black-panel thermometer, black-standard thermometer, white-panel thermometer, and white-standard thermometer in 5.2 and Table 2 have been clarified;

— reference to ISO 23741 has been added in 5.3.1;

— new subclause 7.3 “Sampling for intermediate and final evaluation” has been added;

— requirements for the test report have been updated;

— reference to CIE 85 in Annex C has been updated to CIE 241.

A list of all parts in the ISO 4892 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Plastics are often used outdoors or in indoor locations where they are exposed to solar radiation or to window-glass-filtered solar radiation for long periods. It is therefore very important to determine the effects of solar radiation, heat, moisture and other climatic stresses on the colour and other properties of plastics. Outdoor exposures to solar radiation and to solar radiation filtered by window glass are described in ISO 877 (all parts)[1]. However, it is often necessary to rapidly determine the effects of radiation, heat and moisture on the physical, chemical and optical properties of plastics with artificial accelerated weathering or artificial accelerated irradiation exposures that use specific laboratory light sources. Exposures in these laboratory devices are conducted under more controlled conditions than found in natural environments and are intended to accelerate eventual polymer degradation and product failures.

Relating results from accelerated weathering or artificial accelerated irradiation exposures to those obtained in actual-use conditions is difficult because of variability in both types of exposure and because laboratory tests never reproduce exactly all the exposure stresses experienced by plastics exposed in actual-use conditions. No single laboratory exposure test can be specified as a total simulation of actual-use exposures.

The relative durability of materials in actual-use exposures can be very different depending on the location of the exposure because of differences in UV radiation, time of wetness, temperature, pollutants and other factors. Therefore, even if results from specific accelerated weathering or artificial accelerated irradiation exposures are found to be useful for comparing the relative durability of materials exposed in a particular outdoor location or in particular actual-use conditions, it cannot be assumed that they will be useful for determining the relative durability of materials exposed in a different outdoor location or in different actual-use conditions.

Plastics — Methods of exposure to laboratory light sources —

Part 1:
General guidance and requirements

1 Scope

This document provides general guidance and requirements relevant to the selection and operation of the methods of exposure described in detail in subsequent parts of the ISO 4892 series. It also specifies general performance requirements for devices used for exposing plastics to laboratory light sources. Information regarding performance requirements is for producers of artificial accelerated weathering or artificial accelerated irradiation devices.

This document also provides information on the interpretation of data from artificial accelerated weathering or artificial accelerated irradiation exposures. More specific information about methods for determining the change in the properties of plastics after exposure and reporting these results is not part of this document.

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

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

ISO 4582, *Plastics — Determination of changes in colour and variations in properties after exposure to glass-filtered solar radiation, natural weathering or laboratory radiation sources*

ISO 4892-2, *Plastics — Methods of exposure to laboratory light sources — Part 2: Xenon-arc lamps*

ISO 4892-3, *Plastics — Methods of exposure to laboratory light sources — Part 3: Fluorescent UV lamps*

ISO 4892-4, *Plastics — Methods of exposure to laboratory light sources — Part 4: Open-flame carbon-arc lamps*

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

ASTM G113, *Standard terminology relating to natural and artificial weathering tests of nonmetallic materials*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ASTM G113 and the following apply.

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

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

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

3.1
control material
<weathering testing> material which is of similar composition and construction to the test material and which is exposed at the same time for comparison with the test material

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

Note 2 to entry: A control material is sometimes referred to as control.

3.2
file specimen
portion of the material to be tested which is stored under conditions likely to cause minimal material degradation

Note 1 to entry: These are typically dark, dry and temperate conditions.

Note 2 to entry: The file specimen is used for comparison between the exposed and unexposed states.

3.3
artificial accelerated weathering
exposure of a material in a laboratory device intended to simulate outdoor ageing faster by radiation, temperature, and moisture, typically including liquid water

Note 1 to entry: These exposures are typically using a laboratory light source intended to simulate outdoor conditions in an attempt to produce more rapidly the same changes that occur when the material is used in an outdoor environment.

Note 2 to entry: The conditions can be cyclic and intensified compared with those encountered in outdoor exposure.

Note 3 to entry: The device can include means for control and/or monitoring of the light source and other weathering parameters. It may also include exposure to special conditions, such as acid spray to simulate the effect of air pollution.

3.4
artificial accelerated irradiation
exposure of a material to a light source in a laboratory device intended to simulate ageing faster by radiation, temperature, and moisture, typically only in the form of relative humidity, but without liquid water

Note 1 to entry: These exposures are typically using a laboratory light source intended to simulate window-glass-filtered solar radiation or radiation from interior lighting sources in an attempt to produce more rapidly the same changes that occur when the material is used in an indoor environment.

Note 2 to entry: These exposures are commonly referred to as fading or lightfastness tests.

3.5
weathering reference material
material of known performance when exposed to solar radiation, heat and moisture

Note 1 to entry: Weathering reference materials are used for weathering and irradiation testing.

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

3.7
black-panel thermometer
BPT
flat, black coated metal plate which is exposed to radiation, with a temperature sensor attached to the front centre of the exposed surface

Note 1 to entry: The intention is to mimic the thermal conditions of a coated black metal panel. The measured temperature depends on heat fluxes by short and long wavelength radiation and convection on the front side and the rear side of the panel.

Note 2 to entry: The BPT provides a measure for the reference surface temperature of irradiated surfaces. The BPT will typically show lower temperatures than the black-standard thermometer under the same conditions.

Note 3 to entry: Black-panel thermometers are sometimes referred to as uninsulated black-panel thermometers.

3.8
black-standard thermometer
BST
flat, black coated metal plate which is exposed to radiation, with a thermal insulation on the backside and the temperature sensor is attached to the rear centre of the exposed plate and between metal plate and insulation

Note 1 to entry: The intention is to mimic the thermal conditions of a common black polymer specimen. The measured temperature depends on heat fluxes by short and long wavelength radiation and convection on the frontside of the panel only.

Note 2 to entry: The BST will show one of the highest temperatures in the specimen plane.

Note 3 to entry: Black-standard thermometers are sometimes referred to as insulated black-panel thermometers.

3.9
white-panel thermometer
WPT
flat, white coated metal plate which is exposed to radiation, with a temperature sensor attached to the front centre of the exposed surface

Note 1 to entry: The intention is to mimic the thermal conditions of a coated white metal panel. The measured temperature depends on heat fluxes by short and long wavelength radiation and convection on the front side and the rear side of the panel.

Note 2 to entry: The WPT provides a measure for the reference surface temperature of irradiated surfaces. The WPT will typically show lower temperatures than the white-standard thermometer.

3.10
white-standard thermometer
WST
flat, white coated metal plate which is exposed to radiation, with a thermal insulation on the backside and the temperature sensor is attached to the rear centre of the exposed plate and between metal plate and insulation

Note 1 to entry: The intention is to mimic the thermal conditions of a common white polymer specimen. The measured temperature depends on heat fluxes by short and long wave radiation and convection on the frontside of the panel only.

4 Principle

4.1 General

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

NOTE In this document, the term “light source” refers to radiation sources that emit UV radiation, visible radiation, infrared radiation or any combination of these types of radiation.

4.2 Significance

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

4.2.2 No laboratory exposure test can be specified as a total simulation of actual-use conditions. Results obtained from artificial accelerated weathering or artificial accelerated irradiation exposures can be considered as representative of actual-use exposures only when the degree of rank correlation has been established for the specific materials being tested and when the type and mechanism of degradation are the same. The relative durability of materials in actual-use conditions can be different depending on location because of differences in UV radiation, time of wetness, relative humidity, temperature, pollutants and other factors. Therefore, even if results from a specific exposure test conducted in accordance with any of the parts of ISO 4892 are found to be useful for comparing the relative durability of materials exposed in a particular environment, it cannot be assumed that they will be useful for determining the relative durability of the same materials in a different environment.

4.2.3 A specific exposure duration or radiant exposure in an artificial accelerated weathering or artificial accelerated irradiation exposure cannot generally be correlated to a defined duration under end use conditions. It is therefore incorrect to assign a general acceleration factor valid for all materials. Such an acceleration factor cannot be general for the following reasons.

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

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

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

NOTE Acceleration factors determined for a specific formulation of a material are valid, but only if they are based on data from a sufficient number of separate exterior or indoor environmental tests and artificial accelerated weathering or artificial accelerated irradiation exposures. Results used to relate times to failure or to a specified property change in each exposure can be analysed using statistical methods. An example of a statistical analysis using multiple laboratory and actual exposures to calculate an acceleration factor is described in Reference [2].

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

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

   NOTE ISO/TR 18486[3] provides information to compare a laboratory light source to a reference solar spectrum.

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

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

d) specimen temperatures higher than those in actual conditions;

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

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

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

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

4.3 Use of accelerated tests with laboratory light sources

4.3.1 Results from artificial accelerated weathering or artificial accelerated irradiation exposures conducted in accordance with any of the parts of ISO 4892 are best used to compare the relative performance of materials. Comparisons between materials are best made when the materials are tested at the same time under the same conditions in the same exposure device. Results can be expressed by comparing the exposure time or radiant exposure necessary to reduce the level of a characteristic property to some specified level. A common application of this is a test conducted to establish that the level of quality of different batches does not vary from that of a control of known performance.

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

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

4.3.2 In some specification tests, test materials are exposed at the same time as a weathering reference material (e.g. blue wool test fabric). The property or properties of the test material are measured after a defined property of the weathering reference material reaches a specified level. If the weathering reference material differs in composition from the test material, it can be insensitive to exposure stresses that produce failure in the test material or it can be very sensitive to an exposure stress that has very little effect on the test material. If that is the case, the variability in results for the weathering reference material may be very different from that for the test material. Different sensitivities of the weathering reference material and the test material can produce misleading results when the weathering reference material is used as a control or to determine the length of the exposure period.

NOTE Weathering reference materials can also be used to monitor the consistency of the operating conditions in an exposure test. Information about the selection and characterization of weathering reference materials used for this purpose can be found in Reference [4]. Reference [5] describes a procedure which uses the change in the carbonyl index of a specific polyethylene weathering reference material to monitor conditions in both natural weathering and artificial accelerated weathering exposures.

4.3.3 In some specification tests, properties of test specimens are evaluated after a specific exposure time or radiant exposure using a test cycle with a prescribed set of conditions. Results from any accelerated exposure test conducted in accordance with any of the parts of ISO 4892 should not be used to make a "pass/fail" decision for materials, based on the level of a specific property after a specific exposure time or radiant exposure, unless the combined reproducibility of the effects of a particular exposure cycle and property measurement method has been established.