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Plastics — Test method of exposure to white LED lamps

Plastiques — Méthode d'essai d'exposition aux lampes à LED blanches

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

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Introduction

Fluorescent lamps and incandescent lamps have long been used in homes, offices, retail outlets, factory and commercial facilities. Recently, these facilities have begun changing to white LED (Light Emitting Diode) lamps. White LED lamps are now in wide use. White LED lamps emit no UV radiation, but can cause degradation of some materials. This effect is reported in “Study on conservation aspects using LED technology for museum lighting”[7] and “Study of the light stability of colour photographic reflection prints under LED lighting”[8]. Coloured and uncoloured plastics are used in many places, such as homes, offices and factories. Different plastics can experience different degradation when exposed to white LED lamps as compared to when exposed to fluorescent and incandescent lamps. Therefore, a test method to estimate a product life under white LED lamp is important. This document provides such a test method and also provides some information about the result between this test method and a test method using a xenon-arc lamp (see Annex A).

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Plastics — Test method of exposure to white LED lamps

1 Scope

This document specifies a method for exposing test specimens to white light emitting diode (LED) lamps at specified temperatures and relative humidity.

This document is applicable to coloured and uncoloured plastics that are exposed to white LED lamps in indoor environments such as homes, offices, retail outlets, factory and commercial facilities that do not experience solar radiation through window glass. It can be applicable to plastics in other environments as well.

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

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

CIE 13.3, *Method of measuring and specifying colour rendering properties of light sources*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4892-1 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/

4 Principle

Specimens to be tested are exposed to white LED lamps under controlled conditions. White LED lamps shall emit only visible radiation, excluding ultraviolet radiation. Test conditions of temperature and humidity shall be selected to simulate home or office environments.

5 Apparatus

5.1 Light source

5.1.1 General

The light source shall comprise one or more white LED lamps. Typically, a white LED lamp is used, which is a blue LED chip with phosphors. The following characteristics of the white LED lamps used shall be reported:

— correlated colour temperature, CCT;

— average colour rendering index, R_a, according to CIE 13.3;

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— the manufacturer.

The following additional information should also be reported, if available:

— dominant wavelength of the excitation LED;

— relative spectral irradiance.

NOTE An LED lamp can be an integrated LED lamp (LEDi lamp), or a semi-integrated LED lamp (LEDsi lamp), or a non-integrated LED lamp (LEDni lamp).

5.1.2 Spectral irradiance

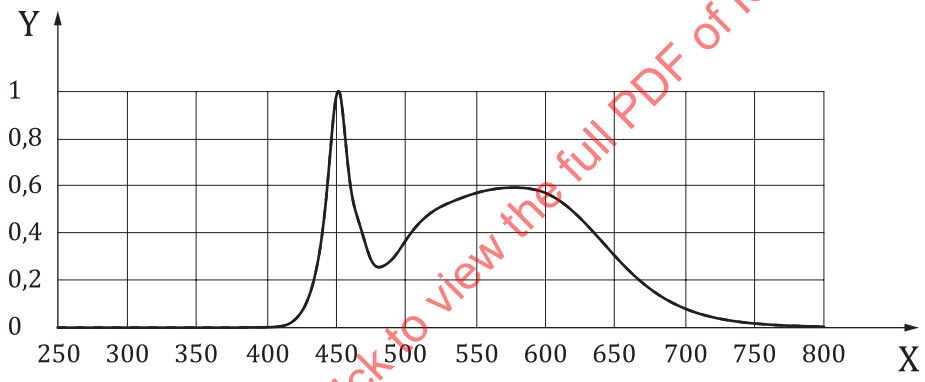
The specification of a typical white LED lamp used in this test method is as follows:

— CCT of 5 000 K ± 250 K;

— R_a > 80;

— Spectral irradiance over the range 300 nm < λ < 400 nm is less than 0,2 % of the total irradiance over the range 300 nm < λ < 800 nm.

Figure 1 shows an example of relative spectral irradiance of a white LED lamp suitable for this test method.



Key

X wavelength (nm)

Y relative spectral irradiance

Figure 1 — Example of relative spectral irradiance of a white LED lamp suitable for this test method

5.1.3 Illuminance uniformity

NOTE The illuminance is the spectral irradiance multiplied by the spectral luminous efficiency function (spectral brightness sensitivity of the human eye in daylight).

The illuminance at any position in the area used for specimen exposure shall be at least 90 % of the maximum illuminance, unless specimen repositioning is performed. Requirements for periodic repositioning of specimens when this requirement is not met are described in ISO 4892-1.

For some materials that have high reflectivity or high sensitivity to illuminance and temperature, periodic repositioning of specimens is recommended to ensure uniformity of exposures, even when the illuminance uniformity in the exposure area is within the limits so that repositioning is not required.

5.2 Test chamber

The design of the exposure chamber can vary, but it shall be constructed from inert material and provide uniform illuminance in conformance with 5.1.3, with means for controlling the temperature.

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5.3 Integrated illuminance meter

An illuminance meter built into the laboratory exposure device shall be used to measure the illuminance, $E_{\text{illuminance}}$, and the illuminance exposure, $H_{\text{illuminance}}$. This meter shall have spectral response corresponding to the photopic standard luminous efficiency V(λ), which is identical to the colour-matching function y(λ) specified in ISO 11664-1. In this case, the illuminance is reported in lux and the illuminance exposure is reported in lux·h.

5.4 Black-panel thermometer

The black-panel thermometer used shall conform with the requirements for these devices given in ISO 4892-1.

5.5 Humidity

Relative humidity shall be measured. The location of the sensors used to measure the humidity shall be as specified in ISO 4892-1.

5.6 Specimen holders

Specimen holders shall conform with the requirements in ISO 4892-2.

5.7 Apparatus to assess changes in properties

If an International Standard relating to the determination of the properties chosen for monitoring the changes in properties exists (see, in particular, ISO 4582), the apparatus specified by the International Standard concerned shall be used.

6 Test specimens

Test specimens shall conform to ISO 4892-1.

7 Exposure conditions

The range of set points and allowable deviation are specified in Table 1 and shall be used.

Other parameters may be used when agreed on by the interested parties, but shall be stated in the test report.

Table 1 — Range of set points and allowable deviation for exposure condition

Set point parameter	Range of setpoint	Allowable deviation
Illuminance at the specimen plane (klx)	≤ 80	±5
Black panel temperature (°C)	25 to 35	±3
Chamber air temperature (°C)	21 to 27	±3

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8 Procedure

8.1 General

It is recommended that at least three test specimens of each material evaluated be exposed in each run to allow statistical evaluation of the results.

8.2 Mounting of test specimens

Mounting of test specimens shall conform to ISO 4892-2.

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8.3 Exposure

The procedure of exposure shall conform to ISO 4892-2.

8.4 Measurement of illuminance exposure

Mount and calibrate the integrated illuminance meter so that it measures the illuminance exposure (lux·h) at the exposed surface of the test specimen.

8.5 Determination of changes in properties after exposure

Determination of changes in properties after exposure shall conform to ISO 4892-2.

NOTE Annex A describes a study that compares exposure test results from the use of white LED lamps and from the use of a xenon-arc lamp through window glass.

9 Test report

The test report shall contain at least the following information:

a) a reference to this document, including the year of publication, i.e. ISO/TS 5733:2024;

b) specimen description in accordance with ISO 4892-1;

c) description of exposure test conducted

   1) type of white LED lamp (manufacturer, model name, CCT and R_a);

   2) set points of illuminance, black panel temperature and chamber air temperature;

   3) measured relative humidity;

   4) illuminance exposure (lux·h);

   5) description of the method used to mount the specimens in the exposure frame, including a description of any material used as backing for the test specimens;

   6) procedure for test specimen repositioning, if used;

   7) date of the exposure test;

d) test result in accordance with ISO 4892-1.

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Annex A
(informative)

Example of exposure test results

A.1 Purpose of this study

This annex describes a study that compares exposure test results from the use of white LED lamps and from the use of a xenon-arc lamp through window glass.

A.2 Test conditions

A.2.1 Exposure test using white LED lamps

The light source for this test is white LED lamps with CCT of 5 000 K, R_a of 86, and dominant wavelength of excitation LED of 450 nm. Test parameters are shown in Table A.1. The spectral irradiance is shown in Figure A.1.

Table A.1 — Parameters of exposure test using white LED lamps

Parameter	
Illuminance at the specimen plane (klx)	70 ± 3
Black panel temperature (°C)	32 ± 3
Chamber air temperature (°C)	23 ± 3
Relative humidity (% rh)	50 ± 10

A.2.2 Exposure test using a xenon-arc lamp through window glass

Conditions for this test are in accordance with ISO 4892-2, method B5, with test parameters shown in Table A.2. The spectral irradiance is shown in Figure A.1.

Table A.2 — Set points of exposure test using a xenon-arc lamp

Parameter	
Irradiance, 300 to 400 nm (W/m^2)	50 ± 2
Black panel temperature (°C)	63 ± 3
Chamber air temperature (°C)	38 ± 3
Relative humidity (% rh)	50 ± 10

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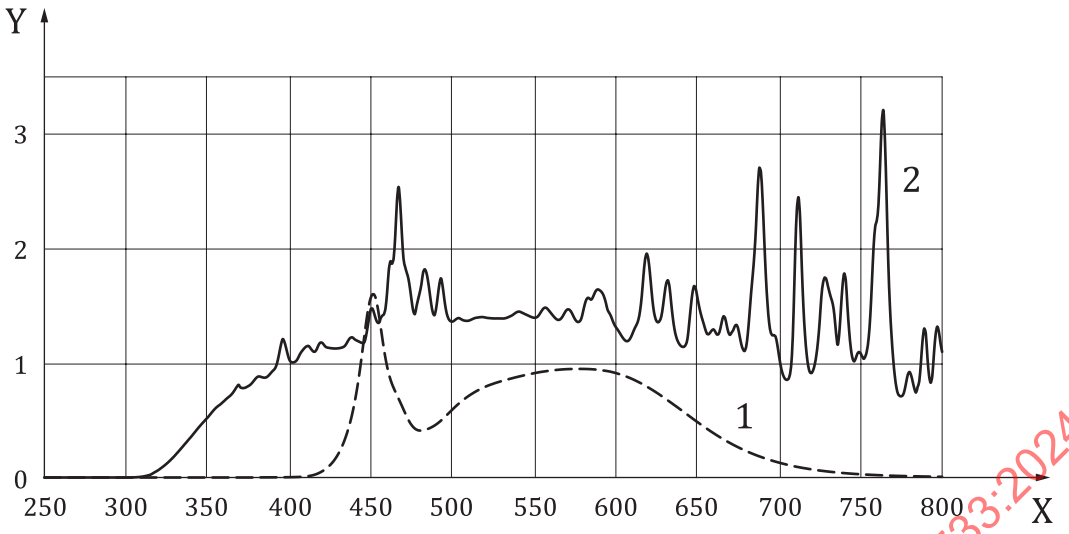

Key

X	wavelength (nm)	1	white LED lamp
Y	spectral irradiance ($W \cdot m^{-2} \cdot nm^{-1}$)	2	xenon-arc lamp through window glass

Figure A.1 — Spectral irradiance of light source

A.3 Test specimens

Two types of polypropylene (PP) specimens were tested (with and without weathering-resistant additive), each with four different colourings (un-coloured, yellow, pink and red). The weathering resistant additive is based on hindered amine light stabiliser (HALS). Acrylonitrile-butadiene-styrene (ABS) specimens were also tested with the same four colourings (un-coloured, yellow, pink and red).

A.4 Evaluation by spectral reflectance and colour difference

Colour measurement is performed according to CIE 15. The spectral reflectance from 380 nm to 780 nm is determined using de:8° geometry, with measured diameter of 5 mm. Colour difference (ΔE*ab) is calculated according to ISO/CIE 11664-4 with C-2°.

A.5 Test result

A.5.1 Exposure test using white LED lamp

The results of exposure tests using white LED lamp are shown in Figure A.2.

The ΔE*ab of PP with and without weathering-resistant additive were almost the same. Both grades of un-coloured PP experienced a small degree of colour change. Red PP changed colour more than yellow and pink.

In the case of ABS, un-coloured specimens exhibited more colour change than the coloured specimens.

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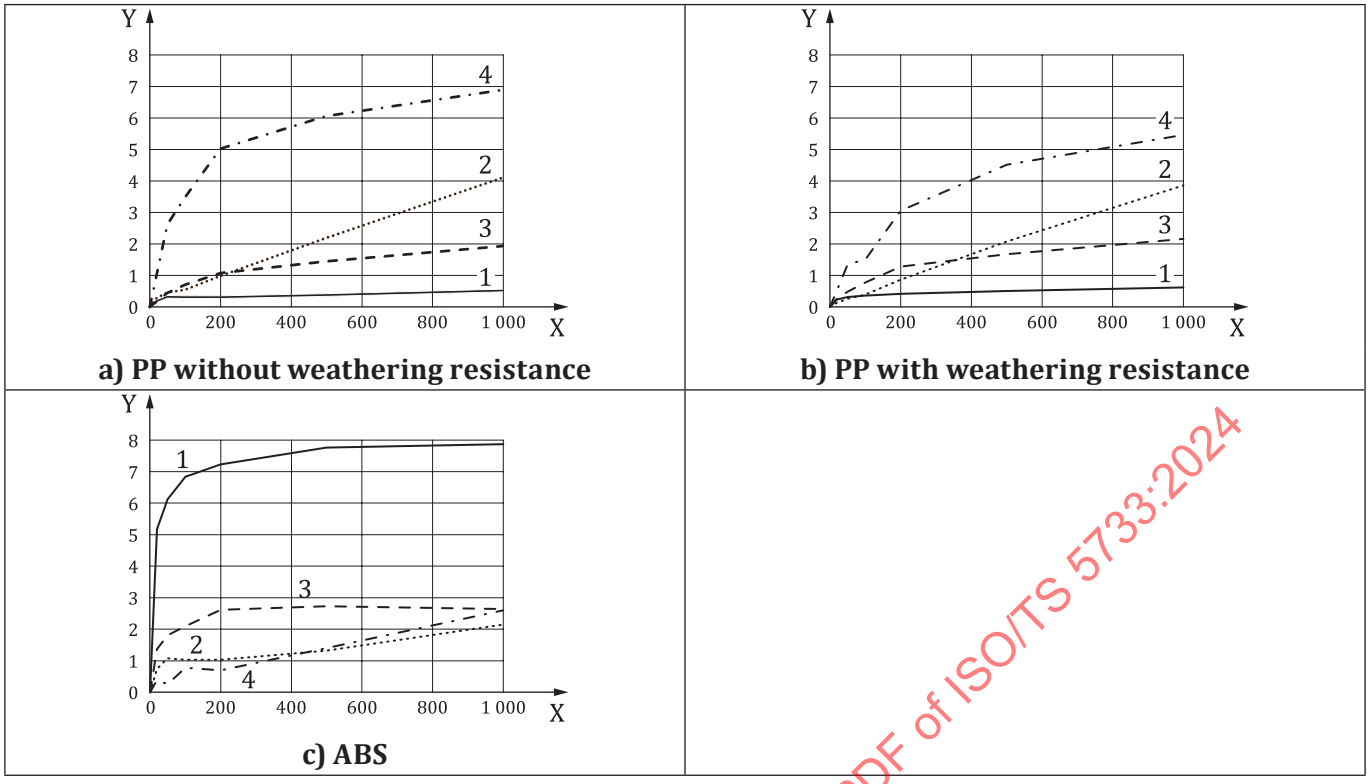

Key

X	test period (h)	Y	colour difference (ΔE*ab)
1	un-coloured	2	yellow
3	pink	4	red

Figure A.2 — Results of exposure test using white LED lamp

A.5.2 Exposure test using xenon-arc lamp through window glass

The results of exposure tests using xenon-arc lamp through window glass are shown in Figure A.3.

The ΔE*ab of un-coloured PP with weathering-resistant additive was less than without weathering-resistant additive. The ΔE*ab values of pink and red PP specimens with weathering-resistant additive were also less than without weathering-resistant additive. Both grades of yellow PP experienced large colour changes.

In the case of ABS, un-coloured ABS exhibited greater change in colour than the yellow, pink, and red specimens.

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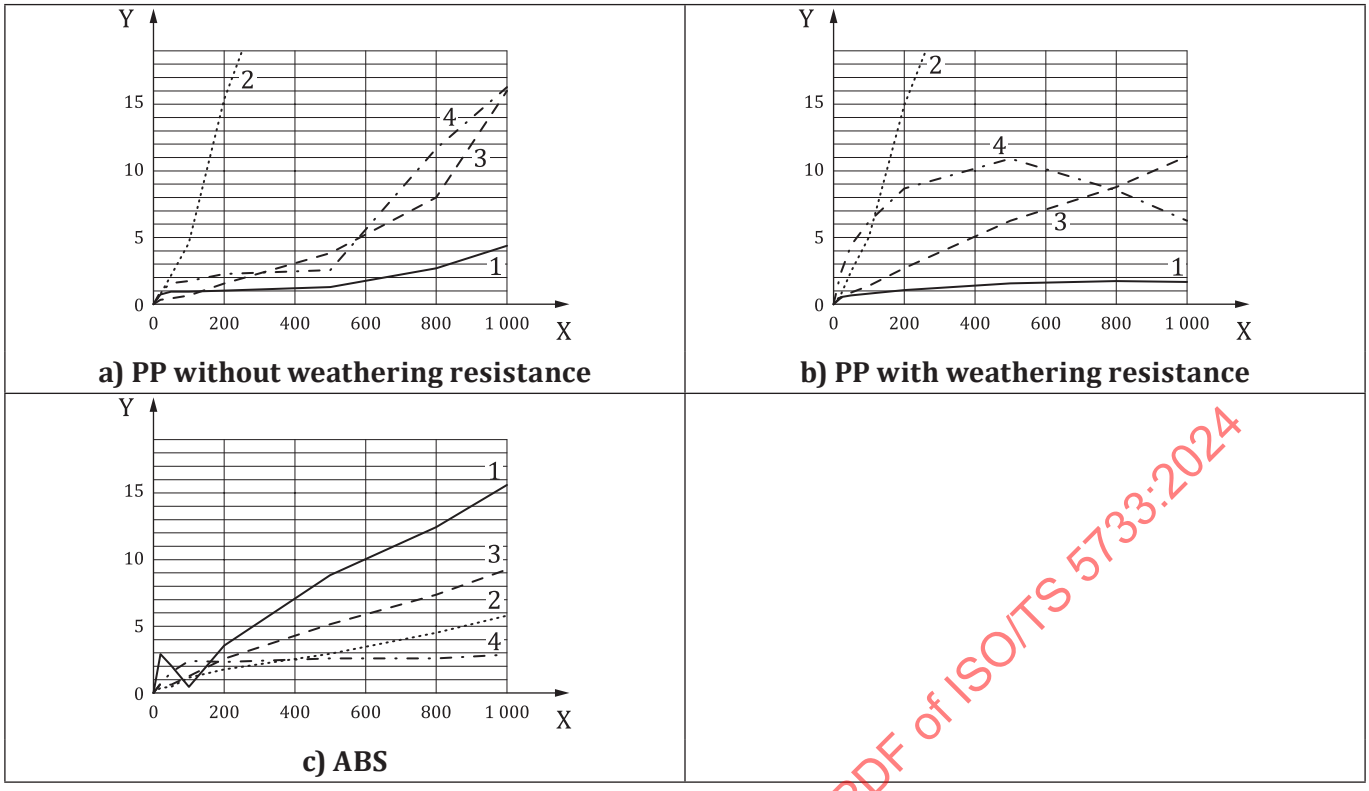

a) PP without weathering resistance

b) PP with weathering resistance

c) ABS

Key

X	test period (h)	Y	colour difference (ΔE*ab)
1	un-coloured	2	yellow
3	pink	4	red

Figure A.3 — Results of exposure test using xenon-arc lamp through window glass

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A.6 Comparison between light sources

A.6.1 PP

Both grades of red PP experienced large colour changes when exposed to white LED lamps, while both grades of yellow PP showed large colour changes when exposed to a xenon-arc lamp through window glass. The ΔE*ab of PP without weathering-resistant additive was, as expected, larger than PP with weathering-resistant additive when tested with a xenon-arc lamp. However, both grades experienced almost the same degree of colour change when they were tested with white LED lamps.

A.6.2 ABS

The results of spectral reflectance for un-coloured ABS are shown in Figure A.4. The un-coloured ABS has a slight yellow colour to begin with. This material changed to yellow during the exposure test using a xenon-arc lamp, but experienced whitening during the exposure test using white LED lamps.

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