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Imaging materials — Methods for measuring indoor light stability of photographic prints —

Part 2: Xenon-arc lamp exposure

Matériaux pour l'image — Méthodes de mesure de la stabilité de la lumière en intérieur des épreuves photographiques —

Partie 2: Exposition à une lampe à arc au xénon

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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.

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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For an explanation of 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 42, *Photography*. This first edition of ISO 18937-2 cancels and replaces the second edition of ISO 18937:2020, which has been technically revised.

The main changes are as follows:

— This revision of the existing ISO 18937 separates the International Standard into three separate parts in a similar way to two other artificial exposure testing series, ISO 4892 (Plastics, in TC 61), and ISO 16474 (Paints and varnishes, in TC 35).

A list of all parts in the ISO 18937 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.

Imaging materials — Methods for measuring indoor light stability of photographic prints —

Part 2:
Xenon-arc lamp exposure

1 Scope

This document describes test equipment and procedures for measuring the light stability of photographic prints when subjected to a filtered xenon-arc light source at specified levels of illuminance (irradiance), temperature and relative humidity. It is applicable to both colour and monochrome reflection prints, transparent films, or translucent films. It is also applicable to photographic prints in general, photobooks, or prints for backlit displays.

General indoor display conditions described herein are intended to simulate common use conditions found in houses, apartments and other dwelling places where indirect lighting due to filtering (through window glass) and shading is often the principal illumination causing displayed photographs to fade.

Simulated in-window display conditions are intended to simulate terrestrial daylight transmitted through standard architectural window glass (double glazing). A typical example of such display can be found when images are displayed in store windows, facing toward the outdoors, so that they can be viewed by people outside of the store[5][6].

NOTE It is recognized that in some instances, physical degradation such as support embrittlement, image layer cracking, or delamination of an image layer from its support, rather than the stability of the image itself, will determine the useful life of a print material.

General guidance is given in ISO 18937-1.

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

ISO 18913, *Imaging materials — Permanence — Vocabulary*

ISO 18937-1, *Imaging materials — Photographic reflection prints — Methods for measuring indoor light stability — Part 1: General guidance and requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 18913 apply.

ISO and IEC maintain terminological 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

A xenon arc lamp, fitted with filters, is used to simulate the relative spectral irradiance of various end-use conditions to simulate standardized indoor lighting conditions by their relative spectral irradiance in the ultraviolet (UV) and visible regions of the spectrum.

Depending on intended user or application cases, specimens are exposed to desired levels of light, heat, and relative humidity under controlled environmental conditions.

The exposure conditions are varied by selection of

a) the light filter(s),

b) the irradiance or illuminance level,

c) the temperature during exposure to light,

d) the relative humidity in the chamber during light and dark exposures,

e) the relative duration of the light and dark periods.

The procedure includes measurements of the irradiance or illuminance and radiant exposure in the plane of the specimens.

5 Apparatus

5.1 Laboratory light source.

5.1.1 General

The light source shall comprise one or more quartz-jacketed xenon-arc lamps which emit radiation from below 270 nm in the ultraviolet through the visible spectrum and into the infrared. In order to simulate the end-use conditions, filters shall be used to remove short-wavelength UV radiation.

5.1.2 Optical filters.

Filters are used with the intention of reproducing as closely as possible different end-use lighting conditions[3][4]. Special filtering of the xenon-arc lamp is used to achieve two specific lighting conditions applicable to this method.

The optical filters shall be placed at any position between the light source and the specimens to achieve the required spectral irradiance conditions. The filters can be placed near the light source or near the specimens, but the air gap between the specimens and the filter shall allow an unobstructed airflow between the filter and the specimens.

5.1.3 Irradiance uniformity.

The irradiance at any position in the area used for specimen exposure shall be at least 80 % of the maximum irradiance. Periodic repositioning of specimens when irradiance uniformity is between 80 % and 90 % is described in ISO 18937-1.

NOTE For some materials of 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 where repositioning would not be required.

5.2 Test chamber.

The design of the test chamber may vary, but it shall be constructed from inert material. The test chamber shall provide control systems for irradiance, temperature and humidity.

The light source(s) shall be located, with respect to the specimens, such that the irradiance (or illuminance) at the specimen surface conforms with 7.1.

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 can be reduced by using a rotating rack.

5.3 Radiometer.

Radiometers or illuminance meters used shall conform with the requirements outlined in ISO 18937-1 and ISO 9370.

5.4 Black-panel thermometer.

The black-panel thermometer shall conform with the requirements for these devices given in ISO 18937-1.

5.5 Humidity.

The specific end-use conditions describe the required humidity level control. The location of the sensors used to measure the humidity shall be as specified in ISO 18937-1.

5.6 Specimen holders.

Specimen holders may be constructed in the form of an open frame, leaving the backs of the specimens exposed, or they may provide a solid backing for the specimens. Transparent or translucent materials shall always be exposed with an open backing. They shall be made from inert materials that will not affect the results of the exposure. The backing used may affect the results, especially with respect to specimen temperature.

5.7 Apparatus to assess changes in properties.

For print materials, measurements of colorimetric or densitometric properties are typically used to assess property change before and after exposure. Data are commonly reported in graph form, with exposure level as the x-axis and densitometric or colorimetric change as the y-axis.

5.8 Air quality in the test environment.

Some types of print materials can be highly sensitive to degradation caused by ozone or other airborne pollutants. See ISO 18937-1 for requirements related to monitoring and reduction of these pollutants.

6 Test specimens

ISO 18937-1 contains information related to the requirements for test specimen creation, replication, conditioning, handling, and positioning in the exposure area.

7 Exposure conditions

7.1 General

If a reciprocity behaviour test is conducted, lower radiant intensity, e.g. 10 % of nominal condition, shall be used (details are described in ISO 18937-1:2023, Annex A).

7.2 General indoor display

7.2.1 Application

This test is intended to simulate common use conditions found in houses, apartments and other dwelling places where indirect lighting due to filtering (through window glass) and shading is often the principal illumination causing displayed photographs to fade. A UV-filtered xenon-arc lamp is found to provide a reasonable match to indirect, window-filtered daylight[6][7][8]. The specimen temperature is dominated by ambient conditions.

7.2.2 Filters to simulate general indoor display conditions

This filter system shall consist of window-glass filters and an additional UV cut-off filter that has 50 % transmittance at a wavelength between 370 nm and 375 nm. The resulting spectral irradiance shall be in accordance with Table 1.

Examples of the standard UV cut-off filter and their corresponding spectral transmission characteristics are shown in Table A.1 and Table A.2.

NOTE 1 The window-glass filters with a spectral irradiance conforming to Table 3 can be used.

NOTE 2 Examples of an acceptable UV cut-off filter are L-37 (Hoya Co.) and SC-37 (Fujifilm Co.).

In order to maintain conformity, the filter shall be cleaned or replaced per OEM instructions.

Optical filters shall be positioned according to the second paragraph of 5.1.2.

Table 1 provides the relative spectral irradiance in the given passband, expressed as a percentage of the total irradiance between 300 nm and 800 nm.

Table 1 — Relative spectral irradiance for filtered Xenon-arc lamp for simulated general indoor display

Spectral passband wavelength, λ nm	Relative spectral irradiance %
$300 \leq \lambda < 340$	0,0 to 0,1
$340 \leq \lambda < 370$	0,2 to 1,0
$370 \leq \lambda < 400$	2 to 5
$400 \leq \lambda < 430$	4 to 8
$430 \leq \lambda < 800$	86 to 93

7.2.3 Radiation intensity, temperature, and humidity

The following range of set points given in Table 2 shall be used, with acceptable deviations based on the data provided in Annex B.

Table 2 — Set values for simulated general indoor display

Illuminance at the specimen plane (klx)	≤80
Black panel temperature (uninsulated) (°C)	25 to 35
Chamber air temperature (°C)	21 to 27
Relative humidity (%RH)	50

The tolerance of operational fluctuation for the parameters above are listed in ISO 18937-1.

The radiation intensity, black panel temperature, and chamber air temperature range of set points in the above table are intended to result in a photographic print exposed under these conditions to be indirectly controlled at a temperature between 25 °C to 30 °C. The construction and absorption properties of the black panel temperature will result in temperatures 3 °C to 8 °C higher than the photographic prints exposed, as shown by the data in Annex B.

An IR-reducing filter can be used if the uninsulated black panel temperature and/or chamber temperature cannot be controlled at the set points listed.

NOTE Annex B provides a table of temperature measurement data of a gray (0,75 OD) target sample with a variety of illuminance and chamber temperature settings, as well as with/without IR-attenuating filters. Combinations of these variables can be used based on guidance from this table in order to achieve the targeted sample temperature of 25 °C to 30 °C.

Radiation intensity can be measured in irradiance units in place of the stated illuminance units. When testing with the L-37 or SC-37 filter, light intensity shall be measured in lux with an illuminance meter or in irradiance with an irradiance meter. If radiation intensity is measured in irradiance units in place of the stated illuminance units, irradiance may be controlled at 420 nm. Contact the radiant exposure apparatus manufacturer to obtain appropriate conversions from illuminance to irradiance.

7.3 Simulated in-window display

7.3.1 Application

This test is intended to simulate terrestrial daylight transmitted through standard architectural window glass (double glazing). A typical example of such display can be found when images are displayed in store windows, facing toward the outdoors, so that they may be viewed by people outside of the store[2][5].

Two testing conditions are noted. Table 4 describes a test that includes higher temperatures caused by strong radiative heating, and light/dark cycling to promote stress fatigue. The cycling simulates episodes with elevated temperature differences between colours and between the imaging layer and support, as well as episodes of elevated specimen temperature with reduced moisture content (hot light phase) and remoistening (cool dark phase). Table 5 describes a continuous light test at lower temperatures to simulate limited radiative heating, such as show windows in an air-conditioned air space, with sun shade or orientation away from the equator. The continuous light simulates limited stress fatigue as compared to the cyclic test conditions.

7.3.2 Filtered xenon arc configuration to simulate in-window display conditions

This filter system shall consist of a window-glass filter with spectral irradiance in accordance with Table 3 and may be used with or without a standard IR filter (the IR filter can be used if it is necessary to attain the black panel temperature).

In order to maintain conformance, the filter shall be cleaned or replaced per OEM instructions.

Optical filters shall be positioned according to the second paragraph of 5.1.2.

Table 3 gives the relative spectral irradiance in the given bandpass, expressed as a percentage of the total irradiance between 300 nm and 800 nm.

Table 3 — Relative spectral irradiance for filtered Xenon-arc lamp for in-window display

Spectral bandpass Wavelength, λ nm	Relative spectral irradiance %
$300 \leq \lambda < 340$	0,2 to 1,2
$340 \leq \lambda < 370$	2,8 to 3,5
$370 \leq \lambda < 400$	3 to 5
$400 \leq \lambda < 430$	4 to 7
$430 \leq \lambda < 800$	83 to 88

7.3.3 Radiation intensity, temperature and humidity

Two test cycles are listed: a light/dark cycling test and a continuous light test. The conditions for the light cycle and dark cycle are shown in Table 4. The conditions for the continuous light test are shown in Table 5.

Depending on the intended use profile, of the of sets of set points in Table 4 or Table 5 shall be used:

Table 4 — Set values for light/dark cycling conditions for simulated in-window display

Parameter	Light phase	Dark phase
Illuminance at the specimen plane (klx)	≤100	Not controlled
Phase duration (hours)	3,8	1,0
Black panel temperature (uninsulated) (°C)	63	Not controlled
Chamber air temperature (°C)	40	25
Relative humidity (%RH)	40	80

Table 5 — Set values for continuous conditions for simulated in-window display

Parameter	Conditions
Illuminance at the specimen plane (klx)	50 to 80
Black panel temperature (uninsulated) (°C)	35
Chamber air temperature(°C)	25
Relative humidity (%RH)	50

The tolerance of operational fluctuation for the parameters above are listed in ISO 18937-1.

Radiant intensity can be measured in irradiance units in place of the stated illuminance units. Contact the radiant exposure apparatus manufacturer to obtain appropriate conversions from illuminance to irradiance.

Exposures to simulate other specific use-cases (backlit displays, for example) may require different exposure conditions than those referenced in the previous sections.

8 Test result measurement and report

Reporting requirements are listed in ISO 18937-1:2023, Clause 8.

Annex A
(informative)

Relative spectral transmittance of filters

Table A.1 — Relative spectral transmittance of L37 filter

Wavelength nm	Transmittance %		Wavelength nm	Transmittance %		Wavelength nm	Transmittance %
300	0,0		470	90,4		640	90,7
305	0,0		475	90,5		645	90,7
310	0,0		480	90,4		650	90,8
315	0,0		485	90,6		655	90,8
320	0,0		490	90,5		660	90,8
325	0,0		495	90,5		665	90,8
330	0,0		500	90,7		670	90,7
335	0,0		505	90,5		675	90,9
340	0,0		510	90,6		680	91,0
345	0,0		515	90,5		685	90,9
350	0,0		520	90,5		690	91,0
355	1,0		525	90,5		695	91,2
360	6,6		530	90,6		700	91,0
365	20,7		535	90,6		705	91,0
370	37,0		540	90,6		710	91,0
375	52,6		545	90,6		715	91,1
380	63,6		550	90,7		720	91,0
385	72,0		555	90,6		725	91,2
390	77,4		560	90,6		730	91,1
395	81,4		565	90,7		735	91,2
400	84,1		570	90,6		740	91,1
405	86,0		575	90,7		745	91,1
410	87,1		580	90,7		750	91,4
415	88,2		585	90,5		755	91,1
420	88,7		590	90,6		760	91,3
425	89,2		595	90,7		765	91,2
430	89,5		600	90,5		770	91,3
435	89,7		605	90,5		775	91,5
440	89,9		610	90,7		780	91,1
445	90,1		615	90,7		785	91,0
450	90,1		620	90,6		790	91,5
455	90,1		625	90,7		795	91,3
460	90,4		630	90,7		800	91,2
465	90,3		635	90,8			

Table A.2 — Relative spectral transmittance of SC37 filter

Wavelength nm	Transmittance %	Wavelength nm	Transmittance %	Wavelength nm	Transmittance %
300	0,0	470	92,1	640	92,3
305	0,0	475	92,1	645	92,3
310	0,0	480	92,1	650	92,4
315	0,0	485	92,2	655	92,5
320	0,0	490	92,2	660	92,4
325	0,0	495	92,2	665	92,5
330	0,0	500	92,3	670	92,4
335	0,1	505	92,2	675	92,5
340	0,1	510	92,2	680	92,6
345	0,4	515	92,2	685	92,5
350	1,5	520	92,2	690	92,5
355	5,0	525	92,2	695	92,7
360	12,7	530	92,3	700	92,5
365	26,7	535	92,3	705	92,5
370	42,5	540	92,2	710	92,6
375	58,8	545	92,3	715	92,6
380	70,5	550	92,2	720	92,6
385	79,0	555	92,2	725	92,7
390	84,3	560	92,3	730	92,6
395	87,5	565	92,3	735	92,8
400	89,3	570	92,3	740	92,7
405	90,4	575	92,4	745	92,8
410	90,8	580	92,2	750	92,7
415	91,3	585	92,2	755	92,5
420	91,5	590	92,4	760	92,6
425	91,7	595	92,2	765	92,8
430	91,7	600	92,2	770	92,7
435	91,9	605	92,3	775	93,2
440	91,8	610	92,3	780	92,5
445	91,9	615	92,3	785	92,5
450	91,9	620	92,2	790	93,1
455	92,0	625	92,4	795	92,9
460	92,0	630	92,3	800	92,7
465	92,0	635	92,4		

Annex B
(informative)

Sample temperature measurements based on different parameters

Table B.1 provides a range of sample surface temperatures measured by two xenon-arc instrument manufacturers. The samples were a gray (0,75 ± 0,05) OD target, measured with an IR pyrometer, see also Figure (B.1) and Figure (B.2). The purpose of this table is to provide the user with information on appropriate parameter settings to achieve a sample temperature range of 25 °C to 30 °C, since the actual sample temperature will be a factor of the illuminance, the chamber air temperature, and if IR-attenuating filters are used.

In summary, three chamber temperature set points, three illuminance levels, and three filter systems (without IR filter, with IR filter, and with two IR filters are presented. Note that for one manufacturer, either the chamber air temperature could not be achieved, or the double IR-attenuating filters are not available. Those conditions have been indicated with a “N/A,” or “Not Achievable” designation.

For the 0,75 OD sample temperatures, cells have been highlighted to indicate if the sample temperature was below (grey), within (light gray), or above (dark grey) the target temperature of 25 °C – 30 °C.

Table B.1 — Grey sample and BPT surface temperatures with different filters, illumination levels, and chamber temperatures for instruments from two different manufacturers.

Infrared filter used -->	No IR	w/ IR	w/ IRx2	No IR	w/ IR	w/ IRx2	No IR	w/ IR	w/ IRx2
Illuminance (klx) -->	**40**	**40**	**40**	**50**	**50**	**50**	**80**	**80**	**80**
Chamber air temperature (°C)	20			20			20		
BPT - Mfgr. #1 (°C)	25,6	22,3	21,4	26,9	23,2	22,1	30,2	25,4	24,4
BPT - Mfgr. #2 (°C)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Gray (OD 0,75) - Mfgr. #1 (°C)	24	21,4	20,9	24,9	22,2	21,5	27,8	23,7	22,9
Gray (OD 0,75) - Mfgr. #2 (°C)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Chamber air temperature (°C)	23			23			23		
BPT - Mfgr. #1 (°C)	28,5	25,3	24,3	30	26,4	25,3	32,8	28,4	27,4
BPT - Mfgr. #2 (°C)	30	27,9	N/A	31,5	30	N/A	36,2	33	N/A
Gray (OD 0,75) - Mfgr. #1 (°C)	26,9	24,3	23,5	28,3	25,4	24,7	30,3	26,4	25,9
Gray (OD 0,75) - Mfgr. #2 (°C)	23,8	22,6	N/A	24,3	23,6	N/A	27,9	25,5	N/A
Chamber air temperature (°C)	25			25			25		
BPT - Mfgr. #1 (°C)	30,1	27,2	26,3	31,9	28,4	27,2	35	30,7	29,5
BPT - Mfgr. #2 (°C)	31,2	30	N/A	32,4	32	N/A	36,4	35	N/A
Gray (OD 0,75) - Mfgr. #1 (°C)	28,8	26,2	25,6	30,1	27	26,6	32,4	28,9	27,9
Gray (OD 0,75) - Mfgr. #2 (°C)	24,6	24,4	N/A	25,1	25,9	N/A	27,9	27,7	N/A
Chamber air temp (°C)	27			27			27		
BPT - Mfgr. #1 (°C)	32,3	29,2	28,3	33,8	30,2	29,4	37,2	32,7	31,3
BPT - Mfgr. #2 (°C)	32,8	32,1	N/A	34,3	34	N/A	38	37	N/A
Gray (OD 0,75) - Mfgr. #1 (°C)	30,5	28,3	27,6	31,8	29,2	28,8	34,6	30,7	29,8
Gray (OD 0,75) - Mfgr. #2 (°C)	26,3	26,3	N/A	27,4	27,5	N/A	29,6	29,7	N/A