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Permanence and durability of commercial prints —

Part 22: Backlit display in indoor or shaded outdoor conditions — Light stability

Permanence et durabilité des impressions commerciales —

Partie 22: Écran rétroéclairé en intérieur ou en extérieur ombragé — Stabilité de la lumière

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Foreword

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This document was prepared by Technical Committee ISO/TC 42, *Photography*.

A list of all parts in the ISO 21139 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

Backlit display of prints is a market segment in context of commerce (advertisement, brand shops) and information (maps, directories). This use profile has specific spectral irradiance and environmental conditions which are different from e.g. general indoor or in-window display (ISO/TS 21139-21).

Backlit display applies with prints on transparent or translucent foils and/or prints on a textile. The document focusses on LED-based backlit units and on the other hand provides information on fluorescent-based backlit units for reference. These backlit displays may be installed indoor or in shaded outdoor conditions, for examples backlit display units in shelters and patios. Backlit displays which are subject to solar radiative heating or precipitation, introducing extensive temperature cycling, are excluded.

Prints on backlit display may fade or otherwise change in appearance due to various environmental stresses, including light, heat, humidity, atmospheric pollutants, or biological attack, and the combination of these factors. One of the most critical degradations is light fading caused by intense irradiation from the backlit unit as well as illumination from the viewing environment, which may represent various levels of intensity and degrees of spectral irradiance, depending on the installation site in a building, near to a window or in a shaded outdoor condition. The factors determining the exposure doses form either frontside or backside are introduced, and the severity of the actual spectral irradiance is expressed as a ratio to the standardized exposure condition “general indoor” as defined by ISO 18937-2.

The lighting design of the backlit display unit may cause inhomogeneity of the backside exposure of the print, which may in turn introduce inhomogeneous patterns of colour fading or discoloration leading to enhanced visibility of degradation (an example is illustrated in Annex B). The test method described in this document does not include the assessment of the impact from inhomogeneity of the backside exposure.

This document provides information about the test conditions for colour fading and discoloration applicable for the different types of display materials, including transparent or translucent films, fabrics as well as paper-based reflection prints. Furthermore, the document gives guidance for estimation of an equivalent exposure dose for the intended time of display, acknowledging the limitations of such generic extrapolations. The display use profile applies for digital and analogue prints.

This test method does not address the adverse effects of exposure to atmospheric pollutants, including ozone, and is also limited to the evaluation of colour changes and therefore does not require specific methods for the evaluation of physical properties, including changes of tensile strength, cockling etc. In the case that backlit materials are constructed from laminates, the aforementioned factors are of less importance.

The general concepts for the exposure characterization of prints on a backlit display provided in this document may also be considered in museum context with details defined by ISO/TS 18950.

Permanence and durability of commercial prints —

Part 22:
Backlit display in indoor or shaded outdoor conditions — Light stability

1 Scope

This document describes the test methods for light stability measurements of prints on transparent or translucent foils, sheets and paper or printed on a textile, which are displayed on backlit units installed in indoor or in shaded outdoor conditions, which are protected against direct precipitation and radiative heating. Installations of backlit display units in outdoor areas without shading, which are exposed to direct weathering and/or radiative heating, are excluded.

This document is applicable to the various product classes of "commercial prints" that are suitable for backlit display. These commercial prints often contain combinations of text, pictorial images and/or artwork.

This document provides guidelines for colour measurements, data analysis and also provides guidance for translation of test results into suitable image permanence performance claims considering the variability of backlit designs and environmental conditions.

This document is applicable to both analogue and digitally printed matter. Methods and principles apply to both, colour, and monochrome prints.

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

ISO 18937-2, *Imaging materials — Methods for measuring indoor light stability of photographic prints — Part 2: Xenon-arc lamp exposure*

ISO/PAS 18940-1, *Imaging materials — Image permanence specification of reflection photographic prints for indoor applications — Part 1: Test methods*

ISO/TS 21139-1, *Permanence and durability of commercial prints — Part 1: Definition of use profiles and guiding principles for specifications*

ISO/TS 21139-21, *Permanence and durability of commercial prints — Part 21: In-window display — Light and ozone stability*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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/

3.1 Measures of exposure severity

3.1.1
relative severity
$\rho_{\mathrm{RSI1/RSI2}}$
ratio of density loss due to light fading for exposure under a given RSI1 in comparison to another given RSI2 with both exposures at the same level of illuminance E_{v} [klx], based on the evaluation of average light fading for a set of colorants used in digital prints

Note 1 to entry: For standardized RSI the relative degree of light fading obtained for the same exposure dose expressed in klx·h has been expressed in relative units to each other based on experimental data and an action spectrum model obtained for typical CMY colorants used in digital printing. The combined information of exposure intensity [klx] and $\rho_{\mathrm{RSI1/RSI2}}$ is therefore equivalent to the description of a spectral exposure, see Annex A.

Note 2 to entry: Standardized RSI include daylight filtered Xenon-arc (see ISO 18930), window-glass filtered Xenon-arc for simulated in-window display or with additional UV blocking for general indoor display (see ISO 18937-2), fluorescent light (see ISO 18909) and LED light (see ISO 18937-3).

EXAMPLE In this method, $\rho_{\mathrm{RSI/GI}}$ denotes the relative severity of a RSI under question compared to the condition of “General Indoor” exposure.

3.1.2
severity weighted exposure
$\tilde{E}_{\mathrm{RSI1/RSI2}}$
measure of the exposure intensity of a given RSI1, where the illuminance E_{v} [klx] is weighted with the duty cycle τ [%] in application and with the *relative severity* (3.1.1) in comparison to a reference RSI2

Note 1 to entry: In this test method, the RSI of the general indoor filtered Xenon-arc test method as defined in ISO 18937-2 is used as the reference RSI, so RSI2 = GI. This spectral irradiance can be achieved using optical filters such as L-37 (Hoya Co.) and SC-37 (Fujifilm Co.).

Note 2 to entry: The severity weighted exposures of the frontside and the backside of a print display on a backlit unit are typically different because of different RSIs, duty cycles and/or intensity.

3.1.3
severity weighted exposure dose
$\tilde{H}_{\mathrm{RSI1/RSI2}}$
measure of the severity weighted exposure that is accumulated during a nominal display duration time, t

Note 1 to entry: In this test method, the RSI of the general indoor filtered Xenon-arc test method as defined in ISO 18937-2 is used as the reference RSI, so RSI2 = GI (“General Indoor”).

Note 2 to entry: The severity weighted exposure dose accumulated on the frontside and the backside of a backlit displayed print, respectively, are typically different and both contribute to colour fading.

3.2 Exposure conditions

3.2.1
UV cut-on [wavelength]
$\lambda_{0,05\,\%}$

wavelength at which the cumulative intensity of a RSI $I(\lambda)$ has reached 0,05 % of its total integrated intensity over the spectral range of 295 nm to 800 nm

Note 1 to entry: $\int_{295\,\text{nm}}^{»0{,}05\,\%} I(»)\,\text{d}» \Big/ \int_{295\,\text{nm}}^{800\,\text{nm}} I(»)\,\text{d}» = 0{,}05\,\%$

3.2.2
shaded outdoor conditions
exposure to indirect terrestrial daylight in a shadow zone, that is characterized by the absence of radiative heating of the prints on backlit display

Note 1 to entry: The UV cut-on ($\lambda_{0,05\,\%}$) is in the range of 295 nm to 310 nm.

EXAMPLE Display in outside shelters and patios.

3.2.3
glass-filtered shaded outdoor display
exposure to *shaded outdoor conditions* (3.2.2) with optical filtering of the irradiance by the front screen material of the backlit display unit

Note 1 to entry: Backlit display units in shaded outdoor conditions practically always require a front screen in front of the print for reasons of electrical safety. Such a front screen is most often realized by safety glass or a similar suitable material. The UV cut-on of PVB laminated safety glass varies between 300 nm to 400 nm depending on its construction and its material formulation. For the purpose of this standard, 6 mm window glass is defined as reference for the filter transmission, acknowledging that the UV transmission of different types of front screens varies.

EXAMPLE Display in backlit units in shaded outdoor conditions with a safety glass front screen.

3.2.4
in-window display
exposure to indirect terrestrial daylight through standard architectural window glass (6 mm)

Note 1 to entry: The UV cut-on ($\lambda_{0,05\,\%}$) is around 320 nm.

EXAMPLE Display in store windows or in other glass-enclosed architectural constructions (hallways, lobbies, verandas), that face toward the outdoors.

3.2.5
general indoor display
exposure to indirect lighting, from due to filtering (through window glass) and shading is often the principal illumination

Note 1 to entry: The UV cut-on ($\lambda_{0,05\,\%}$) is around 350 nm.

EXAMPLE Display in store windows or in other glass-enclosed architectural constructions (hallways, lobbies, verandas), that face toward the outdoors.

3.3 Abbreviations

CCT	correlated colour temperature (IEV ref: 845-23-068)
CIE	Commission internationale de l'éclairage (International Commission on Illumination)
ΔE_{ab}	colour difference defined in ISO/CIE 11664-4[2]
$\Delta E_{ab,\,ave}$	average of the colour differences of the patches of the test target (vs. initial)
$\Delta E_{ab,\,max}$	maximum of the colour differences of the patches of the test target (vs. initial)
ΔE_{00}	colour difference ΔE2000 as defined in ISO/CIE 11664-6[3]

klx·h	kilolux times hour
Mlx·h	megalux times hour
RSI	relative spectral irradiance in $W/(m^2\ nm)$
GI	RSI defined by the test condition "General Indoor" – see ISO 18937-2
E_v [klx]	illuminance (visually weighted)
$\tilde{E}_v^{GI}$ [klx]	illuminance at the test condition of "General Indoor"
τ [%]	duty cycle
$\tilde{H}_{\Delta Eab}$	severity weighted exposure dose at which a certain colour change ΔE_{ab} is observed

4 Use profile

4.1 General

This document describes a test method for prints on transparent or translucent foils and/or on textiles that are displayed on backlit units indoors or in shaded outdoor conditions, where the primary stress factors are exposure to light from both backside and frontside.

NOTE 1 Heat, humidity and atmospheric pollutants can also be stress factors, however this document focuses on light stability. Heat can have effects on prints that are displayed for long time periods on backlit units with elevated temperature, e.g. due to radiative heating by sunlight through window glass or due to dissipative heating from electrical appliances in poor-ventilated constructions of the backlit unit itself.

The use profile of commercial prints is described in general in ISO/TS 21139-1. It specifically describes test methods for backlit display indoor and in shaded outdoor conditions, defined as display use profiles A3 and B1 b) of ISO/TS 21139-1:2019, Table 3, respectively.

NOTE 2 The overall appearance of the displayed prints can also be affected by factors given by the backlit unit itself, including a non-homogenous distribution of the intensity and/or the correlated colour temperature (CCT) of the backlit lighting and/or changes of any other element of the backlit unit, e.g. yellowing of the front screen.

4.2 Parameters of backlit display

A backlit display unit is designed to provide a backside illumination of the print, such that the brightness of the displayed print is comparable to or larger than the light level of the surrounding viewing environment. Furthermore, the CCT of the lamps in the backlit unit is often selected to match the viewing environment, which is typically between 5 000 K to 6 500 K for naturally illuminated areas and 3 000 K or 4 000 K for some indoor installations.

The spectral irradiance, intensity, and homogeneity of the backside exposure of the print depends on the construction of the backlit unit. These parameters together with the duty cycle of the backside illumination determine the severity of the exposure of the print from its backside. Table 1 provides an overview of typical parameters associated with LED or fluorescent lamp illuminated light box designs.

The level of temperature increase of the print on backlit display is driven by the dissipative heating from the backlit lighting system in operation and the degree of air ventilation of the light box in a certain environment. The amount of temperature increase is larger in the case of poor air ventilation. Factors that reduce air ventilation include an airtight design of the housing, its eventual installation onto or especially into a wall, the use of a front screen and/or the display of a print on a foil (as opposed to a fabric with an open mesh structure). For heat sensitive materials the temperature increase above the surrounding temperature may have to be considered.

Table 1 — Parameters of backlit displays

Backlit displays		**Illumination type[a]**		
Display parameters		**LED**	**Bare-bulb Fluorescent**	**Glass-filtered Fluorescent**
Relative spectral irradiance (RSI)		see ISO 18937-3, phosphor-converted 'blue pumped' LED (5 000 K CCT)	See Annex A	see ISO 18909
Irradiance level E_v **at the backside of the print** [klx]		7 to 10		
Typical UV content[a]		no RSI below 400 nm, but intense blue emission peak at 450 nm	mercury lines at 313 nm and 365 nm[b]	
relative severity $\rho_{RSI/GI}$		0,73[a]	0,74[a]	0,64[a]
Temperature increase [K] **over ambient**	**non-ventilated (e.g. front screen and/or foil)**	+7	+15	+15
	ventilated (e.g. open front and mesh material / fabric)	+5	+10	+10
Duty cycle τ [%]		Between "*x* %" ('cyclic') and 100 % ('24/7')		

[a] See Annex A.

[b] The intensity of the UV lines at 313 nm and 365 nm, that are typically emitted from fluorescent lamps, depends on several factors, including the amount of mercury used in a specific type of lamp and the level of UV attenuation from the glass envelope of the lamp and the type and thickness of the phosphor layer. During the use time of the fluorescent lamps, pinholes can be introduced in the phosphor layer, which can increase the intensity of the UV emission lines over time. On the other hand, the UV lines will be largely attenuated when an UV absorbing (diffusor) screen is present in between the fluorescent lamps and the print on display. The glass-filtered fluorescent condition is realized most often, whereas the bare-bulb condition can be regarded as worst case.

For print materials with limited light stability a certain level of inhomogeneity of the backlit illumination (see example in Annex B) may be sufficient to introduce visible patterns of discoloration. The level of inhomogeneity of the light intensity, expressed as $2 \times (I_{max} - I_{min})/(I_{max} + I_{min})$, may typically range from 10 % to 50 % and stems from the light box design, including:

a) the position, geometry, and type of the lighting elements, such as e.g.

   1) array of linear lamps, e.g. LED lines, or fluorescent tubes,

   2) array of spot lamps, e.g. grid or matrix of individual LED spots, and

   3) continuous area illumination, e.g. edge-lit backside diffusor screen;

b) the efficiency of the light distribution by the combination of all optical elements:

   1) angular emission of the lighting elements, also considering lenses;

   2) diffusor screens;

   3) reflectivity of the inner walls.

Also, the reflectivity of the backside of the print itself, when mounted on the backlit unit, may contribute to the overall system illumination homogeneity.

4.3 Frontside exposure and environmental conditions

The frontside of the print is exposed by the ambient illumination that is present at the installation site of the backlit display unit. The corresponding environmental parameters may range between those typical for general indoor display [A2 of ISO/TS 21139-1:2019, Table 3], for in-window display [A1 of ISO/TS 21139-1:2019, Table 3] or for protected outdoor display [B1 b) ISO/TS 21139-1:2019, Table 3]. Users shall identify the most severe test condition anticipated for their display application and based on that condition estimate a typical amount of total light exposure during the defined display period. Guidelines are provided in ISO/TS 21139-1 and examples are given further below.

Table 2 — Characterization of standardized environmental display conditions

Environmental display parameters	General indoor display	In-window display	Glass-filtered shaded outdoor display
Relative spectral irradiance (RSI)	See ISO 18937-2 (General indoor display)	See ISO 18937-2 (In-window display) [a]	See ISO 18937-2 (In-window display) [a] *
UV filter function in the front screen of the backlit unit	Depending on their UV filtering characteristics some screen materials between light source and print may reduce the UV fraction, to which the print is exposed from the frontside or backside, respectively. Also, the supporting substrate (film) of the print may act as UV-filter for the corresponding direction of exposure.		
Informative: UV fraction[b]	4 %	6 %	6 %
Informative: $\lambda_{50\,\%\,\mathrm{T}}$ [nm]	370 to 375	340 to 345	340 to 345
Informative: $\lambda_{0,05\,\%}$ [nm]	350 nm	320 nm	320 nm
Relative severity[c] $\rho_{\mathrm{RSI/GI}}$	1,0[c]	1,2[c]	1,2[c]
Duty cycle τ [%]	12/24 (= 50 %) to 24/24 (= 100 %)	Typically, 12/24 (= 50 %)	Typically, 12/24 (= 50 %)

[a] The test method 'in-window display' of ISO 18937-2 with continuous light exposure is equivalent to the light stability test method stipulated in ISO/TS 21139-21.

[b] UV fraction is indicated as ratio of cumulative radiant energy in the range of 300 nm to 400 nm versus the cumulative radiant energy in the range of 300 nm to 800 nm (see ISO/TS 21139-1:2019, Annex D). For comparison: natural daylight has ~8 % UV fraction.

[c] Reference values from Annex A.

4.4 Equivalent test conditions

In the practical application, any of the combinations of Table 1 for backside exposure and Table 2 for frontside exposure could be observed. To reduce the variability of testing the concept of equivalent test conditions is applied in this test method and the equivalent exposure dose is determined.

In this method the concept of "severity weighted exposure" is applied, which allows to characterize the exposure intensity in terms of illuminance (lux), still considering the different UV content of a given RSI. More background on this approach is given in Annex A.

4.4.1 Severity weighted exposure condition

In a first step, the user of this method needs to determine the "severity weighted exposure" $\tilde{E}_{\mathrm{RSI/GI}}$ of frontside and backside exposure, respectively, as given in Formulae (1) and (2). $\tilde{E}_{\mathrm{RSI/GI}}$: represents a measure of light intensity E_v [klx], that is weighted with the duty cycle τ of the exposure and the relative severity $\rho_{\mathrm{RSI/GI}}$ of the RSI of either side of the print, respectively, i.e. $\rho_{\mathrm{front/GI}}$ or $\rho_{\mathrm{back/GI}}$. The relative severity $\rho_{\mathrm{RSI/GI}}$ provides a ratio of degradation due to photolytic action of exposure under a given RSI in comparison to that of the "general indoor" condition as defined in ISO 18937-2. Annex A provides reference values for the relative severity of typical colorants based on a general action factor