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Permanence and durability of commercial prints —

Part 21: In-window display — Light and ozone stability

Permanence et durabilité des impressions commerciales —

Partie 21: Fenêtre de visualisation — Stabilité à la lumière et à l'ozone

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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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For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

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

In commercial application of colour prints, displaying the prints under ambient light or artificial illumination is one of the typical use cases. These prints may fade or otherwise change in appearance due to various environmental stresses, such as light, heat, humidity, pollutant gas, or biological weathering, and the combination of these factors. One of the most critical degradations is light fading caused by bright light which includes some UV components. A typical example of such a case is where prints are displayed in a display window (see Annex A) and are illuminated with bright light, especially daylight through window glass.

A test method for light stability of prints by simulating daylight through window glass directly falling on a print displayed in a window is described in of ISO 18937. The test method described in ISO 18937 has broader application (for example covers a broad range of temperatures) than is required for this document and so requires some modification. A test method for ozone stability is described in ISO 18941.

In addition, ISO 18937 and ISO 18941 focus on test method itself, and do not cover translation of test results into performance in specific use profile which is one of the aims of this document.

Permanence and durability of commercial prints —

Part 21:
In-window display — Light and ozone stability

1 Scope

This document describes the test method for light stability and ozone stability for commercial prints, which are displayed in indoor bright places in or near to windows, especially in display windows with air conditioning.

This document also provides guidelines for data analysis.

This document is applicable to the various product classes of "commercial prints" that, following the terminology of ISO/TR 19300, include commercial production prints (flyers, brochures), transactional and stationary prints, signage, newspapers and periodical prints, book printing as well as packaging printing. These commercial prints often contain combinations of text, pictorial images and/or artwork. Prints for non-commercial use, including prints used and displayed in consumer home environments and prints exhibited or stored in museum context, are outside the scope of this document.

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 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 12647-7, *Graphic technology — Process control for the production of halftone colour separations, proof and production prints — Part 7: Proofing processes working directly from digital data*

ISO 13655, *Graphic technology — Spectral measurement and colorimetric computation for graphic arts images*

ISO 18937:—[1], *Imaging materials — Photographic reflection prints — Methods for measuring indoor light stability*

ISO 18941:2017, *Imaging materials — Colour reflection prints — Test method for ozone gas fading stability*

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

3 Terms and definitions

No terms and definitions are listed in this document.

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 http://www.electropedia.org/

1) Under preparation. Stage at the moment of publication ISO/DIS 18937:2019.

4 Use profile

4.1 General

This document describes a test method for prints that are displayed in display windows, where the primary stress factors are exposure to daylight through window glass and exposure to ozone. The effects of light and ozone are assessed separately, instead of combined, in this document.

NOTE Heat, humidity and other pollutant gases also can be stress factors, however this document focuses on light stability and ozone stability. Heat can have to be considered for long time display in windows, where print is exposed to direct sunlight.

The use profile of commercial prints in general is described in ISO/TS 21139-1. This document specifically describes test methods for in-window display with daylight through window glass (see display use profile A1 of Table 3 in ISO/TS 21139-1).

4.2 Environmental light condition

To determine the cumulative light exposure which is most appropriate for their intended purpose, users should make an estimate of the typical amount of light exposure anticipated for their application. The light level depends on geographic location, time of year, window direction and shading factors. Guidelines are provided in ISO/TS 21139-1.

Users should identify a suitable reference display condition that is likely to be used to display prints. In such cases, the actual light exposure can be measured for a sufficiently long period. These calculations will provide a light exposure estimate for this use profile and so may be used to determine the likely fading.

4.3 Environmental ozone condition

To determine the cumulative ozone exposure which is most representative for their intended purpose, users should make an estimate of the typical amount of ozone exposure anticipated for the duration of display. The ozone level depends on ventilation of outdoor air, deactivation factors of the room, such as room size, materials of the wall, ventilation filter, and the weather condition, especially solar radiation.

For measurement of ozone level, passive samplers (filter badges) can be used[9].

The indoor ozone level may also be estimated using the ratio of the indoor to outdoor level. This ratio is calculated by measuring the indoor level for a short period of time and using published measurement data from a nearby air quality station for this same period. The indoor ozone level may be estimated from the published outdoor measurement data over a longer period of time using this ratio[10][11].

NOTE In most cases, the ratio of indoor to outdoor ozone is more stable compared to the fluctuation of outdoor ozone level itself[10][11].

Users should identify a suitable reference display condition that is likely to be used to display prints. In such cases, the actual ozone exposure can be measured for a sufficiently long period. These calculations will provide an ozone exposure estimate for this use profile and so may be used to determine the likely fading.

5 Test method

5.1 General

The sample specimens shall be exposed to controlled light or ozone gas for a certain duration. The change from the initial state shall be measured.

The duration of the exposure is determined based on the total anticipated exposure identified in the use profile.

5.2 Sample preparation

5.2.1 Outline

Sample specimens shall be prepared with the specific procedures, which correspond to the actual prints to be evaluated. The printing equipment, the driver setting, the media, finishing shall be recorded.

5.2.2 Test target

The test target described in ISO 12647-7 (Control strip) shall be used. Other test patterns or natural picture images can also be used depending on the purpose of the test.

5.2.3 Storage conditions between printing and light or ozone exposure test

The storage conditions for the period between printing and the start of the light exposure test and between the end of aging exposure and the start of the data measurement shall be controlled when the test results can be affected by the condition, ensuring that the ambient environment (temperature, relative humidity and air flow around the stored prints) remains within the permitted levels. In any event, the time between printing and the start of the light exposure test shall be less than two months.

5.2.4 Reference samples

Extra specimens may be prepared for each sample for use as reference samples. When this is done, the extra specimens shall be sealed in an opaque or dark enclosure and stored at cold place with the temperature of no higher than 20 °C, so that they can either be measured with the exposed sample specimens simultaneously or can be assessed visually by comparing the exposed sample specimen with the unexposed sample specimen side-by-side.

5.2.5 Backing of the specimens

The sample specimens are usually backed. Suitable backing materials include non-reactive and non-yellowing white material such as 100 % cotton cellulose mount board (100 % 'rag' board) or metal (white-painted aluminium or stainless steel plate).

NOTE 1 “Backing” refers to an extra rigid and stable sheet of material, to which print is mounted, and backing also can be a direct printing on such backing material (rag board/coated metal composite sheet).

NOTE 2 The type of backing material used can influence the sample temperature. It is recommended to use a backing that most closely represents use case conditions.

5.3 Light exposure

5.3.1 Outline

For the light source, xenon arc light filtered with standard window glass filter is used to simulate daylight through window glass.

Xenon arc lamp equipment that can achieve the test conditions stipulated in this sub-clause shall be used.

Temperature and humidity control equipment shall be used to attain the sample temperatures and the air relative humidity stipulated in this document.

5.3.2 Spectral power distribution

The spectral power distribution (SPD) stipulated in ISO 18937:—, 7.2, shall be used. This SPD can be achieved using light from a xenon arc lamp filtered with a window glass filter.

NOTE A soda lime flat glass is usually used to filter the light from the xenon arc lamp in order to achieve the SPD.

5.3.3 Light intensity

Light intensity measured at the sample position shall be between 50 klx and 80 klx. The sample specimens are exposed to the light continuously.

The light intensity shall be maintained and controlled as stipulated in ISO 18937:—, Table 5.

It is recommended that proven samples are tested parallel to check that the results of the reference materials show the consistent results with the previous tests.

In a light exposure chamber, in order to maintain a uniform and consistent light level, all sample positions shall be filled with samples, or with dummy samples which are equivalent in average density or reflectance to the actual test samples, for both light exposure tests and for the calibration of light, temperature and humidity.

5.3.4 Temperature and humidity

The set point of the uninsulated black panel temperature shall be 35 °C or less, and the set point of the temperature and relative humidity of the chamber air shall be approximately 25 °C and 50 % RH respectively. These settings should be adjusted to ensure that the sample temperature is kept at around 30 °C which is typical temperature of the prints displayed under bright light in display windows.

NOTE The conditions of 25 °C and 50 % RH are used intending to simulate the performance in the display windows with air conditioning.

The temperature, relative humidity and air quality shall be maintained and controlled as stipulated in ISO 18937:—, Clause 5.

5.3.5 Duration of the light exposures

The duration of exposure shall be determined based on the total exposure anticipated by the use profile. For example, a print intended to be displayed under light of 3 000 lx for 12 h per day for 1 year, the total exposure during testing should be sufficiently larger than 13 Mlx·h (3 000 × 12 h/days × 365 days).

5.4 Ozone test

5.4.1 Outline

The sample specimens are exposed to high concentration ozone gas under controlled air flow, temperature and humidity for a certain duration.

5.4.2 Apparatus

The test apparatus described in ISO 18941:2017, 8.2, shall be used.

5.4.3 Test procedure

The test procedure stipulated in ISO 18941:2017, 8.3, shall be used.

5.4.4 Test conditions

5.4.4.1 General

The test conditions described in ISO 18941:2017, Clause 9, shall be used. The specific test conditions described in 5.4.4.2 to 5.4.4.4 shall be selected.

5.4.4.2 Ozone concentration

Unless otherwise specified, the test shall be carried out at 1,0 µl/l, with an operational uniformity of ±0,1 µl/l ozone.

Other ozone concentrations, such as 0,5 µl/l or 5 µl/l may be used for testing.

5.4.4.3 Temperature and humidity

The temperature and relative humidity shall be maintained and controlled as stipulated in ISO 18941.

5.4.4.4 Duration of the ozone exposures

The duration of exposure shall be determined based on the total exposure anticipated by the use profile. For example, a print intended to be displayed under ozone gas of 9 nl/l for 1 year, the total exposure during testing should be sufficiently larger than 80 µl/l·h (9 nl/l × 24 h/days × 365 days).

6 Measurement

6.1 General

A spectrophotometer shall be used when making measurements. The chromaticities of the samples shall be measured before and after light exposure and the colour difference shall be calculated based on CIELAB 2000[1][6] and se also ISO 13655.

NOTE 1 It is reported that the colour difference CIEDE2000 (as defined in ISO/CIE 11664-6[6]) corresponds well to the visual impression of the fading[8].

6.2 Measurement conditions

The chromaticity of all patches of the sample specimen are measured before and after the light exposure.

The measurement condition M1 or M2 described in ISO 13655 shall be used. Where materials contain significant optical brightening agents and are likely to be displayed in an environment where significant UV is present, M1 measurement should be used, and where possible the same instrument should be used to make measurements before and after the test period.

NOTE M1 is more appropriate for the use case where UV light is included in the ambient light for the observation and the printing materials contain optical brightening agents. However, for M1, the consistency of the measurements is poor as it is not easy to calibrate the measurement equipment since there are no certified reference materials for calibration. M2 is more appropriate for the use case where UV light is not included in the ambient light for the observation, such as LED lighting or sun light through UV filtered window, or when the printing materials do not contain optical brightening agents.

The geometry shall be 45°/0 or 0/45°. The colour value shall be computed using the CIE 1931 model with a 2° observer for the detector and the illuminant is CIE standard illuminant D50.

6.3 Calculation of colour difference

The colour difference CIEDE2000 (ΔE_{00}) between after versus before light or ozone exposure is calculated for the each patch of the sample.

The average of ΔE_{00} of the all patches of the specified test target shall be calculated. The ΔE_{00} of 95th percentile of the patches may be calculated as described in ISO 21139-1:2019, Annex G. The largest

colour deviation should also be identified, or the ΔE_{00} of the worst 5th percentile patches should also be calculated.

NOTE The average is applied in this document, because it corresponds well to the human perception as shown in Reference [8]. The average usually provides more stable test results compared to applying the worst patch value.

7 Data analysis

7.1 General

Only the basic concept of the data analysis is described in this document. For example, further details are given in ISO 12647-7.

The values of ΔE_{00} at each exposure level shall be plotted as shown in Figure B.3 and this plot may be analysed using either of the two following methods.

— Method A: read the colour difference (ΔE_{00}) resulting from a specific exposure level from the plot of ΔE_{00}/ exposure level.

— Method B: read the exposure required for the colour difference to reach a speficic value of ΔE_{00}. Here, the specific value of ΔE_{00} is used for the “Image Quality Parameter”.

Method A is especially applicable when the concerned exposure level is specified, while Method B is especially applicable when the exposure level is not specified.

For translation of the test results into use case performance, consideration of the endpoint criteria and the environmental conditions of the use case are the deciding factors. However, endpoint criteria and environmental conditions are not specified in this document.

7.2 Image quality parameter for data analysis

The image quality parameter, the specific value of ΔE_{00} for data analysis, can be determined based on the application and purpose of the prints. In actual applications, sometimes even the change of ΔE_{00} = 1 can be problematic, while the changed prints with the order of ΔE_{00} = 10 are still displayed effectively.

NOTE Concerning the value of ΔE_{00}, for example, ΔE_{00} = 2, 5 or 10 can be used. ΔE_{00} = 2 can be appropriate to discuss the small changes which are close to the just noticeable differences, however, ΔE_{00} = 2 can be used as the image quality parameter for fading tests only when the precision of the fading tests is sufficiently better than ΔE_{00} = 2. On the other hand, ΔE_{00} = 10 cannot be reached in some system in the appropriate test duration, because the fading curve expressed in ΔE_{00} is usually convex upward and tends to flatten before reaching to ΔE_{00} = 10.

7.3 Environmental conditions

The environmental light and ozone conditions shall be estimated as described in Clause 4 or in ISO/TS 21139-1.

NOTE 1 When the actual light level of the display conditions is not determined, for example, a reference display condition of 3 000 lx intensity for 12 h exposure can be used in order to compare the performance of prints displayed in display windows.

NOTE 2 When the actual ozone level of the display conditions is not determined, for example, a reference display condition of 10 nl/l can be used in order to compare the performance of prints displayed in display windows.

7.4 Estimation of time to reach certain change

Time to reach certain change can be estimated with the following Formula (1):

$$t = E/I \tag{1}$$

where

t is the time to reach certain change caused by light or ozone exposure;

E is the total light or ozone exposure to a specific image quality parameter;

I is the average level of the ambient of light or ozone exposed to the displayed prints.

NOTE 1 Time to reach certain change here indicates the duration reaching the specified image quality parameter.

NOTE 2 There is no method available to estimate display life for the combined action of light and ozone, as non-linear interactions between both degradation modes can be present depending on the nature of the underlying print technology.

The users of this document are reminded that results from accelerated tests cannot perfectly match degradation in actual use because of limitations of accelerated testing. Published "year ratings" is regarded as "years in standardized test conditions" and therefore do not necessarily match with years in actual use. This is often a matter of dispute if communication is not detailed enough in that respect."

NOTE 3 Use of Blue Wool Scale is discouraged as described in ISO/TS 21139-1.

8 Reporting

The report of test results shall include the following:

a) details of samples, such as printing system or printing technology, ink and media, printer and driver settings;

b) test target design, and the measured patches;

c) test method, test conditions and measurement;

d) test results, including one or more of the followings:

   1) graph of ΔE_{00} versus exposures;

   2) ΔE_{00} at the specific exposures;

   3) amount of exposures which lead to the specific ΔE_{00}.

When there is any difference from the standard test method or standard measurement conditions described in this document, those differences shall be also reported.

Annex A
(informative)

Display window type and lighting design

A.1 Type of display windows

There are many display windows. The display window environment can be classified roughly into following types from point of view on print permanence.

a) Lighting control:

   1) facing to south direction (higher solar irradiance, partially shaded);

   2) facing to north direction (lower solar irradiance, fully shaded);

b) Ozone control:

   1) high air flow from outdoor (higher ozone potential);

   2) low air flow from outdoor (lower ozone potential);

c) Temperature and humidity control:

   1) the space of the display window is connected to the sales floor;

   2) the display window is independent from other space (such as the sales floor and outside of the shop).

There are many design factors that determine the overall environment of the display window. A detailed discussion of these factors is outside the scope of this annex. However, roughly speaking, the lighting control a) is the most important factor for the presentation of the products to the viewer or customer. Therefore, it is necessary to carefully consider the lighting condition from perspective of printed materials that are displayed in the window.

A.2 Lighting design

Display windows are designed to create an atmosphere to entice visitors into stores and to attract the attention and provide information about the products to customers. Even in the case of a) 1) or a) 2) in A.1, they are designed to provide appropriate illumination by the combination of interior lighting and exterior light (window glass filtered daylight and/or reflected light from the surroundings of the display windows). Therefore, from the perspective of the display window lighting, there may not be a significant difference between a) 1) and a) 2) in A.1, unless periods with elevated temperature when sunlight may directly hit the displayed material.

Guidance of illuminance in lighting design is specified in ISO/CIE 8995-3[5] and standards of each country (e.g. JIS Z 9110[7]). Although 1 000 lx or 2 000 lx illuminance are specified for featured products of display areas, these specifications only apply to indoor display windows where the illuminance is kept constant at these levels. However, actual lighting is not constant or uniform due to daylight. Display windows require supplemental lighting to compensate for variable daylight conditions during a day and often incorporate spot lights and back lighting.

The printed materials that are displayed in the window can be products, posters, price tags, or other advertisements. They may only shaded partially, i.e. sunlight may directly fall through the window glass onto the displayed print at various times during the day. The printed materials are sometimes even applied directly to the window glass.

A.3 Air conditioning (ozone, temperature and humidity control)

Concerning the temperature and humidity, many kinds of display windows are classified as type c) 1) in A.1. Some display windows may have only a back wall, but others may have a back wall and ceiling. In these cases, display windows have the space connected with the sales floor. In type c) 1) in A.1, the prints used in this case have very wide variety in their use period. In some shops, prints are changed frequently because people can access the display area easily. In other cases, it might not be necessary to change the prints, for example those consisting only of characters and symbols for a long time. There might be a case that the prints might be used for a long time in shops which require a low-cost because this type of display window is a type which can be installed easily and cheaply.

On the other hand, type c) 2) in A.1 can often be found in large-scale shops and large commercial buildings. This type of display window is located at or near the entrance of the department store, for example, In many cases, they play an important role in communicating both the range and quality of the products inside of the stores. The prints to be used in this type of display window would be changed every few weeks or months in accordance with the seasonal events of the stores, and good print permanence is highly desired.

In the both types of display environments, air conditioning usually protects the exhibits, and the range of the temperature and humidity is relatively small. While there is ozone and other pollutants present at street level in store display windows and office lobbies, the predominant factor driving fading in display windows is the elevated light levels due to daylight, especially where good air conditioning and filtering is present in commercial establishments. The ozone test in ISO 18941:2017, 5.4 to determine ozone sensitivity is performed in the dark and may not be totally predictive of any possible synergistic effect of ozone exposure in the presence of high levels of UV-containing daylight. This document is not applicable to prints displayed in windows in establishments that generate air pollutants, such as print shops, or nail and hair salons, where printed display materials may require more frequent replacement.

Annex B
(informative)

Example of test results

B.1 Outline

An example of test results based on the test method described in this document is shown here. A total of 6 prints for commercial application were tested. The chromaticities of the specimens were measured before and after exposure to different amounts of light. The colour differences, ΔE_{00}, were calculated for each set of fresh and faded specimens. The total quantity of light exposure required to reach the specific image quality parameter, i.e. ΔE_{00} = 5, for each specimen was also calculated. In parallel, two professional observers conducted visual assessments of the faded colour patches by comparing them with their corresponding initial ones. The correlations between the visual assessments (human perception) and the image permanence estimated as the total exposure to the image quality parameter calculated using the colour difference data were then evaluated.

B.2 Light exposure test

B.2.1 Samples

A total of 6 prints for commercial application were tested. The details are shown in Table B.1.

Table B.1 — Samples

	Printing technology	Media	over coat, lamination
1)	Offset lithography print – oil based	Coated paper	No
2)	Electrophotography – liquid toner	Coated paper	No
3)	Electrophotography – dry toner	Coated paper	No
4)	Electrophotography – dry toner	Coated paper	No
5)	Inkjet –pigment based aqueous ink	Coated paper	No
6)	Inkjet – pigment based aqueous ink	Coated paper	No

B.2.2 Test procedures

The test procedures described in Clause 4 were used.

For the test chart, the image of the test charts are shown in Figure B.1. The input signals of the each patch are described in ISO 12647-7.

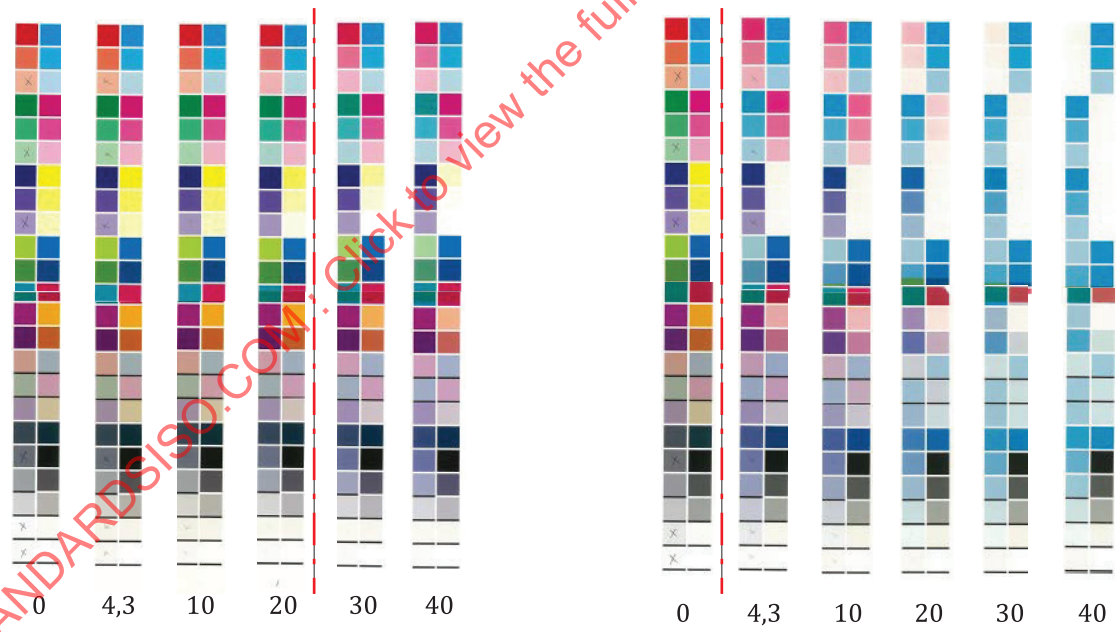
The measurements were carried out based on the methods described in Clause 5.

Figure B.1 — Image of the printed test target

B.2.3 Test results

The examples of scanned images of the initial and the faded patches of the each specimen are shown in Figure B.2.

The averages of the ΔE_{00} of 48 patches at the each light exposure of the each specimen are show in Figure B.3.



a) Light exposure of sample A in Mlx·h **b) light exposure of sample B in Mlx·h**

NOTE The red dotted lines indicate the positions related to the image quality parameter described in B.3.1.

Figure B.2 — Examples of faded images