INTERNATIONAL STANDARD

ISO 18937

Second edition
2020-01

Imaging materials — Photographic reflection prints — Methods for measuring indoor light stability

Matériaux pour l'image — Tirages photographiques par réflexion — Méthodes de mesure de la stabilité de la lumière en intérieur

Reference number
ISO 18937:2020(E)

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Published in Switzerland

Contents

Page

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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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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*.

This second edition cancels and replaces the first edition (ISO 18937:2014), which has been technically revised. The main changes compared to the previous edition are as follows:

— Removal of non-xenon light sources;

— Removal of non-essential verbiage to improve method clarity;

— Inclusion of annex on actual sample temperature measurements during exposure;

— Inclusion of continuous phase test for in-window display conditions.

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

This document addresses the methods and procedures for measuring the indoor light stability of photographic reflection prints[3]–[5][11]–[16][20].

The length of time that such photographs are to be kept can vary from a few days to many hundreds of years and the importance of image stability can be correspondingly small or great. Often the ultimate use of a particular photograph may not be known at the outset. Knowledge of the lightfastness level of colour photographs is important to manufacturers to improve print materials and to many users, especially since stability requirements may vary depending upon the application.

The images of most modern analogue and digitally-printed colour photographs are made up of cyan, magenta, yellow, red, green, blue, orange, black, grey, white or other colourants. Colour photographic images typically fade during storage and display; they will usually also change in colour balance because the various image colourants seldom fade at the same rate. In addition, a yellowish (or occasionally other colour) stain may form and physical degradation may occur, such as embrittlement and cracking of the support and image layers. The rate of fading and staining can vary appreciably and is governed principally by the intrinsic stability of the colour photographic material and by the conditions under which the photograph is stored and displayed. For silver halide prints, the quality of any chemical processing is another important factor. Post processing treatments and post-production treatments, such as application of lacquers, plastic laminates, and retouching colours, also may affect the stability of colour materials.

The light stability of colour photographs is influenced primarily by the intensity of the radiation/light source, the duration of exposure to light, the relative spectral irradiance of the light source, and the ambient temperature and humidity conditions. However, the normally slower dark fading and staining reactions also proceed during display periods and will contribute to the total change in image quality. Ultraviolet radiation is particularly harmful to some types of colour photographs and can cause rapid fading as well as degradation of the underlying substrate. Information about the light stability of colour photographs can be obtained from accelerated light stability tests. These require special test units equipped with high-intensity light sources in which test strips can be exposed for days, weeks, months, or even years, to produce the required amount of image fading (or staining). The temperature and moisture content of the specimen prints should be directly or indirectly controlled throughout the test period, and the types of light sources should be chosen to yield data that can be correlated satisfactorily with those obtained under conditions of normal use.

Accelerated light stability tests for predicting the behaviour of photographic colour images under normal display conditions may be complicated by “reciprocity failure." When applied to light-induced fading and staining of colour images, reciprocity failure refers to the failure of a colourant to fade, or to form stain, equally when irradiated with high-intensity versus low-intensity light, even though the total light exposure (intensity × time) is kept constant through appropriate adjustments in exposure duration. The extent of colourant fading and stain formation can be greater or smaller under accelerated conditions, depending on the photochemical reactions involved in the colourant degradation, on the kind of colourant dispersion, on the nature of the binder material, and on other variables. For example, the supply of oxygen that can diffuse into a photograph’s image-containing layers from the surrounding atmosphere may be restricted in an accelerated test (dry gelatine, for example, is an excellent oxygen barrier). This may change the rate of colourant fading relative to the fading that would occur under normal display conditions. The magnitude of reciprocity failure may also be influenced by the temperature and moisture content of the test specimen prints. Furthermore, light fading may be influenced by the pattern of irradiation — continuous versus intermittent — as well as by light/dark cycling rates (see Annex A).

Imaging materials — Photographic reflection prints — Methods for measuring indoor light stability

1 Scope

This document describes test equipment and procedures for measuring the light stability of colour photographic reflection prints designed for display, when subjected to a filtered xenon-arc light source simulating daylight through windows at specified temperatures and relative humidity.

This document is applicable to photographic reflection prints, made with analogue and digital print processes. The recommended test methods can be applied to both colour and black-and-white photographic prints.

This test method assesses colour and density change.

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 2471, *Paper and board — Determination of opacity (paper backing) — Diffuse reflectance method*

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

ISO 18913, *Imaging materials — Permanence — Vocabulary*

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

ISO 18944, *Imaging materials — Reflection colour photographic prints — Test print construction and measurement*

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 http://www.electropedia.org/

4 Requirements and limitations

This document specifies a set of recommended test methods with associated requirements for permitted reporting. Data from these tests shall not be used to make life expectancy claims, such as time-based print lifetime claims, either comparative or absolute. Conversion of data obtained from these methods for the purpose of making public statements regarding product life shall be in accordance with the applicable documents for specification of print life.

The test methods in this document may be useful as stand-alone test methods for the absolute or comparative stability of image materials with respect to colour fading or measurement of physical properties. Caution shall be used when comparing test results for different materials. Comparisons shall be limited to test cases using test apparatus with matching specifications and matching test conditions.

No accelerated laboratory exposure test can be specified as a total simulation of actual use conditions. Results obtained from these laboratory accelerated exposures can be considered as representative of actual use exposures only when the correlation has been established for the specific materials being tested and when the type of degradation is the same. The relative durability of materials in actual use conditions can be very different in different locations because of differences in radiant energy (both in spectral irradiance and intensity), relative humidity, temperature, pollutants such as ozone, and other factors.

Print image stability results from this test method, especially in terms of the amount of acceleration and/or correlation to end-use service life, that are determined for one printer model, software settings, colourant, and media combination should not be applicable to another printer model, software settings, colourant, and media combination.

5 Test methods — General

5.1 Safety cautions

In light stability tests, a high irradiance level is used, often with significant UV content. Special care shall be taken to avoid eye injury or skin erythema. Precautions should be taken to ensure that the light source cannot inadvertently be viewed without suitable eye and skin protection.

5.2 Light source and filters

This document references the use of a filtered xenon-arc light source (daylight behind window glass) as described in ISO 4892-2 for accelerated tests with the intention of reproducing as closely as possible different end-use lighting conditions[17][18]. In addition, special filtering of the xenon-arc lamp is used (which is not referenced in ISO 4892-2) to achieve the lighting conditions applicable to this method.

5.3 Humidity control

The relative humidity of the air circulating the test chamber shall be controlled. The location of sensors used for measuring humidity shall be as specified in ISO 4892-1.

5.4 Temperature control

Uninsulated black metal panels are used to indirectly control specimen temperature. The black panel shall be constructed in accordance with ISO 4892-1 and mounted at the specimen exposure plane. The uninsulated black panel shall be controlled.

Chamber (ambient) temperature shall be controlled. The sensor shall be shielded from light and mounted near the exposure zone.

Most lightfastness apparatus use ambient laboratory air to control chamber air temperature. Therefore, laboratory conditions shall be maintained such that the apparatus can control temperature effectively. Air refrigeration units may be required to maintain the chamber air temperature depending on the laboratory air temperature.

NOTE The ± tolerances given for testing set points are the allowable fluctuations of the parameter about the given value under equilibrium conditions. This does not mean that the apparatus set point value can be varied by ± the amount indicated from the given value, just that the measured value may. These ± tolerances are also not intended as requirements for chamber uniformity.

5.5 Air quality in the test environment

Some types of print materials can be highly sensitive to degradation caused by ozone or other airborne pollutants. Therefore, the test facility where print specimens are made, dried, exposed, and measured, shall be ozone free (<2 nl/l average over any 24-h period) for ozone sensitive samples, as determined in accordance with ISO 18941. A material that is not sensitive to ozone shall have demonstrated no measurable D_{min} or printed patch colour change at ambient ozone exposure levels and measurement condition temperature and humidity.

NOTE 1 nl/l = 1 ppb (1×10^{-9}). Although the notation “ppb” (parts per billion) is widely used in the measurement and reporting of trace amounts of pollutants in the atmosphere, it is not used in International Standards because it is language-dependent.

Either active or passive ozone monitoring can be used. Active monitoring includes real-time measuring and logging of ozone levels in the test facility. Passive monitoring measures long-term cumulative ozone levels yielding a final verification that pollutant levels were at or below acceptable levels during the test. Active monitoring is preferred as passive monitoring cannot indicate whether test conditions were valid until the test is completed.

If necessary, the apparatus can be fitted with an appropriate filter in the incoming chamber air stream to reduce the ozone concentration levels, or ozone can be scrubbed in the laboratory air by appropriate filters.

NOTE 2 The susceptibility of specimens to a given level of airborne pollutants in the air of the test environment (laboratory) can be qualitatively assessed by exposure of replicate specimens to the condition of high air flow in a darkened section of the test environment (with the same air quality), running parallel to the intended test described in this document. If "no measurable change" is obtained as a result of this additional exposure test, the material is regarded as "not susceptible to airborne pollutants" for the duration of the test and for the given test environment. This approach represents a fail-safe test for each imaging material of interest that integrates the effects of ozone and all other potentially harmful pollutants that could be present in the laboratory atmosphere.

5.6 Duration of exposures

The duration of exposures shall be determined with the following considerations:

a) Total exposure required, for example:

   1) Total exposure expected in the usage;

   2) Total exposure required for the warranty;

   3) Total exposure stipulated as endpoint criteria in the applicable International Standards for specification of print life, when such a specification document is available.

b) Total exposure that will cause an aim change, for example:

   1) Total exposure that will cause expected change;

   2) Total exposure that will reach endpoint criteria specified in the applicable International Standards for specification of print life.

c) Total exposure required to cause a change to be reliably detected beyond the noise of the system, particularly for highly stable systems. A reliable change is considered detected when the test result has progressed beyond the noise of the test system.

This test method does not include test endpoints to establish test duration.

6 Light source conditions

6.1 Light source measurements

The filtered xenon-arc light source shall be measured at the specimen plane in terms of radiation source intensity as described in ISO 4892-1.

NOTE Measurement of illuminance or irradiance is used as an integral part of the control system in light test equipment. The control system can then compensate for reduced UV transmission due to solarisation of the lamp and filters.

6.2 Light exposure equipment

Xenon-arc radiant exposure apparatus that can achieve the test conditions and the tolerances stipulated in Clause 5 shall be used. Any configuration of xenon-arc lamp exposure apparatus can be used, provided it can achieve the required test conditions and the tolerances.

6.3 Specifications for optical filters

6.3.1 General

The spectral irradiance of the test light source can be modified by the use of optical filters in order to simulate a particular usage condition. To control the specimen surface temperature at the desired aim value, IR filters may be employed to reduce infrared energy above 800 nm.

NOTE Ultraviolet radiation is considerably more harmful to some types of printed matter than it is to others and, therefore, variations in the level (and spectral irradiance) of the ultraviolet radiation in the light source will affect some materials more than others.

6.3.2 Filter specifications for simulating general indoor display conditions

This filter system shall consist of window-glass filters with spectral irradiance in accordance with Table 3 and an additional UV cut-off filter with a half-cut wavelength (λ at T = 50 %) of 370 nm to 375 nm. The resulting spectral irradiance shall be in accordance with Table 1. The intent of this filter is to simulate an indoor exposure further away from a window, when a large part of the window-glass filtered daylight has undergone reflection off the interior of the room before hitting the displayed print.

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

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

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

6.3.3 Filter specifications for simulating in-window display conditions

This filter system shall consist of window glass filters with spectral irradiance in accordance with Table 3. The intent of this filter is to simulate terrestrial daylight transmitted through standard architectural window glass.

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

6.3.4 Use of an IR-reducing filter

An IR-reducing filter can be used with the filter systems specified in 6.3.2 or 6.3.3 as needed to meet the black panel temperature and chamber air temperature requirements.

6.3.5 Filter configuration

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 be at least 2 mm with an unobstructed airflow between the filter and the specimens.

6.4 Verification of chamber fade uniformity

Chamber fade uniformity assessment is required to qualify the initial illuminance or irradiance, specimen mounting, air flow configuration, and filter placement configuration with the light stability test conditions (including lamp and filter spectral irradiance, light intensity, air quality, temperature and humidity levels). See Annex C for specific information about this procedure.

The chamber fade uniformity between any two locations in the exposure plane used for specimen exposure, as indicated by percent optical density change, shall be at least 80 %.

$$U_{CF} = \frac{C_{SOC}}{C_{LOC}} \times 100$$

where

U_{CF} is the chamber fade uniformity (CFU);

C_{SOC} is the the smallest optical density change (SOC);

C_{LOC} is the the largest optical density change (LOC).

For chamber fade uniformity testing, the following requirements apply.

Design the specimen and equipment configuration that will be used in the light stability testing before evaluating chamber fade uniformity. Each aspect of the specimen and equipment configuration including number of specimens, size of specimens, placement of specimens, specimen holders, light intensity, filtration, whether air refrigeration is used, relative humidity of the environment, and chamber airflow shall be specified in the design and fixed before beginning the chamber fade uniformity verification.

7 Light source specifications

7.1 Simulated general indoor display

7.1.1 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[11][21][22]. The specimen temperature is dominated by ambient conditions.

7.1.2 Filtered xenon-arc configuration to simulate general indoor display conditions

The xenon-arc lamp shall be configured with a UV filter specified in 6.3.2 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).

Optical filters shall be positioned according to 6.3.5.

7.1.3 Spectral irradiance

The spectral irradiance shall conform to the tolerances in Table 1.

Table 1 provides the relative spectral irradiance in the given bandpass, 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 bandpass λ (wavelength) nm	**Relative spectral irradiance** %
$310 \leq \lambda < 340$	0,0 to 0,1
$340 \leq \lambda < 370$	0,1 to 1,0