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

Part 1:
General guidance and requirements

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

Partie 1: Lignes directrices générales et exigences

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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 18937-1 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.

Introduction

This document addresses the methods for measuring the indoor light stability of reflection prints, and transparent or translucent films, both colour and monochrome[10][18] to [23][24] to [30].Outdoor light stability is addressed in ISO 18930, with additional background referenced in ISO TR 18945.

This document focuses on general guidance, which includes aspects of the testing that applies to all of the other specific parts, including minimum performance requirements of the instruments used, details of control systems, calibration requirements, test specimen development, and reporting requirements. ISO 18937-2 focuses on exposures using xenon-arc lamps. ISO 18937-3 focuses on exposures using LED lamps. Specific testing requirements based on simulation to the defined use cases and capabilities of the instruments are included in ISO 18937-2 and ISO 18937-3 documents.

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. If display is part of the intended use, knowledge of the lightfastness level of colour photographs is important to manufacturers to improve print materials and to many users to match their display longevity expectations for any given use profile, 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, black and white or colour, 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 — Methods for measuring indoor light stability of photographic prints —

Part 1:
General guidance and requirements

1 Scope

This document provides information and general guidance about the methods for measuring the indoor light stability of reflection prints, both colour and monochrome, transparent or translucent films, and photographic prints for backlit displays. This document is relevant to the selection and operation of the methods of exposure to radiation and environmental stress factors described in detail in subsequent parts. It also describes general performance requirements for devices used for exposing printed material to laboratory light sources. Information regarding performance requirements is for producers of artificial accelerated lightfastness devices.

NOTE In this document, the term “light source” refers to radiation sources that emit UV radiation, visible radiation, infrared radiation, or any combination of these types of radiation.

This document does not include test procedures for determining the effects of light exposure on the physical stability of images, supports, or binder materials. However, 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, determines the useful life of a print material.

Print image stability results determined for one printer model, software settings, colorant, and media combination may not be applicable to another combination.

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 18913, *Imaging materials — Permanence — Vocabulary*

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

4.1 General

4.1.1 Specimens of the samples to be tested are exposed to laboratory light sources under controlled environmental conditions. The methods described include the requirements for the measurement of the irradiance (or illuminance) and radiation exposure in the plane of the specimen, the temperature of specified black panel sensors, the chamber air temperature, and the relative humidity.

4.1.2 The test methods in this series can be useful as stand-alone methods for comparing the stability of image materials with respect to one specific failure mode. Data from the test methods in this series can be used in stand-alone reporting of the absolute or comparative stability of image materials with respect to the specific failure mode described in this document, when reported in accordance with the reporting requirements of this document.

4.2 Significance

4.2.1 When conducting exposures in devices that use laboratory light sources, it is important to consider how well the accelerated-test conditions simulate the actual-use environment with respect to the light spectrum for the sample being tested. In addition, it is essential to consider the effects of variability in both the accelerated test and actual exposures when setting up experiments and interpreting results from those exposures.

4.2.2 Even though it is very tempting, it is invalid to assign to all materials a “general acceleration factor” relating “*x*” hours, megajoules, or klx-hours of radiant exposure in an artificial accelerated exposure to “*y*” months or years of actual exposure. Such general acceleration factors are invalid for the following reasons.

a) Acceleration factors are material-dependent and can be significantly different for each material and for different formulations of the same material in both actual-use and artificial accelerated exposures.

b) Acceleration factors calculated based on the ratio of irradiance between a laboratory light source and filtered daylight or other illuminations representative for specific indoor use profiles (even when identical passbands are used) do not take into consideration the effects of temperature, moisture, and differences in relative spectral irradiance between the laboratory light source and solar radiation.

NOTE Acceleration factors determined for a specific formulation of a material may be valid, but only if they are based on data from a sufficient number of tests in the end-use environment and artificial accelerated exposures so that results used to relate times to failure in each exposure can be analysed using statistical methods.

4.2.3 There are a number of factors that may decrease the degree of correlation between accelerated tests using laboratory light sources and exposures in end-use conditions:

a) differences in the relative spectral irradiance of the laboratory light source and that representative for the indoor use case;

b) irradiance/illuminance levels higher than those experienced in actual-use conditions;

c) exposure cycles that use continuous exposure to radiation from a laboratory light source without any dark periods;

d) specimen temperatures different than those in actual conditions;

e) exposure conditions that produce unrealistic temperature differences between light- and dark-coloured specimens;

f) unrealistic levels of moisture in the accelerated test compared with actual-use conditions.

4.3 Use of accelerated tests with laboratory light sources

4.3.1 Results from artificial accelerated exposures conducted in accordance with any of the parts of this document are best used to compare the relative performance of materials. Comparisons between materials when tested in different exposure devices must consider variables inherent to the design of those devices. Results can be expressed by comparing the exposure time or radiant exposure necessary to reduce the level of a characteristic property to some specified level. A common application of this is a test conducted to establish that the level of quality of different batches does not vary from that of a control of known performance.

4.3.2 It is strongly recommended that at least one control be exposed with each test for the purpose of comparing the performance of the test materials to that of the control.

NOTE A control would be a material of similar composition and construction to the test material. An example would be when a formulation different from one currently being manufactured for commercial use is being evaluated. In this case, the control would be the material made with the original, or current, formulation.

4.3.3 In some specification tests, properties of test specimens are evaluated after a specific exposure time or radiant exposure using a test cycle with a prescribed set of conditions. Results from any accelerated exposure test conducted in accordance with any of the parts of this document should not be used to make a “pass/fail” decision for materials, based on the level of a specific property after a specific exposure time or radiant exposure, unless the combined reproducibility of the effects of a particular exposure cycle and property measurement method has been established.

4.4 Other limitations

4.4.1 Conversion of data obtained from these methods for the purpose of making public statements regarding product life should be in accordance with the applicable documents for specification of print life.

4.4.2 No accelerated laboratory exposure test can be specified as a total simulation of actual use conditions. Results obtained from 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. Even if results from a specific exposure test conducted in accordance with any of the parts of this document are found to be useful for comparing the relative durability of materials exposed in a particular environment, it cannot be assumed that they will be useful for determining the relative durability of the same materials in a different environment.

4.4.3 Print image stability results from the test methods in those documents, 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, colorant, and media combination should not be applied to another printer model, software settings, colorant, and media combination.

4.5 Safety cautions

In light stability tests, a high irradiance level is used, often with significant UV content. Special care should 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 Requirements for laboratory exposure devices

5.1 Irradiance

5.1.1 Laboratory light sources are used to provide irradiance for the test specimens. In ISO 18937-2, a xenon-arc lamp for use with dedicated optical UV filters is specified and in ISO 18937-3 an LED lamp is specified.

5.1.2 The exposure device should provide holders or space appropriate for placement of specimens and any designated sensing devices in positions that allow uniform irradiance from the radiation source.

5.1.3 Exposure devices should be designed such that the irradiance at any location in the area used for specimen exposures is at least 80 % of the maximum irradiance measured in this area. Procedures for measuring irradiance uniformity by the device manufacturers are given in Annex B.

NOTE The irradiance (illuminance) uniformity in exposure devices depends on several factors, such as the configuration of the lamp with respect to the exposed samples. In addition, irradiance uniformity can be affected by the type of specimen and the number of specimens being exposed.

5.1.4 If the minimum irradiance at any position in the specimen exposure area is between 80 % and 90 % of the maximum irradiance, specimens should be periodically repositioned to reduce the variability in radiant exposure. The repositioning procedure and schedule should be agreed upon by all interested parties.

NOTE There are several possible procedures, including random positioning of replicate specimens, that can be used to reduce the variability in exposure stresses experienced by specimens during exposure. Consult the device manufacturer for guidance.

5.1.5 If the irradiance at any position in the area used for specimen exposure is at least 90 % of the maximum irradiance, it is not necessary to use periodic repositioning of the specimens during exposure to ensure uniform radiant exposure. While periodic repositioning of the specimens is not necessary in this case, it is nevertheless good practice in order to assure that the variability in exposure stresses experienced during the exposure period is kept to the minimum.

NOTE 1 Depending on the specific sensitivity of the material to the exposure stress factors, periodic repositioning of the specimens is good practice to minimize variability of material degradation in replicate specimens. Minimizing variability in exposure stress levels is especially important when the test involves relative comparison of prints made with different printing methods or with different colourant/substrate material combinations.

NOTE 2 Random placement of replicate specimens is also good practice to reduce the effect of any variability in the conditions within the exposure area.

5.1.6 Follow the device manufacturer's instructions for lamp and filter replacement and for any pre-ageing of lamps and/or filters.

5.1.7 General

5.1.7.1 A radiometer for measuring irradiance in a specific wavelength range or a narrow passband that complies with the requirements outlined in ISO 9370 should be used to measure the irradiance, E, or spectral irradiance, E_λ, and the radiant exposure, H, or spectral radiant exposure, H_λ, in the plane of the specimen surface.

5.1.7.2 Alternatively, a radiometer for measuring illuminance that has a spectral response corresponding to the photopic standard luminous efficiency $V(\lambda)$, which is identical to the colour-matching function $y(\lambda)$ specified in ISO 11664-1 should be used to measure the irradiance (illuminance).

In this case, the irradiance (illuminance) is reported in lux and the radiant exposure is reported in lux·hours.

5.1.7.3 The radiometer should be mounted so that it receives the same radiation as the specimen surface. If it is not positioned in the specimen plane, it should have a sufficiently wide field of view and be calibrated for irradiance at the specimen distance. The radiometer should be calibrated using a light source filter combination of the same type that will be used for testing or an appropriate spectral mismatch factor has been taken into account, especially for passband radiometers. The calibration should be checked in accordance with the radiation measuring instrument manufacturer's instructions. A full calibration of the radiometer that is traceable to a recognized radiometric standards body should be conducted at least once per year. More frequent calibrations are recommended.

NOTE 1 ASTM G130[11] provides specific guidance on the calibration of radiometers using spectroradiometers. This method can be used to calibrate the instrument radiometer(s).

NOTE 2 See ISO 9370 for definitions of field and reference radiometers.

NOTE 3 The definition of passbands is found in ISO 9370.

5.1.7.4 When measured, the irradiance in the wavelength range agreed upon by all interested parties should be reported. Some types of device provide sensor(s) for measuring irradiance in a specific wavelength range (e.g. 300 nm to 400 nm or 300 nm to 800 nm), in a narrow passband that is centred around a single wavelength (e.g. 340 nm or 420 nm), or for measuring illuminance (lux).

5.2 Temperature

5.2.1 The surface temperature of exposed materials depends primarily on the amount of radiation absorbed, the thermal emissivity of the specimen at the specimen surface temperature, the amount of thermal conduction within the specimen and the amount of heat transmission between the specimen and the air or between the specimen and the specimen holder. The rate of air flow over the specimen and its sample holders influences the total amount of heat continuously extracted from the specimen (see also 5.3.5 and 5.6.3 for other effects of chamber air flow). Since it is not practical to monitor the surface temperature of individual test specimens, a specified black-panel sensor is used to measure and control the temperature of a representative specimen surface under given exposure conditions. The black surface of the black panel sensor should be measured, controlled, and mounted within the specimen exposure area so that it is in the same plane and orientation and receives the same radiation and experiences the same cooling conditions as a flat test panel surface.

5.2.2 An uninsulated black-panel thermometer should be used as a reference temperature sensor. These panels consist of a plane (flat) metal plate that is resistant to corrosion. Typical dimensions are about 150 mm long, 70 mm wide, and 1 mm thick, but these dimensions may vary depending on the type of exposure apparatus used. The surface of this plate that faces the radiation source should be coated with a black layer which has good resistance to ageing. The coated black plate should reflect no more than 10 % of all incident radiation from the light source, up to 2 500 nm. A thermally sensitive element should be firmly attached to the centre of the exposed surface. This thermally sensitive element can be a black-coated bimetallic dial sensor, a resistance-based sensor, a thermistor or a thermocouple. The back side of the metal panel should be open to the atmosphere.

5.2.3 The temperature indicated by the black-panel thermometer depends on the irradiance produced by the laboratory light source and the temperature and speed of the air moving in the exposure chamber. Black-panel temperatures generally correspond to those for dark coatings on metal panels without thermal insulation on the rear side.

5.2.4 At low irradiance/illuminance levels, the difference between the temperature indicated by a black-panel thermometer and the real specimen temperature may be small. When radiation sources that emit very little infrared radiation are used, there will generally be only very small differences