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Imaging materials — Processed colour photographs — Methods for measuring thermal stability

Matériaux pour l'image — Photographies couleurs après traitement — Méthodes de mesure de la stabilité thermique

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Contents

Page

Foreword ... **iv**
Introduction ... **v**
1 Scope ... **1**
2 Normative references ... **1**
3 Terms and definitions ... **1**
4 Requirements ... **2**
5 Sample preparation ... **2**
5.1 Target selection ... 2
5.2 Use of replicates and reference samples ... 3
6 Holding and measurement conditions ... **3**
7 Test methods — Thermal stability ... **4**
7.1 General ... 4
7.1.1 "Free hanging" versus "sealed bag" methods ... 4
7.1.2 Humidity effects ... 5
7.1.3 Testing of low glass transition temperature products ... 5
7.1.4 Concerns around the effects of atmospheric pollutants ... 5
7.2 Test methods and equipment ... 6
7.2.1 Temperature ... 6
7.2.2 Relative humidity ... 6
7.2.3 Number of specimens ... 7
7.2.4 Free hanging method at constant relative humidity ... 7
7.2.5 Sealed bag method (constant moisture content) ... 8
7.3 Computation of dark stability ... 8
8 Test report ... **8**
8.1 General reporting requirements ... 8
8.2 Test reporting ... 9
Annex A (informative) **Illustration of Arrhenius calculation for dark stability** ... **10**
Bibliography ... **13**

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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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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

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 42, *Photography*.

This second edition cancels and replaces the first edition (ISO 18936:2012), which has been technically revised.

The main changes compared to the previous edition are as follows:

— the test methods for environmental stress factors have been changed to align with ISO 18944;

— the calculations and computations section has been removed as they are now contained in ISO 18944;

— Annex A has been removed as the method for interpolation is now contained in ISO 18944:2018, Annex B;

— the usage and reporting requirements have been updated to ensure consistency within the documents of the ISO 189## family.

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.

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Introduction

This document covers the methods and procedures for measuring the long-term, dark storage stability (thermal stability) of colour photographs.

Today, the majority of photographs are made with colour dyes and pigments. 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 useful life of colour photographs is important to many users, especially since stability requirements often vary depending upon the application. For museums, archives and others responsible for the care of colour photographic materials, an understanding of the behaviour of these materials under various storage and display conditions is essential if they are to be preserved in good condition for long periods of time.

Any change in density, contrast or stain, whether due to colourant fading, changes in colourant morphology or discolouration of residual substances will change the appearance of the photograph.

The most damaging change tends to be contrast balance distortions brought about by differential fading of the three image colourants. These manifest themselves as shifts in colour balance from highlights to shadows that are especially noticeable in a scale of neutrals, for example a shift from magenta to green due to fading of the photograph's magenta image colourant, or from yellow to blue or cyan to red due to fading of the yellow or cyan colourant.

The second most consequential change is that caused by an increase in stain. The result may simply be a discolouration of the $D_{\min}$ areas (unexposed processed media or unprinted substrate) or a change in the $D_{\min}$ colour balance.

Cyan, magenta, yellow, and sometimes black, red, green and blue colourants that are dispersed in transparent binder layers, or absorbed onto special receiver layers coated onto transparent or white opaque supports, form the images of most modern colour photographs. Colour photographic images typically fade during storage and display; they will usually also change in colour balance because the image colourants seldom fade at the same rate. In addition, a yellowish (or occasionally another 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 is governed principally by the intrinsic stability of the colour photographic material and by the conditions under which the photograph is stored and displayed. The quality of chemical processing or post-processing is another important factor. Post-processing treatments and, in the case of digitally generated photographs, post-production treatments, such as application of lacquers, plastic laminates and retouching colours, also may affect the stability of colour materials.

The three main factors that influence storage behaviour or dark stability are the temperature and relative humidity (RH) of the air that has access to the photograph, as well as atmospheric pollutants to which the photograph is exposed. High temperature, particularly in combination with high relative humidity, will accelerate the chemical reactions that can lead to degradation of one or more of the image colourants. Low-temperature, low-humidity storage, on the other hand, can greatly prolong the life of photographic colour images for typical materials. Other potential causes of image degradation are microorganisms and insects.

Most modern photographs degrade too slowly under normal room conditions to permit evaluation of their dark storage stability within reasonable periods. However, it is possible to assess the probable, long-term changes of some photographs under low and moderate storage conditions with accelerated, high-temperature tests, because recognizable losses in image quality under high temperatures are apt to be generated also under milder temperatures, if at a slower pace. The effects of relative humidity on thermal degradation can also be evaluated with Arrhenius tests conducted at two or more humidity levels.

Long-term changes in image density, colour balance and stain level can be reasonably estimated only when good correlation has been confirmed between accelerated tests and actual conditions of use.

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Density changes induced by the test conditions and measured during and after incubations include those in the support and in the various auxiliary layers that may be in a particular product. With most materials, however, the major changes occur in the image-bearing layer. An exception to this is found in some inkjet papers where the inks are thermally stable and substrate yellowing is the failure mode (see Reference [9]).

The tests for predicting the stability of colour photographic images in dark storage are based on an adaptation of the Arrhenius method described by Bard et al. (see References [2] and [3]) and earlier references by Arrhenius, Steiger and others (see References [4], [5] and [6]). Although this method is derived from well understood and proven theoretical precepts of chemistry, the validity of its application to predicting changes of photographic images rests on empirical confirmation. Although many chromogenic-type colour products yield image fading and staining data in both accelerated and non-accelerated dark ageing tests that are in agreement with the Arrhenius relationship, some other types of products do not. For example, integral-type instant colour print materials often exhibit atypical staining at elevated temperatures. The treatment of some chromogenic materials at temperatures above 80 °C and 60 % RH may cause the loss of incorporated high-boiling solvents and abnormal image degradation. The dyes of silver dye-bleach images deaggregate at combinations of very high temperature and high relative humidity, causing abnormal changes in colour balance and saturation (see Reference [7]). In general, photographic materials tend to undergo dramatic changes above 60 % RH (especially at the high temperatures used in accelerated tests) owing to changes in the physical properties of gelatine and other binder materials. Lower maximum relative humidity may need to be tested for some of the more humidity-sensitive inkjet materials because of phase changes such as melting point or glass transition temperature.

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Imaging materials — Processed colour photographs — Methods for measuring thermal stability

1 Scope

This document describes test methods for determining the long-term dark storage stability of colour photographic images.

It is applicable to colour photographic images made with traditional photographic materials. These images are generated with systems such as chromogenic, silver dye-bleach, dye transfer, dye-diffusion-transfer "instant", and similar systems. The test method specified in this document also covers the dark-stability of digital colour images produced with dry- and liquid-toner electrophotography, thermal dye transfer (sometimes called "dye sublimation"), and inkjet printing systems.

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 5-3, *Photography and graphic technology — Density measurements — Part 3: Spectral conditions*

ISO 5-4, *Photography and graphic technology — Density measurements — Part 4: Geometric conditions for reflection density*

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

ISO 18913, *Imaging materials — Permanence — Vocabulary*

ISO 18924, *Imaging materials — Test method for Arrhenius-type predictions*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 18913 and the following 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/

3.1
operational fluctuations
positive and negative deviations from the setting of the sensor at the operational control set point during equilibrium conditions in a laboratory-accelerated weathering device

Note 1 to entry: The operational fluctuations are the result of unavoidable machine variables and do not include measurement uncertainty. The operational fluctuations apply only at the location of the control sensor and do not imply uniformity of conditions throughout the test chamber.

[SOURCE: ASTM G 113]

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3.2
operational uniformity
range around the operational control point for measured parameters within the intended exposure area within the limits of intended operational range

[SOURCE: ASTM G 113]

3.3
uncertainty of measurement
parameter, associated with the result of a measurement, that characterizes the dispersion of the values which could be reasonably attributed to the measurement

Note 1 to entry: The parameter may be, for example, a standard deviation (or a given multiple of it), or the half-width of an interval having a stated confidence level.

Note 2 to entry: Uncertainty of measurement comprises, in general, many components. Some of these components may be evaluated from statistical distribution of the results of series of measurements and can be characterized by experimental standard deviations. The other components, which can also be characterized by standard deviations, are evaluated from assumed probability distributions based on experience or other information.

Note 3 to entry: It is understood that the result of the measurement is the best estimate of the value of the measurement, and that all components of uncertainty, including those arising from systematic effects, such as components associated with corrections and reference standards, contribute to the dispersion.

[SOURCE: ASTM G 113]

4 Requirements

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. The conversion of data obtained from these methods for the purpose of making public statements regarding product life shall be in accordance with the applicable document(s) for specification of print life.

The test methods in this document may be useful as stand-alone test methods for comparison of the stability of image materials with respect to one specific failure mode. The data from the test methods of this document may be used in stand-alone reporting of the absolute or comparative stability of image materials with respect to the specific failure mode dealt with in this document, when reported in accordance with the reporting requirements of this document. Caution shall be used when comparing test results for different materials. Comparisons shall only be made when using equipment with matching specifications, under matching test conditions.

Further clarification is required for this method because it makes use of the Arrhenius methodology which may directly lead to a predicted product lifetime. Fundamentally, the Arrhenius method defines a rate of change (see ISO 18924). This document shall use the ISO 18924 Arrhenius method only as a predictor of rate of change for chemical reactions, not as a predictor of print longevity.

5 Sample preparation

5.1 Target selection

For general testing purposes, users of this document are free to choose whatever target, patches and starting densities they feel are appropriate for their testing needs. An example of such a target is included in ISO 18944[26], along with requirements and recommendations for sample preparation. Applicable documents(s) for specification of print life may require the use of specific targets. Other recommendations for sample preparation are contained in ISO 18909[20]. Image prints may also be used. When specific starting densities are desired or required, there may not be a step on a printed test target that corresponds to the exact desired density. Interpolation between two neighbouring density

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