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Imaging materials — Reflection colour photographic prints — Method for testing stability under low humidity conditions

Matériaux pour l'image — Tirages photographiques en couleurs par réflexion — Méthode d'essai de la stabilité dans des conditions de faible humidité

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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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).

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 ISO/TC 42, *Photography*.

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 covers the methods and procedures for testing the low humidity fastness of reflection colour photographic prints. Low relative humidity exposure is covered; for high relative humidity testing see ISO 18946. Both low and high relative humidity testing is of particular relevance to dye- and pigment-based inkjet prints printed on swellable and porous media, dye diffusion process prints, and silver halide prints, see References [11] to[17].

In this test method the impact on the sample to be measured is the result of low moisture content in the sample, caused by low absolute humidity. When a temperature is fixed and equilibrium reached in the test environment, the measurement of the moisture content in the test environment is most easily done by specifying the relative humidity, not the humidity or absolute humidity. Therefore, the term “low relative humidity” will be used throughout this document.

The method and procedures described in this document can be used to test any colour hardcopy technology. Some types of colour photographic prints experience changes in image appearance when exposed to a low relative humidity environment. It has been observed that low relative humidities can accelerate the substrate yellowing of certain types of inkjet papers and this increase in the blue D_{min} (substrate white) has been observed with certain types of porous media, resulting in a yellow appearance. A possible mechanism for this effect is degradation of optical brighteners, see Reference [12].

The low relative humidity indoor environment can arise from cold dry air being drawn into the storage environment and heated to room temperature. Indoor low relative humidities are common in colder climates and can be especially prevalent in higher latitude countries in winter where outside air dew point temperatures can be well below 0 °C. When this air is warmed to room temperature in the print storage environment, relative humidities as low as 5 % or lower can be encountered.

Indoor low relative humidities are also common in hot, dry climates in combination with air conditioning. Low relative humidity environment is often encountered in desert environments or areas with long dry seasons..

In addition to substrate yellowing, very low relative humidities have also been shown to cause physical degradation of image receiving layers. Visual assessment and reporting of physical degradation are included.

Imaging materials — Reflection colour photographic prints — Method for testing stability under low humidity conditions

1 Scope

This document describes test methods to evaluate reflection colour photographic prints with regard to changes in image appearance resulting from exposure to low relative humidity.

The observed changes relate primarily to substrate yellowing. Other observed humidity related physical damage factors such as curl, cockle, cracking, or delamination due to humidity cycling are also within the scope of this test method.

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

ISO 18913, *Imaging materials — Permanence — Vocabulary*

ISO/TR 18931, *Imaging materials - Recommendations for humidity measurement and control*

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 used 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 control point
set point for equilibrium conditions measured at sensor location(s) in an exposure device

[SOURCE: ASTM G113]

3.2
operational fluctuation
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 G113]

3.3
operational uniformity
range around the *operational control point* (3.1) for measured parameters within the intended exposure area within the limits of intended operational range

[SOURCE: ASTM G113]

3.4
uncertainty (of measurement)
parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could be reasonably attributed to the measurement

Note 1 to entry: The parameter can 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 can 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 G113]

3.5
delamination
separation of a laminate into its constituent layers

3.6
cockle
planar distortion in flat materials, especially paper or vellum, that is characterized by puckering, waves, or rippling

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. Conversion of data obtained from these methods for the purpose of making public statements regarding product life shall be in accordance with the applicable International Standard(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. 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 compliance with the reporting requirements of this document. Comparisons shall be limited to test cases using test equipment with matching specifications.

5 Outline of test procedure

The eight-patch test target shown in Figure 1 shall be printed at 23 °C ± 2 °C and 50 % RH ± 10 % RH.

The test samples shall be conditioned, positioned with unrestricted airflow, for 24 h ± 2 h at 23 °C ± 2 °C and 50 % RH ± 10 % RH.

The printed samples shall be exposed to low humidity as specified in Clause 7.

Colorimetric measurements shall be taken from ISO 13655 as specified in Clause 8.

The colour and minimum density, D_{min}, patches shall be measured using CIELAB colorimetry before and after the relative humidity exposures. The CIELAB colour difference, ΔE^*_{ab}, for each of the eight test patches of the test target shall be calculated.

This document specifies a test method that demonstrates the degree of the deterioration (average ΔE of the printed image) quantitatively in a fixed relative humidity condition. This includes demonstrating the propensity of the image receiving layer or underlying substrate to yellow upon exposure to low relative humidities, i.e. 25 °C at 10 % RH for 12 months, see Reference [19]. This test method is most useful for research and development of printing systems or printing materials where humidity fastness of many samples can be screened and closely compared.

NOTE To achieve relative humidities as low as 10 %, it can be necessary to either reduce the ambient relative humidity in and around the test chamber environment to well below 50 %, or install a dry air tank to provide separate dry air to the humidity test chamber.

The test procedure is summarized in Table 1.

Table 1 — Summary of the test procedures

Steps		**Procedures and test conditions**
Sample preparation	Test target	Eight patch target shown in Figure 1
	Temp and RH	23 °C ± 2 °C and 50 % RH ± 10 % RH
Sample conditioning	Temp and RH	23 °C ± 2 °C and 50 % RH ± 10 % RH
	Duration	24 h ± 2 h, unrestricted airflow
Measurement	Method	CIE colorimetry conforming to ISO 13655, M2 conditions. Optionally, condition M1 may also be used
	Parameter	$L^*a^*b^*$ of eight patches in the test target before the humidity exposure
Humidity exposure	Method	25 °C at 10 % RH for 12 months
Measurement	Method	CIE colorimetry conforming to ISO 13655, M2 conditions. Optionally, condition M1 may also be used
	Parameter	$L^*a^*b^*$ of eight patches in the test target after the humidity exposure. Visual observations for physical changes
Calculation		Individual ΔE^*_{ab} of eight colour patches in the test target after the humidity exposure. All ΔE^* measurements calculated from measurements taken before and after the humidity exposure.
Report		Measured deterioration at a fixed relative humidity, both ΔE^* and physical

6 Sample preparation

6.1 General

The test target shown in Figure 1 shall be printed at 23 °C ± 2 °C and 50 % RH ± 10 % RH.

NOTE The sample printing conditions in this test method refer only to the ambient printing environment, not the conditions inside the printer during the printing process.

The test samples shall be conditioned for 24 h ± 2 h at 23 °C ± 2 °C and 50 % RH ± 5 % RH before the humidity exposure, positioned with unrestricted airflow.

The sample holding environment shall be ozone free (<2 nl/l average concentration over any 24 h period) for ozone sensitive samples, as determined according to 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, during the 12-month test and measurement time periods.

At least two replicate prints are required for each test case. Replicates shall be located for testing in different regions of the test chamber volume.

Reference samples are recommended to be included in every exposure test to track consistency of the test procedures as well as unintended changes of test conditions. See Reference [10].

6.2 Test target

The test pattern (see Figure 1) shall be used as the test target. The original file of this test file is contained in the Low Humidity Print Stability Digital Test File collection[1]. The standard Low Humidity Print Stability Digital Test File shall be downloaded and maintained in the Tagged Image File Format (TIFF). No lossy image or file compression shall be applied to the target file.

The change in the CIELAB colorimetric value of each patch in Figure 1 caused by low relative humidity exposure shall be measured as specified in Clause 8.

It is recommended that a printed reference be kept at 23 °C ± 2 °C and 50 % RH ± 10 % RH.

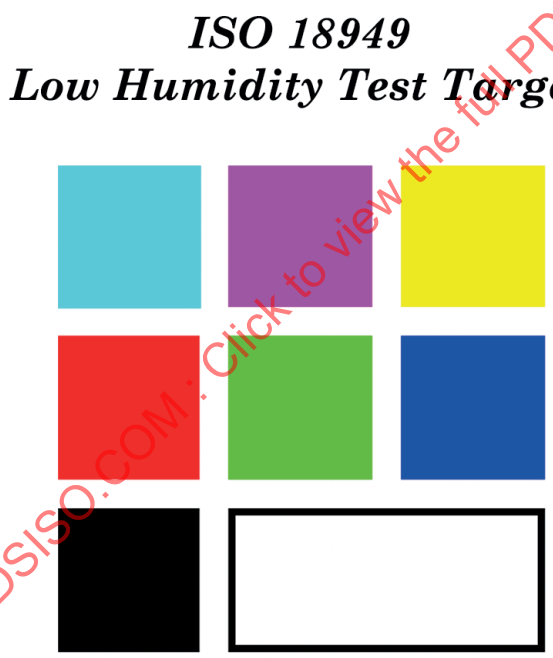

Figure 1 — Test target for low humidity fastness test

6.3 Printer driver setting

When making prints for the low humidity test, the printer driver settings in accordance with the manufacturer's recommendation should be used for each applicable media. Other printer driver settings may be used, dependent on the objectives of the test. The driver setting used shall be reported.

The standard target file shall be used with no density or colour adjustment in the preparation of the test samples.

1) http://www.imaging.org/site/IST/IST/Standards/Image_Permanence_Targets.aspx

6.4 Printing conditions

The test samples shall be printed according to the manufacturer's recommended procedures for each printing system. The temperature and the relative humidity for printing shall be 23 °C ± 2 °C and 50 % RH ± 10 % RH.

6.5 Sample conditioning

The printed samples shall be conditioned for 24 h ± 2 h at 23 °C ± 2 °C and 50 % RH ± 10 % RH before the humidity test, positioned with unrestricted airflow. This is not mandatory for traditional chromogenic prints and electrophotographic prints. These prints shall be prepared within one month before the starting time of the test.

Although other standards on imaging materials (e.g. ISO 18941) specify two weeks for the conditioning period, this test method specifies a shorter conditioning time. This is to better replicate actual user practice, and take into account that most inkjet manufacturers recommend drying prints for 24 h or overnight before framing or placing in an album. Prolonged conditioning can often improve humidity fastness in some systems due to the removal of not only water from the media, but also organic solvents in the ink, both of which can contribute to the diffusion of the colourants.

The sample holding environment shall be ozone free (<2 nl/l average concentration over any 24 h period) for ozone sensitive samples, as determined according to 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, during the 12-month test and measurement time periods.

7 Humidity exposure

7.1 Equipment and calibration

A test chamber which can control temperature and relative humidity to within the specifications described below shall be used.

Each test chamber shall be calibrated for relative humidity control and measurement accuracy by using a chilled mirror hygrometer or other type of measurement device as specified in ISO/TR 18931. A check of the calibration shall be performed when there is any indication of sensor failure. Ongoing use of redundant sensors is recommended so that sensor integrity can be ascertained.

7.2 Test environment control

The relative humidity shall be maintained and controlled throughout testing with an operational fluctuation within ±3 % RH of aim. The 24 h running average of the operational fluctuation, sampled at least every 15 min, shall be within ±1 % RH of aim. The running average shall not include the test condition transition time of at most 1 h after operation at the test condition is initiated. Operational uniformity of the equipment at the test conditions shall be evaluated prior to test start and shall be within ±3 % RH of aim, at a constant temperature. Regions of the test chamber shall be selected for use to comply with the required operational uniformity conditions. If the running average of the operational fluctuation does not meet the requirement it shall be documented and explained.

The air temperature shall be maintained and controlled throughout testing with an operational fluctuation within ±2,0 °C of aim. The 24 h running average of the operational fluctuation, sampled at least every 15 min, shall be within ±1,0 °C of aim. The running average shall not include the test condition transition time of at most 1 h after operation at the test condition is initiated. Operational uniformity of the equipment at the test conditions shall be evaluated prior to test start and shall be within ±2,0 °C of aim. Regions of the test chamber shall be selected for use to comply with the required operational uniformity conditions. If the running average of the operational fluctuation does not meet the requirement it shall be documented and explained.

The air flow shall be sufficiently high to produce uniform temperature and relative humidity conditions in the chamber.

NOTE To achieve relative humidities as low as 10 %, it can be necessary to either reduce the ambient relative humidity around the test chamber to well below 50 %, or install a dry air tank to provide separate dry air to the humidity test chamber.

The test chamber design must also eliminate the possibility of light exposure on the print surface.

Because of the potential sensitivity to air pollution for some imaging materials, the tests described in this document shall be run in as near to pollutant-free conditions as possible. One way to comply with the requirement for pollutant-free conditions is to use environmental chambers in a laboratory with an average ozone concentration of <2 nl/l over any 24 h test period.

Recent work has shown that for those materials studied (and especially so for the porous inkjet media) the effects once thought to be light-fade reciprocity failure are actually dark interactions of atmospheric pollutants with the prints, see Reference [20]. Separate testing for sensitivity to atmospheric pollutants shall be conducted following the methods specified in ISO 18941.

7.3 Fixed low relative humidity condition

The print samples shall be held at 25 °C at 10 % RH for 12 months. Colorimetric measurements shall be done before and after the humidity exposures for 12 months. Additional measurements at shorter intervals, such as three and six months, are also recommended. Although low relative humidities have been shown to primarily affect the colorimetry of the D_{min} patches, the colour patches of the test target shall also be measured. Studies have shown it takes considerable time for the D_{min} changes to occur at 25 °C and relative humidities as low as 20 %, hence the requirement for very low relative humidity and long test times, see References [19][21]. As an alternative to these test conditions, an Arrhenius test at constant dew point and elevated temperatures can be considered, see References [19][21]. Constant dew point of 13 °C at a range of temperatures up to 50 °C is recommended. See ISO 18936 for details and requirements on Arrhenius testing.

8 Colorimetric measurement

The low humidity test target patches shall be measured as follows.

Measurements and sample holding for measurement and next test phase preparation shall be conducted in a controlled environment with no time constraint or in a less controlled environment with a time constraint. The measurement environment and sample holding environment can influence measured densities.

The controlled sample holding environment with no time constraint shall meet the following set of conditions: samples shall be kept in dark, 23 °C ± 2 °C, 50 % RH ± 10 % RH conditions while waiting for measurement and while holding between test stages.

The sample holding environment shall be ozone free (<2 nl/l average concentration over any 24 h period) for ozone sensitive samples, as determined according to 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, during the sample measurement time periods.

The controlled measurement environment with no measurement process time constraint shall meet the following set of conditions: ambient illuminance on the sample surface no greater than 200 lx, temperature 23 °C ± 2 °C and relative humidity 50 % RH ± 10 % RH, and ozone free (<2 nl/l average concentration over any 24 h period) for ozone sensitive samples.

When sample holding and/or measurement are conducted in the less controlled environment, samples shall be held or measured in the less controlled environment for a maximum of 2 h for each test stage.

The less controlled environment may be unfiltered for ozone and shall have a maximum of 75 % RH and 30 °C, with ambient illuminance on the sample surface less than or equal to 1 000 lx.

NOTE 1 Stray light decreases the accuracy of measurements taken in less controlled lighting environments, see References [22][23]. Shielding the measurement instrument from direct lighting so that the actual measurement surface lighting is no more than 200 lx can improve measurement accuracy and repeatability.

The temperature and relative humidity tolerances for the sample holding and measurement environments apply specifically to the vicinities in which the samples are held and measured. Operational fluctuations, operational uniformity, and uncertainty of measurement shall be contained within the stated tolerances in those vicinities.

The colour difference shall be measured using ISO 13655 measurement condition M2 (UV excluded) for the relative spectral power distribution of the flux incident on the specimen surface.

NOTE 2 Measurement condition M1 (UV included) can also be used. Use of both measurement conditions will provide reliable data for analysing potential losses of optical brightening agents.

White backing is recommended in accordance with ISO 13655. Report the backing used or report the material opacity, according to ISO 2471, such that backing has no influence on the measurement. Measurement conditions shall be consistent throughout the test process. Conforming to ISO 13655, calculated tristimulus values and corresponding CIELAB values shall be computed using CIE illuminant D_{50} and the CIE 1931 standard colorimetric observer (often referred to as the 2° standard observer).

NOTE 3 With completely opaque materials such as the aluminium substrate used in outdoor testing the backing has no relevance.

A single measurement instrument shall be used for all of the measurements taken pertaining to a particular test. For example, initial patch values of a test target print and subsequent degraded patch values of that particular test target print shall be measured using the same measurement instrument. Replicate prints may be measured on separate measurement instruments as long as each is consistently measured on the same instrument as its initial readings. According to best practice, in the case of equipment failure, the test should be invalidated. A replacement instrument with a known offset, determined for the test measurement conditions and materials such as those currently under test, may be used when the original instrument is not available. In this case all measurements shall be corrected with the known offset.

9 Data analysis

The low humidity test target patches shall be measured as described in Clause 8, before and after the humidity exposure.

$L^*a^*b^*$ values of each patch measured after the humidity exposure test are compared to values measured after the sample conditioning step before humidity exposure.

ΔE^*_{ab} is calculated using the following Formula (1):

$$\Delta E^*_{ab} = \sqrt{(L^*_t - L^*_0)^2 + (a^*_t - a^*_0)^2 + (b^*_t - b^*_0)^2} \quad (1)$$

where L^*, a^*, and b^* are the colour coordinates at the initial time 0 and at time t, as defined by ISO/CIE 11664-4 [5].

In this test method, the initial values thus refer to measurements made on each colour patch just after sample conditioning, and values at time t are the data for the corresponding patches re-measured after humidity incubation at time t.

ΔE^*_{ab} of the eight colour patches shall be calculated according to Formula (1).

10 Test report

10.1 General

Reporting based singly on this test method shall be restricted to reporting the specific humidity fastness test result, and shall include reporting of the relative humidity (% RH) and temperature test conditions, and the test time duration.

Users are cautioned that results from this test method apply only to the specific system tested. For example, in inkjet systems, a specific ink used with a specific paper may have very different results from another. Test reporting shall include this disclaimer.

10.2 Samples information

For digital output samples, the following details shall be reported:

— the printer model, printer driver version, printer driver settings, printer front panel settings, the name of the host application used in generating the print, the cartridge configuration, and the colour controls selected in that application;

— the colourant (ink, toner, donor, ribbon, etc.);

— the paper used (manufacturer's name and model number), and any other necessary information, such that the print file can be reproduced by another user of this document.

For silver-halide based samples, the processing conditions (i.e. chemicals, procedures) shall be reported.

10.3 Test conditions

The following test conditions shall be reported:

a) temperature, relative humidity, duration and air flow (if it is known) for humidity exposure of both the test and reference samples;

b) type of colorimeter or spectrophotometer, light source and measuring parameter.

10.4 Results

10.4.1 General

The ΔE^*_{ab} of the eight colour patches shall be reported.

NOTE The colour difference ΔE, which is measured on the eight colour patches after humidity exposure, is used as a measure of colour change. The standard interpretation of ΔE values in terms of just noticeable colour differences is thus not applicable. According to a psychophysical study, see Reference [14], the change which affects the value of the actual photo corresponds to the average ΔE of 7. However, this document does not refer to any criteria, because these criteria vary depending on the scenes captured or the usage of the photo prints.

10.4.2 Test results

The values of ΔE^*_{ab} of a 12-month test duration shall be reported. It is recommended that measurements and reporting of 3- and 6-month data also take place.

Any visual observations of print quality degradation, such as sharpness, and/or physical deformations, such as curl, cockle, cracking, or delamination that occurred during the test shall also be reported.

