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Imaging materials — Reflection colour photographic prints — Test print construction and measurement

Matériaux pour l'image — Réflexion des impressions photographiques en couleurs — Mesurage et construction d'une impression d'essai

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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 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 third edition cancels and replaces the second edition (ISO 18944:2014), which has been technically revised.

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

— the document structure has been simplified in order to be better understood by users;

— definitions for measurement condition, colour attributes measured and calculations of colour changes have been included.

Introduction

This document is one of a family of International Standards on the physical properties, stability and permanence of imaging materials.

This document provides constraints on factors pertaining to target print preparation and resulting target print measurement which can cause a confounding test-process-induced variation in measured colour values and densities.

The requirements in this document are intended to be used with test methods that produce test data to be shared publicly, with the aim that test results can be duplicated in an alternate test facility.

Topics addressed include:

— digital file preparation;

— digital test file usage;

— target print uniformity;

— printing system configuration and control;

— test print conditioning;

— measurement timing and measurement conditions;

— sRGB encoded patch value for test targets and the corresponding patch selection process;

— densitometric and colorimetric calculations for colour changes.

Test target design and test print preparation are important elements in the characterization of image stability of prints, namely changes in colour attributes such as discoloration of D_{min} as well as lightness, hue and chroma changes in colour and neutral patches.

A test target realizes a specific sampling of colours from colour space that is representative for characterization of image stability in the envisaged use case. Other important elements in that characterization process are the definition of colour attributes the changes of which are evaluated and the construction of a metric as well as the choice of the statistical assessment of data analysis, such as choice of average, median or maximum changes of either individual colours or all colours. Unless a psychovisual correlation with observer judgments have been implemented, measured changes have *ad hoc* character.

In this document, the definition and the calculation of changes in colour attributes of colour and neutral patches are expressed in terms of densitometry, whereas discoloration of D_{min} is characterized colorimetrically. Changes in colour attributes evaluated with the target and definition of colour attributes in this document are intended to feed an end point system that can be used in image life specification under development in the series of print life specification standards. Previously, the definitions of colour attributes were included in the various test methods which are now consolidated into this document.

Imaging materials — Reflection colour photographic prints — Test print construction and measurement

IMPORTANT — The electronic file of this document contains colours which are considered to be useful for the correct understanding of this document. Users should therefore consider printing this document using a colour printer.

1 Scope

This document specifies requirements and recommendations for the digital test file content, printer setups and printing procedures that are used to generate target prints for test method standards and specifications for image stability in the context of reflection colour photographic prints.

Furthermore, this document defines measurement procedures of the test patches as well as how changes of colour attributes are calculated in the course of a given image stability test.

Definition of the statistical procedure for data reduction and the translation of those changes into psychophysical end point levels does not belong to the scope of this document, but results obtained with the methods defined in this document can feed into the appropriate statistical evaluation and end point systems of a print life specification defined in other documents.

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 11664-4, *Colorimetry — Part 4: CIE 1976 L*a*b* Colour space*

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

ISO 18913, *Imaging materials — Permanence — Vocabulary*

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

IEC 61966-2-1, *Multimedia systems and equipment — Colour measurement and management — Part 2-1: Colour management — Default RGB colour space — sRGB*

3 Terms, definitions and symbols

3.1 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/

3.1.1
printing system
system to generate reflection colour photographic prints, including printing colorants, printing equipment hardware and software, and typically the print media

3.1.2
RGB printer
printer configured to accept digital files with RGB printer-independent encoded colours and apply a conversion to obtain printer colourant code values

3.2 Symbols

Symbol	Definition
D_{min}	optical density of the unprinted substrate
D_{max}	maximum optical density aim chosen for the test

4 Requirements

This document specifies constraints on factors pertaining to target print preparation and resulting target print measurement which can cause confounding test-process-induced variation of measured colour values and densities. The requirements of this document shall be applied in image stability test methods that are used to characterize changes of a print material due to a specific failure mode, or to make life expectancy claims, such as time-based print lifetime claims, either comparative or absolute, in accordance with the applicable International Standard(s) for specification of print life.

The analysis of colour changes in the course of image stability testing requires the following.

a) A definition of how test colours are sampled in colour space in a way representative for the use case. This results in a specific design of a test target as given in this document.

b) A definition of how colour changes are determined, which represents a specific colour distance metrics. In this document, changes in colour and neutral patches are measured densitometrically and discoloration of D_{min} is characterized with colorimetry.

c) A definition of the statistics that is applied to translate the calculated colour changes into end point levels, e.g. average, media or maximum colour change for a selection of starting density values over all colours or per colour. The statistics are not defined in this document but are given by appropriate specifications of print life or characterizations of single failure mode.

d) A correlation of end point levels to visual perception. The necessary establishment of (potentially different) tolerance sets for each colour is an important limitation. Such end point levels system is not defined in this document but is given by an appropriate specification of print life.

5 Digital file preparation

5.1 Digital test file usage situations

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. Applicable International Standard(s) for specification of print life is likely to require the use of specific targets and starting densities.

The digital test file is designed to assess the stability of images printed in end-user-typical fashion. The test file in this case is encoded in standard sRGB, as defined in IEC 61966-2-1.

5.2 Digital test file general requirements

Printing systems can be configured to accept digital files with colours encoded for the printer colourants, such as sRGB. Printers that are configured to accept an RGB printer-independent encoding can process the conversion from the input RGB to the printer colourant encoding in a proprietary manner. These printers can be referred to as "RGB printers". The file preparation process below describes the necessary file treatment for RGB.

The digital test file of encoded colour values shall be constructed so that the target print contains areas of uniform colour (i.e. patches) corresponding to each selected optical density (recommended 0,5, 1,0, and 1,5). The size of each square colour patch area shall be large enough to cover measured area plus positioning error. The appropriate size depends on the equipment used. Aperture size requirement shall comply with the geometric conditions in ISO 5-4.

The digital test file shall incorporate target print patch areas of minimum density.

The digital test file shall produce target prints with individual patches having the selected optical densities within the required "single patch" tolerance limits, or with pairs of "bracketing patches" having the selected optical densities within the required "bracketing patch pair" tolerance limits, according to the requirements of Annex A. In the case of a set of bracketing pair patches, the targeted optical density value shall be obtained using interpolation of measured values of the pair patches as described in Annex B.

No lossy image or file compression shall be applied to the target file. Digital file shall be prepared to fit the native resolution of the printer or by scaling to size with integer numbers.

NOTE 1 A 120 dpi test file is a good starting point, as it can be scaled by integer factors to current printer resolutions such as 600 dpi, 720 dpi and 1 440 dpi.

NOTE 2 Various lossy compression methods can result in slight changes to colour values, particularly at patch edges. This, in turn, can result in additional undesirable mixing of colourants. At the time of publication of this document, the tiff file format provides the means to carry raster image content in digital files with minimal host application and operating system dependence.

NOTE 3 The digital test file can be zipped using lossless compression to minimize file size for storage.

Digital test files defined in compliance with this document can be designed and adapted for particular printing systems in any of the available image programs [such as Adobe Photoshop®[1)]].

5.3 Preparing the digital test file

5.3.1 Constructing the digital file

The digital test file shall be encoded in sRGB as defined in IEC 61966-2-1 and use a data format that enables control of individual pixel RGB values with the sRGB ICC profile embedded and without image or file compression, such as TIFF.

Colourant proportions in a printed image are recognized as system-specific, dependent on image processing, ICC profiles, halftoning, and other physical printer characteristics.

The digital test file is required to include target prints with selected optical densities in:

a) neutral patches;

NOTE Patches that are treated as neutral include white (no colourant printed), black and all values of grey produced from R = G = B sRGB encoded patch values. Such sRGB values correspond to CIELAB values with $L^* \geq 0$, and a^* and b^* both equal to zero.

b) cyan, magenta, and yellow-coloured patches;

1) Adobe Photoshop® is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product.

c) red, green, and blue-coloured patches;

d) D_{min} patch area (used to evaluate substrate discolouration).

In certain cases, the printer driver software is likely to provide an option to assign neutral code values exclusively to the black ink. In such case, composite neutral black printed with cyan, magenta and yellow colourants shall be used.

5.3.2 Adapting the digital file

The image content shall be encoded in sRGB as defined in IEC 61966-2-1. An sRGB digital test file shall be constructed using the required sRGB patch values provided in Annex A, or a selected subset of those required sRGB patch values. Whether used in whole or in part, the sRGB code values of the patches given in Annex A shall not be changed prior to printing.

5.4 Target print uniformity

The impact of the density non-uniformity in a target print or print-to-print, which is likely to affect the accuracies of density change measurement caused by exposure of the light, ozone, thermal, etc. should be minimized. Replicate prints should be printed and duplicate patches can be included within a single target print page.

6 Generating the target prints

6.1 Digital print preparation

If the printing system under test cannot accept the digital file created with the procedure described in 5.3, convert the digital file to the highest quality (e.g. least compressed) file format that the printing system can accept just prior to printing. Ensure that the required patch size is maintained in the converted printable file.

6.2 Source preparation for conventional silver gelatine photographic materials

Conventional silver gelatine photographic materials can be tested. Exposures can be controlled to produce desired print density values. Specific proportions of colourants cannot be directly controlled.

Sensitometrically-exposed specimens designed to achieve the selected optical densities in the target prints shall be processed using the processing system of primary interest and in accordance with the manufacturer's recommendations.

Processing chemicals and procedures can have a significant effect on the dark-keeping and light-keeping stability of conventional silver gelatine photographic materials. For example, a chromogenic colour negative print paper processed in a “washless” or “non-plumbed” system with a stabilizer rinse bath instead of a water wash is likely to have stability characteristics that are different from the same colour paper processed in chemicals requiring a final water wash or using a final water wash. Therefore, the specific processing chemicals and procedure shall be reported, along with the name of the colour product in any reference to the test results.

Stability data obtained from a colour material processed in certain processing chemicals shall not be assigned as belonging to colour material processed in different chemicals, or using a different processing procedure. Likewise, data obtained from colour materials that have been subjected to post-processing treatments (e.g. application of lacquers, plastic laminates, or retouching colours) shall not be assigned as belonging to colour material that has not been similarly treated, and vice versa.

6.3 Configuring the printing system and generating the target prints

When printing a test target, target prints shall be produced using driver and printer settings that are appropriate for photo printing. The printer manufacturer recommended print mode for photo printing shall be used with each printer. When multiple print mode options are available for use with the selected photo paper, the print mode selection used shall be included in the test report.

If the colourant and substrate under test are not an OEM combination, then the closest matching media setup provided in the driver and printer settings (e.g. “generic glossy photo paper”) shall be chosen. As appropriate in the typical use of the printing system, ICC profiles provided by the printing system manufacturer for the test paper and test print conditions can be used in generating target prints. In such a case using ICC profiles, do not turn off colour management when initiating the print.

Photographic material shall be printed in accordance with the manufacturer’s recommendations. The manufacturer’s requirements regarding colourant and print media storage and pre-conditioning and print device operating environment shall be followed. Printed images used for test specimen shall be collected after the printing system reaches a steady-state.

The specific printing system configuration used to generate the target print, as far as it can be determined by the test operator, shall be reported with the test results. The digital test file, as used to generate the digital target prints, shall be included in the test report, and the measurement plan (e.g. single or bracketing patch measurements, use of duplicate patch pairs, and number of replicate prints) shall be described.

6.4 Conditioning the prints after printing

Aqueous and solvent inkjet prints, and prints of any types that require curing/stabilization/dry-down shall be conditioned for two weeks after printing, in an environment with a temperature of (23 ± 2) °C, with a relative humidity (RH) of (50 ± 5) %. The print conditioning environment shall be ozone-free (≤2 nl/l average concentration over any 24 h period) for ozone-sensitive target prints, as determined in accordance with ISO 18941. During the conditioning period, the prints shall be maintained with unrestricted airflow. Prints of any types that do not require curing/stabilization/dry-down shall be held for 24 h. Measurements shall be conducted after conditioning or print hold. The required target densities shall be assessed after conditioning.

7 Target print holding and measurement conditions

7.1 Measurement timing

After the required conditioning and before being subjected to image stability testing, the target prints are measured to determine initial patch density values.

7.2 Holding and measurement conditions

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

NOTE 1 Target print holding environment refers to the environment in which target prints are held in between test phases, such as before and after measurement, while the target prints are not in the active test environment.

The controlled environment, in which target prints can be measured and held with no time constraint, shall meet the following set of conditions: target prints shall be kept in dark for target print holding and in ambient illuminance on the target print surface no greater than 200 lx for measurement process, (23 ± 2) °C, (50 ± 10) % RH conditions, and ozone-free (≤2 nl/l average concentration over any 24 h period) for ozone-sensitive target prints.

Ozone sensitivity shall be determined in accordance with ISO 18941 and this document. 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, over time periods consistent with measurement and test staging time periods.

When target print holding or target print measurement are conducted in the less controlled environment, target prints shall be held or measured in that less controlled environment for a maximum of 2 h for each test stage. The less controlled environment is likely to be unfiltered for ozone, and shall have a maximum relative humidity of 75 % RH and a maximum temperature of 30 °C, with ambient illuminance on the target print surface less than or equal to 1 000 lx.

The CIELAB colour space values of the D_{min} patch (unprinted paper) shall be obtained from measurements using ISO 13655 measurement condition and M1.

NOTE 2 Consistent measurement requires a light source with a constant UV output since most samples include optical brighteners. Measurement condition M0 allows UV output to vary which is likely to cause inconsistent measurements unless this variance is accounted for.

Conforming to ISO 13655, calculated tristimulus values and corresponding CIELAB values of the colourimetry of the D_{min} patch shall be computed using CIE illuminant D50 and the CIE 1931 standard colourimetric observer (often referred to as the 2° standard observer).

The optical densities of the colourant patches shall be measured in accordance with ISO 5-3, with the relative spectral power distribution of the flux incident on the specimen surface conforming to CIE illuminant A, with a correlated colour temperature of 2 856 K ± 100 K. A UV-cut filter shall not be used. Spectral products conforming to Status A or Status T density shall be formed as appropriate for the material under test. Use standard reflection density as defined in ISO 5-4, allowing either annular influx mode or annular efflux mode. Either white or black backing is allowed, but white backing is recommended as noted in ISO 5-4, particularly for measurements of spectral data used to compute both density and colorimetric values.

NOTE 3 The purpose of tests using this document is to characterize the fade of the systems as closely as possible to human perception. Avoiding the use of UV cut filters is consistent with this purpose given that optical brighteners change printed colours as seen by an observer, not only in the media white, but also in the skin tones and in the neutral axis.

NOTE 4 When this document is used in conjunction with an image life specification standard, then either standard status A or status T density is selected according to that specification standard.

Measurement instruments shall be calibrated in accordance with the manufacturer's instructions. A single measurement instrument is recommended to be used for all of the measurements taken pertaining to a particular target print.

8 Measurement of test patches

8.1 Measured attributes

8.1.1 General

Colour and neutral patches are measured densitometrically. *d* is the symbol for measured density.

D_{min} is measured colorimetrically.

A reflective densitometer uses filters with Red, Green and Blue spectral transmission response to measure the absorption of Red, Green and Blue light on the image patches. This corresponds to the measurement of Cyan, Magenta and Yellow densities.

8.1.2 Density attributes to be measured

The following densities of the specimens shall be measured with Red (R), Green (G) and Blue (B) Status A or Status T transmission response before and after the treatment interval.

a) $d\mathrm{N(R)_t}$, $d\mathrm{N(G)_t}$, $d\mathrm{N(B)_t}$

The densities of neutral patches that have been treated for time t, where t takes on values from 0 to the end of the test.

b) $d\mathrm{C(R)_t}$, $d\mathrm{M(G)_t}$, $d\mathrm{Y(B)_t}$

The densities of Cyan, Magenta and Yellow colour patches that have been treated for time t, where t takes on values from 0 to the end of the test.

c) $d\mathrm{R(G)_t}$, $d\mathrm{R(B)_t}$, $d\mathrm{G(R)_t}$, $d\mathrm{G(B)_t}$, $d\mathrm{B(R)_t}$, $d\mathrm{B(G)_t}$

The densities of the composite secondary R, G, B colour patches that have been treated for time *t*, where *t* takes on values from 0 to the end of the test.

8.1.3 Colorimetry values to be measured

Colorimetry values shall be measured as CIELAB L^*, a^* and b^*, as defined in ISO 11664-4. The following colorimetry values of the specimens, prepared as described in Clause 5, shall be measured before and after the treatment interval.

L^*_t, a^*_t, b^*_t

The lightness, red-green, and blue-yellow colour coordinates for the unprinted areas of specimens (paper white) that have been treated for time *t*, where *t* takes on values from 0 to the end of the test.

9 Calculation of colour changes

9.1 General

Any change in density, contrast, or stain in the course of exposure to climate stresses over time (e.g. exposure to heat, humidity, light or air pollution) - whether due to colorant fading, changes in colorant 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 colorants. The second most consequential change is that caused by an increase in stain due to a discolouration of the D_min areas or a change in the D_min colour balance.

Colour patches and neutral patches shall be measured at certain aim density as required by the end point metrics for which the colour changes are determined. For example, aim density values 0,5, 1,0 and 1,5 are considered typical for photographic prints. Positions of the aim density values are identified on the printed test target before the treatment but after completion of conditioning (see 6.4) using the single patch or bracketing pair approach as described in A.4 and following the patch selection procedure (see A.5.3 to A.5.6). Calculations of colour changes as defined in 9.2 to 9.6 shall be performed for selected patches for the range of initial densities. Discoloration of D_min patch is expressed colorimetrically, see 9.7.

9.2 Percent density change in primary colour patches

a) Cyan patch: $\%\Delta d\mathrm{C(R)_t} = \{[d\mathrm{C(R)_t} - d\mathrm{C(R)_0}] \div d\mathrm{C(R)_0}\} \times 100$

b) Magenta patch: $\%\Delta d\mathrm{M(G)_t} = \{[d\mathrm{M(G)_t} - d\mathrm{M(G)_0}] \div d\mathrm{M(G)_0}\} \times 100$

c) Yellow patch: $\%\Delta d\mathrm{Y(B)_t} = \{[d\mathrm{Y(B)_t} - d\mathrm{Y(B)_0}] \div d\mathrm{Y(B)_0}\} \times 100$

9.3 Percent density change in secondary (mixed) colour patches

a) Magenta in Red patch: $\%\Delta dR(G)_t = \{[dR(G)_t - dR(G)_0] \div dR(G)_0\} \times 100$

b) Yellow in Red patch: $\%\Delta dR(B)_t = \{[dR(B)_t - dR(B)_0] \div dR(B)_0\} \times 100$

c) Cyan in Green patch: $\%\Delta dG(R)_t = \{[dG(R)_t - dG(R)_0] \div dG(R)_0\} \times 100$

d) Yellow in Green patch: $\%\Delta dG(B)_t = \{[dG(B)_t - dG(B)_0] \div dG(B)_0\} \times 100$

e) Cyan in Blue patch: $\%\Delta dB(R)_t = \{[dB(R)_t - dB(R)_0] \div dB(R)_0\} \times 100$

f) Magenta in Blue patch: $\%\Delta dB(G)_t = \{[dB(G)_t - dB(G)_0] \div dB(G)_0\} \times 100$

9.4 Percent density change in composite neutral patch

a) Cyan in neutral patch: $\%\Delta dN(R)_t = \{[dN(R)_t - dN(R)_0] \div dN(R)_0\} \times 100$

b) Magenta in neutral patch: $\%\Delta dN(G)_t = \{[dN(G)_t - dN(G)_0] \div dN(G)_0\} \times 100$

c) Yellow in neutral patch: $\%\Delta dN(B)_t = \{[dN(B)_t - dN(B)_0] \div dN(B)_0\} \times 100$

9.5 Colour balance shift in composite neutral patch

Contrast and colour balance distortions brought about by differential fading of the three image colorants can result in significant visually degrading effects. These can be measured as shifts in colour balance from highlights to shadows and 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 colorant, or from yellow to blue or cyan to red due to fading of the yellow or cyan colorant.

Neutral colour balance shift is calculated as the difference in percent change between any two primary colours of a neutral patch. The percent change of individual primary colours in a neutral patch is defined in 9.4.

a) Cyan-magenta shift: $\%\Delta dN(R\text{-}G)_t = |\%\Delta dN(R)_t - \%\Delta dN(G)_t|$

b) Magenta-yellow shift: $\%\Delta dN(G\text{-}B)_t = |\%\Delta dN(G)_t - \%\Delta dN(B)_t|$

c) Yellow-cyan shift: $\%\Delta dN(B\text{-}R)_t = |\%\Delta dN(B)_t - \%\Delta dN(R)_t|$

9.6 Colour balance shift in secondary (mixed) colour patches

Secondary colour balance shift is calculated as the difference in percent change between the two primary colours of each secondary colour patch. The percent change of the individual primary colours in each secondary colour patch is defined in 9.3.

a) Cyan-magenta shift in Blue patch: $\%\Delta dB(R\text{-}G)_t = |\%\Delta dB(R)_t - \%\Delta dB(G)_t|$

b) Magenta-yellow shift in Red patch: $\%\Delta dR(G\text{-}B)_t = |\%\Delta dR(G)_t - \%\Delta dR(B)_t|$

c) Yellow-cyan shift in Green patch: $\%\Delta dG(B\text{-}R)_t = |\%\Delta dG(B)_t - \%\Delta dG(R)_t|$

9.7 Colour balance in D_{min} patches by colorimetry

Colour balance in the D_{min} patches 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 of the D_{min} patch at the initial time 0 and at time t.

10 Reporting

10.1 General

Changes of the colour attributes are reported for starting densities as required by calling standards. Without specific requirements, colour changes of the colour and neutral patches are reported for starting densities of 0,5, 1,0 and 1,5.

10.2 Test report

In the case that a test method standard, e.g. thermal (ISO 18936), light (ISO 18937) or ozone (ISO 18941), or print life specification standard utilizes this document for the sample print preparation or colour change measurement, the following subjects shall be described in its reporting:

— the printing system (printer, colorants and printing substrate) as well as printer driver and printing parameter settings used to create the test target;

— the starting densities for each colour taken in its measurement;

— the test target used in its measurement;

— the text that states "test print patches were prepared according to ISO 18944:2018 ed. 3".

It is preferable to present the report in a table that contains the changes of the various colour attributes (9.2 to 9.7) for that test method at actual sampling times. The table covers changes in colour attributes at all starting densities for colour patches, neutral patches as well as the D_{min} patch. Sampling times may be expressed as actual test time under actual test conditions, using a suitable unit of time such as hours or days, or may be expressed as cumulative dose. The approach follows the stipulations of a test method or specification standard that has called for this test target.

If the aforementioned table is used for statistical analysis for end point determination as given by a print life specification, the values of the table may be regarded as intermediate values of the overall analysis and do not have to be reported separately, but are reported as integral part of that analysis.

Annex A
(normative)

Required sRGB encoded patch values for test targets, tolerance in optical density (OD) and patch selection process

A.1 General

There are two test targets described in this document: One is the sRGB linear target originally designed for the JEITA standard CP-3901, described in A.2, and the other is the CIELAB constant hue target uniquely designed for this document, described in A.3. Users can choose either one of two depending on the objective of evaluation. Applicable International Standard(s) for specification of print life is likely to specify the test target used for the standard(s).

The sRGB linear target produces relatively pure colours with high chroma and is best suited to understanding the stability of individual colorants, either alone or in combination. The CIELAB constant hue target produces less pure colours that better represent actual photographic images. The CIELAB constant hue target is also better able to produce higher density colour patches, although it does so by reducing the chroma of such colours.

Downloadable and printable test targets for CIELAB constant hue and sRGB linear test targets are prepared in the form of PDF files. The user can download the files from the following website: http://standards.iso.org/iso/18944/ed-3/en.

A.2 sRGB code values for sRGB linear target

The sRGB code values described in Table A.1 are selected for the sRGB linear target. Each hue of blue, red, green, cyan, magenta, yellow or neutral has 17 tone patches with the interval of 16 code values (including white of R = 255, G = 255, B = 255).

Each hue angle is defined in the sRGB space, which is generally adopted as input signals in most of the digital camera and computer graphics which usually take relatively larger colour gamut than average printers. Since the locus of each tone patch of R, G, B, C, M and Y traces the gamut edge of the sRGB space, the reproducible colour gamut with this target, constrained by the gamut compressions in printer drivers, can be expanded with future progress in printing technologies. Therefore, this target has an opportunity to evaluate colour degradations for the outer edges of printer gamut, generally showing larger colour changes than inside. In contrast, there is no opportunity to evaluate degradations for expanded colours reproduced by a future printer in case of the CIELAB constant hue test target, which is defined based on the colour gamut of the average printers in the first decade of this century when the test target was designed.

Table A.1 — R, G, B, C, M, Y and neutral patch values in sRGB linear target

	Blue patches			Green patches			Red patches			Cyan patches			Magenta patches			Yellow patches			Neutral patches		
	R	G	B	R	G	B	R	G	B	R	G	B	R	G	B	R	G	B	R	G	B
0	255	255	255	255	255	255	255	255	255	255	255	255	255	255	255	255	255	255	255	255	255
1	240	240	255	240	255	240	255	240	240	240	255	255	255	240	255	255	255	240	240	240	240
2	224	224	255	224	255	224	255	224	224	224	255	255	255	224	255	255	255	224	224	224	224
3	208	208	255	208	255	208	255	208	208	208	255	255	255	208	255	255	255	208	208	208	208
4	192	192	255	192	255	192	255	192	192	192	255	255	255	192	255	255	255	192	192	192	192
5	176	176	255	176	255	176	255	176	176	176	255	255	255	176	255	255	255	176	176	176	176
6	160	160	255	160	255	160	255	160	160	160	255	255	255	160	255	255	255	160	160	160	160
7	144	144	255	144	255	144	255	144	144	144	255	255	255	144	255	255	255	144	144	144	144
8	128	128	255	128	255	128	255	128	128	128	255	255	255	128	255	255	255	128	128	128	128
9	112	112	255	112	255	112	255	112	112	112	255	255	255	112	255	255	255	112	112	112	112
10	96	96	255	96	255	96	255	96	96	96	255	255	255	96	255	255	255	96	96	96	96
11	80	80	255	80	255	80	255	80	80	80	255	255	255	80	255	255	255	80	80	80	80
12	64	64	255	64	255	64	255	64	64	64	255	255	255	64	255	255	255	64	64	64	64
13	48	48	255	48	255	48	255	48	48	48	255	255	255	48	255	255	255	48	48	48	48
14	32	32	255	32	255	32	255	32	32	32	255	255	255	32	255	255	255	32	32	32	32
15	16	16	255	16	255	16	255	16	16	16	255	255	255	16	255	255	255	16	16	16	16
16	0	0	255	0	255	0	255	0	0	0	255	255	255	0	255	255	255	0	0	0	0

A.3 sRGB code values for CIELAB constant hue target

For neutral patches, the following sRGB code values are selected to provide a 48-step set of neutral patches. The 48 neutral patch sRGB code values shall be R = G = B with five patches having values of 0, 10, 20, 30 and 40, respectively, and 43 patches having values 45 to 255, respectively, with an increment of 5 code values between each patch. The 48 neutral patch sRGB code values are shown in Table A.2.

Table A.2 — Neutral patch sRGB code values in CIELAB constant hue test target

	Neutral patches				Neutral patches		
	R	G	B		R	G	B
1	255	255	255	25	135	135	135
2	250	250	250	26	130	130	130
3	245	245	245	27	125	125	125
4	240	240	240	28	120	120	120
5	235	235	235	29	115	115	115
6	230	230	230	30	110	110	110
7	225	225	225	31	105	105	105
8	220	220	220	32	100	100	100
9	215	215	215	33	95	95	95
10	210	210	210	34	90	90	90
11	205	205	205	35	85	85	85
12	200	200	200	36	80	80	80
13	195	195	195	37	75	75	75
14	190	190	190	38	70	70	70
15	185	185	185	39	65	65	65
16	180	180	180	40	60	60	60
17	175	175	175	41	55	55	55
18	170	170	170	42	50	50	50
19	165	165	165	43	45	45	45
20	160	160	160	44	40	40	40
21	155	155	155	45	30	30	30
22	150	150	150	46	20	20	20
23	145	145	145	47	10	10	10
24	140	140	140	48	0	0	0

For colour patches, sRGB code values are selected to provide the hues of red, green, blue, cyan, magenta, and yellow as shown in Table A.5. sRGB patch values are selected to cover a range of lightness and chroma values in each of the selected hues as shown in Table A.3.

Reference colour hue angles in Table A.4 are for information only. RGB values in Table A.3 were selected to reflect a compromise between the various reference values given in Table A.4, with specific care taken to avoid the purple shift that takes place as the blue hue angle approaches the magenta hue angle. The standardization of RGB values to defined hue values, rather than the exact hue values selected, is the key to selection of patches that accurately reproduce the aging of pictorial photographs during accelerated tests.

Tables A.2 and A.5 specify the valid sRGB patch values for the test target.

Table A.3 — Aiming hue angles in CIELAB constant hue test target

	Red	Yellow	Green	Cyan	Blue	Magenta
CIELAB h_{ab}	33	90	135	202,5	270	337,5
NOTE The blue hue angle CIELAB hab = 270 is chosen as a compromise between the ISO 12640-3 and the Munsell lab values in Table A.4, and also to avoid a purple shift (added magenta) in the prints.						

Table A.4 — Hue angles in typical colour systems

	Red	Yellow	Green	Cyan	Blue	Magenta
ISO 12640-3:2007, Table B.5	29	90	140	220	300	340
sRGB CIELAB h_{ab}	40,8	99,8	134,3	196,4	301,3	327,5
Munsell CIELAB h_{ab} CIE 1931 Observer Illuminant C	**5R to 10R** 27,7 to 46,3		**5G to 10G** 163,7 to 175,1		**5B to 10B** 231,7 to 252,9	
Munsell CIELAB h_{ab} CIE 1931 Observer adapted F11 (Bradford)	**5R to 10R** 18,96 to 45,58		**5G to 10G** 164,4 to 176,7		**5B to 10B** 222,5 to 239,4	

Table A.5 — R, G, B, C, M and Y patch values in CIELAB constant hue target

	Red patches			Green patches			Blue patches			Cyan patches			Magenta patches			Yellow patches		
	R	G	B	R	G	B	R	G	B	R	G	B	R	G	B	R	G	B
1	255	227	222	232	255	225	225	233	255	225	254	255	255	225	248	255	248	225
2	255	210	202	220	255	210	210	224	255	210	253	255	255	210	244	255	244	210
3	255	200	192	212	255	200	200	218	255	200	252	255	255	200	241	255	242	200
4	255	195	185	208	255	195	195	214	255	190	251	255	255	190	236	255	240	190
5	255	190	180	204	255	190	190	210	255	180	251	255	255	180	233	255	238	180
6	255	185	175	199	255	185	185	207	255	175	251	255	255	175	230	255	237	175
7	255	180	169	195	255	180	180	204	255	170	251	255	255	170	228	255	236	170
8	255	175	163	190	255	175	175	201	255	165	251	255	255	165	227	255	235	165
9	255	170	158	186	255	170	170	198	255	160	250	255	255	160	226	255	234	160
10	255	165	153	182	255	165	165	195	255	155	250	255	255	155	224	255	233	155
11	255	160	148	177	255	160	160	192	255	150	250	255	255	150	222	255	232	150
12	255	155	142	173	255	155	155	189	255	145	249	255	255	145	220	255	231	145
13	255	150	137	169	255	150	150	187	255	140	249	255	255	140	219	255	230	140
14	255	145	131	164	255	145	145	185	255	135	249	255	255	135	219	255	229	135
15	255	140	126	160	255	140	140	182	255	130	249	255	255	130	219	255	229	130
16	255	135	120	156	255	135	135	180	255	125	249	255	255	125	218	255	228	125
17	255	130	115	151	255	130	130	177	255	120	248	255	255	120	217	255	227	120
18	255	125	110	146	255	125	125	175	255	115	248	255	255	115	216	255	227	115
19	255	120	105	141	255	120	120	172	255	110	248	255	255	110	215	255	226	110
20	255	115	101	135	255	115	115	170	255	105	248	255	255	105	213	255	226	105
21	255	110	96	129	255	110	110	168	255	100	248	255	255	100	213	255	225	100
22	255	105	92	124	255	105	105	165	255	95	248	255	255	95	213	255	225	95
23	255	100	88	119	255	100	100	163	255	90	247	255	255	90	213	255	224	90
24	255	95	84	113	255	95	95	161	255	85	247	255	255	85	213	255	224	85
25	255	90	81	107	255	90	90	159	255	80	247	255	255	80	213	255	224	80

Table A.5 *(continued)*

	Red patches			Green patches			Blue patches			Cyan patches			Magenta patches			Yellow patches		
	R	G	B	R	G	B	R	G	B	R	G	B	R	G	B	R	G	B
26	255	85	77	101	255	85	85	158	255	75	246	255	255	75	212	255	223	75
27	255	80	74	95	255	80	80	157	255	70	246	255	255	70	212	255	223	70
28	255	75	71	89	255	75	75	155	255	65	246	255	255	65	210	255	223	65
29	255	70	68	83	255	70	70	154	255	60	246	255	255	60	209	255	222	60
30	255	65	65	77	255	65	65	153	255	55	246	255	255	55	209	255	222	55
31	255	60	62	71	255	60	60	151	255	50	245	255	255	50	208	255	222	50
32	255	55	59	64	255	55	55	150	255	40	245	255	255	40	207	255	222	40
33	255	50	57	57	255	50	50	149	255	30	245	255	255	30	207	255	222	30
34	255	40	54	50	255	45	40	147	255	20	245	255	255	20	207	255	222	20
35	255	30	51	41	255	40	30	145	255	10	245	255	255	10	207	255	222	10
36	255	20	49	34	255	35	20	144	255	0	245	255	255	0	207	255	222	0
37	255	10	47	26	255	30	10	144	255	0	235	245	245	0	202	245	212	0
38	255	0	47	15	255	25	0	144	255	0	225	235	235	0	192	235	203	0
39	245	0	44	10	240	25	0	138	245	0	215	224	225	0	183	225	195	0
40	235	0	41	10	225	18	0	132	235	0	205	214	215	0	174	215	187	0
41	225	0	39	10	210	18	0	125	225	0	195	203	205	0	165	205	178	0
42	215	0	37	10	195	18	0	120	215	0	185	194	195	0	158	195	168	0
43	200	0	33	10	180	18	0	115	205	0	175	182	185	0	150	185	160	0
44	185	0	30	10	165	18	0	105	190	0	160	166	175	0	141	175	152	0
45	170	0	26	0	145	10	0	96	175	0	145	151	165	0	133	165	143	0
46	155	0	23	0	125	10	0	87	160	0	130	135	155	0	125	155	133	0
47	140	0	20	0	105	4	0	79	145	0	115	120	140	0	113	145	125	0
48	125	0	17	0	85	4	0	70	130	0	100	104	125	0	101	135	117	0

A.4 Tolerances in optical density

Measurement tolerances are specified separately for the single patch and the bracketing patch pair cases. A single patch shall be a valid selection when the measured optical density is within 10 % of the corresponding OD Aim (test aim optical density), regardless of the OD Aim value.

In the bracketing patch pair case, measurement tolerances are specified separately for three OD Aim value ranges. A low-range optical density value bracketing pair patch shall be a valid patch selection when the measured optical density is within 30 % of the corresponding OD Aim, applicable with OD Aim ≤ 0,75 OD. A mid-range optical density value bracketing pair patch shall be a valid patch selection when the measured optical density is within 25 % of the corresponding OD Aim, applicable with 0,75 OD < OD Aim ≤ 1,25 OD. A high-range optical density value bracketing pair patch shall be a valid patch selection when the measured optical density is within 20 % of the corresponding OD Aim, applicable with 1,25 OD < OD Aim.

For example:

OD Aim range	OD Aim	Single patch tolerance	Bracketing pair patch tolerance
Low-range	0,50	10 % (0,50 ± 0,05)	30 % (0,50 ± 0,15)
Mid-range	1,00	10 % (1,00 ± 0,10)	25 % (1,00 ± 0,25)
High-range	1,50	10 % (1,50 ± 0,15)	20 % (1,50 ± 0,30)

A.5 Patch selection methodology

A.5.1 General

The measurement values of the duplicate patches of the required replicate prints shall be averaged together and then each duplicate patch average measurement shall be used as a single measurement in computing patch selection, density change, and image permanence failure. This duplicate patch averaging process shall be used in the initial stage of patch selection and throughout the image stability testing process. The individual raw values of the duplicate patches are not used in evaluations.

For each colour and neutral patch set, if all patch value options available in the complete sRGB patch set of this Annex have been utilized, and if a patch or patch pair are not found within the single or bracketing pair patch tolerances of the high-range OD Aim (initial test aim D_{max} optical density), then the D_{max} exception process given in A.5.5 shall be applied.

For each colour and neutral patch set, having determined a usable high-range OD Aim (from the initial test aim D_{max} optical density or the replacement test aim D_{max} optical density) and the corresponding patch values, compare the usable high-range OD Aim to the mid-range and low-range OD Aims.

If the usable high-range OD Aim for a colour is less than or equal to the mid-range OD Aim plus 10 % (i.e. is within the single patch tolerance), then the usable high-range OD Aim patch shall replace the selected mid-range OD Aim patch or patch pair.

Likewise, if the usable high-range OD Aim for a colour is less than or equal to the low-range OD Aim plus 10 %, then the usable high-range OD Aim patch shall replace the selected low-range OD Aim patch or patch pair.

NOTE If the usable high-range OD Aim patch is greater than the upper bound of the single patch tolerance with respect to the mid-range OD Aim or the low-range OD Aim, patches selected in accordance with those aims are not overridden.

For OD Aims attainable in each colour and neutral:

— choose a single patch (duplicate average) that is within single patch tolerance, if available;

— choose a pair of bracketing patches (two duplicate patch averages) above and below the OD Aim, within the bracketing pair patch tolerance, if no single patch meets a particular OD Aim;

— apply the patch selection processes specified in A.5.2 to A.5.4.

A subset of the patches comprising those having the measurement values within the tolerance of the single patch or the bracketing patch pair can be used. Only the code values described in Table A.1 or A.2 for neutral and in Tables A.1 or Table A.5 for colours shall be used for applications within the scope of this document. An example of the layout of a subset is Figure A.1.

If a subset of the patches defined in this document is used to make initial prints for determination of patch selections, and in the subset no individual patch or bracket pair of patches is found to meet a particular OD Aim, patch selection print(s) shall be re-printed using the full patch set defined in this document or using a new subset of patches selected from the full patch set.

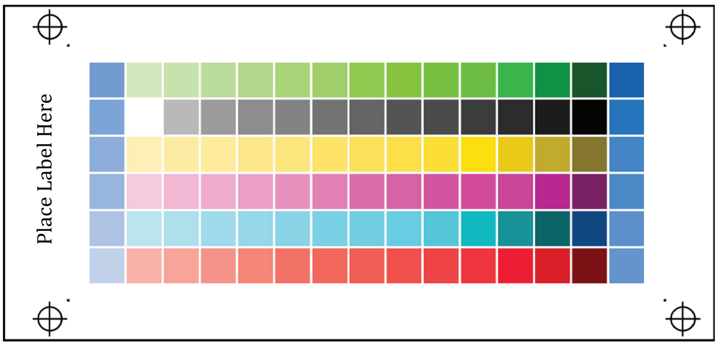

Figure A.1 — Example of a layout of a subset target

A.5.2 Neutral patch selection process

— Average together the optical density values for duplicate patches on the same or replicate targets.

— Select an individual patch or bracketing pair patches (for interpolation) for each aim density that have the optical density values for all three colours of red, green and blue within the tolerances described in A.4.

In selecting the neutral patches for each focus density, the focus is on all three colour densities in the same patch. The desired patches shall have all three colour densities closest to the aim density. Among the patches that meet the tolerance requirement, the patch having the smallest patch value rating (PVR) is selected. The equations to calculate PVR is described in A.5.6. Procedurally, if more than one patch has all three colour densities within the required tolerance, select the patch having the smallest patch value rating calculated by summing the deviations from the aim density for the three colour densities.

EXAMPLE In the case that a neutral patch for 0,50 Aim OD is selected and that one patch has the red density of 0,45, green density of 0,48 and blue density of 0,45 and the other patch has the red density of 0,52, green density of 0,54 and blue density of 0,51, the latter patch shall be selected. Because PVR (= 0,02 + 0,04 + 0,01 = 0,07) for the latter patch is smaller than PVR (= 0,05 + 0,02 + 0,05 = 0,12) for the former patch.

In the case that more than one patch meet the required lower tolerance or upper tolerance for bracketing pair patches and no single patch meets the required single patch tolerance, the patch with the smallest PVR in the patches having lower density than aim and the patch with the smallest PVR in the patches having higher density than aim shall be selected for the most suitable bracketing pair patches.

A.5.3 Patch selection process for Red, Green and Blue

— Average together the optical density values for duplicate patches on the same or replicate targets.

— Select individual patches or bracketing pair patches (for interpolation) in which both of two optical densities for complementary colours corresponding a selected colour (Green and Blue in Red patch selection, Blue and Red in Green patch selection, and Red and Green in Blue patch selection) satisfy the required tolerance described in A.4.

If multiple patches meet the tolerance criteria for single patches or bracketing pair patches, the preferred patch shall have the lowest PVR. The equations to calculate PVR is described in A.5.6.

Procedurally, if more than one patch has the required focus density within the required tolerance, select the patch of the lowest PVR calculated by summing the deviation of the densities of two complementary colours from the aim density and the deviation from zero of the density of selecting colour.

