INTERNATIONAL STANDARD

ISO

18944

First edition
2012-04-15

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

ISO 18944:2012(E)

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 18944 was prepared by Technical Committee ISO/TC 42, *Photography*.

Introduction

This International Standard is one of a series of International Standards prepared by ISO/TC 42 on the physical properties, stability and permanence of imaging materials.

This International Standard 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 International Standard 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:

— description of test types (image print stability testing versus image forming materials testing);

— digital file preparation;

— digital test file usage;

— addressing target print uniformity;

— managing test equipment non-uniformity;

— print system configuration and control;

— test print conditioning;

— measurement timing and measurement conditions;

— required sRGB encoded patch set for image print stability test target and the corresponding patch selection process;

— informative guidance for test file construction and use;

— informative guidance on statistical approaches to minimize measurement error.

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

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

1 Scope

This International Standard specifies requirements and recommendations for the digital test file content, number of print replicates, 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.

2 Normative references

The following referenced documents are indispensable for the application 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 2471:2008 *Paper and board — Determination of opacity (paper backing) — Diffuse reflectance method*

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

ISO 12640-3, *Graphic technology — Prepress digital data exchange — Part 3: CIELAB standard colour image data* (CIELAB/SCID)

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

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*

TIFF, Revision 6.0. Adobe Systems Incorporated 1992 http://partners.adobe.com/public/developer/en/tiff/TIFF6.pdf

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
CMYK printer
printer configured to accept digital files with colours encoded for CMYK printer colourants and print without further colour conversion

3.2
image forming materials stability test
test to evaluate the print stability of the component materials that comprise image prints, intended for manufacturers who are designing new colourants or for customers who are specifying colourant characteristics

3.3
image print stability test
test to evaluate the print stability of images printed in end-user-typical fashion

3.4
operational control point
set point for equilibrium conditions measured at sensor location(s) in an exposure device

NOTE   Adapted from ASTM G 113.

3.5
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   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.

NOTE 2   Adapted from ASTM G 113.

3.6
operational uniformity
range around the operational control point for measured parameters within the intended exposure area within the limits of intended operational range

NOTE 1   Operational uniformity evaluates the measured parameters throughout the volume of a test chamber so that regions of the test chamber volume can be determined to comply within the required stated limits of the measured parameter operating aim.

NOTE 2   Adapted from ASTM G 113.

3.7
RGB printer
printer configured to accept digital files with RGB printer-independent encoded colours and apply a conversion to obtain printer colourant code values

3.8
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 measurand

NOTE 1   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. 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. It is understood that the result of the measurement is the best estimate of the value of the measurand, 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.

NOTE 2   Adapted from ASTM G 113.

4   Requirements

This International Standard 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 International Standard shall be applied in test methods that are used 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 requirements of this International Standard should be applied with image stability test methods when those test methods are used to report stand-alone absolute or comparative stability of image materials with respect to the specific failure mode of the test method standard.

In alternative test situations, when the conditions and constraints set forth in this International Standard are not followed, then the test report of that test method result shall include a statement of each condition that differs from the requirements of this International Standard. Caution shall be used when comparing test results for different materials and for different target print preparation and measurement conditions. Comparisons shall only be made when using equipment with matching specifications, under matching test conditions.

5 Digital file preparation

5.1 Digital test file usage situations

For general testing purposes, users of this International Standard 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 may require the use of specific targets and starting densities.

Reference target prints should be included in every exposure test to track consistency of the test procedures, as well as to detect unintended changes in test conditions.

NOTE 1   See ASTM G156.

The target prints of this International Standard can be used for two kinds of image stability testing:

1)   a printing system test for image print stability, including substrate discolouration, or

2)   a materials test for image forming materials stability (colourant stability and substrate discolouration).

The digital test file is adapted and the target prints are generated differently for these two cases. After the digital test file is printed, when subjected to the test method standards, the target prints are treated identically.

The *image print stability test* assesses 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.

NOTE 2   The sRGB colour encoding is widely used in digital photography. This is a particular RGB encoding that has a standardized visual colour meaning for each RGB code value. The standardized colour meaning for each sRGB code value means that "sky blue" and "grass green", etc. are represented by certain RGB code values. Because the sRGB colour encoding is well known, printers that print digital photographs can be configured to print sRGB encoded images. Printing sRGB code values that have standardized colour meanings of cyan, magenta, yellow, red, green, blue and neutral will result in target print patches that have colourant proportions similar to consumer image prints of those colours produced through the specific print system.

Real world image print stability is a function of combinations of colourants in real images. Colourant proportion significantly impacts the results of the stability tests. Using colourant proportions similar to those in consumer prints for specific well defined colours improves estimation of consumer image stability. The print colourant proportions in the image stability target print will be slightly different for different print systems, however in each case the target print is a realistic representation of the colourant proportions in real photos printed via those printers.

Printing the primaries and secondaries and neutrals does not cover all possible kinds of inks that a printer may contain. Testing for additional colourants is a recommended extension for both the image print and image forming materials.

The *image forming materials stability test* assesses the stability of the component materials that comprise the prints. Care is taken to isolate the materials from influences of the print system as far as is possible.

NOTE 3   This test is intended for manufacturers who are designing new inks or for customers who are specifying ink characteristics, and require testing on individual components.

5.2   Digital test file general requirements

Print systems can be configured either to accept digital files with colours encoded for the printer colourants, such as CMYK, or to accept digital files with colours defined using a printer-independent encoding, 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". Printers that can be configured to accept (and print without further colour conversion) digital files with colours encoded for CMYK printer colourants can be referred to as "CMYK printers". The file preparation process below describes the necessary file treatment for RGB and CMYK printers.

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 at least 2 mm greater in length and width than the measurement instrument aperture, plus twice the measurement instrument positioning accuracy specification, according to the following equation:

$$S = 2 + (2 * A) + D$$

where:

S is the minimum size of each square colour patch area, in millimetres;

A is the measurement instrument "measurement positioning accuracy" specified by the instrument manufacturer, in millimetres;

D is the measurement instrument "measurement aperture diameter" specified by the instrument manufacturer, in millimetres.

For example, with a measurement positioning accuracy of ± 0,25 mm and a measurement aperture diameter of 4,5 mm, the minimum allowed patch size = (2,0 + 0,50 + 4,5) mm, which is 7 mm^2. Spacing between patches shall be adjusted to minimize degrading influence between patches during the testing and measurement processes. The appropriate inter-patch spacing depends on the materials and the equipment used.

The digital test file shall produce target print patch areas of minimum density (i.e. paper white).

The digital test file shall produce target print patches of selected optical densities utilizing cyan, magenta, yellow and black printer colourant primaries, and utilizing red, green and blue printer secondaries.

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 pair" tolerance limits, according to the requirements of Annex A. In the case of bracketing patch pairs, the selected optical density values shall be obtained using interpolation as described in Annex B.

The digital test file shall be created and maintained continuously in the tiff file format. No lossy image or file compression shall be applied to the target file. The digital image file resolution shall be 600 dpi.

NOTE 1   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 writing of this International Standard, the tiff file format provides the means to carry raster image content in digital files with minimal host application and operating system dependence.

NOTE 2   The digital test file can be zipped using lossless compression to minimize file size for storage.

Digital test files defined in compliance with this International Standard can be designed and adapted for particular printing systems in any of the available image programs (such as Adobe Photoshop®[1]). Ensure that the image resolution is 600 dpi after editing.

5.3 Preparing the digital test file for an image print stability test

5.3.1 Constructing the digital file for an image print stability test

The image print stability digital test file shall be encoded in sRGB as defined in IEC 61966-2-1 and saved in the tiff format with the sRGB ICC profile embedded.

NOTE 1   Even though sRGB is a standard, the ICC profiles for sRGB can differ. Retaining the original sRGB ICC profile with the file contributes to test repeatability.

For image print stability testing, the encoded colour values of the patches in the digital test file shall not be manipulated to control the colourant proportions in the patches of the target print. Rather, the objective is to obtain cyan, magenta, yellow, red, green, and blue coloured patches in the target print that are typical in a pleasing pictorial image. Pure primary colourant patches and two-colourant secondary patches may or may not occur in the print. When subjected to an image print stability test method, the measurable target print patch density changes can be compared to image print changes that a user would experience. See Annex A and Annex C.

Colourant proportions in the image print stability target print are recognized as system-specific, dependent on image processing, ICC profiles, halftoning, and other physical printer characteristics.

The image print stability test requires target prints with selected optical densities in:

a)   neutral patches;

NOTE 2   Patches that are treated as neutral are produced from sRGB encoded patch values that equate to CIELAB values with $L^* >$ zero, a^* and b^* zero, i.e. R=G=B.

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

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

d) D_{min} patch (i.e. paper white) area (used to evaluate substrate discolouration).

NOTE 3   Additional coloured patches, e.g. black, orange, and flesh tones, can also be tested, although such test patches are not within the scope of this International Standard.

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

5.3.2 Adapting the digital file for an image print stability test — RGB printers

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.

5.3.3 Adapting the digital file for an image print stability test — CMYK printers

The image content shall be encoded in "device CMYK" that is specific to the printer under test. The device CMYK digital test file for the specific printer under test shall be obtained from an sRGB digital test file constructed using the required sRGB patch values provided in Annex A, or a selected subset of those required sRGB patch values. The CMYK encoded digital test file shall be obtained for the specific printer under test using the photo print colour management transformation method that is appropriate for consumer users of the printer. For

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1)   Photoshop is the trade name of a product supplied by Adobe. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

example, an ICC profile provided by the printing system manufacturer and matched to the print conditions and media of the test can be used. Whether used in whole or in part, the sRGB code values of the patches given in Annex A shall not be changed prior to conversion to CMYK for the printer under test; and the resulting printer-specific CMYK code values shall not be changed prior to printing.

When the image print stability of a specialized configuration of a printing system is being tested, e.g. prints produced using a specialized configuration in a professional or commercial print environment, a customized ICC profile may be used. Such a customized ICC profile shall be appropriate to produce end-customer quality printing in the configuration under test. The use of any such ICC profile shall be reported in the test results.

5.4   Preparing the digital test file for an image forming materials stability test

5.4.1   Constructing the digital file for an image forming materials stability test

For digital print systems, the image forming materials stability test is used to test the stability of the component materials that comprise digital prints. For example, one cyan dye may exhibit greater resistance to light fade than another. When testing for primary colourant stability (e.g. C, M, Y, K colourants), it is ideal that each colourant be printed in a pure form isolated from other colourants. Colourant interactions can produce catalytic fading effects, whereby a primary colourant in a multi-colourant patch will fade at a different rate than would be observed had the colourant been printed alone. Additionally for image forming materials stability tests, secondary (mixed) colour patches (e.g. a red patch comprised of magenta and yellow colourant) are ideally comprised of equal amounts of two respective primary colourants, as it is known that any variance in these proportions can result in differing rates of catalytic change. In the image forming materials stability test, "test ready" target prints shall be produced after careful manipulation of the digital test file colour code values so that pure printer colourant primaries and correctly proportioned printer colourant secondaries are produced in the target print for each of the selected optical densities. Evaluation of preliminary printer assessment prints, using, for example drop count measurements and high resolution inspection, can be useful to determine the colour code values that produce pure (or closest to pure) colourant primaries and correctly proportioned colourant secondaries through a given system (see Annex D). Target print generation can also include such steps as selectively removing and replacing ink cartridges or tanks, cutting and splicing the thermal donor, etc., to achieve a desired effect in isolating specific colourants.

The image forming materials stability test requires target prints with selected optical densities in:

a)   neutral patches containing equal proportions of the printer primary colourants cyan, magenta, and yellow;

b)   patches containing isolated primary (pure) printer colourants (e.g. pure cyan, magenta, yellow and black colourants);

c)   patches containing isolated secondary (two equally proportioned primary colourants) printer colours (e.g. red, green and blue colour patches, each comprised of equal proportions of two printer primary colourants).

As far as is achievable in the printing system under test, isolated C, M, Y, K colourant primaries shall be tested. As far as is achievable in the printing system under test, secondaries of R, G, B, each comprised of equal parts of two colourant primaries, shall be tested. The colourant proportion is required, whereas exact colour hue and colourfulness are not. Additional primary and secondary colourant patches (e.g. red and green primaries and their associated secondaries) can be tested as needed to address specific system capabilities, understanding that these capabilities may or may not apply to all or any other printing systems (see Annex D).

5.4.2   Adapting the digital file for an image forming materials stability test — RGB printers

The RGB image forming materials stability digital test file shall be encoded in sRGB as defined in IEC 61966-2-1 and saved in the tiff format with the sRGB ICC profile embedded.

NOTE   Even though sRGB is a standard, the ICC profiles for sRGB can differ. Retaining the ICC profile with the file contributes to test repeatability.

The image content shall be encoded in sRGB as defined in IEC 61966-2-1. The RGB printer case presents challenges for the image forming materials stability test due to the lack of direct control over the printer colourants. Adapt and evaluate the digital test file and the resulting assessment print using the print system

configuration that provides the most direct colour matching control. With an sRGB encoding, neutrals are typically encoded with R=G=B equal value codes. In certain cases, the printer driver software may provide an option to assign such neutral values to the black ink. If such a single colourant black can be obtained, then including additional selected density patches for that case is recommended (see Annex D).

5.4.3 Adapting the digital file for an image forming materials stability test — CMYK printers

The CMYK image forming materials stability digital test file shall be encoded in device CMYK and saved in the tiff format with the device CMYK ICC profile embedded, if available.

NOTE   Take care to associate the CMYK digital test file with the printing system configuration it is tuned for, e.g. using a coded filename, storing it with an associated metadata file.

The image content shall be encoded in "device CMYK". The CMYK digital test file shall include patches of minimum density (paper white), and patches planned to produce the selected optical densities using the cyan, magenta, yellow and black printer primary colourants, from patch code values with only non-zero C, M, Y, and K, respectively. In addition, the CMYK digital test file shall include patches planned to produce the selected optical densities in red, green and blue secondary printer colours, from patch code values with equal M and Y (zero C), equal C and Y (zero M), and equal C and M (zero Y), respectively. Finally, the CMYK digital test file shall include patches planned to produce the desired optical densities in composite neutral printer colour, from patch code values with equal C, M and Y.

5.5 Target print uniformity

Typical digital printing systems exhibit print non-uniformities (in-page and page-to-page) that can affect density measurements. Digital printing systems also differ in the availability of printer process controls that can be used to compensate for these non-uniformities. As a result, in a best case scenario, individual patch densities can be predicted within some tolerance limits of a selected density value, but cannot be ensured to match exactly to a selected density value, even when patch code values are tuned for the particular printer.

The impact of these non-uniformities and control variabilities shall be minimized through target layout design and adaptation to the particular system under test. Replicate prints can be printed and duplicate patches can be included within a single target print page as necessary to obtain target prints that satisfy the selected optical density requirements. Statistical analysis of the print non-uniformity characteristics of the print system under test should be conducted to determine the number of replicate prints and number of duplicate patches to use.

At least two replicate prints are required. Replicates shall be positioned for testing in different regions of the test chamber volume. Refer to Annex E for guidance in determining a measurement plan to limit measurement error.

Many modern imaging systems now employ multiple density inks (i.e. light cyan and dark cyan) with the result that such printing systems may or may not utilize the same colourant for each density. Furthermore, the light and dark inks may be printed singularly or combined in various proportions to achieve a specified density. For such printing systems, monitoring multiple densities throughout each colour tone scale is recommended so that the stability of each colourant can be evaluated as they occur in various combinations. The image print stability test is particularly applicable to evaluating such print systems.

5.6 Test chamber condition uniformity

Locally varying environmental conditions in a given test, due to patch position within a target print or due to target holder position within a chamber, e.g. the amount of light falling on a patch in a light stability test, can result in different OD changes in patches that are initially identical.

When noticeable effects are determined due to such locally varying conditions, it is recommended to position the two or more replicate prints to be oriented differently in the test chamber and average the raw measurements of each two or more duplicate patches in the replicates. The averages of the measurements of the replicas shall be used as single measurements for the successive computations of test results.

NOTE 1   Such test chamber non-uniformity effects become noticeable when measurement differences between replicates change after testing by an amount that is greater than the expected ± variation of the measurement instrument when measuring identical patches.

NOTE 2   Duplicate patches are patches that were printed with the same starting code values, either in replicate prints or in redundant print areas in one target print.

6   Generating the target prints

6.1   Digital print preparation

If the printing system under test cannot accept tiff image files for printing, convert the digital test file (designed and saved as a tiff 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 and patch spacing is maintained in the converted printable file. Retain the original tiff format digital test file for future testing.

NOTE   Lossy compressed files further degrade when they are opened and closed successively in imaging applications. For this reason, the digital test file creation and editing process uses the uncompressed tiff image, with conversion to the lossy compressed format only as required for printing.

6.2   Source preparation for conventional silver gelatine photographic materials

Conventional silver gelatine photographic materials can be tested using the image print stability test approach. 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 may 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 pertain 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 pertain to colour material that has not been similarly treated, and vice versa.

6.3   Configuring the print system and generating the target prints

When printing the image print stability 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 ink 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 may be used in generating image print stability target prints. In such a case using ICC profiles, do not turn off colour management when initiating the print.

When printing the image forming materials stability target, target prints may be produced using driver and printer settings that afford the test operator the required control over colourant proportions.

In the digital printing case, the printer manufacturer recommended resolution for photo printing shall be used with each printer. When multiple photo print resolution options are available, the printing resolution used shall be reported.

If the print system requires image pre-scaling, then pre-scale the image using nearest neighbour interpolation to the closest available printer resolution.

In accordance with the measurement plan determined during test preparation (see Annex E), necessary replicate prints shall be printed within the closest possible time proximity.

NOTE 1   The printing system configuration should match the exact conditions that were in place when printer assessment targets were printed, if the digital test file was adapted (patch selection in the case of an image print stability test or patch selection and adjustment in the case of an image forming materials stability test) using a print assessment process.

Photographic material shall be printed in accordance with the manufacturer's recommendations. Manufacturer's requirements regarding colourant and print media storage and pre-conditioning and print device operating environment shall be followed.

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.

Image print stability test results shall be documented with respect to the complete printing system: host system identification and settings, printer driver version and driver settings, associated image processing software, colour management software and settings, print engine, hardware configuration, colourant set, processing chemistry, and media.

NOTE 2   Software imaging applications, e.g. Photoshop, provide print options concerning colour management. In such an application, the options chosen should be the same as those used in a typical user print workflow for the printer under test. When printing from Photoshop, colour management processing can be assigned either to the printer or to Photoshop. If the printer ships with ICC profile(s) intended to install on the host computer for use by the host computer in preparing a typical print job, then assign the colour management task to Photoshop and select the printer profile, from the printer manufacturer, that is correct for the printer setup and the print media. If the printer does not ship with ICC profiles that install on the host computer, then when printing from Photoshop assign the colour management task to the printer and use no colour management in Photoshop.

Image forming materials stability test results shall be documented with respect to the printed components: colourant set, specific colourant proportions in each patch, processing chemistry, and media.

6.4   Conditioning the prints after printing

Aqueous and solvent inkjet prints, and prints of any type 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 hour 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. For example, it has been observed that colour shifts can occur in the first few hours or days after printing in some systems, and this conditioning period allows the system to stabilize. This conditioning requirement pertains both to printer assessment prints used to develop a patch subset target and to the actual target prints that will be used in image stability testing. Prints of any types that do not require curing/stabilization/dry-down shall be held for 24 hours. 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 may 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 target print holding environment with no time constraint shall meet the following set of conditions: target prints shall be kept in dark, (23 ± 2) °C, (50 ± 10) % RH conditions while waiting for measurement and while holding between test stages.

The controlled target print holding environment shall be ozone-free (≤2 nl/l average concentration over any 24 hour period) for ozone-sensitive target prints. Ozone sensitivity shall be determined in accordance with ISO 18941 and this International Standard. 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.

The controlled measurement environment with no measurement process time constraint shall meet the following set of conditions: ambient illuminance on the target print surface no greater than 200 lux, temperature (23 ± 2) °C and relative humidity (50 ± 10) %; the environment shall be ozone-free (≤2 nl/l average concentration over any 24 hour period) for ozone-sensitive target prints.

When target print holding or target measurement are conducted in the less controlled environment, target prints shall be held or measured in the less controlled environment for a maximum of 2 hours for each test stage. The less controlled environment may 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 lux.

NOTE 2   Stray light decreases the accuracy of measurements taken in less controlled lighting environments. Shielding the measurement instrument from direct lighting so that the actual measurement surface lighting is no more than 200 lux can improve measurement accuracy and repeatability.

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

Measurement environment and target print holding environment conditions, if differing from those specified with respect to temperature, relative humidity, ozone, and light levels, fluctuations, and uniformity, shall be reported in the test report.

The CIELAB colour space values of the D_{min} patch (unprinted paper) shall be obtained from measurements using ISO 13655 measurement condition M0. In accordance with the M0 condition, the relative spectral power distribution of the flux incident on the specimen surface shall conform to CIE illuminant A, with a correlated colour temperature of 2 856 K ± 100 K. The metamerism index of the M0 light source used in the measurements, comparing with CIE illuminant A, shall be equal to or less than 1,5.

NOTE 3   Measurement condition M0 is used for the relative spectral power distribution of the flux incident on the specimen surface. Instruments conforming to M1 are not generally available at the time of writing of this International Standard. Image permanence measurement deals primarily with relative data, and image permanence test results do not rely on visual matching in a corresponding viewing environment.

White backing is recommended in accordance with ISO 13655. Report the backing used or report the material opacity, in accordance with ISO 2471, such that backing has no influence on the measurement. Measurement conditions shall be consistent throughout the test process.

NOTE 4   With completely opaque materials, such as an aluminium substrate used in outdoor testing, the backing has no relevance.

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 colorimetric 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. White backing is recommended as noted in ISO 5-4, particularly for measurements of spectral data used to compute both density and colourimetry. Either white or black backing is allowed. Report the backing used. Measurement conditions shall be consistent throughout the test process.

NOTE 5   The purpose of image print stability tests 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. Conversely, if the test goal is to characterize the inks themselves, as in image forming materials stability testing, then such testing can be facilitated by avoiding testing on substrates with optical brighteners.

NOTE 6   When this International Standard 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.

A single measurement instrument shall be used for all of the measurements taken pertaining to a particular target print. 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 used for 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.

NOTE 7   Inter-instrument agreement, within the same instrument model, assuming both units are in proper order and within their certification parameters, can be 0,8 deltaE average and 2 deltaE max. This error bound is given in relation to BCRA calibration tiles, so actual errors will be higher than these limits. In addition, if comparing instruments across vendors, the unknown absolute calibration error difference between the instruments is to be considered.

NOTE 8   It is useful to retain freezer check prints of the measurement materials so that instrument offsets can be measured if needed. Offset measurements from materials matched to those under test are preferred to measurements using BCRA tiles. Refer to ISO 18920 for print storage methods.

Annex A
(normative)

Required sRGB encoded patch values for image print stability test target and patch selection process

A.1   General

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.

For colour patches, sRGB code values are selected to provide the hues of red, green, blue, cyan, magenta, and yellow primaries as shown in Table A.1. 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 and Table A.4. The specified patch code values align approximately with the aim lightness, chroma and hue values for each primary.

Table A.1 — Selected aim colour primary and secondary hues

	red	yellow	green	cyan	blue	magenta
Selected CIELAB h_{ab}	33	90	135	202,5	270	337,5

NOTE   The blue hue angle CIELAB $h_{ab} = 270$ is chosen as a compromise between the Table B.5 value and the Munsell lab values, and also to avoid a purple shift (added magenta) in the prints.

Table A.2 — Reference colour primary and secondary hues (informative)

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	

Tables A.3 and A.4 specify the valid sRGB patch values for the image print stability test target. All or a subset of the values shall be used as needed to obtain the required densities. Only the colour patch values in Tables A.3 and A.4 shall be used for applications within the scope of this International Standard.

Table A.3 — Red, green, and blue patch values

sRGB	Red patches			Green patches			Blue patches		
Patches	R	G	B	R	G	B	R	G	B
1	255	237	234	211	255	199	236	241	255
2	255	227	222	205	255	192	228	235	255
3	255	219	212	199	255	185	218	229	255
4	255	207	199	194	255	178	210	223	255
5	255	193	184	188	255	171	200	217	255
6	255	187	176	182	255	164	189	211	255
7	255	177	166	176	255	156	180	205	255
8	255	167	154	170	255	152	170	199	255
9	255	150	137	164	255	143	162	193	255
10	255	120	105	146	252	128	150	187	255
11	255	105	92	132	249	112	140	181	255
12	255	90	80	128	246	110	128	175	255
13	255	66	64	122	243	104	95	160	250
14	255	43	54	118	240	100	80	150	245
15	255	0	43	115	237	97	60	140	240
16	250	0	43	105	234	87	0	130	240
17	245	0	43	85	231	70	10	124	235
18	240	0	42	78	228	64	10	112	230
19	235	0	41	72	225	60	0	100	228
20	230	0	40	60	222	52	0	95	227
21	225	0	39	50	219	45	0	95	220
22	220	0	39	46	216	38	0	95	215
23	215	0	39	40	213	34	0	95	210
24	210	0	36	20	210	24	0	95	205
25	205	0	35	16	207	22	0	94	200
26	200	0	34	16	204	22	0	93	195
27	195	0	33	16	201	22	0	92	190
28	190	0	32	12	198	18	0	90	185
29	185	0	30	2	195	12	0	90	180
30	180	0	30	0	190	1	0	90	175
31	175	0	28	0	185	14	0	90	170
32	170	0	26	0	180	14	0	89	165
33	165	0	26	0	175	12	0	86	160
34	160	0	26	0	170	12	0	84	155
35	155	0	24	0	165	12	0	81	150
36	150	0	22	0	160	10	0	78	145
37	145	0	22	0	155	10	0	74	140
38	140	0	20	0	150	10	0	72	135
39	135	0	19	0	145	10	0	68	130
40	130	0	19	5	140	10	0	67	125
41	125	0	18	0	135	10	0	65	120
42	120	0	16	0	130	6	0	62	115
43	110	0	14	0	125	6	0	58	110

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Table A.3 *(continued)*

sRGB	Red patches			Green patches			Blue patches		
Patches	R	G	B	R	G	B	R	G	B
44	100	2	10	8	110	6	0	55	105
45	90	4	7	0	85	4	0	53	100
46	80	4	2	0	70	3	0	47	90
47	70	4	0	2	55	0	0	38	75
48	60	4	0	10	35	0	0	30	60

Table A.4 — Cyan, magenta, and yellow patch values

sRGB	Cyan patches			Magenta patches			Yellow patches		
Patches	R	G	B	R	G	B	R	G	B
1	192	253	255	255	246	252	255	245	215
2	168	253	255	255	240	250	255	243	205
3	156	250	255	255	230	248	255	240	195
4	139	250	255	255	220	246	255	237	180
5	125	250	255	255	210	244	255	234	165
6	99	248	255	255	200	240	255	231	145
7	79	248	255	255	190	236	255	228	125
8	55	246	255	255	180	236	255	225	100
9	25	245	255	255	170	231	255	225	80
10	0	243	253	255	160	224	255	223	60
11	0	240	250	255	150	222	255	222	30
12	0	238	248	255	140	220	255	222	0
13	0	234	244	255	130	218	250	216	0
14	0	231	241	255	120	214	245	212	0
15	0	228	236	255	110	214	240	208	0
16	0	221	231	255	100	214	235	204	0
17	0	217	226	255	90	210	230	199	0
18	0	212	221	255	80	210	225	194	0
19	0	207	216	255	70	210	220	190	0
20	0	203	211	255	60	209	215	186	0
21	0	198	206	255	50	208	210	182	0
22	0	193	201	255	40	208	205	178	0
23	0	187	196	255	30	206	200	174	0
24	0	183	191	255	0	206	195	169	0
25	0	179	186	250	0	202	190	164	0
26	0	174	181	245	0	198	185	160	0
27	0	169	176	240	0	194	180	156	0
28	0	165	171	235	0	190	175	152	0
29	0	160	166	230	0	186	170	147	0
30	0	155	161	225	0	182	165	142	0
31	0	150	156	220	0	178	160	138	0
32	0	145	151	215	0	174	155	134	0
33	0	140	146	210	0	170	150	130	0

Table A.4 *(continued)*

sRGB	Cyan patches			Magenta patches			Yellow patches		
Patches	R	G	B	R	G	B	R	G	B
34	0	136	141	205	0	166	145	125	0
35	0	131	136	200	0	161	140	120	0
36	0	126	131	195	0	158	135	117	0
37	0	121	126	185	0	150	130	112	0
38	0	116	121	175	0	140	125	108	0
39	0	111	116	165	0	132	120	104	0
40	0	107	111	155	0	124	115	99	0
41	0	102	106	145	0	116	110	95	0
42	0	97	101	135	0	108	105	90	0
43	0	92	96	125	0	99	100	86	0
44	0	88	91	115	0	91	87	74	0
45	0	77	80	105	0	83	74	63	0
46	0	63	65	85	0	67	61	52	0
47	0	48	50	65	0	50	48	40	0
48	0	32	34	45	0	35	35	29	0

Measurement tolerances are specified separately for the single patch case and the bracketing pair patch cases. A single patch shall be a valid selection when the measured density is within 10 % of the corresponding OD Aim (aim density), regardless of the OD Aim level. In the bracketing pair patch case, measurement tolerances are specified separately for three OD Aim ranges. A low density bracketing pair patch shall be a valid selection when the measured density is within 30 % of the corresponding OD Aim, applicable with OD Aim ≤ 0,75 OD. A mid-range density bracketing pair patch shall be a valid selection when the measured density is within 25 % of the corresponding OD Aim, applicable with 0,75 OD < OD Aim ≤ 1,25 OD. A D_{max} or high density bracketing pair patch shall be a valid selection when the measured density is within 20 % of the corresponding OD Aim, applicable with 1,25 OD < OD Aim.

For example:

OD Aim	Single patch tolerance	Bracketing patch tolerance
0,50	10 % (0,50 ± 0,05)	30 % (0,50 ± 0,15)
1,00	10 % (1,00 ± 0,10)	25 % (1,00 ± 0,25)
1,50	10 % (1,50 ± 0,15)	20 % (1,50 ± 0,30)

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 patch tolerance, if no single patch meets a particular OD Aim.

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.

If a subset of the patches defined in this International Standard is used, and in the subset no individual patch or bracket pair of patches is found to meet a particular OD Aim, a new subset of patches shall be selected using alternative patches from the full patch set defined in this International Standard. The target print(s) shall be re-printed using the new subset.

A.2 D_{max} exception and cautions

For a given print system, if a digital test file, conforming to the requirements of the test case, and utilizing all patch value options available in the complete sRGB patch set of this annex, cannot be devised to produce a selected D_{max} optical density (i.e. maximum aim density for the test) in a particular colour, then the unattainable maximum optical density is dropped and the measured value for the maximum attainable optical density is used in its place for that colour. The report shall indicate that a specified optical density could not be produced for that colour; the attained initial maximum optical density for that colour shall be documented in the test report.

D_{max} caution: in determining the patch selection for the maximum attainable optical density in a colour, be aware that some systems may attempt to apply more colourant than the substrate can receive. This can result in a colourant build-up in high density patches. Such patches can give artificially long life predictions. The digital file code value used to produce the D_{max} patch in each colour shall be selected as the first patch code value in the colour tone scale that produces the D_{max} optical density, when ascending the colour tone scale from light to dark.

A.3 Neutral patch selection process:

— Select individual patches or bracketing patch pairs (for interpolation) that have the required red optical density values.

— Select individual patches or bracketing patch pairs (for interpolation) that have the required green optical density values.

— Select individual patches or bracketing patch pairs (for interpolation) that have the required blue optical density values.

In selecting the neutral patches, the focus is on three colour densities, one colour density at a time. The desired patches will have closest to equal values in all R G B colour densities. However, the red density patch is selected independently of the blue density patch, etc.

Procedurally, if more than one patch has the required focus density within the required tolerance, sum the deviation of the focus density from the aim density with the average of the two other colour densities' deviations from the same aim density.

EXAMPLE   When measuring red density of a neutral patch with 0,50 Aim OD, and the red density is 0,45, green density in the same patch is 0,48, and blue density in the same patch is 0,45, then the patch value rating = 0,05 + [(0,02 + 0,05)/2].

For each focus density, among patches that meet the tolerance requirement, the patch having the smallest patch value rating is selected.

Use the same selection algorithm, simply changing the allowed tolerance range, when selecting single patches or bracketing pair patches.

A.4 Red patch selection process:

— Select individual patches or bracketing patch pairs (for interpolation) that have the required green optical density values.

— Select individual patches or bracketing patch pairs (for interpolation) that have the required blue optical density values.

In selecting the red patches, the focus is on two colour densities, one colour density at a time. The green density patches are selected independently of the blue density patches (and vice versa), and in each case if multiple patches meet the tolerance criteria, the preferred patch will have the lowest red colour density relative to the focus density.

Procedurally, if more than one patch has the required focus density within the required tolerance, sum the deviation of the focus density from the aim density and the deviation from zero of the red density of the same patch.

EXAMPLE   When measuring green density of a red patch with 0,50 Aim OD, and the green density is 0,45, red density in the same patch is 0,12, then the patch value rating = 0,05 + (0,12).

For each focus density, among patches that meet the tolerance requirement, the patch having the smallest patch value rating is selected.

Use the same selection algorithm, simply changing the allowed tolerance range, when selecting single patches or bracketing pair patches.

A.5   Green patch selection process:

— Select individual patches or bracketing patch pairs (for interpolation) that have the required red optical density values.

— Select individual patches or bracketing patch pairs (for interpolation) that have the required blue optical density values.

Selection algorithm is as described in the red patch case, except sum the deviation of the focus density from the aim density and the deviation from zero of the green density of the same patch.

A.6   Blue patch selection process:

— Select individual patches or bracketing patch pairs (for interpolation) that have the required red optical density values.

— Select individual patches or bracketing patch pairs (for interpolation) that have the required green optical density values.

Selection algorithm is as described in the red patch case, except sum the deviation of the focus density from the aim density and the deviation from zero of the blue density of the same patch.

A.7   Cyan patch selection process:

— Select individual patches or bracketing patch pairs (for interpolation) that have the required red optical density values.

In selecting the cyan patches, the focus is on one colour density, with desired lowest values in the other colour densities.

Procedurally, if more than one patch has the required focus density within the required tolerance, sum the deviation of the focus density from the aim density with the average of the two other colour densities' deviations from zero.

EXAMPLE   When measuring red density of a cyan patch with 0,50 Aim OD, and the red density is 0,45, green density in the same patch is 0,10, and blue density in the same patch is 0,08, then the patch value rating = 0,05 + [(0,12 + 0,08)/2].

For each focus density, among patches that meet the tolerance requirement, the patch having the smallest patch value rating is selected.

Use the same selection algorithm, simply changing the allowed tolerance range, when selecting single patches or bracketing pair patches.

A.8   Magenta patch selection process:

— Select individual patches or bracketing patch pairs (for interpolation) that have the required green optical density values.

In selecting the magenta patches, the focus is on one colour density, with desired lowest values in the other colour densities.

Procedurally, if more than one patch has the required focus density within the required tolerance, sum the deviation of the focus density from the aim density with the average of the two other colour densities' deviations from zero. See the example in A.7.

A.9   Yellow patch selection process:

— Select individual patches or bracketing patch pairs (for interpolation) that have the required blue optical density values.

In selecting the yellow patches, the focus is on one colour density, with desired lowest values in the other colour densities.

Procedurally, if more than one patch has the required focus density within the required tolerance, sum the deviation of the focus density from the aim density with the average of the two other colour densities' deviations from zero. See the example in A.7.

Annex B
(informative)

Method of interpolation for step wedge exposures

If a step wedge is used to make the sensitometric exposure for the specimen, generally there will not be a step that is of exactly the desired density. For example, the densities of the two steps nearest to $d_{min} + 1,0$ may be used to calculate the desired density by linear interpolation. After each fading time, the same coefficient is used for interpolating the density after fading.

First, on the unfaded strip, the step with the density d_1 just below $d_{min} + 1,0$ and the step with the density d_2 just above $d_{min} + 1,0$ are chosen (see Figure B.1). After fading, these two steps will have reached the densities $d_1(t)$ and $d_2(t)$. The density $d(t)$ of the initial $d = d_{min} + 1,0$ is then estimated through linear interpolation:

$$d_t = d_{1(t)} + [d_{2(t)} - d_{1(t)}]\alpha \qquad (B.1)$$

where

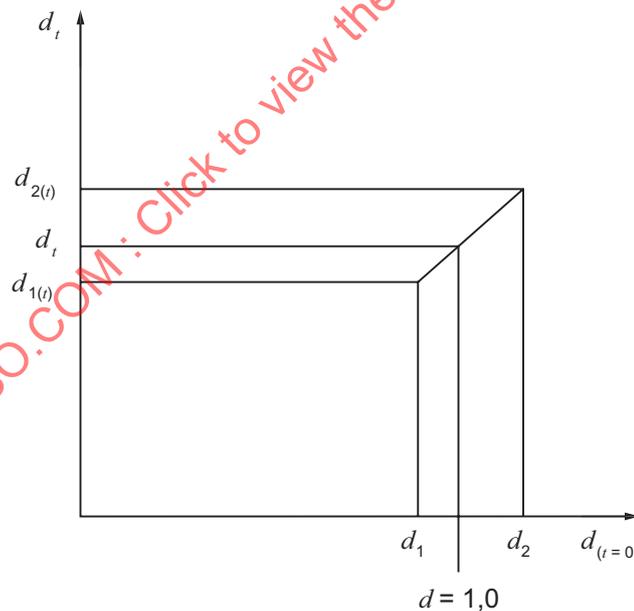$$\alpha = \frac{(d_{min} + 1,0) - d_{1(t=0)}}{d_{2(t=0)} - d_{1(t=0)}}$$

Figure B.1 — Interpolation for step wedge exposures