INTERNATIONAL STANDARD

ISO 18944

Second edition
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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

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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

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

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 42, *Photography*.

This second edition cancels and replaces the first edition (ISO 18944:2012), which has been technically revised.

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 test versus image forming materials stability test);

— digital file preparation;

— digital test file usage;

— addressing target print uniformity;

— managing test equipment non-uniformity;

— printing 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 documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 12640-3:2007, *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[1)]

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 in terms of CMYK printer colourants

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

1) Available at http://partners.adobe.com/public/developer/en/tiff/TIFF6.pdf

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

[SOURCE: ASTM G113 — modified]

3.5
operational fluctuations
positive and negative deviations from the setting of the operational control set point during equilibrium conditions in a laboratory-accelerated weathering device

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

[SOURCE: ASTM G113 — modified]

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 to entry: Operational uniformity evaluates the measured parameters throughout the test chamber so that regions of the test chamber can be determined to comply within the required limits of the measured parameter operating aim.

[SOURCE: ASTM G113 — modified]

3.7
OD
optical density

3.8
printing system
system to generate reflection colour photographic prints, including printing colorants, printing equipment hardware and software, and typically the print media

3.9
PVR
Patch Value Rating used in the patch selection process equations

3.10
reflection colour photographic print
positive photographic image intended to be viewed with reflected light, made using colourants such as cyan, magenta, and yellow

[SOURCE: ISO 18913 — modified]

3.11
RGB printer
printer configured to accept digital files with RGB printer-independent encoded colours and apply a conversion to obtain printer colourant code values

3.12
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 to entry: The parameter may be, for example, a standard deviation (or a given multiple of it), or the half-width of an interval having a stated confidence level. 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.

[SOURCE: ASTM G113 — modified]

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.

This International Standard has not been tested with printing systems having the capability to deposit analogue variations in colourant thickness, e.g. an analogue CMYK press, and is not suitable as is for use with such printing systems.

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:

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

b) a materials test for image forming materials stability (colourant stability, substrate discolouration and any interaction between them).

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 printing 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 printing 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 printing system hardware and software 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

Printing 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 colourant mixing) 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 above D_{min}). 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:

$$S = \mathrm{K} + (2 * A) + D$$

where

- S is the minimum side length of each square colour patch area, in millimetres;
- K is the constant value of 2 mm as specified in the requirement above the equation;
- 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 (if available) printer colourant primaries, and utilizing red, green and blue printer secondaries.

NOTE 1 Some printing processes use CMY primaries only.

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 bracketing pair patches, 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 in the tiff file format. The digital image file resolution shall be 600 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 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 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 International Standard can be designed and adapted for particular printing systems in any of the available image programs (such as Adobe Photoshop®[2)]). Ensure that the image resolution is 600 dpi after editing.

2) 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.

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 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 $L^* > 0$, and a^* and b^* both equal to zero.

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. 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. In such case, 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 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 printing 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 test digital 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 printing 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 test digital 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 printing 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 printing 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.

NOTE 3 In addition to the use of duplicate patches, with certain chamber configurations, periodic sample repositioning in the test chamber during an accelerated ageing test can be useful to compensate for test chamber non-uniformity.

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 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 the image forming materials stability 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 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 driver and printer settings for photo printing shall be used with each printer. When multiple photo print options for resolution, print speed, and other settings are available, the values used for each setting shall be recorded.

If the printing 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[2)], 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[2)], colour management processing can be assigned either to the printer or to Photoshop[2)]. 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[2)] 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[2)] assign the colour management task to the printer and use no colour management in Photoshop[2)].

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 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. 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 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 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 h 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 lx, temperature (23 ± 2) °C and relative humidity (50 ± 10) %; the environment shall be ozone-free (≤2 nl/l average concentration over any 24 h 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 h 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 lx.

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 lx 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 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. 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 (CERAM) 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. The 48 neutral patch sRGB code values are shown in Table A.1.

Table A.1 — 48 neutral patch sRGB code values

sRGB	Neutral patches			sRGB	Neutral patches		
Patches	R	G	B	Patches	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 primaries as shown in Table A.2. 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.4 and Table A.5. The specified patch code values align approximately with the aim lightness, chroma and hue values for each primary.

Reference colour primary and secondary hues in Table A.3 are for information only.

Table A.2 — 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 in ISO 12640-3:2007 and the Munsell lab values, and also to avoid a purple shift (added magenta) in the prints.

Table A.3 — Reference colour primary and secondary hues (informative)

	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	

The first paragraph of this annex and Tables A.1, A.4 and A.5 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 neutral values as stated in the first paragraph of this annex and in Table A.1, and the colour patch values in Tables A.4 and A.5 shall be used for applications within the scope of this International Standard.

Table A.4 — 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	227	222	232	255	225	225	233	255
2	255	210	202	220	255	210	210	224	255
3	255	200	192	212	255	200	200	218	255
4	255	195	185	208	255	195	195	214	255
5	255	190	180	204	255	190	190	210	255
6	255	185	175	199	255	185	185	207	255
7	255	180	169	195	255	180	180	204	255
8	255	175	163	190	255	175	175	201	255
9	255	170	158	186	255	170	170	198	255
10	255	165	153	182	255	165	165	195	255
11	255	160	148	177	255	160	160	192	255
12	255	155	142	173	255	155	155	189	255
13	255	150	137	169	255	150	150	187	255
14	255	145	131	164	255	145	145	185	255

Table A.4 *(continued)*

sRGB	Red patches			Green patches			Blue patches		
Patches	R	G	B	R	G	B	R	G	B
15	255	140	126	160	255	140	140	182	255
16	255	135	120	156	255	135	135	180	255
17	255	130	115	151	255	130	130	177	255
18	255	125	110	146	255	125	125	175	255
19	255	120	105	141	255	120	120	172	255
20	255	115	101	135	255	115	115	170	255
21	255	110	96	129	255	110	110	168	255
22	255	105	92	124	255	105	105	165	255
23	255	100	88	119	255	100	100	163	255
24	255	95	84	113	255	95	95	161	255
25	255	90	81	107	255	90	90	159	255
26	255	85	77	101	255	85	85	158	255
27	255	80	74	95	255	80	80	157	255
28	255	75	71	89	255	75	75	155	255
29	255	70	68	83	255	70	70	154	255
30	255	65	65	77	255	65	65	153	255
31	255	60	62	71	255	60	60	151	255
32	255	55	59	64	255	55	55	150	255
33	255	50	57	57	255	50	50	149	255
34	255	40	54	50	255	45	40	147	255
35	255	30	51	41	255	40	30	145	255
36	255	20	49	34	255	35	20	144	255
37	255	10	47	26	255	30	10	144	255
38	255	0	47	15	255	25	0	144	255
39	245	0	44	10	240	25	0	138	245
40	235	0	41	10	225	18	0	132	235
41	225	0	39	10	210	18	0	125	225
42	215	0	37	10	195	18	0	120	215
43	200	0	33	10	180	18	0	115	205
44	185	0	30	10	165	18	0	105	190
45	170	0	26	0	145	10	0	96	175
46	155	0	23	0	125	10	0	87	160
47	140	0	20	0	105	4	0	79	145
48	125	0	17	0	85	4	0	70	130

Table A.5 — Cyan, magenta, and yellow patch values

sRGB	Cyan patches			Magenta patches			Yellow patches		
Patches	R	G	B	R	G	B	R	G	B
1	225	254	255	255	225	248	255	248	225
2	210	253	255	255	210	244	255	244	210

Table A.5 *(continued)*

sRGB	Cyan patches			Magenta patches			Yellow patches		
Patches	**R**	**G**	**B**	**R**	**G**	**B**	**R**	**G**	**B**
3	200	252	255	255	200	241	255	242	200
4	190	251	255	255	190	236	255	240	190
5	180	251	255	255	180	233	255	238	180
6	175	251	255	255	175	230	255	237	175
7	170	251	255	255	170	228	255	236	170
8	165	251	255	255	165	227	255	235	165
9	160	250	255	255	160	226	255	234	160
10	155	250	255	255	155	224	255	233	155
11	150	250	255	255	150	222	255	232	150
12	145	249	255	255	145	220	255	231	145
13	140	249	255	255	140	219	255	230	140
14	135	249	255	255	135	219	255	229	135
15	130	249	255	255	130	219	255	229	130
16	125	249	255	255	125	218	255	228	125
17	120	248	255	255	120	217	255	227	120
18	115	248	255	255	115	216	255	227	115
19	110	248	255	255	110	215	255	226	110
20	105	248	255	255	105	213	255	226	105
21	100	248	255	255	100	213	255	225	100
22	95	248	255	255	95	213	255	225	95
23	90	247	255	255	90	213	255	224	90
24	85	247	255	255	85	213	255	224	85
25	80	247	255	255	80	213	255	224	80
26	75	246	255	255	75	212	255	223	75
27	70	246	255	255	70	212	255	223	70
28	65	246	255	255	65	210	255	223	65
29	60	246	255	255	60	209	255	222	60
30	55	246	255	255	55	209	255	222	55
31	50	245	255	255	50	208	255	222	50
32	40	245	255	255	40	207	255	222	40
33	30	245	255	255	30	207	255	222	30
34	20	245	255	255	20	207	255	222	20
35	10	245	255	255	10	207	255	222	10
36	0	245	255	255	0	207	255	222	0
37	0	235	245	245	0	202	245	212	0
38	0	225	235	235	0	192	235	203	0
39	0	215	224	225	0	183	225	195	0
40	0	205	214	215	0	174	215	187	0
41	0	195	203	205	0	165	205	178	0
42	0	185	194	195	0	158	195	168	0

Table A.5 *(continued)*

sRGB	Cyan patches			Magenta patches			Yellow patches		
Patches	R	G	B	R	G	B	R	G	B
43	0	175	182	185	0	150	185	160	0
44	0	160	166	175	0	141	175	152	0
45	0	145	151	165	0	133	165	143	0
46	0	130	135	155	0	125	155	133	0
47	0	115	120	140	0	113	145	125	0
48	0	100	104	125	0	101	135	117	0

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.2 Patch selection methodology

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 Clause A.3 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.

If a subset of the patches defined in this International Standard 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 International Standard or using a new subset of patches selected from the full patch set.

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 Clause A.4 to Clause A.10.

A.3 D_{max} exception methodology

For a given printing system, if a digital test file, conforming to the requirements of a test case, and utilizing all patch value options available in the complete sRGB patch set of this annex, cannot be devised to produce the high-range OD Aim (i.e. the initial test aim D_{max} optical density, the maximum optical density aim chosen for the test) in a particular colour, then the unattainable initial test aim D_{max} optical density for that colour shall be replaced by an attainable test aim optical density for that colour.

The replacement test aim D_{max} optical density and corresponding patch shall be selected using a two step evaluation. First, using the patch value options available in the sRGB patch set of this annex for the colour, the maximum attainable D_{max} optical density for the colour shall be determined. Second, the replacement test aim D_{max} optical density and corresponding patch shall be chosen by applying the appropriate patch selection process for the colour or neutral (see Clause A.4 to Clause A.10), while using the maximum attainable D_{max} optical density in the equations in place of the initial test aim D_{max} optical density. Using this approach, the selected replacement test aim D_{max} optical density and patch may not be the same as the maximum attainable D_{max} optical density and patch. In the case of replacement test aim D_{max} optical densities for cyan, magenta, yellow, red, green, and blue, this approach favours lower densities in the non-focus colours. In the case of a neutral replacement test aim D_{max} optical density, this approach favours neutrality.

In the case of cyan, for example, select the replacement test aim D_{max} optical density and corresponding cyan patch having the lowest result for:

Patch value rating = ABS(cyan maximum attainable D_{max} (Red OD) − cyan patch(n) density(Red OD)) + 1/2·(ABS(cyan patch(n) density(Green OD)) + ABS(cyan patch(n) density(Blue OD)).

In the case of the selection for neutral(Green), for example, select the replacement test aim D_{max} optical density and corresponding neutral patch having the lowest result for:

Patch value rating = ABS(neutral maximum attainable D_{max} (Green OD) − neutral patch(n) density(Green OD)) + 1/2·(ABS(neutral maximum attainable D_{max} (Green OD) − neutral patch(n) density(Red OD)) + ABS(neutral maximum attainable D_{max} (Green OD) − neutral patch(n) density (Blue OD))).

Replacement test aim D_{max} optical density selection shall not be confined within an optical density aim tolerance restriction and may select a patch other than the patch with the maximum attainable D_{max} optical density in the case that another patch has lower non-focus density values, i.e. more 'pure' colour or more balanced neutral.

The report shall indicate that a specified initial test aim D_{max} optical density could not be produced for the colour; the replacement test aim D_{max} optical density for that colour shall be documented in the test report.

D_{max} caution: in determining the patch selection for a replacement test aim D_{max} optical density in a colour, be aware that some systems may 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. Applying the patch selection process to select the replacement test aim D_{max} optical densities and thereby favouring more ‘pure’ colours or more balanced neutrals mitigates against selecting such patches.

A.4 Neutral patch selection process

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

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

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

— Select individual patches or bracketing pair patches (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.5 Red patch selection process

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

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

— Select individual patches or bracketing pair patches (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.6 Green patch selection process

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

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

— Select individual patches or bracketing pair patches (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.7 Blue patch selection process

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

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

— Select individual patches or bracketing pair patches (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.8 Cyan patch selection process

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

— Select individual patches or bracketing pair patches (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 + [(0,10 + 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.9 Magenta patch selection process

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

— Select individual patches or bracketing pair patches (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.10 Yellow patch selection process

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

— Select individual patches or bracketing pair patches (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.

A.11 Patch selection process equations

To select CMY (Cyan, Magenta, Yellow) patches:

PVR(dC(R)) = |OD Aim point − dC(R)| + [(|dC(G)| + |dC(B)|) ÷ 2]

PVR(dM(G)) = |OD Aim point − dM(G)| + [(|dM(R)| + |dM(B)|) ÷ 2]

PVR(dY(B)) = |OD Aim point − dY(B)| + [(|dY(R)| + |dY(G)|) ÷ 2]

To select the Dmax CMY (Cyan, Magenta, Yellow) patches:

PVR(dCmax(R)) = |dCmax(R) − dC(R)| + [(|dC(G)| + |dC(B)|) ÷ 2]

PVR(dMmax(G)) = |dMmax(G) − dM(G)| + [(|dM(R)| + |dM(B)|) ÷ 2]

PVR(dYmax(B)) = |dYmax(B) − dY(B)| + [(|dY(R)| + |dY(G)|) ÷ 2]

To select RGB (Red, Green, Blue) patches:

PVR(dR(G)) = |OD Aim point − dR(G)| + |dR(R)|

PVR(dR(B)) = |OD Aim point − dR(B)| + |dR(R)|

PVR(dG(R)) = |OD Aim point − dG(R)| + |dG(G)|

PVR(dG(B)) = |OD Aim point – dG(B)| + |dG(G)|

PVR(dB(R)) = |OD Aim point – dB(R)| + |dB(B)|

PVR(dB(G)) = |OD Aim point – dB(G)| + |dB(B)|

To select the Dmax RGB (Red, Green, Blue) patches:

PVR(dRmax(G)) = |dRmax(G) – dR(G)| + |dR(R)|

PVR(dRmax(B)) = |dRmax(B) – dR(B)| + |dR(R)|

PVR(dGmax(R)) = |dGmax(R) – dG(R)| + |dG(G)|

PVR(dGmax(B)) = |dGmax(B) – dG(B)| + |dG(G)|

PVR(dBmax(R)) = |dBmax(R) – dB(R)| + |dB(B)|

PVR(dBmax(G)) = |dBmax(G) – dB(G)| + |dB(B)|

To select Neutral patches:

PVR(dN(R)) = |OD Aim point – dN(R)| + [(|OD Aim point – dN(G)| + |OD Aim point – dN(B)|) ÷ 2]

PVR(dN(G)) = |OD Aim point – dN(G)| + [(|OD Aim point – dN(R)| + |OD Aim point – dN(B)|) ÷ 2]

PVR(dN(B)) = |OD Aim point – dN(B)| + [(|OD Aim point – dN(R)| + |OD Aim point – dN(G)|) ÷ 2]

To select the Dmax Neutral patch:

PVR(dNmax(R)) = |dNmax(R) – dN(R)| + [(|dNmax(R) – dN(G)| + |dNmax(R) – dN(B)|) ÷ 2]

PVR(dNmax(G)) = |dNmax(G) – dN(G)| + [(|dNmax(G) – dN(R)| + |dNmax(G) – dN(B)|) ÷ 2]

PVR(dNmax(B)) = |dNmax(B) – dN(B)| + [(|dNmax(B) – dN(R)| + |dNmax(B) – dN(G)|) ÷ 2]

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:

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

where

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

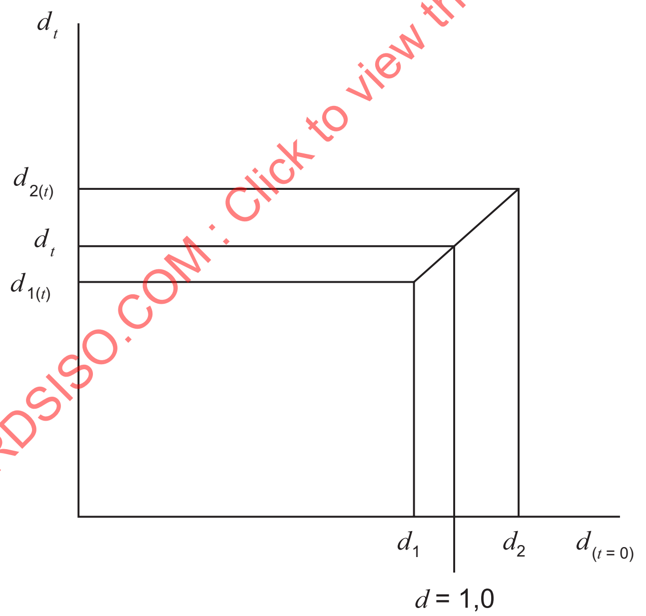

Figure B.1 — Interpolation for step wedge exposures

