International Standard

ISO/IEC 22592-1

First edition
2024-01

Office equipment — Print quality measurement methods for colour prints —

Part 1: Image quality measurement methods

Reference number
ISO/IEC 22592-1:2024(en)

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Published in Switzerland

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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 document 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 or www.iec.ch/members_experts/refdocs).

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This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 28, *Office equipment*.

A list of all parts in the ISO/IEC 22592 series can be found on the ISO and IEC websites.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html and www.iec.ch/national-committees.

Introduction

There are several standard measurement methods to evaluate image quality attributes of printed images formed by office equipment, i.e. colour reproductions, line reproductions, image structures of sharpness and graininess, gloss properties. Included are ISO/IEC 19799, ISO/IEC 24790 and ISO/IEC 29112. ISO/IEC 24790 specifies the measurement methods for large area density uniformity of graininess, mottle and banding, as well as line qualities. ISO/IEC 29112 specifies the methods for measuring sharpness attributes of edge blurriness and raggedness, special frequency response, etc. ISO/IEC 19799 specifies the methods for gloss uniformity. By utilizing these documents, users can obtain consistent test results when they comply with the protocols specified in the documents.

There are no standard methods to measure colour reproduction consistencies and geometrical accuracies in consecutive printing, and image stabilities in typical use case of print images formed by office equipment and used in office environments. In the current state, each printer distributer and its user can provide test results for those attributes measured by its own test methods and procedures, which are often convenient for its product, resulting in misleading customers in the selection of a printing system suitable for their use cases. The ISO/IEC 22592 series can provide standard methods and procedures for these print image attributes: ISO/IEC 22592-1 for colour consistency, ISO/IEC 22592-2 for geometrical accuracies and ISO/IEC 22592-3[1)] for image stabilities. By using these International Standards, consistent and comparable test results suitable for typical use cases of office prints can be obtained independent of data providers.

This document specifies measurement methods that quantitatively evaluate image quality attributes and test charts to measure the attributes as well as the variations in measured attributes in colour prints formed under the environment and stress assuming general office use case. The attributes for duplex colour print sets are within the scope as most of office documents are currently printed in duplex print sets comprising several sheets printed with colour images on both surfaces of substrates.

The measurement methods described in this document are used to access image qualities of a print set formed by a printing system on a substrate. When test results are compared among various printing systems, it is essential to use the same product of substrates and set equivalent printing conditions under default printer settings among the printing systems.

Electrophotography, thermal inkjet, or piezoelectric inkjet technologies are commonly used to form such prints. The purpose of this document is to provide objective measurement methods for image quality attributes of duplex colour print sets.

This document prescribes the following:

— test charts for the measurements which specify colour codes and locations in page to be measured;

— measurement method for colour reproduction range;

— measurement methods for colour variations, including variation by location within a page (within-page variation), variation between front and back side (side-to-side variation), variation among the sheets in the same print set (sheet-to-sheet variation) and variations depending on the colours printed on its back side (show-through variation);

— measurement methods for the attributes of line quality, graininess and mottle based on ISO/IEC 24790 and variations (side-to-side, sheet-to-sheet variations, etc.) in attributes.

The above methods relating to image quality variations are mainly designed to quantify the variations in duplex print sets. On the other hand, it is convenient for users to evaluate simplex print sets, comprising several sheets which are printed with colour images on one surface of a substrate and no image on the other surface, by using the same methods for duplex print sets. Therefore, some attributes for variations, such as colour variations “within a printed image”, “sheet-to-sheet variations”, can also be applicable for a simplex print set.

Measurement methods for gloss and its variations are out of the scope of this document, and have already been specified in ISO/IEC 19799.

1) Under preparation. Stage at the time of publication: ISO/IEC DIS 22592-3:2023.

In this document colour codes for the test charts are defined in sRGB colour space as specified in IEC 61966-2-1 as is common in office documents colour measurements are based on CIELAB specified in ISO/CIE 11664-4.

Office equipment — Print quality measurement methods for colour prints —

Part 1: Image quality measurement methods

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

1 Scope

This document specifies test methods as well as test charts to measure the image quality attributes and those variations in colour prints typically used in office environment. Included are digital colour prints formed by using a multifunction or single function printer. Printers supporting a maximum paper size of A4 or larger are suitable for the measurements using the test charts defined in this document.

The image quality attributes included are colour reproduction, line quality, graininess and mottle.

The sources of variation considered are locations in a page (within-page variation), printed side in a sheet (side-to-side variation), printed order of the sheet (sheet-to-sheet variation) and colours printed on the back side of evaluated patch (show-through variation).

A duplex print set, comprising several sheets which are printed by multifunction or single function printer with colour images on both surfaces of a substrate, is a main application of the test methods to measure image quality variations in the set. Variations, such as within-page variation and sheet-to-sheet variation, are also applicable for a simplex print set comprising several sheets which are printed colour images on one surface of a substrate and no image on the other surface.

Both duplex and simplex printers are applicable to form a print set. When image qualities of duplex prints are measured, duplex printers which are capable to print images on both sides of substrate automatically are applicable to form duplex prints. However, simplex printers which require a manual arrangement of substrates between the front side and back side printing to form duplex prints are out of scope of this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

ISO/IEC 24790, *Information technology — Office equipment — Measurement of image quality attributes for hardcopy output — Monochrome text and graphic images*

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

ISO/CIE 11664-6, *Colorimetry — Part 6: CIEDE2000 colour-difference formula*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 24790 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
back side
print side (3.10) corresponding to an even page of input data

3.2
blurriness
appearance of being hazy or indistinct in outline, a noticeable transition of darkness from line element to background substrate whose intended transition width is zero (i.e. ideally sharp)

[SOURCE: ISO/IEC 24790:2017, 3.5]

3.3
character darkness
appearance of blackness of a line or character image

[SOURCE: ISO/IEC 24790:2017, 3.7]

3.4
colour reproduction range
index corresponding to colour reproduction property of a print taking only input colours of C, M, Y, K and W (blanc area) into account

3.5
front side
print side (3.10) corresponding to an odd page of input data

3.6
graininess
appearance of unintended microscopic, but visible, aperiodic fluctuations of lightness

Note 1 to entry: Microscopic means: variations with spatial frequencies greater than about 0,4 cy/mm.

[SOURCE: ISO/IEC 24790:2017, 3.13]

3.7
line width
average stroke width, where the stroke width is measured from edge to edge along a line normal to the centre line of the image element

[SOURCE: ISO/IEC 24790:2017, 3.23]

3.8
mottle
measure of the appearance of unintended, aperiodic macroscopic fluctuations of lightness

Note 1 to entry: Macroscopic means: variations with spatial frequencies less than about 0,4 cy/mm.

[SOURCE: ISO/IEC 24790:2017, 3.26]

3.9
print set
set of sheets printed in a print operation

3.10
print side
one of the duplex print surfaces, either *front side* (3.5) or *back side* (3.1)

3.11
raggedness
appearance of geometric distortion of an edge from its ideal position

Note 1 to entry: An ideal edge should be absolutely straight along the length of the line.

Note 2 to entry: A ragged edge appears rough or wavy rather than smooth or straight.

[SOURCE: ISO/IEC 24790:2017, 3.29]

3.12
sheet-to-sheet variation
change in an attribute at the same input data on the same *print side* (3.10), either the *front side* (3.5) or *back side* (3.1), within a *print set* (3.9)

3.13
show-through variation
change in the colour at the same input colour code value caused by the colour image printed on the *back side* (3.1) of the same sheet

3.14
side-to-side variation
change in an attribute at the same input data in the same sheet between front and *back side* (3.1)

3.15
within-page variation
change in an attribute at the same input data by location within a page

4 Test charts

4.1 General

There are three test charts defined in this document. The first is illustrated in Figure 1 for the measurements of colour reproduction, and within-page, side-to-side, sheet-to-sheet variations in colour reproduction. The second is illustrated in Figure 2 for the measurement of show-through variations. The third is illustrated in Figure 3 for the measurement of line quality, graininess and mottle, and those variations. The colour codes of the test charts shall be encoded in standard sRGB, as defined in IEC 61966-2-1, which is commonly used in office documents.

Those test charts are prepared in the PDF file format and can be downloaded from:

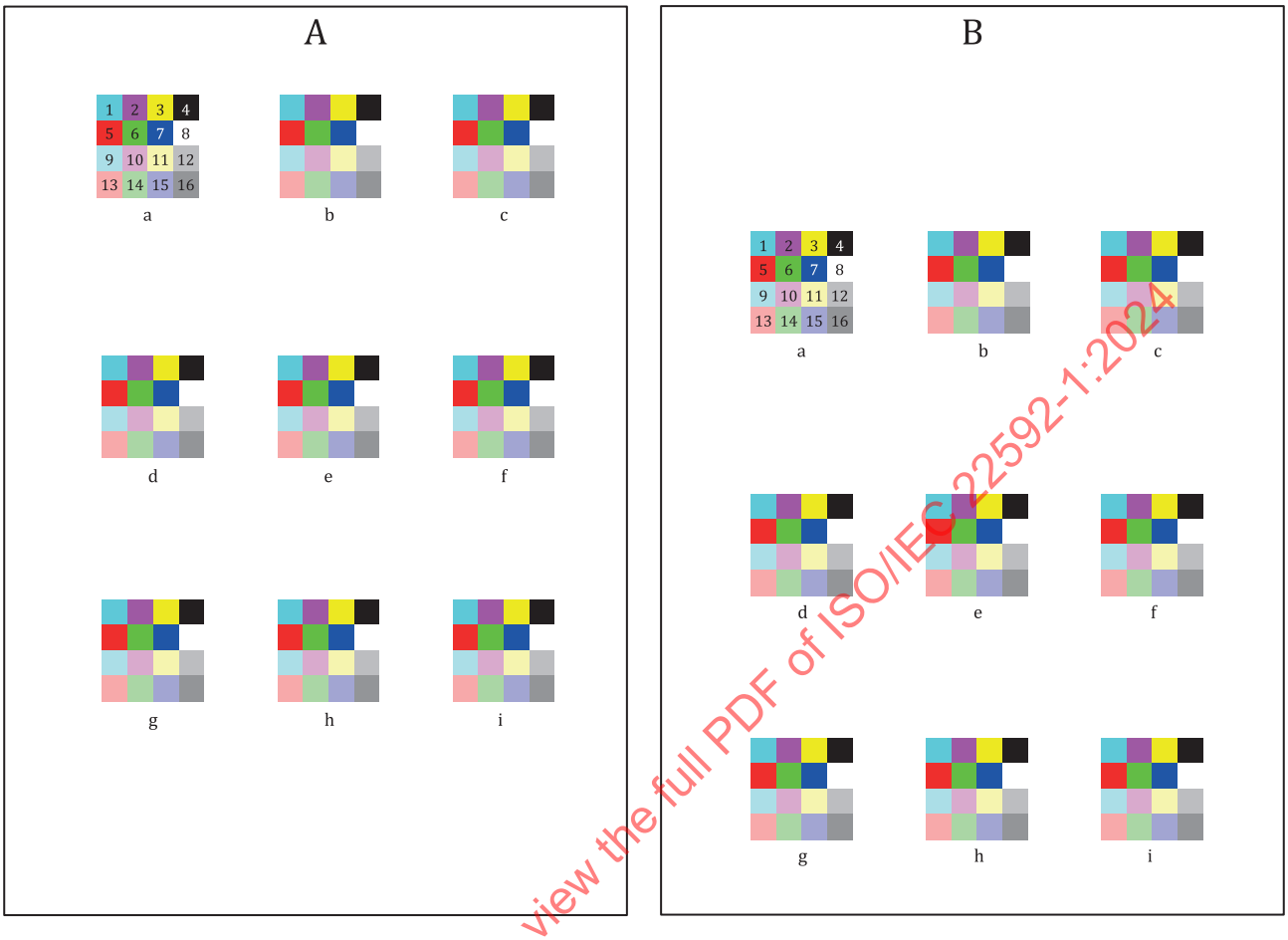
https://standards.iso.org/iso-iec/22592/-1/ed-1/en/ .

4.2 Test chart for colour reproduction and variations in colour reproduction

The outline of the test chart is described in Figure 1. The test chart is composed of the two images in raster graphics. The first page is used to print an image for front side and the second for back side. The size is A4 for both sides.

Total of nine components, each comprising the 16 patches of cyan (C), magenta (M), yellow (Y), black (K), red (R), green (G), blue (B), white (W), light cyan (LC), light magenta (LM), light yellow (LY), light grey (LK), light red (LR), light green (LG), light blue (LB) and mid grey (MK), are arranged in a print side to evaluate within-page variations. Each component for the back side is shifted by half pitch towards the long-edge direction from the corresponding component for the front side to measure patch colour value without the influence of printed image on its back side.

The sRGB colour codes of those patches are described in Table 1. The colour codes of C, M, Y, K, R, G, B and W patches outline the edge of intended colour reproduction range in the sRGB colour space. Each colour code for the light colour patches of LC, LM, LY, LK, LR, LG and LB is located at 30 % highlight of the corresponding saturated patch (colour code = 178). Colour code for MK is located midpoint between W and K patches.



Key

A frontside
B backside
a Component A.
b Component B.
c Component C.
d Component D.
e Component E.
f Component F.
g Component G.
h Component H.
i Component I.

Figure 1 — Illustrated test chart for colour reproduction and its variations

Table 1 — sRGB colour codes of colour patches of test chart for colour reproduction and its variations

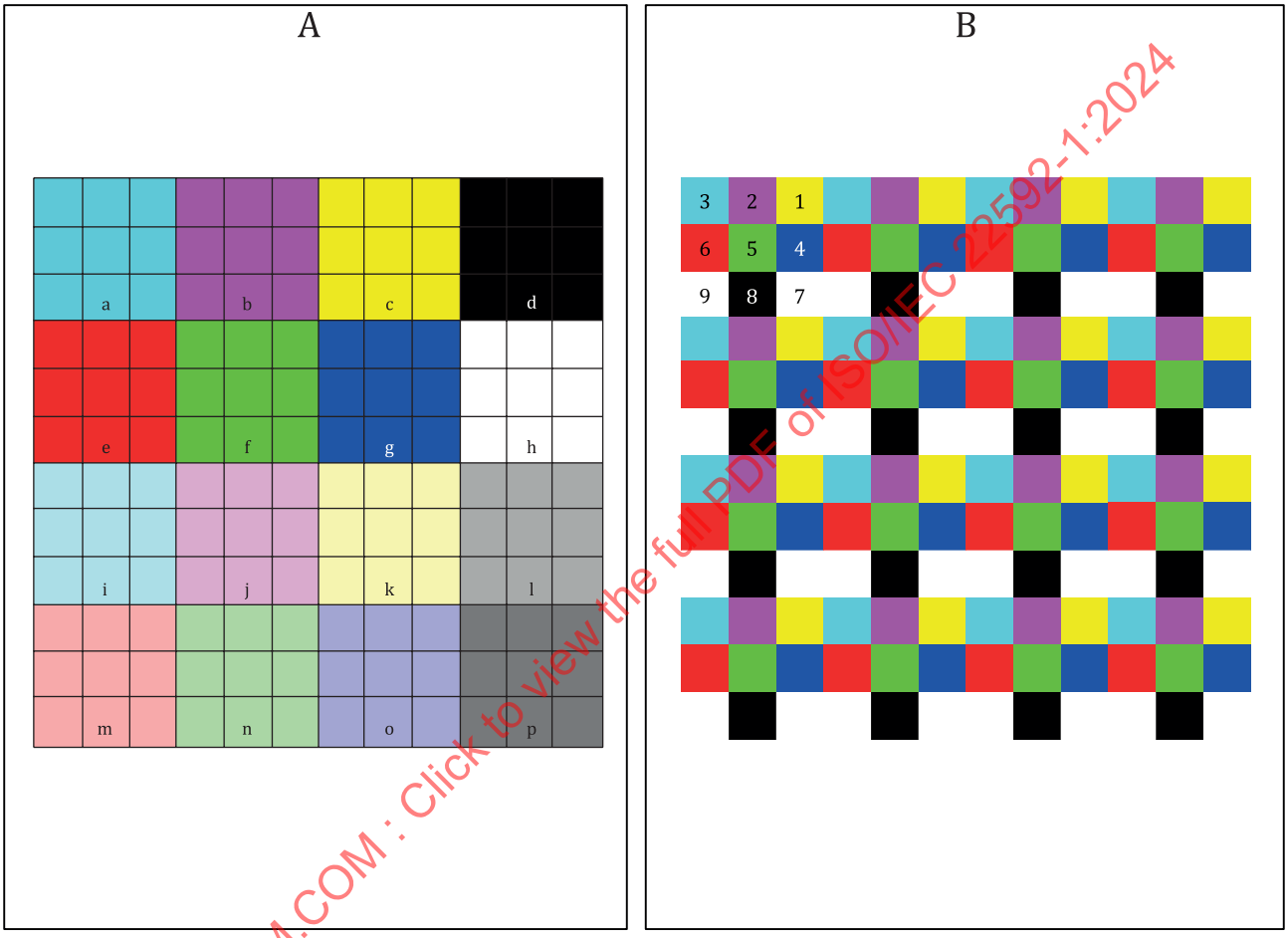
Colour code	C	M	Y	K	R	G	B	W	LC	LM	LY	LK	LR	LG	LB	MK
R	0	255	255	0	255	0	0	255	178	255	255	178	255	178	178	128
G	255	0	255	0	0	255	0	255	255	178	255	178	178	255	178	128
B	255	255	0	0	0	0	255	255	255	255	178	178	178	178	255	128

4.3 Test chart for show-through variations

The outline of the test chart is described in Figure 2. The test chart is composed of the two images in raster graphics. The first page is used to print an image for the front side and the second for the back side. The size is A4 for both sides.

A total of 16 components of C, M, Y, K, R, G, B, W, LC, LM, LY, LK, LR, LG, LB and MK, each comprising the 9 patches of the same colour code, are arranged at the centre of the front side. Each component has the 9 different saturated colour patches of C, M, Y, R, G, B, W, K and W printed on its back side to measure colour values dependence on the back-side colours.

The sRGB colour codes of those patches are the same as those in 4.2 as described in Table 1.



Key

A frontside
B backside
a Component A.
b Component B.
c Component C.
d Component D.
e Component E.
f Component F.
g Component G.
h Component H.
i Component I.
j Component J.
k Component K.
l Component L.
m Component M.
n Component N.
o Component O.
p Component P.

Figure 2 — Illustrated test chart for show-through variations

4.4 Test chart for line quality, graininess and mottle, and those variations

The outline of the test chart is described in Figure 3. The size of each page is A4.

The same four image patterns are arranged in page 1 and page 4. Each image pattern comprises nine halftone patches of shadow, mid and highlight for C, M and K, and three set of line patterns of different line angles of vertical, horizontal and diagonal, each composed of three different line widths of 0,12 pt, 0,24 pt and 0,36 pt (equivalent to 1 dot, 2 dots and 3 dots at 600 dpi), corresponding to around 42,3 µm, 84, 7 µm and 127,0 µm, based on the definition of 1 inch = 25,4 mm, for three input colours of C, M and K. Blank pages are inserted for page 3 and page 4 to eliminate the influence of show through.

Each patch size shall be equal to or larger than 25 mm × 25 mm. The length of each line image shall be equal to or longer than 20 mm.

The sRGB colour codes of those patches and line images are described in Table 2.

Each element in the first and fourth pages shall be vector graphics.

The test chart is encoded to PDF under the following conditions:

— no colour and tone correction,

— no reduction or enlargement in printed size,

— no image compression,

— resolution higher than 2 400 dpi of a pitch of around 10,6 µm.

Key

A page 1 (front side of odd sheet)
B page 2 (back side of odd sheet)
C page 3 (front side of even sheet)
D page 4 (front side of even sheet)

Figure 3 — Illustrated test chart set for line quality, graininess and mottle, and those variations

Table 2 — Area coverage of colour patches and line images of test chart for line quality, graininess and mottle and its variations

Colour code	Shadow			Mid			Highlight			Line object		
	C	M	K	C	M	K	C	M	K	C	M	K
R	51	255	51	127	255	127	192	255	192	0	255	0
G	255	51	51	255	127	127	255	192	192	255	0	0
B	255	255	51	255	255	127	255	255	192	255	255	0

5 Print preparation procedures

5.1 Printing environment

Printers shall be installed in an environment having a temperature of (23 ± 5) °C, with a relative humidity (RH) of (50 ± 10) % at least 2 h prior to print operations and the print operations shall be completed in the same environment. The paper to be used shall be placed in a paper tray when the printers are installed. Prior to the installation of printers, additional seasoning of papers under the same environmental conditions described above for more than 24 h is recommended to stabilize the water content of the papers which often affects image qualities of prints.

If a printer has not been used for a long period or if the environmental difference between storage and evaluation area is large, it is recommended to install it 12 h prior to the test and to print 10 or more sheets for warm up before the test.

5.2 Printing materials

An A4 sized plain paper shall be used to correspond well with a typical usage case of office prints. Coated papers for ink jet or lithography can be used for a specific usage case with a rational explanation in reporting. The grammage of the paper shall be from 60 g/m^2 to 90 g/m^2. The other grammage for paper can be used for a specific usage case with a rational explanation in reporting. The name, grammage and supplier of the paper shall be reported.

The opacity of substrates specified in ISO 2471 should also be reported.

Toner or ink materials recommended by the manufacturer of the printer to be tested shall be used. The other materials provided by the suppliers other than the original manufacturer of a printer for measurements can be used as long as the product name and supplier are included in the report.

The other printing materials, such as photoreceptors in electrophotographic printer, or the print head in an ink jet printer, shall be in accordance with the recommendations of the printer's manufacturer. The printing materials provided by the suppliers other than the original manufacturer of a printer for measurements can be used as long as the product name and supplier are included in the report.

5.3 Printer settings

Colour and paper settings in the driver and printer usually control mass density of colourants in high area coverage input images as well as halftone dot structures in mid-tone and highlight input images. Therefore, the former affects the colour reproduction range and the show through, and the latter affects graininess and mottle at the corresponding input images.

When printing a test chart, prints shall be produced using driver and printer settings that are appropriate for a typical usage case in office. Default settings for the substrate subjected to evaluation, which correspond to initial settings when a printer shipped out are recommended to be used. When performances of printing systems are compared, the default settings for each printing system shall be selected. The driver and printer settings used shall be described in the test report.

No reduction or enlargement in printed size shall be made. Modifications in colour and tone reproduction, sharpness enhancement, or noise reduction in the printer settings shall not be used. The printing mode by

which an input image is printed at the centre of the substrate shall be selected. No binding margin shall be arranged.

NOTE It is important to check if the size and position in a substrate are consistent. In some application viewers or printer settings for PDF files, settings related to size modification or printed position in a substrate at the previous print operation remain unchanged.

For the printers of the maximum applicable paper size of A3 or larger, the feed direction parallel to the short edge of A4 paper shall be selected and the feed direction perpendicular to the short edge of A4 paper can optionally be selected. In the printers of the maximum applicable paper size of A4, the feed direction shall be in accordance with printer setting for A4 size paper. Long edge binding shall be selected in duplex printing.

5.4 Printing operation

Printing can be initiated under any operational mode defined in Reference [7], i.e. 'On Mode' ('Active State', 'Ready State'), 'Off Mode' or 'Sleep Mode'. In order to evaluate overall performance of a printing system, it is recommended to carry out the tests under multiple operational modes. When performances of printing systems are compared, the same operational mode shall be used. The operational mode selected shall be included in the report.

Ten sheets of a duplex print shall be printed continuously by using the test chart described in 4.2 for the measurement of colour reproduction and variations in colour reproduction. When a simplex print is subjected to be measured, ten sheets of a simplex print shall be printed continuously by using only the front side image in the test chart described in 4.2 for the measurement of colour reproduction and variations in colour reproduction.

A sheet of a duplex print shall be printed by using the test chart described in 4.3 for the measurement of show-through variations.

Ten print sets, each set comprising two sheets of duplex prints shall be printed continuously by using the test chart described in 4.4 for the measurement of line quality, graininess and mottle, and those variations. When a simplex print is subjected to be measured, ten print sheets of simplex prints shall be printed continuously by using page 1 in the test chart described in 4.4 for the measurement of line quality, graininess and mottle, and those variations.

It is recommended to prepare duplicated print sets for each measurement for backup and to carry out measurements with duplicated print sets for measurement noise reduction.

5.5 Conditioning the prints after printing

Prior to measurements, aqueous inkjet prints, or prints of any type that require curing/stabilization/dry-down, shall be conditioned in a controlled environment for at least 24 h after printing. Considering mitigating colour changes caused by the exposure of environmental factors, such as light, high temperature and humidity during the conditioning, the controlled environment shall be the relative humidity between 30 % to 70 % and the temperature between 15 °C to 28 °C, with ambient illuminance on the print surface less than 1 000 lx.

6 Measurement conditions

6.1 Measurement environmental condition

All measurements in this document shall be completed in a controlled environment of relative humidity between 30 % to 70 % and temperature between 15 °C to 28 °C. It is recommended to complete a series of measurements continuously in a short duration to prevent the change in colour because of environmental factors.

6.2 Colour measurement

The CIELAB colour space values shall be obtained from measurements using ISO 13655 measurement conditions.

Conforming to ISO 13655, calculated tristimulus values and corresponding CIELAB values of the colorimetry shall be computed using CIE illuminant D50 and the CIE 1931 standard colorimetric observer (often referred to as the 2° standard observer). Self-backing or white-backing is recommended with respect to a typical office document composed of several sheets of a low area coverage print. The same illuminant condition, either M0, M1 or M2 shall be maintained for a series of colour measurements. It is recommended to apply M2, which is insensitive to the variation of optical brightener in papers when the colour variations originated by the performance of print equipment are evaluated.

Measurement instruments shall be calibrated in accordance with manufacturer's instructions. The same measurement instrument is recommended to be used for all of the same kind of measurements.

6.3 Measurement of line quality, graininess and mottle

The measurement methods described in ISO/IEC 24790 shall be used for line quality, graininess and mottle measurements. Line quality includes line width, line blurriness, line raggedness and line darkness. A scanner complying with the requirements in ISO/IEC 24790 shall be used to capture printed objects. Measurement procedures in detail shall be in accordance with those in ISO/IEC 24790.

7 Measurement procedures and analysis of measured results

7.1 General

This clause describes the measurement procedures and analysis of the measurement results. The overview of the measurements is described below. There are three groups of measurements: colour reproductions and those variations, line quality and graininess and mottle.

The outline of measurements is as following:

Group of attribute	Attribute	Subclause
Colour reproductions and those variations		**7.2**
	Metric for colour reproduction and those variations	7.2.1
	Colour reproduction range	7.2.2
	Within-page variations for colour reproduction	7.2.3
	Side-to-side variations for colour reproduction	7.2.4
	Sheet-to-sheet variations for colour reproduction	7.2.5
	Show-through variations for colour reproduction	7.2.6
Line quality		**7.3**
	Line-quality measurements	7.3.1
	Overall line quality	7.3.2
	Side-to-side variations for line quality	7.3.3
	Sheet-to-sheet variations for line quality	7.3.4

Graininess and mottle 7.4

Graininess and mottle measurements 7.4.1

Overall quality for graininess and mottle 7.4.2

Side-to-side variations for graininess and mottle 7.4.3

Sheet-to-sheet variations for graininess and mottle 7.4.4

NOTE 1 Those attributes can be evaluated quantitatively using the measurement methods in 7.2. However, the correlations between indexes and subjective impressions of the attributes included in this document has not been demonstrated.

NOTE 2 Examples of test results are shown in Annex A.

7.2 Colour reproductions and those variations

7.2.1 Metric for colour reproduction and those variations

Colour reproduction properties shall be evaluated in terms of CIELAB L*, a* and b* values defined in ISO/CIE 11664-4. Variations in the colour reproductions shall be evaluated in terms of ΔE^*_{ab} (delta E 76) as defined in ISO/CIE 11664-4 or ΔE^*_{00} (delta E 00) as defined in ISO/CIE 11664-6.

Colour variations can be specified by three kinds of indexes: the average ΔE^*, worst ΔE^* and 95 % tile in ΔE^*. It is recommended to use 95 % tile which shows conservative values for users and eliminates the effect of accidental errors in measurements. In the case 95 % tile is taken, C = 1 in the linear interpolation between closest ranks method described in ISO/TS 15311-1:2020, Annex C in which the value for 95 % tile is linearly interpolated from the value for the closest rank over 95th and that under 95th, is recommended to be adopted to estimate the value when 0,95 is not equal to the multiple number of 1/(*n*-1), in which "*n*" is the number of the data to estimate the value for 95 % tile.

NOTE The PERCENTILE.INC function in Microsoft® Excel® corresponds to 95 % tile at C = 1 in the linear interpolation between closest ranks.

7.2.2 Colour reproduction range

Colour reproduction range, R_{cr} shall be evaluated in terms of the average L*a*b* colour coordinates for the input data of C, M, Y, R, G, B, W and K patches in 4.2. The average colour coordinate for each colour shall be calculated by averaging the colour coordinates of 180 patches for the colour within a print set, comprising 10 sheets of front side and back side prints each includes 9 patches for the colour. Optionally, the average colour coordinate for each colour can be the average colour coordinate for each colour patch of the front side and back-side prints of the fifth sheet to reduce the burden for the colour measurements with a comment in its report that 'Colour reproduction range is calculated only for the fifth sheet of the print set and sheet-to-sheet variations of colour reproduction range are not taken into account'.

NOTE 1 Colour reproduction range is affected by random substrate variation which changes not only the colour of the white background but also the colour of the patches due to the variation in colourant penetration and spreading with the surface and inner properties of substrate.

Colour reproduction range can be evaluated in terms of the index obtained by summing the total of 12 colour difference values in the CIELAB colour space, i.e. the colour difference values in ΔE^*_{ab} between the average colour coordinate of W and that of each colour of C, M, Y, R, G and B, and between that of K and that of each colour of C, M, Y, R, G and B.

The colour difference value in ΔE^*_{ab} can be calculated by Formula (1):

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

where $i \in$ {C, M, Y, R, G, B}, and $j \in$ {W, K}.

Consequently, the metric for the range corresponding to colour reproduction range can be calculated by Formula (2):

$$R_{\mathrm{cr}} = \sum_i \sum_j \sqrt{(L_i^* - L_j^*)^2 + (a_i^* - a_j^*)^2 + (b_i^* - b_j^*)^2} \tag{2}$$

where $i \in \{C, M, Y, R, G, B\}$, and $j \in \{W, K\}$.

NOTE 2 Formula (2) assumes additive mixture in colour reproduction, which is applicable only in a linear system, such as display devices in the sRGB colour space. However, the assumption is not true due to no linearity in colour mixture at the CIELAB colour space as well as the subtractive mixture caused by the duplicated colourant layer structure in common printing devices. The formula is beneficial to estimate a schematic overview of colour reproduction range of a printing system. An example showing the correlation between the colour reproduction range and volume of tetrahedral comprising C, M, Y, R, G, B, W, and K is shown in Annex B.

7.2.3 Within-page variations for colour reproduction

For each of the 16 input colours in Figure 1 of C, M, Y, K, R, G, B, W, LY, LM, LC, LK, LR, LG, LB and MK printed on each page, the worst colour difference, "Wst ΔE^* for a page" in terms of ΔE^*_{ab} (delta E 76) or ΔE^*_{00} (delta E 00) of all the combinations of two patches of the 9 components printed on the different locations in the page shall be calculated.

NOTE There are total 576 (= $9C_2 \times 16 = (9 \times 8)/(2 \times 1) \times 16$) ΔE^* to be calculated for the 2-patches-combinations of 9 components for 16 input colours for a page. Within-page variation for each colour shall be calculated in terms of average or 95 % tile value of "Wst ΔE^* for a page" among the 20 pages (10 sheets ×2 sides). Optionally, within-page variation for each colour can be obtained by averaging "Wst ΔE^* for a page" for each colour patch of the front-side and back-side prints of the fifth sheet to reduce the burden for the colour measurements with a comment in its report that 'within-page variation for each colour in this report is calculated only for the fifth sheet of the print set and Sheet-to-sheet variation are not taken into account'.

7.2.4 Side-to-side variations for colour reproduction

For each of the 16 input colours in Figure 1 of C, M, Y, K, R, G, B, W, LY, LM, LC, LK, LR, LG, LB and MK printed on all the sheets, "side-to-side ΔE^*", the colour difference in terms of ΔE^*_{ab} (delta E 76) or ΔE^*_{00} (delta E 00) between the average CIELAB colour coordinate of the 9 components on the front side and that on the back side shall be calculated.

NOTE There are total of 1 440 (= 16 × 9 × 10) "side-to-side ΔE^*" to be calculated for the combinations of 9 components, 16 input colours and 10 sheets.

Side-to-side variation for each colour shall be calculated in terms of average or 95 % tile value of 90 Side-to-side ΔE^* (9 components of 10 sheets). Optionally, the side-to-side ΔE^* for each colour on the fifth sheet can be used as side-to-side variation to reduce the burden for the colour measurements with a comment in its report that 'side-to-side variation for each colour in this report is calculated only for the fifth sheet of the print set and Sheet-to-sheet variation are not taken into account'.

7.2.5 Sheet-to-sheet variations for colour reproduction

For each of 16 input colours in Figure 1 of C, M, Y, K, R, G, B, W, LY, LM, LC, LK, LR, LG, LB and MK, the average colour coordinates of the 9 components in each page shall be calculated.

Sheet-to-sheet variation for each colour shall be calculated in terms of average or 95 % tile value of ΔE^*_{ab} (delta E 76) or ΔE^*_{00} (delta E 00) of the 10 front sides or 10 back sides of the 10 sheets. Optionally, the colour coordinate of the centre component in each page can be used instead of "average colour coordinate" to calculate Sheet-to-sheet variation for each colour with a comment in its report that 'Sheet-to-sheet variation for each colour in this report is calculated only by using the centre component in each page and Within page variation is not taken into account'.

7.2.6 Show-through variations for colour reproduction

For each of the 16 components of varied input colours of C, M, Y, K, R, G, B, W, LY, LM, LC, LK, LR, LG, LB and MK printed on the front side in Figure 2 left, the colour coordinates for all the back-side colours of C, M, Y, K, R, G, B and W in Figure 2 right shall be measured.

For any given component on the front side, the measured colour patch positioned over the W patch (#7 and #9 in each component) on the back side would be the baseline for zero show through for the component. The delta E of every non-white patch versus that baseline is a metric of show through for each of the other patches. The maximum of these delta Es shall then be the metric for show-through variation for each component.

NOTE As the back-side colour of general office documents of low area coverage is mostly white (no images), the colour difference between coloured back side and white back side is the most important metric for show through.

An optional metric for show-through variation for each component which is defined as the largest colour difference [in terms of ΔE^*_{ab} (delta E 76) or ΔE^*_{00} (delta E 00)] among any of the 9 patches in the component on the front side that is caused by the show through of 9 back-side colours can also be used when a document composed of high area coverage prints is its usage case.

7.3 Line quality

7.3.1 Line quality measurements

Line quality attributes, i.e. line width, blurriness, raggedness and character darkness (specified in ISO/IEC 24790) of black colour lines of vertical and horizontal direction at four locations (upper left, upper right, lower left and lower right) on a page, each comprising 0,12 pt, 0,24 pt and 0,36 pt lines of vertical, horizontal and diagonal directions described in Figure 3 shall be measured for the front side and back side of the first and tenth sheets. Diagonal black lines can optionally be measured. Cyan and magenta lines shall not be measured using test method in ISO/IEC 24790, whose scope only covers the test method to evaluate monochrome prints.

If a line element is not reproduced continuously, the line quality for this element cannot be measured correctly and measurement error will be shown in the measurement. So, test results including such elements shall be removed from the evaluation.

7.3.2 Overall line quality

Average values of line width, blurriness, raggedness and character darkness of the 16 measurement points (four locations in each page × two sides of front and back × two sheets of the first and tenth) shall be calculated for the 4 kinds of line (two line widths of 1 dot and 2 dots × 2 directions of vertical and horizontal).

7.3.3 Side-to-side variations for line quality

The differences in the line width, blurriness, raggedness and character darkness between the average values of the four locations on the front side and those on the back side of the first sheet shall be calculated for the four kinds of line (two line widths × two directions of vertical and horizontal).

7.3.4 Sheet-to-sheet variations for line quality

The differences in the line width, blurriness, raggedness and character darkness between the average values of the four locations on the first sheet and those on the tenth sheet of each side shall be calculated for the four kinds of line (two line widths × two directions).

7.4 Graininess and mottle

7.4.1 Graininess and mottle measurements

The graininess and mottle (specified in ISO/IEC 24790) of black colour patches located at the upper left, upper right, lower left and lower right on a page, each comprising shadow, mid tone and highlight described in Figure 3 shall be measured for the front side and back side of the first and tenth sheets. Cyan and magenta patches shall not be measured using test method in ISO/IEC 24790, whose scope only covers the test method to evaluate monochrome prints.

7.4.2 Overall quality for graininess and mottle

Average values of graininess and mottle of the 16 measurement points (four locations in each page × two sides of front and back × 2 sheets of the first and tenth) shall be calculated for the three tone patches of shadow, mid tone and highlight of K.

7.4.3 Side-to-side variations for graininess and mottle

The differences in the graininess and mottle between the average values of the front side and those of the back side shall be calculated for the three patches of different tone values.

7.4.4 Sheet-to-sheet variations for graininess and mottle

The differences in the graininess and mottle between the average values of the four locations on the first sheet and those on the tenth sheet shall be calculated for the three patches of different tone values both for the front and back sides.

8 Reporting

8.1 General requirements for reporting

The measurement methods described in this document are used to access physical properties of a print set formed by a printing system on a substrate. Comparison of test results among various printing systems shall only be made if the same product of substrates is used among all the printing systems in addition to set equivalent printing conditions under default printer settings for all the printing systems.

Reporting shall include all information to replicate the test.

8.2 Reporting items

The test report shall include the following information in addition to a series of the test results described in Clause 7:

a) date and place test samples were printed,

b) product name and suppliers of the printer,

c) driver and printer settings,

d) operational mode,

e) product name, suppliers and grammage of the substrate,

f) product name and suppliers of toner or ink materials, if third party suppliers provide them,

g) product name and suppliers of the printing materials, if third party suppliers provide them,

h) product name, suppliers and driver settings of the scanner that performs the line quality, graininess and mottle measurements,

i) reference to this document, i.e. ISO/IEC 22592-1,

j) any deviation from this document or any circumstances or influence that have affected the results.

Annex A
(informative)

Example of colour measurement test results

A.1 General

The example of colour measurement test results based on this document is described in this annex. The print sets evaluated were formed on plain papers of 70 g/m^2 grammage using a dry toner base electrographic printer and on plain papers of 60 g/m^2 grammage using a pigment base ink jet printer. Printing procedures and measurement conditions were set up to comply with Clause 5 and Clause 6 respectively.

A.2 Colour reproduction range

The measurement results are summarized in Table A.1.

In Table A.1, ΔE^*_{ab} between the CIELAB colour coordinate of W and those of primary and secondary colours of C, M, Y, R, G and B of 100 % coverage, and ΔE^*_{ab} between that of K and those of primary and secondary colours are described in addition to C* values (= (a* ^{2} + b * ^{2}) ^{0,5}) for the primary and secondary colours as well as total area in the a*-b* plane of the hexagon composed of the primary and secondary colours.

In the a*-b* plain, the edge of colour reproduction range can be represented by a* and b* values for the primary and secondary colours of 100 % coverage. So, the C* values of those colours and area of the hexagon composed of those colours can be a good representative metric for the colourfulness of a printing system.

On the other hand, the size of colour reproduction range should reflect not only reproducible C* representing colourfulness but also reproducible lightness range of a printing system. Consequently, the sum of ΔE^*_{ab} values from white background and black to all of the primary and secondary colours should be a better metric for the size of colour reproduction range than the sum of C* for six colours of primary and secondary or the total area of the hexagon.

Table A.1 — Summary of test results for colour reproduction range

	EP					IJ				
	ΔE^*_{ab}			C*		ΔE^*_{ab}			C*	
	from W	from K	from K + W	C*	Hexagon area	from W	from K	from K + W	C*	Hexagon area
C	50,4	63,5	113,9	40,3	1140,7 1264,1 2838,1 1525,9 1892,4	55,9	61,0	116,8	49,6	1210,9 1308,4 1924,7 860,6 1253,9
M	69,7	68,8	138,5	56,6		66,3	68,2	134,5	60,3	
Y	93,1	117,8	210,9	92,4		73,3	91,0	164,3	67,8	
R	90,5	81,1	171,6	75,1		68,3	66,1	134,4	59,2	
G	69,0	71,8	140,8	57,9		59,8	62,8	122,5	49,2	
B	73,2	49,4	122,6	44,7		59,3	49,4	108,6	43,8	
Sum	445,9	452,4	898,3	367,1	8661,2	382,8	398,4	781,2	329,9	6558,5

A.3 Within-page variations

The measurement results are summarized in Table A.2 and Table A.3.

For delta E 76 or delta E 00, the delta E 00 can be a better metric while delta E 76 seems too stringent of an index to evaluate variations of saturated primary and secondary colours.

For average, maximum or 95 % tile, the 95 % tile can be a conservative metric preventing from overestimating the effect of accidental errors.

Table A.2 — Summary of test results for within-page variations in electrophotographic printer

			EP															
			C	M	Y	K	R	G	B	W	LC	LM	LY	Lgry	LR	LG	LB	Gry
ΔE^*_{00}	Max. in page	Max.	3,71	3,53	1,44	2,98	2,67	4,53	3,85	0,55	2,08	1,56	2,39	4,04	2,61	3,20	4,24	4,36
		95 % Tile	3,59	3,52	1,33	2,94	2,67	4,34	3,66	0,53	1,91	1,52	2,23	3,91	2,50	2,88	4,22	3,42
		Average	2,73	2,38	1,18	2,11	2,35	3,34	2,69	0,41	1,67	1,12	1,58	2,78	1,85	2,04	1,87	2,76
	95 % tile in page	Max.	3,29	3,33	1,31	2,71	2,45	4,41	3,46	0,48	1,75	1,39	2,20	3,63	2,41	2,49	4,15	3,49
		95 % Tile	3,26	3,12	1,26	2,69	2,40	4,13	3,32	0,46	1,71	1,38	2,03	3,43	2,19	2,46	3,81	2,98
		Average	2,47	2,18	1,07	1,93	2,17	3,14	2,48	0,35	1,53	0,95	1,35	2,53	1,62	1,81	1,66	2,45
	Average in page	Max.	1,89	1,59	0,65	1,36	1,23	2,24	1,74	0,23	1,02	0,67	1,00	1,94	1,28	1,23	1,53	1,72
		95 % Tile	1,87	1,55	0,62	1,34	1,23	2,08	1,70	0,23	1,01	0,60	0,94	1,82	1,19	1,21	1,46	1,63
		Average	1,36	1,07	0,54	0,98	1,11	1,65	1,28	0,18	0,86	0,49	0,64	1,45	0,89	0,96	0,87	1,42
ΔE^*_{ab}	Max. in page	Max.	7,09	5,85	6,89	4,46	5,95	7,98	5,03	0,66	2,51	2,49	5,41	4,09	3,95	4,73	3,76	3,62
		95 % Tile	6,47	5,82	6,44	4,22	5,48	7,61	4,90	0,59	2,21	2,33	5,20	4,05	3,66	4,28	3,67	3,59
		Average	5,03	4,06	5,54	3,10	4,78	6,22	3,63	0,44	1,98	1,74	3,57	2,99	2,72	2,99	2,19	2,82
	95 % tile in page	Max.	6,33	5,50	6,30	3,95	5,24	7,41	4,65	0,50	2,09	2,18	4,95	3,63	3,61	3,66	3,65	2,97
		95 % Tile	5,93	5,32	5,99	3,85	5,03	7,05	4,49	0,47	2,00	2,16	4,76	3,62	3,14	3,65	3,39	2,90
		Average	4,54	3,71	5,01	2,80	4,37	5,74	3,35	0,37	1,81	1,47	3,07	2,75	2,39	2,67	1,91	2,51
	Average in page	Max.	3,43	2,65	3,09	1,93	2,63	3,91	2,36	0,25	1,23	1,05	2,27	1,88	1,87	1,80	1,66	1,61
		95 % Tile	3,33	2,63	2,89	1,88	2,47	3,77	2,29	0,24	1,23	0,92	2,16	1,84	1,72	1,79	1,44	1,56
		Average	2,48	1,84	2,48	1,37	2,18	3,11	1,77	0,20	1,05	0,75	1,43	1,52	1,29	1,38	1,02	1,41

Table A.3 — Summary of test results for within-page variations in ink jet printer

			IJ															
			C	M	Y	K	R	G	B	W	LC	LM	LY	Lgry	LR	LG	LB	Gry
ΔE^*_{00}	Max. in page	Max.	0,70	0,58	0,41	0,87	0,48	0,96	1,07	0,44	0,84	1,05	0,82	1,01	0,93	1,59	1,13	1,83
		95 % Tile	0,64	0,57	0,40	0,70	0,46	0,84	0,80	0,36	0,84	0,85	0,78	0,92	0,77	1,32	1,06	1,81
		Average	0,42	0,40	0,29	0,47	0,36	0,56	0,65	0,20	0,67	0,66	0,60	0,74	0,67	0,98	0,77	1,22
	95 % tile in page	Max.	0,56	0,47	0,37	0,65	0,39	0,88	0,79	0,42	0,74	0,72	0,74	0,85	0,78	1,37	0,96	1,66
		95 % Tile	0,48	0,45	0,32	0,54	0,37	0,70	0,71	0,34	0,65	0,70	0,71	0,81	0,66	1,20	0,90	1,59
		Average	0,35	0,33	0,25	0,40	0,32	0,49	0,57	0,18	0,56	0,55	0,52	0,64	0,58	0,84	0,66	1,10
	Average in page	Max.	0,28	0,23	0,16	0,30	0,21	0,35	0,36	0,18	0,31	0,33	0,36	0,45	0,40	0,60	0,52	0,82
		95 % Tile	0,22	0,22	0,15	0,28	0,21	0,30	0,35	0,15	0,31	0,33	0,33	0,44	0,35	0,58	0,48	0,78
		Average	0,17	0,17	0,12	0,21	0,18	0,24	0,29	0,09	0,26	0,26	0,24	0,36	0,31	0,43	0,35	0,60
ΔE^*_{ab}	Max. in page	Max.	1,24	1,19	1,66	1,12	0,91	2,19	1,11	0,63	1,43	2,07	1,75	0,89	1,67	2,74	1,46	1,68
		95 % Tile	1,21	1,15	1,56	0,91	0,85	1,57	1,10	0,49	1,32	1,69	1,67	0,83	1,43	2,30	1,39	1,63
		Average	0,75	0,82	1,14	0,60	0,70	1,21	0,88	0,26	1,11	1,26	1,27	0,68	1,14	1,68	1,10	1,16
	95 % tile in page	Max.	1,02	0,87	1,40	0,84	0,74	2,03	0,97	0,59	1,26	1,40	1,58	0,75	1,38	2,36	1,33	1,58
		95 % Tile	0,89	0,86	1,29	0,70	0,70	1,32	0,93	0,47	1,09	1,36	1,42	0,73	1,20	2,05	1,20	1,52
		Average	0,64	0,67	0,95	0,51	0,62	1,05	0,78	0,23	0,95	1,05	1,10	0,60	1,00	1,43	0,97	1,05
	Average in page	Max.	0,50	0,43	0,59	0,38	0,42	0,77	0,49	0,25	0,52	0,64	0,70	0,44	0,68	1,01	0,70	0,81
		95 % Tile	0,41	0,43	0,58	0,36	0,39	0,65	0,49	0,17	0,52	0,62	0,69	0,41	0,57	0,97	0,65	0,78
		Average	0,32	0,34	0,44	0,26	0,34	0,54	0,41	0,11	0,44	0,50	0,50	0,35	0,51	0,72	0,51	0,59

A.4 Side-to-side variations

The measurement results are summarized in Table A.4.

For delta E 76 or delta E 00, delta E 00 can be a better metric while delta E 76 seems too strict for saturated primary and secondary colours.

For average, maximum or 95 % tile, the combination of 95 % tile[2)] and 95 % tile[3)] can be a conservative metric preventing from overestimating the effect of accidental errors.

2) Source of variations is page-to-page in 10 sheets.

3) Source of variations is 16 input colours.

Table A.4 — Summary of test results for side-to-side variations

	EP						IJ					
	ΔE^*_{ab}			ΔE^*_{00}			ΔE^*_{ab}			ΔE^*_{00}		
	Ave.[a]	Max.[a]	95 % tile[a]	Ave.[a]	Max.[a]	95 % tile[a]	Ave.[a]	Max.[a]	95 % tile[a]	Ave.[a]	Max.[a]	95 % tile[a]
C	0,81	1,08	1,03	0,44	0,57	0,56	0,43	1,05	0,83	0,25	0,43	0,39
M	1,50	2,03	1,95	0,85	1,07	1,06	0,27	1,34	0,87	0,14	0,50	0,36
Y	2,17	2,78	2,66	0,46	0,57	0,55	0,76	2,29	1,61	0,25	1,20	0,75
K	1,12	1,41	1,38	0,77	0,97	0,96	0,20	0,83	0,60	0,20	1,09	0,71
R	2,20	2,75	2,62	1,00	1,16	1,13	0,35	1,20	0,87	0,17	0,34	0,31
G	2,07	2,54	2,47	1,04	1,40	1,28	0,44	1,75	1,17	0,17	0,71	0,47
B	1,55	2,05	1,98	1,09	1,40	1,38	0,27	0,77	0,58	0,19	0,64	0,47
W	0,14	0,20	0,18	0,12	0,19	0,17	0,28	1,81	1,08	0,31	2,36	1,37
LC	0,49	0,77	0,76	0,36	0,59	0,56	0,34	1,57	1,00	0,21	1,02	0,65
LM	0,44	0,73	0,71	0,28	0,47	0,46	0,47	1,40	1,00	0,26	0,85	0,59
LY	0,53	1,04	0,96	0,24	0,45	0,43	0,50	1,97	1,28	0,31	1,63	0,99
LGry	0,34	0,62	0,59	0,34	0,59	0,55	0,33	1,62	0,99	0,36	2,13	1,28
LR	0,57	0,96	0,88	0,42	0,71	0,66	0,28	1,73	1,05	0,17	0,95	0,59
LG	0,52	0,88	0,85	0,40	0,66	0,65	0,30	1,57	0,96	0,20	1,07	0,64
LB	0,53	0,76	0,74	0,45	0,71	0,70	0,24	1,41	0,86	0,21	1,30	0,77
Gry	0,60	0,85	0,84	0,65	0,93	0,93	0,28	1,35	0,87	0,30	1,69	1,03
Ave.[b]	0,97	1,34	1,29	0,56	0,78	0,75	0,36	1,48	0,98	0,23	1,12	0,71
Max.[b]	2,20	2,78	2,66	1,09	1,40	1,38	0,76	2,29	1,61	0,36	2,36	1,37
95 % tile[b]	2,18	2,76	2,63	1,05	1,40	1,31	0,57	2,05	1,37	0,33	2,19	1,30

[a] Source of variations is page-to-page in 10 sheets.
[b] Source of variations is 16 input colours.

A.5 Sheet-to-sheet variations

The measurement results are summarized in Table A.5.

For delta E 76 or delta E 00, delta E 00 can be a better metric while delta E 76 seems too stringent of an index to evaluate variations of saturated primary and secondary colours.

For average, maximum or 95 % tile, 95 % tile can be a conservative metric preventing from overestimating the effect of accidental errors.