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Office equipment — Print quality measurement methods for colour prints —

Part 2: Registration and magnification accuracy

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Foreword

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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.

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Introduction

Measurement methods that quantitatively evaluate geometric property attributes of duplex print sets need to be standardized, as most of the office documents are currently printed as duplex print sets comprising several sheets printed colour images on both surface of substrates.

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 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 those documents, users can obtain consistent test results when they comply with the protocols specified in the documents.

While 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 those print image attributes: ISO/IEC 22592-1 for colour consistency, this document 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.

The measurement methods described in this document are used to access geometric properties 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.

As for the metrics for registration and magnification based on images captured by an RGB scanner, prints with four primary colourants other than cyan, magenta, yellow and black are not suitable for the measurement methods described in this document. For example, if a print includes a light colourant image of a primary colour in addition to a standard colourant image, registration and magnification of this print will not be measured correctly because the complementary colour channel of the primary in a scanned image of the print includes two kinds of sources for registration and magnification.

Electrophotography, thermal inkjet, or piezoelectric inkjet technologies are commonly used to form such prints. The main purpose of this document is to provide objective measurement methods for geometric property attributes of duplex print sets, however, some attributes are also applicable for a set of simplex prints.

This document prescribes the following:

— digital test charts for the measurements in which colour codes and locations in page to be measured are specified,

— a test chart to measure the positional accuracy of a scanner,

— conformance requirements for the positional accuracy of a scanner to utilize registration and magnification measurements,

— measurement methods relating to the registration including accuracy of printed positions to substrate for each colour and printed position variations among colours,

— measurement methods relating to the magnification including absolute magnitude of printed size to input and relative difference in the magnitude among colours,

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

— measurement methods for the variations of the registration and magnification within a page (within-page variation), between front and back sides (side-to-side variation), among the sheets in the same print set (sheet-to-sheet variations).

Some attributes, such as the attribute “within a printed image”, “sheet-to-sheet variations”, 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.

Some prints show uneven surfaces caused by thermal fusing process of electrophotographic printers or drying process in ink jet printers as well as by storage humidity changes from a highly humid condition to dry condition. Flatness of a print surface is an important aspect for print integrity. On the other hand, there is no proper measure standardized corresponding well with visual impression of flatness. Annex A describes one of the methods to quantify degree of flatness. A further study needed to include this method into the scope of this document.

In this document, colour codes for the test charts are defined in sRGB colour space specified in IEC 61966-2-1 as is common in office documents.

Office equipment — Print quality measurement methods for colour prints —

Part 2: Registration and magnification accuracy

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 geometric property attributes and those variations in duplex colour prints typically used in office environment. This document is applicable to duplex prints comprising several sheets which are printed colour images on both surfaces of a substrate.

"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.

Prints with four primary colourants other than cyan, magenta, yellow and black are outside the scope of this document.

Included are digital prints formed by using a multifunction or single function printer. When a duplex print set is evaluated, duplex printers which are capable to print images on both sides of substrate automatically are applicable, while 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. The printers of the maximum applicable substrate size of A4 or larger are suitable for the measurements.

The geometric property attributes included are registration and magnification of a print set.

Microscopic geometrical density variations, such as graininess, mottle and line raggedness, are outside the scope of this document.

The sources of variations considered are locations in a page, print side in a sheet, print order of sheets in a print set, and variations among primary colours.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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 (3.9) corresponding to an even page of input data in a duplex *print set* (3.8)

3.2
cockle
local deformation of a sheet of print due to unequal shrinkage or swelling giving it a slightly crumpled appearance

3.3
colour-to-colour variation
change in an attribute among the primary colours of the printer to evaluate

3.4
curl
deviation from a flat surface

3.5
fast scan direction
FSD
direction parallel to the sensor array of a scanner

3.6
front side
print side (3.9) corresponding to an odd page of input data in a duplex *print set* (3.8)

3.7
magnification
absolute magnitude of printed size to input

3.8
print set
set of sheets printed in a print operation

3.9
print side
one of the duplex print surfaces, either *front side* (3.6) or *back side* (3.1)

3.10
registration
accuracy of printed positions to substrate for each colour

3.11
slow scan direction
SSD
direction perpendicular to the sensor array of a scanner

3.12
sheet-to-sheet variation
change in an attribute at the same input data on the same *print side* (3.9), either the *front side* (3.6) or *back side* (3.1), within a *print set* (3.8)

3.13
side-to-side variation
change in an attribute at the same input data in the same sheet between the *front side* (3.6) and *back side* (3.1)

3.14
spots per inch
spi
spots per 25,4 mm

[SOURCE: ISO/IEC 24790:2017, 3.34]

3.15
within-page variation
change in an attribute by location within a page

3.16
waviness
geometrical distortion of the print, generally at high-density image area

4 Print preparation procedures

4.1 Printing environment

Printers shall be installed in the environment range of 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 range. The substrate to be used shall be placed in a paper tray when the printers are installed. Prior to the installation of printers, additional conditioning of papers under the same environment for temperature and humidity 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.

4.2 Printing materials

An A4 size plain paper shall be used because it corresponds well with a typical usage case of office prints. Coated papers for ink jet or lithography may 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. Any other grammage for paper may be used for a specific usage case with a rational explanation in reporting. The name, grammage and supplier of the paper shall be reported.

It is recommended to measure the dimensions of the papers prior to tests and after printing.

Toner or ink materials recommended by the manufacturer of the printer to be tested shall be used. Any other materials provided by the other suppliers than the printer manufacturer may be used as long as product name and supplier are included in the report.

Any other printing materials, such as photoreceptors in electrophotographic printer, print head in ink jet printer, shall be in accordance with the recommendations by the printer manufacturer. The printing materials provided by the third-party suppliers may be used as long as product name and supplier are included in the report.

4.3 Printer settings

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 a substrate shall be selected. No binding margin shall be arranged.

Test prints shall be formed using driver and printer settings, except the parameters above mentioned, 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 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.

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.

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

4.4 Printing operations

Printing may 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.

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

4.5 Conditioning the prints after printing

Prior to measurements, each print set shall be conditioned in a controlled environment for at least 24 h after printing to stabilize the dimension of sheet comprising the print set. The controlled environment shall be the relative humidity between 30 % to 70 % and the temperature between 15 °C to 28 °C.

5 General requirements for measurements

5.1 Measurement environmental conditions

All measurements in this document shall be completed in a controlled environment of relative humidity (50 ± 20) % and temperature (21,5 ± 6,5) °C.

In case that a high measurement accuracy is required, the relative humidity and temperature should be (50 ± 10) % and (23 ± 5) °C, respectively, to mitigate the influence of dimension changes in the conformance test chart and print samples with environment.

It is recommended to complete a series of measurements as a short duration as possible to prevent from the change in dimensions of the conformance test chart and print samples with environmental changes.

5.2 Scanner conformance

5.2.1 General

In case a scanning system is used for the measurements, the scanning system shall meet the requirements described in Clause 5.

A scanning system used for the measurements in this document shall be tested using the test chart described in 5.2.2 and procedures specified in 5.2.4 to ensure the measurement results conform to the requirements of this document.

The scanning system is calibrated suitably if it can obtain a value within acceptable tolerances of the goal values given in 5.2.7 for each attribute of registration and magnification.

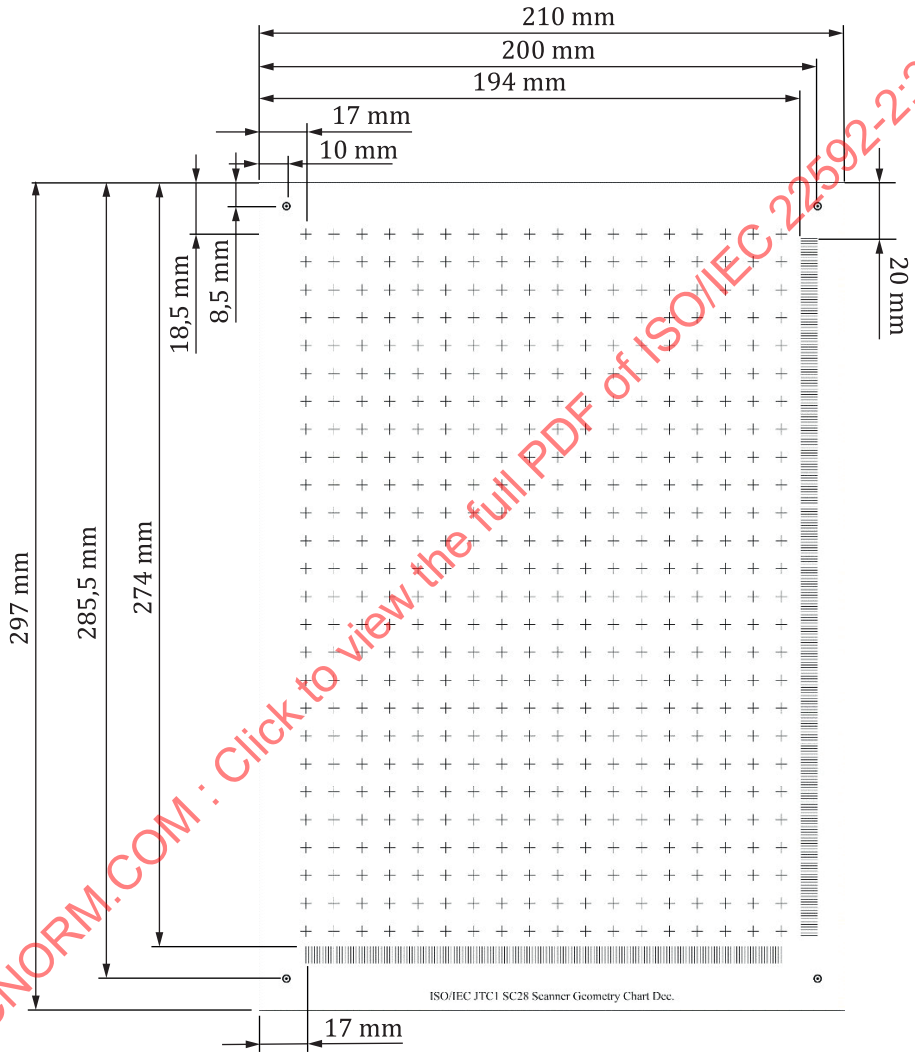
The conformance test shall be completed at least within six months prior to evaluations.

5.2.2 Test chart for scanner conformance

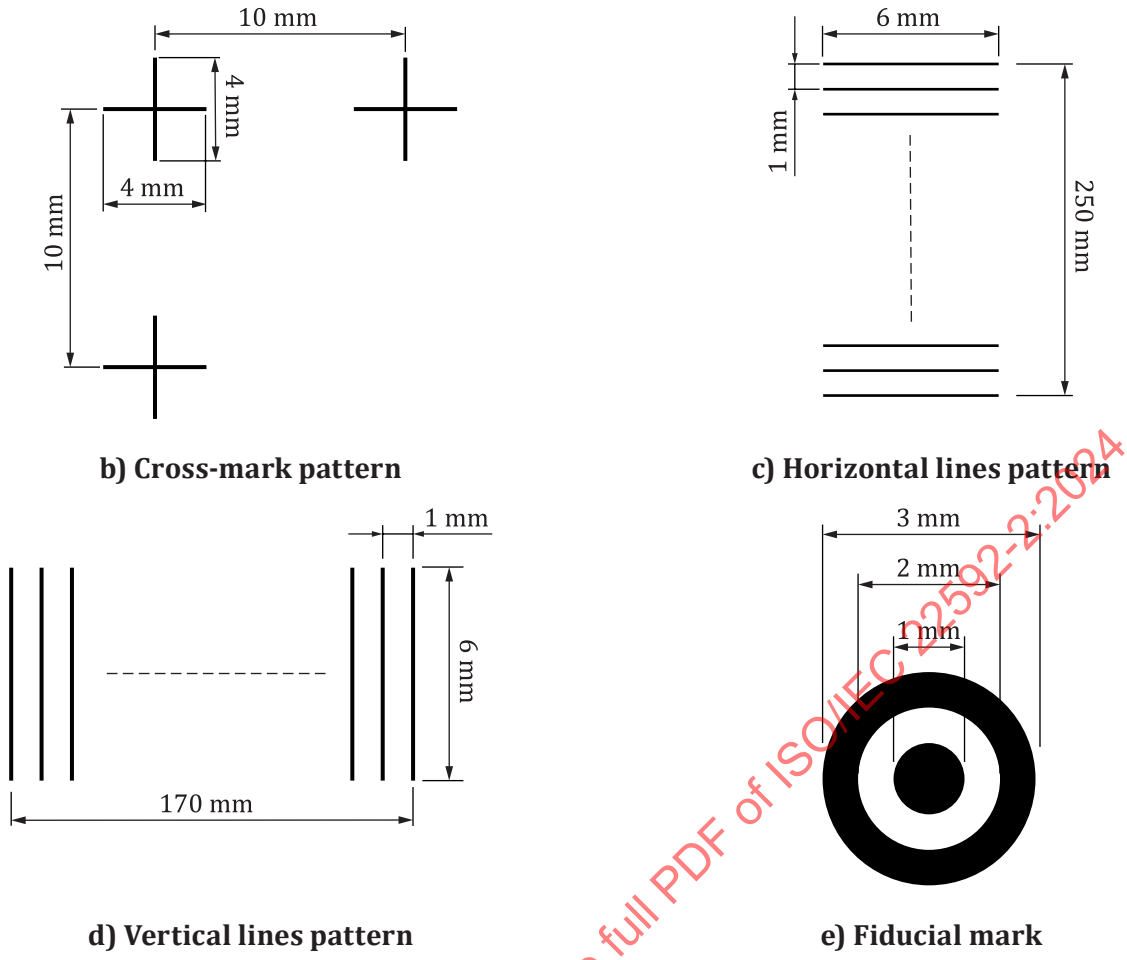
The outline of the test chart to evaluate positional accuracy of scanner is described in Figure 1. The size is A4. Widths of line components are all 100 µm.

The substrate material shall be transparent PET with a coated layer of a high-γ photosensitive emulsion for photolithographic process on its surface. The thickness of the PET film should be from 0,05 mm to 0,2 mm considering handling and durability in scanning operations. A photolithographic process for such as colour masks in a liquid crystal display shall be used to develop the image described in Figure 1 on the surface of the substrate. Positional accuracy shall be 5 µm in a narrow area and 10 µm in page wide.

Information about one of the test charts complying with the requirements in this document can be obtained at https://standards.iso.org/iso-iec/22592/-2/ed-1/en.



a) Layout of test chart



b) Cross-mark pattern

c) Horizontal lines pattern

d) Vertical lines pattern

e) Fiducial mark

Figure 1 — Illustrated test chart for scanner conformance

5.2.3 Scanning equipment

The measurements of registration and magnification in this document shall be carried out with a scanning system that has a minimum of 600 spi and 8 bits per pixel (256 gray levels), with a scanning field larger than A4 area.

5.2.4 Scanning procedures

The test chart in 5.2.2 shall be placed on the platen of a scanner to be evaluated so that the orientation of the test chart is the same as that in actual print evaluations, in which the unprinted side of the test chart shall directly contact with the platen. Then, a diffuse white substrate, such as a blank plane paper, shall be placed on the printed surface of the test chart additionally so that the surface of the diffused white substrate contacts the printed surface. It is recommended to place additional sheets of substrates to have a sufficient contact at the interfaces among the platen, the test chart and the white diffuse substrate.

The scanner settings shall be as following:

— scanning resolution: 600 spi,

— number of bits: 8 bit,

— colour mode: RGB,

— scanning speed: default,

— no spatial filter applied, and

— no colour or tone correction applied.

User may choose any scanner settings except for the above-mentioned settings if they are appropriate for the objective of the measurement.

The above settings shall be maintained for all the scanning operations of the test prints in Clause 6.

Under the above conditions, the test chart shall be scanned to demonstrate that the scanned image satisfies the conformance requirements.

NOTE The scanned images with this procedure are the mirror images of the original test chart.

5.2.5 Magnification accuracy of scanner

The magnification accuracy in each channel of primary colours of a scanner, i.e. scanner RGB shall be evaluated using the four fiducial marks located at the four corners of the scanned images of the conformance test chart in Figure 1.

The centre position of each fiducial mark shall be specified in term of the centre of gravity of each channel signals of a cropped area including a whole fiducial mark, comprising a centre circle and a circle surrounding it.

For each colour channel, four magnification values corresponding to the four edges of a scanned image shall be calculated in terms of the ratio of a distance measured between two fiducial marks along an edge, to the ideal distance of 277 mm or 190 mm depending on the placement of the test chart on the scanner platen.

The average values in two edges for each scan direction, minimum and maximum values among values with four edges shall be specified to verify whether a scanner conforms to the requirements of the goal values described in 5.2.7.

5.2.6 Local magnification deviation of scanner

The local magnification deviation for each primary colour channel of a scanner, i.e. scanner RGB, shall be evaluated using the cross-marks arranged as a matrix of 26 × 18 in the test chart.

A centre position of each cross-mark of a channel shall be specified in the centre of gravity of the signals in each channel for a cropped area including a cross-mark.

For each cross-mark in a primary colour channel, the distances between the centre positions of two cross-marks next to each other shall be measured both for the fast and slow scan directions. A local magnification deviation in millimetres for each direction shall be calculated as the standard deviation for the differences of the measured distances from the ideal distance of 10 mm in the conformance test chart. The local magnification deviation in percent shall be specified in terms of the ratio of the standard deviation in millimetres to the ideal distance 10 mm.

5.2.7 Goal values

5.2.7.1 General

A scanning system conforming to the goal values below shall be used in the measurements described in Clause 6. In case that a scanning system does not satisfy any goal values in 5.2.7.2 and 5.2.7.3, relative comparisons can only be made within the test data obtained by using the same scanning system and it is required to clearly state in the report that the test results can only be comparable within the report and not be comparable with others due to inconsistency with the scanner conformance requirements in this document.

5.2.7.2 Magnification accuracy

The magnification accuracy for all four edges of each colour channel shall be as following:

— (100 – 0,2) % < each difference in magnification < (100 + 0,2) %; and

— (100 – 0,1) % < average difference in magnification < (100 + 0,1) %.

5.2.7.3 Local magnification deviation

The local magnification deviations for each direction in each primary colour channel shall be as following:

— local magnification deviation <0,1 %.

5.2.8 Compensation for magnification accuracy and local magnification deviation

When a scanning system does not satisfy the goal values in 5.2.7 for the fast scan direction, the procedures described in Annex C shall be carried out to compensate the measured results with 6.6.3.2 and 6.6.3.3.

Compensations shall only be effective for the deviations of measured coordinates from ideal ones for the fast scan direction, which are mainly caused by aberrations of the optical unit to focus an image placed on the scanner platen on the sensor plane, depend on the coordinates at the scanner platen for the fast scan direction. While compensations shall not be made for the deviations in the slow scan direction, which are mainly caused by unstable mechanical movements of a sensor unit, are independent of scanner coordinates for the slow scan direction.

To make the compensations correctly, especially for local magnification measurements, users shall place their test images in the measurements as close as possible to the position at the scanning plane where the conformance test chart has been placed so that compensations may be applied at the closest coordinates where compensation parameters, i.e. the magnification correction factor, the correlation function for local magnification deviation, have been determined in the conformance test.

Measurements along the fast scan direction can be done without compensation if goal values for this direction are met or with compensations for this direction if they are not met. If a scanner does not meet the goal value requirements for slow scan direction, measurements along the slow scan direction cannot be done because compensations are not allowed. Consequently, for alternative procedures for the measurements along the slow scan direction at conformance test, users shall carry out measurements by placing their test images arranging 90° rotated from the original arrangement in their conformance test.

To do alternative procedure correctly, users shall place their test images in the measurements to correct their coordinates in the test images at scanning plane with the compensation parameter defined by the original coordinates in their conformance test.

Examples of local magnification measurement and result of magnification compensation on flat bet scanning systems are described in Annex D.

5.3 Reporting for scanner conformance

The following items shall be reported with regard to scanner conformance:

— date, place, temperature and humidity when the scanning carried out,

— scanner settings,

— orientation of the test chart on the platen,

— all the test results for the goal values in 5.2.7,

— conformance of the scanner to the goal values in 5.2.7, and

— necessity of compensations in 5.2.8 when any requirements in 5.2.7 not conformed.

6 Registration and magnification measurements

6.1 General

As mentioned in the Introduction, characteristics for registration and magnification of multi-colour prints comprising more than four primary colours of cyan, magenta, yellow and black shall not be measured by the measurement methods described in Clause 6.

6.2 Test chart for registration and magnification for each primary colour

The outline of the digital test chart to evaluate the registration and magnification for each primary colour of a printer is the same as that shown in Figure 1. While, four digital test charts each comprising only single primary colour, i.e. cyan, magenta, yellow or black, are prepared. The size of those test charts is A4.

Each component comprising the test charts shall be "vector graphics" and line width of 0,1 mm. The colour codes of the digital test charts are encoded in standard sRGB, as defined in IEC 61966-2-1, which is commonly used in office documents. The colour codes in sRGB for cyan, magenta, yellow and black lines are (0,255,255), (255,0,255), (255,255,0), and (0,0,0), respectively.

Sample test charts in PDF complying with the requirements in this document can be obtained by accessing https://standards.iso.org/iso-iec/22592/-2/ed-1/en/.

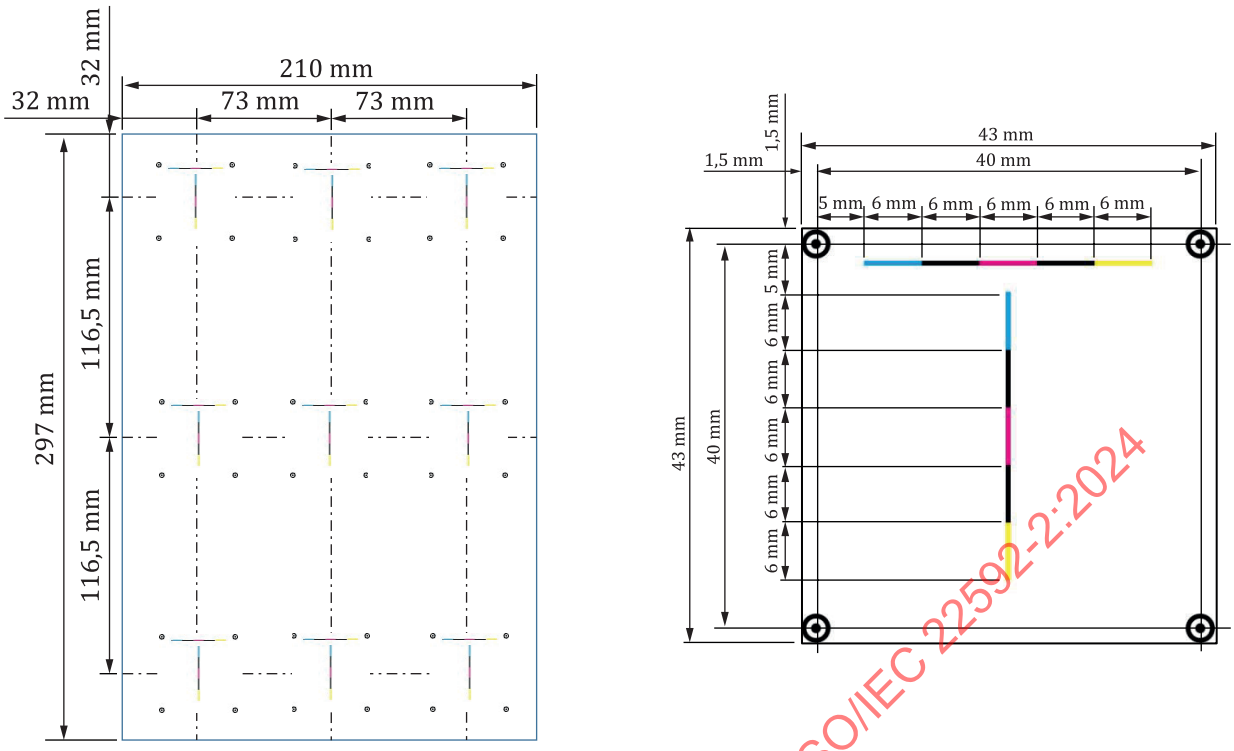
6.3 Test chart for colour-to-colour variation in registration

The outline of the test chart to evaluate the colour-to-colour variations in registration is described in Figure 2. This layout has an advantage to mitigate the effect of inconsistent colour-to-colour registrations in scanner, the variations in colour-to-colour registration for the primary colour image of a printing system, i.e. cyan, magenta or yellow, are specified in terms of the positional deviation of a primary colour line from the black line next to.

The size of the chart is A4. The colour codes of the digital test chart are encoded in standard sRGB, as defined in IEC 61966-2-1, which is commonly used in office documents.

Each line component comprising the test chart shall be "vector graphics" of 0,1 mm in line width. The colour codes in sRGB for cyan, magenta, yellow and black lines are (0,255,255), (255,0,255), (255,255,0), and (0,0,0), respectively.

One of the test charts in PDF complying with the requirements in this document can be obtained by accessing https://standards.iso.org/iso-iec/22592/-2/ed-1/en/.



a) Layout of test chart

b) Colour-to-colour variation measurement pattern

Figure 2 — Test chart for colour-to-colour variation in registration

NOTE Test charts for a more detailed analysis of the colour-to-colour registration variations within a page are shown in Annex B.

6.4 Registration measurement for each primary colour

6.4.1 Print preparations

A print set comprising ten sheets of a duplex print shall be printed continuously under the printing conditions specified in Clause 4. The test chart described in 6.2 shall be used for the measurements of registration in each primary colour of the sheets.

6.4.2 Scanning procedures

A scanner conforming with 5.2 shall be used.

A test print prepared in accordance with 6.4.1 shall be placed on the platen of the scanner in which the printed image subjected to the measurement shall directly contact with the platen. The orientation of the print shall be the same as the orientation of the test chart in the scanner conformance measurement. The two edges of the print shall be set as accurately parallel as possible to the two edges of the platen with narrow margins. Additionally, a sheet of black substrate whose size is sufficiently larger than that of the print shall be placed on the backside of the print without margins at the two edges of the platen. Differences in the margins at the edges of platen between the print and black substrate are utilized to detect the boundary

of the test print in the scanning area. It is recommended to place additional sheets of substrates to have a sufficient contact between the platen and the printed image.

NOTE The positional inaccuracy in the test print placement on the platen causes a small error in defining the position of the substrate corners. However, such inaccuracy does not affect the test results substantially if the difference in the positions between the two substrate corners comprising a boundary from the closest scanning edge is less than a few millimetres. The compensation coefficient to the position is estimated no larger than 4-minex as the inclination of the substrate edge to the scanning edge is the order of one-hundredth radian.

The scanning shall be carried out under the same scanner settings and an equivalent environment condition as in the scanner conformance test in 5.2.

6.4.3 Calculation of side-to-side registration variation

The side-to-side registration variation for each primary colour except black shall be evaluated using the four fiducial marks located at the four corners in the complement colour channel to the primary of the scanned image. In the case of black, those in green channel shall be used for the evaluation.

At least the first sheet and the tenth sheet shall be evaluated, and the other sheets should also be evaluated.

The centre position of each fiducial mark shall be specified in term of the gravity of the corresponding scanned data for the fiducial mark, comprising the centre circle and the circle surrounding it.

The differences in the relative scanned positions of the four fiducial marks to the closest substrate corners between front and back sides shall be calculated. The average and maximum values of the differences for each direction of the fast scan and slow scan between front and back sides, among the four fiducial marks shall be specified for each primary colour, as described in Formulae (1) and (2):

$$R_{\text{ave\_side-to-side}}[l,s]=\left[\frac{1}{4}\sum_{n=1}^{4}|A_n-a_n|,\frac{1}{4}\sum_{n=1}^{4}|B_n-b_n|\right] \quad (1)$$

$$R_{\text{max\_side-to-side}}[l,s]=[\text{Max}|A_n-a_n|,\text{Max}|B_n-b_n|] \quad (2)$$

where

A_n and B_n are the coordinates of the centre of the fiducial mark on the front side;

a_n and b_n are the coordinates of the fiducial mark on the back side.

Figure 3 illustrates the indexes for the Formulae (1) and (2).

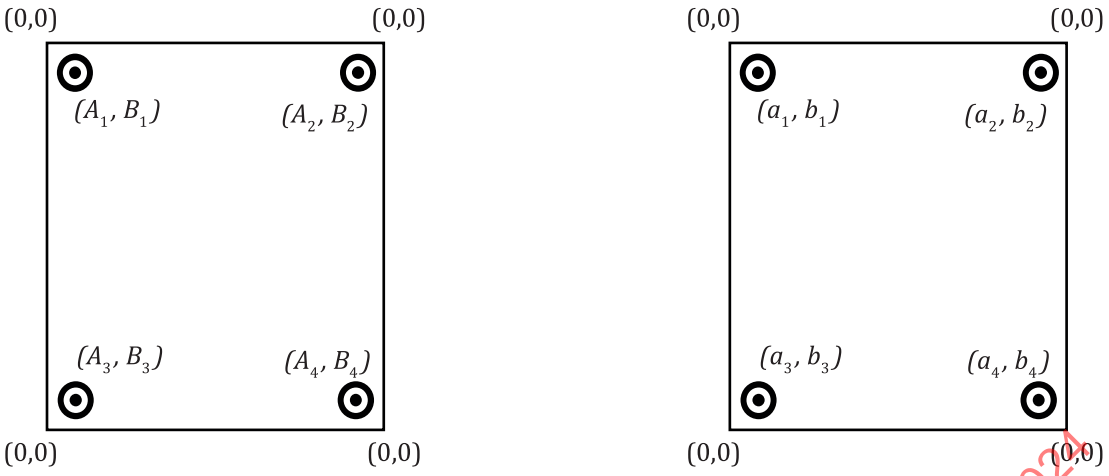
Figure 4 illustrates how to specify the corners of the substrate.

The positions of the substrate corners in scanning data shall be specified as the following manner:

— define the boundary of the substrate area in the scanning data by the average value of maximum and minimum values in the scanned data,

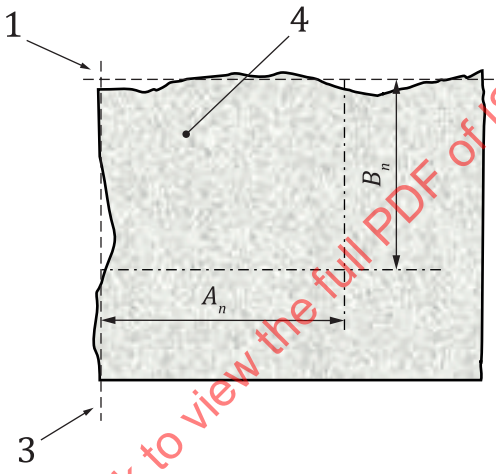
— calculate each of the two edges in the substrate to form the corner to be specified as a regression line of the corresponding substrate boundary, (set the regression region wider than the position of the fiducial mark from the substrate corner in the test chart data),

— calculate the position of the substrate corner as the point of intersection between the two edges.



a) Front side **b) Back side**

Figure 3 — Schematic of side-to-side variation in registration



Key

1 substrate corner
2 regression line of substrate edge
3 regression line of substrate edge
4 substrate (paper)

Figure 4 — Positions of the substrate corners

6.4.4 Calculation of sheet-to-sheet registration variation

The sheet-to-sheet registration variation for each primary colour except Black shall be evaluated using the four fiducial marks located at the four corners in the complement colour channel to the primary of the scanned image. In the case of black, those in green channel shall be used for the evaluation.

The centre position of each cross-mark shall be specified in term of the gravity of the corresponding scanned data for the cross-mark.

The differences in the scanned positions of the four fiducial marks to the substrate corners between the first sheet and the tenth sheet of the same print side shall be evaluated for the two directions of the fast scan

and slow scan. The average difference and standard deviation of the differences for each direction shall be specified for each primary colour in a scanned image, as described in Formulae (3) and (4):

$$R_{ave\_sheet-to-sheet}[x,y]=\left[\frac{1}{4}\sum_{n=1}^{4}|A_n-a_n|,\frac{1}{4}\sum_{n=1}^{4}|B_n-b_n|\right] \quad (3)$$

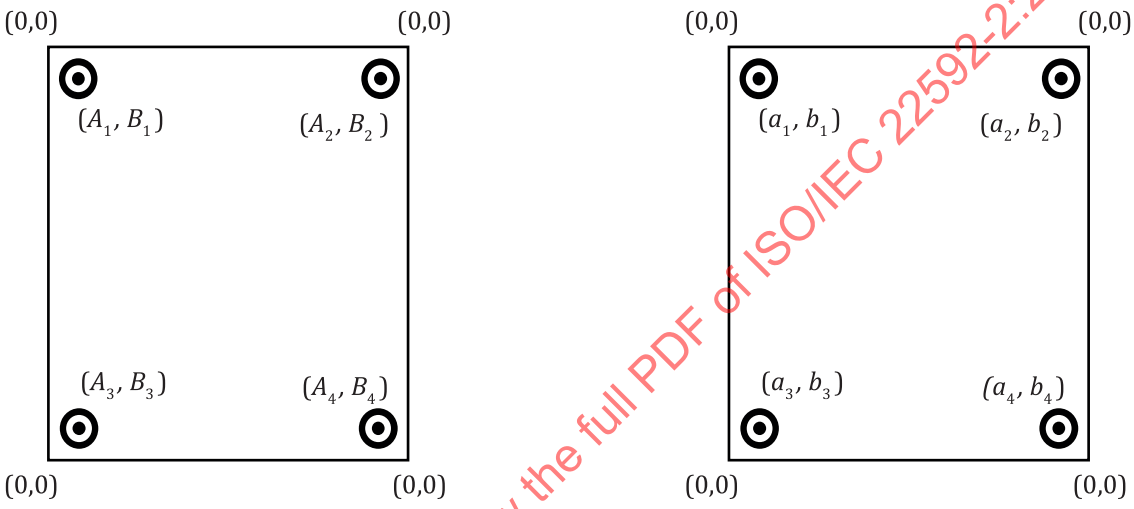
$$R_{max\_sheet-to-sheet}[x,y]=[\mathrm{Max}|A_n-a_n|,\mathrm{Max}|B_n-b_n|] \quad (4)$$

where

A_n and B_n are the coordinates of the centre of the fiducial mark on the 1st sheet;

a_n and b_n are the coordinates of the centre of the fiducial mark on 10th sheet.

Figure 5 illustrates the indexes for the Formulae (3) and (4).



a) Front or back side of the 1st sheet **b) Same side of the 10th sheet**

Figure 5 — Schematic of sheet-to-sheet variation in registration

The positions of the substrate corners in scanning data shall be specified as the same manner described in 6.4.3.

The differences in scanned positions between the pages other than the first and tenth sheets may optionally be evaluated.

6.5 Colour-to-colour registration variation measurement

6.5.1 Print preparations

A print set comprising ten sheets of a duplex print shall be printed continuously under the printing conditions specified in Clause 4. The test chart described in 6.3 shall be used for the measurements of colour-to-colour registration variation of the sheets. Since the colour registration variations are measured in terms of the difference in position of a primary colour line to its reference black line, the reference black line shall be printed mainly with a black colourant.

6.5.2 Scanning procedures

A scanning system conforming to 5.2 shall be used.

A print prepared in accordance with 6.5.1 shall be placed on the platen of the scanner with smaller margins as possible between the edges of the platen and the corresponding edges of the print. The orientation of the print is the same as the orientation of the test chart in scanner conformance measurement, in which the printed image subjected to the measurement shall directly contact with the platen. It is recommended to place additional sheets of substrates to have a sufficient contact between the platen and the printed image.

The scanning shall be carried out under the same conditions as in the scanner conformance test in 5.2.

6.5.3 Skew compensation

In colour-to-colour registration variation measurements, skew of the test chart on the platen of a scanning system makes errors in measured results. These errors can be compensated by the skew correction procedure which compensates the measured values based on the skew angles θ_1 and θ_2, clockwise rotation angles each from the fast scan direction and slow scan direction, calculated from the gravity centre coordinates of the fiducial marks located at the upper left (x_1, y_1), upper right (x_2, y_2), and lower left (x_3, y_3) of a scanned image as described in Figure 6. The angles of θ_1 and θ_2 are given by Formulae (5) and (6), respectively.

$$\theta_1 = \tan^{-1}\{(y_2 - y_1)/(x_2 - x_1)\} \tag{5}$$

$$\theta_2 = \tan^{-1}\{(x_1 - x_3)/(y_3 - y_1)\} \tag{6}$$

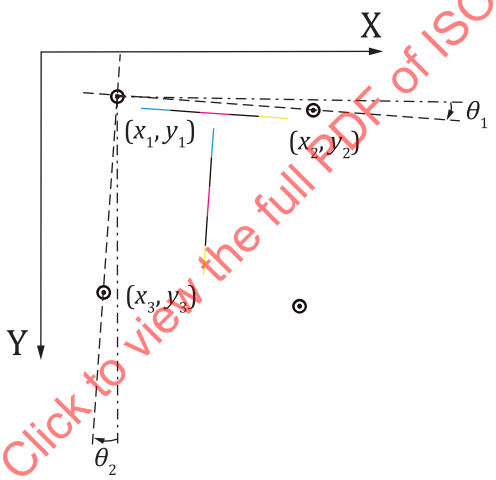


Figure 6 — Illustration for skew angles defined by coordinates of fiducial marks

Figure 7 illustrates an error in a measured registration value of $(y_a - y_b)$ for the y-direction caused by the skew angle of θ_1. The compensated registration for y-direction, y_{comp} is given by Formula (7):

$$y_{comp} = (y_a - y_b)\cdot\cos\ \theta_1 - (x_a - x_b)\cdot\sin\ \theta_1 \tag{7}$$

As with y_{comp}, the compensated registration for x-direction, x_{comp} illustrated in Figure 8 is given by Formula (8):

$$x_{comp} = (x_c - x_d)\cdot\cos\ \theta_2 + (y_c - y_d)\cdot\sin\ \theta_2 \tag{8}$$

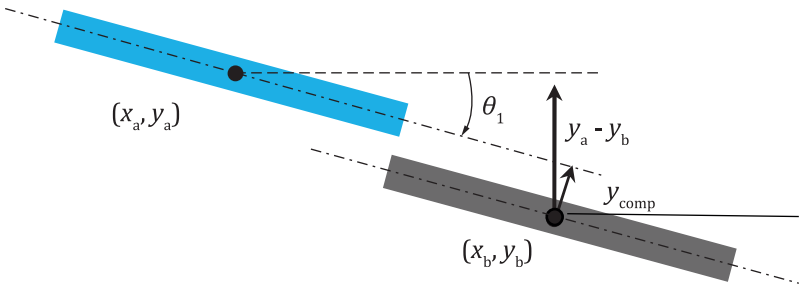


Figure 7 — Illustration for skew compensation for y-direction

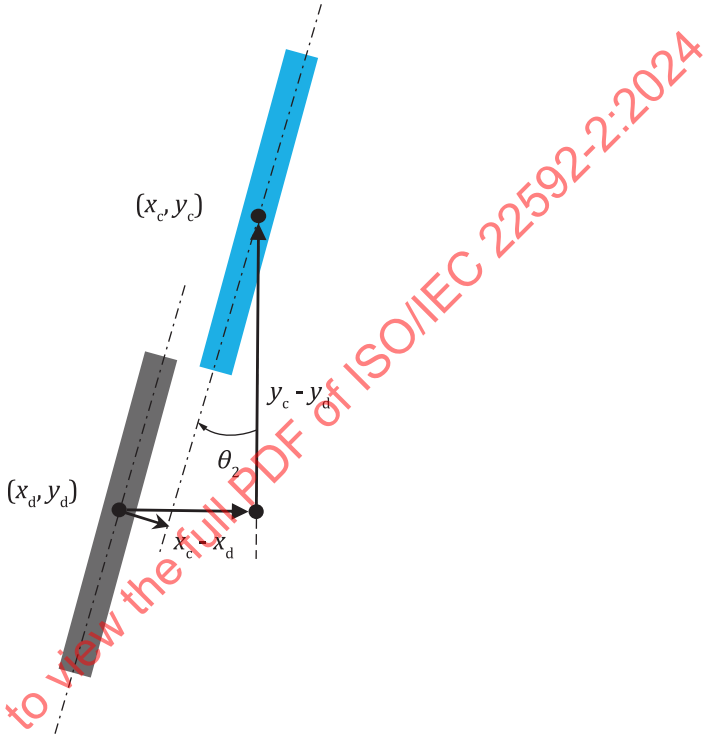


Figure 8 — Illustration for skew compensation for x-direction

6.5.4 Calculation of colour-to-colour registration variations within printed image

The colour-to-colour registration differences for two directions of the fast scan and slow scan between two primary colours among cyan, magenta, yellow and black, i.e. C-M, M-Y, Y-C, K-C, K-M, K-Y, shall be specified as the difference in relative positions for the two colour lines to each Black line next to. In case a position difference of a primary colour of either C, M or Y, to K, i.e. K-C, K-M or K-Y, is evaluated, the complementary colour channel for the primary colour, i.e. R, G or B channel, respectively, shall be used to specify the difference. A position difference between each combination of two primary colours, i.e. C-M, M-Y, Y-C, shall be calculated by subtracting the relative difference of one primary colour to K from that of the other primary colour to K.

The average and standard deviations in colour-to-colour registration differences among the 9 locations shall be specified for the two directions of all three combinations of the three primary colours.

The relative position of each primary colour line in the scanned data shall be specified in terms of the difference in the position for the line width direction of each line to that of Black line next to. The procedures are as following:

— set an ROI area for each line element in addition to black line elements to capture more than 80 % for the length direction and whole line for the width direction in a scanning image,

— calculate the centre position of each line element in addition to black line elements in terms of the gravity of the corresponding scanned data in the ROI area, and

— calculate the relative position for each colour line as the difference in the coordinate of the centre position for the line width direction between each colour line and Black line next to.

6.5.5 Calculation of side-to-side variations in colour-to-colour registration

The side-to-side variation in the colour-to-colour registration shall be calculated in terms of the differences in the average colour-to-colour registration between front and back sides of the same sheet for two directions of the fast scan and slow scan of all the three combinations among the three primary colours. Each colour-to-colour registration shall be calculated as described in 6.5.4.

6.5.6 Calculation of sheet-to-sheet variations in colour-to-colour registration

The sheet-to-sheet variation in the colour-to-colour registration shall be calculated in terms of the differences in the average colour-to-colour registration between front and back sides of the same sheet for two directions of the fast scan and slow scan of all the three combinations among the three primary colours. Each colour-to-colour registration shall be calculated as described in 6.5.4.

The variations between the pages other than the first and tenth sheets may optionally be evaluated.

6.6 Magnification measurement for each primary colour

6.6.1 Print preparations

A print set comprising ten sheets of a duplex print shall be printed continuously under the printing conditions specified in Clause 4. The test chart described in 6.2 shall be used for the measurements of magnification in each primary colour of the sheets.

6.6.2 Scanning procedures

A scanning system conforming to 5.2 shall be used. In case a scanner does not satisfy the goal vales in 5.2.7 in the conformance test, the compensation procedure in 5.2.8 may be applicable, and it is required to report that the test results are compensated using its scanner conformance test results.

A print prepared in accordance with 6.6.1 shall be placed on the platen of the scanner so that the orientation of the print is the same as the orientation of the test chart in scanner conformance measurement, in which the printed image subjected to the measurement shall directly contact with the platen. It is recommended to place additional sheets of substrates to have a sufficient contact between the platen and the printed image.

The scanning shall be carried out under the same conditions as in the scanner conformance test in 5.2.

6.6.3 Calculation of magnification variations within printed image

6.6.3.1 General

The magnifications for each primary colour of a printed image except Black shall be evaluated using scanning data of the complementary colour channel for the primary of the fiducial marks located at the corners of the image and the cross-marks in a printed image. In the case of the primary colour of black, the scanned data of the green channel shall be used for the evaluation.

6.6.3.2 Average magnifications within printed image

The centre position of each fiducial mark shall be specified in term of the gravity of the corresponding scanned data for the fiducial mark, comprising the centre circle and the circle surrounding it.

The ratio of the scanned distance between the fiducial marks next to each for the upper fast scan, lower fast scan, left slow scan and right slow scan directions, to the original distances of the edges in the test chart in

Figure 1 of 5.2.2, i.e. 277 mm for long edge and 190 mm for short edge, shall be calculated as magnifications. Thus, the four values in magnification can be specified for each primary colour image of cyan, magenta, yellow and black.

6.6.3.3 Calculation of local magnification variations within printed image

The registration for each primary colour of a printed image except Black shall be evaluated using the cross-marks arranged in the matrix of 26 × 18 in the test chart in the complementary colour channel to the primary in the scanning data. In the case of the primary colour of Black, those in the green channel shall be used for the evaluation.

The centre position of each cross-mark shall be specified in term of the gravity centre of the corresponding scanned data for the cross-mark.

For each cross-mark, the differences in the ratios of scanned distances between the cross-marks next to each other for the two directions of the fast scan and slow scan, to the ideal distance of 10 mm shall be calculated. The average difference and standard deviation of the differences in the ratios for each direction shall be specified for each primary colour.

At least the first sheet and the tenth sheet shall be evaluated, and the other sheets should also be evaluated.

6.6.4 Calculation of side-to-side magnification variation

The side-to-side magnification variation for each primary colour image of a sheet shall be evaluated using the four average magnification values obtained in the procedure described in 6.6.3.2.

The differences in the magnification values between front and back sides shall be evaluated for the four edges in each primary colour.

6.6.5 Calculation of sheet-to-sheet magnification variation

The sheet-to-sheet magnification variation for each primary colour image of a print side shall be evaluated using the four average magnification values for each image obtained in the procedure described in 6.6.3.2.

The differences in the magnification values between the first and10th sheets of the same print side shall be evaluated for the four edges in each primary colour.

The differences in the magnification between the sheets other than the first and tenth sheets may optionally be evaluated.

6.7 Reporting for registration and magnification measurements

The following items shall be reported in addition to the test results described in the next paragraph:

— date, place, temperature and humidity when the test print formed,

— date, place, temperature and humidity when the scanning carried out,

— scanner settings,

— orientation of the test prints on the platen in the scanning operations, and

— feed direction of the test sheets in the printing operations either the fast scan or slow scan.

The test results for the following indexes:

— the average and standard deviation in the registration variations within an image for the two directions in each primary colour,

— the average and maximum differences in the side-to-side registration variations for the two directions in each primary colour,

— the average and maximum differences in the sheet-to-sheet registration variations for the two directions in each primary colour,

— the average and maximum differences in the colour-to-colour registration variations within an image for the two directions of all three combinations of the three primary colours,

— the average side-to-side variations in colour-to-colour registration between front and back sides for the three primary colour for each scanning direction,

— the average sheet-to-sheet variations in colour-to-colour registration between the first and tenth sheets for the three primary colour for each scanning direction,

— the magnifications for the four edges for each primary colour image,

— the average side-to-side magnification variations in the colour-to-colour variations for all the two combinations among four primary colours,

— the average sheet-to-sheet magnification variations in the colour-to-colour variations for all the two combinations among four primary colours, and

— compensations for scanner conformance in 5.2.8 if applied.

7 Reporting

7.1 General requirements for reporting

The measurement methods described in this document are used to access geometric 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.

7.2 Reporting items

In addition to a series of the test results in each reporting clause of the corresponding test methods, the total test report shall include the following information:

— date and place test samples printed,

— product name and suppliers of the printer,

— printer settings,

— product name and suppliers of the substrate,

— product name and suppliers of toner or ink materials, if the other suppliers than the printer manufacturer provide them,

— product name and suppliers of the printing materials, if the other suppliers than the printer manufacturer provide them,

— product name, supplier and driver settings of the scanner for the registration and magnification measurements,

— compensations for scanner conformance in 5.2.8 if applied,

— reference to this document, i.e. ISO/IEC 22592-2, and

— any deviation from this document or any circumstances or influence that may have affected the results.

Annex A
(informative)

Flatness of prints

A.1 General

The flatness of a print can be changed by a drying process in ink images and fixing process of toner images.

In addition to such processes, the flatness of a print upon long term storage or keeping is most likely affected by the temperature and humidity that the print is stored at. High humidity is believed to be the primary stressor, and temperature a contributory stressor; however, low humidity conditions will also cause deformations. Changes from a high humidity or high temperature condition to a low humidity or low temperature condition may further change the print flatness. Poor flatness of the print often affects the visual impression of the print flatness, such as curl, cockle and waviness.

A.2 Test chart

The digital test chart described in ISO 22592-1:2024, 4.2 should be used. A PDF file of the test chart can be obtained by accessing https://standards.iso.org/iso-iec/22592/-1/ed-1/en/.

A.3 Procedure

Ten sheets of a duplex test print should be prepared in accordance with Clause 4.

The prints are recommended to be conditioned at (23 ± 3) °C and (50 ± 3) % RH for 24 h prior to testing. A sheet of print should then be stored horizontally on a flat surface in a chamber whose environment is controlled at (25 ± 3) °C and (85 ± 3) %RH. Measurements should be taken at time zero (to assess the effect of drying or fixing processes), one week, and four weeks. Additional measurements early in the test cycle are recommended.

The print should be placed on a flat surface immediately when it is removed from the chamber and conditioned at (23 ± 3) °C and (50 ± 3) %RH for 1 h prior to the evaluation.

A.4 Evaluation

The flatness of the print should be measured by the maximum deviation (mm) from the flat surface. The print should also be visually evaluated if the attributes of curl, cockle or waviness are obvious when it compared with an unprinted substrate conditioned under the same environment at (23 ± 3) °C and (50 ± 3) %RH for 1 h prior to the evaluation. It is recommended to rate the visual evaluation results by scores, such as no difference from the unprinted substrate, a little difference from the unprinted substrate, moderate difference from the unprinted substrate, significant difference from the unprinted substrate.

A.5 Reporting

The flatness in terms of the maximum deviations for the prints at time zero and after storage should be reported. Optionally, visually evaluated results with respect to the attributes of curl, cockle or waviness should also be reported.

Annex B
(informative)

Test charts for colour-to-colour variation in registration

B.1 General

The test chart used to measure colour-to-colour registration variations for a page is defined in 6.3. This annex provides a test chart for a more detailed analysis of the variations within a page. Examples of this test chart can be obtained by accessing https://standards.iso.org/iso-iec/22592/-2/ed-1/en/.

The test chart in this annex is composed of similar colour line elements for two directions of fast scan and slow scan, each comprising three primary colour lines of cyan, magenta, yellow, and two black lines arranged between primary colours, designed to measure relative registration of each primary colour to black.

B.2 Test chart A

The test chart A shown Figure B.1 is composed of the 11 × 15 elements, each comprising the 5 lines both for fast scan and slow scan directions. The size of each element in this chart is smaller than that specified in 6.3 to increase the number of measurement locations in a page from 9 to 165.

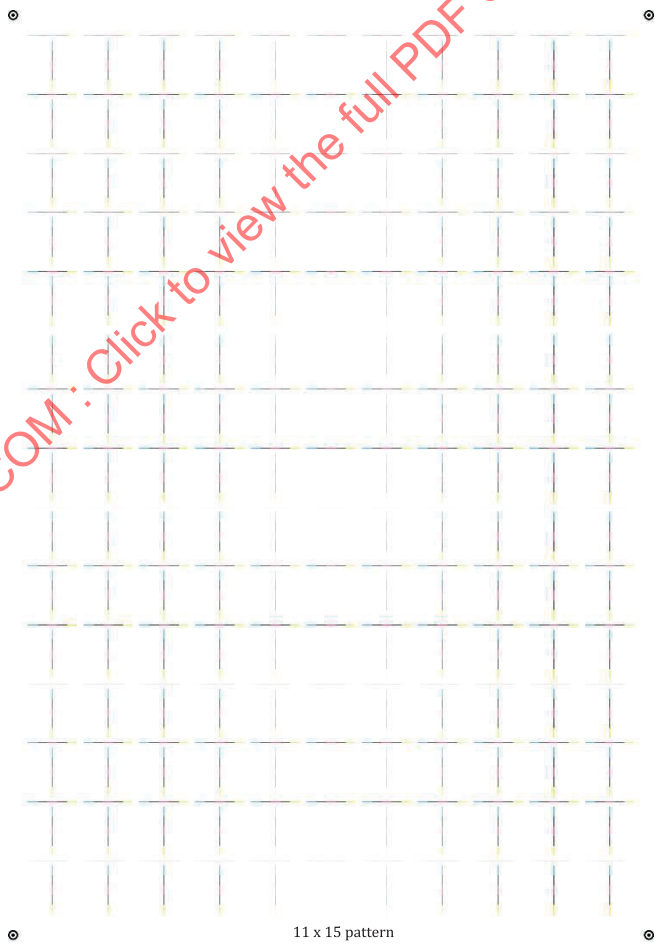


Figure B.1 — Test chart type A

Annex C
(normative)

Compensation procedure for scanner conformance

C.1 General

When a scanning system cannot satisfy scanner conformance requirements specified by the goal values in 5.2.7, users can compensate measured test results with this system using the procedures described C.2 and C.3. Measured test results regarding the fast scan direction can only be compensated, so users shall place print images rotated by 90° at the scanning plane when scanner conformance requirements regarding the slow scan direction inconsistent.

C.2 Average magnification error correction

When a scanner does not satisfy the goal values for the magnification accuracy in 5.2.7 for the fast scan direction, a compensation procedure of a magnification error based on the magnification value obtained in its conformance test can be adopted for magnification values measured with 6.6.3.2.

In each compensation for a channel, a compensated magnification value reported for 6.6.3.2 shall be calculated as M_{mean}, the ratio of a measured magnification value to the mean value of the magnifications at two edges along the fast scan direction measured in its conformance test with 5.2.5.

In case average magnification error correction used, users shall report that test results for 6.6.3.2 are compensated based on the average magnification error correction.

C.3 Correction of local magnification deviation

When a scanner does not satisfy the goal values for the local magnification deviation in 5.2.7 for the fast scan direction, the results measured with 6.6.3.3 can be interpolated using a correction formula obtained based on its conformance test results. Compensation procedures are described below in detail. Each symbol in the descriptions is illustrated in Figure C.1.

a) Calculate a gravity centre coordinates, $G_{ij}(x_{ij}, y_{ij})$ of all the cross-mark in the scanned image at the conformance test, where G_{ij} is the gravity centre coordinate for i-th row for the fast scan direction and j-th column for the slow scan direction, x_{ij} and y_{ij} are the coordinate values of G_{ij} at the scanning plane for the fast scan direction and the slow scan direction, respectively(i = 1 to m, and j = 1 to n).

   NOTE 1 For an A3 scanner, i = 1 to 26, j = 1 to 18, and for an A3 scanner, i = 1 to 18, j = 1 to 27 defined by the arrangement of the conformance test chart comprising the cross-mark array of 26 × 18.

b) Calculate x_i values for each i-th row by averaging x_{ij} over all columns of i-th row, assuming that the scanned image is not tilted at the scanning plane significantly,

$$x_i = \frac{1}{n}\sum_{j=1}^{n} x_{ij} \qquad \text{(C.1)}$$

c) Calculate x'_i values from x_i using M_{mean}, the ratio of a measured magnification value to the mean value in C.2,

$$x'_i = x_i \,/\, M_{mean} \qquad \text{(C.2)}$$

d) Calculate P'_i, the cross-mark pitch between i-th row and i+1-th row,

$$P_i' = x_{i+1}' - x_i' \quad \text{(C.3)}$$

e) Calculate C'_i, the centre position between i-th and i+1-th cross marks,

$$C_i' = (x_{i+1}' + x_i')/2 \quad \text{(C.4)}$$

f) Calculate M'_i, the local magnification value by dividing P'_i by P_{ideal} the ideal pitch of 10 mm for the position at C_i,

$$M_i' = P_i' / P_{\text{ideal}} \quad \text{(C.5)}$$

g) Define a correlation formula of M'_i, as a function of C'_i based on the 4th-order polynomial approximation,

$$M_i' = f(C_i') \quad \text{(C.6)}$$

NOTE 2 An example of this correlation formula is shown in Figure C.2.

h) Calculate M'_i, compensated local magnification values for the fast scan direction at C'_i by interpolating M_i, measured local magnification values for the fast scan direction at C_i using the correction formula $f(C_i')$.

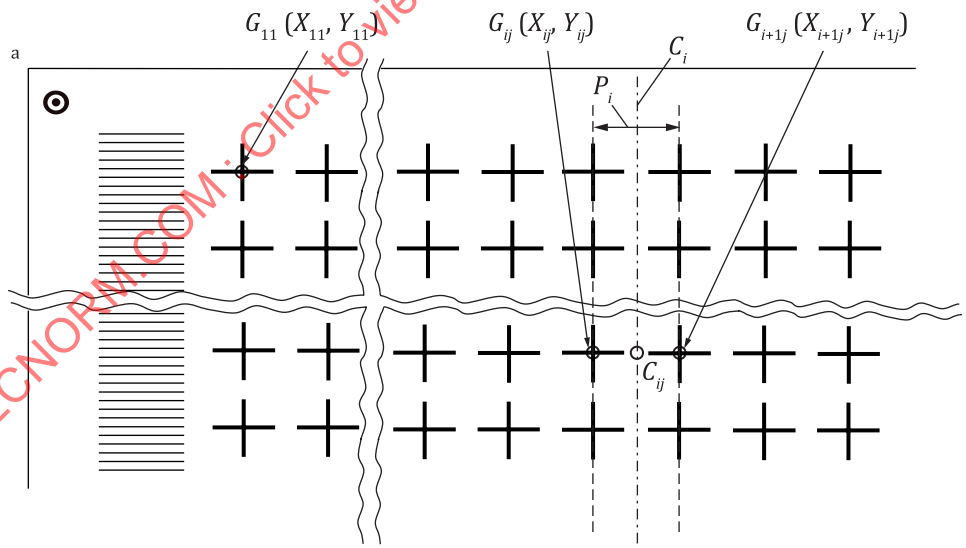
i) Calculate M_{average}', the average local magnification with magnification correction, by averaging M'_i,

$$M_{\text{average}}' = \frac{1}{m}\sum_{i=1}^{m} M_i' \quad \text{(C.7)}$$

j) Calculate $\Delta M_{\text{average}}'$, deviation of $\Delta M_{\text{average}}'$ from the ideal magnification of 100(%).

k) Calculate M_{stdev}', the standard deviation of M'_i over a scanned image for the fast scan direction,

$$M_{\text{stdev}}' = \text{Stdev}(M_i') \quad \text{(C.8)}$$



a Origin (0,0).

Figure C.1 — Illustrated parameters for local magnification compensated by average magnification

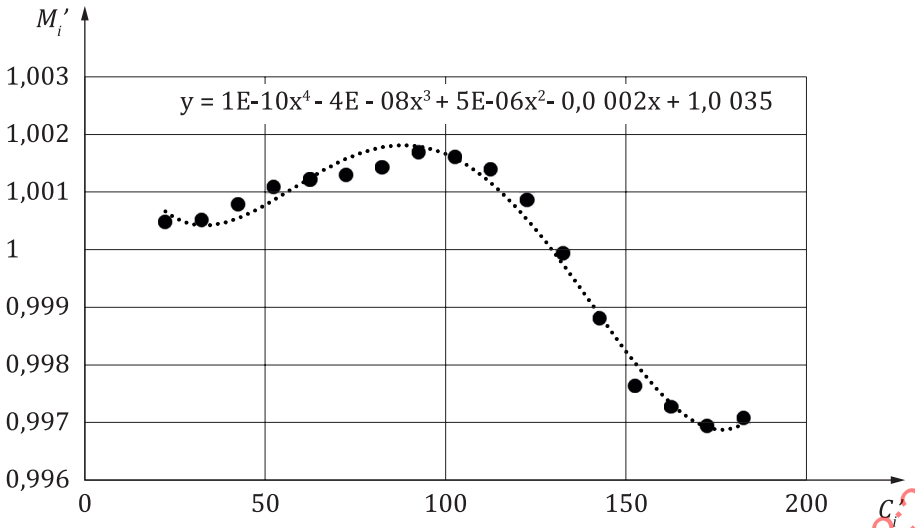


Figure C.2 — Example of correlation formula $f(c_i')$ for local magnification compensation

Annex D
(informative)

Examples of local magnification measurement on flat bet scanning systems

D.1 General

Examples of measurement results for the local magnifications of a few kinds of flat bet scanning systems are described below. Focal positions on a sensor plane of a commercial flat bet scanner fluctuate mainly due to aberrations of its optical system to focus a printed image on its platen on sensor plane for the fast scan direction, scanner motion errors for the slow scan direction, etc.

The fluctuations due to aberrations are stable for slow scan direction and show relatively moderate changes with the coordinates at the platen for the fast scan direction. While fluctuation with motion errors show high-frequency and stochastic patterns and are independent of the coordinates for the slow scan direction.

D.2 Measurement procedures

The three scanning system of scanner A, scanner B and scanner C were evaluated. The conformance test chart in Figure 1 in 5.2.2 was used to measure local magnifications. The test chart was placed on the platen of each scanning system as its short edge along the fast scan direction and long edge along the slow scan direction, in addition, arranging its corner as close as at upper the right corner of the platen.

The test chart was scanned as a colour image of 600 spi. The gravity centres of cross-marks arranged as a 26 ×18 matrix of the uniform interval of 10 mm for each direction were measured for each primary colour channel of a scanned image. The local magnification between a cross-mark and one next to was calculated based on the procedures in Clause C.3.

D.3 Measurements in fast scan direction

The dependences of the local magnifications of each primary colour for the three scanning systems on the coordinates for the fast scan direction at the scanning plane are shown in Figure D.1. The coordinates are specified as the distances from the left edge of each scanned images. The lines coloured in red, green and blue correspond to the data in R channel, G channel and B channel of a scanner, respectively. The yellow lines show the ideal local magnification of 100 %.

The difference in the curves among three primary colour channels were not obvious for all the three scanners. While the shapes of curves varied noticeably among the scanners. Scanner A showed curves of downward sloping from the centre to the right edge, but average values of local magnifications were about 100 %. The curves in scanner B shows slight downward sloping from the left edge to right edge and the average magnifications were much higher than 100 %. The magnification curves in scanner C were slightly concave but relatively with small variations, and the average magnification is about 0,1 % smaller than 100 %.