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Information technology — Office equipment — Measurement of image quality attributes for hardcopy output — Monochrome text and graphic images

Technologies de l'information — Équipement de bureau — Mesurage des attributs de qualité d'image — Texte monochrome et images graphiques

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

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

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

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

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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

This first edition of ISO/IEC 24790 cancels and replaces ISO/IEC TS 24790:2012 and ISO/IEC 13660:2001, which have been technically revised.

Introduction

This document is designed to help a quality control engineer evaluate the image quality of prints from office imaging systems.

In traditional imaging systems (such as ink-on-paper printing), an image is evaluated by comparison to an original or master version of that image. In many electronic imaging systems, however, the image is created digitally within the system. There is no hardcopy master and so there can be no evaluation by comparison in the ordinary way.

Often, those who operate electronic imaging systems ensure good image quality by controlling the imaging process. They use test targets and reference images to evaluate the performance of the system.

If it is not possible to control image quality by controlling the imaging process and if no test target or reference image is available, we can rely only on direct evaluation of properties of the image itself.

To perform intrinsic evaluations of image quality, consider the nature of an image that is an output. An image is some organization of information in space. We assume that these signals have some purpose or are making some attempt at communication. Good image quality means that the image is legible (the organization and information can be interpreted) and that it has a pleasing appearance.

Our goals in developing this document were to compile a list of image quality attributes that (taken together) correlate to human perception of print quality and to develop measurement methods for these attributes that can be automated and carried out on a simple system.

Legibility and appearance have several aspects:

— detail can be detected easily;

— image elements are well isolated from the background;

— the image has a minimum of gross defects;

— the imaging system has good geometric fidelity.

Not all these factors can be covered by evaluation of intrinsic, quantitative image quality attributes. Many of them have a large psychological or cultural component that is difficult to evaluate.

A print made with large optical reduction or one that is out of focus can still have excellent edge quality (and be totally lacking in gross defects, banding, noise, etc.) and yet be illegible. This could occur primarily because of the high process gamma (contrast) that is characteristic of many xerographic processes. Thus, the process can produce apparently sharp edges in spite of the loss in resolution. Without a resolution target of some kind, the extent of the resolution loss, and hence legibility, may not be known.

The purpose of this document is to present a set of objective, measurable attributes that give some correlation to the perceived quality of an image to a human observer at a standard viewing distance. This document allows a user of printed material to sort samples into several groups, from excellent to bad.

The attributes and methods for their assessment are based on several assumptions:

— the image represents an attempt at communication;

— there is uniformity within identifiable image elements;

— character images, symbols and graphic elements are regular (that is, they are intended to be identical when they have multiple, similar occurrences);

— samples with extreme gross defects have been screened out.

This document applies to monochrome images made up of text, graphics and other image objects with two tone levels of a single colour (typically black image on white paper) or halftones, images with more nominal gray levels. This document does not cover continuous tone images, colour images and so on.

Image quality measurement can be thought of as divided into diagnostic (high resolution) and visual scale (low resolution) procedures. Diagnostic measurements typically use precision test targets and instrumentation and are key to much engineering work. The present procedure, by contrast, is limited to phenomena visible to the naked eye and does not permit test patterns.

The working group has taken the approach of selecting simple and (in our judgment) effective metrics, rather than attempting to prove that our method of doing a given job will always be the most exact.

How will this document actually be implemented? A complete evaluation system has four components: an image capture device, evaluation software, application-specific quality standards and sampling plan. The end user may choose to develop all these parts himself or he may choose to purchase one or more components from a commercial supplier.

Any equipment capable of gathering data appropriate to these measurements is understood to have a complex instrument function. Rather than attempting to explore the relationship among these instrument functions, the working group has defined reference images and target values for them. If these target values are achieved by an instrument, calibration will be acceptably good.

This is not an attempt to break new ground in image science. It is an attempt to provide suppliers and customers for copies/prints with a practical and objective way to communicate about basic image quality parameters.

ISO/IEC 13660 was developed and standardized by the point of view described above. ISO/IEC 13660 is currently the only available systematic image quality attribute measurement standard. ISO/IEC 13660 has had a great influence on related industries and image quality measurement instruments based on ISO/IEC 13660 are already marketed. However, due to the limited development time, it was standardized with many issues unresolved and therefore, ISO/IEC 13660 has not been adopted as widely as expected. The main issues are listed as following:

a) the test chart and methods for measurement system conformance are only specified for some of character and line attributes. For large area graphic image quality attributes, neither test charts nor methods are specified. Eight items of image quality attribute for character and line image and six items of image quality attribute for large area graphic image are defined, and each measuring method is specified. Of the 14 image quality attributes, the conformance test method, the conformance test chart and the targeted value for measurement apparatus conformance are specified for only four of the character and line image quality attributes, leaving 10 of the image quality attributes with no conformance specifications;

b) physical measures (line width, large area voids) and psychophysical factors (darkness, graininess, etc.) are intermingled and are all defined as image quality attributes;

c) the goal values for measurement system conformance are available for only four character and line attributes, and the allowances are very large;

d) when one measures the character and line image quality attributes according to ISO/IEC 13660, the resulting values have large variation and they do not correspond well with subjective evaluations.

This document added the following content to ISO/IEC 13660 to resolve the issues which ISO/IEC 13660 had and to improve the measurement accuracy.

a) Banding which is a common image quality defect of the hard copy output in a printer or a copying machine is added as one of the image quality attributes of a large area graphic image.

b) Conformance test charts and the goal values for measurement system qualification are specified for three character and line image quality attributes and seven large area graphic image quality attributes.

c) The fundamental resolution of the scanner for measurement was increased from 600 spi to 1 200 spi to reduce the measurement variation.

d) Nearly all of the image quality attributes defined in ISO/IEC 13660 have been redefined in ISO/IEC 24790 to eliminate intermingling physical measures and psychophysical factors.

e) In order to improve the correspondence between image quality attributes and subjective evaluations, an image quality attribute measurement evaluation experiment was conducted on seven items (graininess, mottle, banding, line width, character darkness, blurriness and raggedness) of image quality attributes to select prediction algorithms for image quality attributes that have the highest correlation with subjective evaluation. The measurement evaluation experiment was conducted by five countries which includes Japan, U.S.A, China, South Korea and the Netherlands.

According to the measuring method of the image quality attributes chosen in the measurement evaluation experiment, the conformance chart was revised and a measurement tool which can measure automatically all the image quality attributes specified in this document was developed. An initial set of conformance chart goal values were defined using those tools, and ISO/IEC TS 24790 was published in 2012.

Experience with the use of the published Technical Specification over the following three years led to a second revision of the conformance chart, a revision of the conformance evaluation methods and a revision of the measurement tool. An international conformance chart measurement experiment was conducted to refine the conformance chart goal values and to establish realistic measurement tolerances for these goal values. This document is the result of this collective development and measurement experience.

Information technology — Office equipment — Measurement of image quality attributes for hardcopy output — Monochrome text and graphic images

1 Scope

This document specifies device-independent image quality attributes, measurement methods and analytical procedures to describe the quality of output images from hardcopy devices. This document is applicable to human-readable monochrome documents produced from printers and copiers.

The attributes, methods and procedures rely on measurable properties of printed text and graphic images. Special targets or reference images are not required, but image elements are useful for adequate measurements only if they meet some minimal requirements, e.g. on size or number present. This document is not applicable to images on media other than hardcopy (e.g. images on a visual display) or to images that are intended to be machine readable only (e.g. bar codes).

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 2470-1, *Paper, board and pulps — Measurement of diffuse blue reflectance factor — Part 1: Indoor daylight conditions (ISO brightness)*

ISO 14524, *Photography — Electronic still-picture cameras — Methods for measuring opto-electronic conversion functions (OECFs)*

ISO 21550, *Photography — Electronic scanners for photographic images — Dynamic range measurements*

ISO 16067-1, *Photography — Spatial resolution measurements of electronic scanners for photographic images — Part 1: Scanners for reflective media*

3 Terms and definitions

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

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

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

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

3.1
background area
region outside the edge of any *image element* (3.16)

3.2
background darkness
appearance of shade in *background area* (3.1) due to presence of unintended colourant particles that cannot be resolved as individual marks

3.3
background extraneous mark
colourant particle or agglomeration of colourant particles in the *background area* (3.1) that is visible at a viewing distance of 25 cm to 40 cm with the unaided eye

3.4
banding
appearance of one dimensional bands within an area that should be homogeneous

3.5
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)

3.6
boundary
contour by *reflectance threshold* (3.35)

3.7
character darkness
appearance of blackness of a line or character image

3.8
character surround area
region runs from the outer edge of the character image or other *image element* (3.16) out 500 micrometres

3.9
character surround area haze
colourant particles or agglomerations of colourant particles within a *character surround area* (3.8) that are visible, but not resolvable as distinct marks

3.10
character surround area extraneous mark
colourant particle or agglomeration of colourant particles within a *character surround area* (3.8) that is visible at a viewing distance of 25 cm to 40 cm with the unaided eye as a distinct mark

3.11
character void
appearance of homogeneity of darkness within the *boundary* (3.6) of a line segment, character image or other glyph image

3.12
edge threshold
level in the reflectance gradient profile of an edge that is at 40 % of the transition from the *minimum reflectance factor* (R_{min}) (3.33) to the *maximum reflectance factor* (R_{max}) (3.31) as: $R_{40} = R_{min} + 40\ \%\ (R_{max} - R_{min})$.

3.13
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.

3.14
graphic image
images except a character and a symbol

3.15
image area
region inside portion of *inner boundary* (3.17)

3.16
image element
single, evidently intentional, object not connected to other objects

3.17
inner boundary
contour of points of an *image element* (3.16) where edge gradient profiles cross a reflectance level that is at 10 % of the transition from the *minimum reflectance factor* (R_{min}) (3.33) to the *maximum reflectance factor* (R_{max}) (3.31) as: $R_{10} = R_{min} + 10\ \% \ (R_{max} - R_{min})$.

3.18
large area darkness
appearance of blackness of a large area graphic image element

3.19
large area
image area (3.15) of graphical element or background that has a minimum size of 12,7 mm in both dimensions

Note 1 to entry: Equivalent to 600 pixels when sampling resolution is 1 200 spi.

3.20
large area void
visible hole or gap within a solid *image area* (3.15) that is large enough to be individually distinguished at a viewing distance of 25 cm to 40 cm

3.21
line image
line at least 1 mm long

3.22
line image density
average *optical density* (3.27) within the *R_{25} boundary* (3.6)

Note 1 to entry: The average optical density should be converted from average reflectance factor.

3.23
line width
average stroke width, where the stroke width is measured from edge to edge along a line normal to the center line of the *image element* (3.16)

3.24
metric
measure of image quality attribute

3.25
monochrome image
image perceived as achromatic colour

3.26
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.

3.27
optical density
negative logarithm to the base 10 of the *reflectance factor* (3.30), measured using a 0/45-degree geometry, Illuminant A and ISO visual density calibration as specified in ISO 5-1, ISO 5-3 and ISO 5-4 with an instrument using no polarization filters

3.28
outer boundary
contour of points of an *image element* (3.16) where edge gradient profiles cross a reflectance level that is at 70 % of the transition from the *minimum reflectance factor* (R_{min}) (3.33) to the *maximum reflectance factor* (R_{max}) (3.31) as: $R_{70} = R_{min} + 70\ \% \ (R_{max} - R_{min})$.

3.29
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.

3.30
reflectance factor
ratio of the reflected flux as measured to the reflected flux under the same geometrical and spectral conditions for an ideal 100 % diffuse reflecting surface

3.31
maximum reflectance factor
$\boldsymbol{R_{max}}$
highest *reflectance factor* (3.30) measured by a slit aperture in the *background area* (3.1), typically of the substrate

3.32
region of interest
ROI
area (inside defined boundaries) that the user wants to analyse

Note 1 to entry: ROI for character and line image attribute includes *image element* (3.16) and *background area* (3.1).

Note 2 to entry: ROI for large area graphic image attribute is within *image area* (3.15).

Note 3 to entry: The difference between ROI for character and *line image* (3.21) and large area graphic image is shown in Annex D.

3.33
minimum reflectance factor
$\boldsymbol{R_{min}}$
lowest *reflectance factor* (3.30) measured by a slit aperture in the *image element* (3.16), typically of the image

3.34
spots per inch
spi
spots per 25,4 mm

3.35
reflectance threshold
level in the reflectance gradient profile of an edge that is at some specified percentage of the transition from the *minimum reflectance factor* (R_{min}) (3.33) to the *maximum reflectance factor* (R_{max}) (3.31) as: $R_p = R_{min} + p\ \% \ (R_{max} - R_{min})$.

4 Report of results and sampling scheme

4.1 Report of results

4.1.1 Test identification information

The report shall include the date of the measurements, the identity of the test operator, lot identifications, etc.

4.1.2 Instrument system

The report shall include a description of the instrument system used, noting any of Clause 5, attribute measurement specifications that are emulated or deviated from in any way.

4.1.3 Conformance

Report the results of the conformance tests, Instrument, specs, Instrument OECF, Instrument dynamic range, Large area attributes: (7) large area darkness, background darkness, graininess, mottle, background extraneous mark, large area void, banding, Character and line attributes: (7) line width, character darkness, blurriness, raggedness, character void, character suround area extraneous mark, character surround area haze (see Clause 6 and Annex B).

4.1.4 Sampling scheme

The report shall include a complete description of the sampling scheme (4.3) used to select the pages and images.

4.1.5 Results

For each attribute, the report shall include the number of samples per page and the mean, standard deviation and range of the results for each page and for the entire lot.

Table 1 — Sample report of an evaluation

ORIGINATOR	XYZ Printing Company
Test Description	Results of March 15, 2012 print set
Date of Report	April 2, 2012
Test Operator	RJC
INSTRUMENTATION	XYZ Optical Company, Model XXX
Type	1 200 dpi flatbed scanner
Measurement and analysis software	ISO 24790 ANALYZER by ABC Inc.
Instrument OECF compensation software	Auto OECF by ABC Inc.
Instrument dynamic range measurement software	Auto DR by ABC Inc.
CONFORMANCE TESTS	within the tolerance
Density Measurements	within the tolerance
Spatial Measurements	within the tolerance
Line Attributes Measurements	within the tolerance
Graininess & Mottle Measurements	
SAMPLING SCHEME	Random Sampling
LARGE AREA IMAGE QUALITY ATTRIBUTES	*# of samples/page Mean Std*
large area darkness	*# of samples/page Mean Std*
background darkness	
graininess	
mottle	
background extraneous mark	
large area void	
banding	
CHARACTER AND LINE IMAGE QUALITY ATTRIBUTES	
line width	
character darkness	
blurriness	
raggedness	
character void	
character surround area extraneous mark	
character surround area haze	

4.2 Sampling of pages

The pages chosen shall be taken from a homogeneous lot. They shall all (as far as can be determined) be on the same substrate, produced with the same process and be of the same age.

The number of pages to be sampled depends on the user's optimal balance between risk and cost and on the uniformity of the process that produced the lot.

Any sampling scheme selected shall allow for the screening of pages with defects beyond the scope of this document (such as physical damage to pages) and pages with defects which would be unacceptable to practically all observers. These pages should not be evaluated.

4.3 Sampling of images

4.3.1 General

Three sampling schemes and the information required to specify them in the report of results are given below. Use one of these three schemes. The report shall contain enough specific information that the sampling scheme can be duplicated exactly.

4.3.2 Discretionary sampling

In discretionary sampling, a human operator intervenes to select features for analysis, based on some subjective criteria.

4.3.2.1 Procedure

a) For each attribute, establish decision rules for selecting regions.

EXAMPLE 1 "Select the 10 regions with the highest apparent mottle."

EXAMPLE 2 "Find the three lightest character images. Find the three darkest character images."

b) Visually inspect the page and select regions that meet the criteria.

c) Evaluate the attribute within each region selected.

4.3.2.2 Specification of sampling scheme

If this sampling method is selected, the report shall include

a) all decision rules used, and

b) location of each region evaluated, for each attribute.

4.3.3 Random sampling

4.3.3.1 General

In random sampling, features are taken from a portion of the page that has been selected blindly to represent the whole page.

4.3.3.2 Procedure

a) Cover the page with a grid of uniform rectangular cells.

b) Select a cell at random (using any random or pseudorandom method that ensures that each cell has the same chance of being selected as any other).

c) If the attribute being evaluated does not apply to the cell, discard it and select a replacement.

d) Evaluate the attribute within the cell.

e) Sample cells until the desired accuracy is obtained.

4.3.3.3 Specification of sampling scheme

If this sampling method is used, the report shall include the following:

a) dimensions of the grid cells;

b) method of placing grid on page:

   1) location of origin;

   2) orientation of axes;

c) decision rule for deciding if attribute is applicable to cell;

d) any other decision rules used;

e) decision rule for deciding when to stop sampling;

f) method of randomization in selection of grid cells;

g) stratification, if any (stratification is dividing the grid into homogeneous sections and then selecting samples from each section according to a predetermined proportion of the total number of samples).

4.3.4 Whole page sampling

In whole page sampling, features are extracted from throughout the page.

4.3.4.1 Procedure

Divide the page into the cells and measure each attribute (if present) in each cell.

4.3.4.2 Specification of sampling scheme

If this sampling method is selected, the report shall include the following:

a) dimensions of the grid cells;

b) method of placing grid on page:

   1) location of origin;

   2) orientation axes;

c) decision rule for deciding if attribute is applicable to cell;

d) any other decision rules used.

5 Attributes and their measures

5.1 Schema of attributes

The table below gives an overview of the image quality attributes. They have been divided into two groups. The attributes in each group generally require similar assumptions and have similar or related measurement procedures.

Group of Attribute	Attribute	Clause
Large area graphic image quality attributes		
	large area darkness	5.2.3
	background darkness	5.2.4
	graininess	5.2.5
	mottle	5.2.6
	background extraneous mark	5.2.7
	large area void	5.2.8
	banding	5.2.9
Character and line image quality attributes		
	line width	5.3.3
	character darkness	5.3.4

5.2 Large area graphic image quality attributes

5.2.1 General

This subclause contains measuring procedures for attributes characterizing areas larger than 161 mm^2 and with minimum dimension of 12,7 mm (equivalent to 600 pixels when resolution is 1 200 spi).

All measurements described in this subclause shall be made under the conditions prescribed in Clause 6 and Annex B.

5.2.2 Large area R_{max} and R_{min}

In order to determine the inner boundary, the maximum reflectance factor (R_{max}) is determined by averaging the data measured in the area selected by the user as background area and the minimum reflectance factor (R_{min}) is determined by averaging the data measured in the area selected by the user as image area. Then, from R_{max} and R_{min}, R_{10} is computed and the inner boundary edge is determined.

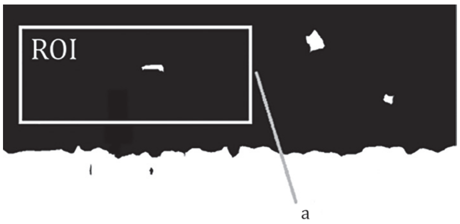
5.2.3 Large area darkness

a) Find a region of interest (ROI) with a minimum dimension of 12,7 mm contained wholly within the inner boundary (R_{10}) of an image element.

b) Measure the optical reflectance factor $Y(x, y)$ wholly within the ROI.

c) Compute the average optical density of the ROI as the large area darkness using Formula (1). The average optical density should be converted from the average reflectance factor.

$$\text{Large area darkness metric} = \log_{10}\left(\frac{1}{\frac{1}{n \times m}\sum_{y}\sum_{x} Y(x,y)}\right) \quad (1)$$



Key

a smallest dimension ≥12,7 mm

Figure 1 — Large area darkness

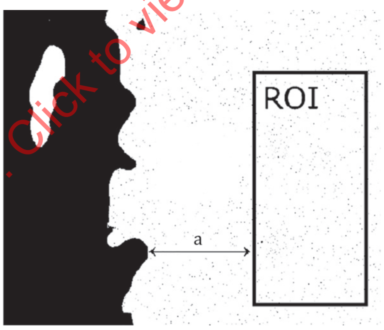
5.2.4 Background darkness

a) Find an ROI of a minimum dimension of 12,7 mm in the background area (with marks excluded) at least 500 micrometres away from the outer boundary of any image element.

b) Measure the optical reflectance factor $Y(x, y)$ wholly within the ROI.

c) Compute the average optical density of the ROI as background darkness using Formula (2). The average optical density should be converted from the average reflectance factor.

$$\text{Background darkness metric} = \log_{10}\left(\frac{1}{\frac{1}{n \times m}\sum_{y}\sum_{x} Y(x,y)}\right) \tag{2}$$



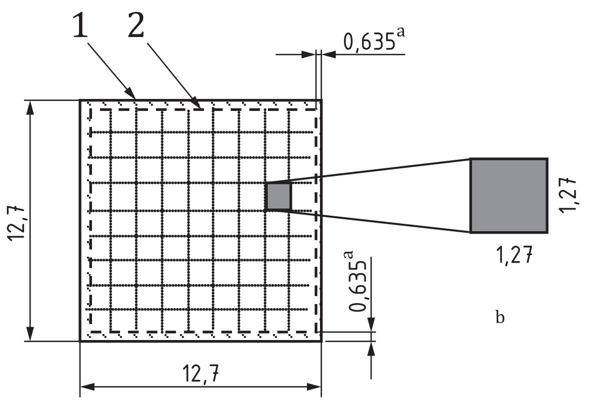
Key

a at least 50 µm away

Figure 2 — Background darkness

5.2.5 Graininess

5.2.5.1 Sampling for the graininess measurement



Key

1 wavelet-processed ROI

2 cropped ROI

a 30 pixels at 1 200 spi

b 3 600 measurements

Figure 3 — ROI divided into tiles; a tile (with dimensions)

Find an ROI of a minimum dimension of at least 12,7 mm (600 pixels at 1 200 spi), contained wholly within the area. Apply the wavelet filtering to this ROI. Remove margins 0,635 mm (30 pixels at 1 200 spi) from each side of the wavelet-processed ROI to get a cropped ROI, as shown in Figure 3. Divide the cropped ROI into at least 81 (9 × 9) uniform, non-overlapping square tiles. The height and width of each tile is at least 1,27 mm (60 pixels at 1 200 spi).

Within each tile, make 3 600 (60 × 60) pixels evenly-spaced, non-overlapping measurements of reflectance.

NOTE For a 1 200 spi detector system, the cropped ROI corresponds to a region of 291 600 (540 × 540) pixels divided into 81 (9 × 9) tiles of 3 600 (60 × 60) pixels each.

5.2.5.2 Graininess measurement

a) Find an ROI of a minimum dimension of at least 12,7 mm contained wholly within the inner boundary of an image element.

b) Measure the optical reflectance factor R (x, y), G (x, y) and B (x, y) of 360 000 (600 × 600) pixels, using red, green and blue filter, respectively. Pixels are evenly-spaced, non-overlapping elements within the ROI.

c) Convert the three optical reflectance factors to a single CIE Y (x, y), using Formula (3) (see http://www.color.org/sRGB.xalter):

$$Y\left(x,y\right)=0{,}212\,6R\left(x,y\right)+0{,}715\,2G\left(x,y\right)+0{,}072\,2B\left(x,y\right) \quad (3)$$

d) Apply the wavelet transform (Daubechies wavelets of order 16) to the 600 × 600 pixels ROI. Set the number of wavelet levels n = 6.

e) Zero all the detail components (horizontal, vertical and diagonal) of the four highest-detail wavelet levels (scale levels 2, 3, 4 and 5). The frequency band of each wavelet level is shown in Table 2.

f) Zero the approximation component of the wavelet image (this is the low-pass component at the lowest scale: level 0).

Table 2 — Frequency band of 6 wavelet levels

Scale level	Frequency band (cy/mm)	
5	23,6220 to 11,8110	High frequencies to be removed
4	11,8110 to 5,9055	
3	5,9055 to 2,9526	
2	2,9526 to 1,4763	
1	1,4763 to 0,7382	Frequencies for graininess
0	0,7382 to 0,3691	

g) Apply the inverse wavelet transform to get the filtered image $Y(x, y)$.

h) Crop the filtered image, removing 0,635 mm (30 pixels) from each side (as shown in Figure 3).

i) Divide the cropped image into non-overlapped tiles of uniform size. There shall be at least 81 tiles, with at least nine tiles vertically and at least nine tiles horizontally. The area of each tile shall be at least 1,27 mm × 1,27 mm (60 × 60 pixels each).

j) Compute the reflectance variance $v_{i,j}$ of each tile of i-th row and j-th column [Formula (4) assumes a total of 60 × 60 = 3 600 pixels per tile]:

$$v_{i,j} \frac{1}{60\times 60-1}\sum_{x=1}^{60}\sum_{y=1}^{60}\left[Y'_{i,j}(x,y)-\bar{Y}'_{i,j}\right]^2 \tag{4}$$

k) Compute the graininess metric as the square root of the average of all tiles' variances using Formula (5) [Formula (5) assumes a total of 9 × 9 = 81 tiles, obtained after cropping a 600 × 600 wavelet-processed image into a 540 × 540 image]:

$$\text{Graininessmetric} = \sqrt{\frac{1}{9\times 9}\sum_{i=1}^{9}\sum_{j=1}^{9} v_{i,j}} \tag{5}$$

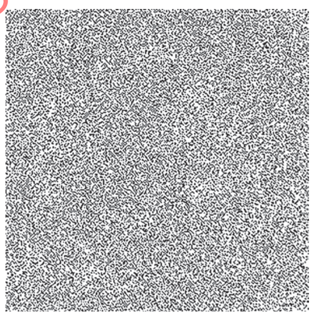
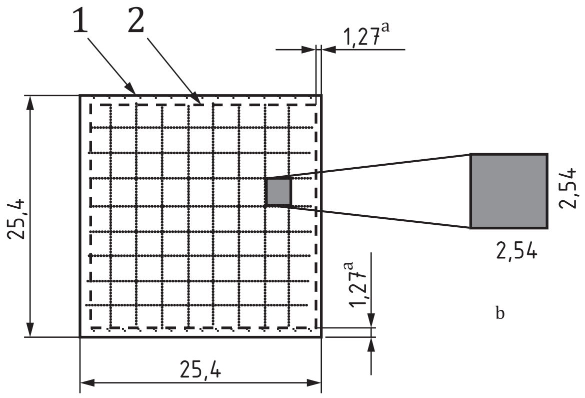


Figure 4 — Graininess

5.2.6 Mottle

5.2.6.1 Sampling for the mottle measurement



Key

1 wavelet-processed ROI

2 cropped ROI

a 60 pixels at 1 200 spi.

b 14 400 measurements.

Figure 5 — ROI divided into tiles; a tile (with dimensions)

Find an ROI of a minimum dimension of at least 25,4 mm (1 200 pixels at 1 200 spi), contained wholly within the area. Apply the wavelet filtering to this ROI. Remove margins 1,27 mm (60 pixels at 1 200 spi) from each side of the wavelet-processed ROI to get a cropped ROI, as shown in Figure 5. Divide the cropped ROI into at least 81 (9 × 9) uniform, non-overlapping square tiles. The height and width of each tile is at least 2,54 mm (120 pixels at 1 200 spi).

Within each tile, make 14 400 (120 × 120 pixels) evenly spaced, non-overlapping measurements of density.

NOTE For a 1 200 spi detector system, the cropped ROI corresponds to a region of 1 166 400 (1 080 × 1 080) pixels divided into 81 (9 × 9) tiles of 14 400 (120 × 120) pixels each.

5.2.6.2 Mottle measurement

a) Find an ROI of a minimum dimension of at least 25,4 mm contained wholly within the inner boundary of an image element.

b) Measure the optical reflectance factor $R(x,y)$, $G(x,y)$ and $B(x,y)$ of 14 400 (1 200 × 1 200) pixels, using a red, green and blue filter, respectively. Pixels are evenly spaced, non-overlapping elements within the ROI.

c) Convert the three optical reflectance factors to a single CIE $Y(x,y)$, using Formula (6):

$$Y(x,y) = 0,212\,6R(x,y) + 0,715\,2G(x,y) + 0,072\,2B(x,y) \quad (6)$$

d) Apply the wavelet transform (Daubechies wavelets of order 16) to the 1 200 × 1 200 pixels ROI. Set the number of wavelet levels $n = 9$.

e) Zero all the details components (horizontal, vertical and diagonal) of the six highest-detail wavelet levels (scale levels 3, 4, 5, 6, 7 and 8). The frequency band of each wavelet level is shown in Table 3.

f) Zero the approximation component of the wavelet image (this is the low-pass component at the lowest scale: level 0).

g) Apply the inverse wavelet transform to get the filtered image $Y(x, y)$.

h) Crop the filtered image, removing 1,27 mm (60 pixels) from each side (as shown in Figure 5).

i) Divide the cropped image into non-overlapped tiles of uniform size. There shall be at least 81 tiles, with at least nine tiles vertically and at least nine tiles horizontally. The area of each tile shall be at least 2,54 mm × 2,54 mm (120 × 120 pixels each).

Table 3 — Frequency band of nine wavelet levels

Scale level	Frequency Band (cy/mm)	
8	23,6220 to 11,8110	High frequencies to be removed
7	11,8110 to 5,9055	
6	5,9055 to 2,9526	
5	2,9526 to 1,4763	
4	1,4763 to 0,7382	
3	0,7382 to 0,3691	
2	0,3691 to 0,1846	Frequencies for mottle
1	0,1846 to 0,0923	
0	0,0923 to 0,0461	

j) Compute the reflectance variance $v_{i,j}$ of each tile of i-th row and j-th column [Formula (7) assumes a total of 120 × 120 = 14 400 pixels per tile]:

$$v_{i,j} = \frac{1}{120 \times 120 - 1} \sum_{x=1}^{120} \sum_{y=1}^{120} \left[Y'_{i,j}(x,y) - \bar{Y}' \right]^2 \tag{7}$$

j) Compute the mottle metric as the square root of the average of all tiles' variances [Formula (8) assumes a total of 9 × 9 = 81 tiles, obtained after cropping a 1 200 × 1 200 wavelet-processed image into a 1 080 × 1 080 image]:

$$\text{Mottle metric} = \sqrt{\frac{1}{(9 \times 9)} \sum_{i=1}^{9} \sum_{j=1}^{9} v_{i,j}} \tag{8}$$

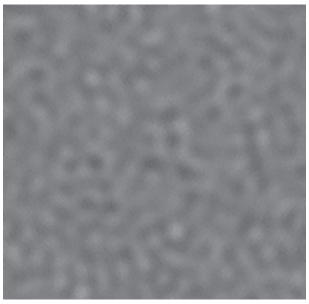


Figure 6 — Mottle

5.2.7 Background extraneous mark

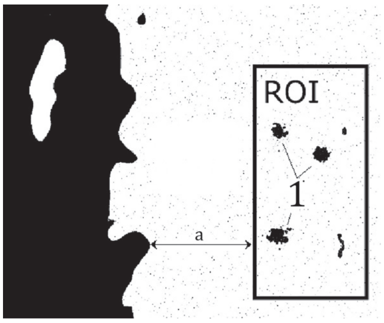
a) Find an ROI of a minimum dimension of 12,7 mm in the background area (with marks included) at least 500 micrometres away from the outer boundary of any large area graphic image element.

b) Compute the edge threshold using maximum reflectance factor, R_{max}, and minimum reflectance factor, R_{min}.

c) Compute the total area A_{EM} (in square micrometers) of all marks consisting of connected pixels (in one or more of eight directions) with reflectance value below R_{40} that together have a minimum size of 7 850 µm^2, which is the size of a 100 micrometer diameter circle.

d) Report the results as a list of all marks and their areas along with the area of the ROI or as a summary. For a summary, report the total area of all the marks divided by the area of the ROI.

$$\text{Background extraneous mark metric} = \frac{A_{\text{EM}}}{\text{Area of the ROI}} \tag{9}$$



Key

1 marks

a at least 500 µm away

Figure 7 — Background extraneous mark

5.2.8 Large area void

a) Find an ROI of at least 161 mm^2 and a minimum dimension of 12,7 mm contained wholly within the inner boundary of any large area graphic image element within a nominally solid image area.

b) Compute the edge threshold (R_{40}) using the maximum reflectance factor, R_{max}, and minimum reflectance factor, R_{min}.

c) Compute the total area A_V (in square micrometers) of all large area voids consisting of connected pixels (in one or more of eight directions) with reflectance value above R_{40} that together have a minimum size of 7 850 µm^2, which is the size of a 100 micrometer diameter circle.

d) Report the results as a list of all large area voids and their areas along with the area of the ROI or as a summary. For a summary, report the total area of all the large area voids divided by the area of the ROI as shown in Formula (10):

$$\text{Large area void metric} = \frac{A_{\text{V}}}{\text{Area of the ROI}} \tag{10}$$

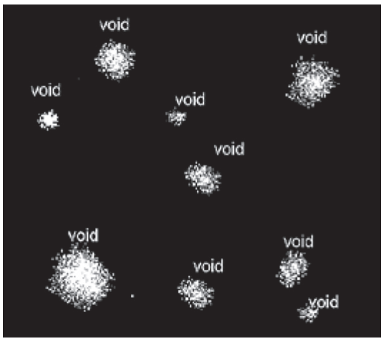


Figure 8 — Large area void

5.2.9 Banding

a) Find a nominally uniform ROI of at least 150 mm (x-direction) by 100 mm (y-direction), contained wholly within the inner boundary edge of an image element.

b) Measure the optical reflectance factors $R(x)$, $G(x)$ and $B(x)$ within the ROI at a minimum of 600 dpi using red, green and blue filters, such that R, G and B represent RGB color.

c) Calculate one-dimensional reflectance profiles $R(x)$, $G(x)$ and $B(x)$ by averaging in the y-direction. However, inclination of a picture should be 0,2° or less.

d) Convert the three reflectance profiles to a single CIE $Y(x)$ profile, using Formula (11):

$$Y(x) = 0{,}212\,6R(x) + 0{,}715\,2G(x) + 0{,}072\,2B(x) \tag{11}$$

e) Calculate an L^* profile by converting $Y(x)$ into $L^*(x)$.

$$L^*(x) = 116\left[Y(x)\right]^{1/3} - 16 \qquad Y(x) > 0{,}008\,856 \tag{12}$$

f) Calculate a modulated profile, $L'(x)$, by applying a band pass filter to $L^*(x)$ as in Formula (13):

$$L'(x) = \mathrm{FFT}^{-1}\left\{Q(f)\,\mathrm{FFT}\left[L^*(x)\right]\right\} \tag{13}$$

where $Q(f)$ is a modulation function given by Formula (14):

$$Q(f) = 0{,}617 + 0{,}40\tan^{-1}\left[1{,}33\log\left(f/0{,}074\right)\right] \tag{14}$$

where f is frequency in cycle per millimeter and where $Q(f)$ is set to zero for $f > 0{,}5$ c/mm.

g) Separate the $L'(x)$ profile into three frequency channel profiles D_1, D_2 and D_3, using three Gaussian convolution kernels as in Formulae (15) and (16):

$$G_i(x) = e^{-(x/w_i)^2} \quad \text{with } w_1 = 50\text{ mm}, w_2 = 5\text{ mm}, w_3 = 0{,}5\text{ mm} \tag{15}$$

$$\begin{cases} D_1(x) = G_1(x) * L'(x) \\ D_2(x) = G_2(x) * L'(x) - G_1(x) * L'(x) \\ D_3(x) = G_3(x) * L'(x) - G_2(x) * L'(x) \end{cases} \tag{16}$$

h) From each of the three profiles, discard the first 5 mm and last 5 mm (in order to avoid potential FFT artifacts). Then, for each of the three profiles D_1, D_2 and D_3, find local extrema $\left\{\delta_{ki}\right\}_{i=1}^{N_k}$ counting only local maxima that are above zero, and counting only local minima that are below zero. Here, $k = 1, 2, 3$ identifies the profile (D_1, D_2 or D_3), and i is an index corresponding to the local extrema on a given profile. Only the absolute value (not the sign) of the extrema is retained.

i) The local extrema defined in this way for each profile are combined into a single list of extrema values $\left\{\tilde{\delta}_\mathrm{i}\right\}_{i=1}^{N}$ sorted by descending magnitude.

j) The local extrema are pooled using “tent-pole summation”:

$$M = \sum_{i=1}^{N} \frac{\tilde{\delta}_\mathrm{i}}{p^{i-1}}, \text{with } \delta_\mathrm{i} \geq \delta_\mathrm{i} + 1 \tag{17}$$

where $p = 2$.

k) The banding metric is calculated using Formula (18):

$$\text{Banding metric} = 3{,}66\sqrt{M} \tag{18}$$

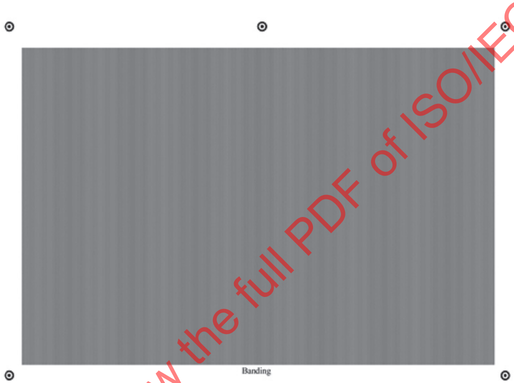


Figure 9 — Banding

5.3 Character and line image quality attributes

5.3.1 General

This subclause contains measuring procedures for attributes applicable to character images (and their near vicinity).

These attributes also apply to lines at least 1 mm long. In this case, the interior of the line is taken to be the interior of the line that falls within the ROI.

NOTE Blurriness, raggedness and extraneous colourant in the character surround area are caused by similar processes and their effects are often confounded. This document does not attempt to completely separate the effects in the proposed measurement methods, so (for example) the blur measurement can contain some component of raggedness or the raggedness measurement can contain some component of extraneous marks.

All measurements described in this subclause shall be made under the conditions prescribed in Clause 6 and Annex B.

5.3.2 Character and line image R_{max} and R_{min}

To determine the edge threshold, perform the following steps. Separately measure the reflectance distribution of an image element and a background area, to determine the maximum reflectance factor (R_{max}) and the minimum reflectance factor (R_{min}). In the reflectance measurement, the aperture size should be 0,2 mm to 0,3 mm in a direction parallel to the edge of image element and 0,01 mm to 0,03 mm in a perpendicular direction. Sample three or more locations in the horizontal and vertical direction for each image element and calculate the average value. From R_{max} and R_{min}, R_{40} is computed and the edge threshold is determined.

5.3.3 Line width

a) Find an ROI that includes lines at least 1 mm long and background. The recommended width of the ROI is no less than (line width) +2 mm, the height no less than 5 mm, and any particles which have a computed area greater than the area (7 850 µm^2) of a 100 micrometer diameter circle are removed at the time of measurement.

b) Compute the edge threshold R_{40} using the maximum reflectance factor R_{max} and the minimum reflectance factor R_{min} within ROI.

c) Compute the distance from the right edge position to the left edge position along a line normal to the centre line of the image element.

d) Compute the average distance using Formula (19) by carrying out data sampling at equal intervals within the ROI:

$$\text{Line width metric} = \frac{1}{N}\sum_{K=1}^{N}\left(\text{left edge threshold position}\right)-\left(\text{right edge threshold position}\right) \tag{19}$$

Key

1 stroke width

2 edge threshold R_{40}

3 line width

Figure 10 — Line width

5.3.4 Character darkness

a) Find an ROI that includes lines at least 1 mm long and background, and any particles which have a computed area greater than the area (7 850 µm^2) of a 100 micrometer diameter circle removed at the time of measurement. The recommended width of the ROI is no less than (line width) +2 mm, the height no less than 5 mm.

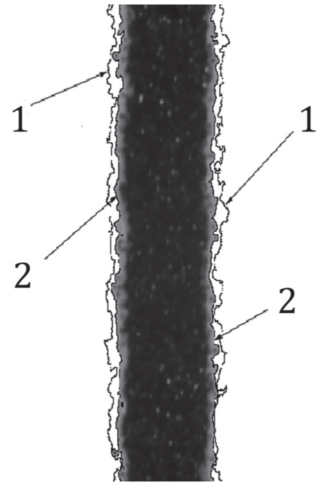
b) Compute the R_{25} boundary threshold using the maximum reflectance factor R_{max} and the minimum reflectance factor R_{min} within the ROI.

c) Compute the line image density (LID) by averaging the density within the R_{25} boundary. The average optical density should be converted from the average reflectance factor.

d) Compute darkness using Formula (20):

$$\text{Character darkness metric} = \text{LID} \times \sqrt{LW} \quad (20)$$

where *LW* is the line width specified in 5.3.3.



Key

1 edge

2 R_{25} boundary

Figure 11 — Character darkness

5.3.5 Blurriness

a) Find an ROI that includes lines at least 1 mm long and background, and any particles which have a computed area greater than the area (7 850 µm^2) of a 100 micrometer diameter circle removed at the time of measurement. The recommended width of the ROI is no less than (line width) +2 mm, the height no less than 5 mm.

b) Compute the R_{70} and R_{10} boundary threshold using maximum reflectance factor, R_{max}, and minimum reflectance factor, R_{min} within ROI.

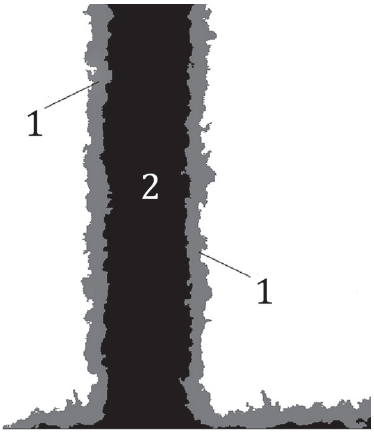
c) Compute the distance between R_{70} and R_{10} boundary of each scan and compute the average distance (DIS_{70-10}) of two or more scans. If the line is broken off inside the ROI, select a different ROI as measurement is impossible.

d) Compute the R_{25} boundary threshold using the maximum reflectance factor, R_{max}, and the minimum reflectance factor, R_{min}, within the ROI.

e) Compute the line image density (LID) by averaging the density within the R_{25} boundary. The average optical density should be converted from the average reflectance factor. The R_{25} boundary is determined based on the R_{max} and R_{min} defined in b).

f) Compute the average blurriness by using Formula (21):

$$\text{Blurriness metric} = \text{DIS}_{70-10} \,/\, \sqrt{\text{LID}} \quad (21)$$



Key

1 region between boundary edges

2 image segment

Figure 12 — Blurriness

5.3.6 Raggedness

a) Find an ROI that includes lines at least 1 mm long and background, and any particles which have a computed area greater than the area (7 850 µm^2) of a 100 micrometer diameter circle removed at the time of measurement. The recommended width of the ROI is no less than (line width) +2 mm, the height no less than 5 mm.

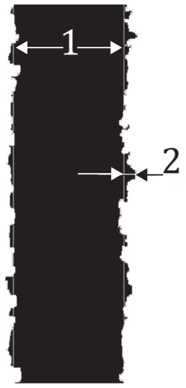
b) Compute the edge threshold R_{40} using the maximum reflectance factor, R_{max}, and the minimum reflectance factor, R_{min}, within ROI.

c) Compute the standard deviation of the residuals from a straight line fitted to the edge threshold boundary (calculated perpendicular to the fitted straight line).

d) Compute the average of right and left side standard deviations using Formula (22):

$$\text{Raggedness metric} = \frac{1}{N}\sum_{j=1}^{n}\sqrt{\frac{1}{k-1}\sum_{i=1}^{k}\left(\text{residuals from a line}\right)^2} \quad (22)$$

NOTE The raggedness evaluation is optimized for use with edges containing aperiodic noise.



Key

1 fitted line

2 residuals

Figure 13 — Raggedness

5.3.7 Character void

a) Find an ROI that includes line segment, character image or other glyph image and background, and any particles which have a computed area greater than the area (7 850 µm^2) of a 100 micrometer diameter circle is removed at the time of measurement.

b) Compute the R_{25} boundary threshold using the maximum reflectance factor, R_{max}, and the minimum reflectance factor, R_{min}, within the ROI.

c) Transform the image into binary data using the R_{25} boundary value as the threshold. If there is small scattering (noise), it will be removed, and I-1 is created.

d) All the holes within I-1 are filled and the image I-2 is created.

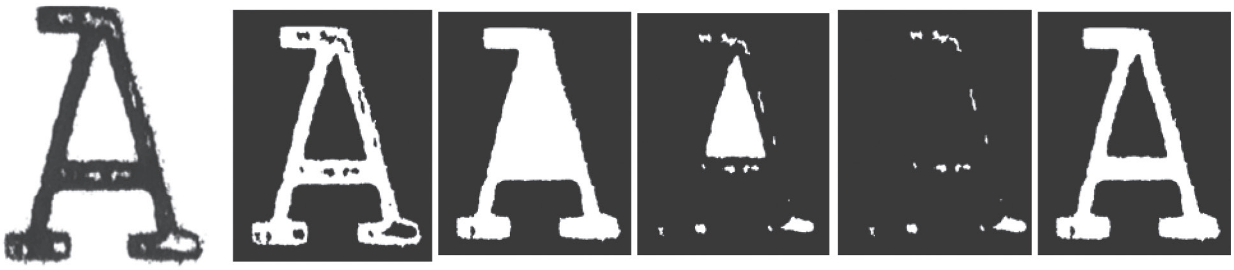
e) Compute the exclusive OR (XOR) of I-1 and I-2, and I-3 is created.

f) Create the image I-4 by eliminating part of character design holes in the image I-3 and compute the total area A_4 of the portion which remained.

g) Compute the OR image of I-1 and I-4 and I-5 is created, and compute the image area A_5 of I-5.

h) Compute the ratio of the area A_4 to the area A_5 using Formula (23):

$$\text{Character void metric} = \frac{A_4}{A_5} \tag{23}$$



(I-1) (I-2) (I-3) (I-4) (I-5)

Figure 14 — Character void and transformed images (original, I-1 to I-5)

5.3.8 Character surround area extraneous mark

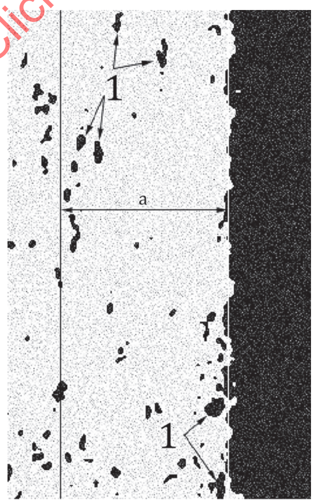
a) Find an ROI of at least 10 mm in length along with both line edge and 0,5 mm width in contact with both line edge within a character surround area.

Compute the edge threshold R_{40} using the maximum reflectance factor, R_{max}, within the ROI and the minimum reflectance factor, R_{min}, within the image area.

b) Compute the area A_{EM} (in square micrometres) within the edge threshold of each mark which can be any shape, but must have a computed area greater than the area (7 850 µm^2) of a 100 micrometer diameter circle.

c) Compute the ratio of the area of the marks to the total area A_{CF} of the character surround area by Formula (24):

$$\text{Character sorround area extraneous mark metric} = \frac{A_{EM}}{A_{CF}} \qquad (24)$$



Key

1 mark

a within 500 micrometers

Figure 15 — Character surround area extraneous mark

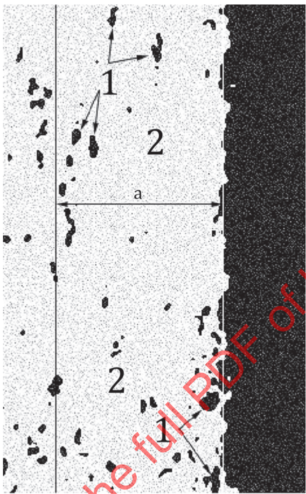
5.3.9 Character surround area haze

a) Find an ROI of at least 10 mm in length along with both line edge and 2 mm width in contact with both line edge in the character surround area (with marks excluded).

b) Measure the mean reflectance factor R_{HC} of the character surround area (with extraneous marks and image elements excluded) and the reflectance factor R_{BKG} of the nearby background area (outside any character surround area).

c) Compute the ratio of reflectance factor R_{HC} to R_{BKG} by Formula (25):

$$\text{Character sorround area haze metric} = \frac{R_{HC}}{R_{BKG}} \tag{25}$$



Key

1 mark

2 haze

a within 500 micrometers

Figure 16 — Character surround area haze

6 System conformance

The purpose of this test is to verify that the complete measuring system (hardware, software and operator) has been well calibrated and that it is accurate and precise enough for the requirements of this document. This subclause does not describe a calibration procedure. It describes a procedure for verifying that suitable calibration has been achieved.

6.1 Conformance standard

The instrument system used to carry out the procedures of this document shall be tested using the test objects and procedures specified below to assure that it is operating in conformance with the requirements of this document.

The measuring system is calibrated suitably if it can obtain a value within acceptable tolerances of the goal values given in 6.4 for each attribute and for each test object specified in 6.3, independent of the orientation of the object and of its location within the field of view.

The conformance test of a measurement system is carried out at least once every six months, and the repeat stability of a measurement system measures OECF at least 16 times and verifies the average value and standard deviation once at least in half a year. For measuring the OECF, the central axis of the line and large area image parts of the system conformance test chart shall be aligned with the central axis of the fast scan lines of a scanner as shown in the figure in B.4.2.

NOTE It is convenient to prepare a system conformance test chart composed of the test objects specified in 6.3 and an automatic measurement tool in order to maintain conformance of the measurement system. An example of the system conformance test chart developed by SC 28 is shown in Annex E and its layout is shown in Annex C. An automatic measurement tool was also prepared by SC 28. An example of measurement procedure using the tool is explained in Annex B.

6.2 Instrument

The measures of attributes in this document shall be carried out with an instrument that has a minimum of 1 200 spi and 8 bits per pixel (256 gray levels), with a large field of view (for example, a 1 200 spi flatbed scanner) and a dynamic range of optical density at least 0,1 to 1,5 according to ISO 21550. A 1 200 spi instrument has an optical sampling pitch of 21,2 micrometers in the vertical and horizontal direction and a sampling window of close to 21,2 micrometers × 21,2 micrometers. The measures described in this document assume that data has been collected on such an instrument.

Any instrument may be used, however, as long as the conformance standard in this subclause can be met.

To achieve optimal comparison between systems, instruments should have similar characteristics (spi, illumination, spatial response and spectral response).

6.2.1 OECF conversion

An OECF created with the following procedures as specified in ISO 14524 is used for measurement of image quality attributes using the large area darkness pattern of system conformance test chart specified in 6.3.2.6.

a) Measure the visual reflection density D_v of 13 patches of large area darkness pattern contained in ISO/IEC 24790 system conformance test chart.

b) Calculate the visual reflectance R_v from the visual reflection density D_v:

$$R_{vi} = 10^{-D_{vi}} \tag{26}$$

where i is a step of gray scale.

c) Scan gray scale with a scanner in RGB mode and calculate the average output signal O_{gi} of the G channel of each gray scale step.

d) Develop the weighted least squares equation which predicts the visual reflectance R_{vi} by the 5th degree polynomial of the average output signal O_{gi}.The weight is the reciprocal of the reflectance of each gray scale patch.

e) In the polynomial, when the visual reflectance R_{vi} becomes smaller than 0,001, set the visual reflectance R_{vi} to 0,001, and when the visual reflectance R_{vi} is larger than 0,933, clip the visual reflectance R_{vi} to 0,933.

f) Using the procedure c) to d), develop regression equations for the R and B channels.

The gray scale used for creation of an OECF should be with 12 or more steps.The minimum optical density should be 0,1 or less and the maximum optical density should be 1,7 or more.

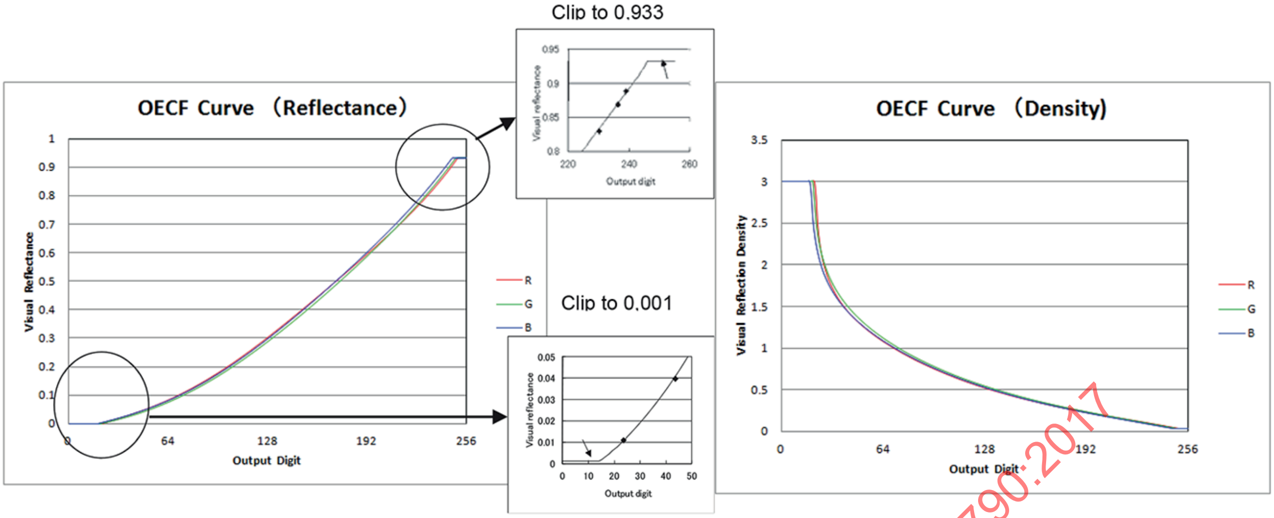


Figure 17 — Example of scanner OECF

6.2.2 MTF compensation

An MTF measured with the following procedures, as specified in ISO 16067-1, is used for compensating the scanner MTF. The scanner MTF is measured using the slanted edge pattern of the system conformance test chart specified in 6.3.3. The slanted edges are rotated approximately 5° from horizontal and vertical directions. MTF is measured by the following method about the fast scan and slow scan:

a) scan the slanted edge patch contained in ISO/IEC 24790 system conformance test chart with a scanner in RGB mode, 8 bit/channel, 1 200 spi;

b) compute the SFR (spatial frequency response) of R, G, B and luminance of four orientation edges;

c) compute the average of G and luminance SFR characteristics over the frequency range [0 (DC) to Nyquist frequency];

d) compute the scanner MTF using the measured system MTF characteristic and target MTF characteristic:

$$MTF_{scanner} = MTF_{system}/MTF_{target} \tag{27}$$

The target MTF is average characteristic of typical scanners as shown in Figure 18.

The target MTF of 1 200 ppi is shown in Formula (28):

$$\text{Target MTF}\left(f\right) = 1 - 0{,}103\,039\,6\,f + 0{,}004\,226\,88\,f^{2} - 0{,}000\,091\,552\,1\,f^{3} + 0{,}000\,001\,030\,79\,f^{4} \tag{28}$$

where f is spatial frequency (cycle/mm).

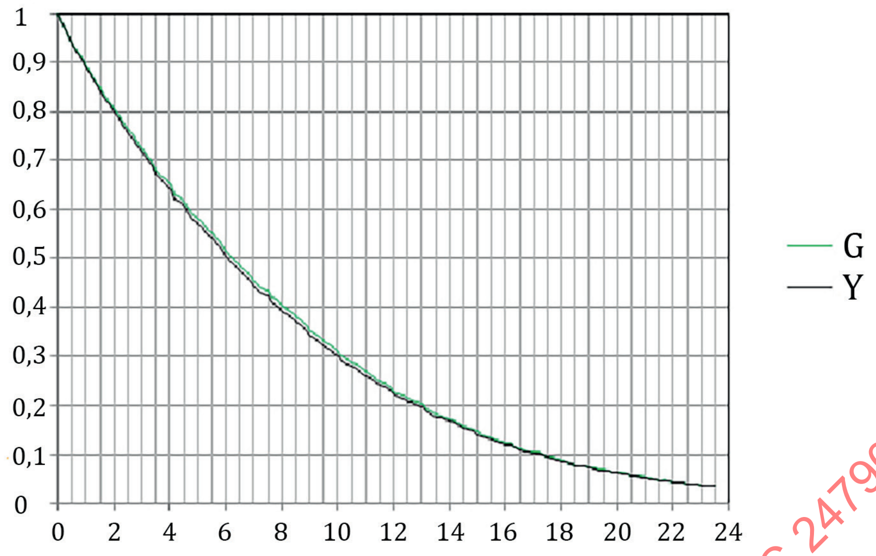


Figure 18 — Target MTF characteristic of 1 200 spi

e) measure the optical reflectance factors $d(x, y)$ within the ROI of each attribute;

f) compute a two-dimensional Fourier spectrum $F[d(x, y)]$;

g) compute a one-dimensional Fourier spectrum of horizontal direction and divide by the MTF compensation factor;

h) compute a one-dimensional Fourier spectrum of vertical direction and divide by the MTF compensation factor;

i) compute a MTF compensated image $d_c(x, y)$ using the following two-dimensional inverse Fourier transform in Formula (29):

$$d_c(x, y) = F^{-1}\left\{F\left[d(x, y)\right] \times \mathrm{MTF}_{\mathrm{Target}}(fx, fy) / \mathrm{MTF}_{\mathrm{scanner}}(fx, fy)\right\} \quad (29)$$

6.3 Test objects

The system conformance procedure requires the use of several test lines and area patterns. These test objects shall be produced as specified.

6.3.1 Specification for production of lines

6.3.1.1 Line set 1

Line set 1 is built from the 800 dpi bitmaps in Annex A. Each test line is produced by duplicating the corresponding bitmap at least 50 times to produce a line that is at least 30 mm long.

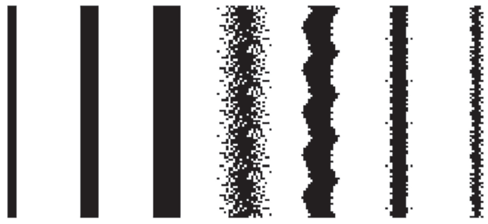
a) In each bitmap, “0” defines a white pixel. “1” defines a black pixel.

b) Each pixel shall be square and sharp, with an area between 700 square micrometers and 1 000 square micrometers.

c) The total area of any 3 × 3 block of adjacent pixels shall be between 7 600 square micrometers and 9 600 square micrometers.

d) The substrate shall have an ISO brightness of at least 85 as specified in ISO 2470-1.

e) The colorant shall have an average density of 1,3 or higher.



NOTE For illustration only; not to be used to test conformance.

Figure 19 — Sample of line set 1 for conformance test

6.3.1.2 Line set 2

Line set 2 is built from the line width specified in Table 4, assuming a bitmap addressability of 800 dpi.

a) Any 3 × 3 block of pixels shall be square and sharp, with an area between 700 square micrometers and 1 100 square micrometers.

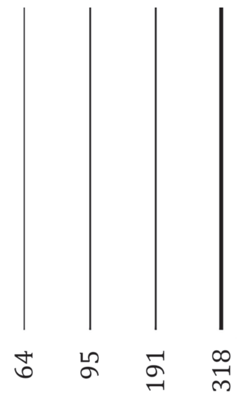
b) The total area of any 9 × 9 block of adjacent pixels shall be between 7 600 square micrometers and 9 600 square micrometers.

c) The substrate shall have an ISO brightness of at least 85 as specified in ISO 2470-1.

d) The colorant shall have an average density of 1,3 or higher.

Table 4 — Specification of line set 2 (assumed as 800 dpi resolution)

Line name	Pixel width	Line width (µm)
64	2	63,5 ± 5
95	3	95,3 ± 5
191	6	190,5 ± 5
318	10	317,5 ± 5



NOTE For illustration only, not to be used to test conformance.

Figure 20 — Sample of line set 2 for conformance test

6.3.1.3 Line set 3

Line set 3 for character surround area haze, character surround area extraneous mark and character void is built from the bitmaps specified in Figures 21 to 23, assuming a bitmap addressability of 800 dpi.

a) A test line is produced by duplicating the corresponding bitmap at least 20 times to produce a line that is at least 30 mm long.

b) In each bitmap, “0” defines a white pixel. “1” defines a black pixel.

c) Each pixel shall be square and sharp, with an area between 700 square micrometers and 1 000 square micrometers.

d) The total area of any 3 × 3 block of adjacent pixels shall be between 7 600 and 9 600 square micrometers.

e) The substrate shall have an ISO brightness of at least 85 as specified in ISO 2470-1.

f) The colorant shall have an average density of 1,3 or higher.

```
10001000100010011111111001000100010001
00000000000000011111111000000000000000
00000000000000011111111000000000000000
00000000000000011111111000000000000000
10001000100010011111111001000100010001
00000000000000011111111000000000000000
00000000000000011111111000000000000000
00000000000000011111111000000000000000
10001000100010011111111001000100010001
00000000000000011111111000000000000000
00000000000000011111111000000000000000
00000000000000011111111000000000000000
10001000100010011111111001000100010001
00000000000000011111111000000000000000
00000000000000011111111000000000000000
00000000000000011111111000000000000000
10001000100010011111111001000100010001
00000000000000011111111000000000000000
00000000000000011111111000000000000000
00000000000000011111111000 000000000000
```

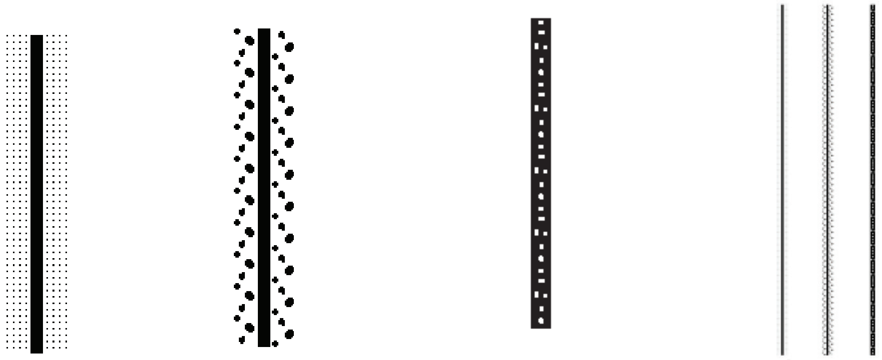
Figure 21 — Bitmap for line set 3 for the conformance test of character surround area haze


```
00110000000000011111111000000000000000
01111000000000011111111000000000000000
01111000000000011111111000000000000000
00110000000000011111111000011000000000
00000000000000011111111000111100000000
00000000111000011111111000111100000000
00000001111100011111111000111100000000
00000001111110011111111000001100000000
00000001111110011111111000000000000000
00000000111110011111111000000000000000
00000000011100011111111000000000111000
00000000000000011111111000000001111100
00000000000000011111111000000011111100
00000110000000011111111000000011111100
00011110000000011111111000000011111000
00011110000000011111111000000001110000
00011110000000011111111001100000000000
00001100000000011111111011110000000000
00000000000000011111111011110000000000
00000000000000011111111001100000000000
```

Figure 22 — Bitmap for line set 3 for the conformance test of charactre surround area extraneous mark

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 1
1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 1
1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 0 0 0 0 0 1 1 1 1 1
1 1 1 1 1 1 0 0 0 0 0 1 1 1 1 1
1 1 1 1 1 1 0 0 0 0 0 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 0 0 0 1 1 1 1 1 1 1 1 1 1
1 1 1 0 0 0 1 1 1 1 1 1 1 1 1 1
1 1 1 0 0 0 1 1 1 1 0 0 0 1 1 1
1 1 1 0 0 0 1 1 1 1 0 0 0 1 1 1
1 1 1 0 0 0 1 1 1 1 0 0 0 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 0 0 0 1 1 1 1 1 1
1 1 1 1 1 1 1 0 0 0 1 1 1 1 1 1
1 1 1 1 1 1 1 0 0 0 1 1 1 1 1 1
1 1 1 1 1 1 1 0 0 0 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 0 0 1 1 1 1 1 1 1
1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 1
1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 1
1 1 1 1 1 1 0 0 0 0 1 1 1 1 1 1
1 1 1 1 1 1 1 0 0 0 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

Figure 23 — Bitmap for line set 3 for the conformance test of character void



Key

1 haze

2 mark

3 character void

NOTE For illustration only; not to be used to test conformance.

Figure 24 — Sample of line set 3 for conformance test

6.3.2 Specification for production of large images

The image patterns for the measurement of large area darkness, background darkness, graininess, mottle, background extraneous mark and large area void are specified in 6.3.2.1 to 6.3.2.7. The bitmap addressability is 2 400 dpi.

6.3.2.1 Graininess pattern

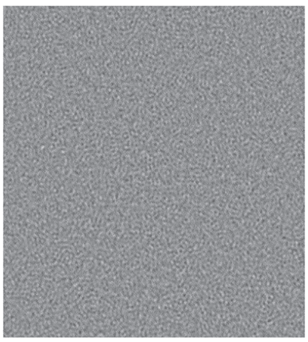
a) Generate a two-dimensional white noise pattern (2 400 dpi 32 bit Real) with standard deviation 12.

b) Perform bandpass filter processing with a minimum cut-off frequency of 0,2 cycle/mm and a maximum cutoff frequency of 4,0 cycle/mm to the white noise.

c) Create uniform data (2 400 dpi 32 bit Real) of a level 127.

d) Add the filtered white noise to the uniform data.

e) Convert into 8-bit data (2 400 dpi 8 bit) without a sign.



NOTE For illustration only; not to be used to test conformance.

Figure 25 — Sample of graininess pattern for conformance test

6.3.2.2 Mottle pattern

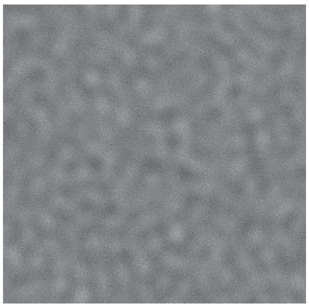
a) Generate a two-dimensional white noise pattern (2 400 dpi 32 bit Real) with standard deviation 12.

b) Perform low pass filter processing with a cut-off frequency of 0,6 cycle/mm to the white noise.

c) Create uniform data (2 400 dpi 32 bit Real) of a level 127.

d) Add the filtered white noise to the uniform data.

e) Convert into 8-bit data (2 400dpi 8 bit) without a sign.



NOTE For illustration only; not to be used to test conformance.

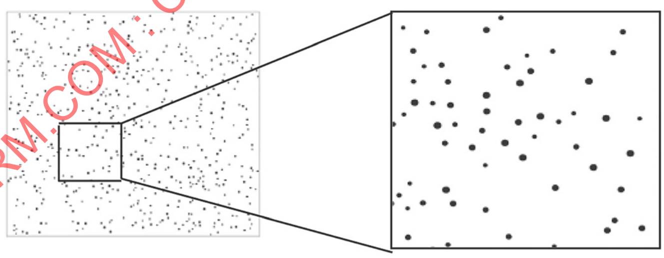
Figure 26 — Sample of mottle pattern for conformance test

6.3.2.3 Background extraneous mark pattern

a) Generate circular dots whose center coordinates and radius change randomly until the area coverage of all circles becomes 2 % in an area of 25,4mm × 25,4 mm.

b) The radius change between adjacent circular dots shall be within range of 6 pixels (0,0635 mm) to 10 pixels (0,1058 mm).

c) A diameter of 0,1 mm or more is maintained.



NOTE For illustration only; not to be used to test conformance.

Figure 27 — Sample of background extraneous mark pattern for conformance test

6.3.2.4 Large area void pattern

a) The large area void evaluation pattern is generated by inverting the binary marks evaluation pattern.

NOTE For illustration only; not to be used to test conformance.

Figure 28 — Sample of large area void pattern for conformance test

6.3.2.5 Background darkness pattern

a) The background darkness evaluation pattern is a circular dot pattern of 5 % area coverage at a dot pitch of 200 line/25,4 mm.

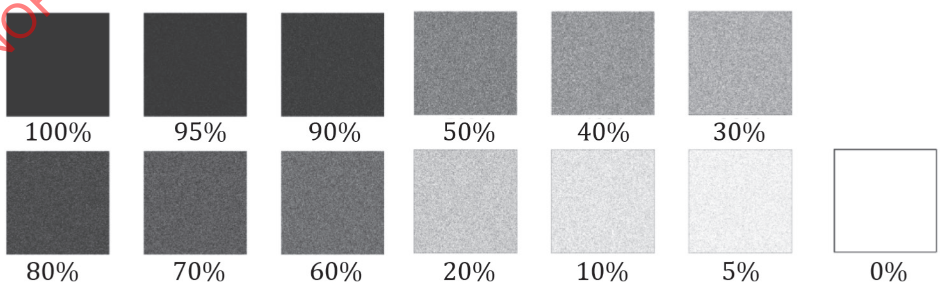
NOTE For illustration only; not to be used to test conformance.

Figure 29 — Sample of background darkness pattern for conformance test

6.3.2.6 Large area darkness pattern

a) The large area darkness evaluation pattern consists of 13 patches with specified dot area coverages in percent of 100, 95, 90, 80, 70, 60, 50, 40, 30, 20, 10, 5 and 0.

b) The size of each patch is (15 × 15) mm.



NOTE For illustration only; not to be used to test conformance.

Figure 30 — Sample of large area darkness pattern for conformance test

6.3.2.7 Banding pattern

a) Generate a pattern synthesized using following three kinds of sine waves (2 400 dpi:32 bit Real).

Table 5 — Specification of sine waves

Wave length (pixels)	Spatial frequency (cycles/mm)	Amplitude	Initial phase
50	1,89	16	0
200	0,47	16	0
1 000	0,09	16	0

b) Create the uniform data (2 400 dpi 32 bit Real) of a level 127.

c) Add the synthesized pattern to the uniform data.

d) Convert into 8-bit data (2 400 dpi 8 bit) without a sign

e) Binarize using error diffusion treatment (2 400dpi 1 bit).

Figure 31 — Sample of banding pattern for conformance test

6.3.3 Slanted edge pattern

The slanted edge pattern is specified in ISO 16067-1 as near-vertical and near-horizontal slanted edges.

a) Generate a square pattern. The minimum and maximum densities should nominally match the Dmax and Dmin of the grey-scale patches.

b) Rotate approximately 5° from horizontal and vertical directions.

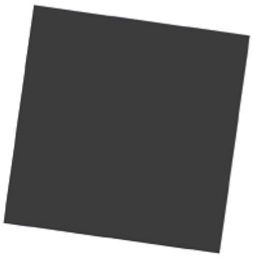


Figure 32 — Slanted edge pattern for MTF measurement

6.4 Goal values

The orientation of lines in the following tables follows their orientation in the conformance test chart. The lower side of these line segments 1 to 7 corresponds to the right edge of the bitmaps defined in Annex A.

Table 6 — Goal values for system conformance test of line set 1

Line	Character darkness	Line width (micrometers)	Raggedness upper side (micrometers)	Raggedness lower side (micrometers)	Blurriness upper side	Blurriness lower side
1	0,305 – 0,375	128 – 148	0 – 1,5	0 – 1,5	37,6 – 57,6	37 – 57
2	0,511 – 0,621	257 – 277	0 – 1,5	0 – 1,5	35,9 – 55,9	35,5 – 55,5
3	0,673 – 0,823	385 – 405	0 – 1,5	0 – 1,5	35,5 – 55,5	35,3 – 55,3
4	0,576 – 0,706	471 – 511	37,6 – 47,6	32,2 – 42,2	149,1 – 189,1	165,3 – 205,3
5	0,649 – 0,789	379 – 399	35,1 – 39,1	31,4 – 35,4	44,3 – 64,3	44,3 – 64,3
6	0,454 – 0,554	228 – 248	8,5 – 12,5	9,2 – 13,2	49,2 – 69,2	47 – 67
7	0,294 – 0,354	139 – 159	12,5 – 16,5	8,7 – 12,7	54,7 – 74,7	58,2 – 78,2

Table 7 — Goal values for system conformance test of line set 2

Line	Character darkness	Line width (micrometers)	Raggedness upper side (micrometers)	Raggedness lower side (micrometers)	Blurriness upper side	Blurriness lower side
64	0,175 – 0,215	67 – 87	0 – 1,5	0 – 1,5	39,4 – 59,4	38,5 – 58,5
95	0,237 – 0,287	98 – 118	0 – 1,5	0 – 1,5	40,1 – 60,1	39,3 – 59,3
191	0,403 – 0,493	192 – 212	0 – 1,5	0 – 1,5	39,3 – 59,3	38,6 – 58,6
318	0,578 – 0,708	321 – 341	0 – 1,5	0 – 1,5	39,3 – 59,3	38,8 – 58,8

Table 8 — Goal values for system conformance test of line set 3

Attribute	Ratio
Character void	0,086 – 0,098
Character surround area extraneous mark	0,174 – 0,184
Character surround area haze	0,843 – 0,859

Table 9 — Goal values for system conformance test of large area darkness pattern

Coverage (%)	Large area darkness
0	0,062 – 0,102
5	0,119 – 0,159
10	0,177 – 0,217
20	0,314 – 0,354
30	0,447 – 0,487
40	0,601 – 0,641
50	0,749 – 0,809
60	0,921 – 0,981
70	1,093 – 1,153
80	1,276 – 1,336
90	1,452 – 1,532
95	1,561 – 1,661
100	1,718 – 1,858

Table 10 — Goal values for system conformance test of background darkness, mottle, graininess and banding

Attribute	Range		
Background darkness	0,128	–	0,14
Mottle	2,69	–	2,89
Graininess	1,89	–	2,09
Banding	3,36	–	3,56

Table 11 — Goal values for system conformance test of large area void and background extraneous mark

Attribute	Ratio		
Large area void	0,0125	–	0,0155
Background extraneous mark	0,019	–	0,021

Annex A
(normative)

Bitmaps for conformance test lines

Table A.1 — Bitmap for Line 1

```
000000000011110000000000
000000000011110000000000
000000000011110000000000
000000000011110000000000
000000000011110000000000
000000000011110000000000
000000000011110000000000
000000000011110000000000
000000000011110000000000
000000000011110000000000
000000000011110000000000
000000000011110000000000
000000000011110000000000
000000000011110000000000
000000000011110000000000
000000000011110000000000
000000000011110000000000
000000000011110000000000
000000000011110000000000
000000000011110000000000
```

Table A.2 — Bitmap for Line 2

```
000000001111111100000000
000000001111111100000000
000000001111111100000000
000000001111111100000000
000000001111111100000000
000000001111111100000000
000000001111111100000000
000000001111111100000000
000000001111111100000000
000000001111111100000000
000000001111111100000000
000000001111111100000000
000000001111111100000000
000000001111111100000000
000000001111111100000000
000000001111111100000000
000000001111111100000000
000000001111111100000000
000000001111111100000000
000000001111111100000000
```

Table A.3 — Bitmap for Line 3

```
000000111111111111000000
000000111111111111000000
000000111111111111000000
000000111111111111000000
000000111111111111000000
000000111111111111000000
000000111111111111000000
000000111111111111000000
000000111111111111000000
000000111111111111000000
000000111111111111000000
000000111111111111000000
000000111111111111000000
000000111111111111000000
000000111111111111000000
000000111111111111000000
000000111111111111000000
000000111111111111000000
000000111111111111000000
000000111111111111000000
```

Table A.4 — Bitmap for Line 4

```
000010110111110101010000
100001011111100101011000
000001001111111100100000
000010111111111111000100
001110111111111110000000
000000100111111101101000
000010011111111110100000
000010101111111110001000
000000011011111001100000
011101110111111010011000
000101110111111111010000
000110011111101111000110
000001101101111010110000
000010001111111100000000
000000011101111111100000
011000011011011101001110
000001101010111111100000
000101100111111111100000
000001011111111010110001
000001111111110010010000
```


Table A.5 — Bitmap for Line 5

000000111111111111000000
000000011111111111110000
000000001111111111100000
000000011111111111100000
000000111111111111000000
000000111111111110000000
000001111111111110000000
000011111111111110000000
000011111111111100000000
000011111111111100000000
000111111111111110000000
000011111111111100000000
000011111111111100000000
000001111111111110000000
000001111111111100000000
000001111111111100000000
000000111111111100000000
000000111111111110000000
000000011111111111000000
000000111111111111000000

Table A.6 — Bitmap for Line 6

000000001111111100000000
000000000111111100000000
000000000111111100000000
000000001111111000000000
000000001111111100000000
000000001111111000000000
000000000111111100000000
000000000111111000000000
000000001111111100000000
000000000111111100000000
000000000111111000000000
000000001111111000000000
000000001111111000000000
000000001111111000000000
000000000111111000000000
000000100111111101000000
000000000111111100000000
000000001111111100000000
000000001111111000000000
000000000111111000000000

Table A.7 — Bitmap for Line 7

000000000001110000000000
000000000111110000000000
000000000011100000000000
000000000101111000000000
000000000011110000000000
000000000111101000000000
000000000011100000000000
000000000011110000000000
000000000001110000000000
000000000011101000000000
000000000111110000000000
000000000111110000000000
000000000011111000000000
000000000011110000000000
000000000001110000000000
000000000011111000000000
000000000011100000000000
000000000001110000000000
000000000001110000000000
000000000111101000000000

Annex B
(informative)

How to use this document

B.1 General

Annex B provides a procedural outline for use of this document. The conditions that shall be met to allow implementation are given in B.2. The stepwise approach required is given in B.3. The procedure of system conformance test using the system conformance test chart and automatic measurement tool developed by SC 28 is given in B.4.

B.2 Conditions

a) The page to be evaluated contains background regions, character images, lines, halftone and solid areas of an appropriate size, shape and orientation to be specified and analysed according to the methodology of this document.

b) The image elements are distributed throughout the page in sufficient quantity and are in locations so as to allow adequate sampling for the statistics required by the task at hand. Adequate sampling will be determined by the image quality variations across the page and by the confidence level required for the assessment.

c) If line data are required for both horizontal and vertical orientations, the procedure is repeated as needed for correspondingly oriented edges and lines.

d) The scanning or imaging hardware shall have an optical resolution (addressability) of at least 1 200 spi and field coverage adequate to cover the regions of interest.

e) The data from the scanning or imaging hardware will be analysed in some way by appropriate software. There are three basic ways to obtain this software:

   — the end user develops his own software in a high-level programming language such as C++;

   — the algorithms are implemented as a supplementary application (such as a set of macros) for commercial image analysis software. These might be coded by the end user or obtained from a commercial source;

   — the end user obtains a complete application package dedicated to implementation of this document from a commercial source;

   — the complete application package tool which the WG 4 developed and was used in the verification measurements for this document can be obtained from the website of the Japanese Business Machine and Information System Association (JBMIA).

f) Means are available to select appropriate regions of interest, to threshold the image element and to execute the algorithms as required by this document. Such means may be implemented in software.

g) The recommended instrument is a 1 200 spi optical resolution (addressability) flatbed scanner. Use of a different instrument type (such as an image analyser) requires the procedure to be modified as appropriate for the particular instrument used.

B.3 Procedure

a) Establish the user's own quality standards and sampling requirements for user's application.

b) OECF calibration of the measuring system as specified in ISO 14524.

c) Place the sample page in the scanner as required by the instructions for use of the instrument.

d) Scan the page. The resultant scan data are stored (for example, as a TIFF file).

e) Run the image processing software.

f) Open the image file.

g) Select a region of interest to isolate the desired area to be analysed (an edge, line, halftone, solid area, background, image element or character surround area).

h) Execute the measurement algorithm.

i) Return to g) until all regions of interest on the page are evaluated.

j) Return to c) until all pages are evaluated.

k) Summarize the data as required for the test at hand (for example, calculate means and standard deviations, ranges, minima and maxima).

l) Report the data in a suitable format.

m) Compare the results of the test to user's own quality standards.

B.4 Procedure to measure the system conformance test chart

The following are procedure to measure the ISO/IEC 24790 system conformance test chart using the tool which was used in the verification measurements for this document.

B.4.1 Tools

Tool name is "TS24790_Tool_Ver.1.5.exe". The tool for the system conformance test can be obtained from the Japanese Business Machine and Information System Association (JBMIA) website at the following URL: http://iso.jbmia.or.jp/test_c_new.html.

To use this tool you will need to install following programs;

a) "LabVIEW2014 Run-time Engine" can be downloaded from the following URL.

http://www.ni.com/download/labview-run-time-engine-2014/4887/en/

b) "MATLAB Compiler Runtime 2012a" can be download from the following URL.

http://www.mathworks.com/products/compiler/mcr/index.html

c) "Visual C++2010 redistributable" can be downloaded from the following URL.

http://www.microsoft.com/

B.4.2 Scan conformance chart

Scan the conformance chart, including fiducial marks, three times with a qualified scanner (see 6.2) according to the following procedure.

Image 1: For banding measurement

Resolution: 600 ppi, Mode: RGB 24 bit, File format: TIFF.

Chart position and direction.: Set up the center of the banding chart on the center of the fast scan direction of the scanner.

Image 2: For measuring line attributes, large area attributes (except banding) and creating the 1 200 ppi scanner MTF file.

Resolution: 1 200 ppi, Mode: RGB 24 bit, File format: TIFF.

Image 3: For creating the OECF file.

Resolution: 600 spi, Mode: RGB 24 bit, File format: TIFF.

Chart position and direction: Set up the center of the line and large area parts on the center of the fast scan direction of the scanner.

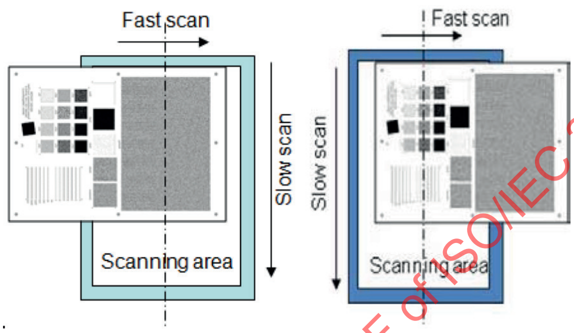
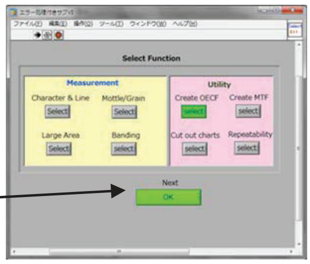


Image 1 **Images 2 and 3**

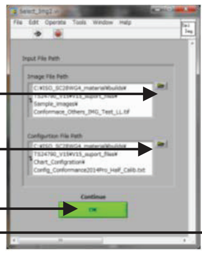
Chart position and direction :
Set up the center of the line and larger area parts on the center of the fast scan direction of the scanner.

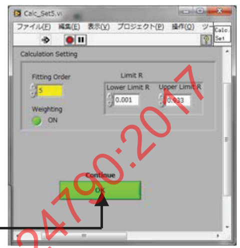


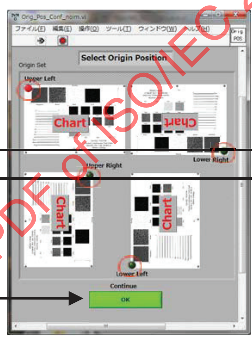
B.4.3 Create OECF

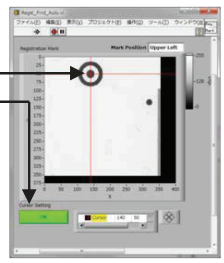
Use “ Image 3”. Resolution : 600spi, Mode : RGB 24bit, File format : TIFF.
Double click the tool file (TS24790_Tool_Ver.1.5.exe) and the function select panel open.

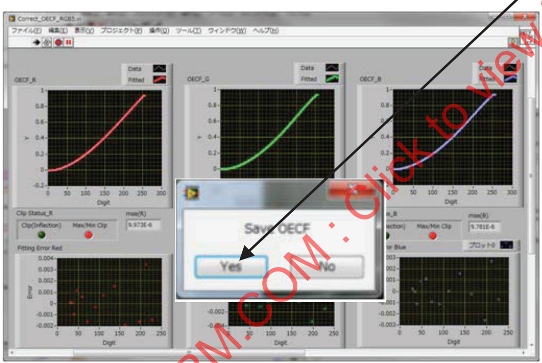
1) Click “Create OECF” button.
2) Click “OK” button.
3) Click reference button and dialog box opens, and select the scanned image file.
4) Click reference button and dialog box opens, and select the configuration file.
 The configuration file is in “data\Chart_Configuration” folder of tool folder.
 File name is “Config_Conformance2014Pro_Half_Calib.txt”.
5) Click “OK” button.
6) Click “OK” button.
7) Select the origin position of image.
 (The origin position is upper left corner of conformance chart.)
8) Click “OK” button.
9) Check the red cursor is in the center of the registration mark.
10) If the cursor is not in the center of a registration mark, click and move the cursor to the center of a registration mark.
11) Click “OK” button.
12) Do same operation to other two registration marks.
13) Open dialog box and click “Yes” button if you save OECF file.
14) Open dialog box, select save location and file name.
15) Click “OK” button.

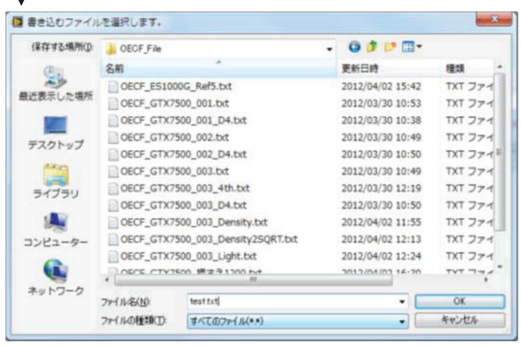










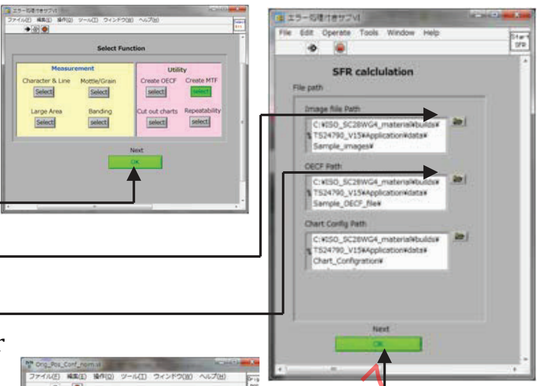


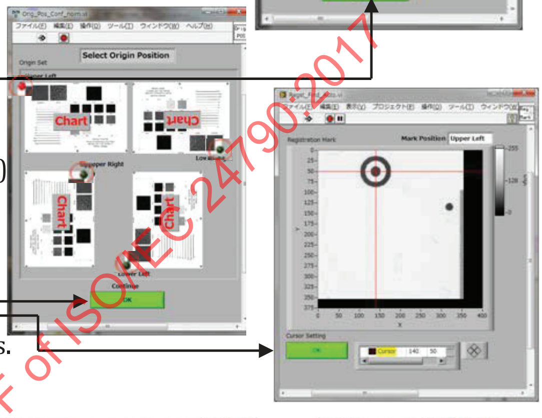
B.4.4 Create scanner MTF file

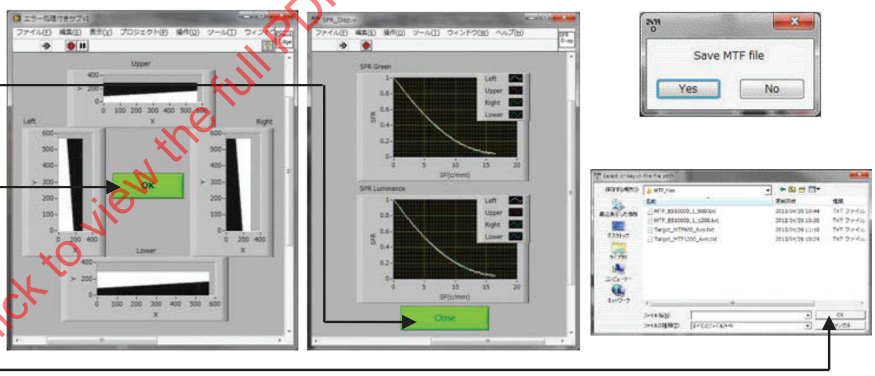
Create 1 200spi scanner MTF file for MTF compensation of the character and line image quality attributes.
Use " Image 2".
Double click the tool file (TS24790_Tool_Ver.1.5.exe) and the function select panel open.

1) Click "Create MTF" button.
2) Click "OK" button.
3) Click reference button and dialog box opens, and select the scanned image file.
4) Click reference button and dialog box opens, and select the OECF file. (Created in last step)
5) The configuration file is in "data\Chart_Configuration" folder of tool folder.
   File name "Config_Conformance_TS24790_SFR.txt"
6) Click "OK" button.

7) Select the origin position of image.
   (The origin position is Upper Left corner of conformance chart)
8) Click "OK" button
9) Check the red cursor is in the center of a registration mark.
10) If the cursor is not in the center of a registration mark, click and move the cursor to the center of a registration mark.
11) Click "OK" button.
12) Do same operations (9)-(11) to other two registration marks.
13) Check the slanted edge image is selected correctly.
14) Click "OK" button
15) Open panel and displayed G-channel and luminance MTF.
16) Click "OK" button.
17) Open dialog box and click "Yes" button if you save MTF file.
18) Open dialog box, select saving location and key-in file name.
19) Click "OK" button.

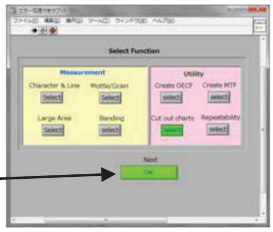
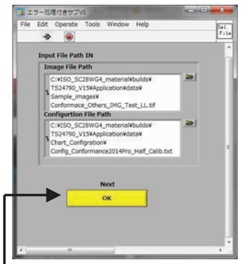




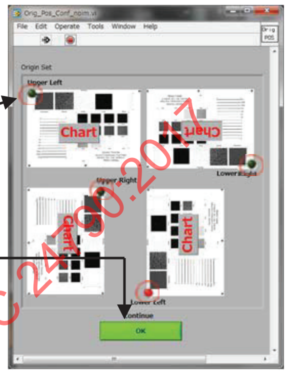
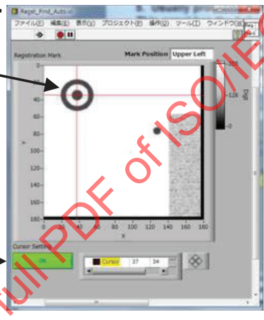


B.4.5 Cutting out ROI

Use "Image 2" scanned with 1 200spi.
Double click the tool file (TS24790_Tool_Ver.1.5.exe) and the function select panel open.

1) Click "Cut out chart" button.
2) Click "OK" button.
3) Click reference button and dialog box opens, and select the scanned image file.
4) Click reference button and dialog box opens, and select the configuration file.
   The configuration file is in "data\Chart_Configuration" folder of tool folder.
   File name is "Config_Conformance_2014Pro_Half_Calib.txt".
5) Click "OK" button.
6) Select the origin position of image. (The origin position is Upper Left corner of conformance chart)
7) Click "OK" button.
8) Check the red cursor is in the center of the registration mark.
9) If the cursor is not in the center of a registration mark, click and move the cursor to the center of a registration mark.
10) Click "OK" button.
11) Do same operations (10)-(12) to other two registration marks.
12) Cut out images are saved in the folder of scanned image.

B.4.6 Measurement

B.4.6.1 Measuring condition

Measuring conditions for each measurement are as follows

Attribute	Scanner resolution	MTFcompensation	MTF file
Character and line	1 200 spi	ON	1 200 spi MTF
Large area	1 200 spi	OFF	
Mottle and graininess	1 200 spi	OFF	
Banding	600 spi	OFF	

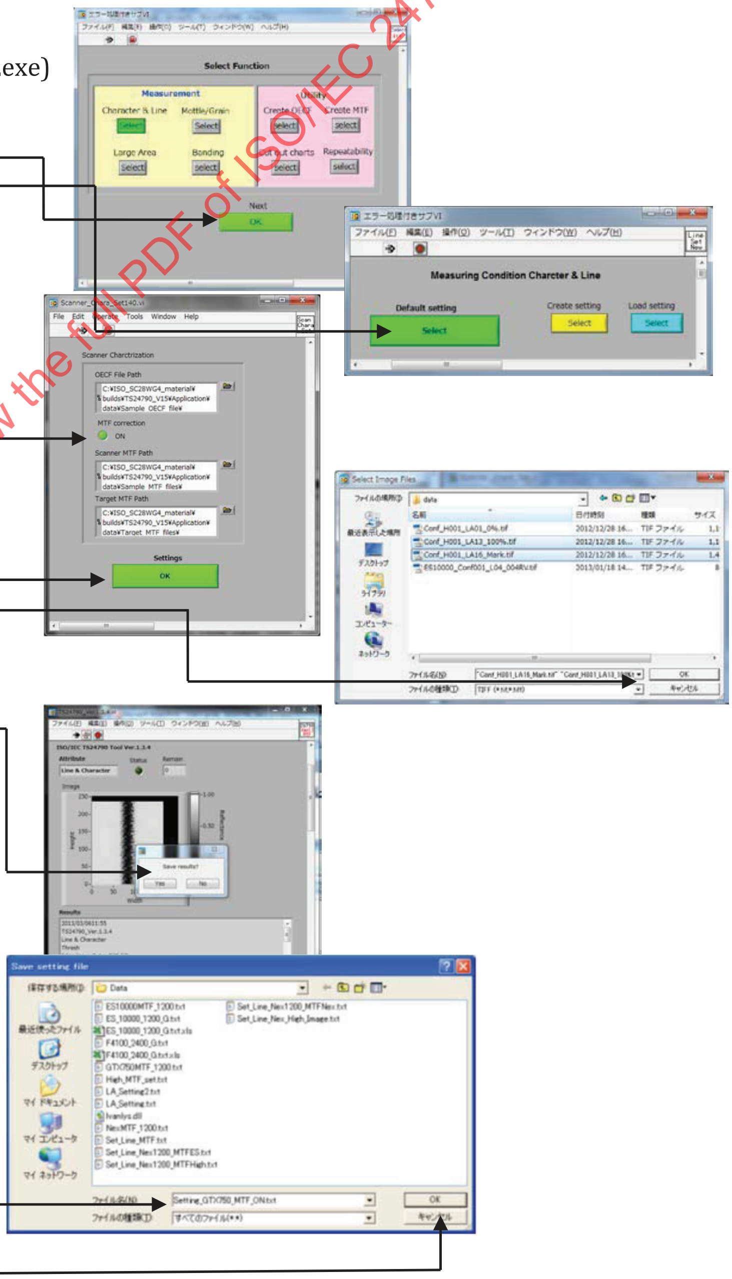
B.4.6.2 Character and line attributes

Double click the tool file (TS24790_Tool_Ver.1.5.exe) and the function select panel open.

1) Click “Character & Line” button.
2) Click “OK” button.
3) Click “Select” for default settings.
4) When you click the reference button, dialog box opens and select OECF.
5) Light on : MTF compensation ON.
6) When you click the reference button, dialog box opens and select Scanner MTF file.
7) When you click the reference button, dialog box opens and select the target MTF file. The target MTF file is in “data\Taget_MTF_files” folder of tool folder. File name is “Target_MTF_1200_2014.txt”.
8) Click “OK” button.
9) Dialog box opens and select image files. Multiple files : Shift+Click
10) Click “OK” button after selecting.

After measurement, dialog box opens.

11) Click “Yes” saving dialog box opens. Click “No” stop tool without saving.
12) Key in the setting file name with the Extension.
13) Click “OK” button.



B.4.6.3 Large area attributes (Except mottle, graininess and banding)

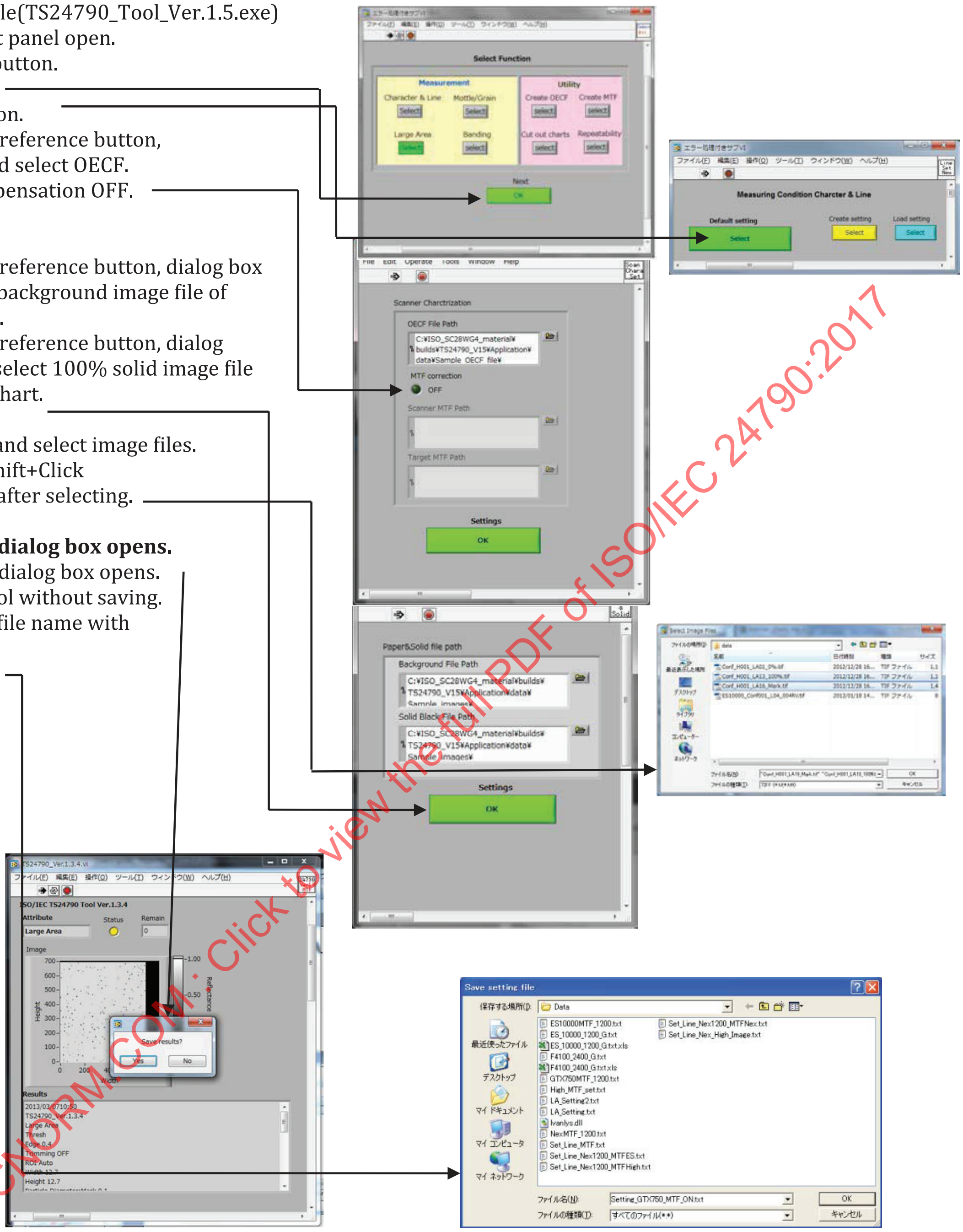
Double click the tool file(TS24790_Tool_Ver.1.5.exe) and the function select panel open.

1) Click “Large Area” button.
2) Click “OK” button.
3) Click “Default” button.
4) When you click the reference button, dialog box opens and select OECF.
5) Light off: MTF compensation OFF.

6) Click “OK” button.
7) When you click the reference button, dialog box opened and select background image file of conformance chart.
8) When you click the reference button, dialog box opened and select 100% solid image file of conformance chart.
9) Click “OK” button.
10) Dialog box opens and select image files. Multiple files : Shift+Click
11) Click “OK” button after selecting.

After measurement, dialog box opens.

12) Click “Yes” saving dialog box opens. Click “No” stop tool without saving.
13) Key in the setting file name with the extension.
14) Click “OK” button.



B.4.6.4 Mottle and graininess

Measurement of mottle and graininess takes a very long time on account of the I/O specification of program in this version.

Please wait for a while until finished.

Double click the tool file (TS24790_Tool_Ver.1.5.exe) and the function select panel opens.

1) Click "Mottle/Grain" button.

2) Click "OK" button.

3) When you click the reference button, dialog box opens and select OECF.

4) Light on : MTF compensation OFF

5) Click "OK" button.

6) Dialog box opens and select image files
Multiple files:Shift+Click.

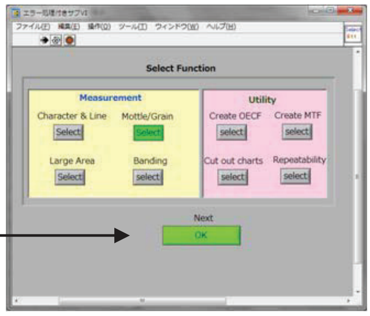
7) Click "OK" button after selecting.

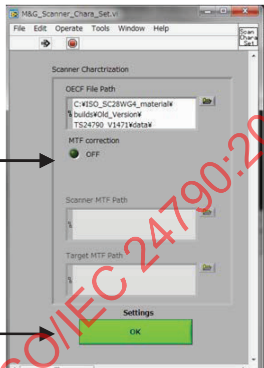
After measurement, dialog box opens.

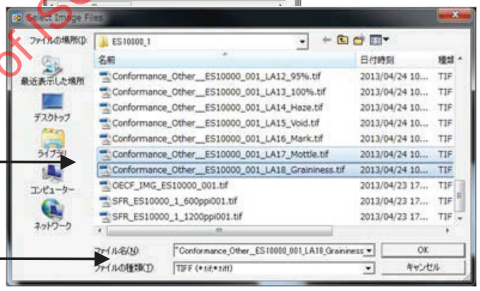
8) Click "Yes" saving dialog box opens.
Click "No" stop tool without saving.

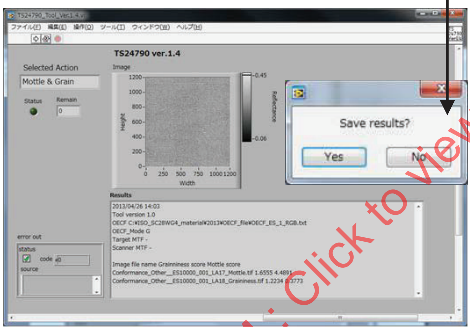
9) Key in the setting file name with the extension.

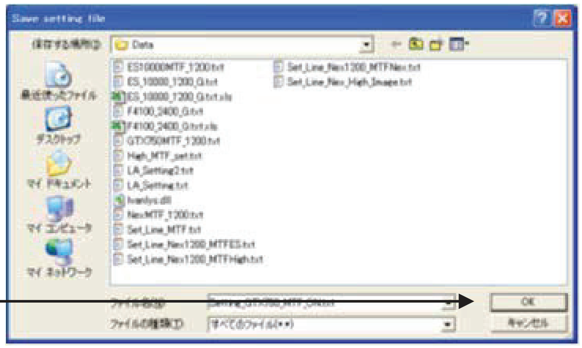
10) Click "OK" button.











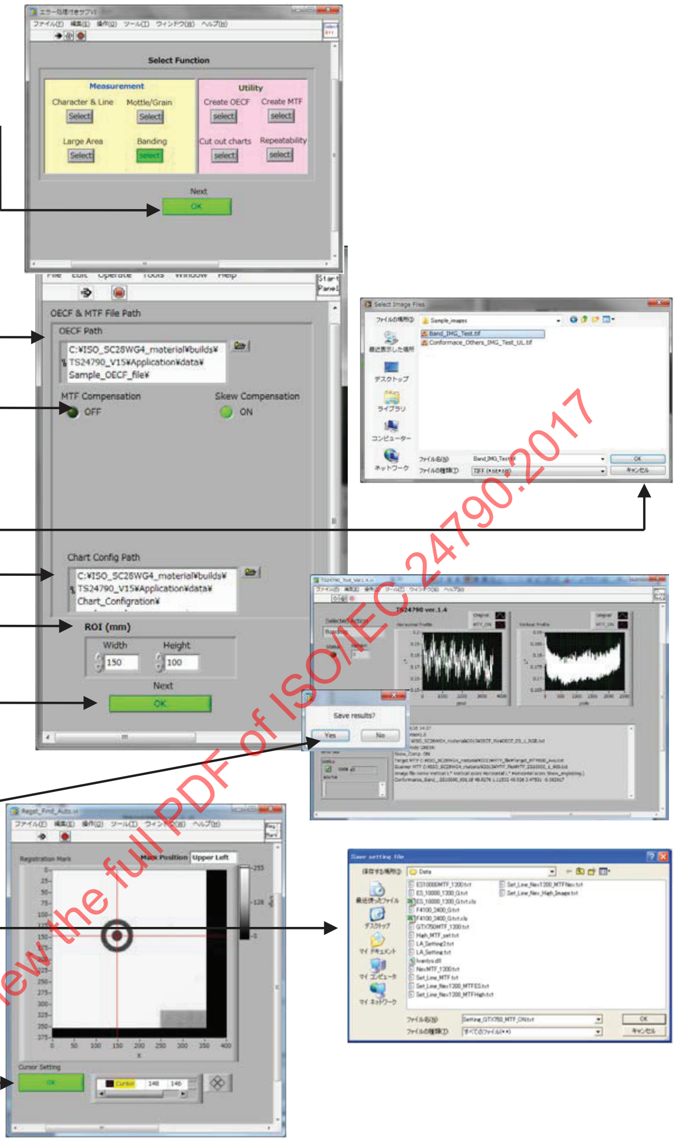
B.4.6.5 Banding

Double click the tool file (TS24790_Tool_Ver.1.5.exe) and the function select panel opens.

1) Click “Banding” button.
2) Click “OK” button.
3) When you click the reference button, dialog box opens and select OECF.
4) Light off: MTF compensation OFF.
5) Skew compensation ON. (Fixed condition)
6) Click reference button and dialog box opens, and select the configuration file. The configuration file is in “data\Chart_Configration” folder of tool folder. File name is “Config_Conformance_Band2.txt”.
7) ROI size (Fixed condition)
8) Click “OK” button.
9) Dialog box opens and select image files. Multiple files : Shift+Click
10) Click “OK” button after selecting.
11) Check the red cursor is in the center of the registration mark
12) If the cursor is not in the center of a registration mark, click and move the cursor to the center of a registration mark
13) Click “OK” button
14) Do same operation to other two registration marks

After measurement, dialog box opens

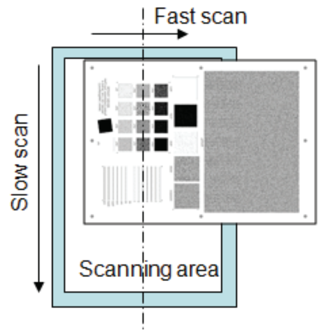
15) Click “Yes” saving dialog box opens Click “No” stop tool without saving.
16) Enter the setting file name with the extension.
17) Click “OK” button.



B.4.7 Repeatability test of scanner

B.4.7.1 Scan conformance chart

1) Turn on the power of scanner.
2) Set the conformance chart on
   the scanner. (as shown in the figure right)
3) Capture the chart with 600spi.
4) Continuously, capture the chart
   twice with 1 200spi.
5) Turn off the power of scanner.
6) 10 minutes later, capture the chart
   3 times with 1 200spi.

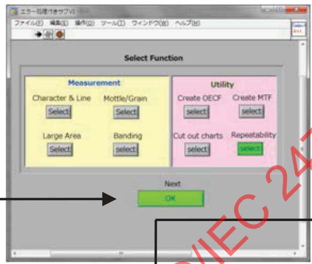


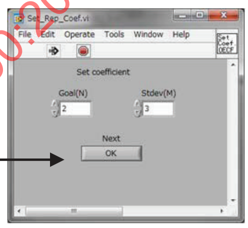
B.4.7.2 Create OECFs

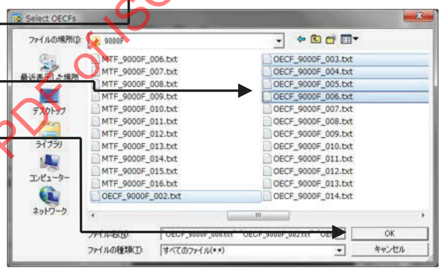
1) Create six OECFs using six image files according to the procedure **B.4.3** Create OECF.

B.4.7.3 Repeatability test

Double click the tool file (TS24790_Tool_Ver.1.5.exe) and the function select panel opens.
1) Click “Repeatability” button.
2) Click “OK” button.
3) Click “OK” button
   Coefficient Goal(N)=2, Stdev(M)=3 are fixed values
4) Dialog box opens and select OECFs
   Multiple files : Shift+Click
5) Click “OK” button

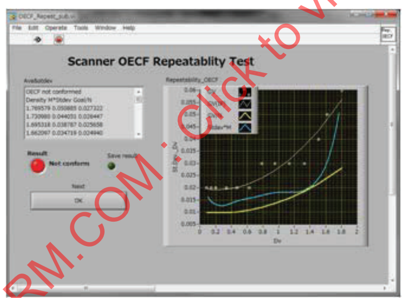


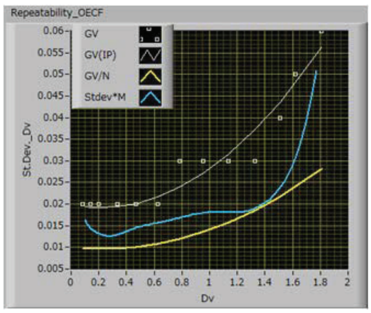




B.4.7.4 Test result panel

1) When not passed, the lamp blinking Red and Yellow.





2) When passed, the lamp blinking Green and Yellow.