TECHNICAL SPECIFICATION

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Graphic technology — Requirements for printed matter for commercial and industrial production —

Part 1: Measurement methods and reporting schema

Technologie graphique — Exigences pour les imprimés pour les productions industrielle et commerciale —

Partie 1: Méthodes de mesure et schémas de rapport

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ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

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Foreword

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

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

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

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

The committee responsible for this document is ISO/TC 130, *Graphic technology*.

ISO/TS 15311 consists of the following parts, under the general title *Graphic technology — Requirements for printed matter for commercial and industrial production*:

— *Part 1: Measurement methods and reporting schema*

The following parts are under preparation:

— *Part 2: Commercial production printing*

Introduction

When producing a colour reproduction, it is important that the persons responsible for data creation, colour separation, proofing and printing operations have previously agreed a minimum set of parameters that define the visual characteristics and other technical properties of the planned print product. This part of ISO/TS 15311 identifies a number of metrics that can be applied to printed sheets and that can be used as the basis for such communication. The range of metrics is large and it is not intended that all of these metrics are to be applied to any given printed product and for any given application, the range of metrics is to be carefully selected, for example based on subsequent parts of ISO/TS 15311.

The metrics described by this part of ISO/TS 15311 can be applied to any type of print. They are likely to most often be applied to digitally printed prints.

When selecting the set of metrics, only those metrics that have a clear specification and that correlate well with human perception are included in this part of ISO/TS 15311. Since this is an area of significant research activity, new metrics are expected to emerge and existing metrics to be revised in the next few years. For this reason, we anticipate the need to revise this part of ISO/TS 15311 within a very short time scale as new metrics are tested and found to be reliable.

Additional tests to those specified in this this part of ISO/TS 15311, for example visual assessment of smoothness, images and other elements may be required when assessing print quality.

As with any parameter that is used as part of a product specification, it is important for readers to understand clearly what the metric means. For this reason, a reporting schema is to be followed when reporting measurements in conformance with this part of ISO/TS 15311.

Graphic technology — Requirements for printed matter for commercial and industrial production —

Part 1: Measurement methods and reporting schema

1 Scope

This part of ISO/TS 15311 defines print metrics, measurement methods and reporting requirements for printed sheets that are suitable for all classes of printed products.

Guidance as to which of these metrics to apply to any given category of product along with acceptable conformance criteria is provided in subsequent parts of ISO/TS 15311.

Although this part of ISO/TS 15311 is expected to be used primarily to measure prints from digital printing systems, the metrics are general and can be applied to other kinds of print.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2813, *Paints and varnishes — Determination of specular gloss of non-metallic paint films at 20 degrees, 60 degrees and 85 degrees*

ISO 8254-2, *Paper and board — Measurement of specular gloss — Part 2: 75 degree gloss with a parallel beam, DIN method*

ISO 12642-2, *Graphic technology — Input data for characterization of 4-colour process printing — Part 2: Expanded data set*

ISO 12647-8:2012, *Graphic technology — Process control for the production of half-tone colour separations, proof and production prints — Part 8: Validation print processes working directly from digital data*

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

ISO 18924, *Imaging materials — Test method for Arrhenius-type predictions*

ISO 18930, *Imaging materials — Pictorial colour reflection prints — Methods for evaluating image stability under outdoor conditions*

ISO 18937:2014, *Imaging materials — Photographic reflection prints — Methods for measuring indoor light stability*

ISO/IEC TS 24790:2012, *Information technology — Office equipment — Measurement of image quality attributes for hardcopy output — Monochrome text and graphic images*

ISO/IEC TS 29112, *Information technology — Office equipment — Test charts and methods for measuring monochrome printer resolution*

3 Terms and definitions

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

3.1
achromatic colour
perceived colour of low chroma, in the perceptual sense

Note 1 to entry: The colour names “white”, “grey” and “black” are commonly used for objects that reflect light. For objects that transmit light, the words “colourless” and “neutral” are used.

Note 2 to entry: In printing practice, achromatic colours can be produced either by a single black ink or three chromatic (and one achromatic) inks suitably balanced.

Note 3 to entry: Colours with low chroma are also called near neutral colours.

3.2
banding
appearance of one dimensional bands within an area that should be homogeneous

Note 1 to entry: This is also known as streakiness, while the artefacts are called streaks, bands, or stripes.

Note 2 to entry: Adapted from ISO 24790.

3.3
CIEDE2000 colour difference
total colour difference as defined in ISO/CIE 11664-6:2014 (CIE S 014-6/E:2013)

Note 1 to entry: The unit is ΔE00. The default weights for lightness, chroma and hue are (1:1:1).

3.4
colour deviation
difference between the colour aim value and the mean of a set of colour measurements

3.5
colour variation
colour difference from the mean of a set of colour measurements

Note 1 to entry: Colour variation is also known as colour fluctuation and may be reported as the mean or 95 percentile.

3.6
digital print
print where the image is printed directly from the digital domain

Note 1 to entry: Digital printing is a process for text and image reproduction with a colour marker on a medium using a marking device, on which the marking information is generated from digital data directly to the medium. It differs from traditional ink-based printing on which the marking information is generated from a form produced offline prior to imaging on the medium.

Note 2 to entry: Adapted from ISO 18913.

3.7
permanence
ability to remain chemically and physically stable over long periods of time

[SOURCE: ISO 18913:2012, 3.134]

3.8
image quality
impression of the overall merit or excellence of an image, as perceived by an observer neither associated with the act of photography, nor closely involved with the subject matter depicted

Note 1 to entry: The purpose of defining image quality in terms of third-party (uninvolved) observers is to eliminate sources of variability that arise from more idiosyncratic aspects of image perception and pertain to attributes outside the control of imaging system designers.

3.9
printing condition
set of primary process parameters which describe the conditions associated with a specific printed output, associated with spectral, colorimetric and/or densitometric aim values

Note 1 to entry: Such parameters usually include (as a minimum) printing process, paper category, printing ink, screening and printing sequence. The aim values typically comprise the colorant description and tone value increase aims.

Note 2 to entry: For the purposes of colour management, a printing condition is fully characterized by giving the relationship between the CMYK digital input values (as stipulated in ISO 12642-2) and the corresponding measured colorimetric values.

Note 3 to entry: Based on a given set of characterization data according to 3.9, Note 2 entry and a definition of achromatic perception, a grey condition might be extracted.

3.10
tone value
proportional printing value encoded in a data file and interpreted as defined in the file format specification

$$A = 100 \times \left(\frac{V_p - V_0}{V_{100} - V_0} \right) \%$$

where

V_p is the integer value of the pixel;

V_0 is the integer value corresponding to a tone value of 0 %;

V_{100} is the integer value corresponding to a tone value of 100 %.

Note 1 to entry: Tone value is expressed in units of percent.

Note 2 to entry: Most files store these data as 8-bit integer values, i.e. 0 to 255. The tone value of a pixel is typically computed from the formula.

4 Requirements

4.1 General

The following subclauses provide a number of metrics that define attributes of printed sheets and requirements for reporting them.

In many cases, the existing standards use CIE ΔE_{ab} rather than CIEDE2000. Although these are not interchangeable quantities, ΔE_{ab} has been superseded by CIEDE2000 in ISO/TC 130 standards. For this reason, CIEDE2000 shall be used to report colour difference metrics in this part of ISO/TS 15311.

Similarly, printing density is seldom used to measure colour and where the referenced standards specify printing density, approximately equivalent CIELAB colour measurements shall be used.

4.2 Single or multiple sheet assessment

Unless otherwise specified, metrics shall be assumed to apply to the assessment of a single sheet.

In many cases, it is useful to be able to report metrics for a set of sheets; for example, the set of sheets produced in a single print run or the set of sheets to be delivered as part of an order for print. In these cases, it is important to be able to indicate the likely variation across the entire set of sheets.

Sheets should be selected randomly with no replacement.

Samples should be selected with the following provisos:

a) sheets should be selected throughout the entire press run;

b) sheets should not be selected synchronous to any press event, e.g. at each roll change or after every blanket wash.

In cases where metrics are reported for a set of sheets, the report shall indicate the following: the total number of sheets in the set to be assessed, the number of sheets measured and, unless random selection with no replacement is used, the sampling method used to select the sheets shall be indicated.

4.2.1 Total number of sheets

The total number of sheets in the set of sheets assessed shall be reported (when metrics are reported). Details of the printing system used to create the sheets should also be reported.

4.2.2 Number of sheets measured

As a general rule, the higher the number of sheets measured from the set, the lower the uncertainty in the metric will be. Where there is a large number of sheets in the set, it may be impractical to measure a high percentage of these sheets and so the uncertainty (likely spread of values) may be high. Table 1 provides guidelines for the suggested number of sheets to be assessed for different sizes of sets of sheets to ensure that the metric being reported is somewhat representative of the entire set of sheets.

Table 1 — Guidelines for the number of sheets to be assessed

Total number of sheets in set	Suggested number of sheets to be measured
50	12
100	13
1 000 and greater	15

Table 1 provides typical sampling strategies used in the industry today. Users should be aware that where these values are used, the average value for the total set of sheets may vary substantially from the average measured for the sample set. Annex A provides details of how the likely difference between these two values varies with the sample size and provides a method for finding the sampling rate needed to reduce the uncertainty to a required level.

4.2.3 Reporting

When multiple sheets are assessed, the total number of sheets and the number of samples shall be reported as shown in the example below.

EXAMPLE 1 Sheets assessed: 13 (500).

When multiple sheets are assessed, the mean and standard deviation for each metric shall be reported as shown below except when reporting colour difference metrics.

EXAMPLE 2 Average line width: 0,12 mm, σ = 0,01 mm.

When reporting colour difference metrics for a single colour measured on multiple sheets, both the colour deviation and colour variation should be reported.

EXAMPLE 3 Colour deviation 3,2 DE_{00}, colour variation 0,8 DE_{00}.

Where the spread of colour difference values is reported, the average colour difference and the 95 percentile (and not the standard deviation) should be used.

EXAMPLE 4 Average colour difference: 2,8 DE_{00}, 95 percentile: 4,2 DE_{00}.

NOTE Standard deviation is not an appropriate measure for colour difference as this assumes a normal distribution, whereas colour differences generally have a chi-squared (k = 3) distribution. The 95 percentile provides a more reliable estimate of the spread of values.

4.3 Print quality measures

4.3.1 Overview

Image quality metrics or attributes are aspects, dimensions or components of overall perceived print image quality.

The visual attributes specified in this part of ISO/TS 15311, to be used by the remaining parts of ISO/TS 15311, are defined in the following clauses.

4.3.2 Colour, tone reproduction and gloss

4.3.2.1 General

Colour accuracy describes the visual closeness between a defined reference and a reproduction. It is important to distinguish two concepts: absolute and media relative colour accuracy.

Absolute colour accuracy is usually required for side-by-side viewing, whereas media relative colour accuracy is usually more desirable for sequential viewing where the prints being compared are never viewed together.

When selecting a suitable metric, it is important to know which kind of comparison is expected and when reporting colour metrics, the colour accuracy method and the intended evaluation method should be indicated.

4.3.2.2 Print substrate

In some cases, it may be desirable to indicate the substrate that is used when reporting other attributes. For example, the colour accuracy achieved for a particular reference printing condition usually depends on the substrate. This is only likely to be useful for cases where isotropic (paper-like) substrates are used.

When such substrate attributes are included they shall be reported as shown in Table 2.

Table 2 — Substrate reporting requirements

Print substrate attribute	Description	Example
Substrate name	(Required) A text string that provides details of the substrate used. This should include sufficient detail to enable purchase of similar substrate.	Substrate name: StoraEnso NovaPress
Substrate colour	(Required) CIELAB D50/2° M1 colour value of the substrate measured as specified in ISO 13655	Substrate colour: (95,0.5, –2) CIELAB
Other metrics from ISO 15397 may be reported	(Optional)	Report metric as indicated in ISO 15397

4.3.2.3 Absolute colour reproduction (process colours)

In some cases, particularly when proofing, it is useful to be able to estimate the accuracy to which the print simulates a reference printing condition and this attribute is called “absolute colour accuracy”.

When reported, assessment of absolute colour accuracy shall be performed by printing and measuring an ISO 12642-2 characterization data chart or where appropriate a subset of these patches (control strip patches) according to ISO 12647-8:2012, 5.2.

The values shown in Table 3 shall be reported using the measurement units shown and values shall be reported to two significant figures.

Table 3 — reporting absolute colour reproduction parameters

Description	Full label	Abbreviated label	Units
Maximum colour difference for all control strip patches	Control strip maximum	CSMax	ΔE_{00}
Average colour difference for control strip patches	Control strip average	CSAve	ΔE_{00}
Average chromaticness difference for CMY neutral control strip patches	Control strip neutrals average	CSAveNeutral	ΔC_h
Average colour difference for selected surface gamut patches	Characterization chart surface patches average	CCAveSurface	ΔE_{00}
The average colour difference for the characterization chart	Characterization chart average	CCAve	ΔE_{00}
The 95th percentile for the characterization chart	Characterization chart 95th percentile	CC95 %	ΔE_{00}

EXAMPLE 1 **Absolute colour accuracy**: CSMax (8,0 ΔE_{00}), CSAve (3,0 ΔE_{00}), CSAveNeutral (2,5 ΔC_h), CCAveSurface (4,0 ΔE_{00}), CCAve (3,0 ΔE_{00}), CC95 % (6,0 ΔE_{00}).

EXAMPLE 2 **Absolute colour accuracy**

Control strip maximum: 8,0 ΔE_{00}

Control strip average: 3,0 ΔE_{00}

Control strip neutrals average: 2,5 ΔC_h

Characterization chart surface patches average: 4,0 ΔE_{00}

Characterization chart average: 3,0 ΔE_{00}

Characterization chart 95th percentile: 6,0 ΔE_{00}

4.3.2.4 Media relative colour reproduction (process colours)

In some cases, particularly when creating final use prints, it is useful to be able to estimate the accuracy to which the print simulates a reference printing condition but where the print substrate used differs from that of the reference. In this case, there is no intent to be able to compare the print "side-by-side" with the reference but instead, the intent is "sequential viewing", where the print is viewed some time after the reference.

When reported, assessment of media relative colour accuracy shall be performed by printing and measuring an ISO 12642 characterization data chart and a subset of these patches (control strip patches) according to ISO 12647-8:2012, 5.2 as follows. CIEXYZ colour coordinates X, Y and Z shall be calculated for each printed patch as detailed in ISO 13655. The CIEXYZ colour of the substrate (Xn, Yn, Zn) shall be determined by averaging the measurements of the white patches from the printed target. Media-relative Lab values are then calculated according to CIELAB colour space formulae defined in ISO 13655 using the XYZ values of the substrate as Xn, Yn and Zn.

The colour difference between the print substrate used and reference printing condition substrate should be reported.

In a similar way, media-relative Lab values are calculated for the reference printing condition characterization data and these two sets of media-relative values compared to calculate the colour differences for corresponding colour values. The values shown in Table 4 shall be reported using the measurement units shown and values shall be reported to at least two significant figures.

Table 4 — Reporting media relative colour reproduction parameters

Description	Full label	Abbreviated label	Units
Colour difference between the print substrate used and reference printing condition substrate	Substrate difference (mr)	mrSub	ΔE_{00}
Maximum colour difference for all control strip patches	Control strip maximum (mr)	mrCSMax	ΔE_{00}
Average colour difference for control strip patches	Control strip average (mr)	mrCSAve	ΔE_{00}
Average chromatic difference for CMY neutral control strip patches	Control strip neutrals average (mr)	mrCSAveNeutral	ΔC_h
Average colour difference for selected surface gamut patches	Characterization chart surface patches average (mr)	mrCCAveSurface	ΔE_{00}
The average colour difference for the characterization chart	Characterization chart average (mr)	mrCCAve	ΔE_{00}
The 95th percentile for the characterization chart	Characterization chart 95th percentile (mr)	mrCC95 %	ΔE_{00}

EXAMPLE 1 **Media relative colour accuracy**: mrSub (3,2 ΔE_{00}), mrCSMax (8,0 ΔE_{00}), mrCSAve (3,0 ΔE_{00}), mrCSAveNeutral (2,5 ΔC_h), mrCCAveSurface (4,0 ΔE_{00}), mrCCAve (3,0 ΔE_{00}), mrCC95 % (6,0 ΔE_{00}).

EXAMPLE 2 **Media relative colour accuracy**

Substrate difference (mr): 3,2 ΔE_{00}

Control strip maximum (mr): 8,0 ΔE_{00}

Control strip average (mr): 3,0 ΔE_{00}

Control strip neutrals average (mr): 2,5 ΔC_h

Characterization chart surface patches average (mr): 4,0 ΔE_{00}

Characterization chart average (mr): 3,0 ΔE_{00}

Characterization chart 95th percentile (mr): 6,0 ΔE_{00}

4.3.2.5 Gloss

When proofing, the gloss of substrate and solid tone colours should be visually similar to the reference print to be simulated. For this reason, where information about the ink set gloss of the printing condition is known, it is useful to indicate ink set gloss when proofs are made.

NOTE Definitions for reference printing conditions often do not specify a gloss level for either the substrate or ink set.

Where ink set gloss is reported, the gloss of solid coloured patches of each of the process inks shall be measured with either 75° (15° from the plane of the print substrate) or 60° (30° from the plane of the print substrate) gloss angles. The gloss of solid colours shall be measured by the same condition with the substrate gloss measurement.

An instrument that conforms to ISO 8254-1 or ISO 2813 (for the 60°) shall be used to make measurements.

Values shall be reported as percentages and shall reference ISO 8254-1 or ISO 2813 as the method.

EXAMPLE 1 Substrate Gloss (ISO 8254-1 TAPPI gloss): 60 GU.

EXAMPLE 2 Ink Set Gloss (ISO 8254-1 TAPPI gloss): Cyan (60 GU), Magenta (54 GU), Yellow (50 GU), Black (30 GU).

4.3.3 Uniformity

4.3.3.1 General

Uniformity (homogeneity) refers to the subjective impression of colour uniformity across a large image that is intended to have a uniform colour. Colour uniformity refers to all types of colour variation: lightness, hue, saturation or derivatives of these measures separately or in combination. All types of colour variation are taken into account including, but not restricted to: 1D, 2D, periodic, aperiodic, localized, large-scale and small-scale variation, separately or in combination such as streaks, bands, gradients, mottle and moiré.

When measuring homogeneity the intended viewing distance shall be taken into account.

4.3.3.2 Banding — Monochrome

When measuring banding, the method defined in ISO/IEC TS 24790:2012, 5.2.9 shall be used.

Banding has no measurement unit but typically produces a number in the range 0-5.

EXAMPLE Banding (monochrome): 1,8.

4.3.3.3 Large area uniformity

When measuring large area uniformity, ISO 12647-8:2012, 4.2.2.1 shall be used.

The maximum CIEDE2000 colour difference between the average of the 9 readings and any one reading shall be reported.

EXAMPLE Large area uniformity: max colour difference 1,3 ΔE_{00}.

4.3.3.4 Mottle — Monochrome

Mottle measurements provide an indication of the apparent low frequency image noise in prints and usually refers to those fluctuations with a spatial resolution below 0,4 cycles per millimetre in all directions for standard viewing distance of 400 mm.

When reporting Mottle, the method defined in ISO/IEC TS 24790 shall be used.

This part of ISO/TS 15311 assumes a viewing distance of 400 mm and should be adapted for different viewing distances.

Mottle has no measurement unit but produces a number in the range 0-5.

EXAMPLE Mottle: 2,8.

4.3.3.5 Graininess — Monochrome

Graininess measurements provide an indication of the apparent high frequency noise in prints and typically refers to aperiodic fluctuations of density at a spatial frequency greater than 0,4 cycles per millimetre in all directions for standard viewing distance of 400 mm.

When reporting Graininess, the method defined in ISO/IEC TS 24790 shall be used.

This part of ISO/TS 15311 assumes a viewing distance of 400 mm and should be adapted for different viewing distances.

Graininess has no measurement unit but produces a number in the range 0-5.

EXAMPLE Graininess: 3.0.

4.3.3.6 Show through

When show through (the level to which a colorant is seen from the back of a print) is reported, it shall be measured as follows.

A test form similar to that shown in Figure 1 shall include a patch of solid Black and should also include solid patches of the other solid process colours, two-colour overprints (MY, CY, CM) and three colour overprint (CMY) printed on only one side of the sheet. The other side of the sheet shall remain unprinted.

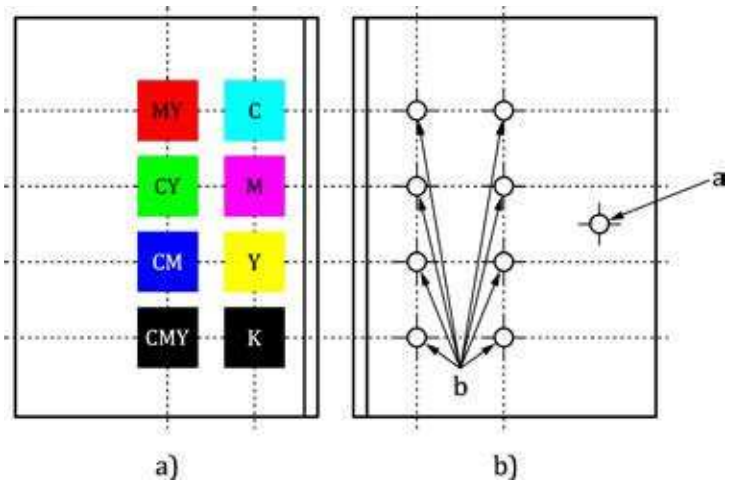

Figure 1 — Test print for measuring show through

The CIELAB colour value of a region of the substrate which is unprinted on both sides of the sheet (a) shall be measured.

The CIELAB colour value of each point at the centre(s) of each of the patches of solid process colour on the reverse (unprinted) side of the sheet (b) shall be measured.

The CIEDE2000 colour difference between each of the measurements (b) and the measurement of the unprinted substrate (a) shall be calculated. The maximum value of these colour differences shall be reported as the show through metric. The set of solid process colours actually measured shall be specified, for example (K) or (CMYK).

Measurements shall be made with white backing as specified in ISO 13655.

EXAMPLE Show through: 1,7 ΔE_{00} (C,M,Y,K,MY,CY,CM,CMY).

4.3.4 Detail rendition capabilities

4.3.4.1 General

Resolution (or sharpness) is a measure of the ability of a printing system to print fine detail. It is a perceptually complex concept, which has no single, simple, objective measure. Sometimes sharpness and resolution will be further differentiated where sharpness of a printer refers to the capability of that printer to produce a distinct edge and the resolution of a printer refers to the capability of that printer to reproduce fine details.

The attributes described in this sublcause contribute to resolution perception.

4.3.4.2 Line width

Line width is a measure of the ability of a print to resolve fine detail accurately. Where this measure is reported, the width of the line measured normal to the line from edge threshold to edge threshold as defined in ISO/IEC TS 24790 shall be used.

The line width of a black-only line shall be reported and the line width of a CMY line should be reported. Both vertical and horizontal lines shall be measured and the specified line width shall be reported.

Measurement units shall be mm.

EXAMPLE 0,1 mm vertical line width: 0,12 mm (K), 0,15mm (CMY).

0,1 mm horizontal line width: 0,09 mm (K), 0,11 mm (CMY).

4.3.4.3 Line darkness

Line image density is a measure of the readability of text on a print. When measuring line image density, the method defined in ISO/IEC TS 24790 (character darkness) shall be used.

The line width of the evaluated line shall be specified and reported.

Measurements shall be reported as density which has no unit.

EXAMPLE 100 µm line darkness: 1,9.

4.3.4.4 Line blurriness

Blurriness (inverse of sharpness) is a measure of prints from a printing system being hazy or indistinct in outline.

Where blurriness is reported, a noticeable transition of blackness from background to character shall be measured using the method defined in ISO/IEC TS 24790. Where blurriness is measured, both edges of line shall be measured and the average of them shall be reported. At least vertical and horizontal line shall be measured. The line width of the evaluated line shall be specified and reported.

Measurement units shall be mm.

EXAMPLE 0,100 mm vertical line blurriness: 0,200 mm.

0,100 mm horizontal line blurriness: 0,100 mm.

4.3.4.5 Line raggedness

Raggedness is a measure of the readability of text on a print. The appearance of geometric distortion of an edge from its ideal position is called raggedness. A ragged edge appears rough or wavy rather than smooth or straight.

Where raggedness is reported, the standard deviation of the residuals from a line fitted to the edge threshold shall be measured using the method defined in ISO/IEC TS 24790. Where raggedness is measured both edges of line shall be measured and the average of them shall be reported. At least vertical and horizontal line shall be measured. The line width of the evaluated line shall be specified and reported.

Measurement units shall be mm (standard deviation of the residual) and shall be reported to two significant digits.

EXAMPLE 0,100 mm vertical line raggedness: 0,062 mm.

0,100 mm horizontal line raggedness: 0,055 mm.

4.3.4.6 Modulation transfer function (MTF)

Modulation transfer function is basically a measure of a printing system's ability to reproduce details. In detail, it is the ratio, as a function of spatial frequency, of the measured modulation response in a print produced by a printing system, to the stimulus modulation presented to that printing system.

Where MTF is reported, the method defined in ISO/IEC TS 29112 shall be used.

Measurement units shall be line pairs per mm (lp/mm).

EXAMPLE MTF: 286 lp/mm.

NOTE Bonnier gives an overview of different ways to compute the MTF of a printing systems in Reference [17].

4.3.4.7 Effective addressability

The effective addressability is a measure of a printing system's ability to produce sharp images. When effective addressability is reported, the method defined in ISO/IEC TS 29112 shall be used.

Measurement units shall be lines per mm (mm^{-1}).

EXAMPLE Effective addressability: 47 lines per mm.

Frequently, native addressability is confused with effective addressability; this is often called "resolution" which, in most cases, is very misleading as it does not usually correlate well with perceived resolution or image sharpness. This measure should not be reported as an image quality metric.

4.3.5 Permanence

The following requirements provide a basis for typical permanence behaviours. However, each part of ISO/TS 15311 can use and reference additional standards and procedures for physical properties, permanence behaviour and the effect of environmental factors on printing materials such as those defined by ISO/TC 42.

4.3.5.1 Indoor light stability

When reported, the indoor light stability shall be measured according to the method described in ISO 18937.

For indoors home and office display, “Simulated indoor daylight typical home display” condition stipulated in ISO 18937:2014, 7.2 shall be used.

NOTE Including the dark cycle may make the evaluation period unnecessarily long and if a suitable shorter alternative can be demonstrated which produces the same results that alternative may be used as long as an explanation of the method is provided.

For in-window display, “simulated direct sunlight indoor in-window display” condition stipulated in ISO 18937:2014, 7.3 shall be used.

The test sheet used to assess light stability shall include the set of control strip patches specified in ISO 12647-8 and the mean and maximum colour difference (CIEDE2000) between the measurements of these patches before and after the test shall be reported.

Reported results shall indicate whether “indoors” or “in-window” testing were performed.

Where the change in colour affects one set of colours significantly more than others, this should be reported.

Full details of the testing performed should be made available in a separate document and its URI (Uniform Resource Indicator) provided.

EXAMPLE 1 Colour stability (ISO 18937, indoors, <URI>): colour change 3,2 ΔE_{00} (max) 1,3 ΔE_{00} (mean).

EXAMPLE 2 Colour stability (ISO 18937, in-window, <URI>): colour change 3,8 ΔE_{00} (max) 1,5 ΔE_{00} (mean).

4.3.5.2 Weathering

When reported, the outdoor stability shall be measured according to the method described in ISO 18930.

The test sheet used to assess outdoor weathering shall include the set of control strip patches specified in ISO 12647-8 and the mean and maximum colour difference (CIEDE2000) between the measurements of these patches before and after the test shall be reported.

Reported results shall indicate whether accelerated laboratory testing (lab) or outdoor weathering testing (outdoor) was performed.

Where the change in colour affects one set of colours significantly more than others, this should be reported.

Full details of the testing performed should be made available in a separate document and its URI provided.

EXAMPLE 1 Weathering (ISO 18930, lab, <URI>): colour change 4,2 ΔE_{00} (max) 3,1 ΔE_{00} (mean).

EXAMPLE 2 Weathering (ISO 18930, outdoor, <URI>): colour change 4,2 ΔE_{00} (max) 3,1 ΔE_{00} (mean).

4.3.5.3 Thermal stability

When reported, thermal stability should be measured according to the method described in ISO 18936. Based on the test results, the expected print life stored at the specific environmental condition shall be estimated using Arrhenius prediction method described in ISO 18924.

Where the estimated print life is less than one year, the number of days shall be reported, otherwise the integral number of years (rounding down) shall be reported.

The lifetime cannot always be determined by Arrhenius plot because the changes due to heat is hardly observed for some prints. In such cases, the report may include the words “at least” to qualify the time period.

Full details of the testing performed should be made available in a separate document and its URI provided.

EXAMPLE 1 Thermal stability (ISO 18936, <URI>): 50 years.

EXAMPLE 2 Thermal stability (ISO 18936, <URI>): at least 100 years.

4.4 Printing conditions

The actual printing conditions used to print a document or test chart play a significant role in the quality of the printed material; therefore, the actual printing conditions shall be reported to the extent necessary to permit an accurate reproduction of the print whose metrics are being reported.

NOTE The information necessary to allow repeat prints to be made varies substantially from one system to another and so standardized reporting is not possible. The following items are examples of typical printer settings: print mode, print speed, number of passes, corrections for offset and miss-registration, heating/fusing settings, uni- or bi-directional printing, resolution and any other adjustments made that would influence the quality of the final output.

Annex A
(informative)

Sampling of sheets

A.1 Calculating the number of sheets to be sampled

The number of sheets to be sampled was determined using the standard sampling formula [Formula (A.1)]. Formula (A.1) is most commonly used to calculate the number of samples required for a survey for public opinion polls.

Formula for calculating the number of sheets to be sampled:

$$n = \frac{N}{\left(\frac{E}{Z}\right)^2 \left\{\frac{N-1}{P(1-P)}\right\} + 1} \tag{A.1}$$

where

N is the total number of sheets in the set of sheets to be sampled;

E is the desired maximum error in the resulting estimate;

Z is the reliability coefficient;

P is the assumed ratio of population mean.

A.2 Desired maximum error *E*

The observed variation comprises the sum of the true variation, the measurement error and the statistical sampling error. The objective is that the statistical error should be significantly smaller than the true variation. Attempting to reduce the sampling error to a value less than 10 % of the maximum sampling error requires a large increase in the number of sheets sampled. For example, approximately half of the sheets must be sampled when the set of printed sheets to be assessed is small (less than 100 sheets).

In this part of ISO/TS 15311, it is necessary to determine the number of sheets to be sampled to ensure that the result remains statistically significant. This means that the measured average values of the variation do not overlap even if including the range of statistical error.

In order to satisfy these conditions, a desired maximum error, E, of 0,25 (25 %) is used. Table A.1 shows the number of sheets from a set of 1 000 sheets that need to be measured for different values of E.

Table A.1 — Number of sheets to be measured for different values of *E*

N	*E*	*Z*	*P*	*n*	*n* (rounded)
1 000	0,25	1,96	0,5	15,148 77	15
1 000	0,20	1,96	0,5	23,469 96	23
1 000	0,15	1,96	0,5	40,976 37	41
1 000	0,10	1,96	0,5	87,704 56	88
1 000	0,05	1,96	0,5	277,740 8	278

A.3 Reliability coefficient *Z*

The reliability coefficient is the ratio of the standard deviation of the actual sheet measurements to the standard deviation of the measured sheets. A value of 1,96 was used for *Z* which corresponds to a confidence interval of 95 % when the measurement data has a normal distribution.

A.4 Ratio of population mean *P*

The value of *P* was set to 0,5 as general statistical value.

A.5 Total number of sheets *N*

This part of ISO/TS 15311 provides advice for sampling of sets of sheets of 50, 100, 1 000 and greater than 1 000 sheets. For these cases, the value calculated for n using Formula (A.1) is as shown in Table A.2.

Table A.2 — Calculated total number of sheets *n*

N	*E*	*Z*	*P*	*n*	*n* (rounded)
50	0,25	1,96	0,5	11,936 66	12
100	0,25	1,96	0,5	13,436 11	13
1 000	0,25	1,96	0,5	15,148 77	15
100 000	0,25	1,96	0,5	15,364 19	15
1 000 000	0,25	1,96	0,5	15,366 18	15

As can be seen from Table A.2, there is little benefit in sampling more than 15 sheets even for a large sample set.

A.6 Statistical distribution

The results described above apply to measurement data with a normal distribution and hold only approximately for other distributions. This is an important aspect to consider when measuring colour difference as CIEDE2000 does not have a normal distribution and is typically closer to a chi-squared (k = 3) distribution.

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