TECHNICAL SPECIFICATION

ISO/TS 15311-1

Third edition
2020-12

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

Part 1: Measurement methods and reporting schema

Technologie graphique — Exigences relatives aux imprimés destinés à la production commerciale et industrielle —

Partie 1: Méthodes de mesure et schémas de rapport

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 of 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 130, *Graphic technology*.

This third edition of cancels and replaces the second edition (ISO/TS 15311-1:2019), which has been technically revised.

The main changes compared to the previous edition are as follows:

— the following new subclauses have been added:

  — 4.3.2.8, Computing and analysing colour gamut

  — 4.3.5.3, Indoor light stability (display window)

  — 4.3.6.2, Contouring

  — 4.3.4.8, Perceived resolution

  — 4.3.3.8, Macroscopic uniformity

— 4.3.5.2, Indoor light stability (home and office display) has been modified.

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

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 document 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 document can be applied to any type of print. They are likely most often to 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 document. 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 document within a very short time scale as new metrics are tested and found to be reliable.

Additional tests to those specified in this document, 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 document.

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

Part 1: Measurement methods and reporting schema

1 Scope

This document defines print quality 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 product category along with acceptable conformance criteria is provided in subsequent parts of ISO/TS 15311.

Although this document 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 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 2813, *Paints and varnishes — Determination of gloss value at 20°, 60° and 85°*

ISO 8254-1, *Paper and board — Measurement of specular gloss — Part 1: 75 degree gloss with a converging beam, TAPPI method*

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

ISO 12647-8, *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 15184, *Paints and varnishes — Determination of film hardness by pencil test*

ISO 18619, *Image technology colour management — Black point compensation*

ISO/TS 18621-11, *Image quality evaluation methods for printed matter — Part 11: Colour gamut analysis*

ISO/TS 18621-21, *Graphic technology — Image quality evaluation methods for printed matter — Part 21: Measurement of 1D distortions of macroscopic uniformity utilizing scanning spectrophotometers*

ISO/TS 18621-31, *Graphic technology — Image quality evaluation methods for printed matter — Part 31: Evaluation of the perceived resolution of printing systems with the contrast–resolution chart*

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 18935, *Imaging materials — Colour images — Determination of water resistance of printed colour images*

ISO 18936, *Imaging materials — Processed colour photographs — Methods for measuring thermal stability*

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

ISO 18947, *Imaging materials — Photographic reflection prints — Determination of abrasion resistance of photographic images*

ISO/TS 21139-21, *Permanence and durability of commercial prints — Part 21: In-window display — Light and ozone stability*

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

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

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:

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

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

3.1
banding
appearance of one dimensional variation within an area that should be homogeneous

3.2
CIEDE2000 colour difference
method of/formula for calculating colour difference, ΔE_{00}/CIEDE00

Note 1 to entry: See ISO/CIE 11664-6 for details.

3.3
colour deviation
colour difference between the colour aim value and a colour measurement or the mean of a set of colour measurements

Note 1 to entry: In addition to the ΔE_{00} the ΔL^* with Δa^* and Δb^* and/or with ΔC^* and ΔH^* may be reported.

3.4
colour variation
colour difference between the mean of a set of colour measurements and each sample

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

3.5
digital printing
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

Note 1 to entry: Digital printing differs from traditional ink-based printing on which the marking information is generated from a form produced offline prior to imaging on the medium.

3.6
permanence
ability to remain chemically and physically stable over long periods of time

[SOURCE: ISO 18913:2012, 3.134]

3.7
image quality
impression of the overall merit or excellence of an image, as perceived by an observer

Note 1 to entry: For a meaningful technical evaluation of image quality, the evaluation should be based on a third-party assessment, i.e. by an observer neither associated with the artistic creation of the image, nor closely or emotionally involved with the subject matter being depicted. This restriction is designed to eliminate sources of variability that arise from more idiosyncratic aspects of image perception that are outside control of imaging system designers.

[SOURCE: Handbook of Image Quality: Characterization and prediction]

3.8
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 digital input values (for example 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 to entry and a definition of achromatic perception, a grey printing condition might be extracted.

3.9
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.

3.10
URI
Uniform Resource Identifier
compact sequence of characters that identifies an abstract or physical resource

Note 1 to entry: See IETF RFC 3986 for details.

3.11
CIELAB chromaticness difference
ΔC_h
difference between two colours of approximately the same lightness projected onto a constant lightness plane in the CIELAB colour space

Note 1 to entry: This is calculated as $\Delta C_h = \sqrt{\left(\text{CIE}\,a_1^* - \text{CIE}\,a_2^*\right)^2 + \left(\text{CIE}\,b_1^* - \text{CIE}\,b_2^*\right)^2}$

Note 2 to entry: [SOURCE: ISO 13655:2017, 3.5]

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 document.

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

4.2.1 General

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.

NOTE Best practice sampling is time-stamped to demonstrate what time and date the sample was taken.

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.

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.

4.2.2 Total number of sheets

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

4.2.3 Number of sheets measured

Conformance with this document requires only that values measured for the sampled set of sheets are reported. As a general rule, the higher the number of sheets measured from the set, the closer this value will be to that of the entire set of sheets. Where there are a large number of sheets in the set, it may be impractical to measure a high percentage of these sheets and so the likely spread of values may be high. Table 1 provides guidelines for the suggested number of sheets to be assessed for different numbers of sheets in the set.

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 (and the 95th percentile) 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 increase the confidence in the metric to a required level.

NOTE ISO 186 suggests increasing the number of samples to 20 for run lengths greater than 5 000.

In order to verify whether the difference between the two values is statistically significant, the variable E of Annex A can be used as a point of reference. The number of samples may be chosen to avoid overlapping error bars by selecting an appropriate value for E.

4.2.4 Reporting

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

EXAMPLE 1 Sheets assessed: 15 (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 Estimated line width: sample mean = 0,12 mm, sample standard deviation = 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.

The colour deviation shall be calculated as follows: calculate the mean CIELAB value of the samples. The colour deviation is given by the CIEDE2000 colour difference between the CIELAB colour aim value and the mean CIELAB value. In addition to the ΔE_{00} value the ΔL^*, Δa^* and Δb^* values (Mean - Reference) should be reported.

EXAMPLE 3 Colour deviation 3,2 ΔE_{00}, $\Delta L^* = 2{,}8$, $\Delta a^* = 0{,}3$, $\Delta b^* = 1{,}4$.

The colour variation shall be calculated as follows: calculate the mean CIELAB value of the samples. Calculate the CIEDE2000 colour differences between this mean and the CIELAB of each sample. The colour variation is given by the mean value of these CIEDE2000 colour differences or the corresponding 95th percentile. Refer to Annex C for details on the calculation of the 95th percentile.

EXAMPLE 4 Colour variation 0,8 DE_{00}.

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

EXAMPLE 5 Colour variation 0,8 DE_{00}, 95th percentile 1,2 DE_{00}.

NOTE Standard deviation is not an appropriate measure for colour difference as this assumes a normal distribution, whereas colour differences are not normally distributed. The 95 percentile provides a more reliable estimate of the spread of values.

The parameters of arithmetic average (mean from a small sample set) and 95th percentile are well known and easy to compute. However, neither parameter is insensitive to the changes in the underlying distribution of readings or the presence of erroneous or outlier readings (statistical robustness). With the small numbers of readings being collected, a single bad read can move either the mean or the 95th percentile several points further away from their ideal values. When reporting these parameters, if the results are much larger than expected, then the data should be examined for values that are much larger than the rest of the sample. If this is the case, then that reading should be examined to determine if there is a cause for this difference and this may provide justification to leave that outlier out of the analysis.

Colour errors across multiple sheets shall be calculated and reported as follows. For all patches on all sheets, calculate the colour error between the patch and the corresponding reference colour. This results in a total of n × m colour errors where n is the number of colour patches on each sheet and m is the number of sheets. Calculate and report the mean and 95th percentile of this entire set of colour errors.

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 document, to be used by the remaining parts of ISO/TS 15311, are defined in the following subclauses.

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 Colour accuracy (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 (Validation print control strip).

NOTE Where the option to preserve 100 % K elements is used, the 100 % K patch on the control strip is likely to include an unexpected error.

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
Colour difference for substrate	Substrate	Sub	ΔE_{00}
Maximum colour difference for all control strip patches	Control strip maximum	CSMax	ΔE_{00}
The 95th percentile for the control strip patches	Control strip 95th percentile	CS95 %	ΔE_{00}
Average colour difference for control strip patches	Control strip average	CSAve	ΔE_{00}
Maximum chromaticness difference for CMY neutral control strip patches	Control strip neutrals maximum	CSMaxNeutral	ΔC_h
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}
NOTE Technically speaking the "unit" in this table represents the method by which the value is calculated.			

EXAMPLE 1 **Absolute colour accuracy**: Sub (1,2 ΔE_{00}), CSMax (8,0 ΔE_{00}), CS95 % (6,0 ΔE_{00}), CSAve (3,0 ΔE_{00}), CSMaxNeutral (3,2 ΔC_h), 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:

— Substrate: 1,2 ΔE_{00}

— Control strip maximum: 8,0 ΔE_{00}

— Control strip 95th percentile: 6,0 ΔE_{00}

— Control strip average: 3,0 ΔE_{00}

— Control strip neutrals maximum: 3,2 ΔC_h

— 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 Colour accuracy (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 sometime after the reference.

When reported, assessment of media relative colour accuracy shall be performed by printing and measuring an ISO 12642-2 characterization data chart and a subset of these patches (control strip patches) according to ISO 12647-8 (Validation print control strip) as follows. The reference CIEXYZ tristimulus values for each colour of these charts shall be calculated for the characterized printing condition to be simulated (X_{ref}, Y_{ref} and Z_{ref}) and these values shall be adjusted to provide aim values (X_{aim}, Y_{aim} and Z_{aim}) according to Formulae (1) to (3):

$$X_{aim} = X_{ref} \times \frac{X_s}{X_{rs}} \tag{1}$$

$$Y_{aim} = Y_{ref} \times \frac{Y_s}{Y_{rs}} \tag{2}$$

$$Z_{aim} = Z_{ref} \times \frac{Z_s}{Z_{rs}} \tag{3}$$

where

X_s, Y_s, Z_s are the CIEXYZ tristimulus values for the substrate colour determined by averaging the measurements of the white (unprinted) patches from the chart;

X_{rs}, Y_{rs}, Z_{rs} are the CIEXYZ tristimulus values for the reference substrate colour.

NOTE 1 These formulae are the same as ISO 12647-2:2013, Formulae (B.1) and (B.2), with X_{min}, Y_{min}, Z_{min} all equal to zero. The adjustment described by ISO 12647-2 is sometimes referred to as Substrate-Corrected Colorimetric Aims or SCCA.

CIELAB aim values are calculated using D50 as the reference white and the CIEDE2000 colour differences between these aim values and the values measured for each patch calculated to provide the media relative colour differences.

NOTE 2 Where the option to preserve 100 % K elements is used, the 100 % K patch on the control strip is likely to include an unexpected error.

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}
95th percentile colour difference for all control strip patches	Control strip 95th percentile (mr)	mrCS95 %	ΔE_{00}
Average colour difference for control strip patches	Control strip average (mr)	mrCSAve	ΔE_{00}
Maximum chromatic difference for CMY neutral control strip patches	Control strip neutrals maximum (mr)	mrCSMaxNeutral	ΔC_h
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}
NOTE Technically speaking, the "unit" in this table represents the method by which the value is calculated.			

EXAMPLE 1 Media relative colour accuracy: mrSub (3,2 ΔE_{00}), mrCSMax (8,0 ΔE_{00}), mrCS95 % (7,0 ΔE_{00}), mrCSAve (3,0 ΔE_{00}), mrCSMaxNeutral (3,2 ΔC_h), 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 95th percentile (mr): 7,0 ΔE_{00}

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

— Control strip neutrals maximum (mr): 3,2 ΔC_h

— 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 Colour accuracy (media relative colour reproduction with BlackPoint compensation)

In many cases, the BlackPoint of the actual printing condition is different from the BlackPoint of the reference characterized printing condition. For these cases, it is often necessary to use ICC Media Relative colour rendering with BlackPoint compensation (Media relative with BPC) in order to preserve shadow detail. Media relative colour reproduction with BlackPoint compensation is also assumed to have been applied according to ISO 18619 and prints are assessed as follows.

When reported, assessment of media relative colour accuracy with BlackPoint compensation should be performed by printing and measuring an ISO 12642-2 characterization data chart. A subset of these patches (control strip patches) according to ISO 12647-8 (Validation print control strip) shall be printed and measured. CIEXYZ tristimulus values X, Y and Z shall be calculated for each printed patch as detailed in ISO 18619 as follows:

— The CIEXYZ colour of the substrate (X_s, Y_s, Z_s) shall be determined by averaging the measurements of the white patches from the printed target.

— The reference CIELAB value for each patch of the control strip shall be estimated from the characterized reference printing condition for the sheet and the reproduction CIELAB values shall be measured from the printed sheet.

— Where possible, the BlackPoint of the reference shall be determined from a reference ICC Profile as described in ISO 18619, where no reference ICC Profile is available, the reference CIELAB value with the lowest neutral CIELAB L* value shall be used.

— Where possible, the BlackPoint of the print under test shall be determined from the ICC Profile used to create the print as described in ISO 18619. Where this ICC Profile is not available, the reproduction CIELAB value with the lowest neutral CIELAB L* value should be used.

NOTE 1 The method using the reference and reproduction CIELAB measurements is implemented in the Excel™ spreadsheet developed by Fogra which is available as an electronic attachment to Annex B.

NOTE 2 Where the BlackPoint is determined from the reference or reproduction CIELAB values the result is likely to be different from that where the BlackPoint is determined from the ICC Profile. This difference can be substantial in some cases.

The aim colour values for each patch are then calculated according to the formulae defined in ISO 18619 using these BlackPoints and using the XYZ values of the substrate as X_s, Y_s and Z_s. These aim values are then compared with the values measured from the charts.

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

The BlackPoint of the reference printing condition and the BlackPoint estimated from the control strip shall be reported.

In some cases, it is possible to identify the ICC Profile that was used by the printing system when making the print and in these cases the BlackPoint of this profile should be reported.

The values shown in Table 5 shall be reported using the measurement units shown and values shall be reported to at least two significant figures.

Table 5 — Required reporting for Media Relative with BPC

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 (bpc)	bpcCSMax	ΔE_{00}
Average colour difference for control strip patches	Control strip average (bpc)	bpcCSAve	ΔE_{00}
Average chromatic difference for CMY neutral control strip patches	Control strip neutrals average (bpc)	bpcCSAveNeutral	ΔC_h
Reference printing condition (RPC) BlackPoint	RPC BlackPoint	rpcBlackPoint	CIELAB
Estimated control strip BlackPoint from the printed sheet	Estimated control strip BlackPoint	printBlackPoint	CIELAB

The values shown in Table 6 should be reported.

Table 6 — Optional reporting for Media Relative with BPC

Description	Full label	Abbreviated label	Units
Average colour difference for selected surface gamut patches	Characterization chart surface patches average (bpc)	bpcCCAveSurface	ΔE_{00}
The average colour difference for the characterization chart	Characterization chart average (bpc)	bpcCCAve	ΔE_{00}
The 95th percentile for the characterization chart	Characterization chart 95th percentile (bpc)	bpcCC95 %	ΔE_{00}
Printer ICC Profile BlackPoint	ICC Profile BlackPoint	profileBlackPoint	CIELAB

EXAMPLE 1 Media relative (BPC) colour accuracy: mrSub (3,2 ΔE_{00}), bpcCSMax (8,0 ΔE_{00}), bpcCSAve (3,0 ΔE_{00}), bpcCSAveNeutral (2,5 ΔC_h), bpcCCAveSurface (4,0 ΔE_{00}), bpcCCAve (3,0 ΔE_{00}), bpcCC95 % (6,0 ΔE_{00}).

EXAMPLE 2 Media relative (BPC) colour accuracy:

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

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

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

— Control strip neutrals average (bpc): 2,5 ΔC_h

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

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

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

— RPC BlackPoint: CIELAB (9,00 0,00 -2,00)

— Estimated control strip BlackPoint: CIELAB (12,0 0,25 −1,23)

— ICC Profile BlackPoint: CIELAB (10,0 0,02 −2,0)

4.3.2.6 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).

4.3.2.7 Colour accuracy (spot colours)

When considering the colour accuracy of spot colours (for example when using brand colours) it is often necessary to match a reference under different illuminants. To achieve that, the reference is specified using spectral reflectance values. The objective of this test is to measure and report the colour difference between the reference and the printed colour when viewed under a number of different illuminants. The colour accuracy for spot colours test can be applied both when the spot colour is printed with a single spot colour ink, or when it is emulated using process colours.

NOTE 1 This is not generally done for process colours as matching of this kind would require a special ink set for each colour to be matched.

Spectral reflectance aim values for the reproduction of a solid patch of the spot colour shall be identified. Where intermediate tones of the spot colour are used, the spectral reflectance aim values for these intermediate tones should be identified.

A solid patch shall be printed and its spectral reflectance shall be measured. Where intermediate tones of the spot colour are used, patches corresponding to these intermediate tones shall be printed and their spectral reflectance shall be measured. One example is described in ISO 17972-4.

Measurements should be made according to ISO 13655 M1, M2 or M3 mode. The measurement standard (M1, M2 or M3), or the measurement conditions in absence of a standard, shall be reported.

NOTE 2 It is a common practice in the market to evaluate spot colours using UV filtered measurements (e.g. ISO 13655 M2). This is appropriate when no UV is expected to be present in the viewing environment. Other measurement geometry could be used to adapt to industry practice (e.g. d/8).

The CIELAB colour values for these reference patches and for the printed patches shall be calculated for the following illuminants: D50, A and F11 as described in ASTM E308 Tables 5.1, 5.9 and 5.33.

NOTE 3 Where optical brighteners are used in the reference sample or reproduction and where the measurement condition includes UV, it is important that the measurement instrument light source is calibrated to the UV content of the calculation illuminant.

In some cases, a colour match is required under a non-standard (custom) illuminant. In such cases the CIELAB colour values for the reference and printed patches should be calculated for this custom illuminant. Details of the custom illuminant shall be reported.

The CIEDE2000 colour difference between the reference patches and the printed patches under each illuminant shall be calculated and reported as follows.

— CIEDE2000 colour difference between reference and measured colour of solid spot under reference illuminant (D50),

— Maximum CIEDE2000 colour difference between reference and measured colour of solid spot for all illuminants (D50, A, F11 and, where specified, Custom),

— CIEDE2000 colour difference between reference and measured colour of 50 % spot under reference illuminant (D50),

— Maximum CIEDE2000 colour difference between reference and measured colour of 50 % spot for all illuminants (D50, A, F11 and, optionally, Custom),

— The illuminant for which the largest colour error in the spot colour was estimated,

— CIEDE2000 colour difference between reference and measured colour of substrate under reference illuminant (D50).

When reporting results, in order to present these in a consistent way that is easy for readers to understand, the format of Table 7 should be used.

Table 7 — Recommended reporting format showing an EXAMPLE for two spot colours

Spot ink name	**CIEDE2000 error under D50**			**Maximum CIEDE2000 error under test illuminants**[a]		
	Solid	**50 %**		**Solid**	**50 %**	
Substrate	2,1	N/A	Other tint levels	3,2 (LED)	N/A	Other tint levels
Spot name 1	3,5	3,1		3,6 (F11)	3,2 (F11)	
Spot name 2	6,4	8,4		8,2 (LED)	9,1 (F11)	
Other spot inks as required	...	...		...	...	
	...	...		...	...	
	...	...		...	...	

[a] Illuminants used: D50, D65, A (A), F11, Custom (white light LED) <URI>.

4.3.2.8 Computing and analysing colour gamut

It is often useful to be able to measure the size of the colour gamut of a print or to compare the sizes of two colour gamuts, for example:

a) the use of the colour gamut of a print as an indicator of its colour range,

b) where two prints have been produced by the same printing system but use different media or inks,

c) where two prints have been produced by two different printing systems,

d) where a print is a proof according to ISO 12647-7 and a second print is a production print. In this case it is useful to be able to check that the colour gamut of the proof is the same or completely contains the colour gamut of the production print,

e) where a print is to be compared to a reference characterisation data set or ICC Profile.

NOTE Comparisons like this are often used to indicate the relative performance of printing systems or between different configurations of the same printing system. Details of how to make prints and of the additional data that needs to be communicated to make such comparisons meaningful are outside the scope of this document.

Colour gamut surface and volume shall be computed using the methods described in ISO/TS 18621-11 as follows.

Print and measure a characterisation chart as specified in ISO 12642-2. Identify coloured patches on the surface of the colour gamut and compute the gamut surface as specified in ISO/TS 18621-11.

Where required, the gamut volume shall be computed as specified in ISO/TS 18621-11.

When comparing with a reference characterisation data set or reference ICC Profile, identify the set of colours on the gamut surface and compute the gamut surface as specified in ISO/TS 18621-11.

When indicating the relationship between a print gamut and a reference gamut or proof print the following shall be computed as specified in ISO/TS 18621-11:

— the percentage of the reference gamut which is inside the test gamut,

where it is likely to be useful the Gamut Comparison Index should be calculated.

EXAMPLE 1 Print1 gamut size: 319,626 cubic CIELAB units

EXAMPLE 2 FOGRA51 reference gamut size: 400,260 cubic CIELAB units

Print1 gamut size: 319,626 cubic CIELAB units

Print1 coverage of FOGRA51: 99,8 %

EXAMPLE 3 FOGRA51 reference gamut size: 400,260 cubic CIELAB units

Print2 gamut size: 420,512 cubic CIELAB units

Print2 coverage of FOGRA51: 100 %

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 24790 (Banding) 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 (Validation print system within sheet uniformity) 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 24790 (Mottle) shall be used.

This document assumes a viewing distance of 400 mm. Where a different viewing distance is used, the measurement method should be adapted for different viewing distances and the viewing distance shall be reported.

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 24790 (Graininess) shall be used.

This document assumes a viewing distance of 400 mm. Where a different viewing distance is used, the measurement method should be adapted for different viewing distances and the viewing distance shall be reported.

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.

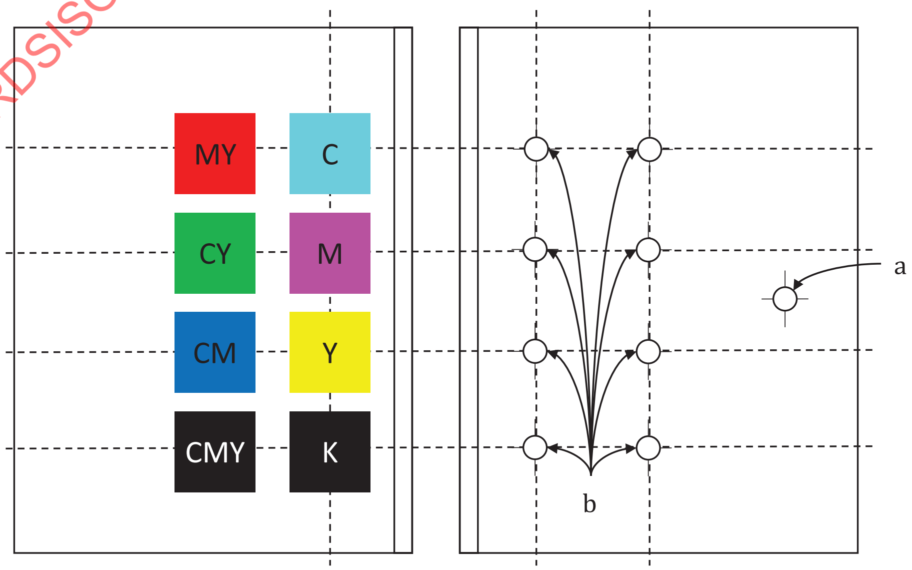


Figure 1 — Test print for measuring show through

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.

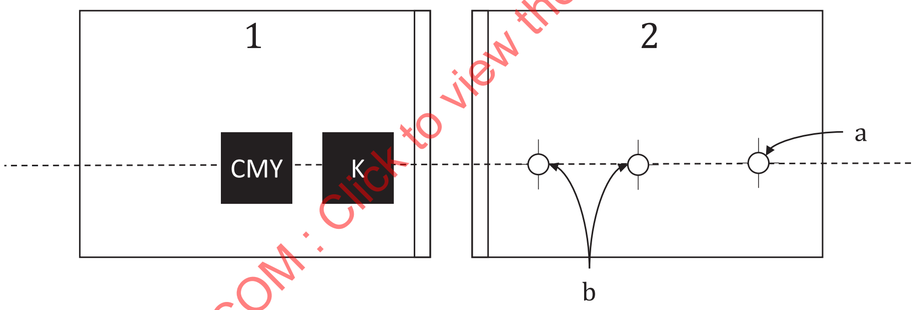
EXAMPLE Show through: 1,7 ΔE_{00} (C,M,Y,K,MY,CY,CM,CMY).

4.3.3.7 Print-through resistance

Many times, paper is printed on both sides and in some cases the ink penetrates into the paper from the one side to the other side. When this ink penetration is very strong, the ink can be visible at the other side and reading the printed matter on the other side can be affected. This phenomenon is known as print through. The level to which ink penetrates the printed sheet shall be measured as follows.

NOTE This metric is based on a method developed by IGT Testing Systems[1)] which has been widely adopted by the print industry. Details of this method are available on request from IGT Testing Systems (https://www.igt.nl).

A test form similar to that shown in Figure 2 shall include a patch of solid Black and should also include a patch of three colour overprint (CMY) printed on only one side of the sheet. The other side of the sheet shall remain unprinted.



Key

1 front

2 back

Figure 2 — Test print for measuring print through resistance

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

The CIELAB L* 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 (L_b).

1) This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of these products.

Print through resistance (R_{pt}) is defined as Formula (4):

$$R_{pt} = \left(\frac{L_b}{L_a}\right) \times 100\,\% \qquad (4)$$

Measurements shall be made with black backing as specified in ISO 13655. The lower of the two values calculated for patches "b" shall be reported along with the substrate type and name.

EXAMPLE Print through resistance: 95 % (super calendared uncoated, MyBrand BrandName).

4.3.3.8 Macroscopic uniformity

Macroscopic distortions in prints reduce their perceived image quality. These distortions, generally larger than a few millimetres, are typically visible across or down the page and are often described as banding, cording stripes or streaks. These artefacts are most noticeable in large regions where a single colour is used. A perfect print should have no such artefact visible.

When reporting macroscopic uniformity, the method defined in ISO/TS 18621-21 shall be used.

Macroscopic uniformity score has no measurement unit but produces a number in the range 0 to 100. The values should be rounded to the closest integer. The test form, colour of region and measurement condition shall be reported.

NOTE For some uses, it can be important to provide details of how the print was made so that the test can be repeated. Such details are out of scope for this document.

Macroscopic Uniformity Score may be abbreviated as MUS, S_{MU} or MUS-score.

EXAMPLES Macro-Uniformity-Score: 70

Test form: Fogra Homo-Testform A4, 185 × 155 mm,

Colour: CMYK = 20,15,15,15,

Measurement condition: M1, black backing

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 subclause 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 24790 (Line width) 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 and shall be reported to two significant digits.

EXAMPLE 0,1 mm vertical line width: 0,12 mm (K), 0,15 mm (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 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 and shall be reported to two significant digits.

EXAMPLE 0,1 mm 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 24790 (Blurriness). 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 and shall be reported to two significant digits.

EXAMPLE 0,1 mm vertical line blurriness: 0,022 mm.

0,1 mm horizontal line blurriness: 0,10 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 24790 (Raggedness). 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 0,1 mm vertical line raggedness: 0,062 mm.

0,1 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 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 system in Reference [15].

4.3.4.7 Effective addressability

The effective addressability is a measure of a printing system's ability to produce sharp images. 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. Native addressability should not be reported as an image quality metric.

When effective addressability is reported, the method defined in ISO/IEC 29112 shall be used.

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

EXAMPLE Effective addressability: 47 lines per mm.

4.3.4.8 Perceived resolution

Perceived resolution is a measure of the fine detail visible in prints. The perceived resolution depends on many factors including printing system configuration, inks, substrates and in some cases the printing environment. When assessing prints, details of how the print was produced should be recorded.

When perceived resolution is reported, one of the methods described in ISO/TS 18621-31 shall be used (device specific, inherent or practical resolution capability).

a) Device-specific resolution capability should be measured for engineering evaluations, for example when comparing capabilities of different states of a single printing system.

b) Inherent resolution capability should be used to assess the ultimate capability of a printing system to depict fine detail.

c) Practical resolution capability should be used to assess the capability of a printing system to depict fine detail with full process colour in the context of normal colour managed printing system operation. Where possible, the colour calibration aims should be a standardised reference printing condition and where this is used the reference printing condition shall be indicated in the colour management section of the report.

The report structure shown below shall be used. The evaluation intent shall be one of the following: "Device-specific resolution capability", "Inherent resolution capability" or "Practical resolution capability".

Resolution-score value is a number in the range 0 100 which may be useful when comparing printing systems.

REPORT STRUCTURE

Test chart used:	*Identifier (e.g. URL) of the Contrast-Resolution test chart utilized.*
Printing system evaluated:	*Printing system Manufacturer and Model.*
Printing system addressability:	*Printing system addressability used in printing test chart samples, e.g. 1 200 ppi.*
Substrate surface:	*Substrate surface characteristics (optional substrate manufacturer and name).*
Evaluation intent:	**Practical resolution capability**
Observed image structure:	*Single colorant or multiple process colours.*
Colour management:	*Colour management settings and ICC profiles employed,* *Method utilized or N/A if colour management not utilized.*
Linearization method:	*Method utilized ("CIELab" if Lab target utilized) or N/A if linearization not utilized*
Linearization measurement:	*Measurement method ("Inherent" if Lab target utilized) or N/A if linearization not utilized.*
Additional documentation:	*Documentation of settings that may affect printing system resolution capability.*

Scanning system utilized:	*Scanner manufacturer and Model.*
Scanner calibration:	*Single-channel (specify which channel and CIE Y or CIE L*) or* *ICC profile for CIELab colour calibration of RGB scans.*
Scanner MTF @ 12 cy/mm:	*Evaluated value from scanner qualification.*

Resolution-score value:	**86**
Number of prints evaluated:	**32**

4.3.4.9 Registration

4.3.4.9.1 General

Problems related to the accurate positioning of printing elements on a printed sheet fall into one of the following categories:

— colour separation registration error: difference in the position of a colour separation relative to other colour separations of the same element,

— front-to-back alignment error: difference in positioning of printing elements printed on one side of the sheet to elements printed on the other size of the sheet,

— alignment relative to sheet: location of printing elements relative to finishing references, for example sheet edge, folding and cutting marks.

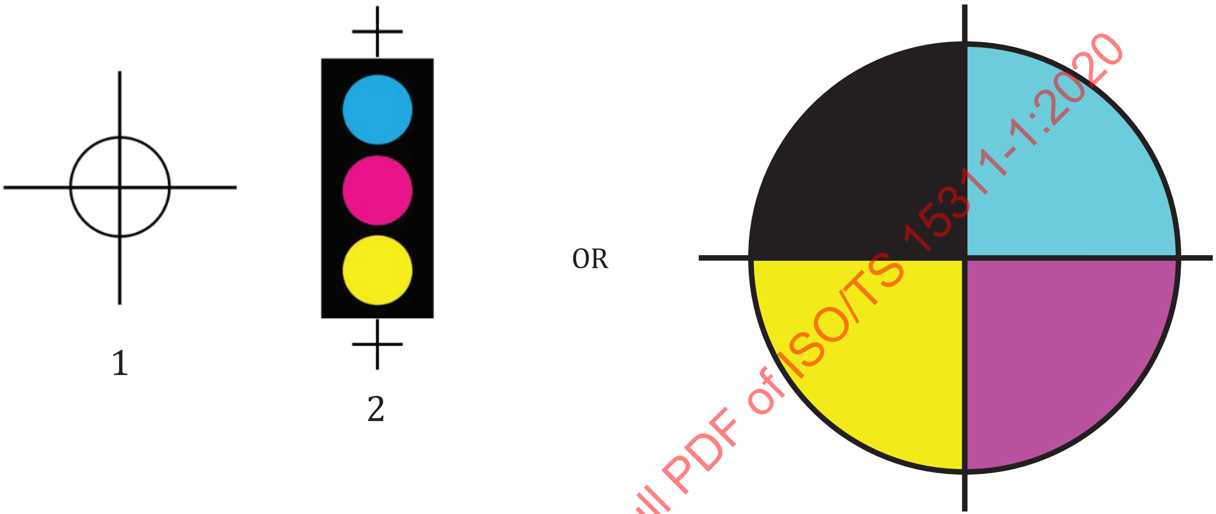
The following procedure allows the accuracy of positioning of printing elements to be measured and reported.

Register marks shall be printed using all of the process colours commonly used by the printing system to be tested.

Reported registration errors shall be in micrometres (µm or micron).

A minimum of four register marks shall be printed between 2 cm and 10 cm from each corner of the sheet on both sides of the sheet.

The marks should be similar to those shown in Figure 3.



Key

1 traditional cross-hair

2 RIT traffic light registration target

Figure 3 — Examples of registration target

The width of each line of the register mark should be less than 1,0 mm and the length of each line element should be 5 mm or longer.

Additional register marks should be printed at the centre points of each sheet edge and at the centre of the sheet. When present, these additional marks shall be printed on both sides of the sheet.

All register marks printed on the front side of the sheet shall be oriented so that they are aligned with a corresponding mark on the reverse of the sheet.

NOTE In this document no consideration is made as to whether the measured registration errors are acceptable or not, for example ISO 16762 provides guidance on front-to-back and page position registration requirements to ensure accurate folding.

4.3.4.9.2 Colour separation registration error

Colour separation registration error is determined by measuring the horizontal and vertical distance between the edges of the lines printed in each of the separation colours (where visible) and the edge of each of the other separation colours for each mark. The maximum distance shall be measured for each mark. The maximum value for all register marks on the sheet shall be reported as the colour separation registration error.

EXAMPLE Colour separation registration error: 80 µm.

4.3.4.9.3 Front-to-back alignment error

For non-opaque substrates, the evaluation should be done in transmission by means of a light table.

For opaque substrates, the front/back register marks shall contain two pin holes placed next to each. The holes will be punched and the print will be fixed on two rigid pins. The holes shall be sized and positioned to accurately fit the pins. The Front/back register shall be determined by calculating the maximum deviation for the process colour black and should be for the remaining process colours.

EXAMPLE Front-to-back alignment error: 100 µm.

4.3.4.9.4 Alignment relative to sheet

Where alignment relative to the sheet edge is assessed, at least 25 sheets shall be evaluated at random from a production run of at least 200 copies. The crop register is first determined by measuring the distance between the black frame and the nearest substrate edge for all four corner-elements, within and across printing direction. Based on the 8 measurements per print the crop register should be computed by taking the standard deviation of all 8 × 25 measurements.

EXAMPLE Alignment relative to sheet: 200 µm.

4.3.5 Permanence

4.3.5.1 General

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.

4.3.5.2 Indoor light stability (home and office display)

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 shall be used.

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.

The test chart should also include pictures similar to those that are expected to be used in practice, for example photographs of people, landscapes, or food. Visual inspection of these images shall be conducted and changes in colour should be noted. Where changes in colour affect some aspects of these pictures 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 Colour stability (ISO 18937, indoors, <URI>): colour change 3,2 ΔE_{00} (max) 1,3 ΔE_{00} (mean). Note that colour changes are visible on skin tones.

4.3.5.3 Indoor light stability (display window)

Indoor light stability for printed products displayed in a show window shall be measured according to the method described in ISO/TS 21139-21.

Where the intended display conditions are not known, it shall be assumed that the primary stress factor is light exposure with a light level of 10 Mlx-hr.

The maximum and mean colour change for the end point analysis shall be reported as CIEDE2000 colour differences.

The estimated print life shall be reported as an integer number of weeks or years, rounding down to the nearest integer value.

EXAMPLE End point colour change 5 ΔE_{00} (max) 2,5 ΔE_{00} (mean), estimated print life 100 weeks.

4.3.5.4 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.

The test chart should also include pictures similar to those that are expected to be used in practice, for example photographs of people, landscapes, or food. Visual inspection of these images shall be conducted and changes in colour should be noted. Where changes in colour affect some aspects of these pictures more than others, this should be reported.

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

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). Note that colour changes are visible in blues of sky and ocean.

4.3.5.5 Thermal stability

When reported, thermal stability shall 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 are hardly observed for some prints. In such cases, the report may include the words “at least” to qualify the time period.

The endpoints chosen for the Arrhenius extrapolation, e.g. mean and maximum colour change shall be reported. Full details of the testing performed should be made available in a separate document and its URI provided.

For lifetimes between 20 and 50 years, lifetimes shall be reported to the nearest 5 years (rounding down), and for lifetimes greater than 50 years, lifetimes shall be reported to the nearest 10 years (rounding down).

NOTE Examples of rounding down: values between 20 and 24,999 round to 20, values between 25 and 29,999 round to 25, values between 50 and 59,999 round to 50.

EXAMPLE 1 Thermal stability (ISO 18936, <URI>): 50 years (for maximum colour change of 4,5 ΔE_{00}, mean colour change 1 ΔE_{00}).

EXAMPLE 2 Thermal stability (ISO 18936, <URI>): at least 100 years (for maximum colour change of 5 ΔE_{00}, mean colour change 2 ΔE_{00}).

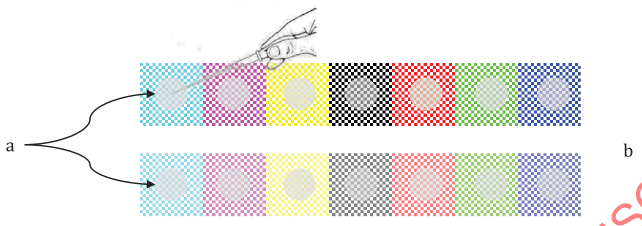
4.3.5.6 Water resistance

Water resistance shall be measured according to ISO 18935 as follows.

4.3.5.6.1 Method 1 — Standing water evaporation

Print a set of checkerboard patches using single colour and two-colour overprints with 100 % and 50 % tone value for the printed regions as shown in Figure 4. Add a 0,1 ml drop of water on the centre of each patch and allow to dry for 24 h in an environment with a temperature of 23 ± 1 °C and Relative Humidity of 50 ± 5 %.

Following the drying period, the patches shall be inspected and any deterioration in the printed patches noted. The notes should be accompanied by a photograph showing any visible marks.



Key

a 0,1 ml drop of water on each patch.

b Leave to dry for 24 h ambient conditions environmental conditions of (23 ± 1) °C and (50 ± 5) % RH.

Figure 4 — Standing water evaporation assessment

4.3.5.6.2 Method 2 — Standing water plus wiping

Print a set of checkerboard patches using single colour and two-colour overprints with 100 % tone value for the printed regions as shown in Figure 5. Add a 0,1 ml drop of water on the centre of each patch. After one minute, a 50 g weight applied to laboratory tissue shall be pulled once across the sample at a speed of approximately 5 cm/s.

Patches shall be inspected and any deterioration in the printed patches noted. The notes should be accompanied by a photograph showing any visible marks.

Key

a 1 min.

b 50 g weight.

c 50 g weight applied to laboratory tissue pulled once across the sample (~5 cm/s).

Figure 5 — Standing water plus wiping assessment

4.3.5.6.3 Reporting

Report the primary failure mode, for example: colorant bleed, paper cockle, delamination, formation of rings, loss of gloss, removal of colorant, colour to colour bleed, etc. Comparison to the control (untreated) print is very helpful in this regard.

Overall water resistance shall also be assigned using the categories: (a) water resistant, (b) moderately water resistant or (c) not water resistant.

Note conditions where the print is damaged to the point that image information is lost.

Record printer settings used to make the print sample.

NOTE Method 2 is generally only used in cases where the prints are intended to be used in wet environments or where they are intended for outdoor use.

EXAMPLE In many cases, this method can be used in comparison of samples as shown in Table 8.

Table 8 — Example showing results of water resistance on two samples

Failure mode	Sample A	Sample B
Colorant bleed	not observed	slight (magenta)
Paper cockle	not observed	not observed
Delamination	not observed	very slight
Formation of rings	not observed	slight
Loss of gloss	no change	slight lost
Removal of colorant	not observed	not observed

These results may be summarised as:

— Sample A: water resistant

— Sample B: moderately water resistant (slight colorant bleed, very slight delamination, slight formation of rings, slight loss of gloss)

4.3.5.7 Scratch resistance

Scratch resistance shall be measured according to ISO 15184 which shall be modified so that the tip of the pencil exerts a force of (4,0 ± 0,1) N on the printed surface.

NOTE 1 ISO 15184 is intended to be used on painted surfaces and specifies a force of 7,5 N but such a force will tear most paper substrates.

A set of patches of the solid process colours and two-colour overprints shall be printed and tested using the set of pencils with different hardness.

NOTE 2 The diameter of the pencil lead used and the shape of the tip when sharpened is important. Guidance for this is provided in ISO 15184:2020, Clause 8.

NOTE 3 The symbols, B, HB, H etc. describe darkness and not hardness. When using this test, it is important that a rough relationship between these symbols and pencil hardness is established.

The report shall indicate at which hardness level the substrate becomes visible and shall report any other visible artefacts. The report shall be accompanied by a photograph.

4.3.5.8 Abrasion resistance (transportation of sheets)

4.3.5.8.1 General

Abrasion resistance provides an indication of ink transfer between sheets which can occur, for example during sheet feeding, mail sorting, shipping and transportation of a stack of sheets from a printing site to a finishing site. Three levels of testing are conducted to reflect light handling (10 cycles), moderate handling (50 cycles) and rough handling (100 cycles).

Abrasion resistance shall be measured according to ISO 18947 and shall use a rub tester with a flat surface as described in Annex A with a weight that produces a force equivalent to 0,342 N/cm^2.

NOTE 1 The Sutherland Rub Tester is an example of a widely used rubbing tester of the type described in ISO 18947:2013, A.1.

The receptor shall be an unprinted sheet of the same substrate as the print to be tested.

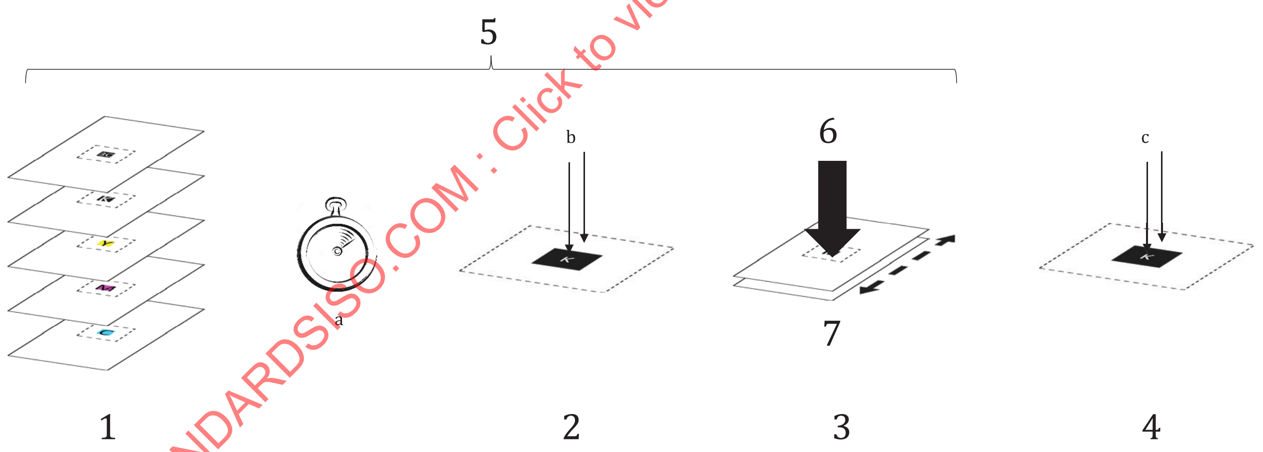
The printed image area shall include patches of approximately 25,4 mm × 25,4 mm corresponding to 100 % black and coloured prints shall include a 100 % CMY overprint patch and patches of 100 % tone of each separation colour. Patches shall have an unprinted border of at least 12,7 mm.

The print stabilisation period shall be 1 day.

The test result shall be reported following 10 cycles and 50 cycles and where rough handling is likely shall be reported following 100 rub cycles. Where a different number of rub cycles is used, the number of cycles used shall be reported.

The method of printing and handling of printed samples shall be consistent with the anticipated product end use.

The test procedure is illustrated in Figure 6.



Key

1 printing
2 preparation
3 testing
4 measurement
5 conditioning and testing at 23° and 50 % RH
6 0,342 N/cm^2
7 rub tester
a Test specimens shall be conditioned uncovered for at least 24 h.
b, c Measure colour and gloss of each patch and its surround.

Figure 6 — Abrasion resistance assessment method

NOTE 2 Where the substrates used by printing systems are different, it might not be appropriate to compare these test results directly. It is never appropriate to compare the results of printing on coated with uncoated substrates.

4.3.5.8.2 Alternative test method

In some cases, it may be appropriate to use other test specimen and receptor dimensions, applied loads and rub cycles where the intended conditions of use are such that the specified parameters and conditions produce results that do not adequately correlate to the abrasion, smudge, or scuff experienced under the intended conditions of use. In these cases, the test method and reporting shall be as described in ISO 18947. Full details of the test method used shall be provided.

4.3.5.8.3 Reporting

All patches shall be assessed as described in ISO 18947 and the following shall be reported:

— Abrasion Resistance: the patch having the largest CIEDE2000 colour difference shall be identified and the colour difference between measurements made before and after testing shall be reported,

— Smudge Resistance: the patch having the largest CIEDE2000 colour difference in the unprinted margin shall be identified and the colour difference between measurements made before and after testing shall be reported,

— Colorant Transfer: the patch producing the largest CIEDE2000 colour difference change of the receptor shall be identified and the colour difference between measurements made before and after testing shall be reported,

— Scuff: all significant changes in gloss of the colour patches or unprinted margin of each colour patch shall be reported.

Describe any visible change not accounted for by changes in gloss, optical density, or colorimetry.

Printer settings shall be recorded.

EXAMPLE Abrasion resistance:

— Abrasion Resistance: 1,5 ΔE_{00} (CMY),

— Smudge Resistance: 0,5 ΔE_{00} (Magenta),

— Colorant Transfer: 2,0 ΔE_{00} (CMY),

— Scuff: no significant changes,

— General observations: light streaking observed,

— Printer settings: <URL> or description.

4.3.6 Artefacts

4.3.6.1 General

When structuring and classifying image quality attributes it is sometimes not easy to find a clear correspondence between an image quality metric or significant characteristic and one of the three groups defined above, namely colour and surface finish, homogeneity and resolution. For the sake of simplicity, the remaining attributes clause covers all the criteria that haven’t been grouped so far. Those attributes are prone to cause a loss in overall image appearance when evident and are typically technology dependent.

4.3.6.2 Contouring

Smooth transitions in device RGB or CMYK are printed and inspected for smoothness and absence of artefacts by expert visual inspection and/or psychophysical experiment.

4.3.6.3 Background extraneous marks and voids (monochrome)

The method described in ISO/IEC 24790 (Background extraneous mark) shall be used to assess prints for background extraneous marks and voids.

NOTE Background extraneous marks are often caused by "scumming" or "ghosting" for some printing processes.

4.3.6.3.1 Reporting

Extraneous marks: report the results as a list of all marks and their areas along with the area of the ROI or report the total area of all the marks divided by the area of the ROI.

Voids: report the results as a list of all voids and their areas along with the area of the ROI or report the total area of all the voids divided by the area of the ROI.

EXAMPLE Refer to ISO/IEC 24790.

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 can 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 (A.1) is used 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 need to be sampled when the set of printed sheets to be assessed is small (less than 100 sheets).

In this document 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