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

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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

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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).

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

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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.

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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.

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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

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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.

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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*

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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/

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

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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.

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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.

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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.

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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.

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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.

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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 $\Delta C_{\mathrm{h}} = \sqrt{\left(\mathrm{CIE}\,\alpha_1^* - \mathrm{CIE}\,\alpha_2^*\right)^2 + \left(\mathrm{CIE}\,b_1^* - \mathrm{CIE}\,b_2^*\right)^2}$

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.

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4.2 Single or multiple sheet assessment

4.2.1 General

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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

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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

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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.

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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.

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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.

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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.

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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).

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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.

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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}).

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