
**Information technology — Office
equipment — Test method of colour
gamut mapping algorithm for office
colour softcopy and hardcopy**

*Technologies de l'information — Équipement de bureau — Méthode
d'essai des algorithmes de mappage des gammes de couleurs pour
images à l'écran et copies papier*

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Published in Switzerland

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Foreword

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

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

In exceptional circumstances, when the joint technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide to publish a Technical Report. A Technical Report is entirely informative in nature and shall be subject to review every five years in the same manner as an International Standard.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

ISO/IEC TR 29186 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 28, *Office equipment*.

Introduction

Gamut mapping is a mapping of the colour-space coordinates of the elements of a source image to the colour-space coordinates of the elements of a reproduction to compensate for differences in the source and reproduction medium colour gamut capability. A test guideline for evaluating cross-device and cross-media colour image reproduction gamut mapping algorithms (GMAs), desirable for colour scientists and colour equipment manufacturers, has already been published as CIE 156:2004. CIE 156:2004 has been applied and evaluated in various fields. This Technical Report is intended as a supplement to CIE 156:2004 for use with office colour softcopy and hardcopy equipment.

Members of the colour management study group in JBMIA applied CIE 156:2004 to office colour printers and found it necessary to specify additional information to ensure consistency in colour gamut mapping algorithm evaluation. The information required for use with office colour equipment, in addition to CIE 156:2004, pertains to the output medium, viewing environments, test charts, test chart image processing parameters and workflow, etc. This experience led to the development of this Technical Report.

CIE 156:2004 specifies general principles to be applied when evaluating colour gamut mapping algorithms of various colour imaging equipment. In addition to these general principles, equipment-specific detailed descriptions and exceptions are essential. CIE 156:2004 also specifies colour imaging equipment colour gamut mapping algorithm evaluation methods pertinent to photography and graphic arts. Specification of details pertinent to office colour equipment colour gamut mapping algorithm evaluation is desirable.

Without additional information for the office colour equipment application, users of CIE 156:2004 would have to choose details of the evaluation test method by trial and error and would be unlikely to achieve the same result as one another. With the use of this Technical Report, users not only save time and effort, but also obtain test data that is useful for comparison across different test instances. Consistent test methods will facilitate technological improvements in the area of colour gamut mapping algorithms.

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Information technology — Office equipment — Test method of colour gamut mapping algorithm for office colour softcopy and hardcopy

IMPORTANT — The electronic file of this document contains colours which are considered to be useful for the correct understanding of the document. Users should therefore consider printing this document using a colour printer.

1 Scope

This Technical Report is a supplement to CIE 156:2004, applicable for use in evaluating the colour gamut mapping algorithms of office colour softcopy and hardcopy equipment. This Technical Report defines test charts, test chart image processing workflow, media, viewing conditions, measurements, colour spaces and experimental methods, suitable for use with office equipment, which either do not exist in CIE 156:2004 or are different from CIE 156:2004. Colour softcopy may be displayed on monitors, incorporating display technologies such as CRT and LCD. Colour hardcopy may be produced by non-impact colour printers, including technologies such as ink jet and electro photography.

2 Normative references

The following referenced documents are indispensable for the application 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.

CIE 156:2004, *Guidelines for the Evaluation of Gamut Mapping Algorithms*

ISO 3664:2009, *Graphic technology and photography — Viewing conditions*

3 Terms and definitions

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

3.1

gamut mapping

<colour> mapping of the colour-space coordinates of the elements of a source image to colour-space coordinates of the elements of a reproduction to compensate for differences in the source and output medium colour gamut capability

3.2

colour gamut

dynamic range and colour extent, comprising a volume of colour representation capability

3.3

colour gamut boundary

surface determined by a colour gamut's extremes

3.4

gamut boundary descriptor

GBD

overall way of approximately describing a colour gamut boundary

3.5

veiling glare

light, reflected from an imaging medium, that has not been modulated by the means used to produce the image

NOTE 1 Veiling glare lightens and reduces the contrast of the darker parts of an image.

NOTE 2 In CIE 122, the veiling glare of a CRT display is referred to as ambient flare.

3.6

viewing flare

veiling glare that is observed in a viewing environment but not accounted for in radiometric measurements made using a prescribed measurement geometry

NOTE The viewing flare is expressed as a percentage of the luminance of adapted white.

3.7

image surround

characteristics of the field surrounding the image being viewed, filling the field of vision

NOTE 1 Adapted from ISO 22028-1.

NOTE 2 The region surrounding the stimulus subtending approximately 10 degrees is called background in CIE Standard S 017/E:2011 ILV.

4 Requirements

4.1 General

The reproduction intent for the colour reproduction systems in which GMAs will be evaluated in this Technical Specification is defined to be subjective similarity. This subjective similarity intent is one that aims at reproducing a given colour image so that the reproduction is as close to the original as possible, with no image enhancing intent. Furthermore, the similarity is determined psychophysically.

4.2 Reference viewing environments for softcopy and hardcopy

The following reference viewing conditions define the reference viewing environment for subjective accuracy experiments. They are based on conditions for appraisal of images displayed on colour monitors as specified in ISO 3664:2009, 4.5 and are based on conditions for practical appraisal of prints as specified in ISO 3664:2009, 4.3 unless otherwise noted. They are also based on conditions for appraisal of images displayed on colour monitors and prints as specified in CIE 156:2004, 5.4 (b).

4.2.1 Ambient light source white point

Use an ambient light source white point that approximates CIE standard illuminant D50.

4.2.2 Ambient illuminance on monitor for softcopy evaluation

Use an ambient illuminance on the monitor at the plane of viewing for softcopy evaluation that is less than or equal to 7/10 of Monitor luminance.

Position the source, image being viewed, and observer's eyes to minimize the amount of light that is specularly reflected toward the eyes of an observer on or near the normal to the centre of the viewing surface.

4.2.3 Ambient illuminance for hardcopy evaluation

Use a light source that delivers illumination at the plane of viewing that approximates the CIE standard illuminant D50. Use the illuminance at the viewing surface of $500 \text{ lx} \pm 125 \text{ lx}$ as specified in ISO 3664:2009 for the practical appraisal of prints.

4.2.4 Monitor diagonal size

Use a monitor with a diagonal size greater than or equal to 17 inches.

4.2.5 Monitor white point

Select the monitor white point to approximate that of CIE standard illuminant D65.

4.2.6 Monitor luminance

Use an absolute luminance level for the adapted white in the reference viewing environment that is greater than or equal to 80 cd/m^2 , preferably greater than or equal to 160 cd/m^2 .

4.2.7 Required adaptation time

Allow users to adapt for each softcopy and hardcopy viewing for at least 20sec, preferably use an adaptation time of 120 sec for a full adaptation as in CIE 162:2010, Figure 5.

NOTE Before beginning the process of observations, wait at least 10 minutes to adapt to the ambient light. This 10 minutes adaptation time only applies at the start of the process of observations, and not when looking back and forth between softcopy and hardcopy during the process of observations.

4.2.8 Viewing distance for softcopy evaluation

Use a viewing distance for softcopy evaluation that is greater than or equal to the least of the distance of distinct vision (25cm) or preferably approximately 1.5 x monitor diagonal size.

NOTE Most importantly, ensure that the entire document subtends approximately the 10 degrees of field of view.

4.2.9 Viewing distance for hardcopy evaluation

Use a viewing distance for hardcopy evaluation that is greater than or equal to the least of the distance of distinct vision (25cm) or preferably approximately 1.5 x A4/Letter diagonal size or 54cm.

Most importantly, ensure that the entire document subtends approximately the 10 degrees of field of view.

4.2.10 Softcopy image surround luminous reflectance

Use either no image surround or use a softcopy image surround with a luminous reflectance of 20%.

4.2.11 Hardcopy image surround luminous reflectance

Use a hardcopy image surround with a luminous reflectance of 20% with or without a paper white border.

4.2.12 Veiling glare and viewing flare

The veiling glare in the reference viewing environment is to be included in the display black point, as would result from measurement of the display from the viewer position in the reference viewing environment. Viewing flare that may result in viewing conditions different from the reference viewing conditions is not to be included.

NOTE When positioning a display in a viewing environment, it is important to arrange the ambient lighting so that specular reflections off the display faceplate, as seen from the viewer position, are avoided. This can usually be achieved by placing ambient light sources at an angle of at least 45 degrees relative to the normal to the display faceplate, which is assumed to be the viewer's direction of gaze.

4.2.13 Measurements

Take measurements using the conditions described in CIE 156:2004, Measurement and Appendix B recommended measurement procedures for different media.

4.3 Test chart Image processing

4.3.1 Test Charts

The test charts of this test method include 5 different images as listed in Table 1.

Table 1 — Test chart list

Test chart Name	File format	Colour Encoding	Availability
BEISPIEL Ski	TIFF	sRGB, ROMMRGB	CIE TC 8-03 homepage
N7	TIFF	sRGB	ISO 12640-2:2004
Weather	PDF	sRGB	See Annex A
OFFICEGAMUT MAPPING	PDF	sRGB	See Annex B
False contour chart	TIFF	sRGB	See Annex C

The three test charts in Table 1, such as Weather, OFFICEGAMUT MAPPING and False contour chart, are downloadable at the following address: http://standards.iso.org/ittf/PubliclyAvailableStandards/SC28_Test_Pages/

For softcopy to hardcopy sample preparation, test charts are processed with the workflow as shown in Annex D.

The evaluating gamut mapping algorithms include Hue-angle preserving minimum ΔE^*ab clipping and Chroma-dependent sigmoidal lightness mapping and cusp knee scaling as described in CIE 156:2004, 8.1 and 8.2 respectively.

NOTE The role of having these two algorithms is to make it possible to reconcile the different interval scales used in different experiments.

The XYZ values were transformed to the gamut mapping colour space by using CAT + CIELAB and CIECAM02, and the colour values were mapped to the printer gamut. CAT02 matrix was used for chromatic adaptation from display white point to D50. CIELAB or CIECAM02 may be used as gamut mapping colour space in order to estimate the effect of the hue uniformity of these two colour spaces.

The mapped colours are to be transformed to the XYZ value by using CIELAB + CAT or CIECAM02, and the printer dependent colours by the each individual printer characterization model prepared by manufacturer. The mapped colours are transformed to the printer dependent colours by the each individual printer characterization model prepared by manufacturer.

The following practices are helpful to avoid false colour contouring: GBD segments used in the gamut mapping calculation greater than or equal to 72 segments, and the number of colour gamut boundary data

greater than or equal to 15000. The colour gamut boundary data can contain both measured data and interpolated data generated from measured data.

NOTE Inappropriate number of GBD segments and colour gamut boundary data may produce false contour on softcopy and hardcopy which may affect subjective ratings in 4.5. It is recommended that before processing 4 test charts in 4.4.2, using False contour chart in Annex C to confirm no false contour appeared on both softcopy and hardcopy.

4.4 Format of test charts

Appropriate format of test charts for office use are PPT, PDF, WORD, TIFF and JPEG. In each case the colour information is encoded in an RGB colour space and has an associated or embedded ICC profile. Standard test charts supplied with this Technical Specification use the ISO 32000-1:2008 PDF and ISO 12639:2004 TIFF formats to exercise raster and vector colour gamut mapping options.

Unless the original sRGB values are preserved during the test chart conversion to other image file formats a type of colour processing or enhancement may occur and confound the results.

Colour rendering, digital filtering and tone reproduction characteristics set as specified, either default or recommended, by the manufacturer of the monitor and printer that produces softcopy and hardcopy, respectively, will allow the test process to evaluate the manufacturer's intended colour behavior. Similarly, avoid using any application program that imposes extra colour processing or enhancement.

4.5 Experiments

4.5.1 Observer instructions

Observer is asked to rate subjective similarity of colour appearance between softcopy and hardcopy. Experiments involving colour softcopies and hardcopies need to be carried out under the viewing conditions in 4.2. At least 15 observers are needed for the subjective rating experiments, using the psychophysical method of category judgment. For better results, ask some of the observers to repeat the experiment so that observer repeatability can be evaluated.

Use either 5 or 7 levels in the Category rating method (highest number is the best and 1 is the worst) for the rating test. Prior to the rating test, raters are asked not to take other image quality attributes, such as defects, into account for the rating score, and only to focus on the subjective similarity of colour appearance between softcopy and hardcopy.

5 Indicating the Use of Test Method of Colour Gamut Mapping Algorithm for Office Colour Printer

5.1 General

Carry out all sampling in line with the conditions specified in the operation manuals of the colour printer, unless otherwise specified in this Technical Specification. Setup the display device in line with the conditions specified in the operation manuals of the display, unless otherwise specified in this Technical Specification. Be careful to select a display device to satisfy the conditions as given in 4.2. At minimum, use the test charts given in 4.3.1. Other test chart(s) can be added according to the needs of the user of this Technical Specification. Use care in constructing additional test charts following the example test charts provided with this Technical Specification. Colour gamut mapping algorithms of 4.3.2 are used in addition to the target colour gamut mapping algorithm(s).

5.2 Preparation of samples

Process the test charts according to 4.3.2. Form the softcopy samples according to 4.2.10. Produce hardcopy samples according to 4.2.11. In order to obtain consistent and repeatable ratings, minimize unintended defects appearing in the print samples.

Figure 1 shows an example of false contour due to the inappropriate number of GBD segments. The false contour level depends on the printer technology and it might be reduced by increasing the number of GBD segments.

5.3 Presentation of the result

The typical example of category judgment experiments result is shown in Figure 2. GMA1, GMA2, GMA3 and GMAX are four different types of gamut mapping algorithm. GMA1 is HPMINDE in CIELAB, and HPMINDE is “Hue-angle preserving minimum ΔE^*_{ab} clipping”. GMA2 is SGCK in CIELAB, and SGCK is “Chroma-dependent sigmoidal lightness mapping and cusp knee scaling”. GMA3 is SGCK in CIECAM02. GMAX is manufacturer’s own GMA. According to Figure 2, the best GMA is GMA1 in average of four different test chart rating scores.



Figure 1 — False contour

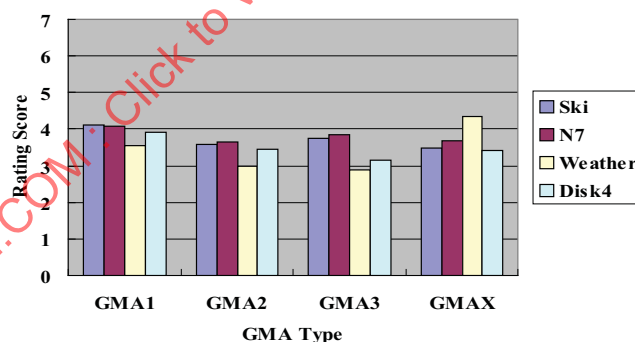


Figure 2 — Comparison of the rating score of gamut mapping algorithms

The comparison of GMA1 and GMAX on CIELAB colour coordinate is shown in Fig.3. According to Figure 3, GMA1 has smaller variation in terms of printer models.

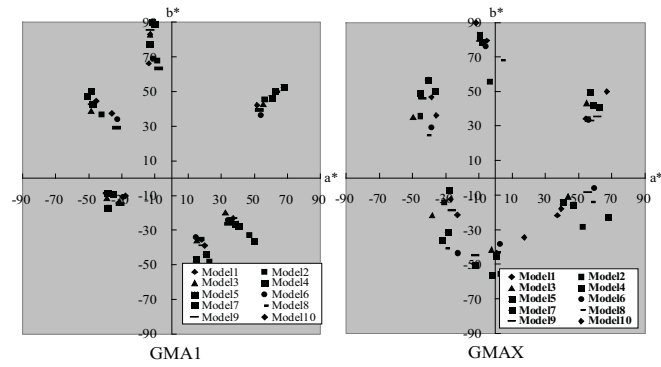
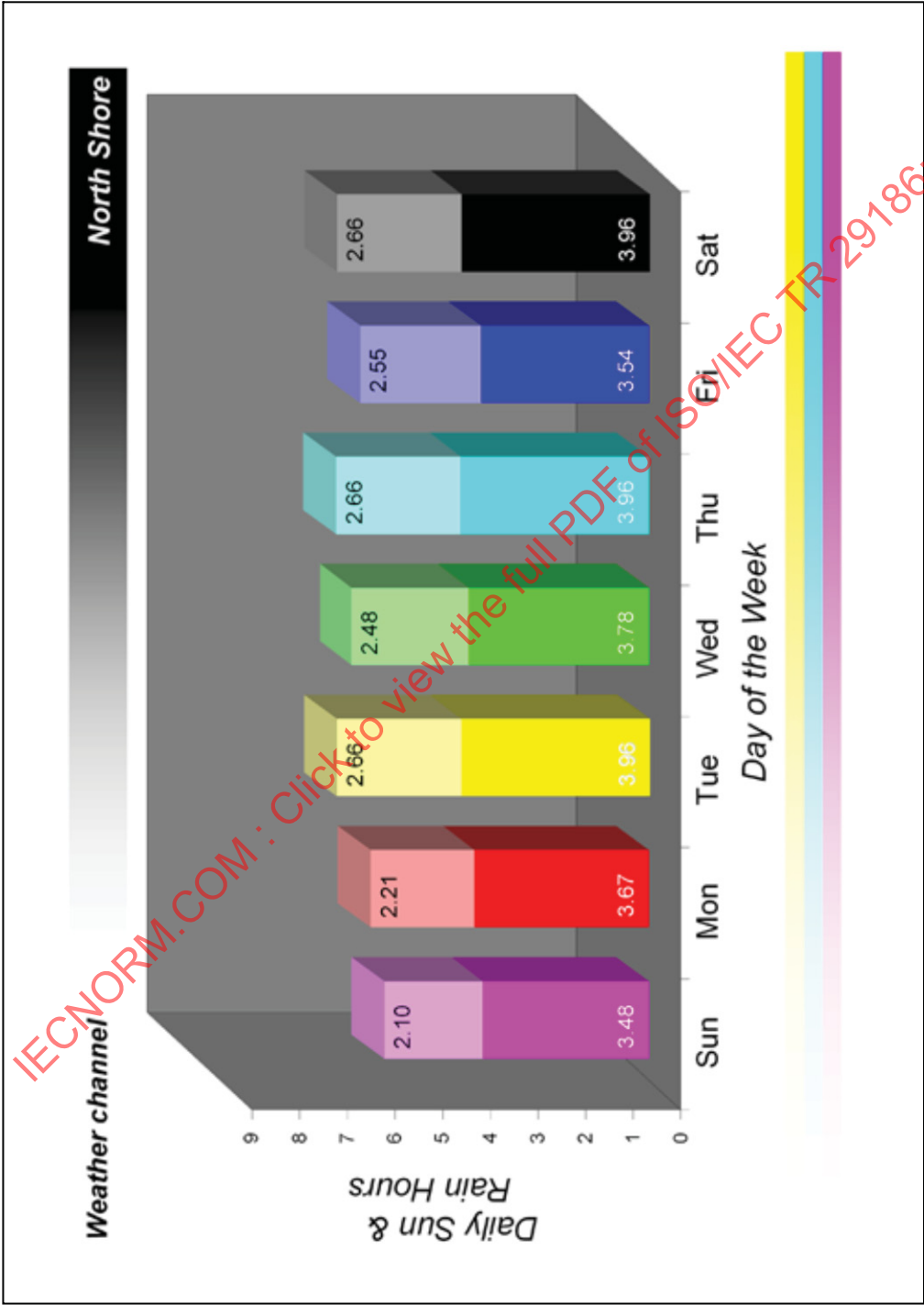


Figure 3 — Comparison of gamut mapping algorithms on CIELAB colour coordinates

Annex A
(informative)

Test Chart — Weather



Annex B (informative)

Test Chart — OFFICE GAMUT MAPPING



Annex C
(informative)

Test Chart — False contour chart

