TECHNICAL REPORT

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Information technology — Office machines — Machines for colour image reproduction — Method of specifying image reproduction of colour devices by digital and analog test charts

Technologies de l'information — Machines de bureau — Machines pour reproduction d'image couleur — Méthode pour spécifier la reproduction d'image des dispositifs couleur par des organigrammes d'essai numériques et analogiques

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Contents

Page

Foreword ..... **v**
Introduction ..... **vi**

1. Scope **1**
2. Normative References **1**
3. Terms and definitions **2**
3.1 Definitions 2
3.2 Colours in colour metrics, printing and television 5
4. ISO/IEC-test charts **6**
4.1 General 6
4.2 Content and purpose of ISO/IEC-test charts 6
4.3 Modes and production of ISO/IEC-test charts 12
4.4 Codes of the ISO/IEC-test charts and their reproduction 14
4.5 Colorimetric data of intended and reproduced colours 15
4.6 Limits of visual resolution and colour perceptibility 21
4.7 Applications of analog and digital ISO/IEC-test charts 22
5. Visual and colorimetric tests for all applications **24**
5.1 General 24
5.2 Visual test 24
5.3 Colorimetric specification 25
6. Test report for all applications **25**
6.1 General 25
6.2 Description of input and output and comparison of output and reference 25
7. Test charts for image reproduction of printer systems: “digital – analog” **26**
7.1 General 26
7.2 Output technique for colour image reproduction devices: “digital – analog” (printers) 26
7.3 Parameters for the PS-output of colour image reproduction devices: “digital – analog” 28
7.4 Parameters for the creation and output of *PDF*-files 28
8. Visual and colorimetric tests of printer systems: “digital – analog” **29**
8.1 General 29
8.2 Visual test 29
8.3 Colorimetric specification 29
9. Test report of printer systems: “digital – analog” **29**
9.1 General 29
10. Test charts for image reproduction of scanner systems: “analog – digital” **30**
10.1 General 30
10.2 Output technique for colour image reproduction devices: “analog – digital” (scanners) 30
10.3 Methods to determine the *‘coordinates of the digital scanner-test chart 34
11. Visual and colorimetric test of scanner systems: “analog – digital” **38**
11.1 General 38
11.2 Visual test 38
11.3 Colorimetric specification 38
12. Test report of scanner systems: “analog – digital” **38**
12.1 General 38
13. Test charts for image reproduction of monitor systems: “digital – analog” **40**
13.1 General 40
13.2 Output technique for colour image reproduction devices: “digital – analog” (monitors) 40
13.3 Parameters for the PS-output of colour image reproduction devices: “digital – analog” 42
13.4 Parameters for the creation and output of *PDF*-files 42

14. Visual and colorimetric test of monitor systems: "digital – analog" **43**
14.1 General 43
14.2 Visual test 43
14.3 Colorimetric specification 43

15. Test report of monitor systems: "digital – analog" **43**
15.1 General 43

Annex A: Form A for the picture area 44

Annex B: Form B for the picture area 45

Annex C: Form C for the picture area 46

Annex D: Form D for the picture area 47

Annex E: Form E for the frame area 48

Annex F: Form F for the frame area 49

Annex G: Colorimetric specification 50

Annex H: Code lists of input, output and reference 53

Annex I: Digital ISO/IEC-test charts of this Technical Report 55

Annex J: Colorimetric basis for the Systems OLS and TLS 60

Annex K: Offset Luminous System for L*N = 0, 18, 27, 33 63

Annex L: Colours of Offset and Television Luminous Systems 65

Annex M: 16-step CIELAB scales and luminance reflectance 70

Annex N: Information on web sites 71

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, the joint technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, 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).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

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 24705, which is a Technical Report of type 3, was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 28, *Office equipment*.

This Technical Report is based on International Standard ISO/IEC 15775 and on the Draft International Multipart ISO/IEC fast track Standard DIS 19839–1 to –4:2001 which together are identical to the multipart standard DIN 33866-1 to -5. In 2002 it was decided at the Ballot Resolution Meeting on DIS ISO/IEC 19839-1 to -4 in Berlin to produce this Technical Report instead of a multipart International Standard.

Introduction

Background Information

This Technical Report is based on **analog** ISO/IEC-test charts with 16-step colour scales equally spaced in CIELAB. The International Standard ISO/IEC 15775 for the specification of image reproduction of colour copiers uses **analog** ISO/IEC-test charts with e. g. a 16 step colour scale between White W and Cyan-blue C which is equally spaced in CIELAB.

In image technology for the output of the colour series W – C the four device coordinates *cmyk* (Cyan-blue, Magenta-red, Yellow, Black) have been used for many years. If the coordinate of Cyan-blue is changed between zero and 1 and the other three are zero then the series W – C appears on the output, e. g. on an office colour laser printer or in offset printing.

Linear relation between device and CIELAB coordinates for office systems

There is much discussion in the field of image technology about the meaning of device coordinates, e. g. *cmyk* or *rgb,* for printers and monitors and their relation to the *L*a*b** data of the device independent colour space CIELAB. The International Standard ISO/IEC 15775 has produced new ideas how to define more meaningful device coordinates which are called e. g. *cmy0*, w*, olv*, 000n*.* This Technical Report defines the calculation methods between the CIELAB coordinates *L*a*b** of the **analog** ISO/IEC-test charts and device *-coordinates (star-coordinates), e. g. *cmy0*, w*, olv*, 000n*.*

According to the International Technical Report ISO/IEC TR 19797 a **linear** relationship can be defined between e.g. the device coordinates *cmy0** and the device independent coordinates *LAB** of the (absolute) CIELAB space. According to TR ISO/IEC 19797 the coordinate $c^* = 1$ produces the Cyan-blue colour if the others are zero, $c^* = 0$ produces the White reference paper and $c^* = 0{,}5$ produces a colour which is exactly in the middle in the CIELAB space between Cyan-blue C and White W. The CIELAB data of the 16-step colour series between White and Cyan-blue are calculated by the following linear equations

$$L^* = L^*_W + c^* (L^*_C - L^*_W) \qquad (0 <= c^* <= 1)$$

and similarly for the CIELAB chroma data a^* and b^*. For the mean device value $c^*=0.5$ the CIELAB data are calculated as mean of the CIELAB data of Cyan-blue C and White W.

Multi-spectral CIELAB imaging and new device *-coordinates (star-coordinates)

If the analog ISO/IEC-test charts are scanned with the new multi-spectral technology then from the spectral reflection or transmission data of any pixel the CIELAB data can be determined. The devices with these properties are called CIELAB scanners or CIELAB cameras. By the calculation methods of ISO/IEC TR 19797 one can transfer the *LAB** data in the digital scan file to the device values such as *cmy0*, w*, olv*, 000n** in the digital scan file.

Digital ISO/IEC-test charts with new device *-coordinates (star-coordinates)

By the calculation methods of ISO/IEC TR 19797 one can transfer the *LAB** data of the **analog** ISO/IEC-test charts to the device coordinates, e. g. *cmy0*, w*, olv*, 000n*.* The **digital** ISO/IEC-test charts are designed using this device data. The CIELAB colour differences between the seven basic colours CMYOLVN and the paper White W of the **analog** ISO/IEC-test charts and the **standard colours of offset printing** are less than the CIELAB colour difference of $\Delta E^* = 3$. This is the *ΔE* tolerance value* specified in ISO/IEC 15775 as reasonable for office equipment image technology. So instead of the production data of the present **analog** ISO/IEC-test charts the **standard colours of offset printing** are used as default device data, e. g. *cmy0*, w*, olv*, 000n*,* in the **digital** ISO/IEC-test charts. Examples are shown in Annex I.

This Technical Report and ISO/IEC 15775

Table 0-1: Application of this Technical Report and ISO/IEC 15775 for specifying image reproduction

Input	Output	Input and output media and applications			Technical Report (TR) or Standard
		Input media	Output media	Application	
–	–	–	–	**Basis**	**TR ISO/IEC 24705**
analog	**analog**	ISO/IEC-test chart (hardcopy)	Hardcopy	**Copier**	**ISO/IEC 15775**
analog	**digital**	ISO/IEC-test chart (hardcopy)	File	**Scanner**	**TR ISO/IEC 24705**
digital	**analog**	ISO/IEC-test chart (file)	Hardcopy	**Printer**	**TR ISO/IEC 24705**
			Softcopy	**Monitor**	**TR ISO/IEC 24705**

TR24705/T1TA000.PS

Table 0-1 includes the applications of this Technical Report and ISO/IEC 15775 to specify image reproduction properties.

This Technical Report describes the classification and a basis for the production and application of **analog** and **digital ISO/IEC-test charts**. It describes methods for the specification of **image reproduction properties** of colour devices. The International Standard ISO/IEC 15775 and this Technical Report define visual and colorimetric methods to specify the image reproduction properties of colour systems. A colour system includes the black box between input and reproduction of digital or analog ISO/IEC-test charts.

The area of the colour copier devices with the reproduction process **"analog – analog"** is excluded here as this area is already covered by the International Standard ISO/IEC 15775. There is a close relationship to the other reproduction process types **"analog – digital"** and **"digital – analog"** which require similar specification methods and corresponding **digital** and **analog** ISO/IEC-test charts. The different reproduction processes are defined in ISO/IEC 15775 and this Technical Report.

This Technical Report consists of:

Section 2. to 6.: *Method of specifying image reproduction of colour systems by **digital** and **analog** test charts – Classification and principles.*

Section 7. to 9.: *Method of specifying image reproduction of colour systems by **digital** input and **analog** output as **hardcopy*** for colour image reproduction devices: ***"digital – analog"** (Printers) – Application and realisation.*

Section 10. to 12.: *Method of specifying image reproduction of colour systems by **analog** input and **digital** output* for colour image reproduction devices:***"analog – digital"** (Scanners) – Application and realisation*

Section 13. to 15.: *Method of specifying image reproduction of colour systems by **digital** input and **analog** output as **softcopy*** for colour image reproduction devices:***"digital – analog"** (Monitors) – Application and realisation.*

Equal relative CIELAB spacing of analog and digital ISO/IEC-test charts

This Technical Report is based on **analog and digital** ISO/IEC-test charts. The **analog** ISO/IEC-test charts are equally spaced in CIELAB between white W and the six colours CMYOLV and black N.

Figure 0-1: Equal relative CIELAB spacing of 16 steps for different hue and lightness

Fig. 0-1 shows on the left side 16 equally spaced steps in the CIELAB colour space between White W and the six chromatic colours CMYOLV. This spacing is realized in **analog** ISO/IEC-test charts by different manufacturers.

On the right two equally spaced series between White–Orange-red (W –O) and White–Cyan-blue (W–C) are shown on both monitors and printers. It is intended here to have equal **relative** spacing in the CIELAB colour space on both the printer and monitor under standard office conditions. Standard office conditions for colour control are defined by the standard daylight CIE illuminant D65 and approximately equal luminance of the white monitor and the illuminated white paper (e. g. in special cases in a light booth). This Technical Report and the figure on the right side assume a monitor black with the CIELAB lightness L^*=18 as standard. This lightness is produced by a standard luminance reflectance Y_r=2,5 of the standard ambient light on the monitor surface.

For chromatic colours, equal CIELAB data on the monitor and for printer output are not intended. A **relative** reproduction is intended which has the following main advantages for the 16-step colour series of the ISO/IEC-test charts:

1. All Landolt-rings are recognized on both devices for the light (0–1), the medium (7–8) and the dark steps (E-F).
2. The recognition of the rings is optimized because the largest possible CIELAB difference is produced.
3. The whole device output colour space is filled which is desired by many applications, e. g. digital photography.
4. Linearized device systems need much less measurement data for profiling compared to unlinearized data.

5. The **relative** reproduction is approximately an **absolute** reproduction, e. g. if the reflective analog ISO/IEC-test charts or other originals are reproduced on printers with 8 basic colours similar to the 8 standard offset colours.

NOTE: When the CIELAB data of ICC profiles which are used to map the CIELAB input colours on the output device do **not** include the information about the 8 device colours then the above simple **relative** reproduction between the input and output space is very complicated. For example one must change all hues differently.

The **digital** ISO/IEC-test charts are equally spaced in digital coordinates between 0 and 1. Different device coordinates, e. g. *cmy0*, 000n*, w** and *olv** are used in the **digital** ISO/IEC-test charts. The star *(*)* indicates a linear relationship between the digital device coordinates, e. g. *cmy0*,* and the CIELAB coordinates *L*a*b*.*

NOTE: The International Technical Report ISO/IEC 19797 describes the linearization methods between device coordinates, e. g. *cmy0*,* and the CIELAB coordinates *L*a*b**.

Production of analog ISO/IEC-test charts according to ISO/IEC 15775 from digital test charts

Anyone may produce ISO/IEC-test charts. To do this it is recommended that use the digital ISO/IEC-test chart files be downloaded from the recommended servers. A producer may include a free digital image which must include the standard 16 step series of the grey scale and the 14 CIE-test colours when the image is taken. According to the International Standard ISO/IEC 15775 any ISO/IEC-test chart producer must publish digital ISO/IEC-test chart files with the standard image in 5 resolutions which correspond to the analog ISO/IEC-test charts of the production. Test charts which correspond to the principles of ISO/IEC 15775 have been published in Germany by DIN as DIN-test charts according to DIN 33866-1 to 5 and in Japan by JBMIA as Asian ISO/IEC-test charts according to ISO/IEC 15775. There are corresponding digital ISO/IEC-test charts on different servers in different resolutions (see Annex N).

Applications and limitations of this Technical Report

This Technical Report includes the basic principles for the application of ISO/IEC-test charts for colour reproduction devices such as for colour printers, colour scanners, colour monitors, colour displays, digital cameras, the Photo-CD system and overhead devices, which can input (scan, read) or output (reproduce, display) **analog** or **digital** test charts.

For this the **analog** and **digital** ISO/IEC-test charts include different image line and character elements, as well as Siemens-stars and Landolt-rings in different colours and contrast combinations. Additionally 14 CIE-test colours as well as 5- and 16-step colour series with equal spacing are included. The specification of image reproduction is based on the differences between **digital** or **analog** ISO/IEC-test charts and their reproduction, especially in terms of resolution, relative luminance and colour.

The layout, content and requirements for the production of the ISO/IEC-test charts are defined in ISO/IEC 15775.

The ISO/IEC-test charts are defined for CIE illuminant D65, the CIE 2 degree observer, the CIE 45/0 geometry and with a three thickness backing of white paper for measurement and visual evaluation. For colour control in offices the recommended illumination of 1000 lux of the CIE is used, which corresponds to 282 (= 1000 / 3,14 x 0,886) cd/m^2 for the white reference paper of the ISO/IEC-test charts. A monitor in a modern office has about the same luminance for the white screen. Therefore the white luminance L_W= 300 cd/m^2 and the same chromaticity as CIE daylight D65 is recommended. Therefore no chromatic or luminance adaptation is required and only the CIELAB data are required for the visual and colorimetric application within this Technical Report. For colorimetric evaluation of monitors the lightness L^*_N = 18 of Black N and L^*_W = 95 of white W of the analog ISO/IEC-test chart no. 3 is normalized to the same data for the monitor. See Annex M.

The ISO/IEC-test charts are defined and available in different device coordinates, e. g. *cmy0*, w*, olv*, 000n*,* and the absolute CIELAB coordinates *L*a*b**. See Annex N. This Annex recommends three digital ISO/IEC-test charts for the tests according to this Technical Report, but additionally other ISO/IEC-test charts of the list can be used if appropriate. The test report requires that the forms of Annex A to Annex F be included. The ISO/IEC-test charts of the tests appear in Annex E and Annex F.

The tests use the same test elements as for the test of colour copiers. See ISO/IEC 15775 and Annex N. The colour series between White W and CMYOLV is tested but e.g. the series between Black and CMYOLV are not included in ISO/IEC 15775. The last series are usually approximately equally spaced in relative CIELAB if the series Black – White is equally spaced.

There is no preference of this Technical Report for any operating system, application software, or device driver. These properties are within a “black box” which influence the workflow of the device systems “digital – analog” (printer and monitor systems) or “analog – digital” (scanner systems) between input and output.

Different CIE illuminants D65 and D50 in different International Standards

In this Technical Report, in ISO/IEC 15775 and in the monitor standard IEC 61966-2 the CIE illuminant D65 is recommended.

NOTE: The International Standard IEC 61966-7-1 measures the CIELAB output colours for RGB input data for the CIE illuminant D50.

Information technology – Office machines – Machines for colour image reproduction

Method of specifying image reproduction of colour devices by digital and analog test charts

1. Scope

The colour reproduction properties of office devices, e.g. printers, scanners and monitors, may depend on the device system, which includes e.g. the device properties and settings, the device driver, the file format, the computer operating system and the application software.

The method of this Technical Report is to test how the reproduction changes if one or several of the parameters are varied, such as the device properties or settings, the device driver, the file format, the computer operating system, the colour space, and the application software. This allows manufacturers and users to get a feeling or data about the influence of the different parameters on the reproduction.

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.

ISO 216:1975, *Writing paper and certain classes of printed matter – Trimmed sizes – A and B series*

ISO 536:1995, *Paper and board – Determination of grammage*

ISO 554:1976, *Standard atmospheres for conditioning and/or testing – Specifications*

ISO 2469:1994, *Paper, board and pulps – Measurement of diffuse reflectance factor*

ISO 2471:1998, *Paper and board – Determination of opacity (paper backing) – Diffuse reflectance method*

ISO 2846–1:1997, *Graphic technology – Colour and transparency of ink sets for four-colour-printing – Part 1: Sheet-fed and heat-set web offset lithographic printing*

ISO 3664:2000, *Viewing conditions – Graphic technology and photography*

ISO 5627:1995, *Paper and board – Determination of smoothness (Bekk method)*

ISO 5651:1989, *Paper board and pulps – Units for expressing properties*

ISO 5737:1983, *Prints – Preparation of standard prints for optical tests*

ISO 7724–1:1984, *Paints and varnishes – Colorimetry – Part 1: Principles*

ISO 7724–3:1984, *Paints and varnishes – Colorimetry – Part 3: Calculation of colour differences*

ISO 8596:1994, *Ophthalmic optics – Visual acuity testing – Standard optotype and its presentation*

ISO 8597:1994, *Optics and optical instruments – Visual acuity testing – Method of correlating optotypes*

ISO 13655:1996, *Graphic technology – Spectral measurement and colorimetric computation for graphic arts images*

ISO 12641:1997, *Graphic technology – Prepress digital data exchange – Colour targets for input scanner calibration*

ISO/IEC 15775: 1999, *Information technology – Office machines – Method of specifying image reproduction of colour copying machines by digital and analog test charts – Realisation and application*

ISO/CIE 10526:1991, *CIE standard colorimetric illuminants*

ISO/CIE 10527:1991, *CIE standard colorimetric observers*

CIE-pub. 13.3:1995, *Colour rendering – Method of Measuring and Specifying Colour Rendering Properties of Light Sources*

CIE-pub. 15.2:1986, *Colorimetry*

DIN 6160:1996, *Anomaloscopes for the diagnosis of red-green colour vision deficiencies (or equivalent)*

DIN 33866–1: 2000, *Information technology – Office machines – Colour image reproduction devices,* Part 1: *Method of specifying image reproduction of colour devices by **digital** and **analog** test charts – Classification and principles*

DIN 33866–2: 2000, *Information technology – Office machines – Colour image reproduction devices – Method of specifying image reproduction of colour copiers by analog test charts – Application and realisation*

DIN 33866–3: 2000, *Information technology – Office machines – Colour image reproduction devices,* Part 3: *Method of specifying image reproduction of colour devices by* ***digital*** *input and* ***analog*** *output as* ***hardcopy*** *for colour image reproduction devices:* ***"digital – analog"*** *(Printers) – Application and realisation*

DIN 33866–4: 2000, *Information technology – Office machines – Colour image reproduction devices,* Part 4: *Method of specifying image reproduction of colour devices by* ***analog*** *input and* ***digital*** *output for colour image reproduction devices:* ***"analog – digital"*** *(Scanners) – Application and realisation*

DIN 33866–5: 2000, *Information technology – Office machines – Colour image reproduction devices,* Part 5: *Method of specifying image reproduction of colour devices by* ***digital*** *input and* ***analog*** *output as* ***softcopy*** *for colour image reproduction devices:* ***"digital – analog"*** *(Monitors) – Application and realisation*

DIN 58220–5:1996, *Test of visual acuity – Part 5: General test of vision*

ITU-R Recommendation BT.709–3:1998, *Parameter Values for the HDTV Standards for Production and International Programme Exchange*

IEC 61966-2-1: 1999, *Multimedia systems and equipment - Colour measurement and management - Part 2-1: Colour management - Default RGB colour space - sRGB*

IEC 61966-7-1: 2001, *Multimedia systems and equipment - Colour measurement and management - Part 7-1: colour printers - reflective prints - RGB inputs*

IEC/CIE publ. 17.4: 1987, *International lighting vocabulary, 4th edition, Joint publication IEC/CIE*

ISO/IEC TR 19797: 2003, *Device output of 16-step colour scales, output linearization method (LM) and specification of the reproduction properties*

3. Terms and definitions

3.1 Definitions

For the purpose of this Technical Report, the following definitions apply.

3.1.1
colour rendering

relation between the original colour of an object and its reproduction colour, either exclusively under another illuminant or additionally after passing through a transfer process

NOTE For calculation with the colours of this Technical Report, see Annex G.

3.1.2
original colour

the perceived colour of an object for the reference condition which is being referred to at the assessment of the colour rendering

3.1.3
non-luminous (perceived) colour

colour of a non-luminous colour, i. e. an area that requires a reflecting light for its appearance

3.1.4
standard tristimulus values *X, Y, Z*
colorimetric parameters *L*a*b**

describe the psycho-physical colour

NOTE 1 Standard tristimulus values *X, Y, Z* are mostly obtained as an immediate result of a colour measurement

NOTE 2 As standard tristimulus values *X, Y, Z* only allow statements referring to equality of two colours, for statements made beyond that, e. g. concerning the kind and size of colour differences, non-linear transformations of *X, Y, Z* into other colorimetric parameters systems, preferably into the colorimetric parameters *L*, a*, b*,* are necessary.

3.1.5
colour difference ΔE^*_{ab}

see CIE publ. 15.2, page 95

3.1.6
lightness *L**

see CIE publ. 15.2, page 95

3.1.7
chroma *C**

see CIE publ. 15.2, page 95

3.1.8
Landolt-ring
standard optotype defined by a ring with an open segment which can be in eight different positions

3.1.9
halftone technique
production of intermediate tones such as grey using only black and white pixels

NOTE In offset printing a halftone cell of a square width 0,16 mm may be filled by 16 x 16 single points with the square width 0,01 mm. This technique allows 256 grey steps which are not visually equally spaced.

3.1.10
continuous tone technique
production of mean tones, e. g. grey, by density variation of the (black) colorant

NOTE: In continuous tone (photographic) technique for the test chart material in A4 size the cells (or pixels) of the square width 0,16 mm may be filled by 16 x 16 single points with the square width 0,01 mm.

3.1.11
***-image ("star-image")**
includes colours defined by the colorimetric parameters *L*a*b** of the CIELAB colour system.

NOTE: The *-image ("star-image") includes colours (of the colour pixels or areas) which are defined either in absolute *(LAB*)* or relative *(lab*)* coordinates

3.1.12
***'-image ("star-prime-image")**
includes colours produced by a standard reproduction process of a colour device and is different than the *-image

NOTE: The *'-image ("star-prime-image") has different colorimetric parameters (*'-coordinates) compared to the *-image ("star-image") with *L*a*b** parameters defined either in absolute *(LAB*)* or relative *(lab*)* coordinates

3.1.13
'*-image ("prime-star-image")
is produced by the standard reproduction process of a colour device and is different than the *-image ("star-image").

NOTE: The '*-image ("prime-star-image") is called the inverse image and includes *L*a*b** parameters defined either in absolute *(LAB*)* or relative *(lab*)* coordinates

3.1.14
standard image transformation
changes a *-image ("star-image") into a *'-image ("star-prime-image") (Fig. 1) or changes a '*-image ("prime-star-image") into a *-image ("star-image") (Fig. 2)

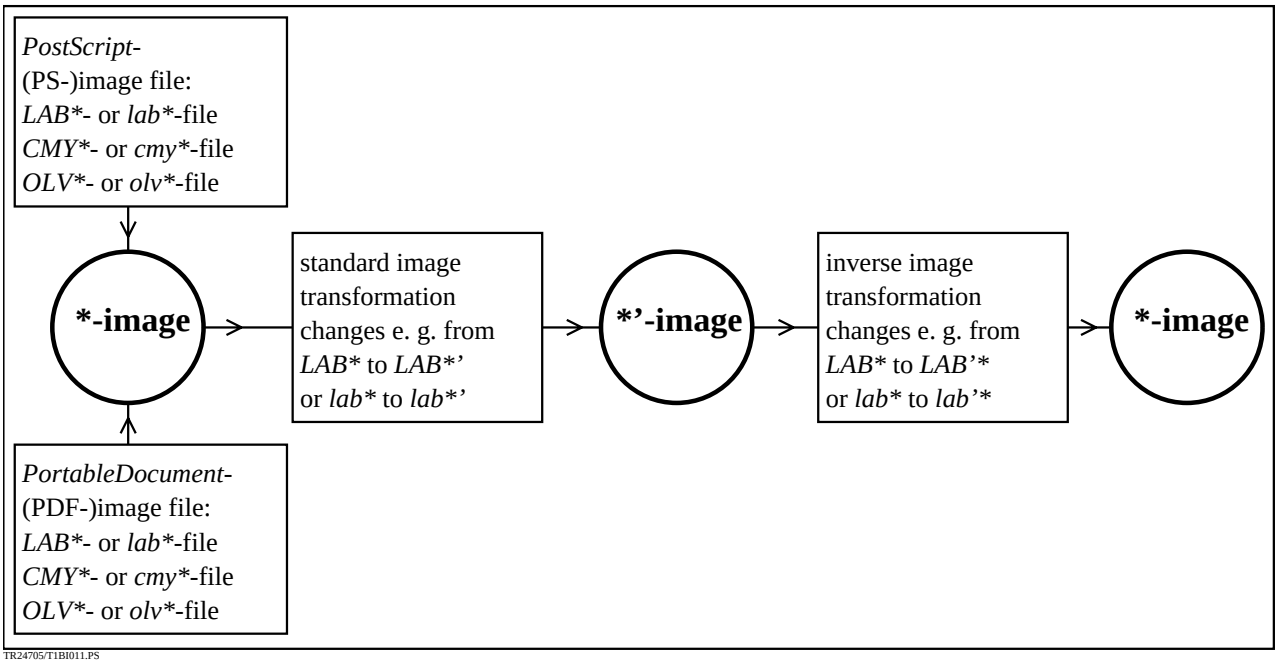

Figure 1: Standard and inverse image transformation

NOTE Fig. 1 shows that the standard image transformation changes a *-image ("star-image") into a *'-image

("star-prime-image") and that the inverse image transformation changes a *'-image ("star-prime-image") into a *-image ("star-image"). There may be small differences between the input (in) and output (ou) in real applications.

3.1.15
inverse image transformation

changes a *-image ("star-image") into a '*-image ("prime-star-image") (Fig. 2) or changes a *'-image ("star-prime-image") into a *-image ("star-image") (Fig. 1)

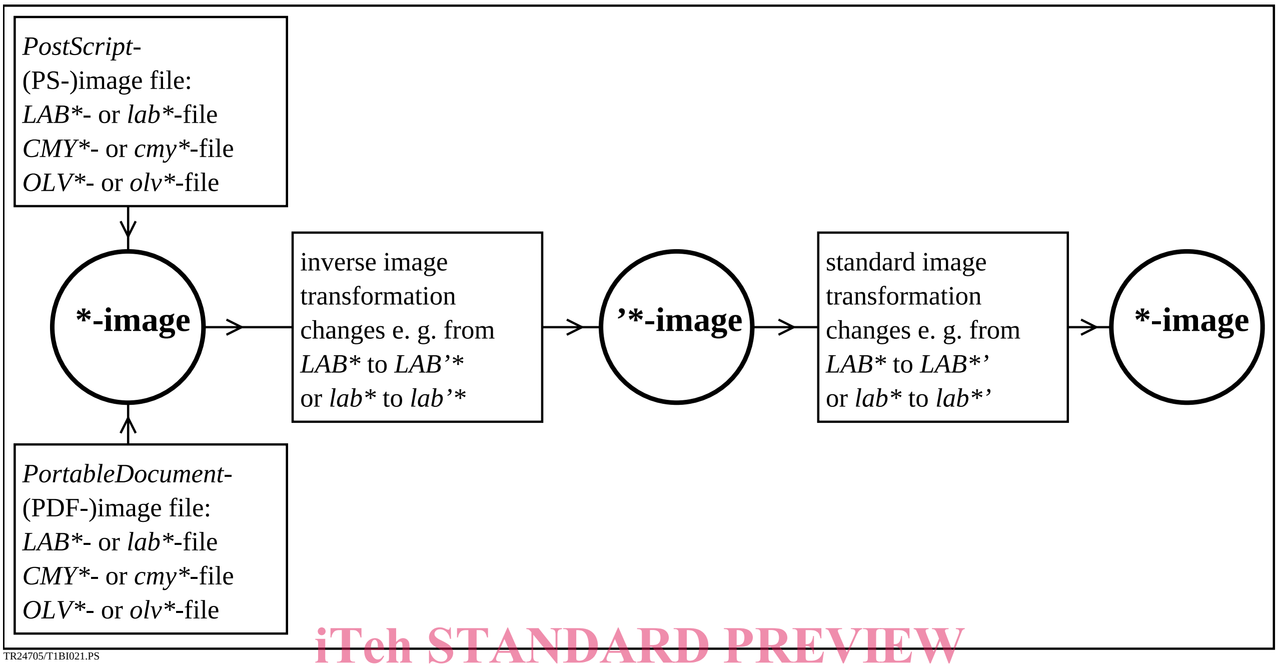

Figure 2: Inverse and standard image transformation

NOTE Fig. 2 shows that the inverse image transformation changes a *-image ("star-image") into a '*-image ("prime-star-image") and that the standard image transformation changes a '*-image ("prime-star-image") into a *-image ("star-image"). There may be small differences between the input (in) and output (ou) in real applications.

3.1.16
additive mixed colours

mixture of three colour lights

3.1.17
subtractive mixed colours

mixture of three colorants (pigments)

3.1.18
hardcopy

output (copy) of an image, typically on paper or film material

3.1.19
softcopy

output (copy) of an image, typically on a monitor or display

3.1.20
scanner

electronic device which illuminates an object, e. g. a sheet of paper or a photography, and digitizes the image of the object

NOTE It is possible to illuminate a transparent material (e. g. negative or positive film) to digitize the image on the transparency.

3.1.21
scanner system

based on hardware and software which produces a changed *'-image ("star-prime-image") from a scanned *-image ("star-image") with the achromatic colour data *(w** or *n*)* or the chromatic colour data *(cmy** or *olv*)*.

NOTE The changed "star-prime-image" has the achromatic colour data *(w*'* or *n*')* or the chromatic colour data *(cmy*'* or *olv')*.

3.1.22
digital output data of a scanner system

include digital *'-coordinates ("star-prime-coordinates") with one (e. g. *w**' or *n**'), three (e. g. *olv**' or *cmy**'), four (e. g. *olvw**' or *cmyn**'), eight *(olvwcmyn**')* or more digital output levels per pixel within a digital area of 4 bit (16 steps), 8 bit (256 steps) up to 16 bit (256 x 256 = 65 000 steps).

NOTE 1 The relative *-coordinates ("star-coordinates") describe the equally spaced colour series in the CIELAB colour space for offset printing. The CIELAB coordinates for offset printing are defined in Table 6.

NOTE 2: The 16-step colour series (e. g. white–black or white–Cyan-blue) for ISO/IEC-test chart 1 and 2 are visually equally spaced in the CIELAB colour space. An ideal scanner system produces for these steps digital *'-image data which are for *n**' or *c**' equally spaced in 16 steps in the decimal range 0 to 1, or the hexadecimal range 0 to F, 00 to FF, or 0000 to FFFF.

NOTE 3 In general a scanner system will try to produce relative digital output values *'-coordinates ("star-prime-coordinates") nearly the same as the relative *-coordinates ("star-coordinates") for the digital input data.

3.2 Colours in colour metrics, printing and television

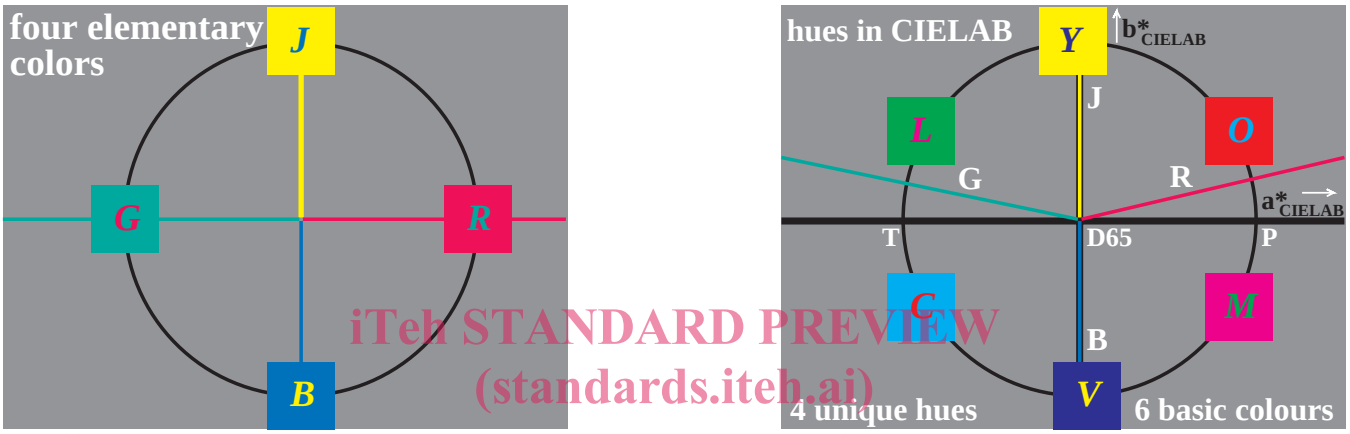

Figure 3: Four elementary and six reproduction colours relative to the CIELAB chroma axes *a*,b**

The colour metrics is based on visual elementary colours with the terms *R, G, B,* and *J* for red, green, blue, and yellow *(„RGBJ")* with e. g. yellow *J* as neither greenish nor reddish or red *R* as neither yellowish nor blueish. The defined colours for (colour) printing and (colour) television differ significantly from the elementary colours and it is required therefore to have other names. The terms *„CMYOLV"* (*C* = Cyan-blue, *M* = Magenta-red, *Y* = Yellow, *O* = Orange-red, *L* = Leaf-green, *V* = Violet-blue) are most appropriate for the visual appearance. Fig. 3 shows the four elementary hues in a symmetric hue circle (left) and the four and six hues relative to the chroma axes *a*, b** of the CIELAB colour space (right)

Table 1: Terms for achromatic colours, elementary colours and reproduction colours

Achromatic colours	**Elementary colours** *"Neither-nor"-colours*	**Reproduction colours** *Television (TV), Print (PR) Photography (PH)*
five achromatic colours:	*four elementary colours:*	*six reproduction colours:*
N black (french noir)	*R* red *neither yellowish nor blueish*	*C* cyanblue
D dark grey	*G* green *neither yellowish nor blueish*	*M* magentared
Z central grey	*B* blue *neither greenish nor reddish*	*Y* yellow
H light grey	*J* yellow (french jaune) *neither greenish nor reddish*	*O* orangered
W white		*L* leafgreen
		V violetblue

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The chromatic colours $(CMYOLV)_{PR}$ and $(CMYOLV)_{TV}$ defined in printing (PR) and television (TV) differ very much. For example, violet-blue$_{PR}$ and violet-blue$_{TV}$ have a CIELAB colour difference of 74 (see Table 14).

NOTE: There is no generally accepted definition of the photographic (PH) colours.

In the International Standard ISO/IEC 15775, the colours $(OLV)_{PR}$ and $(OLV)_{TV}$ are called *OLV* and *RGB*. This distinction is necessary because the colours $(OLV^*)_{PR} = OLV^*$ of the ISO/IEC-test chart 4 (in halftone offset printing) may be reproduced as colours OLV^* on the monitor (absolute reproduction as far as possible) or as colours $(OLV^*)_{TV} = RGB^*$ (relative reproduction). The goal of this Technical Report is a „relative image reproduction" within $\Delta E^* < 3$. See Fig. 1.

The colorimetric data L^*, a^*, b^* (compare 2.1.4) describe the achromatic colours by the visual attribute lightness L^* as well as the chromatic colours in red-green-*(RG-)*direction by the visual attribute *RG*-chroma a^*, and the chromatic colours in yellow-blue-*(JB-)*direction by the visual attribute *JB*-chroma b^* (see 2.1.6 and 2.1.7).

4. ISO/IEC-test charts

4.1 General

The layout, content and requirements for production of ISO/IEC-test charts are defined in ISO/IEC 15775. Eight examples in the two main colour spaces CMYN (CMYK) and OLV (RGB) are given in Annex I.

Analog ISO/IEC-test charts are produced in the standard format A4[1] in high resolution (e. g. 3600 dpi in halftone technique and 300 dpi in continuous tone technique) with intended low tolerances for the included colours („produced colours") compared to the standard CIE-test colours and the visually equally spaced colour series („intended colours") both defined in the CIELAB colour space. The intended colours are defined in CIE-publ. 13.3. The basic colours $(CMY)_{PR}$ of offset printing are defined in ISO 2846–1:1997 in Table D3, and the basic colours of television $(RGB)_{TV}$ in ITU-R BT.709–3.

The **digital** ISO/IEC-test charts have been developed from the **analog** ISO/IEC-test charts. At the same time, the reference colours of the analog ISO/IEC-test charts form the basis for the digital ISO/IEC-test charts.

4.2 Content and purpose of ISO/IEC-test charts

The test charts 1 to 4 include a frame area and a picture area. The frame area is similar in all ISO/IEC-test charts and is described in 4.2.1. The image area is different in ISO/IEC-test charts 1 to 4 and is described in the sections from 4.2.2.1 to 4.2.2.4.

4.2.1 Content and purpose of the frame area

ISO/IEC-test charts 1 to 4 contain a picture area surrounded by a frame area. The frame area is the same in all ISO/IEC-test charts.The content and purpose of the frame as well as the visual tests are described here. The picture area is described in 4.2.2 separately for ISO/IEC-test charts 1 to 4.

In the frame area there are different text and image elements: text with codes for identification, rectangles, 5-step grey scales, and position marks.

NOTE 1: The output of the frame area may differ when reproducing achromatic and chromatic digital ISO/IEC-test charts. For example, if text mode (T) and not colour modes (C) is chosen for the achromatic test chart 1 or test chart 3 or if colour modes (C) is chosen for the output of the chromatic digital test charts 2 and 4.

NOTE 2: The achromatic digital ISO/IEC-test charts 1 and 3 are given for the output in text and colour modes. The digital file version number includes the codes TS, CS, TD and CD. The first letter describes the text modes (T) or colour modes (C) and the second the file format *PostScript* (S) or *Portable Document* (D)[2]. There may be output differences between the output in PS and PDF, so the format used must be specified.

Use of text with codes for identification:

Content:
The text in the frame region may describe the ISO/IEC-test chart number, the ISO/IEC-BAM-identification code, the ISO/IEC-BAM-reference material code[3], the image file version of the test chart, and ordering information depending on the manufacturer.

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[1] For test charts in continuous tone the size may be different for technical reasons. The size must be at least 195 mm x 282 mm and it is required that the inner rectangle of the frame area be included. (See 4.2.1).

[2] *Adobe PostScript* (PS) and *Portable Document Format* (PDF) are registered trade marks of Adobe.

[3] *BAM:* Federal Institute for Materials Research and Testing, VIII.3901 “Visual methods and Image Reproduction for NDT”, Unter den Eichen 87, D-12200 Berlin, Germany

Purpose:
The text is for identification of the ISO/IEC-test chart. To fill out forms E and F the following informations are necessary: test chart text (bottom text), identification code, material code, and the image file version of test charts (see Annex E and F).

Visual test:
There is no visual test of text in frame region.

Test of copied lines of rectangle:

NOTE: An ISO/IEC-reference test chart satisfies the methods of this Technical Report if there are at least complete lines for the *inner (thicker line)* rectangle. For this purpose there are between 4 and 20 lines on an ISO/IEC-test chart.

Content:
On the test charts there are up to five rectangles which are 4 mm smaller on each side. The outer rectangle is defined by the A4 format (297 mm x 210 mm).

Purpose:
The five frame rectangles help to detect the size of the device reproduction area visually.

Visual Test:
In a visual test the number of lines on the ISO/IEC-test chart should be compared with the number of lines reproduced.

Test of 5-step grey scales:

Content:
There are four grey scales with equally spaced steps near the four position marks.

NOTE: The grey samples in test charts 1 and 3 are the same as the 5-step samples of picture A2 or C2 respectively. There are no 5-step gray scales in test charts 2 and 4 for direct comparison.

Purpose:
Agreement test of the four grey scales. Differences can be found by visual comparison of the four grey scales.

Visual test:
In an approximated test a Yes or No decision is to be made if one can clearly see visual differences of the four grey scales. If the four are different a test result must indicate the most different grey scale compared to the average. A test result must also indicate the direction of deviation (darker or lighter) compared to the average.

Test of *x*- and *y*-scale factors by width and height of the inner (thicker) rectangle:

Content:
The inner (thicker) rectangle is 16 mm smaller in width and height compared to the outer rectangle of the A4 format (297 mm x 210 mm).

Purpose:
The width and height of the inner rectangle serve to measure the *x*- and *y*-scale factors of the image reproduction device.

Test: The width and height is to be measured in *x*- and *y*-directions in mm for both the original and the reproduction. The *x*- and *y*-scale factors must be calculated.

NOTE 1: The width and height of the inner rectangle is defined in *PS*-file (or equivalent) as 281 mm in *x*-direction and 194 mm in *y*-direction. To measure the two scale factors with high accuracy it is recommended that both the original and the reproduction be measured with the same ruler.

NOTE 2: The corners of the inner rectangle or the position marks are often used to position colorimetric instruments for automatic *L*a*b** colorimetric measurements and to position the plates in four colour printing.

Visual test:
There is no visual test of the scale factors.

Test of shift for colour lines:

NOTE 1: Test charts are usually produced on colour material in colour mode (C). There are versions of test charts 1 and 3 completely in black and white text mode (T), such as ISO/IEC-test chart 1 on black and white photographic paper.

NOTE 2: In that case the following test is not applicable. For completely black and white production one can omit the following specification of „Test of shift for colour lines“.