TECHNICAL REPORT

ISO/IEC TR 24705

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2005-10-15

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

Reference number
ISO/IEC TR 24705:2005(E)

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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

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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, 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.

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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

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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.*

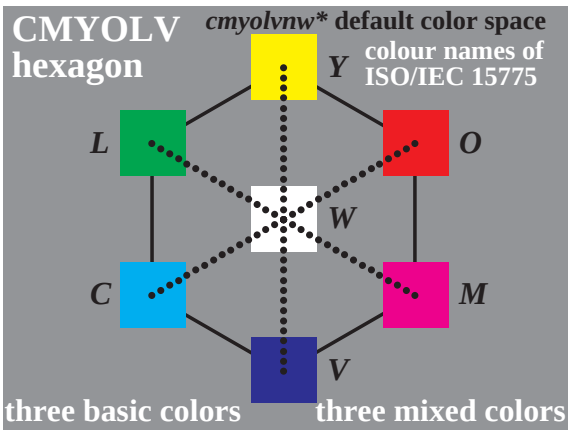
Section 7. to 9.: *Method of specifying image reproduction of colour systems by **digital** input and **analog** output as **hardcopy*** for colour image reproduction devices: ***"digital – analog"** (Printers) – Application and realisation.*

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.



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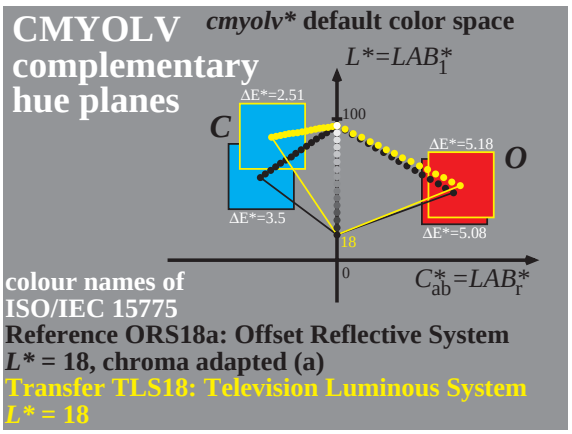

TR24705/B2410-2N

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.

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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.

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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

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*

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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

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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)

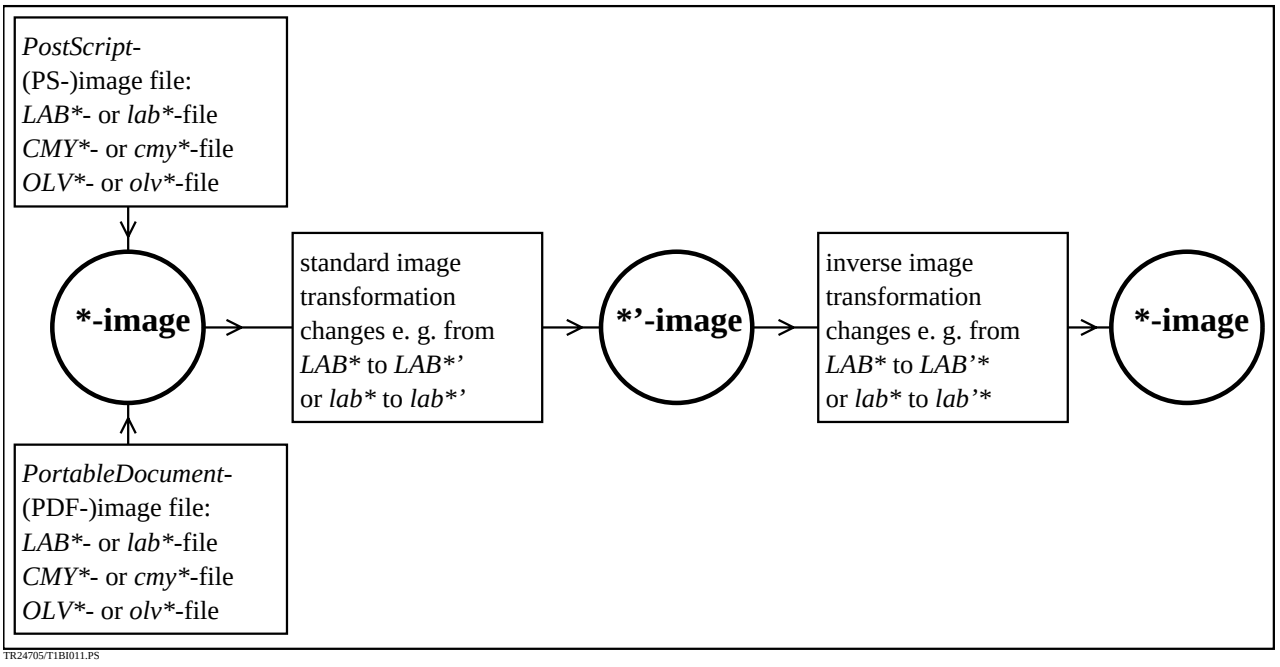

Figure 1: Standard and inverse image transformation

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

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(“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)

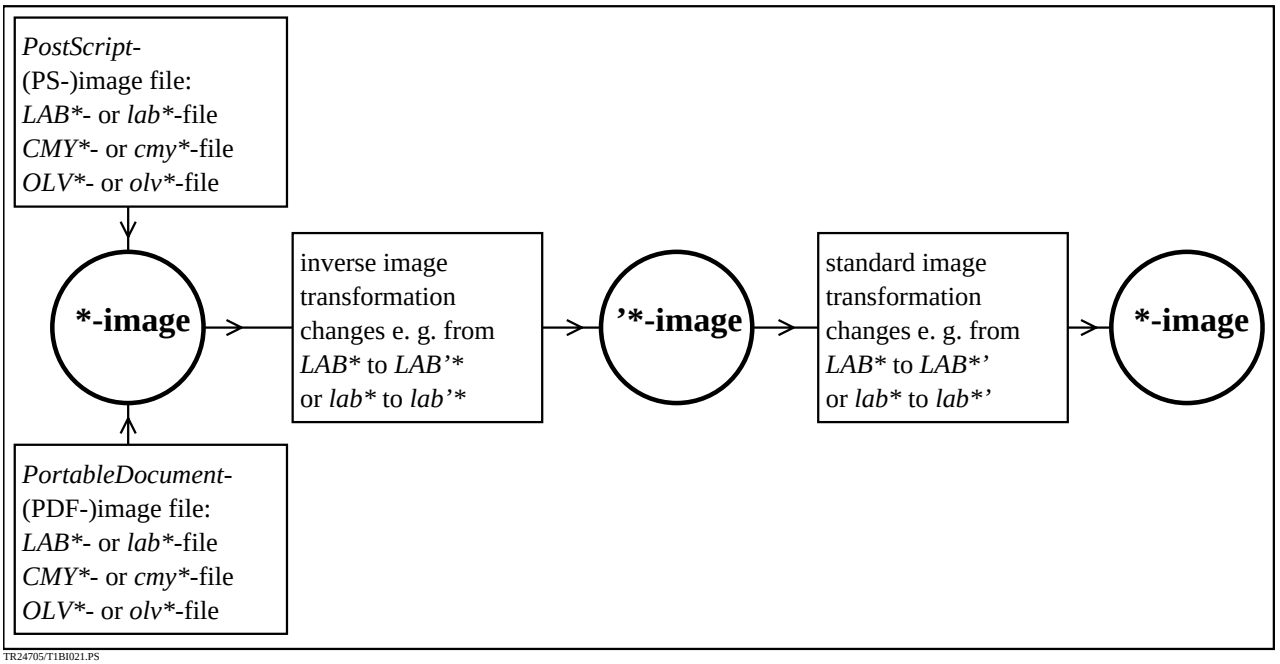

Figure 2: Inverse and standard image transformation

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‘)*.

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3.1.22
digital output data of a scanner system

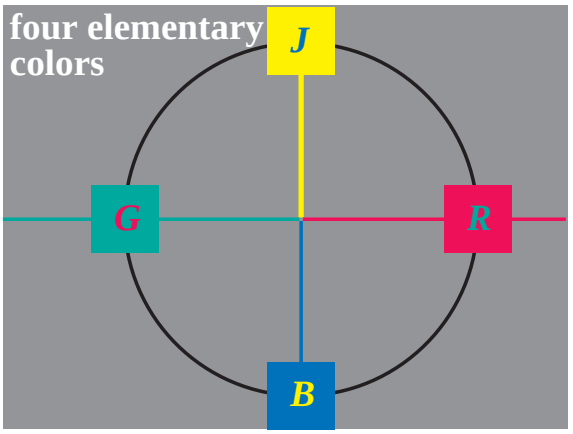
include digital *'-coordinates ("star-prime-coordinates") with one (e. g. *w**' or *n**'), three (e. g. *olv**' or *cmy**'), four (e. g. *olvw**' or *cmyn**'), eight *(olvwcmyn**')* or more digital output levels per pixel within a digital area of 4 bit (16 steps), 8 bit (256 steps) up to 16 bit (256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

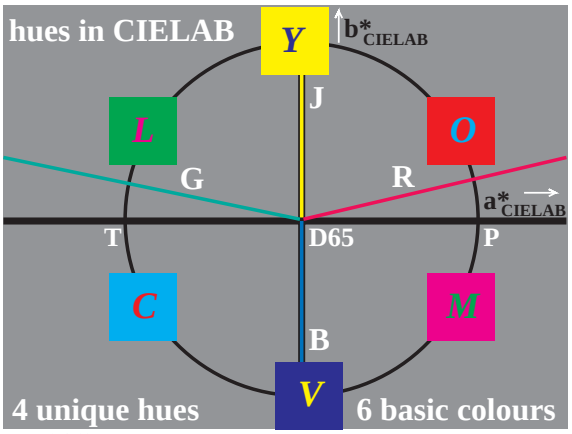
NOTE 2: The 16-step colour series (e. g. white–black or white–Cyan-blue) for ISO/IEC-test chart 1 and 2 are visually equally spaced in the CIELAB colour space. An ideal scanner system produces for these steps digital *'-image data which are for *n**' or *c**' equally spaced in 16 steps in the decimal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



TR24705/E8151−3X



TR24705/E8370-22

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

TR24705/T1TA011.PS

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.

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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.

[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

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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“.

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Content:
The lines defining the *inner rectangles* are drawn in different colours which alternate in colour between black and the colours *C, M, Y, O, L* and *V.*

Purpose:
The colours of the *inner rectangle* allow a visual test for the shifts of the colour lines *C, M, Y, O, L* and *V* compared to the black line in horizontal and vertical directions.

Visual Test:
In an approximated test a Yes- or No- decision is to be made wether the shift of the colour lines *C, M, Y, O, L* and *V* compared to the black *N* line is greater than or equal to 0,2 mm (more than half of the line-width defining the *inner rectangle*).

4.2.2 Content and purpose of the picture area

4.2.2.1 ISO/IEC-test chart 1 (Achromatic test chart with high lightness contrast)

Picture A1: Radial Gratings (Siemens-stars) *N–W, W–N, N–Z, W–Z*

Content:
Radial gratings (Siemens-stars) in the combination of *N–W*, *W–N*, *N–Z*, *W–Z* with marked rings 6, 10, 20 and 30 mm in diameter.

Purpose:
Resolution test of colour reproduction devices. Differences can be found by comparison of the stars in a test chart with the stars in a reproduction of the chart.

Visual test:
In a rough test one should decide if the diameter of the blurred area in the radial grating on the reproduction does not exceed the chosen ring size in all directions (Yes or No decision).

For a detailed test the greatest diameter of the blurred area should be examined with an optical aid such as a magnifying glass-6x.

NOTE 1: The rings with a diameter of 6, 10, 20 and 30 mm should be used as guidance.

NOTE 2: In some cases one can not evaluate the inner area of the 6 mm ring. The blurred area of the original may be larger than the inner area of the 6 mm ring.

Picture A2 and A3: 5 or 16 visually equally spaced *L-grey steps**

Content:
Picture A2 contains five visually equally spaced grey steps between white and black in two rows. A black N_0 and white W_1 is added. Picture A3 contains 16 equally spaced grey steps also in two rows.

In the upper rows, the grey steps are adjacent, in the lower ones the grey steps are separated by the grey background.

For the page as a whole and medium picture content a medium grey with a lightness $L^* = 50 \pm 2$ was chosen for both fields (according to CIE-publ. 15.2 a reflectance factor of 0,2 and a luminance reflectance of $Y = 20$).

On the upper rows the lightness L^* of the CIELAB-colour system is stated above the individual grey steps. The grey steps of halftone ISO/IEC-test chart 1 are produced using only the colour black for the photographic version and not from the four process colours *CMYN.* This is because the colour black cannot be produced with sufficient accuracy from these colours for the test chart. The grey steps of the continuous ISO/IEC-test chart 1 are produced by the three process colours *CMY* of the photographic process.

NOTE 1: The theoretical values $L^* = 0$ and $L^* = 100$ for a black N_0 and white W_1 cannot be reached because there are no completely absorbing or reflecting surfaces. For black *(N)* and white *(W)* in the 5- and 16-step grey series the lightness values are described as L^*_N and L^*_W. In the halftone ISO/IEC-test chart 1 they are approximately 10 and 94 respectively. In the continuous tone ISO/IEC-test charts they are approximately 7 and 91 respectively. In the halftone ISO/IEC-test chart 3 they are approximately 18 and 95 respectively.

The numbers between 0,00 and 1,00 in the respective rows describe the relative lightness $l^*_{relative}$ between black and white for the relevant grey steps.

NOTE 2: $l^*_{relative}$ results of the CIELAB lightness L^*:

$$l^*_{relative} = (L^* - L^*_N) / (L^*_W - L^*_N) \quad \text{(equation 1)}$$

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Picture A3 shows the hexadecimal values above the individual grey steps of the lower rows.

NOTE 3: In printing technology, where paper white is taken as basis and the amount of black is described, the grey scale begins with white and the hexadecimal coding 0 and ends with black and the hexadecimal coding F.

Purpose:
The reproduction of pictures A2 respectively A3 are useful in deciding whether the device is capable of distinguishing the upper rows. If some greys of the upper rows look equal and cannot be distinguished then the lower rows are intended for an optional measurement.

NOTE: For many fields of application a distinction in five grey steps is sufficient, while a distinction of as many of the 16 grey steps as possible is desired for the reproduction of photographic pictures.

A human being is capable of distinguishing about 200 grey steps between white and black positioned side by side.

Visual test:
The user is to judge how many of the five grey steps in picture A2 or 16 grey steps in picture A3 can be distinguished for the upper row of the reproduction.

Picture A4: Landolt-rings *N–W*

Content:
The picture contains 6 lines with 8 Landolt-rings each. For the Landolt-rings and the background (surround) various grey steps of the 16 grey steps of picture A3 have been selected.

NOTE: The values of the grey steps of the Landolt-rings and background correspond to the hexadecimal coding definition in picture A3.

Purpose:
The picture A4 allows a judgement concerning the reproduction in light, medium grey and dark areas. The differences between ring and background are in this area and in the upper three rows it is one grey step. In the lower three rows the difference is two grey steps.

Visual test:
The recognition frequency of the Landolt-rings has to be judged according to 5.2.2.

Pictures A5 and A6: Different line raster diameter under 45° and 90°

Content:
The pictures contain line-elements with an angle of 45° (picture A5) or 90° (picture A6) and a raster with 15 to 240 lines per inch (lpi).

NOTE: In the halftone ISO/IEC-test chart 1 240 lpi are used. In continuous tone ISO/IEC-test chart 1 there is a technical limit of 75 lpi dependent on the 300 dpi digital image setter used for its production.

Purpose:
The pictures A5 and A6 serve to test the line reproduction.

Visual test:
By analogy with the interpretation of the Siemens-stars in picture A1, a rough examination is to be made with the naked eye to determine the highest spatial frequency which is perceptible.

For an exact examination, an optical aid such as a magnifying glass-6x could be used to examine which raster pitch lines can be recognized.

NOTE 1: Colour reproduction devices have a fixed angle of scanning (normally horizontal or vertical). The reproductions correspond to the angles of the copied pattern whose marked pattern structures are shown. These are known in the printing business as Moiré-patterns and will be lower by an angle of 45°. Because of this the test chart 1 contains pictures with screens at two different angles.

NOTE 2: The line raster pitch of 80 to 240 lpi can normally only be distinguished by using optical aids, such as a magnifying glass.

NOTE 3: In pictures A5 and A6 the one with the greatest lpi (lines per inch) for which the lines and spaces can be distinguished is a measure of the system resolution.

NOTE 4: Defects in output made using the test patterns A5 and A6 for areas with greater than 60 lpi may not be important.

NOTE 5: Rotating and moving the test patterns A5 and A6 to different locations on the imaging platen may uncover additional reproduction defects and this is recommended.

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4.2.2.2 ISO/IEC-test chart 2 (Chromatic test chart with *CMY*-colours)

Picture B1:

The content of this picture can be chosen by the manufacturer of the ISO/IEC-test charts. This content should include the 14 CIE-test colours plus N_0 and white W_1 and a 16-step grey scale. In ISO/ISC 15775 a flower image was chosen in test chart 2 and 14 CIE-test colours in ISO/IEC-test chart 4. The purpose of the flower image is described here as an example.

NOTE: The Picture B1 of test chart 2 is equal in content to the picture D1 of test chart 4. A manufacturer may use slide film material to photograph the picture B1 and negative film material to photograph the picture D1.

Picture B1: Flower image, 14 CIE-test colours plus black N_0 and white W_1, and 16-step grey scale.

Content:

The flower image of the chromatic test chart represents especially the colours which are found in nature and these are placed against a neutral grey background. This serves to judge the true reproduction of these colours. Furthermore the colours gold and silver have been included in the picture as metallic balls. The additional CIE-test colours plus black N_0 and white W_1, and a 16-step grey scale may help to judge the fidelity of reproduction (see 4.2.2.4).

Purpose:

Picture B1 serves to compare colour fidelity of the test chart and its reproduction. The neutral grey background helps to recognize colour shifts. The mainly neutral grey background has various shadows.

NOTE 1: The test chart is not for judgement of individual preference colours and body tones, which may be judged differently in different countries.

NOTE 2: An optional radial grating (Siemens-star *N–W)* used in ISO/IEC-test chart 4 helps to get some information on pixel image resolution.

Visual test:

Clear (immediately conspicuous) relative differences between the original and the reproduction should be judged.

Picture B2: Radial gratings (Siemens-stars) *W–C, W–M, W–Y, W–N* and *W–Z*

Content:

Radial gratings (Siemens-stars) in the combinations *W–C*, *W–M*, *W–Y*, *W–N* and *W–Z* with marked rings of 6, 10 and 20 mm in diameter.

Purpose:

Picture B2 serves for the judgement of resolution. The rings with a diameter of 6, 10 and 20 mm serve as guide.

Visual test:

In a rough test one should decide if the diameter of the blurred area in the radial grating on the reproduction does not exceed the chosen ring size in all directions (Yes or No decision).

For a detailed test the greatest diameter of the blurred area should be examined with an optical aid such as a magnifying glass-6x.

NOTE 1: The rings with a diameter of 6, 10 and 20 mm should be used as guidance.

NOTE 2: In some cases one can not evaluate the inner area of the 6 mm ring. The blurred area of the original may be larger than the inner area of the 6 mm ring.

NOTE 3: The lowest resolution is usually the one for the radial grating *W–Y* due to the low contrast between white and yellow.

Picture B3: 14 CIE-test colours, black N_0 and white W_1, 16 equally spaced grey steps

NOTE: Picture B3 is identical to picture D3 of test chart 4.

Content:

In the upper two rows the picture contains 14 CIE-test colours according to CIE-pub.13.3 along with black N_0 and white W_1. In the lower row the picture contains 16 equally spaced grey steps.

In the upper rows, the colours and grey steps are adjacent, and in the lower rows the colours and grey steps are separated by the grey background.

For the page as a whole and medium picture content a medium grey with a lightness $L^* = 50 \pm 2$ was chosen for both fields with a reflectance factor of 0,2 or a luminance reflectance of $Y = 20$ (according to CIE-publ. 15.2).

Purpose:

Picture B3 serves for the judgement of relative colour fidelity of the reproduction.

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Visual test:
Clear (immediately conspicuous) relative differences of the 14 colours between the test chart and the reproduction are to be judged (Yes or No decision). Should this not be the case, the number of distinguishable steps should be stated.

Clear (immediately conspicuous) relative differences of the 16 grey colours between the test chart and the reproduction are being judged (Yes or No decision). Should this not be the case, the number of distinguishable steps should be stated.

NOTE: The test colours reproduced in the test chart show small colour differences compared to the test colours defined in CIE-pub. 13.3. This fact can be ignored for the visual judgement since here the colour difference between the original and a reproduction is assessed.

Picture B4: 16 visually equally spaced steps with the colours *W–C, W–M, W–Y* and *W–N*

Content:
The picture contains four rows with 16 colour steps each, using the colours *C, M, Y* and *N*, starting with white and the hexadecimal coding zero up to the colour with the hexadecimal coding F.

Purpose:
Picture B4 serves for the judgement of different colour steps.

Visual test:
For each of the four colours one should examine visually whether all 16 colour steps of the rows are different (Yes or No decision). Should this not be the case, the number of distinguishable steps should be stated.

NOTE 1: For a reproduction of photographic pictures the differentiation of as many of the 16 colour steps as possible for the individual colours is desired.

NOTE 2: In the *W–Y* row of the test chart 2 not all of the 16-steps may be distinguishable by testing persons.

Picture B5: Script and Landolt-rings in four sizes

Content:
The picture contains (in four groups with the relative sizes 10, 8, 6 and 4) 32 black characters and 8 Landolt-rings in the colours *N, C, M* and *Y* in each group.

Purpose:
Picture B5 serves for testing of reproduction by recognition of characters depending on their size and colour.

Visual test:
Each vertical line in every individual group should be judged to determine if the frequency of recognition for the letters or Landolt-ring respectively is more than 50% (see 5.2.2).

NOTE: For the decreasing relative sizes 10, 8, 6 and 4 the recognition is more difficult. The Landolt-ring *Y* with size 10 of the original test chart may not be recognizable by some testers.

Picture B6 and B7: Landolt-rings *W–C, W–M, W–Y* and *W–N*

Content:
The pictures contain a block with 6 lines and 8 Landolt-rings each for each of the four colours *C, M, Y* and *N*. For the Landolt-rings and the background different colour steps of the 16 colour steps of the corresponding colours in picture B4 have been selected in each case. They differ by one or two colour steps in the blocks *W–C*, *W–M* and *W–N* respectively and by two or four colour steps in the block *W–Y* respectively.

NOTE: The values of the colour steps of the Landolt-rings and the background correspond to the hexadecimal values in picture B4.

Purpose:
Pictures B6 and B7 shall also allow a judgement of how the reproduction of characters on different backgrounds depends on the difference between the chromatic steps of characters and the background.

Visual test:
For tests the recognition frequency of the Landolt-rings has to be judged according to 5.2.2.

4.2.2.3 ISO/IEC-test chart 3 (Achromatic test chart with medium lightness contrast)

The pictures of the ISO/IEC-test chart 3 correspond in relation to content, purpose and visual test to the ISO/IEC-test chart 1. The grey steps differ in lightness contrast.

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NOTE 1: In halftone technique the lightness L^* varies between 18 and 96 in ISO/IEC-test chart 3 and L^* varies between 10 and 94 in ISO/IEC-test chart 1. For lightness L^* of actual production test charts, see web servers (Annex N).

NOTE 2: In continuous tone technique the lightness L^* varies between 13 and 91 in ISO/IEC-test chart 3 and L^* varies between 7 and 91 in ISO/IEC-test chart 1. For lightness L^* of actual production test charts, see web servers (Annex N).

4.2.2.4 ISO/IEC-test chart 4 (Chromatic test chart with *OLV*-colours)

The pictures of the ISO/IEC-test chart 4 correspond to the ISO/IEC-test chart 2 in relation to content, purpose and visual test.

NOTE: The Picture B1 of test chart 2 is in content equal to the picture D1 of test chart 4. A manufacturer may use slide film material to photograph the picture B1 and negative film material to photograph the picture D1.

In the pictures D2 to D6 of ISO/IEC-test chart 4 the *OLV*-colours are used instead of the *CMY*-colours used in the pictures B2 to B6 of ISO/IEC-test chart 2.

4.3 Modes and production of ISO/IEC-test charts

4.3.1 Analog ISO/IEC-test charts

Table 2 and Table 3 show properties of the **analog** ISO/IEC-test charts in halftone and continuous tone technique.

Table 2: Characteristics of analog ISO/IEC-test charts in halftone technique

Characteristics h = halftone	Formula	Unit	Requirements for test chart (type = h)[c]				Test method according to
			no. 1	no. 2[b]	no. 3[b]	no. 4[b]	
Format	−−	−−	A4	A4	A4	A4	ISO 216
Reference Mass (Area weight)	m_A	g/m^2	85	150	150	150	ISO 536
Smoothness	$GL(\text{Bekk})_B$	s	>600	>600	>600	>600	ISO 5627
Opacity	O	%	>90	>90	>90	>90	ISO 2471
Reflectance factor	R_{457}	%	>84	>84	>84	>84	ISO 1469
Lightness of black *N*	L^*_{CIELAB}	1	≤10	≤18	≤18	≤18	a
Lightness of white *W*	L^*_{CIELAB}	1	≥94	≥95	≥95	≥95	a
Resolution of printing film	r	cm^{-1} (dpi)	1417 (3600)	1417 (3600)	1417 (3600)	1417 (3600)	−−
Raster distance	d_r	µm	7	7	7	7	−−
Spot size diameter	d_s	µm	21	21	21	21	−−
Medium colour reproduction index	$R^*_{ab,m}$	1	>87	>60	>87	>60	d

a Test according to CIE publ. 15.2, standard illuminant D65, 2° standard observer, 45°/0° geometry.
b Offset printing with printing inks on fluorescent free ISO reference paper. Contrast range: L^*_N =18, L^*_W = 96 according to ISO 2846.
c Data of actual production samples: see "Technical information" on web site: *http://www.ps.bam.de*
d Calculated according to the method given in Annex G.

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Table 3: Characteristics of analog ISO/IEC-test charts in continuous tone technique

Characteristics c = continuous tone	Formula	Unit	Requirements for test chart (type = c)[c]				Test method according to
			no. 1[b]	no. 2[b]	no. 3[b]	no. 4[b]	
Format	––	––	A4[e]	A4[e]	A4[e]	A4[e]	ISO 216
Reference Mass (Area weight)	m_A	g/m^2	225	225	225	225	ISO 536
Smoothness	$GL(\text{Bekk})_B$	s	>3000	>3000	>3000	>3000	ISO 5627
Opacity	O	%	>95	>95	>95	>95	ISO 2471
Reflectance factor	R_{457}	%	>83	>83	>83	>83	ISO 1469
Lightness of black *N*	L^*_{CIELAB}	1	≤7	≤7	≤13	≤7	a
Lightness of white *W*	L^*_{CIELAB}	1	≥91	≥91	≥91	≥91	a
Resolution of printing film	r	cm^{-1} (dpi)	118 (300)	118 (300)	118 (300)	118 (300)	––
Raster distance	d_r	µm	83	83	83	83	––
Spot size diameter	d_s	µm	167	167	167	167	––
Medium colour reproduction index	$R^*_{ab,m}$	1	>87	>60	>87	>60	d

a Test according to CIE publ. 15.2, standard illuminant D65, 2° standard observer, 45°/0° geometry.
b Digital imaging on photographic paper. Contrast ranges: L^*_N =7, L^*_W = 91 for no. 1, 2, 4; L^*_N =13, L^*_W = 91 for no. 3
c Data of actual production samples: see "Technical information" on web site: *http://www.ps.bam.de*
d Calculated according to the method given in Annex G.
e Many reproduction devices only produce output that is several mm smaller than A4. The size must include the inner rectangle of the frame area.

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The halftone version of the analog ISO/IEC-test chart 1 is produced on photographic paper (85 g/m^2). The halftone ISO/IEC-test charts 2 to 4 are produced on ISO-reference paper (free of fluorescence, art printing paper, glossy, 150 g/m^2). The halftone ISO/IEC-test charts include:

Analog ISO/IEC-test chart 1: Grey steps of the lightness range L^* = 10 to 94
Analog ISO/IEC-test chart 2: *CMY*-colours (chromatic), produced by *CMY*-colours
Analog ISO/IEC-test chart 3: Grey steps of the lightness range L^* = 18 to 95
Analog ISO/IEC-test chart 4: *OLV*-colours (chromatic), produced by *CMY*-colours

The continuous tone version of the analog ISO/IEC-test charts 1 to 4 are produced by digital imaging on photographic paper (fluorescent, glossy, 225 g/m^2). The continuous tone ISO/IEC-test charts include:

Analog ISO/IEC-test chart 1: Grey steps of the lightness range L^* = 7 to 91
Analog ISO/IEC-test chart 2: *CMY*-colours (chromatic), produced by *CMY*-colours
Analog ISO/IEC-test chart 3: Grey steps of the lightness range L^* = 13 to 91
Analog ISO/IEC-test chart 4: *OLV*-colours (chromatic), produced by *CMY*-colours

4.3.2 Digital ISO/IEC-test charts

The digital ISO/IEC-test charts can be used to produce output on colour devices (e.g. colour printers, colour monitors). They are presented in the three lowest resolutions on the Internet (see web servers Annex N). It is planed that the high resolution test charts will be available on a CD-ROM. The digital ISO/IEC-test charts are given in the *Adobe PostScript (PS)* and *Adobe Portable Document (PDF)* formats.

Table 4 and Table 5 show the device dependency of resolution and colour and the storage space necessary for the digital ISO/IEC-test charts.

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Table 4: Device dependency of resolution and colour

Test chart no. *n* = 1 to 4 and image	Device dependency of resolution		Device dependency of colour	
	digital input ISO/IEC-test chart	analog output (reproduction)	digital input ISO/IEC-test chart	analog output (reproduction)
no. 1: image A1 to A6	independent	dependent	independent	dependent
no. 2: image B1 **no. 2: image B2 to B7**	dependent independent	dependent dependent	independent independent	dependent dependent
no. 3: image C1 to C6	independent	dependent	independent	dependent
no. 4: image D1 **no. 4: image D2 to D7**	dependent independent	dependent dependent	independent independent	dependent dependent

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Table 5: Storage space and resolution

Test chart no. *n* = 1 to 4 and image	Resolution independent or pixel amount	Storage space for vector graphic in ISO/IEC-test chart	pixel graphic in ISO/IEC-test chart	vector graphic and pixel graphic
1 or 3: image A1 to A6	independent	50 kByte	–	50 kByte
2 or 4: without B1 or D1	independent	50 kByte	–	–
2 or 4: with image B1 or D1	128 x 192 points 256 x 384 points 512 x 768 points 1024 x 1536 points 2048 x 3072 points	50 kByte 50 kByte 50 kByte 50 kByte 50 kByte	150 kByte 600 kByte 2,400 MByte 9,600 MByte 38,400 MByte	200 kByte 650 kByte 2,450 MByte 9,650 MByte 38,450 MByte

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4.4 Codes of the ISO/IEC-test charts and their reproduction

The ISO/IEC-test charts are given in different modes (paper, film and as digital file) and in different sizes:

– A4
– A6 for Picture B1(identical to D1)
– 24 mm x 36 mm slide and negative film

The analog ISO/IEC-test charts are produced by two methods:

a) halftone technique
b) continuous tone (photographic) technique

The digital ISO/IEC-test charts are given as a *PostScript*-file or equivalent. They can be used to produce the analog form, e. g. as output on a colour printer or on a monitor. A six digit code with a three digit extension is used to describe the ISO/IEC-test charts and their reproduction.

Position 1:
i – input
o – output
r – reference

Position 2:
c – continuous tone technique
h – halftone technique

Position 3 and 4:
a4 – format A4
a6 – format A6
sf – slide (positive) film material
nf – negative film material

Position 5:
r – reflectance mode
t – transmittance mode

Position 6:
a – analog mode
d – digital mode

Examples for clarification (code and description):

iha4ra: input, halftone, format A4, reflectance mode, analog mode

rca4ra: reference, continuous tone, format A4, reflectance mode, analog mode

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The three digit extension is based on a character I (I = ISO/IEC or D = DIN) and includes the ISO/IEC-test chart number 1 to 4.

These codes are required both for the process description when producing outputs with colour devices and for the image comparison of an output with a reference. In Table H.1 and Table H.3 of Annex H the different codes for analog and digital mode are listed. In Table H.2, Table H.4, and Table H.5 three examples for a colour copier, a printer and a scanner are given.

4.5 Colorimetric data of intended and reproduced colours

The basic and mixture colours of the standard printing process (ISO 2846–1:1997) and of the standard television process (recommendation ITU-R BT.709–3) are defined in Table 6 and Table 8. Table 13 compares the intended colours of ISO 2846–1:1997 with the colours produced in DIN-test charts 2 and 4 (these correspond to ISO/IEC-test charts 2 and 4). Table 14 compares the printing colours of ISO 2846–1:1997 with the colours defined for colour television according to ITU-R BT.709–3.

Table 15 shows the CIE-test colours defined in CIE-publ. 13.3 and the CIE-colours produced using halftones for DIN 33866–2. The CIE-test colours produced are the reference colours of the digital DIN-test charts. The DIN-test charts 2 and 4 have been produced with the printing colours defined in ISO 2846–1:1997 which are given in Table 6. The accuracy achieved by DIN is given in Table 13.

Table 6: CIE data for offset printing (ISO 2846–1:1997; ORS18) with Y_W = 88,6 and L^*_W = 18

Basic offset colour or mixture colour for D65 ORS18=OLS18=Standard	**chromaticity**		**tristimulus values** *(Y=88,6 for white D65)*			***L*a*b**-CIELAB data** *(L*=95,4 for white D65)*		
	x	***y***	***X***	***Y***	***Z***	***L****	***a****	***b****
three subtractive basic colours: printing colours acc. to ISO 2846-1								
C cyan-blue	0,1645	0,2337	18,74	26,62	68,54	58,62	−30,63	−42,75
M magenta-red	0,4594	0,2348	33,06	16,90	22,01	48,13	75,20	−6,80
Y yellow	0,4414	0,5000	68,06	77,10	9,03	90,37	−11,16	96,17
three subtractive mixture colours: # DIN 33866-colours; ISO reference paper								
O orange-red#	0,6080	0,3380	30,13	16,75	2,68	47,94	65,31	52,07
L leaf-green#	0,2523	0,5559	8,71	19,18	6,62	50,90	−62,96	36,71
V violet-blue#	0,2158	0,1400	7,17	4,65	21,41	25,72	31,35	−44,36
achromatic colours: # calculated by linear chroma extrapolation in the CIELAB colour space								
W1 (ideal white#, *D65)*	0,3198	0,3387	94,44	100,00	100,84	100,00	−1,07	5,06
W (ISO paper, *D65)*	0,3197	0,3384	83,69	88,60	89,47	95,41	−0,98	4,76
N (black printing colour)	0,3122	0,3251	2,42	2,52	2,81	18,01	0,50	−0,46
N0 (ideal black#, *D65)*	−	−	0,02	0,00	0,12	0,01	0,84	−1,68

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Table 6 shows the standard CIE data for the offset printing colours according to ISO 2846–1:1997 for the CIE standard 45°/0° geometry, the CIE standard illuminant D65 and the CIE standard 2°-observer. The data of Table 7 define the Offset Reflective System ORS18 for lightness L^*_N=18 of Black N. The analog ISO/IEC 15775-test charts have been produced using the CIE data on ISO non-fluorescent standard reference paper. The mean CIELAB difference is given in Table 13 and is less than ΔE^*=3.

There may be a few colorimetric calculation problems in applications. In Table 6 the chromaticity of the colours White W and Black N is different and different compared to the chromaticity of D65 (x=0,3127, y=0,3290). The yellow-blue CIELAB chroma changes for White W from b^*=4,76 to b^*=0,46 for Black N. In applications both colours White W and Black N appear achromatic. Any CIE chromatic adaptation formula can only transform the chromaticity of one colour (either White W or Black N) to the chromaticity of D65, and there is no CIE colorimetric solution for printers and monitors.

The following four equations transform all the CIELAB data $L^*a^*b^*$ which are located on a straight line between N and W in the CIELAB space to the achromatic axis (a^*=b^*=0) in the CIELAB space. The equations are called the chroma adaptation (a) equations.

$l^* = (L^* - L^*_N) / (L^*_W - L^*_N)$ (0<=l^*<=1 is the relative CIELAB lightness between W and N)

$L^*_a = L^*$ (no lightness change by the chroma adaptation (a) equations)

$a^*_a = a^* - a^*_N - (a^*_W - a^*_N)\ w^*$ (a^*_W and a^*_N are CIELAB a^*-chroma of White W and Black N)

$b^*_a = b^* - b^*_N - (b^*_W - b^*_N)\ w^*$ (b^*_W and b^*_N are CIELAB b^*-chroma of White W and Black N)

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The chroma adaptation equations and the following inverse equations

$$l^*_a = (L^*_a - L^*_{Na}) / (L^*_{Wa} - L^*_{Na}) \qquad (L^*_N = L^*_{Na},\ L^*_W = L^*_{Wa})$$

$$L^* = L^*_a$$

$$a^* = a^*_a + a^*_{Na} + (a^*_{Wa} - a^*_{Na})\ l^*_a$$

$$b^* = b^*_a + b^*_{Na} + (b^*_{Wa} - b^*_{Na})\ l^*_a$$

are used for the transform of the achromatic colours in the ISO/IEC-test charts.

The chroma adaptation equations are used to extrapolate the CIELAB data for the achromatic colours Black N0 and White W1 in Table 6 and for the transfer of the chroma adapted colour coordinates of Table 7 which are used to calculate the CIELAB differences between the printer and the monitor colours. There is no lightness colour difference between the monitor and printer White W and Black N. There may be lightness differences for the two 16 step grey scales if the scaling is different. Equal relative scaling between L^*_N and L^*_W is the reference.

Table 7: CIE data of Offset Reflective System ORS18a (= OLS18a) with Y_W = 88,6 and L^*_N = 18

Basic offset colour or mixture colour for D65 ORS18a = OLS18a	**chromaticity**		**tristimulus values** *(Y=88,6 for white D65)*			***L*a*b**-CIELAB data** *(L*=95,4 for white D65)*		
	x_a	y_a	X_a	Y_a	Z_a	L^*_a	a^*_a	b^*_a
three subtractive basic colours: printing colours acc. to ISO 2846-1								
C cyan-blue	0,1610	0,2280	18,79	26,62	71,32	58,62	−30,34	−45,01
M magenta-red	0,4549	0,2319	33,08	16,90	22,90	48,13	75,28	−8,36
Y yellow	0,4388	0,4941	68,47	77,11	10,48	90,37	−10,26	91,75
three subtractive mixture colours: # DIN 33866-colours; ISO reference paper								
O orange-red#	0,6054	0,3363	30,15	16,75	2,90	47,94	65,39	50,52
L leaf-green#	0,2494	0,5484	8,72	19,18	7,07	50,90	−62,83	34,96
V violet-blue#	0,2148	0,1400	7,14	4,65	21,44	25,72	31,10	−44,40
achromatic colours: # calculated by linear chroma extrapolation in the CIELAB colour space								
W1 (ideal white#, *D65)*	0,3127	0,3290	95,05	100,00	108,92	100,00	0,00	0,00
W (ISO paper, *D65)*	0,3127	0,3290	84,21	88,60	96,48	95,41	0,00	0,00
N (black printing colour)	0,3127	0,3290	2,40	2,52	2,74	18,01	0,00	0,00
N0 (ideal black#, *D65)*	–	–	0,00	0,00	0,00	0,01	0,00	0,00

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Table 7 shows the chroma adapted (a) colour data which are calculated from the offset printing colours according to ISO 2846–1:1997. For the achromatic colours the CIELAB chroma data *a** and *b** are equal to zero. This system is called chroma adapted (a) Offset Reflective System ORS18a for the lightness L^*_N=18 of Black N. This System is equal to the Offset Luminous System OLS18a with Y_W=88,6 and Y_r=2.5. Four Offset Luminous Systems OLSxxa with xx=00, 18, 27 and 33 with four different ambient light reflections are given in Annex K.

Table 8: CIE data of television colours according to ITU-R BT.709–3 with Y_W = 100,0 and L^*_N = 0

Basic television colour or mixture colour for D65 CIE data for Yw=100	**chromaticity**		**tristimulus values** *(Y=100,0 for white D65)*			***L*a*b**-CIELAB data** *(L*=100,0 for white D65)*		
	x	***y***	***X***	***Y***	***Z***	***L****	***a****	***b****
three additive basic colours: television colours acc. to ITU-R BT.709−3								
R red	0,6400	0,3300	41,24	21,26	1,93	53,24	80,08	67,20
G green	0,3000	0,6000	35,76	71,52	11,92	87,74	−86,18	83,18
B blue	0,1500	0,0600	18,05	7,22	95,05	32,30	79,19	−107,85
three additive mixture colours: television colours acc. to ITU-R BT.709−3								
C cyan-blue	0,2246	0,3287	53,81	78,74	106,97	91,11	−48,08	−14,12
M magenta-red	0,3209	0,1542	59,29	28,48	96,99	60,32	98,23	−60,82
Y yellow	0,4193	0,5053	77,00	92,78	13,85	97,14	−21,56	94,48
achromatic colours:								
W (−)	–	–	–	–	–	–	–	–
W1 (white monitor, 100%)	0,3127	0,3290	95,05	100,00	108,90	100,00	0,00	0,00
N (black monitor, 0,00%)	–	–	0,00	0,00	0,00	0,00	0,00	0,00
N0 (ideal black, 0,00%)	–	–	0,00	0,00	0,00	0,00	0,00	0,00

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Table 8 shows the standard CIE data for television colours according to ITU-R BT.709–3 for the CIE standard

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illuminant D65, the CIE standard diffuse/0° geometry, the CIE 2°-observer, and normalized to $Y_W = 100$. The normalization to $Y_W = 100$ is the simplest colorimetric. For colorimetric comparison of monitor and paper colours (of often near the same luminance) the colorimetric normalization to $Y_W = 88{,}6$ of the following table is appropriate.

Table 9: CIE data of Television Luminous System TLS00 with $Y_W = 88{,}6$ and $L^*_N = 0$

Basic television colour or mixture colour for D65 TLS00: Yw=88,6 + 0,0	**chromaticity**		**tristimulus values** *(Y=88,6 for white D65)*			***L*a*b**-CIELAB data** *(L*=95,4 for white D65)*		
	x	***y***	***X***	***Y***	***Z***	***L****	***a****	***b****
three additive basic colours: television colours acc. to ITU-R BT.709−3								
R red	0,6400	0,3300	36,54	18,84	1,71	50,50	76,92	64,54
G green	0,3000	0,6000	31,68	63,36	10,56	83,63	−82,77	79,90
B blue	0,1500	0,0600	15,99	6,40	84,22	30,39	76,06	−103,58
three additive mixture colours: television colours acc. to ITU-R BT.709−3								
C cyan-blue	0,2246	0,3287	47,67	69,76	94,78	86,88	−46,17	−13,56
M magenta-red	0,3209	0,1542	52,53	25,24	85,93	57,30	94,35	−58,42
Y yellow	0,4193	0,5053	68,22	82,20	12,27	92,66	−20,70	90,75
achromatic colours:								
W1 (ideal white#, 100%)	0,3127	0,3290	95,05	100,00	108,90	100,00	0,00	0,00
W (white monitor, 88,6%)	0,3127	0,3290	84,21	88,60	96,49	95,41	0,00	0,00
N (black monitor, 0,00%)	–	–	0,00	0,00	0,00	0,00	0,00	0,00
N0 (ideal black, 0,00%)	–	–	0,00	0,00	0,00	0,01	0,00	0,00

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Table 9 shows the CIE colour data for television according to ITU-R BT.709–3 now normalized to $Y_W = 88{,}6$. This system is called Television Luminous System TLS00 for the black lightness L^*_N=0. In Table 9 to Table 12 the luminance factor is always normalized to $Y_W = 88{,}6$ (instead of $Y_W = 100{,}0$ in Table 8) for White W. Then in all cases the luminance factor Y_W and the lightness L^*_W of the White W on the monitor and on the paper are equal.

The normalised luminance reflectance $Y_W = 88{,}6$ is defined by the white standard reference paper of offset colour printing which is used for the production of the standard **analog** ISO/IEC 15775-test charts no. 2 to 4. In case of different reflections for ambient lighting on the monitor surface the same normalised luminance reflectance $Y_W = 88{,}6$ is used. Therefore a transparent (t) normalised luminance reflectance is necessary to calculate the CIE *XYZ* tristimulus values. The normalization changes the *XYZ* tristimulus values and the CIELAB data of any colour in the application. The luminance reflectance Y_r=2,5 depends on the ambient office lighting and the reflection properties of the monitor surface. For the luminance reflectance Y_r=2,5 the (transparent) normalised luminance reflectance is

$$Y_t = Y_W - Y_r = 88{,}6 - 2{,}5 = 86{,}1$$

The equation is also used for the other luminance reflectance values Y_r=0,0, Y_r=5,0, and Y_r=7,5.

Table 10: CIE data of Television Luminous System TLS18 with $Y_W = 88{,}6$ and $L^*_N = 18$

Basic television colour or mixture colour for D65 TLS18: Yw=86,1 + 2,5	**chromaticity**		**tristimulus values** *(Y=88,6 for white D65)*			***L*a*b**-CIELAB data** *(L*=95,4 for white D65)*		
	x	***y***	***X***	***Y***	***Z***	***L****	***a****	***b****
three additive basic colours: television colours acc. to ITU-R BT.709−3								
R red	0,6003	0,3299	37,89	20,82	4,41	52,76	71,63	49,87
G green	0,3009	0,5812	33,18	64,08	13,00	84,01	−79,02	73,94
B blue	0,1612	0,0785	17,93	8,73	84,57	35,47	64,92	−95,08
three additive mixture colours: television colours acc. to ITU-R BT.709−3								
C cyan-blue	0,2278	0,3287	48,71	70,30	94,79	87,14	−44,44	−13,14
M magenta-red	0,3205	0,1622	53,43	27,04	86,23	59,01	89,33	−55,69
Y yellow	0,4144	0,4971	68,67	82,33	14,67	92,74	−20,06	84,97
achromatic colours:								
W1 (ideal white#, 100%)	0,3127	0,3290	95,05	100,00	108,90	100,00	0,00	0,00
W (white monitor, 88,6%)	0,3127	0,3290	84,21	88,60	96,49	95,41	0,00	0,00
N (black monitor, 2,52%)	0,3127	0,3290	2,40	2,52	2,74	18,01	0,00	0,00
N0 (ideal black, 0,00%)	–	–	0,00	0,00	0,00	0,01	0,00	0,00

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Table 10 shows the CIE colour data for the Television Luminous System TLS18 normalized to $Y_W = 88{,}6$ and with the

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luminance reflectance Y_r = 2,5. The calculations in the Table 10 first need the normalized luminance reflectance Y_t = 86,1 (= 88,6 – 2,5) for White W and all other colours of Table 8. Then an ambient light of the chromaticity D65 with X_r = 2,40, Y_r = 2.52, and Z_r = 2,74 must be added to any *XYZ* monitor colour.

Table 11: CIE data of Television Luminous System TLS27 with Y_W = 88,6 and L^*_N = 27

Basic television colour or mixture colour for D65 TLS27: Yw=83,6 + 5,0	**chromaticity**		**tristimulus values** *(Y=88,6 for white D65)*			***L*a*b**-CIELAB data** *(L*=95,4 for white D65)*		
	x	***y***	***X***	***Y***	***Z***	***L****	***a****	***b****
three additive basic colours: television colours acc. to ITU-R BT.709−3								
R red	0,5675	0,3298	39,25	22,81	7,10	54,87	66,84	41,69
G green	0,3017	0,5639	34,67	64,80	15,45	84,38	−75,41	68,76
B blue	0,1715	0,0956	19,87	11,07	84,92	39,70	56,66	−88,04
three additive mixture colours: television colours acc. to ITU-R BT.709−3								
C cyan-blue	0,2309	0,3288	49,75	70,83	94,87	87,40	−42,74	−12,73
M magenta-red	0,3202	0,1699	54,33	28,84	86,53	60,64	84,61	−53,09
Y yellow	0,4096	0,4893	69,13	82,57	17,06	92,82	−19,41	79,81
achromatic colours:								
W1 (ideal white#, 100%)	0,3127	0,3290	95,05	100,00	108,90	100,00	0,00	0,00
W (white monitor, 88,6%)	0,3127	0,3290	84,21	88,60	96,49	95,41	0,00	0,00
N (black monitor, 5,04%)	0,3127	0,3290	4,79	5,04	5,49	26,85	0,00	0,00
N0 (ideal black, 0,00%)	–	–	0,00	0,00	0,00	0,01	0,00	0,00

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Table 11 shows the CIE colour data for the Television Luminous System TLS27 normalized to Y_W = 88,6 and with the luminance reflectance Y_r = 5,0. The calculations of Table 11 for the ambient light reflection Y_r = 5,0 are similar to the calculations of Table 10.

Table 12: CIE data of Television Luminous System TLS33 with Y_W = 88,6 and L^*_N = 33

Basic television colour or mixture colour for D65 TLS33: Yw=81,1 + 7,5	**chromaticity**		**tristimulus values** *(Y=88,6 for white D65)*			***L*a*b**-CIELAB data** *(L*=95,4 for white D65)*		
	x	***y***	***X***	***Y***	***Z***	***L****	***a****	***b****
three additive basic colours: television colours acc. to ITU-R BT.709−3								
R red	0,5400	0,3297	40,61	24,79	9,80	56,87	62,47	36,02
G green	0,3024	0,5479	36,16	65,52	17,89	84,75	−71,95	64,17
B blue	0,1810	0,1113	21,81	13,41	85,26	43,38	50,19	−81.95
three additive mixture colours: television colours acc. to ITU-R BT.709−3								
C cyan-blue	0,2340	0,3288	50,79	71,37	94,92	87,66	−41,08	−12,31
M magenta-red	0,3198	0,1774	55,23	30,64	86,83	62,20	80,15	−50,61
Y yellow	0,4050	0,4817	69,58	82,75	19,46	92,90	−18,77	75,12
achromatic colours:								
W1 (ideal white#, 100%)	0,3127	0,3290	95,05	100,00	108,90	100,00	0,00	0,00
W (white monitor, 88,6%)	0,3127	0,3290	84,21	88,60	96,49	95,41	0,00	0,00
N (black monitor, 7,56%)	0,3127	0,3290	7,19	7,56	8,23	33,05	0,00	0,00
N0 (ideal black, 0,00%)	–	–	0,00	0,00	0,00	0,01	0,00	0,00

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Table 12 shows the CIE colour data for the Television Luminous System TLS33 normalized to Y_W = 88,6 and with the luminance reflectance Y_r = 7,5. The calculations of Table 12 for the luminance reflection Y_r = 7,5 are similar to the calculations in Table 10 and Table 11.

Therefore **four** different cases of ambient light reflections are considered in this Technical Report. The four luminance reflectances Y_r are 0,0, 2,52, 5,04, and 7,06 which corresponds to the CIELAB lightness L^* = 0, 18, 27, and 33. Four different Television Luminous Systems (TLS) and four corresponding CIE colour coordinates and examples figures are given.

NOTE: A similar Offset Luminous System (OLS) of transparent offset colours printed on transparent overhead sheets is defined in Annex K.

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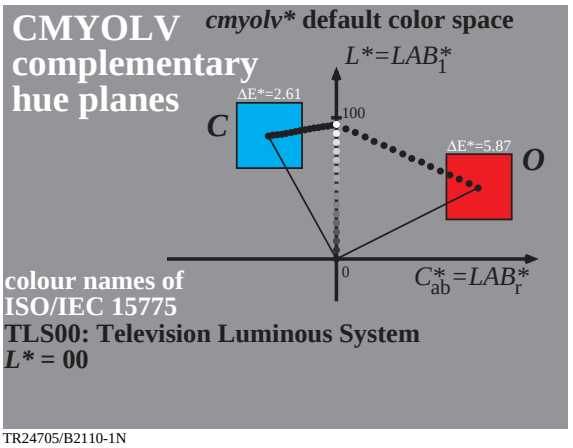
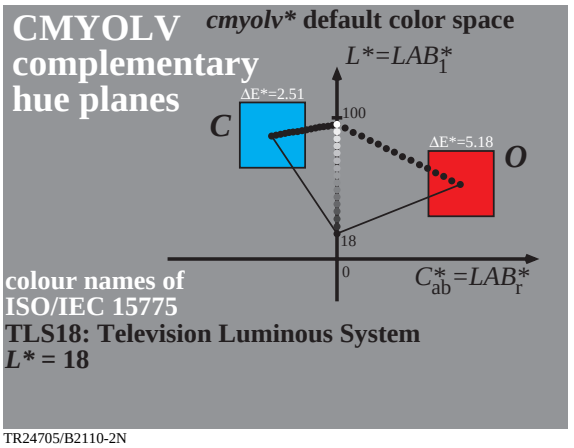
The following list summarizes the definitions and examples:

System name	CIE colour coordinates in:	Example figures:
TLS00	Table 9	Fig. 4, Fig. L.1
TLS18=TRS18	Table 10	Fig. 1, Fig. 4, Fig. L.1, Fig. L.3
TLS27	Table 11	Fig. 4
TLS33	Table 12	Fig. 4
OLS00a	Table K.1	Fig. K.4
ORS18a=OLS18a	Table 7	Fig. K.4
OLS27a	Table K.2	Fig. K.4
OLS33a	Table K.3	Fig. K.4

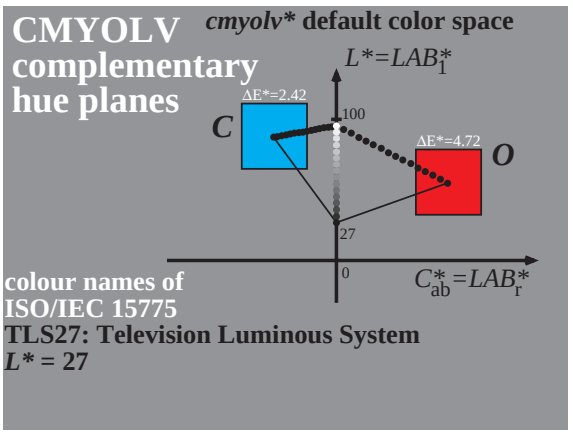
The Standard Systems **TLS00** of Table 9 and **ORS18a** of Table 7 are give in bold letters. All others systems are calculated and the following figure shows the device colours Cyan-blue – Orange-red C – O in a chroma – lightness diagram for the four spaces TLS00, TLS18, TLS27, TLS33.



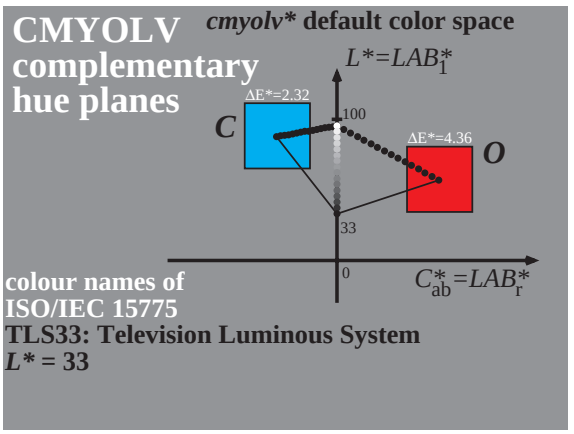
TR24705/B2110-1N



TR24705/B2110-2N



TR24705/B2110-3N



TR24705/B2110-4N

Figure 4: Complementary monitor colours C and O for L^*_N = 0, 18, 27, 33

In Fig. 4 there is a drastic colour change of the monitor colours by the ambient office lighting on the monitor surface. The lightness of the black is L^*=0, 18, 27 and 33 for the luminance reflectance Y_r =0, 2,5, 5,0, and 7,5 respectively. The chroma of the two colours Orange-red O and Cyan-blue C is reduced with increasing ambient light reflections.

The purpose of this Technical Report is to produce equally spaced 16-step series in the CIELAB space independent of the medium used. This includes, for example, monitors or projected overhead sheets with daylight D65 in the office.

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Table 13: Comparison of the printing colours and the produced colours

Basic test colour	Intended CIELAB CMYN (ISO 2846−1) Reference (r)			Produced CIELAB Pictures B2 and C2 Output (o)			CIELAB differences of test colours Difference (o−r)			CIELAB-test colour difference
name	L^*_r	a^*_r	b^*_r	L^*_o	a^*_o	b^*_o	ΔL^*_{o-r}	Δa^*_{o-r}	Δb^*_{o-r}	ΔE^*_{ab}
C	58.62	−30.62	−42.74	59.96	−27.8	−43.15	1.34	2.82	−0.4	3.15
M	48.13	75.2	−6.79	49.19	74.03	−7.4	1.06	−1.16	−0.6	1.69
Y	90.37	−11.15	96.17	87.12	−5.58	105.61	−3.24	5.57	9.44	11.43
O	47.94	65.31	52.07	47.94	65.31	52.07	0.0	0.0	0.0	0.01
L	50.9	−62.96	36.71	50.9	−62.96	36.71	0.0	0.0	0.0	0.01
V	25.72	31.45	−44.35	25.72	31.45	−44.35	0.0	0.0	0.0	0.01
N	18.01	0.5	−0.46	17.16	−0.06	−2.71	−0.84	−0.56	−2.24	2.47
W	95.41	−0.98	4.76	94.98	−0.58	3.28	−0.42	0.4	−1.47	1.59
Average CIELAB colour difference:									$\Delta E^*_{ab,m}$ =	***2.5***

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Table 13 compares the printing colours according to ISO 2846–1:1997 and the produced colours for picture B2 or D2 of test chart 2 and 4 according to ISO/IEC 15775

Table 14: Comparison of the printing colours and the television colours normalized to *Y* = 88,6

Basic test colour	Intended CIELAB data CMYN (ISO 2846−1) Reference (r)			Intended CIELAB data RGB (ITU-R BT.709-2) Output (o)			CIELAB differences of test colours Difference (o−r)			CIELAB-test colour difference
name	L^*_r	a^*_r	b^*_r	L^*_o	a^*_o	b^*_o	ΔL^*_{o-r}	Δa^*_{o-r}	Δb^*_{o-r}	ΔE^*_{ab}
C	58.62	−30.62	−42.74	86.88	−46.16	−13.55	28.26	−15.53	29.19	43.5
M	48.13	75.2	−6.79	57.3	94.35	−58.41	9.17	19.15	−51.61	55.82
Y	90.37	−11.15	96.17	92.66	−20.69	90.75	2.29	−9.53	−5.41	11.21
O	47.94	65.31	52.07	50.5	76.92	64.54	2.56	11.61	12.47	17.23
L	50.9	−62.96	36.71	83.63	−82.76	79.9	32.73	−19.79	43.19	57.69
V	25.72	31.45	−44.35	30.39	76.06	−103.57	4.67	44.61	−59.21	74.29
N	18.01	0.5	−0.46	1.57	0.0	0.0	−16.43	−0.49	0.47	16.45
W	95.41	−0.98	4.76	95.41	0.01	0.01	0.0	1.0	−4.74	4.85
Average CIELAB colour difference:									$\Delta E^*_{ab,m}$ =	***35.1***

TR24705/T1TA131

Table 14 compares the printing colours according to ISO 2846–1:1997 and the television colours according to ITU-R BT.709–3709–3

The colorimetric parameters and the statistics of the production of the DIN-test charts are given as tables on a web server (see last page). Users can put their visual estimation data or the colorimetric data in files to specify their colour image devices in their office environment.

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Table 15: Comparison of the 14 CIE-test colours and the produced colours

CIE test colour	Intended CIELAB data of CIE Publ. 13.3 Reference (r)			Produced CIELAB data of DIN 33866 Output (o), Picture B6			CIELAB differences of test colours Difference (o−r)			CIELAB-test colour difference
no.	L^*_r	a^*_r	b^*_r	L^*_o	a^*_o	b^*_o	ΔL^*_{o-r}	Δa^*_{o-r}	Δb^*_{o-r}	ΔE^*_{ab}
1	61.45	17.53	11.74	56.8	12.93	19.6	−4.64	−4.59	7.86	10.23
2	60.69	0.08	28.92	55.0	−2.42	35.85	−5.68	−2.5	6.93	9.31
3	62.02	−20.58	44.41	56.74	−24.61	42.51	−5.27	−4.02	−1.89	6.91
4	61.2	−33.16	17.07	60.9	−48.14	23.62	−0.29	−14.97	6.55	16.35
5	62.4	−17.47	−8.55	58.17	−19.98	−13.31	−4.22	−2.5	−4.75	6.84
6	61.51	−0.36	−28.39	57.44	0.1	−31.83	−4.06	0.47	−3.43	5.35
7	61.12	20.15	−24.55	56.85	18.29	−25.86	−4.26	−1.85	−1.3	4.84
8	62.77	27.42	−13.63	57.87	27.63	−21.75	−4.89	0.21	−8.11	9.49
9	39.92	58.74	27.99	41.87	38.7	33.27	1.95	−20.03	5.28	20.82
10	81.26	−2.89	71.56	75.56	4.2	74.01	−5.69	7.1	2.45	9.43
11	52.23	−42.42	13.6	47.15	−47.28	18.53	−5.07	−4.85	4.93	8.59
12	30.57	1.41	−46.47	34.8	1.37	−28.6	4.23	−0.03	17.87	18.36
13	80.23	11.37	21.04	77.59	15.62	29.57	−2.63	4.25	8.53	9.89
14	40.75	−13.8	24.23	36.07	−18.23	23.81	−4.67	−4.42	−0.41	6.46
Average CIELAB colour difference:									$\Delta E^*_{ab,m}$ =	***10.2***

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Table 15 compares the CIELAB-data *L*, a**, and *b** of the 14 CIE-test colours according to CIE-publ. 13.3 with the produced colours in Picture B6 of the analog ISO/IEC-test chart 2 according to ISO/IEC 15775

NOTE: The measured CIE-test colours from the production-run test charts are also the reference colours for the digital DIN-test charts

4.6 Limits of visual resolution and colour perceptibility

The visual human system can distinguish elements of 1/6 mm in diameter at the standard viewing distance of 50 cm and with an illuminance of 1000 lux. This light level is recommended in DIN 5035–1 for indoor illumination and colour control. As the illuminance increases it is possible to recognize smaller sized features. The recognition is highest for black-white contrast and is reduced for colour contrast. For a yellow-white contrast the recognition is reduced by at least a factor of 2 and the recognition increases through Magenta-red-white to Cyan-blue-white up to black-white.

Humans can distinguish at least 100 steps between black and white for samples side by side, and twice as many steps can be distinguished with training and sufficiently high illuminance. The colour perceptibility is better by a factor 3 for colours presented side by side than for colours presented separately. The same is true for image comparison between an original (ISO/IEC-test chart in size A4) and the corresponding reproduction (e. g. output in size A4 on a colour copying machine). Therefore, for image comparison about 30 steps are distinguishable.

One must consider the following limits especially for the assessment of reproductions:

– visual resolution 1/6 mm (150 dpi = 60 Points/cm)
– colour perceptibility for image comparison: CIELAB color difference $\Delta E^* = 3$.

The 16 equally spaced grey steps in the original and the reproduction have a lightness contrast gamut of $\Delta L^* = L^*_W - L^*_N = 94 - 10 = 84$. This is a CIELAB-colour difference of $\Delta L^* = 84/15 = 5{,}6$. An assessment of lightness is therefore possible for the 16 steps in the original and the reproduction for each step. With 32 steps in case of image comparison the threshold of colour perceptibility of three CIELAB units is not reached.

Many reproduction devices for colour images produce colour differences of around 20 CIELAB units which one like to reduce to a colour difference of three CIELAB units. We hope that additional standards will improve the assessment capability.

This goal produces a lot of difficulties both with colour measurement devices and for visual comparison of the original and the reproduction. The problems are caused by the following:

a) The colour measurement devices which are used show limits in the absolute accuracy of measurement and for

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example produce measurement differences larger than 10 CIELAB for the yellow printing colour *Y.*

b) The device failures by absolute measurement can be eliminated to a high degree if both the original (the ISO/IEC-test chart) and the copy (the reproduction) are measured with the same device. The measurement of the original is only necessary once for a (constant) colour measurement device.

c) The paper used in the office environment nearly always includes optical brighteners, so the output colours change depending on the illuminating light (daylight) because of fluorescence. The halftone DIN-test charts 2 to 4 are therefore printed on ISO reference paper which is free of fluorescence and this paper could be used for the output of a colour printer.

d) The CIE-test colours of the analog DIN-test charts 2 and 4 are reproduced with mean colour differences of 10 CIELAB-units. The mean measured data for production samples of these DIN-test charts were used to determine the data for the digital DIN-test charts (see also e). The mean absolute accuracy of the data for the production was 10 CIELAB-units and the standard deviation of the production data was much less than 3 CIELAB-units. The colour series (intended to be equally spaced) were produced with mean colour differences of 4 CIELAB-units.

e) The DIN-test charts are supplied in analog mode in halftone and continuous tone technique and as digital file for comparison in the formats *PostScript (PS)* and *Portable Document (PDF)*. The CIELAB-data of the produced analog DIN-test charts were used for the 14 CIE-test colours in the digital DIN-test charts. This way one can compare the output of a digital DIN-test chart with the corresponding analog DIN-test chart and can expect them to agree.

4.7 Applications of analog and digital ISO/IEC-test charts

The following figures show the use of **analog** and **digital** ISO/IEC-test charts with different reproduction devices for colour images. In the following pictures absolute CIELAB coordinates *LAB** or relative CIELAB-coordinates *lab** are used. The corresponding is valid for coordinates *CMY*, cmy*, OLV**, and *olv**

4.7.1 Application for colour copiers

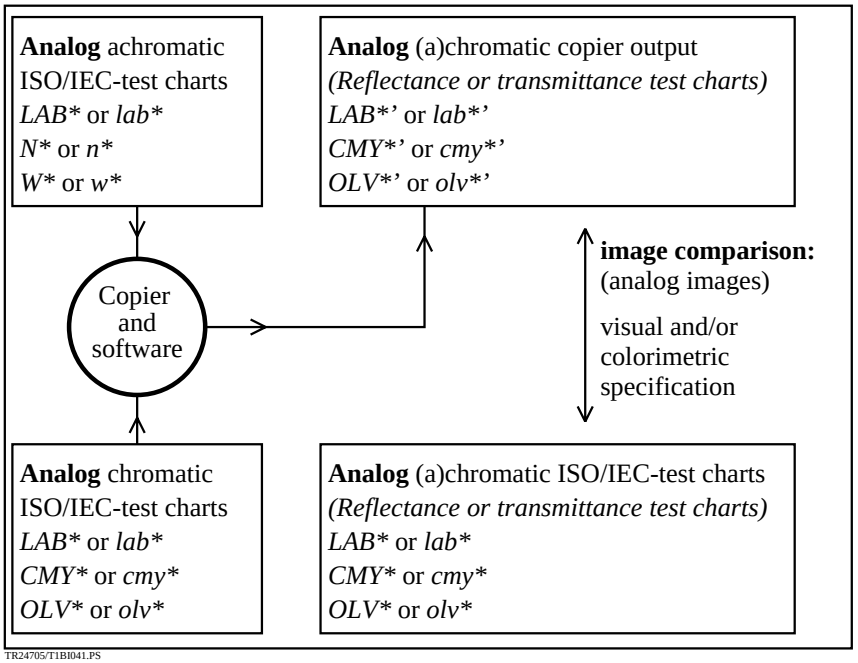

Figure 5: Specification of copiers

The left side of Fig. 5 shows the **analog** ISO/IEC-test charts, which contain colour series which have equally spaced steps in absolute colorimetric *LAB**-coordinates. Additionally a description of their relative spacing *lab** in the original and the output is possible. For example compare the coordinates *L** and *l** in ISO/IEC-test chart 1. Something similar is valid for the coordinates *CMY** or *cmy** and *OLV** or *olv**.

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4.7.2 Application for printers and monitors

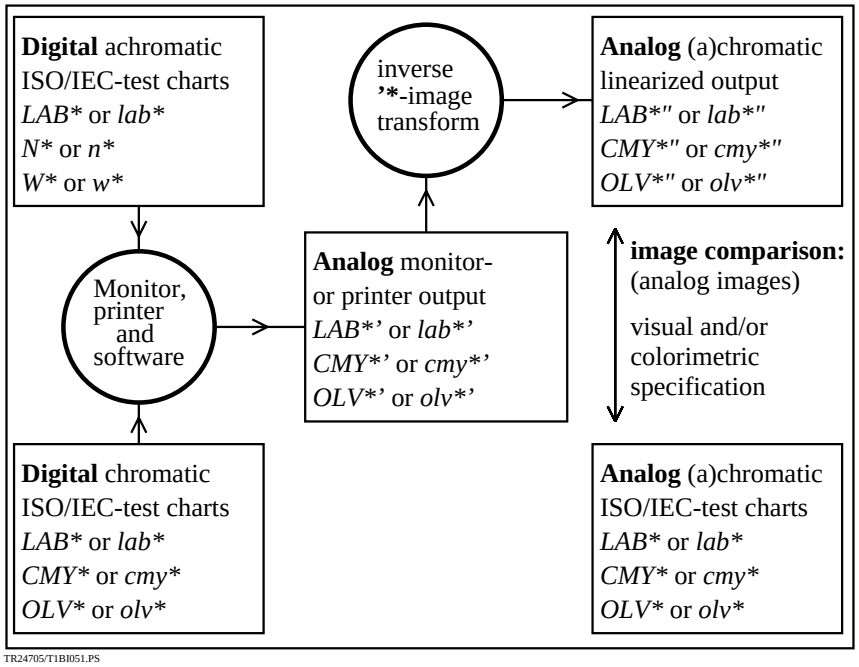

Figure 6: Specification of printers and monitors

The left side of Fig. 6 shows the **digital** ISO/IEC-test charts, which lead to a first **analog** output. If an inverse **digital** image transformations is included (e. g. within the file or the printer) then the output is linearized. The **digital** inverse image transformation can be stored permanently in the printer or for monitors in the *Display-PostScript* operating system (e. g. *Macintosh OS X server)*.

4.7.3 Application for scanners

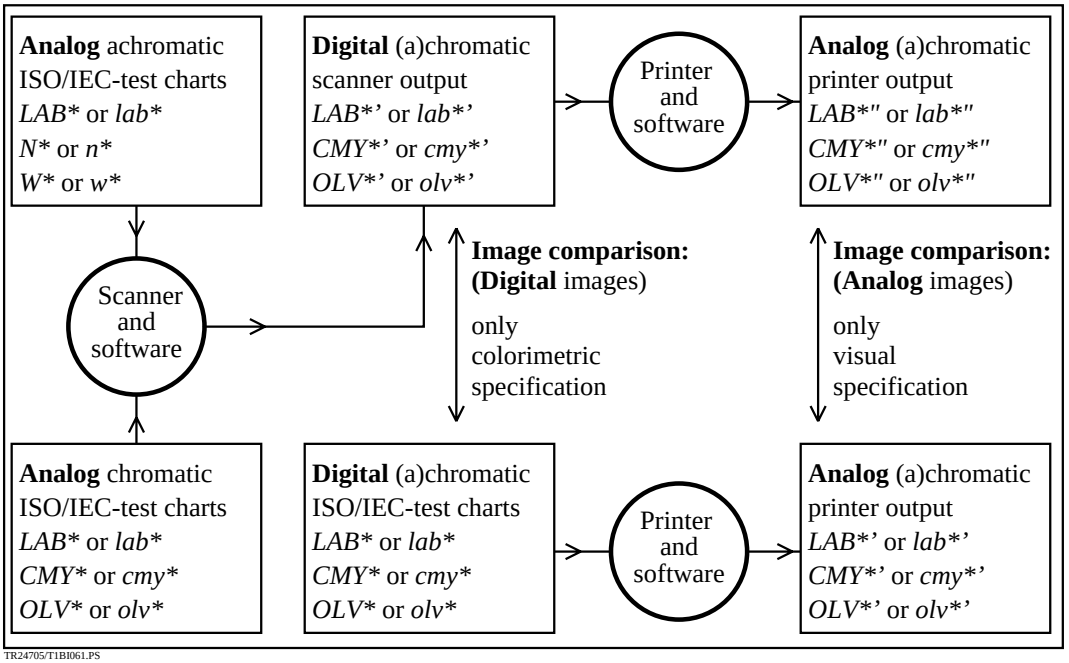

Figure 7: Specification of scanners

The left side of Fig. 7 shows the **analog** ISO/IEC-test charts which lead to a **digital** scanner output. A **colorimetric** specification of the **digital scanner** output (file) compared to the **digital** ISO/IEC test chart (file) is shown. A **visual** test by comparison of the **two analog printer** outputs, one produced by the **digital** scanner output and one by the **digital** ISO/IEC test chart (file) is shown.

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4.7.4 Application for combinations of scanner and printer or scanner and monitor

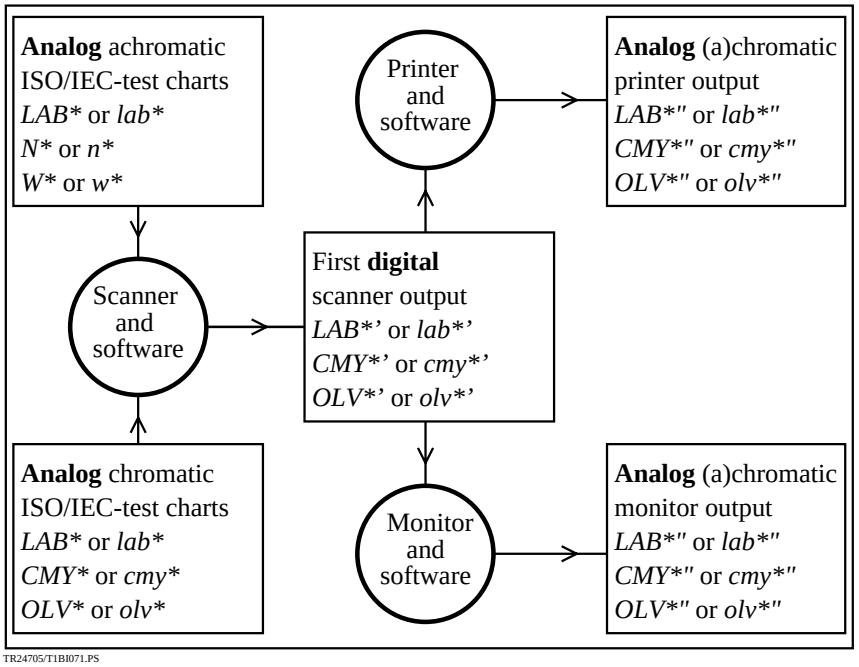

Figure 8: Specification for combinations of scanner and printer or scanner and monitor

The left side of Figure 8 shows the **analog** ISO/IEC-test charts which lead to a first **digital** scanner output with **digital** *LAB*'*-image data. The **analog** output of this **digital** *LAB*'*-image file on a printer *(upper right side)* or on a monitor *(bottom right side)* leads to additional colour changes with *LAB*"*-image data which are different for printers and monitors.

5. Visual and colorimetric tests for all applications

5.1 General

The visual tests and colorimetric specification of image reproduction can be done by comparison of the colour output with the original test chart. For the tests two methods are available:

– visual test, if necessary with optical aid such as a magnifying glass-6x.

– colorimetric specification (for interpretation see Annex G).

For the visual evaluation of the picture area the forms in Annex A to Annex D have to be used.

For the visual evaluation of the frame area the forms in Annex E and Annex F have to be used.

5.2 Visual test

The visual test of the different elements has been already described in 4.2.1 and 4.2.2 in conjunction with the definition of the individual pictures on the test charts.

5.2.1 Testing conditions

The following conditions are to be met when testing:

– Lighting of the testing object under 45° with a minimum of 1000 lux nominal illumination

– Observation of the testing object on an opaque white base (3 sheets of white paper underneath the testing object).

– one can find different and special conditions (e. g. for monitors and scanners) in the corresponding standards

– the testing persons must have normal colour vision and visual acuity.

TEST „Measure colour vision and visual acuity using any of available standard tests“

– For testing normal colour vision the colour vision deficiencies may be tested (for example with an "Anomaloscop" according to DIN 6160 or equivalent).

– The visual acuity (also with seeing aid) is to be checked (for example according to DIN 58220–5 or equivalent).

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5.2.2 Recognition frequency for use of Landolt-rings

The eight rings of the Landolt-ring groups in the different pictures represent the different orientation of the Landolt-rings according to ISO 8596. Test criteria for the visual evaluation of each group is the recognition frequency of the Landolt-rings. The recognition rate must be over 50% as in ISO 8597. The recognition frequency of at least 5 of 8 rings is above 50%.

5.3 Colorimetric specification

A colorimetric specification includes data for (see Annex G):

– Regularity g^*

– Lightness gamut f^*

– Mean lightness difference ΔL^*_m

– Mean colour difference $\Delta E^*_{ab,m}$

– Mean colour reproduction index $R^*_{ab,m}$

5.3.1 Colorimeter

The colorimeter must permit the determination of the CIELAB colorimetric parameters L^*, a^*, b^* (or of the colorimetric tristimulus values X, Y and Z) according to CIE-pub. 15.2 (and ISO/CIE 10526 and 10527) for the CIE-2°-standard observer, the CIE-standard illuminant D65 and the CIE-standard geometry 45°/0°.

5.3.2 Measurements

On the reproduction and the test chart the lightness L^* of the five achromatic test colours of pictures A2 (or C2) and the 14 chromatic CIE-test colours of picture B6 (or D6) as well the CIELAB lightness L^* and the CIELAB chroma a^* and b^* of these colour surfaces are to be measured.

NOTE 1: It is recommended that the ISO/IEC-test chart and the reproduction be measured with the same instrument.

5.3.3 Evaluation

In Annex G the procedures for calculation of each colorimetric parameter resulting from the colorimetric measurement data are described and an example is given.

6. Test report for all applications

6.1 General

The test report with the results of the test shall contain at least the following:

– statement of the colour device model

– selected working mode and/or specification of the selected adjustment

– description of the medium used

– description of other materials used

– Testing method

– forms filled out for the visual interpretation of the reproduction of test charts 1, 2, 3 and 4.

– the normal colour vision and normal visual acuity of the testing persons according to 5.2.1 are to be stated.

– test person, date and place

6.2 Description of input and output and comparison of output and reference

Examples for the description of input and output as well as the comparison of output and reference are given in Annex H.

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7. Test charts for image reproduction of printer systems: “digital – analog”

The test charts for all applications are described in Section 4.

7.1 General

The **analog** test charts for the assessment of printer outputs are desribed in Section 4.

7.2 Output technique for colour image reproduction devices: “digital – analog” (printers)

The **digital** ISO/IEC-test charts 1 to 4 in the format *PS (PostScript)* or equivalent can be read by any editor on nearly every computer operating system. They include the colours in relative device coordinates, e. g. *cmy0*, olv*, w* 000n**, and in absolute *(LAB*)* or relative *(lab*)* CIELAB-coordinates.

A useful standard reproduction process is the following: an **analog** output (reproduction) of a **digital** ISO/IEC-test chart is produced and the **analog** output is compared with the corresponding **analog** reference test chart.

NOTE 1: The printer output is influenced by the computer operating system, the application software, the printer driver, the printer mode and the hardware.

NOTE 2: The image reproduction device transforms the digital *-image („star-image“) into a different *’-image („star-prime-image“) by the standard reproduction process. This transformation is defined as standard image transformation (see Fig. 1).

NOTE 3: Either by the software of the computer operating system or by the software within the *PostScript*-printer the digital *-image („star-image“) can be transformed into an inverse ’*-image („prime-star-image“) and then reproduced with the standard image transformation (see Fig. 2). The colour differences between the digital input values and the resulting output values will then become very small for every colour reproduction system. In addition the output will be very similar to the **analog** reference ISO/IEC-test chart.

NOTE 4: The calculation of the inverse digital ’*-image („prime-star-image“) from the digital *-image („star-image“) to linearize the output is described in the International Technical Report ISO/IEC 19797 and not in this Technical Report.

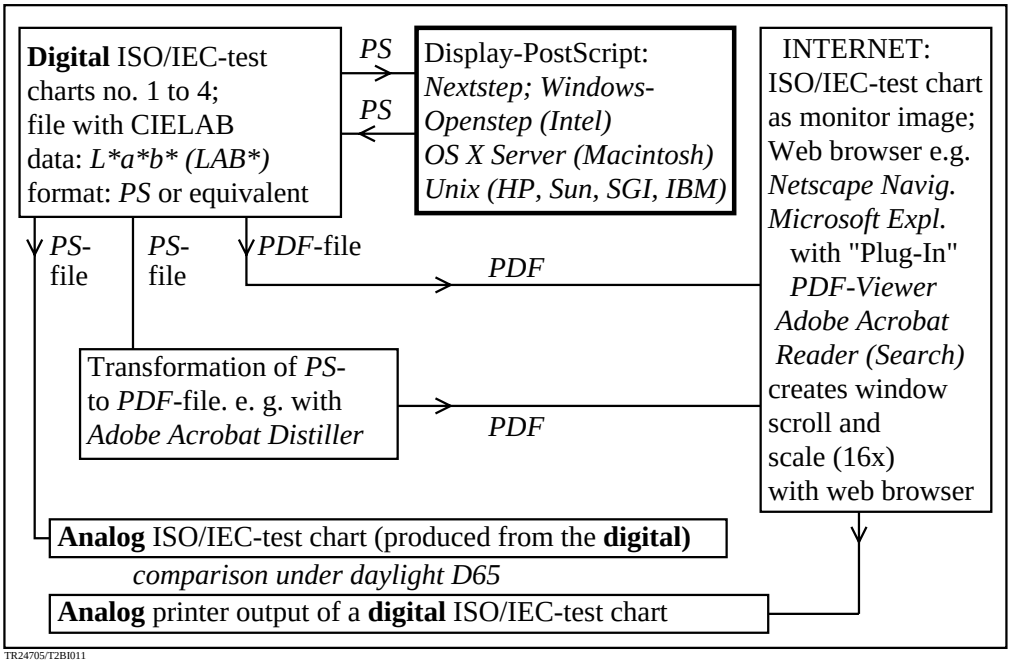

Figure 9: Creation and colour output techniques for the digital test charts on printers

Fig. 9 shows the creation of **digital** ISO/IEC-test charts by *Display-PostScript* and the **analog printer** output made using the **digital** ISO/IEC-test charts with different software and different computer operating systems in the formats *PS (PostScript), PDF (Portable Document)* or equivalent formats. Fig. 9 additionally illustrates the **monitor output** of a **digital** ISO/IEC-test chart in *PDF* format using internet web browsers. This **analog** printer output must be compared with the **analog** reference (**analog** ISO/IEC-test chart).

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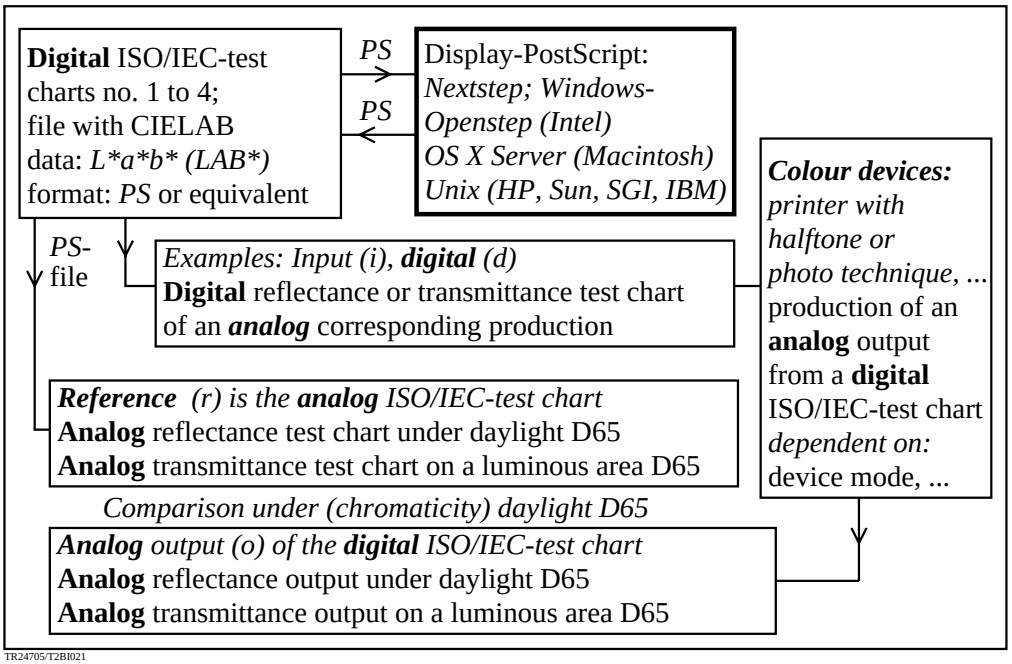

Figure 10: Creation and output for colour image reproduction devices: "digital – analog"

Fig. 10 shows the creation of an **analog** ISO/IEC-test charts as reference from a **digital** ISO/IEC-test chart *(left)* and the creation of an **analog printer** output from a **digital** ISO/IEC-test chart *(right).* This **analog** printer output must be compared with the **analog** reference *(bottom)*.

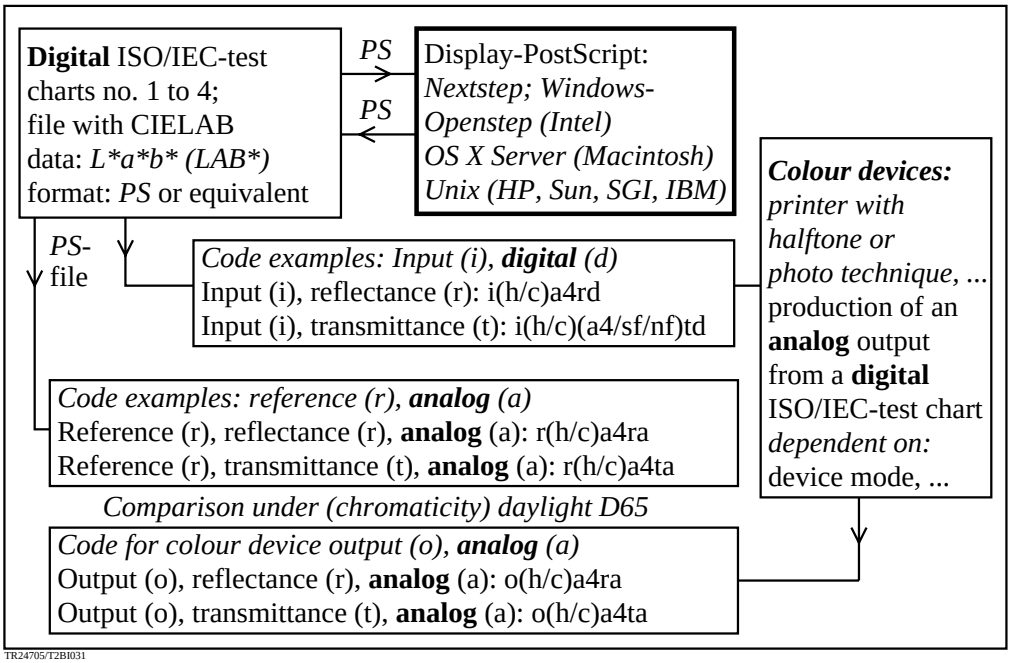

Figure 11: Codes for evaluation of image reproduction for colour devices: "digital – analog"

Fig. 11 shows code examples for the input, output and reference image reproduction process for colour devices: "**digital – analog**" outlined in Fig. 10. The **analog printer** output produced must be compared with the corresponding **analog** reference. The codes are further described in section 4.4 and in Annex H.

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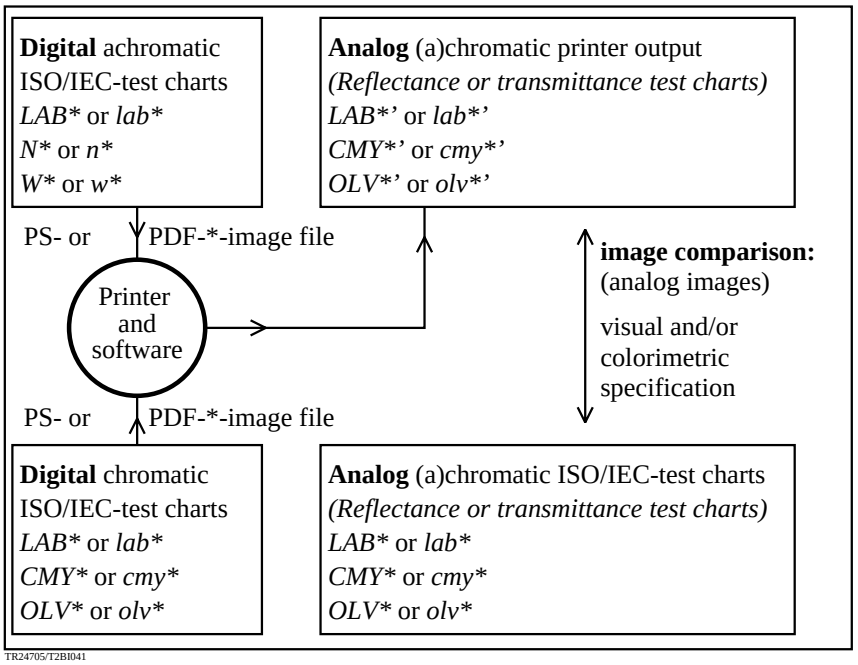

Figure 12: Specification of image reproduction for colour devices: "digital – analog"

Fig. 12 shows the specification of the image reproduction of the printer output by visual assessment and/or colorimetric measurement. The **analog printer** output (reproduction) must be compared with the **analog** reference (the **analog** original of the ISO/IEC-test chart).

7.3 Parameters for the PS-output of colour image reproduction devices: "digital – analog"

The following methods can be used to output the *PS*-files or equivalents:

– *PS*-files are reproduced directly using "copy" or "download" to a *PostScript*-printer (min. Level 2).

NOTE 1: In this case the printer output is not influenced by the printer driver or the computer operating system or the computer software. The printer output is managed by the *PS*-software within the *PS*-printer or equivalent software within an equivalent printer.

NOTE 2: For achromatic ISO/IEC-test charts it is possible to get an output on any *PS*-printer or equivalent.

7.4 Parameters for the creation and output of *PDF*-files

The *PDF*-files or equivalents can e. g. be created from *PS*-files using *"Adobe Acrobat Distiller"* (see Fig. 9).

NOTE: *Distiller*-Version number 3.0 or higher is required so that the device independent *CIELAB*-data of the *PS*-files can be included in the *PDF*-files. *Distiller*-preferences, (such as halftone Yes/No), change the printer output for a halftone image. For example the output of pictures A5 or C5 of the ISO/IEC-test charts 1 or 3 is different depending on the choise of *PDF*-files or *PS*-files for the input.

There are different methods to produce output using the *PDF*-files.

a) *PDF*-files can be viewed on any monitor of any computer operating system with *Adobe Acrobat Reader*. With the menu "print" of *Adobe Acrobat Reader* the digital files can be reproduced on any printer (not only *PostScript*-printers) (see Fig. 10).

NOTE 1: The presentation on the monitor has no influence on the printer output.

b) With the installed Plug-In *Adobe Acrobat Reader* installed, *PDF*-files can be viewed on the internet or "offline" by web browsers (e. g. *Netscape Navigator*, *Microsoft Internet Explorer*) on any operating system and on any monitor. The digital files can be reproduced on any printer (not just *PostScript*-printers) by using the menu option "print" of *Adobe Acrobat Reader* (more colour correct) or the menu "print" of the browser (less colour correct) .

c) *PDF*-files can be reproduced directly by "copy" or by "download" on any *PostScript*-printer, if the functions "*PDF*-copy" or "*PDF*-download" are supported by the printer.

NOTE 2: The printer output is not influenced by the printer driver of the computer operating system nor by the computer software. The printer output is managed by the *PDF*-software within the *PS*-printer.

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8. Visual and colorimetric tests of printer systems: “digital – analog”

The main procedures for the visual and colorimetric tests for all applications are described in Section 5.

8.1 General

For the reproduction systems “digital – analog” (printers) use the Section 5.1 “General” and the following additions:

At least two out of the four **analog printer** outputs are required. These must be produced from the **digital** ISO/IEC-test charts one after another with unchanged mode for the colour **printer**. The colours in the ISO/IEC-test charts are defined in relative *L*a*b**-data, in part also in absolute *L*a*b**-data, see pictures B1 and B6 of test chart 2 as well as picture D1 and D6 of test chart 4.

The operating modes, media and supplies (paper, colour toner, printing inks) recommended by the colour **printe**r manufacturer should be used and must be specified in the test report. Deviations must be specified. It is necessary to test the **printer** outputs soon after the printing.

The visual test and the colorimetric specification of image reproduction of colour devices can be done by comparison of the **analog** colour **printer** output with the **analog** reference (the **analog** ISO/IEC-test chart). For the test two methods are available:

– visual testing, if necessary with an optical aid such as a magnifying glass-6x.
– colorimetric specification (for interpretation see Annex G).

The testing results must be summarized as follows:

For the visual evaluation of the picture area use the forms in Annex A to Annex D.

For the visual evaluation of the frame area use the forms in Annex E and F.

The sections of these forms correspond to the different testing elements.

8.2 Visual test

For the reproduction systems “digital – analog” (printers) use the Section 5.2 “Visual test”.

8.3 Colorimetric specification

For the reproduction systems “digital – analog” (printers) use the Section 5.3 “Colorimetric specification”.

9. Test report of printer systems: “digital – analog”

The test report for all applications is described in Section 6.

9.1 General

For the reproduction systems “digital – analog” (printers) use the Section 6.1 “General” and the following additions:

The test report with the results of the test should at least the following:

– statement of the colour **printer** device model;
– Specification of the ISO/IEC-code for input, output and reference (see Annex H, Table H.4).
– For a **printe**r the following parameters are necessary:
  – The **printe**r working mode selected and/or specification of the selected adjustment,
  – The special adjustment and materials used (for printers),
  – description of the paper used,
  – description of other supplies used (toner, printer cassettes),
  – imageable paper area of the A4 size (e. g. 185 mm x 285 mm);
– at least two forms filled out for the visual interpretation of the image area of test charts 1, 2, 3 and 4,
  at least one form for an achromatic test chart according to Annex A or Annex C,
  at least one form for a chromatic test chart according to Annex B or Annex D;
– two forms filled out for the visual interpretation of the frame area of test charts 1, 2, 3 and 4,
  one form for an achromatic test chart according to Annex E,
  one form for a chromatic test chart according to Annex F;
– the normal colour vision and normal visual acuity of the testing persons are to be stated;
– optional a colorimetric specification according to Annex G;
– test person, place and date

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10. Test charts for image reproduction of scanner systems: “analog – digital”

The test charts for all applications are described in Section 4.

10.1 General

The analog and digital test charts for the assessment of scanner outputs are defined in Section 4.1.

10.2 Output technique for colour image reproduction devices: “analog – digital” (scanners)

A method for the specification of the image reproduction of scanners is defined. It is based on equally spaced colour scales for input.

For the specification of achromatic reproduction analog ISO/IEC-test charts 1 and/or 3 are scanned and for the specification of chromatic reproduction analog ISO/IEC-test charts 2 and/or 4 (chromatic) are scanned.

NOTE: For each analog ISO/IEC-test chart produced by a manufacturer which is scanned there exists a corresponding digital ISO/IEC-test chart (a computer file). It is important that as reference the corresponding digital ISO/IEC-test chart is used as reference.

The digital ISO/IEC-test charts 1 to 4 in the *PS (PostScript)* (or equivalent) format can be read and edited with nearly every editor on any computer operating system. The ISO/IEC-test charts include the colours in absolute *(LAB*)* or relative *(lab*)* CIELAB-coordinates.

The following is a useful output technique: the **digital scanner** output (reproduction) of an **analog** ISO/IEC-test chart is produced by the standard scanning process. The **digital scanner** output is used for comparison with the corresponding **digital** ISO/IEC-test chart (**“digital”**-reference).

NOTE 1: The scanner output is influenced by the computer operating system, the application software, the scanner driver, the scanner mode and the hardware.

NOTE 2: The colour image scanning transforms the digital *-image („star-image“) into a different *’-image („star-prime-image“) by the standard scanning reproduction process. This transformation is defined as a standard image transformation (see Fig. 1).

For the specification of the image reproduction of the scanner system the *‘-coordinates (“star-prime-coordinates”) of the **digital scanner** file are compared with the *-coordinates of the corresponding **digital** ISO/IEC-test chart file.

NOTE 1: Table 6 show the absolute CIELAB-coordinates of offset colour printing.

NOTE 2: The CIELAB-coordinates of offset colour printing are the basis for 16-step relative coordinates, e. g. *n** and *cmy*,* between the two colours White – Black *(wn*)*, White – Cyan-blue, White – Magenta-red, and White – Leaf-green *(cmy*)*.

NOTE 3: The 16-step relative *-coordinates (“star-coordinates”) of the **digital** ISO/IEC-test chart (e. g. *n** or *cmy**) correspond exactly to CIELAB coordinates and vice versa.

NOTE 4: The 16-step relative *‘-coordinates (“star-prime-coordinates”) of the **digital** scanner output file (e. g. *n*‘* or *cmy*‘*) correspond exactly to CIELAB coordinates and vice versa.

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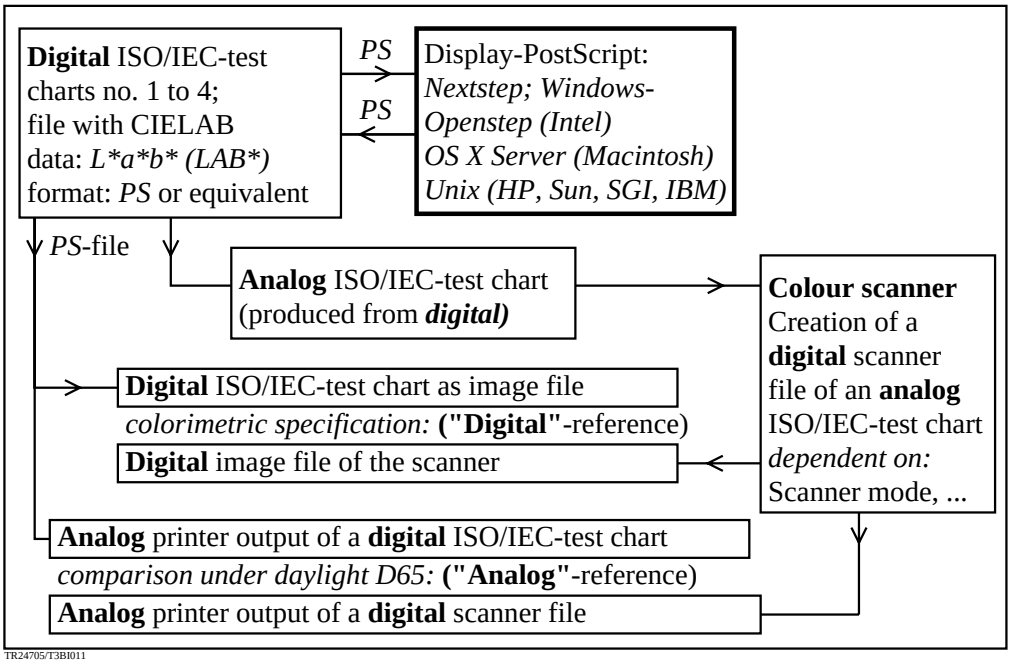

Figure 13: Creation and colour output techniques use of the analog test charts with scanners

Fig. 13 shows the creation of **digital** ISO/IEC-test charts by a *Display-PostScript* system *(top side)*. A **scanner** produces a **digital** scanner-test chart from an **analog** ISO/IEC-test chart *(right side)*. The digital scanner-test chart is used to produce an **analog printer** output *(bottom side).*

A scan of an **analog** ISO/IEC-test chart with *-coordinates ("star-coordinates") is illustrated in the middle upper part of Fig. 13 . There are two methods for comparison:

1. The **digital scanner** file with *'-coordinates, produced by the scanner (including software) from the **analog** ISO/IEC-test chart, is used for comparison with the **digital** ISO/IEC-test chart as reference (**"digital"**-reference).
2. The **digital scanner** file with *'-coordinates and the **digital** ISO/IEC-test chart with *-coordinates are both used to produce **two analog printer** outputs to be compared with each other. In this case the **printer** changes the colours of the **digital** ISO/IEC-test chart file and the **digital** scanner file in similar manner, so the real changes of the scanner should be visible if the printer reproduction process is reasonable stable. The **printer output** of the digital ISO/IEC-test chart is the **"analog"**-reference.

NOTE: There is a third possibility not used here as general method:
The **digital scanner** file with *'-coordinates is used to produce an **analog printer** output. The **analog** printer output is compared with the **analog** ISO/IEC-test chart. In this case the printer changes the colours given defined in the **digital scanner** file. Here the **analog** ISO/IEC-test chart is the **"analog"**-reference

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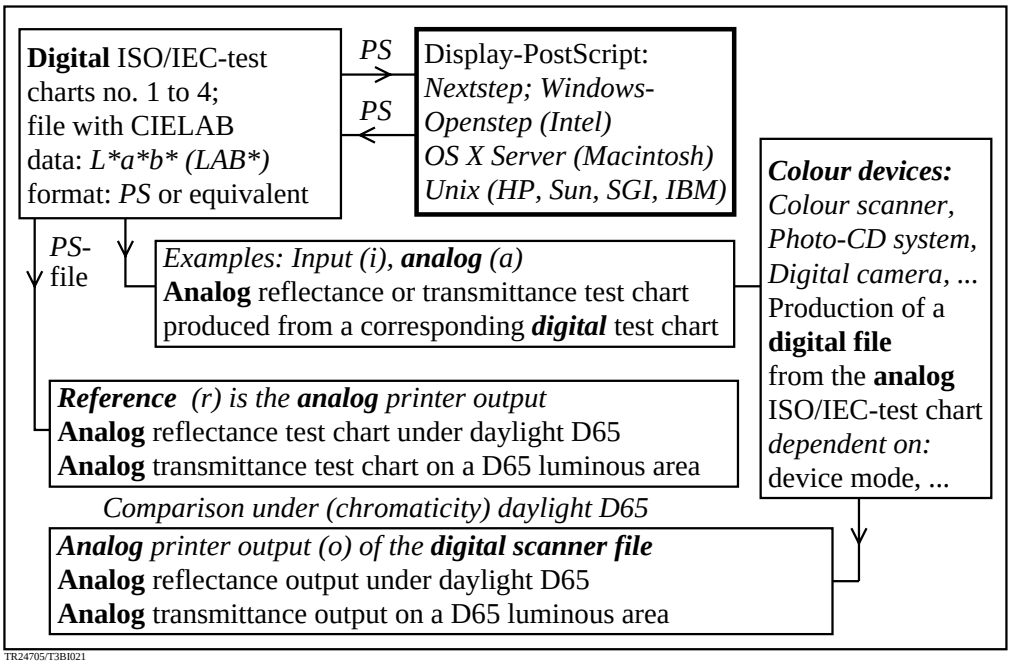

Figure 14: Creation and output for colour image reproduction devices: "analog – digital" with "analog"-reference

Fig. 14 shows the **printer** output as **analog reference** from a **digital** ISO/IEC-test chart *(left)* and the production of an **digital scanner** file output from a **analog** ISO/IEC-test chart *(right).* This **analog printer** output of the scanner file must be compared with the **analog** reference produced with the same printer (*bottom)*.

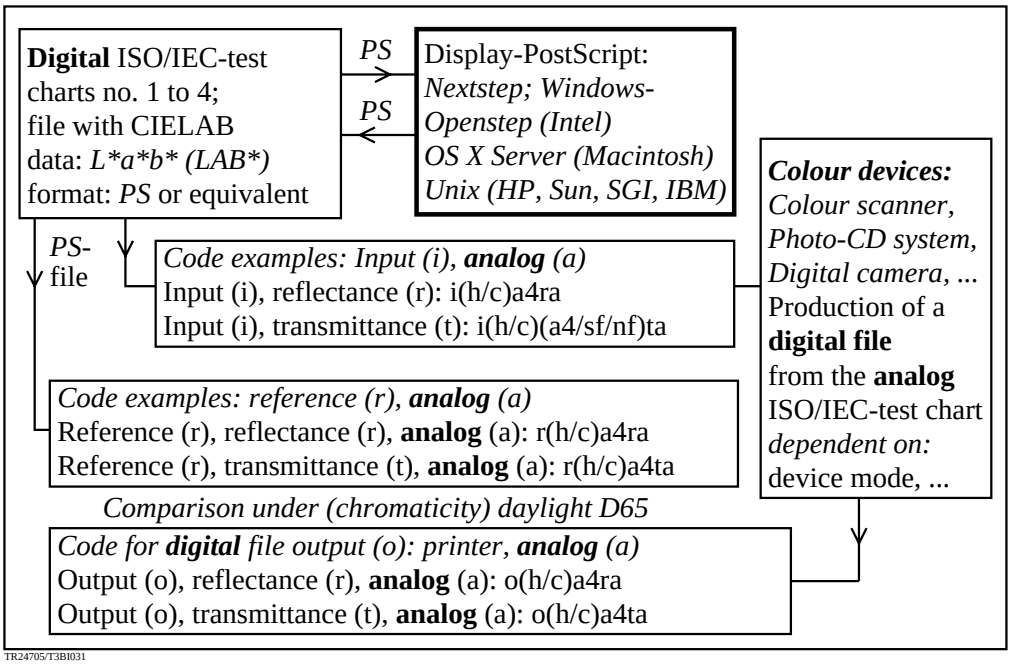

Figure 15: Codes for evaluation of image reproduction for colour devices: "analog – digital" with "analog"-reference

Fig. 15 shows code examples for the input, output and reference of image reproduction for colour devices: **"analog – digital"** shown in Fig. 14. The produced **analog printer** output must be compared with the corresponding **analog** reference produced with the same printer.

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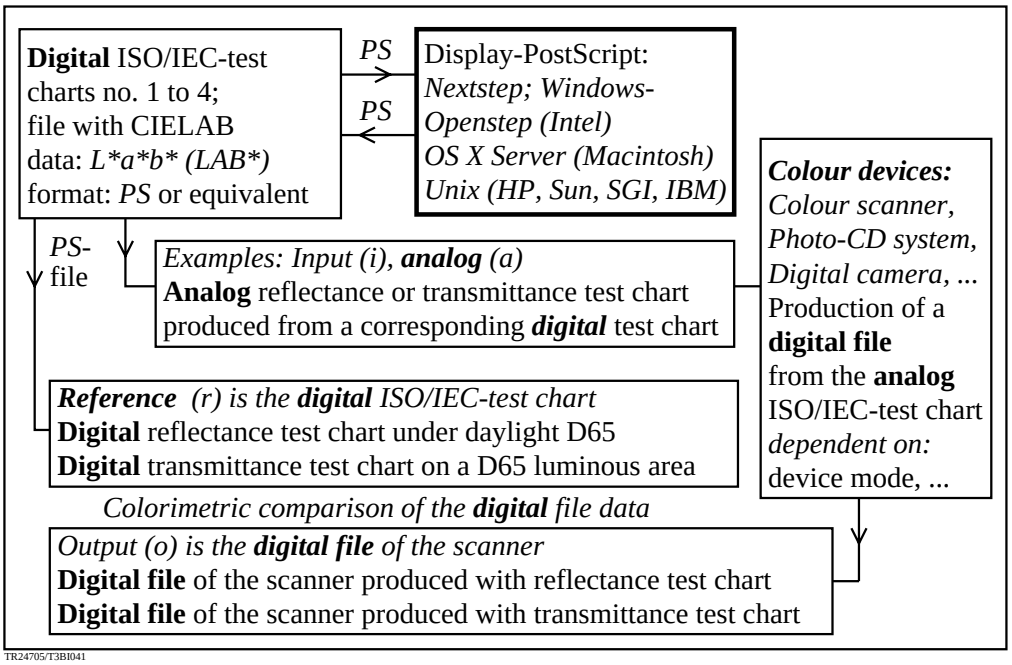

Figure 16: Creation and output for colour image reproduction devices: "analog – digital" with "digital"-reference

Fig. 16 shows the **digital** ISO/IEC-test chart as reference *(left)* and the production of a **digital scanner file** from an **analog** ISO/IEC-test chart *(right).* This **digital scanner** output file must be compared with the **digital** ISO/IEC-test chart as reference *(bottom)*.

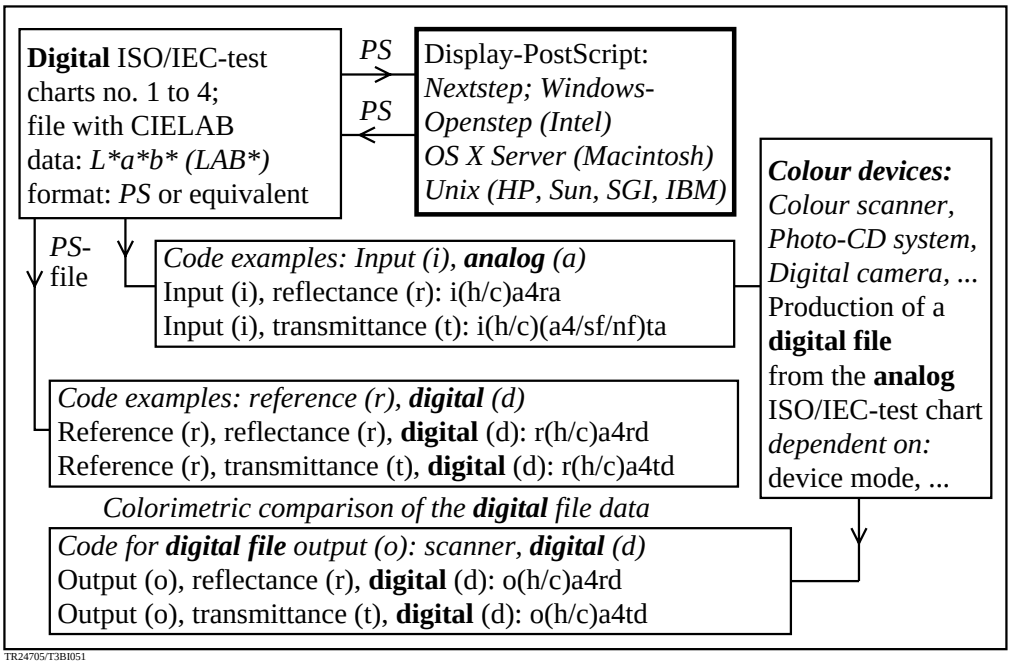

Figure 17: Codes for evaluation of image reproduction for colour devices: "analog – digital" with "digital"-reference

Fig. 17 shows code examples for the input, output and reference of image reproduction for colour devices: **"analog – digital"** shown in Fig. 16. The produced **digital scanner** file output must be compared with the **digital** ISO/IEC-test chart as reference *(bottom)*

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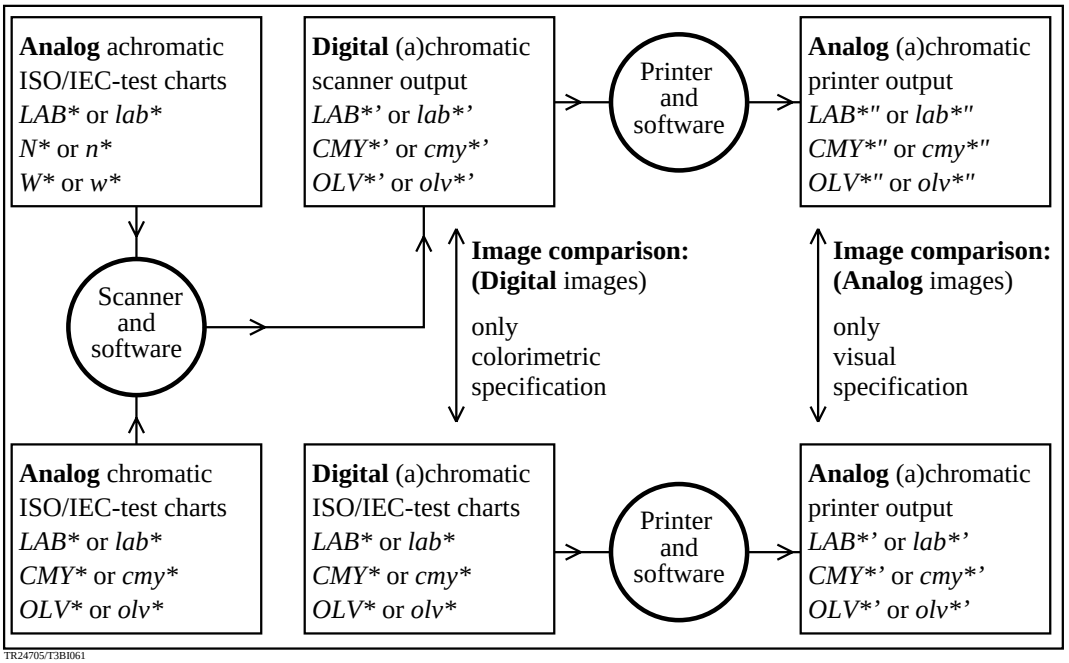

Figure 18: Specification of the image reproduction of scanners for colour devices: "analog – digital" with "digital"-reference and "analog"-reference

Fig. 18 shows the scanner process of **analog** ISO/IEC-test charts *(left side)* with *-coordinates („star-coordinates"). An example for both the **"digital"**-reference *(middle)* and the **"analog"**-reference *(right)* is given.

10.3 Methods to determine the *'coordinates of the digital scanner-test chart

For specifying digital image reproduction of colour scanners the *'-coordinates („star-prime-coordinates") of the digital scanner-test chart must be determined.

NOTE: Scanners (including software) create different digital coordinates which often are called *cmyk* (four coordinates of the subtractive colour mixture) or *rgb* (three coordinates of the additive colour mixture). These coordinates are defined as *'-coordinates („star-prime-coordinates") *cmyn*'* and *olv*'* in this Technical Report. The scanner output coordinates deviate from the *-coordinates („star-coordinates") of the ISO/IEC-test chart.

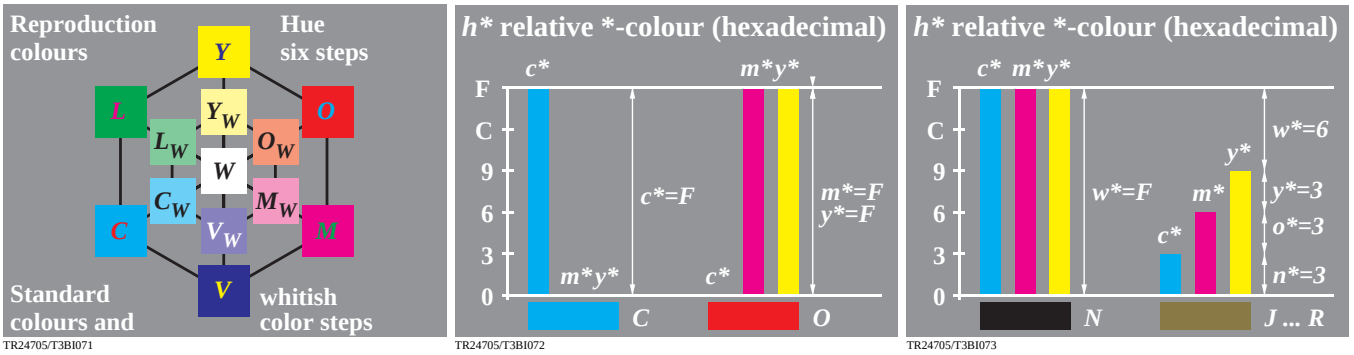

Figure 19: Colour series between white *W* and *C, M, Y, O, L,V* and relative coordinates *cmynw.**

Fig. 19 shows the basic colours of offset printing with relative colour series between white *W* and *C, M, Y, O, L,V*. The basic colours of reproduction technology are located here on a regular hexagon. Each colour is defined by three relative *-coordinates („star-coordinates") *cmy**. Often *n** and *w** are also determined or calculated.

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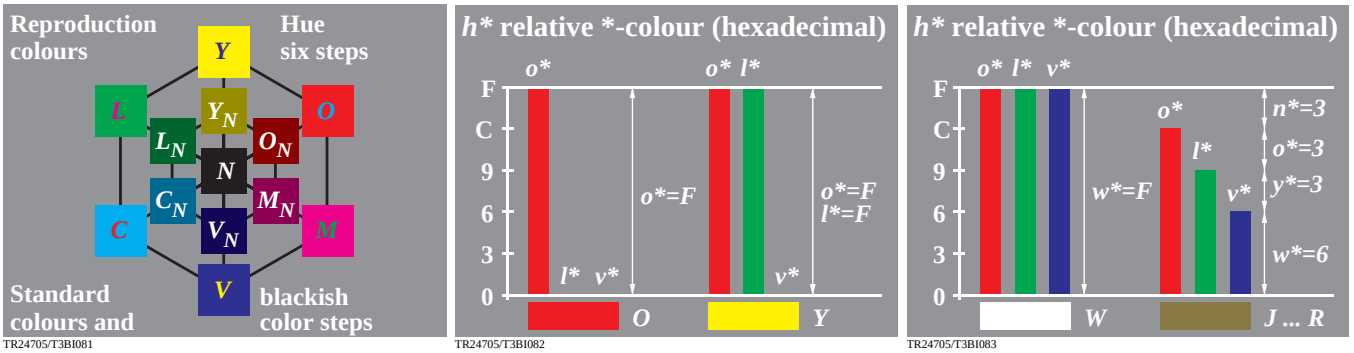

Figure 20: Colour series between black *N* and *C, M, Y, O, L,V* and relative coordinates *olvnw**

Fig. 20 shows the basic colours of offset printing with colour series between black *N* and *C, M, Y, O, L,V.* The basic colours of reproduction technology are located here on a regular hexagon. Each colour is defined by three relative *-coordinates („star-coordinates“) *olv**. Often *n** and *w** are also determined or calculated.

Table 16: Coordinates of Picture A6 of the digital ISO/IEC-test chart 1 in white-black-direction

Coordinates of Picture A6 in digital ISO/IEC-test chart 1 in White−Black direction

grey step decimal no. n*	CIELAB-coordinates absolute coordinates decimal test chart 1 L*	a*	b*	*-coordinates relative coordinates hexadecimal and decimal achrom. n*	w*	chromatic CMY cmy*			chromatic OLV olv*		
01 0,000	94,00	00,00	00,00	00 FF	00 00 00 0,000	0,000	0,000	FF FF FF 1,000	1,000	1,000
02 0,067	88,40	00,00	00,00	11 EE	11 11 11 0,067	0,067	0,067	EE EE EE 0,933	0,933	0,933
03 0,133	82,80	00,00	00,00	22 DD	22 22 22 0,133	0,133	0,133	DD DD DD 0,867	0,867	0,867
04 0,200	77,20	00,00	00,00	33 CC	33 33 33 0,200	0,200	0,200	CC CC CC 0,800	0,800	0,800
05 0,267	71,60	00,00	00,00	44 BB	44 44 44 0,267	0,267	0,267	BB BB BB 0,733	0,733	0,733
06 0,333	66,00	00,00	00,00	55 AA	55 55 55 0,333	0,333	0,333	AA AA AA 0,667	0,667	0,667
07 0,400	60,40	00,00	00,00	66 99	66 66 66 0,400	0,400	0,400	99 99 99 0,600	0,600	0,600
08 0,467	54,80	00,00	00,00	77 88	77 77 77 0,467	0,467	0,467	88 88 88 0,533	0,533	0,533
09 0,533	49,20	00,00	00,00	88 77	88 88 88 0,533	0,533	0,533	77 77 77 0,467	0,467	0,467
10 0,600	43,60	00,00	00,00	99 66	99 99 99 0,600	0,600	0,600	66 66 66 0,400	0,400	0,400
11 0,667	38,00	00,00	00,00	AA 55	AA AA AA 0,667	0,667	0,667	55 55 55 0,333	0,333	0,333
12 0,733	32,40	00,00	00,00	BB 44	BB BB BB 0,733	0,733	0,733	44 44 44 0,267	0,267	0,267
13 0,800	26,80	00,00	00,00	CC 33	CC CC CC 0,800	0,800	0,800	33 33 33 0,200	0,200	0,200
14 0,867	21,20	00,00	00,00	DD 22	DD DD DD 0,867	0,867	0,867	22 22 22 0,133	0,133	0,133
15 0,933	15,60	00,00	00,00	EE 11	EE EE EE 0.933	0,933	0,933	11 11 11 0,067	0,067	0,067
16 1,000	10,00	00,00	00,00	FF 00	FF FF FF 1,000	1,000	1,000	00 00 00 0,000	0,000	0,000

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Table 17: Coordinates of Picture C6 of the digital ISO/IEC-test chart 3 in white-black-direction

Coordinates of Picture C6 in digital ISO/IEC-test chart 3 in White−Black direction

grey step decimal no. n*	CIELAB-coordinates absolute coordinates decimal test chart 1 L*	a*	b*	*-coordinates relative coordinates hexadecimal and decimal achrom. n*	w*	chromatic CMY cmy*			chromatic OLV olv*		
01 0,000	95,41	-0,98	4,76	00 FF	00 00 00 0,000	0,000	0,000	FF FF FF 1,000	1,000	1,000
02 0,067	90,25	-0,88	4,41	11 EE	11 11 11 0,067	0,067	0,067	EE EE EE 0,933	0,933	0,933
03 0,133	85,09	-0,78	4,06	22 DD	22 22 22 0,133	0,133	0,133	DD DD DD 0,867	0,867	0,867
04 0,200	79,93	-0,68	3,71	33 CC	33 33 33 0,200	0,200	0,200	CC CC CC 0,800	0,800	0,800
05 0,267	74,77	-0,58	3,37	44 BB	44 44 44 0,267	0,267	0,267	BB BB BB 0,733	0,733	0,733
06 0,333	69,61	-0,48	3,02	55 AA	55 55 55 0,333	0,333	0,333	AA AA AA 0,667	0,667	0,667
07 0,400	64,45	-0,38	2,67	66 99	66 66 66 0,400	0,400	0,400	99 99 99 0,600	0,600	0,600
08 0,467	59,29	-0,28	2,32	77 88	77 77 77 0,467	0,467	0,467	88 88 88 0,533	0,533	0,533
09 0,533	54,13	-0,19	1,97	88 77	88 88 88 0,533	0,533	0,533	77 77 77 0,467	0,467	0,467
10 0,600	48,97	-0,09	1,62	99 66	99 99 99 0,600	0,600	0,600	66 66 66 0,400	0,400	0,400
11 0,667	43,81	0,00	1,27	AA 55	AA AA AA 0,667	0,667	0,667	55 55 55 0,333	0,333	0,333
12 0,733	38,65	0,10	0,92	BB 44	BB BB BB 0,733	0,733	0,733	44 44 44 0,267	0,267	0,267
13 0,800	33,49	0,20	0,58	CC 33	CC CC CC 0,800	0,800	0,800	33 33 33 0,200	0,200	0,200
14 0,867	28,33	0,30	0,23	DD 22	DD DD DD 0,867	0,867	0,867	22 22 22 0,133	0,133	0,133
15 0,933	23,17	0,40	-0,11	EE 11	EE EE EE 0.933	0,933	0,933	11 11 11 0,067	0,067	0,067
16 1,000	18,01	0,50	-0,46	FF 00	FF FF FF 1,000	1,000	1,000	00 00 00 0,000	0,000	0,000

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Table 16 and Table 17 show the absolute CIELAB and relatives *-coordinates *n**, *w**, *cmy**, and *olv** of the digital

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ISO/IEC-test charts 1 and 3 for the 16-step equally spaced grey scale. The 16 grey steps are given in digital decimal and hexadecimal form and for achromatic colours by *n** or *w** and for chromatic colours by *cmy** and *olv**.

Table 18: Digital *- and *‘-coordinates in an image file

PSL1-program: Horizontal rectangle-grey elements (16 steps) with *("star") and *’("star-dash")-coordinates

```
%!PS-Adobe-3.0 EPSF-3.0  MMTA034:MMTA031.EPS 29.04.2000
%%BoundingBox:70 80 234 160
/FS {findfont exch scalefont setfont} bind def
%%EndProlog
gsave
/picstr 48 string def  %for 16x3 olv*-data

6 /Times-Roman FS
472 83 moveto
     (INFMM034:MMTA031.PS) show
 72 90 translate

/olv*-data [%olv* (dec); %i,j:128x192; k,l: 016x007; hex
  1    0.0    0.0    0.0 %i,j:121   6; k,l: 002 001; 00
  2   17.0   17.0   17.0 %i,j:121  18; k,l: 002 002; 11
  3   34.0   34.0   34.0 %i,j:121  30; k,l: 002 003; 22
  4   51.0   51.0   51.0 %i,j:121  42; k,l: 002 004; 33
  5   68.0   68.0   68.0 %i,j:121  54; k,l: 002 005; 44
  6   85.0   85.0   85.0 %i,j:121  66; k,l: 002 006; 55
  7  102.0  102.0  102.0 %i,j:121  78; k,l: 002 007; 66
  8  118.0  118.0  119.0 %i,j:121  90; k,l: 002 008; 77
  9  135.0  135.0  136.0 %i,j:121 102; k,l: 002 009; 88
 10  152.0  152.0  153.0 %i,j:121 114; k,l: 002 010; AA
 11  169.0  169.0  170.0 %i,j:121 126; k,l: 002 011; BB
 12  186.0  186.0  187.0 %i,j:121 138; k,l: 002 012; CC
 13  203.0  203.0  204.0 %i,j:121 150; k,l: 002 013; DD
 14  220.0  220.0  221.0 %i,j:121 162; k,l: 002 014; EE
 15  237.0  237.0  238.0 %i,j:121 174; k,l: 002 015; DD
 16  255.0  255.0  255.0 %i,j:121 186; k,l: 002 016; FF
] def %End olv*-data

/olv*’-data [%olv*’(dec);%i,j:128x192;i-variation: 6pixel j-variation: 6 pixel
  1   15.8    8.4   11.0 %i,j:121   6 i  2  2  1  3  0  1 j  0  0  0  0  0  0
  2   17.2    8.8   11.0 %i,j:121  18 i  0  1  2  2  2  1 j  4  1  1  0  0  0
  3   35.0   22.4   29.0 %i,j:121  30 i  0  0  3  2  1  2 j  1  1  0  1  1  0
  4   48.2   40.4   41.0 %i,j:121  42 i  1  1  1  0  0  0 j  2  3  3  2  2  1
  5   62.0   56.8   56.4 %i,j:121  54 i  1  1  1  4  4  4 j  1  1  1  1  2  1
  6   73.6   68.6   68.2 %i,j:121  66 i  0  0  0  1  1  2 j  0  0  0  1  1  2
  7   87.2   82.4   81.6 %i,j:121  78 i  1  2  1  1  3  1 j  1  2  1  0  0  0
  8  100.0   95.4   97.2 %i,j:121  90 i  2  1  0  0  0  0 j  2  1  1  0  0  0
  9  113.8  108.4  110.4 %i,j:121 102 i  1  2  2  0  0  0 j  0  0  0  0  0  0
 10  126.2  123.0  126.4 %i,j:121 114 i  1  2  1  1  2  1 j  1  2  1  2  1  1
 11  139.4  136.4  140.4 %i,j:121 126 i  1  1  1  0  0  0 j  1  1  1  0  0  0
 12  153.4  149.4  155.8 %i,j:121 138 i  0  0  0  1  1  2 j  1  1  2  0  0  0
 13  166.8  163.4  167.4 %i,j:121 150 i  2  1  1  2  1  1 j  0  0  0  2  1  1
 14  179.4  175.2  179.2 %i,j:121 162 i  0  0  0  1  2  1 j  0  0  0  1  1  0
 15  196.4  191.0  195.2 %i,j:121 174 i  1  2  2  2  2  1 j  0  0  0  0  0  0
 16  207.0  204.2  207.6 %i,j:121 186 i  0  1  2  4  4  4 j  0  0  0  1  1  1
] def %End olv*’-data

016 3600 div 72 mul 40 mul 12 mul dup 16 div 5 mul scale
                                          %olv*-data (upper row), olv*’-data (bottom row)
016 005 8 [016 0 0 005 neg 0 005]
{currentfile picstr readhexstring pop}
false 3
colorimage
7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F
00000011111122222233333344444455555566666677777788888899999AAAAAABBBBBBCCCCCCDDDDDDEEEEEEFFFFFF
7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F
0F080B11080B23161D3028293E383849444457525164 5F61716C6E7E7B7E8B888C99959BA6A3A7B3AFB3C4BFC3CFCCCF
7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F7F
%%EndData
grestore
showpage
%%Trailer
```

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Table 18 shows digital *- and *‘-coordinates in an original (ISO/IEC-test chart 1) image file for the equally spaced 16-step grey scale. The change of the *-coordinates of the original produced by the scanning process (including software) leads to *‘-coordinates. In the upper part of Table 18 decimal data (*olv**- and *olv**‘-coordinates) are given, in the „colorimage-part“ (bottom part) hexadecimal values between 00 and FF are given.

NOTE 1: Table 18 is a complete *PostScript*-image file which can be read by any editor, viewed with display-*Postscript*, transformed to a PDF-file, viewed on a monitor, or sent to a printer to produce an output.
NOTE 2: The image file includes 16 grey steps (hexadecimal 00 to FF) in the „colorimmage-part“. Background serves as mean grey (decimal 127 and hexadecimal 7F) in the rows 1, 3 and 5 of Table 18. Row 2 includes the original *-coordinates („star-coordinates“) of the digital ISO/IEC-test chart. Row 4 includes the *‘-coordinates („star-prime-coordinates“) produced by a scanner.

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Figure 21: Original 16 grey steps and output of 16 grey steps with *- and *'-coordinates.

In the upper row Fig. 21 shows the *-coordinates („star-coordinates") described by hexadecimal data between 00 and FF for the 16 **equally spaced** grey steps of the input. The fact that they are **equally spaced** is shown in Table 18 for ISO/IEC-test chart 1. In the lower row Fig. 21 shows the *'-coordinates („star-prime-coordinates) with hexadecimal data between 08 and CF for the 16 grey steps of the scanner output. These are **not equally spaced** in Table 18 for the digital scanner-test chart 1.

Table 19: Colorimetric data for the series *W–N* of ISO/IEC-test chart 1 and scanner-test chart 1

i	LAB*ref			olv*out			w*	LAB*out			LAB*ouc			ΔE*
1	10.0	0.0	0.0	15.8	8.4	11.0	0.04	13.58	0.0	0.0	13.58	0.0	0.0	3.58
2	15.6	0.0	0.0	17.2	8.8	11.0	0.05	13.82	0.0	0.0	13.82	0.0	0.0	1.78
3	21.2	0.0	0.0	35.0	22.4	29.0	0.1	18.76	0.0	0.0	18.76	0.0	0.0	2.44
4	26.8	0.0	0.0	48.2	40.4	41.0	0.17	24.16	0.0	0.0	24.16	0.0	0.0	2.64
5	32.4	0.0	0.0	62.0	56.8	56.4	0.23	29.28	0.0	0.0	29.28	0.0	0.0	3.12
6	38.0	0.0	0.0	73.6	68.6	68.2	0.28	33.15	0.0	0.0	33.15	0.0	0.0	4.85
7	43.6	0.0	0.0	87.2	82.4	81.6	0.33	37.67	0.0	0.0	37.67	0.0	0.0	5.93
8	49.2	0.0	0.0	100.0	95.4	97.2	0.38	41.93	0.0	0.0	41.93	0.0	0.0	7.27
9	54.8	0.0	0.0	113.8	108.4	110.4	0.43	46.3	0.0	0.0	46.3	0.0	0.0	8.5
10	60.4	0.0	0.0	126.2	123.0	126.4	0.49	50.87	0.0	0.0	50.87	0.0	0.0	9.53
11	66.0	0.0	0.0	139.4	136.4	140.4	0.54	55.26	0.0	0.0	55.26	0.0	0.0	10.74
12	71.6	0.0	0.0	153.4	149.4	155.8	0.59	59.65	0.0	0.0	59.65	0.0	0.0	11.95
13	77.2	0.0	0.0	166.8	163.4	167.4	0.65	64.2	0.0	0.0	64.2	0.0	0.0	13.0
14	82.8	0.0	0.0	179.4	175.2	179.2	0.69	68.17	0.0	0.0	68.17	0.0	0.0	14.63
15	88.4	0.0	0.0	196.4	191.0	195.2	0.76	73.51	0.0	0.0	73.51	0.0	0.0	14.89
16	94.0	0.0	0.0	207.0	204.2	207.6	0.8	77.57	0.0	0.0	77.57	0.0	0.0	16.43
17	10.0	0.0	0.0	15.8	8.4	11.0	0.04	13.58	0.0	0.0	13.58	0.0	0.0	3.58
18	31.0	0.0	0.0	48.2	40.4	41.0	0.17	24.16	0.0	0.0	24.16	0.0	0.0	6.84
19	52.0	0.0	0.0	87.2	82.4	81.6	0.33	37.67	0.0	0.0	37.67	0.0	0.0	14.33
20	73.0	0.0	0.0	153.4	149.4	155.8	0.59	59.65	0.0	0.0	59.65	0.0	0.0	13.35
21	94.0	0.0	0.0	207.0	204.2	207.6	0.8	77.57	0.0	0.0	77.57	0.0	0.0	16.43
				Mean colour reproduction index:										

Specification according to DIN 33866−1, Annex G

Regularity

g** = 82.2

Lightness gamut

f** = 99.3

Mean colour difference (16 samples)

ΔE^*_{CIELAB} = ***8.2***

Mean colour difference (5 samples)

ΔL^*_{CIELAB} = ***10.9***

$R^*_{ab,m}$ = ***59***

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For the equally spaced colour series *W–N* of digital ISO/IEC-test chart 1, Table 19 shows the original CIELAB-data *(left side).* The digital scanner-test chart includes relative *w**-data which allow calculation of the corresponding CIELAB-data of the scanner-test chart. Table 19 serves as example for the colorimetric specification of the scanner output according to Annex G.

This colorimetric specification of the scanner output depends on transformation possibilities between relative *-coordinates („star-coordinates") *cmyolvnw** and *L*a*b**-coordinates of CIELAB colour space. A unique transform in both directions is possible as long as the basic colours *CMYOLVWN* of colour offset printing are defined by *L*a*b**-coordinates in CIELAB colour space. These data for the offset printing process are given in Table 6.

NOTE: Computer programs for the transformation between relative *cmyolvnw**-coordinates and *L*a*b**-coordinates of CIELAB colour space and vice versa are given as technical information on web sites (see Annex N).

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11. Visual and colorimetric test of scanner systems: “analog – digital”

The main procedures for the visual and colorimetric tests for all applications are described in Section 5.

11.1 General

For reproduction systems “analog – digital” (scanners) use the Section 5.1 “General” and the following additions: for the purposes of this Report at least two out of the four **digital scanner** outputs are required. These must be produced from the **analog** ISO/IEC-test charts one after another with unchanged mode for the colour **scanner**. The colours in the ISO/IEC-test charts are defined in relative *L*a*b**-data, in part also in absolute *L*a*b**-data. See pictures B1 and B6 of test chart 2 as well as picture D1 and D6 of test chart 4.

The operating mode recommended by the colour **scanner** manufacturer should be used and must be specified in the test report. Any deviations must be specified.

The visual test and the colorimetric specification of image reproduction of colour devices can be done by comparison of

– **digital** scanner output with the **digital** ISO/IEC-test chart which corresponds to the **analog** ISO/IEC-test chart used with the scanner

– **analog printer** or **monitor** output or of the **digital** scanner file with the **analog** reference (the **analog** ISO/IEC-test chart).

For the test two methods are available:

a) visual testing, if necessary with optical aid such as a magnifying glass-6x.

NOTE 1: For a visual test of the resolution of the digital scanner file (pixel file) using analog output the printer used must have at least twice the resolution of the scanner file. For example, the scanner file has a resolution of 1200 dpi and 75 dpi halftone resolution (for 16 x 16 points/pixel) then the printer output must have at least 150 dpi halftone resolution.

NOTE 2: The web server http://www.ps.bam.de has digital pixel files of the ISO/IEC-test charts. These are large files and require a lot of storage space (24 or 96 MByte as *PostScript* pixel file for the A4 size of the ISO/IEC-test charts and 300 dpi or 600 dpi halftone resolution). For a visual test the output of a *PostScript*-pixel file of an ISO/IEC-test chart (with twice the resolution of the scanner file) must be included in the test report

b) colorimetric specification (for interpretation see Annex G).

The testing results have to be summarized as follows:

For the visual evaluation of the picture area the forms in Annex A to Annex D must be used.

For the visual evaluation of the frame area the forms in Annex E and Annex F must be used.

The sections of these forms correspond to the different testing elements.

11.2 Visual test

For the reproduction systems “analog – digital” (scanners) use the Section 5.2 “Visual test”.

11.3 Colorimetric specification

For the reproduction systems “analog – digital” (scanners) use the Section 5.3 “Colorimetric specification”.

12. Test report of scanner systems: “analog – digital”

The test report for all applications is described in section 6.

12.1 General

For the reproduction systems “analog – digital” (scanners) use the Section 6.1 “General” and the following additions:

The test report with the results of the test should at least contain the following:

– statement of the colour **scanner** device model;

– selected scanner working mode and/or specification of the selected adjustment

– Specification of the ISO/IEC-code for input, output and reference (see Annex H, Table H.3).

– Statement if **“analog”**- or **“digital”-reference** is chosen.

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– in case of **“analog”-reference:**

For a **printer** the following parameters are necessary:

– statement of the colour **printer** device model,

– selected **printe**r working mode and/or specification of the selected adjustment,

– for the specification of **printers** the special adjustments and materials used,

– description of the paper used,

– description of other supplies used (toner, printer cassettes),

– imageable paper area of A4 size (e. g. 185 mm x 285 mm);

For a **monitor** the following parameters are necessary:

– statement of the colour **monitor** device model

– selected **monitor** working mode and/or specification of the selected adjustment,

– for the specification of **monitors** the special adjustments and materials used,

– specification of the room illumination used,

– specification of other environment conditions (room illuminance),

– viewed monitor area of the A4 size (e. g. 185 mm x 285 mm);

– further in case of **“analog”-reference:**

– at least two forms filled out for the visual interpretation of the image area of test charts 1, 2, 3 and 4,

at least one form for an achromatic test chart according to Annex A or Annex C,

at least one form for a chromatic test chart according to Annex B or Annex D;

– two forms filled out for the visual interpretation of the frame area of test charts 1, 2, 3 and 4,

one form for an achromatic test chart according to Annex E,

one form for a chromatic test chart according to Annex F;

– the normal colour vision and normal visual acuity of the testing persons are to be stated;

– optional a colorimetric specification according to Annex G;

– in case of **“digital”-reference:**

– verbal description of properties (e. g. digital data range, digital distances for equally spaced input scales of the pixel outputs of all colour series of the at least the two used ISO/IEC-test charts),

– if possible a colorimetric specification according to Annex G (Evaluation with *‘-coordinates (”star-prime”-coordinates). See Table 18.

– test person, place and date

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13. Test charts for image reproduction of monitor systems: “digital – analog”

The test charts for all applications are described in Section 4.

13.1 General

The analog and digital test charts for the assessment of monitor outputs are defined in Section 4.1.

13.2 Output technique for colour image reproduction devices: “digital – analog” (monitors)

The **digital** ISO/IEC-test charts 1 to 4 in the *PS (PostScript)* (or equivalent) format can be read by any editor on nearly every computer operating system. They include the colours in absolute *(LAB*)* or relative *(lab*)* CIELAB-coordinates.

A useful standard reproduction process is to produce an **analog** output (reproduction) of a **digital** ISO/IEC-test chart and then to compare the **analog** output with the corresponding **analog** reference test chart. An **analog monitor** output may be compared with a transparent **analog** ISO/IEC-test chart on the surface of a luminous area D65 light source.

NOTE 1: The monitor output is influenced by the computer operating system, the application software, the monitor driver, the monitor mode and the hardware.

NOTE 2: The image reproduction device transforms the digital *-image („star-image“) into a different *’-image („star-prime-image“) by the reproduction process. This transformation is defined as standard device transformation (see Fig. 1)

NOTE 3: The input digital *-image („star-image“) can be transformed into an inverse ’*-image („prime-star-image“) and then reproduced with the standard device transformation (see Fig. 2) either by the software of the computer operating system or by the software within the *Display-PostScript* driver *(e. g. Macintosh OS X Server)*. The colour differences between input and output will then become very small for every colour reproduction device, and they will also be similar to the **analog** reference ISO/IEC-test chart.

NOTE 4: The calculation of the inverse digital ’*-image („prime-star-image“) from the digital *-image („star-image“) to optimize the output is not a part of this Technical Report. This Report serves only to specify the output.

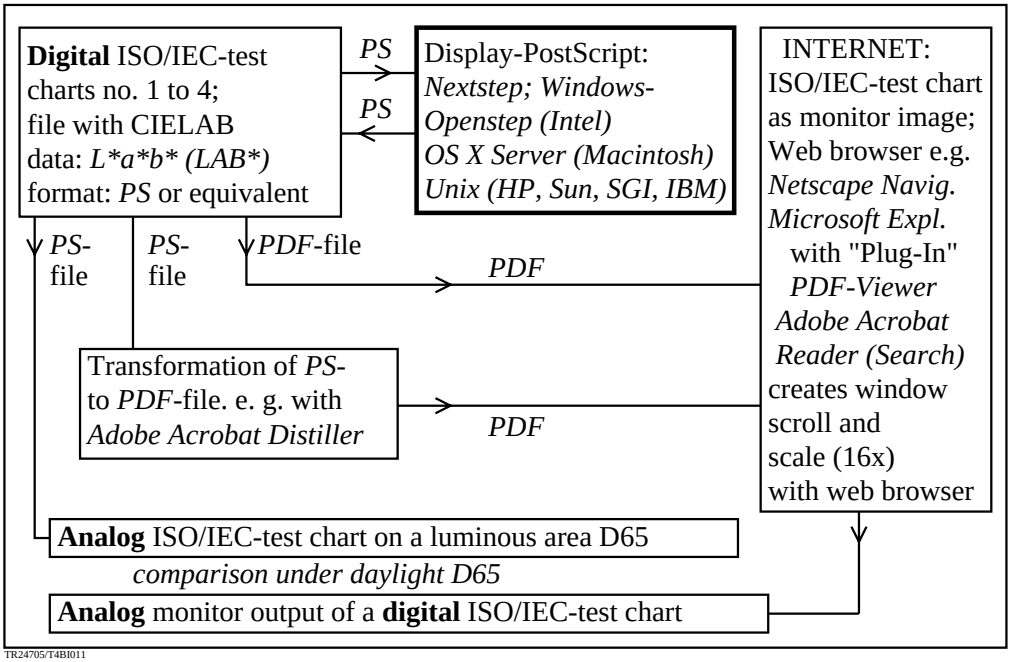

Figure 22: Creation and colour output techniques for the digital test charts on monitors

Fig. 22 shows the creation of **digital** ISO/IEC-test charts by *Display-PostScript* and the **analog monitor** output of **digital** ISO/IEC-test charts with different software and different computer operating systems in the *PS (PostScript), PDF (Portable Document)* (or equivalent) formats. Fig. 22 shows a schematic use of a **digital** ISO/IEC-test chart in the *PDF* format for monitor output using an internet web browser. The **analog monitor** outputs must be compared with the **analog reference monitor** (transparent **analog** ISO/IEC-test chart on a luminous area D65 light source).

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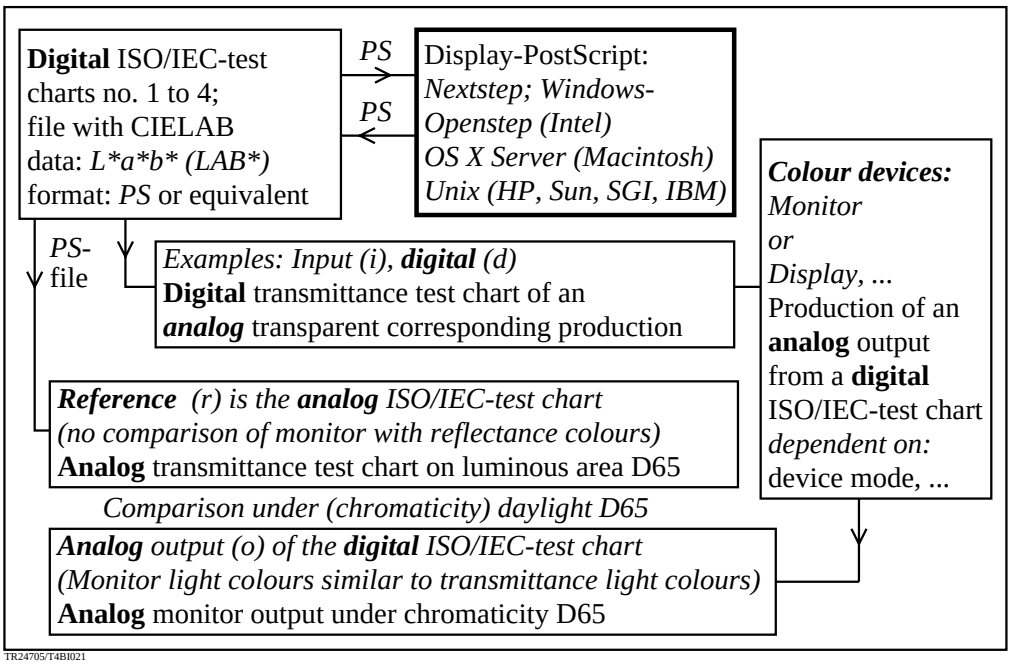

Figure 23: Creation and output for colour image reproduction devices: "digital – analog"

Fig. 23 shows the creation of an **analog** ISO/IEC-test chart as reference from a **digital** ISO/IEC-test chart *(left)* and the creation of an **analog monitor** output from a **digital** ISO/IEC-test chart *(right).* This **analog monitor** output must be compared with the **analog** reference *(bottom)*.

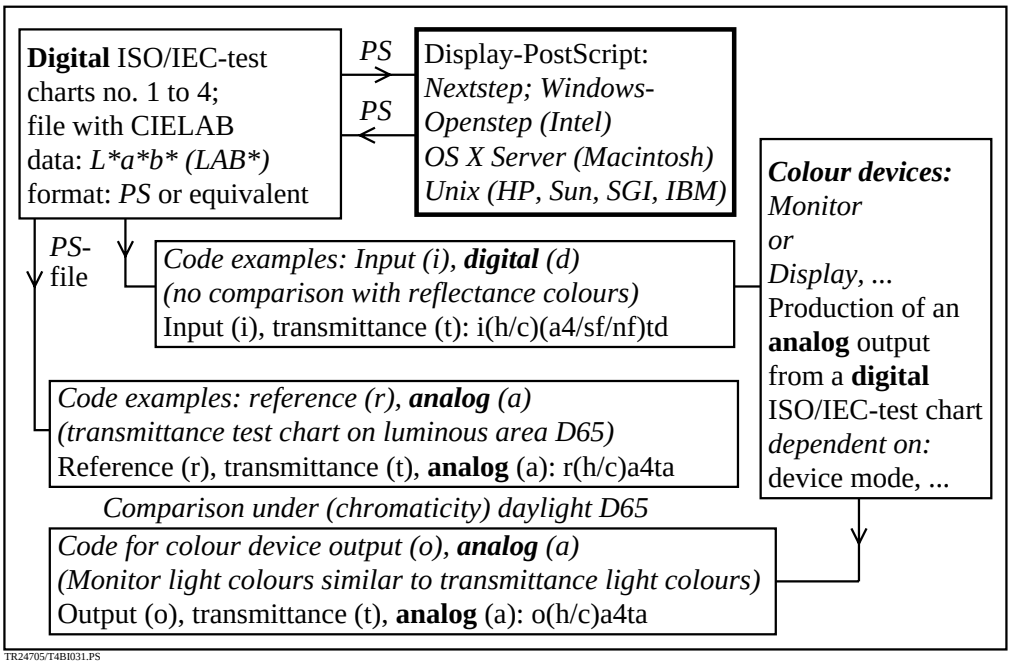

Figure 24: Codes for evaluation of image reproduction for colour devices: "digital – analog"

Fig. 24 shows code examples for the input, output and reference of image reproduction of colour devices: "**digital – analog**" shown in Fig. 23. This **analog monitor** output must be compared with the corresponding **analog** reference.

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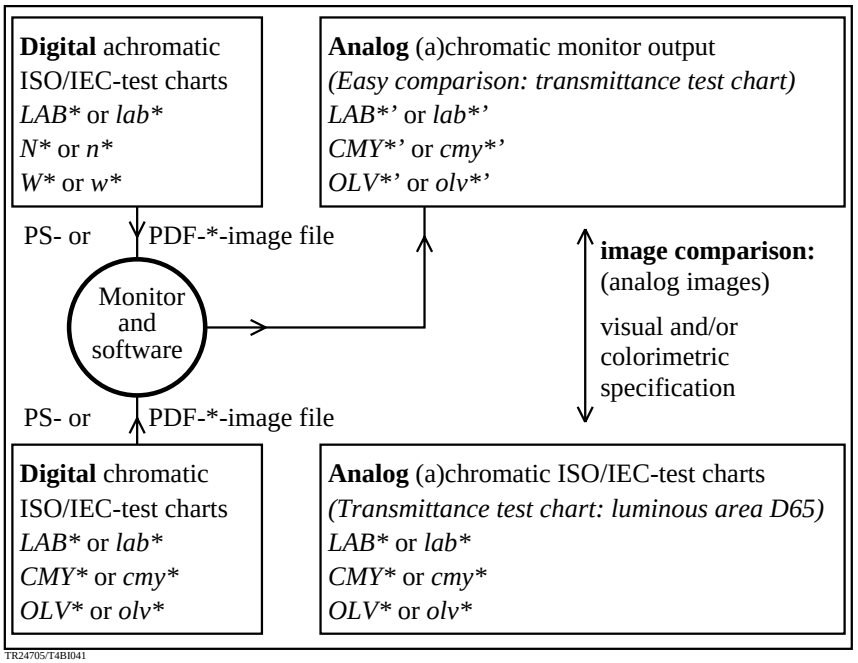

Figure 25: Specification of image reproduction for colour devices: "digital – analog"

Fig. 25 shows the specification of image reproduction for the colour devices: **"digital – analog"** by visual assessment and/or colorimetric measurement. The **analog monitor** output (reproduction) must be compared with the **analog** reference. For example this reference could be an **analog** original transparency of the ISO/IEC-test chart in transparent mode on a luminous area D65 light source.

13.3 Parameters for the PS-output of colour image reproduction devices: "digital – analog"

The following methods can be used to create output using the *PS* (or equivalent) files:

– *PS*-files can be reproduced directly using *Display-PostScript (min. Level 2)* on a colour monitor.

NOTE 1: The monitor output is influenced by the *Display-PostScript* -driver or the computer operating system. The monitor output is managed by the *PS*-software within the *Display-PostScript* -operating system *(e. g. Mac OS X Server)*.

NOTE 2: Achromatic ISO/IEC-test charts can be reproduced with any operating system which uses *Display-PostScript* operating system.

13.4 Parameters for the creation and output of *PDF*-files

The *PDF*-files or equivalents can be created from *PS*-files using *"Adobe Acrobat Distiller"* (see Fig. 22).

NOTE: *Distiller*-Version number 3.0 or higher is required so that the device independent *CIELAB*-data of the *PS*-files can be included in the *PDF*-files. *Distiller*-preferences (e. g. halftone Yes/No), change the printer halftone output, e. g. the output of pictures A5 or C5 of ISO/IEC-test charts 1 or 3 of *PDF*-files compared to *PS*-files.

There are various methods to make output using *PDF*-files.

a) *PDF*-files can be viewed on any monitor of any computer operating system with *Adobe Acrobat Reader* (see Fig. 22).

b) *PDF*-files can be viewed on the internet or "offline" by web browsers (e. g. *Netscape Navigator*, *Microsoft Explorer*) with the installed Plug-In *Adobe Acrobat Reader* on any operating system and on any monitor.

NOTE 2: The monitor output is dependent on the software (Web browser, *Adobe Acrobat Reader) ,* the monitor driver and the monitor settings.

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14. Visual and colorimetric test of monitor systems: “digital – analog”

The main procedures for the visual and colorimetric tests for all applications are described in Section 5.

14.1 General

For the reproduction systems “digital – analog” (monitors) use the Section 5.1 “General” and the following additions:

At least two out of the four **analog monitor** outputs are required. These must be produced from the **digital** ISO/IEC-test charts one after another with unchanged mode for the colour **monitor**. The colours in the ISO/IEC-test charts are defined in relative *L*a*b**-data and also in absolute *L*a*b**-data in part. See pictures B1 and B6 of test chart 2 as well as picture D1 and D6 of test chart 4.

The recommended operating modes of the manufacturer of the colour **monitor** should be used together with glare free room illumination and these must be specified in the test report. If deviations are necessary, these must be specified.

The visual test and the colorimetric specification of image reproduction of colour devices can be done by comparison of the **analog** colour **monitor** output with the **analog** reference (the transparent **analog** ISO/IEC-test chart on a luminous area D65 light source). Two test methods are available:

– visual testing, if necessary with optical aid such as a magnifying glass-6x.

– colorimetric measurement and specification (for interpretation see Annex G).

The testing results have to be summarized as follows:

For the visual evaluation of the picture area the forms in Annex A to Annex D must be used.

For the visual evaluation of the frame area the forms in Annex E and Annex F must be used.

The sections of these forms correspond to the different testing elements.

14.2 Visual test

For the reproduction systems “digital – analog” (monitors) use the Section 5.2 “Visual test”.

14.3 Colorimetric specification

For the reproduction systems “digital – analog” (monitors) use the Section 5.3 “Colorimetric specification”.

15. Test report of monitor systems: “digital – analog”

The test report for all applications is described in Section 6.

15.1 General

For the reproduction systems “digital – analog” (monitors) use the Section 6.1 “General” and the following additions:

The test report with the results of the test shall contain at least the following:

– statement of the colour **monitor** device model

– Specification of the ISO/IEC-code for input, output and reference (see Annex H, Table H.3)

– For a **monitor** the following parameters are necessary:

  – selected **monitor** working mode and/or specification of the selected adjustment,
  – for the specification of **monitors** the special adjustment and materials used,
  – specification of the room illumination type used,
  – specification of other environment conditions (room illuminance),
  – size of the monitor area viewed (e. g. A4 185 mm x 285 mm);

– at least two forms filled out for the visual interpretation of the image area of test charts 1, 2, 3 and 4,

  at least one form for an achromatic test chart according to Annex A or Annex C,

  at least one form for a chromatic test chart according to Annex B or Annex D;

– two forms filled out for the visual interpretation of the frame area of test charts 1, 2, 3 and 4,

  one form for an achromatic test chart according to Annex E,

  one form for a chromatic test chart according to Annex F;

– the normal colour vision and normal visual acuity of the testing persons are to be stated;

– optional – a colorimetric measurement and specification according to Annex G;

– test person, place and date

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Annex A:
Form A for the picture area

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For this test the output (reproduction, display) and the ISO/IEC-test chart 1 (original, reference) is necessary

Test of the radial grating according to picture A1

N–W-radial grating:	Is the resolution diameter < 6 mm?		Yes/No
	Test with magnifying glass (e.g. 6x)	resolution diameter:	..... mm
W–N-radial grating:	Is the resolution diameter < 6 mm?		Yes/No
	Test with magnifying glass (e.g. 6x)	resolution diameter:	..... mm
N–Z-radial grating:	Is the resolution diameter < 6 mm?		Yes/No
	Test with magnifying glass (e.g. 6x)	resolution diameter:	..... mm
W–Z-radial grating:	Is the resolution diameter < 6 mm?		Yes/No
	Test with magnifying glass (e.g. 6x)	resolution diameter:	..... mm

Test of 5 visually equally spaced *L-grey steps according to picture A2**

Are all the 5-steps on the upper row distinguishable?		Yes/No
If No: How many steps can be distinguished?	of the given 5 steps:	..... Steps

Test of 16 visually equally spaced *L-grey steps according to picture A3**

Are all the 16-steps on the upper row distinguishable?		Yes/No
If No: How many steps can be distinguished?	of the given 16 steps:	..... Steps

Test of the Landolt-rings *N–W* according to picture A4

Is the recognition frequency of the Landolt-rings > 50% (5 of 8 at least)?

background – ring	
0 – 1	Yes/No
7 – 8	Yes/No
E – F	Yes/No
2 – 0	Yes/No
8 – 6	Yes/No
F – D	Yes/No

Test of the line screen under 45° according to picture A5

Can equally spaced lines be seen?

Visual testing: Equally spaced line screeen can be seen from 15 to 60 lpi	Yes/No
Test with a magnifying glass (e.g. 6x): Equally spaced line screeen can be seen from 15 lpi:	to ..... lpi

Test of the line screen under 90° according to picture A6

Can equally spaced lines be seen?

Visual testing: Equally spaced line screeen can be seen from 15 to 60 lpi	Yes/No
Test with a magnifying glass (e.g. 6x): Equally spaced line screeen can be seen from 15 lpi:	to ..... lpi

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Form A for the visual interpretation of the ISO/IEC-test chart 1 reproduction for colour devices according to ISO/IEC TR 24705:2005(E)

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Annex B:
Form B for the picture area

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For this test the output (reproduction, display) and the ISO/IEC-test chart 2 (original, reference) is necessary

Test of the (flower) image according to picture B1

Are there clear (immediately conspicuous) differences between reproduction and reference test chart? Yes/No

Subjective remarks about the colour reproduction of the (flower) image, the CIE-test colours and the 16 grey steps:

.....

.....

.....

Test of the resolution in the radial gratings *W–C, W–M, W–Y, W–N* and *W–Z* according to picture B2

	W–C	***W–M***	***W–Y***	***W–N***	***W–Z***
Visual testing: Is the resolution diameter < 6 mm?	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No
Test with magnifying glass: Resolution diameter	..... mm	..... mm	..... mm	..... mm	..... mm

Test of the 14 CIE-test colours according to picture B3

Are clear (immediately conspicuous) differences recognized between reproduction and test chart? Yes/No

If Yes: How many colours have clear differences? of the given 14 colours: ..... Colours

Test of 16 visually equally spaced *L-grey steps according to picture B3**

Are all the 16-steps on the upper row distinguishable? Yes/No

If No: How many steps can be distinguished of the given 16 steps: ..... Steps

Test of 16 visually equally spaced steps of the colour rows *W–C, W–M, W–Y* and *W–N* according to picture B4

W–C White–Cyanblue:	Are all the 16-steps distinguishable?		Yes/No
	If No: How many steps can be distinguished?	of the given 16 steps:	..... Steps
W–M White–Magentared:	Are all the 16-steps distinguishable?		Yes/No
	If No: How many steps can be distinguished?	of the given 16 steps:	..... Steps
W–Y White–Yellow:	Are all the 16-steps distinguishable?		Yes/No
	If No: How many steps can be distinguished?	of the given 16 steps:	..... Steps
W–N White–Black:	Are all the 16-steps distinguishable?		Yes/No
	If No: How many steps can be distinguished?	of the given 16 steps:	..... Steps

Test of characters and Landolt-rings in four sizes according to picture B5

Is the recognition frequency > 50% for letters (17 from 32 at least) and for Landolt-rings (min. 5 of 8)?

Relative size	Letters	Rings ***N***	Rings ***C***	Rings ***M***	Rings ***Y***
10	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No
8	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No
6	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No
4	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No

Test of recognition frequency of Landolt-rings *W–C, W–M, W–Y* and *W–N* according to pictures B6 and B7

Is the recognition frequency of the Landolt-rings > 50% (min. 5 of 8 at least)?

Colour row ***W–C*** background – ring		Colour row ***W–M*** background – ring		Colour row ***W–Y*** background – ring		Colour row ***W–N*** background – ring	
0 – 1	Yes/No	0 – 1	Yes/No	0 – 2	Yes/No	0 – 1	Yes/No
7 – 8	Yes/No	7 – 8	Yes/No	6 – 8	Yes/No	7 – 8	Yes/No
E – F	Yes/No	E – F	Yes/No	D – F	Yes/No	E – F	Yes/No
2 – 0	Yes/No	2 – 0	Yes/No	4 – 0	Yes/No	2 – 0	Yes/No
8 – 6	Yes/No	8 – 6	Yes/No	9 – 5	Yes/No	8 – 6	Yes/No
F – D	Yes/No	F – D	Yes/No	F – B	Yes/No	F – D	Yes/No

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Form B for the visual interpretation of the ISO/IEC-test chart 2 reproduction for colour devices according to ISO/IEC TR 24705:2005(E)

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Annex C:
Form C for the picture area

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For this test the output (reproduction, display) and the ISO/IEC-test chart 3 (original, reference) is necessary

Test of the radial grating according to picture C1

N–W-radial grating:	Is the resolution diameter < 6 mm?		Yes/No
	Test with magnifying glass (e.g. 6x)	resolution diameter:	..... mm
W–N-radial grating:	Is the resolution diameter < 6 mm?		Yes/No
	Test with magnifying glass (e.g. 6x)	resolution diameter:	..... mm
N–Z-radial grating:	Is the resolution diameter < 6 mm?		Yes/No
	Test with magnifying glass (e.g. 6x)	resolution diameter:	..... mm
W–Z-radial grating:	Is the resolution diameter < 6 mm?		Yes/No
	Test with magnifying glass (e.g. 6x)	resolution diameter:	..... mm

Test of 5 visually equally spaced *L-grey steps according to picture C2**

Are all the 5-steps on the upper row distinguishable?		Yes/No
If No: How many steps can be distinguished?	of the given 5 steps:	..... Steps

Test of 16 visually equally spaced *L-grey steps according to picture C3**

Are all the 16-steps on the upper row distinguishable?		Yes/No
If No: How many steps can be distinguished?	of the given 16 steps:	..... Steps

Test of the Landolt-rings *N–W* according to picture C4

Is the recognition frequency of the Landolt-rings > 50% (5 of 8 at least)?

background – ring	
0 – 1	Yes/No
7 – 8	Yes/No
E – F	Yes/No
2 – 0	Yes/No
8 – 6	Yes/No
F – D	Yes/No

Test of the line screen under 45° according to picture C5

Can equally spaced lines be seen?

Visual testing: Equally spaced line screeen can be seen from 15 to 60 lpi	Yes/No
Test with a magnifying glass (e.g. 6x): Equally spaced line screeen can be seen from 15 lpi:	to ..... lpi

Test of the line screen under 90° according to picture C6

Can equally spaced lines be seen?

Visual testing: Equally spaced line screeen can be seen from 15 to 60 lpi	Yes/No
Test with a magnifying glass (e.g. 6x): Equally spaced line screeen can be seen from 15 lpi:	to ..... lpi

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Form C for the visual interpretation of the ISO/IEC-test chart 3 reproduction for colour devices according to ISO/IEC TR 24705:2005(E)

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Annex D:
Form D for the picture area

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For this test the output (reproduction, display) and the ISO/IEC-test chart 4 (original, reference) is necessary

Test of the (flower) image according to picture D1

Are there clear (immediately conspicuous) differences between reproduction and reference test chart? Yes/No

Subjective remarks about the colour reproduction of the (flower) image, the CIE-test colours and the 16 grey steps:

.....

.....

.....

Test of the resolution in the radial gratings *W–O, W–L, W–V, W–N* and *W–Z* according to picture D2

	W–O	***W–L***	***W–V***	***W–N***	***W–Z***
Visual testing: Is the resolution diameter < 6 mm?	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No
Test with magnifying glass: Resolution diameter	..... mm	..... mm	..... mm	..... mm	..... mm

Test of the 14 CIE-test colours according to picture D3

Are clear (immediately conspicuous) differences recognized between reproduction and test chart? Yes/No

If Yes: How many colours have clear differences? of the given 14 colours: ..... Colours

Test of 16 visually equally spaced *L-grey steps according to picture D3**

Are all the 16-steps on the upper row distinguishable? Yes/No

If No: How many steps can be distinguished of the given 16 steps: ..... Steps

Test of 16 visually equally spaced steps of the colour rows *W–O, W–L, W–V* and *W–N* according to picture D4

W–O White–Orangered:	Are all the 16-steps distinguishable?		Yes/No
	If No: How many steps can be distinguished?	of the given 16 steps:	..... Steps
W–L White–Leafgreen:	Are all the 16-steps distinguishable?		Yes/No
	If No: How many steps can be distinguished?	of the given 16 steps:	..... Steps
W–V White–Violetblue:	Are all the 16-steps distinguishable?		Yes/No
	If No: How many steps can be distinguished?	of the given 16 steps:	..... Steps
W–N White–Black:	Are all the 16-steps distinguishable?		Yes/No
	If No: How many steps can be distinguished?	of the given 16 steps:	..... Steps

Test of characters and Landolt-rings in four sizes according to picture D5

Is the recognition frequency > 50% for letters (17 from 32 at least) and for Landolt-rings (min. 5 of 8)?

Relative size	Letters	Rings ***N***	Rings ***O***	Rings ***L***	Rings ***V***
10	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No
8	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No
6	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No
4	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No

Test of recognition frequency of Landolt-rings *W–O, W–L, W–V* and *W–N* according to pictures D6 and D7

Is the recognition frequency of the Landolt-rings > 50% (min. 5 of 8 at least)?

Colour row ***W–O*** background – ring		Colour row ***W–L*** background – ring		Colour row ***W–V*** background – ring		Colour row ***W–N*** background – ring	
0 – 1	Yes/No	0 – 1	Yes/No	0 – 1	Yes/No	0 – 1	Yes/No
7 – 8	Yes/No	7 – 8	Yes/No	7 – 8	Yes/No	7 – 8	Yes/No
E – F	Yes/No	E – F	Yes/No	E – F	Yes/No	E – F	Yes/No
2 – 0	Yes/No	2 – 0	Yes/No	2 – 0	Yes/No	2 – 0	Yes/No
8 – 6	Yes/No	8 – 6	Yes/No	8 – 6	Yes/No	8 – 6	Yes/No
F – D	Yes/No	F – D	Yes/No	F – D	Yes/No	F – D	Yes/No

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Form D for the visual interpretation of the ISO/IEC-test chart 4 reproduction for colour devices according to ISO/IEC TR 24705:2005(E)

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Annex E:
Form E for the frame area

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For this test the output (reproduction, display) and the ISO/IEC-test chart 1 or 3 (original, reference) is necessary

Please fill out or mark by **(x)**:

Test of achromatic ISO/IEC-test chart 1 ( ) or ISO/IEC-test chart 3 ( ):

ISO/IEC-test chart: e. g. Test chart 3 for colour devices (write text from the frame area of ISO/IEC-test chart)

.....

ISO/IEC-BAM-identification: e. g. 20031201-DE88/10L/ (write code from top right side) .....

ISO/IEC-reference material: e. g. r(h/c)a4(r/t)(a/d) (write code from bottom right side) .....

File-name: e. g. L88E00NP.PDF (write code from top side).....

Reproduction technique for „halftone (h)" ( ) or „continuous tone (c)" ( )

NOTE: The usual output technique for printer and copier is **(h)**. For photo, film, monitor and scanner it is **(c)**.

Test of reproduced lines according to lines defining rectangles in the frame region:

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

How many lines are on the ISO/IEC-test chart?	of max. 20 lines:	.... lines are given
How many lines of the ISO/IEC-test chart are reproduced?	of given ..... lines:	.... lines
Are the four *(inner thicker)* lines of the inner rectangle fully reproduced?		Yes/No
If No: How many *inner* lines are fully reproduced?	of given 4 lines:	.... lines

Test of agreement of the four 5-step grey scales according to the grey scales in the frame region:

Are there clearly seen differences between the four 5-step grey scales near the four corners? Yes/No

If Yes: Indicate by **(x)** – only one **(x)** – which grey scale deviates most from the average of the four grey scales and mark if this is darker or lighter.

top left	**( )**	if **(x)**: Is this darker **( )** or lighter **( )**?
top right	**( )**	if **(x)**: Is this darker **( )** or lighter **( )**?
bottom left	**( )**	if **(x)**: Is this darker **( )** or lighter **( )**?
bottom right	**( )**	if **(x)**: Is this darker **( )** or lighter **( )**?

Test of the scaling factors using width and height of the inner rectangle in the frame region:

The width and height of the inner rectangle in *x*- and *y*-direction in mm of the reference test chart (Δx_r and Δy_r; r = reference) and the reproduction (Δx_o and Δy_o; o = output) must be measured. The scaling factors (s_x and s_y) in *x*- and *y*-direction must be calculated. For this 3 digits in mm and with rounding like the example are used (e. g. s_x = 1,01 and s_y = 0,98).

$s_x = \Delta x_o / \Delta x_r$ = . . . mm / . . . mm = . , . . $s_y = \Delta y_o / \Delta y_r$ = . . . mm / . . . mm = . , . .

NOTE: The width Δx_r and height Δy_r of the inner rectangle is defined in *PS*-file (or equivalent) as 282 mm in *x*-direction and 194 mm in *y*-direction. To get high accuracy of the two scaling factors both the original and the reproduction should be measured with the same ruler (do not use values given for the original).

Test of the shift of the colour lines compared to black according to the lines of inner rectangle of the frame:

Are there colour lines ***C, M, Y, O, L*** and ***V*** on the test chart belonging to the inner rectangles? Yes/No

If Yes, answer the following questions:

NOTE The lines of the inner rectangle have a linewidth of 0,3 mm. If a shift of more than half of this linewidth (≥ 0,2 mm) is present, it can be easily seen.

Choose one of the two *horizontal* lines and mark by **(x)**:

bottom horizontal line chosen **( )** top horizontal line chosen **( )**

Is there a clearly seen (≥ 0,2 mm) shift of a colour line ***C, M, Y, O, L*** and ***V*** compared to the black line ***N*** ?

	C	***M***	***Y***	***O***	***L***	***V***
	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No
If Yes:	0, . mm	0, . mm	0, . mm	0, . mm	0, . mm	0, . mm

Choose one of the two *vertical* lines and mark by **(x)**:

left vertical line chosen **( )** right vertical line chosen **( )**

Is there a clearly seen (≥ 0,2 mm) shift of a colour line ***C, M, Y, O, L*** and ***V*** compared to the black line ***N*** ?

	C	***M***	***Y***	***O***	***L***	***V***
	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No
If Yes:	0, . mm	0, . mm	0, . mm	0, . mm	0, . mm	0, . mm

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Form E for the visual interpreting of *achromatic* ISO/IEC-test chart (1 or 3) reproduction for colour devices according to ISO/IEC TR 24705:2005(E)

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Annex F:
Form F for the frame area

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For this test the output (reproduction, display) and the ISO/IEC-test chart 2 or 4 (original, reference) is necessary

Please fill out or mark by **(x)**:

Test of chromatic test chart 2 ( ) or test chart 4 ( ):

ISO-test chart: e. g. Test chart 4 for colour devices ISO/IEC(write text from the frame area of ISO/IEC-test chart)

.....

ISO/IEC-BAM-identification: e. g. 20031201-DE96/10L/ (write code from top right side) .....

ISO/IEC-reference material: e. g. r(h/c)a4(r/t)(a/d) (write code from bottom right side) .....

File-name: e. g. L96E00NP.PDF (write code from top side) .....

Reproduction technique for „halftone (h)" ( ) or „continuous tone (c)" ( )

NOT: The usual output technique for printer and copier is **(h)**. For photo, film, monitor and scanner it is **(c)**.

Test of reproduced lines according to lines defining rectangles in the frame region:

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

How many lines are on the ISO/IEC-test chart?	of max. 20 lines:	.... lines are given
How many lines of the ISO/IEC-test chart are reproduced?	of given ..... lines:	.... lines
Are the four *(inner thicker)* lines of the inner rectangle fully reproduced?		Yes/No
If No: How many *inner* lines are fully reproduced?	of given 4 lines:	.... lines

Test of agreement of the four 5-step grey scales according to the grey scales in the frame region:

Are there clearly seen differences between the four 5-step grey scales near the four corners? Yes/No

If Yes: Indicate by **(x)** – only one **(x)** – which grey scale deviates most from the average of the four grey scales and mark if this is darker or lighter.

top left	**( )**	if **(x)**: Is this darker **( )** or lighter **( )**?
top right	**( )**	if **(x)**: Is this darker **( )** or lighter **( )**?
bottom left	**( )**	if **(x)**: Is this darker **( )** or lighter **( )**?
bottom right	**( )**	if **(x)**: Is this darker **( )** or lighter **( )**?

Test of the scaling factors using width and height of the inner rectangle in the frame region:

The width and height of the inner rectangle in *x*- and *y*-direction in mm of the reference test chart (Δx_r and Δy_r; r = reference) and the reproduction (Δx_o and Δy_o; o = output) must be measured. The scaling factors (s_x and s_y) in *x*- and *y*-direction must be calculated. For this 3 digits in mm and with rounding like the example are used (e. g. s_x = 1,01 and s_y = 0,98).

$s_x = \Delta x_o / \Delta x_r$ = . . . mm / . . . mm = . , . . $s_y = \Delta y_o / \Delta y_r$ = . . . mm / . . . mm = . , . .

NOTE The width Δx_r and height Δy_r of the inner rectangle is defined in *PS*-file (or equivalent) as 282 mm in *x*-direction and 194 mm in *y*-direction. To get high accuracy of the two scaling factors both the original and the reproduction should be measured with the same ruler (do not use values given for the original).

Test of the shift of the colour lines compared to black according to the lines of inner rectangle of the frame:

Are there colour lines ***C, M, Y, O, L*** and ***V*** on the test chart belonging to the inner rectangles? Yes/No

If Yes, answer the following questions:

NOTE The lines of the inner rectangle have a linewidth of 0,3 mm. If a shift of more than half of this linewidth (≥ 0,2 mm) is present, it can be easily seen.

Choose one of the two *horizontal* lines and mark bottom or top line by **(x)**:

bottom horizontal line chosen **( )** top horizontal line chosen **( )**

Is there a clearly seen (≥ 0,2 mm) shift of a colour line ***C, M, Y, O, L*** and ***V*** compared to the black line ***N*** ?

	C	***M***	***Y***	***O***	***L***	***V***
	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No
If Yes:	0, . mm	0, . mm	0, . mm	0, . mm	0, . mm	0, . mm

Choose one of the two *vertical* lines and mark left or right line by **(x)**:

left vertical line chosen **( )** right vertical line chosen **( )**

Is there a clearly seen (≥ 0,2 mm) shift of a colour line ***C, M, Y, O, L*** and ***V*** compared to the black line ***N*** ?

	C	***M***	***Y***	***O***	***L***	***V***
	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No
If Yes:	0, . mm	0, . mm	0, . mm	0, . mm	0, . mm	0, . mm

Form F for the visual interpreting of *chromatic* ISO/IEC-test chart (2 or 4) reproduction for colour devices according to ISO/IEC TR 24705:2005(E)

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Annex G:
Colorimetric specification

Guidance for the colorimetric specification of reproduction for colour reproduction devices using ISO/IEC-test chart 1, 2, 3 and 4 according to this Technical Report (nearly identical to ISO/IEC 15775).

G.1 Grey scale according to picture A2 (or C2): Regularity *g**

The visual lightness difference between adjacent grey steps in picture A2 (or C2) of test charts 1 (or 3) is the same. That is, the steps are visually "equally" spaced grey steps. This does not normally occur for reproductions. The differences of these lightness steps are specified by the measure *g**. It describes the regularity of the lightness reproduction.

Calculation G.1: Regularity *g**

For the specification of the regularity *g**, the CIELAB lightness *L** of the five grey steps 1 to 5 on the reproduction device L^*_{K1} to L^*_{K5} should be measured.

NOTE 1: The grey step 1 is the reproduction of the black colour (*N* = "Noir"), the grey step 5 is the reproduction of the white colour (*W* = White). It follows from this:

$L^*_{K1} = L^*_{KN}$ and $L^*_{K5} = L^*_{KW}$

Next the lightness differences (ΔL^*_{K1} ... ΔL^*_{K4}) to the next lighter step can be calculated:

$$\Delta L^*_{K1} = | L^*_{K2} - L^*_{K1} | = | L^*_{K2} - L^*_{KN} | \quad \text{(eq. 1)}$$
$$\Delta L^*_{K2} = | L^*_{K3} - L^*_{K2} | \quad \text{(eq. 2)}$$
$$\Delta L^*_{K3} = | L^*_{K4} - L^*_{K3} | \quad \text{(eq. 3)}$$
$$\Delta L^*_{K4} = | L^*_{K5} - L^*_{K4} | = | L^*_{KW} - L^*_{K4} | \quad \text{(eq. 4)}$$

The regularity *g** of the lightness scale is defined by the quotient of the smallest and greatest lightness difference (ΔL^*_{min} respectively ΔL^*_{max}) multiplied by a factor 100:

$$g^* = 100\ \Delta L^*_{min} / \Delta L^*_{max} \quad \text{(eq. 5)}$$

NOTE 2: Ideally the regularity has the value *g** = 100. In the case where the two steps are identical the value is *g** = 0.

Example G.1: Regularity *g**

If: $L^*_{K1} = L^*_{KN} = 24$; $L^*_{K2} = 40$; $L^*_{K3} = 56$; $L^*_{K4} = 74$; $L^*_{K5} = L^*_{KW} = 90$ then:

$\Delta L^*_{K1} = | L^*_{K2} - L^*_{K1} | = | L^*_{K2} - L^*_{KN} | = 16 = \Delta L^*_{min}$
$\Delta L^*_{K2} = | L^*_{K3} - L^*_{K2} | = 16 = \Delta L^*_{min}$
$\Delta L^*_{K3} = | L^*_{K4} - L^*_{K3} | = 18 = \Delta L^*_{max}$
$\Delta L^*_{K4} = | L^*_{K5} - L^*_{K4} | = | L^*_{KW} - L^*_{K4} | = 16 = \Delta L^*_{min}$
$g^* = 100\ \Delta L^*_{min} / \Delta L^*_{max} = 100 \times (16 / 18) = 89$

G.2 Grey scale according to picture A2 (or C2): Lightness gamut *f**

Differences occur in the lightness of black and white for the reproduction compared to the original. The lightness gamut *f** is specified with the lightness difference between white and black.

Calculation G.2: Lightness gamut *f**

The CIELAB-lightness *L** of black *(N)* and white *(W)* in the test chart *(V)* and reproduction *(K)* serve for calculation of the lightness gamut *f**.

For the lightness gamut *f** the following applies:

$$f^* = 100\ (L^*_{KW} - L^*_{KN}) / (L^*_{VW} - L^*_{VN}) \quad \text{(eq. 6)}$$

NOTE: Ideally, when white and black are reproduced with the same lightness as in the test chart, the following values apply: $L^*_{VW} = 94$ and $L^*_{VN} = 10$.

$f^* = 100\ (L^*_{KW} - L^*_{KN}) / (L^*_{VW} - L^*_{VN}) = 100\ (94 - 10) / (94 - 10) = 100$

On devices *f** is normally smaller than 100.

Example G.2: Lightness gamut *f**

If: $L^*_{K1} = L^*_{KN} = 24$; $L^*_{K5} = L^*_{KW} = 90$; $L^*_{VN} = 10$; $L^*_{VW} = 94$ then:

$f^* = 100\ (L^*_{KW} - L^*_{KN}) / (L^*_{VW} - L^*_{VN}) = 100\ (90 - 24) / (94 - 10) = 79$

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G.3 Grey steps according to picture A2 (or C2): Mean lightness difference ΔL^*_m

The five equally spaced grey steps normally show various lightness differences in the reproduction and the test chart. From this a mean lightness difference ΔL^*_m for the achromatic test charts 1 (or 3) can be calculated.

Calculation G.3: Mean lightness difference ΔL^*_m

The CIELAB-lightness L^* of the five grey steps of the test chart *(V)* and reproduction *(K)* serve for the calculation of the mean lightness difference ΔL^*_m. The lightness L^*_K of the five grey steps of the reproduction must be centered on the lightness gamut of the test chart to receive the centered lightness L^*_{KZ}.

$$L^*_{KZ} = L^*_K - 0{,}5\ [\ (\ L^*_{KN} - L^*_{VN}\ ) - (L^*_{VW} - L^*_{KW}\ )\ ] \qquad \text{(eq. 7)}$$

The mean lightness difference ΔL^*_m is calculated from the five lightness differences on the reproduction L^*_{KZ} and the test chart L^*_V .

$$\Delta L^*_m = 0{,}2\ (\ |\ L^*_{KZ1} - L^*_{V1}\ |\ +\ |\ L^*_{KZ2} - L^*_{V2}\ |\ +\ ...\ +\ |\ L^*_{KZ5} - L^*_{V5}\ |\ ) \qquad \text{(eq. 8)}$$

NOTE 1: Ideally the mean lightness difference has the value $\Delta L^*_m = 0$.

NOTE 2: A pure regular shift of the lightness of the reproduction compared to the test charts (L^*_{VN} = 10 or 7, L^*_{VW} = 94 or 91) has no influence visually and will not change the calculated mean lightness difference ΔL^*_m.

Example G.3: Mean lightness difference ΔL^*_m

$L^*_{V1} = L^*_{VN} = 10$; $L^*_{V2} = 31$; $L^*_{V3} = 52$; $L^*_{V4} = 73$; $L^*_{V5} = L^*_{VW} = 94$
$L^*_{K1} = L^*_{KN} = 24$; $L^*_{K2} = 40$; $L^*_{K3} = 56$; $L^*_{K4} = 74$; $L^*_{K5} = L^*_{KW} = 90$

$L^*_{KN} - L^*_{VN} = 24 - 10 = 14$

$L^*_{VW} - L^*_{KW} = 94 - 90 = 4$

Centralization:

$L^*_{KZ1} = L^*_{K1} - 0{,}5\ [\ (L^*_{KN} - L^*_{VN}) - (L^*_{VW} - L^*_{KW})\ ]$
$L^*_{KZ1} = 24 - 0{,}5\ (14 - 4) = 19$
$L^*_{KZ2} = 40 - 0{,}5\ (14 - 4) = 35$
$L^*_{KZ3} = 56 - 0{,}5\ (14 - 4) = 51$
$L^*_{KZ4} = 74 - 0{,}5\ (14 - 4) = 69$
$L^*_{KZ5} = 90 - 0{,}5\ (14 - 4) = 85$

Lightness difference and mean lightness difference:

$\Delta L^*_1 = L^*_{KZ1} - L^*_{V1} = 19 - 10 = 9$
$\Delta L^*_2 = L^*_{KZ2} - L^*_{V2} = 35 - 31 = 4$
$\Delta L^*_3 = L^*_{KZ3} - L^*_{V3} = 52 - 51 = 1$
$\Delta L^*_4 = L^*_{KZ4} - L^*_{V4} = 69 - 73 = -4$
$\Delta L^*_5 = L^*_{KZ5} - L^*_{V5} = 85 - 94 = -9$

$\Delta L^*_m = 0{,}2\ (\ |\ L^*_{KZ1} - L^*_{V1}\ |\ +\ |\ L^*_{KZ2} - L^*_{V2}\ |\ +\ ...\ +\ |\ L^*_{KZ5} - L^*_{V5}\ |\ )$
$= 0{,}2\ (9 + 4 + 1 + 4 + 9) = 5{,}4$

G.4 Test colours according to picture B6 (or D6): Mean colour difference $\Delta E^*_{ab,m}$

The 14 test colours of a reproduction normally show colour differences compared to the colours of the test chart. These differences are characterized by the mean colour difference $\Delta E^*_{ab,m}$.

Calculation G.4: Mean colour difference $\Delta E^*_{ab,m}$

For the calculation of the mean colour difference $\Delta E^*_{ab,m}$ the CIELAB-lightness L^* and the red-green chromaticness a^* and yellow-blue chromaticness b^* of the 14 CIE-test colours of the test chart *(V)* and reproduction *(K)* in picture B6 (or D6) are measured.

From this the 14 special colour differences $\Delta E^*_{ab,i}$ (i = 1, 2, ... , 14) of reproduction and test chart are calculated as follows.

$$\Delta E^*_{ab,i} = [\ (L^*_{Ki} - L^*_{Vi}\ )^2 + (a^*_{Ki} - a^*_{Vi}\ )^2 + (b^*_{Ki} - b^*_{Vi}\ )^2\ ]^{1/2} \qquad \text{(eq. 9)}$$

The special colour differences $\Delta E^*_{ab,i}$ are used to define the mean colour difference $\Delta E^*_{ab,m}$:

$$\Delta E^*_{ab,m} = 0{,}0714\ (\Delta E^*_{ab,1} + \Delta E^*_{ab,2} + \Delta E^*_{ab,3} + ... + \Delta E^*_{ab,14}) \qquad \text{(eq. 10)}$$

NOTE: Ideally the mean colour difference has the value $\Delta E^*_{ab,m} = 0$.

Example G.4: Mean colour difference $\Delta E^*_{ab,m}$

The mean colour difference $\Delta E^*_{ab,m}$ is calculated from the colorimetric parameters $L^*a^*b^*$ of the test chart *(V)* and

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reproduction *(K)* with 14 special colour differences $\Delta E^*_{ab,i}$ (i = 1, 2, ... ,14).

Table G.1: Colorimetric parameters of the intended and reproduced 14 CIE-test colours

CIE test colour	Intended CIELAB data of CIE Publ. 13.3 Original (V)			Produced CIELAB data of copied colours Copy (K)			CIELAB differences of test colours Difference (K−V)			CIELAB-test colour difference
no.	L^*_V	a^*_V	b^*_V	L^*_K	a^*_K	b^*_K	ΔL^*_{K-V}	Δa^*_{K-V}	Δb^*_{K-V}	ΔE^*_{ab}
1	61.45	17.53	11.74	60.71	18.5	9.5	−0.73	0.97	−2.23	2.55
2	60.69	0.08	28.92	58.84	3.24	23.57	−1.84	3.16	−5.34	6.48
3	62.02	−20.58	44.41	61.79	−21.49	44.33	−0.22	−0.9	−0.07	0.94
4	61.2	−33.16	17.07	62.06	−35.43	19.12	0.86	−2.26	2.05	3.18
5	62.4	−17.47	−8.55	61.7	−15.02	−10.62	−0.69	2.45	−2.06	3.28
6	61.51	−0.36	−28.39	60.17	2.47	−29.72	−1.33	2.84	−1.32	3.41
7	61.12	20.15	−24.55	63.11	17.05	−23.55	1.99	−3.09	1.0	3.82
8	62.77	27.42	−13.63	62.66	27.66	−13.57	−0.1	0.24	0.06	0.27
9	39.92	58.74	27.99	39.37	55.26	24.74	−0.54	−3.47	−3.24	4.79
10	81.26	−2.89	71.56	82.06	−2.84	81.13	0.8	0.05	9.57	9.6
11	52.23	−42.42	13.6	53.43	−44.12	16.49	1.2	−1.69	2.89	3.56
12	30.57	1.41	−46.47	29.63	4.84	−42.36	−0.93	3.43	4.11	5.44
13	80.23	11.37	21.04	78.28	12.32	20.43	−1.94	0.95	−0.6	2.25
14	40.75	−13.8	24.23	41.47	−12.47	24.78	0.72	1.33	0.55	1.61
Average CIELAB colour difference:									$\Delta E^*_{ab,m}$ =	***3.7***

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Table G.1 shows the *L*a*b** -colorimetric data of the intended and reproduced 14 CIE-test colours and their CIELAB-differences.

G.5 Mean Colour reproduction Index $R^*_{ab,m}$

The reproductions of the five equally spaced grey steps (pictures A2 and C2) and the 14 test colours (picture B6 and D6) indicate different colour differences compared to the corresponding steps of the test chart. These differences are characterized by the mean colour reproduction Index $R^*_{ab,m}$. It considers the mean lightness difference ΔL^*_m (for the grey steps) as well as the mean test colour difference $\Delta E^*_{ab,m}$ (for the chromatic colours).

Calculation G.5: Mean Colour reproduction Index $R^*_{ab,m}$

The mean lightness difference ΔL^*_m according to Annex G.3 and the mean test colour difference $\Delta E^*_{ab,m}$ according to Annex G.4 serve for the calculation of the mean colour reproduction index.

$$R^*_{ab,m} = 100 - 4{,}6\ (\ 0{,}263\ \Delta L^*_m + 0{,}737\ \Delta E^*_{ab,m}\ ) \qquad \text{(eq. 11)}$$

NOTE: Ideally the mean colour reproduction index has the value $R^*_{ab,m} = 100$. It becomes smaller when lightness and test colour differences grow.

Example G.5: Mean Colour reproduction Index $R^*_{ab,m}$

For the mean lightness difference ΔL^*_m according to example G.3 and for the mean test colour difference $\Delta E^*_{ab,m}$ according to example G.4 the following applies:

$$R^*_{ab,m} = 100 - 4{,}6\ (0{,}263\ \Delta L^*_m + 0{,}737\ \Delta E^*_{ab,m})$$

$$= 100 - 4{,}6\ (0{,}263 \times 5{,}4 + 0{,}737 \times 3{,}7) = 100 - (\ 4{,}6 \times 4{,}12\ ) = 81 \qquad \text{(eq. 12)}$$

NOTE: Results in G.1 to G.5 are to be rounded down to two significant digits.

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Annex H:
Code lists of input, output and reference

The codes for input, output and reference are listed in Table H.1 and Table H.3 for analog and digital mode. In Table H.2, Table H.4, and Table H.5 three examples are given: a colour copier, a printer and a scanner are given.

Table H.1: Code list for analog input, output and reference

test chart *n* **= 1 to 4**	**process colour image reproduction device**		**comparison**	
	input (i)	**output (o)**	**output (o)**	**reference (r)**
ISO/IEC-code:	iha4ra-I0*n* (*n* = 1 to 4)	oha4ra-I0*n* (*n* = 1 to 4)	oha4ra-I0*n* (*n* = 1 to 4)	rha4ra-I0*n* (*n* = 1 to 4)
description:	halftone (h) A4 size (a4) reflectance mode (r) analog (a)	halftone (h) A4 size (a4) reflectance mode (r) analog (a)	halftone (h) A4 size (a4) reflectance mode (r) analog (a)	halftone (h) A4 size (a4) reflectance mode (r) analog (a)
ISO/IEC-code:	ica4ra-I0*n* (*n* = 1 to 4)	oca4ra-I0*n* (*n* = 1 to 4)	oca4ra-I0*n* (*n* = 1 to 4)	rca4ra-I0*n* (*n* = 1 to 4)
description:	continuous tone (c) A4 size (a4) reflectance mode (r) analog (a)	continuous tone (c) A4 size (a4) reflectance mode (r) analog (a)	continuous tone (c) A4 size (a4) reflectance mode (r) analog (a)	continuous tone (c) A4 size (a4) reflectance mode (r) analog (a)
ISO/IEC-code:	iha4ta-I0*n* (*n* = 1 to 4)	oha4ta-I0*n* (*n* = 1 to 4)	oha4ta-I0*n* (*n* = 1 to 4)	rha4ta-I0*n* (*n* = 1 to 4)
description:	halftone (h) A4 size (a4) transparent mode (t) analog (a)	halftone (h) A4 size (a4) transparent mode (t) analog (a)	halftone (h) A4 size (a4) transparent mode (t) analog (a)	halftone (h) A4 size (a4) transparent mode (t) analog (a)
ISO/IEC-code:	ica4ta-I0*n* (*n* = 1 to 4)	oca4ta-I0*n* (*n* = 1 to 4)	oca4ta-I0*n* (*n* = 1 to 4)	rca4ta-I0*n* (*n* = 1 to 4)
description:	continuous tone (c) A4 size (a4) transparent mode (t) analog (a)	continuous tone (c) A4 size (a4) transparent mode (t) analog (a)	continuous tone (c) A4 size (a4) transparent mode (t) analog (a)	continuous tone (c) A4 size (a4) transparent mode (t) analog (a)

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Table H.2: Input, output and reference for a copier

test chart no. = 1	**process copier**		**comparison**	
	input (i)	**output (o)**	**output (o)**	**reference (r)**
ISO/IEC-code:	iha4ra-I01	oha4ra-I01	oha4ra-I01	rha4ra-I01
description:	halftone (h) A4 size (a4) reflectance mode (r) analog (a)	halftone (h) A4 size (a4) reflectance mode (r) analog (a)	halftone (h) A4 size (a4) reflectance mode (r) analog (a)	halftone (h) A4 size (a4) reflectance mode (r) analog (a)

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Table H.3: Code list for digital input, output and reference

test chart *n* = 1 to 4	process colour image reproduction device		comparison	
	input (i)	**output (o)**	**output (o)**	**reference (r)**
ISO/IEC-code:	iha4rd-I0*n* (*n* = 1 to 4)	oha4rd-I0*n* (*n* = 1 to 4)	oha4rd-I0*n* (*n* = 1 to 4)	rha4rd-I0*n* (*n* = 1 to 4)
description:	halftone (h) A4 size (a4) reflectance mode (r) digital (d)	halftone (h) A4 size (a4) reflectance mode (r) digital (d)	halftone (h) A4 size (a4) reflectance mode (r) digital (d)	halftone (h) A4 size (a4) reflectance mode (r) digital (d)
ISO/IEC-code:	ica4rd-I0*n* (*n* = 1 to 4)	oca4rd-I0*n* (*n* = 1 to 4)	oca4rd-I0*n* (*n* = 1 to 4)	rca4rd-I0*n* (*n* = 1 to 4)
description:	continuous tone (c) A4 size (a4) reflectance mode (r) digital (d)	continuous tone (c) A4 size (a4) reflectance mode (r) digital (d)	continuous tone (c) A4 size (a4) reflectance mode (r) digital (d)	continuous tone (c) A4 size (a4) reflectance mode (r) digital (d)
ISO/IEC-code:	iha4td-I0*n* (*n* = 1 to 4)	oha4td-I0*n* (*n* = 1 to 4)	oha4td-I0*n* (*n* = 1 to 4)	rha4td-I0*n* (*n* = 1 to 4)
description:	halftone (h) A4 size (a4) transparent mode (t) digital (d)	halftone (h) A4 size (a4) transparent mode (t) digital (d)	halftone (h) A4 size (a4) transparent mode (t) digital (d)	halftone (h) A4 size (a4) transparent mode (t) digital (d)
ISO/IEC-code:	ica4ta-I0*n* (*n* = 1 to 4)	oca4ta-I0*n* (*n* = 1 to 4)	oca4ta-I0*n* (*n* = 1 to 4)	rca4ta-I0*n* (*n* = 1 to 4)
description:	continuous tone (c) A4 size (a4) transparent mode (t) digital (d)	continuous tone (c) A4 size (a4) transparent mode (t) digital (d)	continuous tone (c) A4 size (a4) transparent mode (t) digital (d)	continuous tone (c) A4 size (a4) transparent mode (t) digital (d)

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Table H.4: Input, output and reference for a printer

test chart no. = 2	process printer		comparison	
	input (i)	**output (o)**	**output (o)**	**reference (r)**
ISO/IEC-code:	iha4rd-I02	oha4ra-I02	oha4ra-I02	rha4ra-I02
description:	halftone (h) A4 size (a4) reflectance mode (r) digital (d)	halftone (h) A4 size (a4) reflectance mode (r) analog (a)	halftone (h) A4 size (a4) reflectance mode (r) analog (a)	halftone (h) A4 size (a4) reflectance mode (r) analog (a)

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Table H.5: Input, output and reference for a scanner

test chart no. = 4	process scanner		comparison	
	input (i)	**output (o)**	**output (o)**	**reference (r)**
ISO/IEC-code:	ica4rd-I04	oca4ra-I04	oca4ra-I04	rca4ra-I04
description:	continuous tone (c) A4 size (a4) reflectance mode (r) analog (a)	continuous tone (c) A4 size (a4) reflectance mode (r) digital (d)	continuous tone (c) A4 size (a4) reflectance mode (r) digital (d)	continuous tone (c) A4 size (a4) reflectance mode (r) digital (d)

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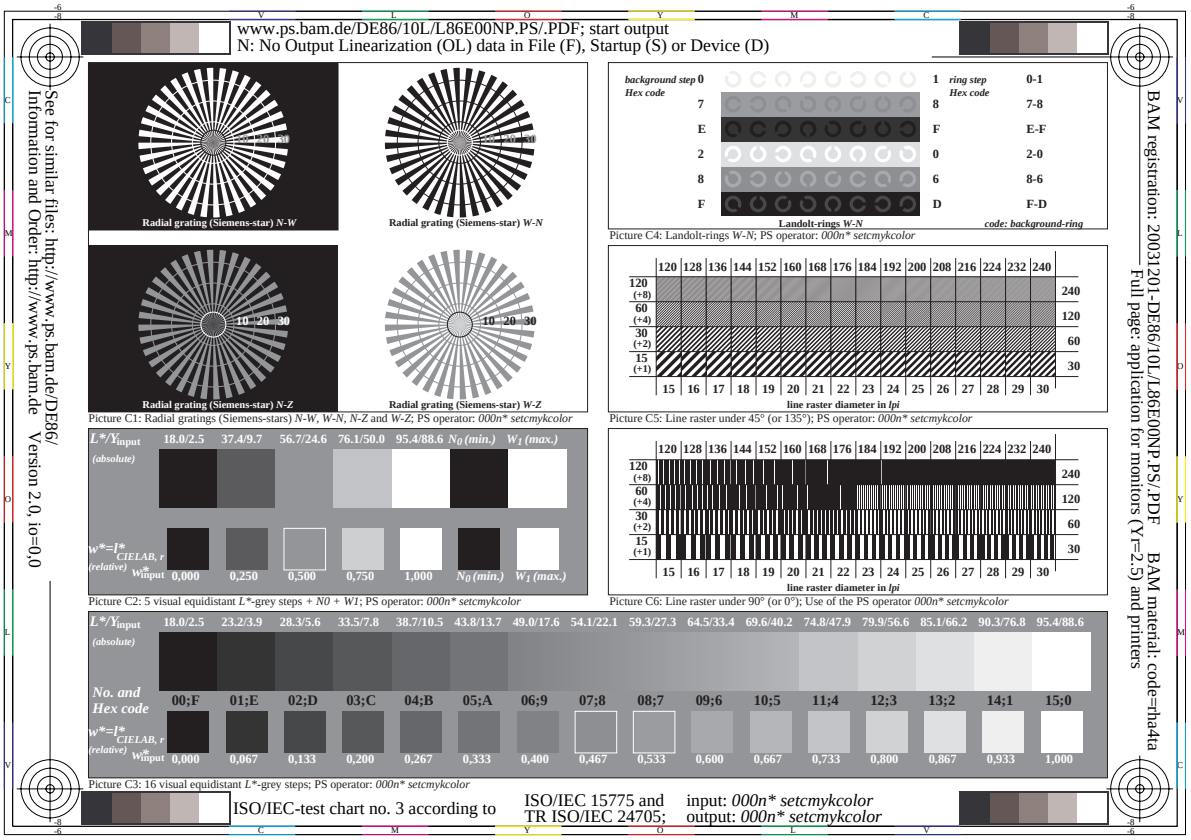
Annex I:
Digital ISO/IEC-test charts of this Technical Report

There are four **achromatic** ISO/IEC-test charts defined with four different device colour space coordinates.

NOTE For any ISO/IEC test report according to Annexes A through F of this International Standard, the original ISO/IEC test charts listed+ at the end of Annex I should be used.



.Fig. I.1: ISO/IEC-test chart no. 3 with colour device coordinates *000n (CMYN)**

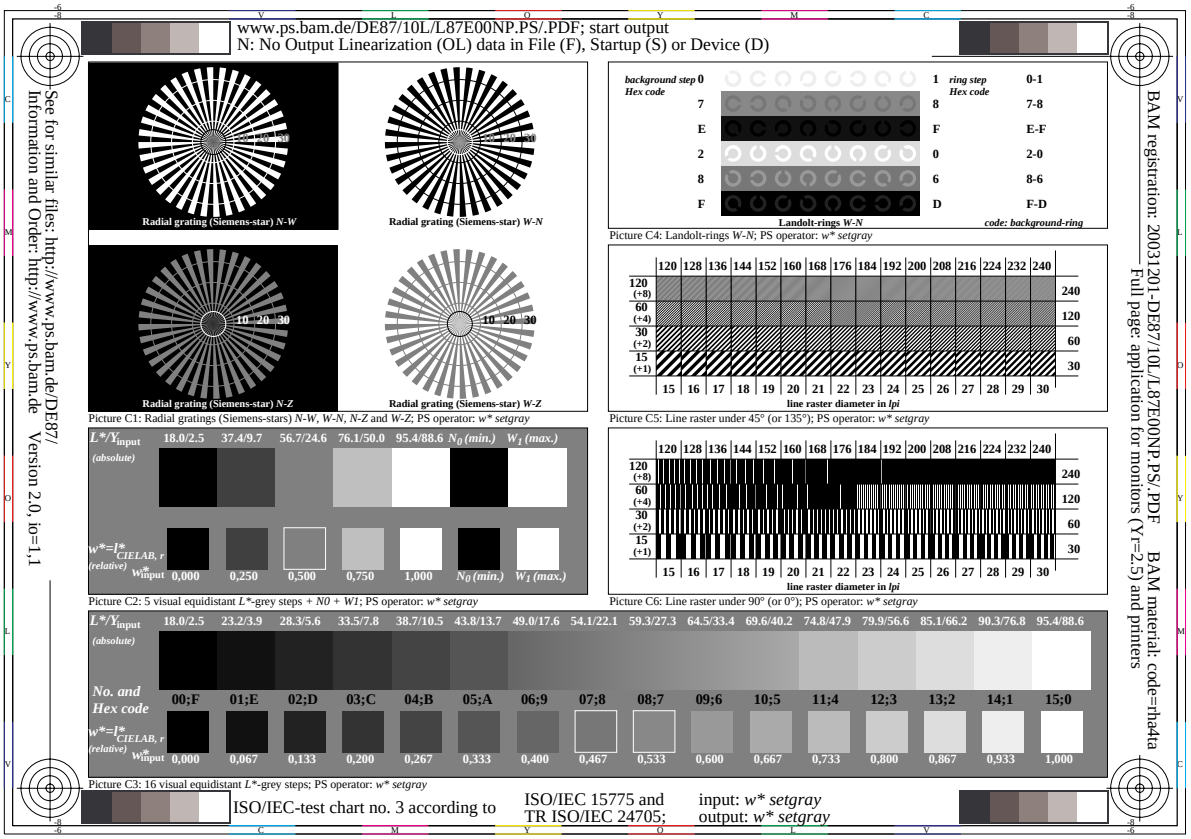


Fig. I.2: ISO/IEC-test chart no. 3 with colour device coordinates *w** **(GREY)**

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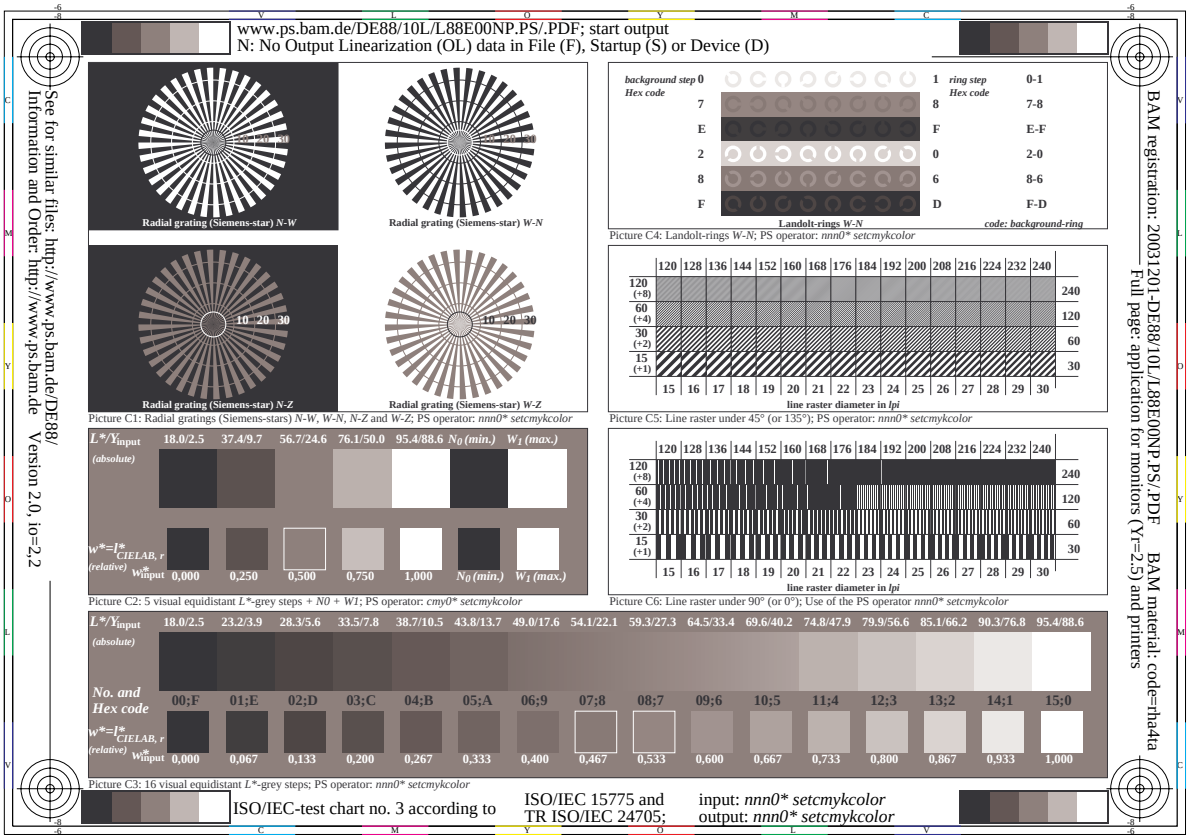

Fig. I.3: ISO/IEC-test chart no. 3 with colour device coordinates *cmy0 (CMYN)**

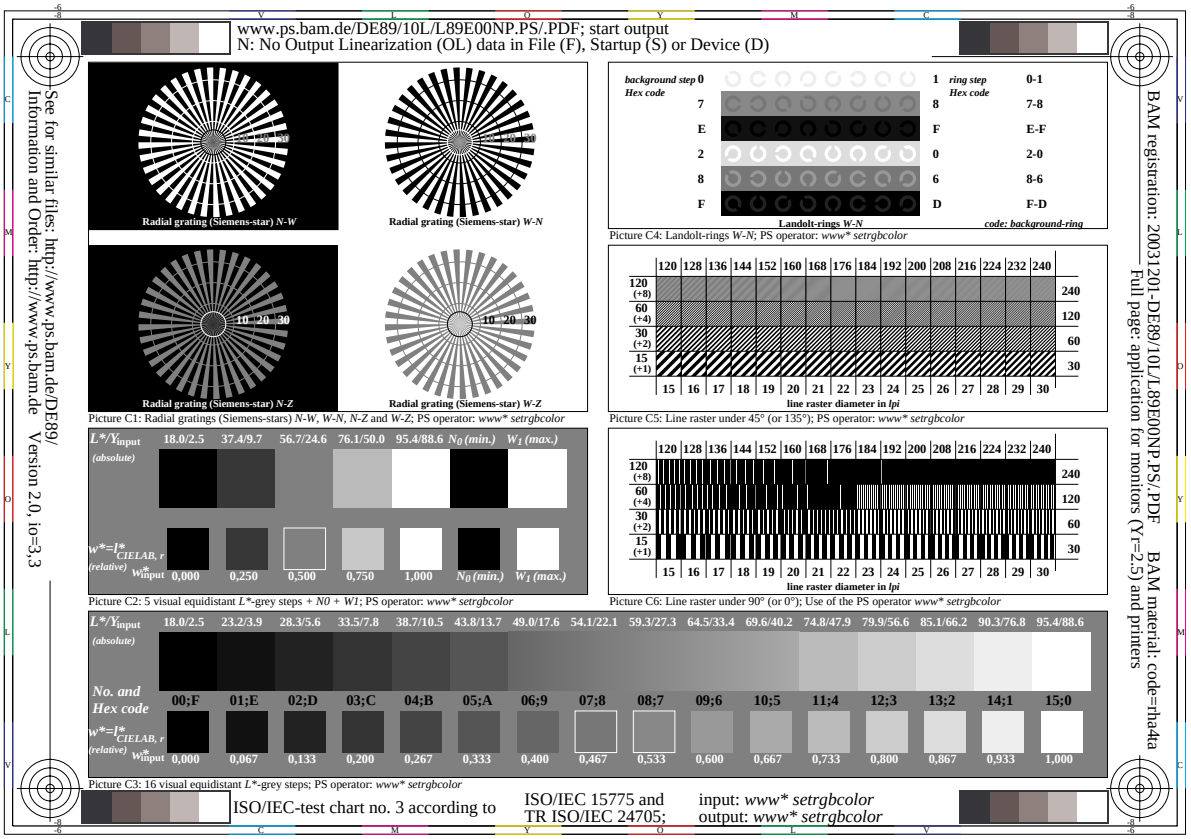

Fig. I.4: ISO/IEC-test chart no. 3 with colour device coordinates *www (OLV)**

There are four achromatic device colour coordinates for achromatic colours *(cmy0*, olv*, 000n* and w*)*.

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Both the **chromatic** ISO/IEC-test charts no. 2 and no. 4 use as device coordinates either *cmy0** and *000n* or olv** and *w**.

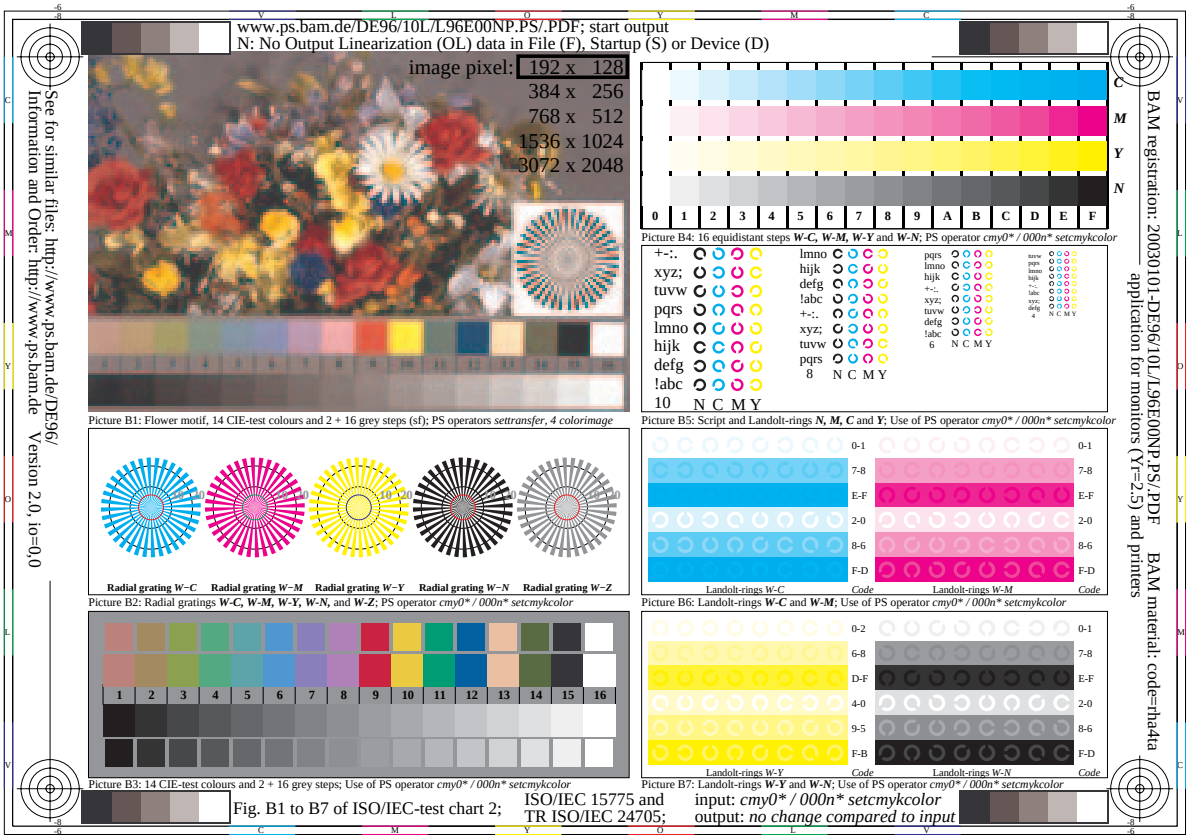

Fig. I.5: ISO/IEC-test chart no. 2 with colour device coordinates *cmy0 (CMYN)**

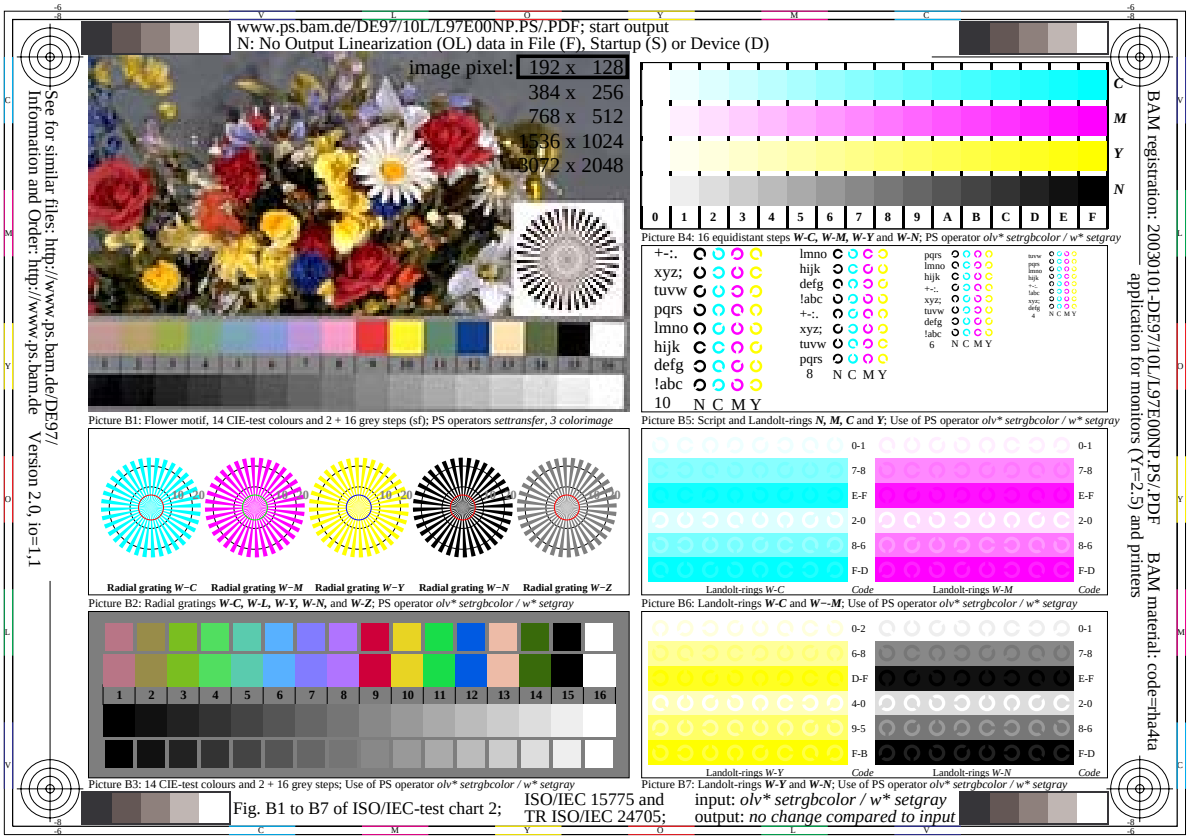

Fig. I.6: ISO/IEC-test chart no. 2 with colour device coordinates *olv (RGB)**

NOTE: The output of both ISO/IEC-test charts no. 2 may be equal or different on the same output device.

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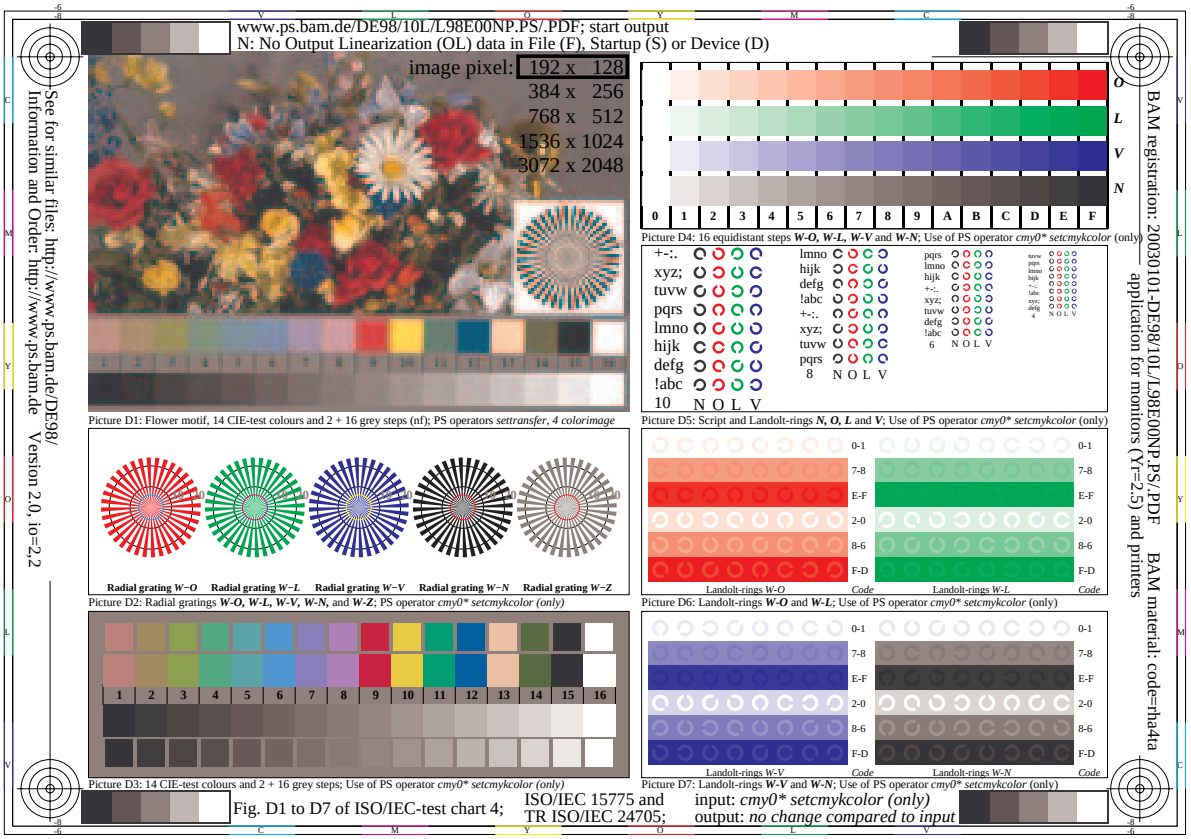

Fig. I.7: ISO/IEC-test chart no. 4 with colour device coordinates *cmy0 (CMYN)**

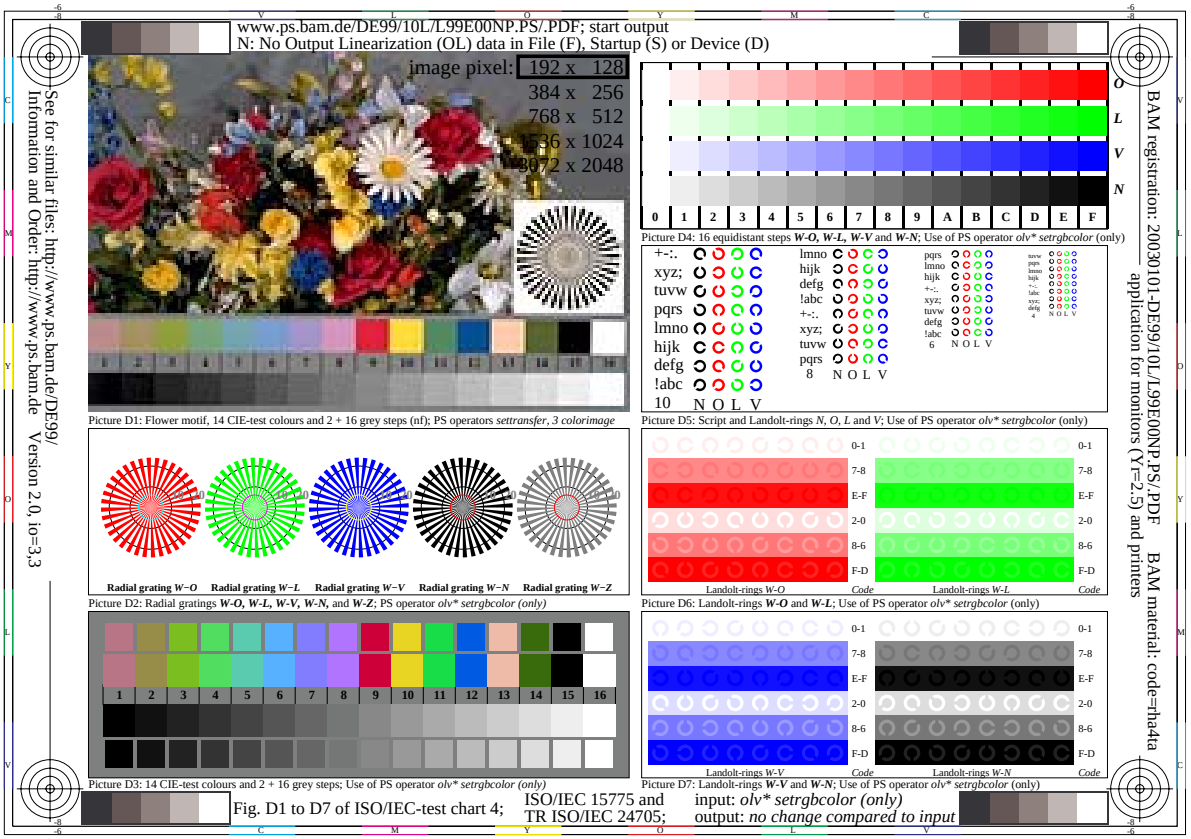

Fig. I.8: ISO/IEC-test chart no. 4 with colour device coordinates *olv (OLV)**

NOTE: The colour output of corresponding colours defined in different device spaces depends on many parameters. e. g. operating system, colour management system, application program, colour workflow, printer or monitor driver.

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The **digital** ISO/IEC-test charts according to ISO/IEC 15775 and this Technical Report can be found on the recommended web servers, see Annex N. An example is given in the following.

Availability of different ISO/IEC-test charts

The following server includes the ISO/IEC-test chart of Fig. I.1 to Fig. I.8 and others

http://www.ps.bam.de

The web address folder is given on the left side of the ISO/IEC-test chart. See Fig. I.1 to Fig. I.8.

The following three equivalent URL's work for the address folder of the ISO/IEC-test chart no. 3 with the device coordinate *w** and the *PostScript* operator *w* setgray.* See Fig. I.2.

http://www.ps.bam.de/DE87/

http://www.ps.bam.de/DE87/index.html

http://www.ps.bam.de/DE87/DE87.HTM

NOTE: Some web browsers fail with the first short version. If this happens please try one of the other two.

The direct web address of the ISO/IEC-test chart no. 3 with the device coordinate *w** and the *PostScript* operator *w* setgray* is given on the top of the ISO/IEC-test chart. See *Fig. I.2.* For the PS file see the URL:

http://www.ps.bam.de/DE87/10L/L87E00NP.PS

For the PDF file see the URL:

http://www.ps.bam.de/DE87/10L/L87E00NP.PDF

The following list gives information about the different ISO/IEC-test charts no. 2 to 4 and the corresponding folders

No.	Resolution	*PostScript* operator	Folder	PS / PDF size/kByte	usage
3	–	*000n* setcmykcolor*	DE86	140 / 210	
3	–	*w* setgray*	DE87	140 / 210	recommended
3	–	*cmy0* (nnn0*) setcymkcolor*	DE88	140 / 210	
3	–	*olv* (www*) setrgbcolor*	DE89	140 / 210	
3	–	*LAB* (L*) setcolor*	DE93	140 / 210	
2	192 x 128 sf	*cmy0* and 000n* setcmykcolor*	DE96	320 / 330	
2	384 x 256 sf	*cmy0* and 000n* setcmykcolor*	EE96	900 / 700	
2	768 x 512 sf	*cmy0* and 000n* setcmykcolor*	FE96	3300 / 2100	recommended
2	192 x 128 sf	*olv* setrgbcolor and w* setgray*	DE97	320 / 330	
2	384 x 256 sf	*olv* setrgbcolor and w* setgray*	EE97	900 / 700	
2	768 x 512 sf	*olv* setrgbcolor and w* setgray*	FE97	3300 / 2100	
2	192 x 128 sf	*LAB* setcolor*	DE92	320 / 330	
2	384 x 256 sf	*LAB* setcolor*	EE92	720 / 600	
2	768 x 512 sf	*LAB* setcolor*	FE92	2500 / 1700	
4	192 x 128 nf	*cmy0* and 000n* setcmykcolor*	DE98	320 / 330	
4	384 x 256 nf	*cmy0* and 000n* setcmykcolor*	EE98	900 / 700	
4	768 x 512 nf	*cmy0* and 000n* setcmykcolor*	FE98	3300 / 2100	recommended
4	192 x 128 nf	*olv* setrgbcolor and w* setgray*	DE99	320 / 330	
4	384 x 256 nf	*olv* setrgbcolor and w* setgray*	EE99	900 / 700	
4	768 x 512 nf	*olv* setrgbcolor and w* setgray*	FE99	3300 / 2100	
4	192 x 128 nf	*LAB* setcolor*	DE94	320 / 330	
4	384 x 256 nf	*LAB* setcolor*	EE94	720 / 600	
4	768 x 512 nf	*LAB* setcolor*	DE94	2500 / 1700	

The image is based on slide film (sf) or negative film material (nf). The recommended ISO/IEC-test chart files for the test are no. 3 with the PS operator *w* setgray*, no. 2 with the PS operator*cmy0* and 000n* setcmykcolor* and no. 4 with the PS operator *cmy0* and 000n* setcmykcolor*. Any ISO/IEC-files used should be listet in the test report, see Annex E.

NOTE: There are additional achromatic ISO-IEC-test charts designed for monitor output linearization between L^*_N = 0, 18, 27 and 33 for Black N and L^*_W = 88,6 for White W. They are used only for the output linearization method of ISO/IEC TR 19797 and use CIEXYZ measurement data in the FP file.

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Annex J:
Colorimetric basis for the Systems OLS and TLS

Large changes of luminous colours by ambient light in offices

The ambient light in offices changes the luminous colours in offices. For example the luminous monitor colours by a reflection on the monitor surface, the luminous overhead projection colours and the luminous slide projection colours and the luminous transparent colours on a flat area lamp are changed by the reflection of room light from the surface of the transparent material.

This Annex includes basis data to calculate the luminous colours for the different applications. The calculations are dependent on the properties of the illumination in the office to a high degree. Therefore this illumination and the change of reflection properties between reflective and transparent materials must be discussed. Section 12. to 14 of this Technical Report includes luminous monitor colours and CIE data are calculated for four different luminance reflectances from the monitor surface (Table 9 to Table 12).

Illumination in the office

ISO/IEC 15775 defines the illumination, viewing and measurement conditions in the office for the comparison of a colour copy with the original. For colour control in offices an illumination of 1000 lux and daylight illuminant D65 is recommended. The CIE 2 degree observer and the CIE viewing and measurement geometry 45/0 is recommended. For viewing and measurement a backing of three sheets of white output paper is recommended.

NOTE: The standard illuminant D65 is recommended for measurement and viewing of most the technical colours (textiles, furniture, cars, house painting, etc.) which must be reproduced on monitors or on paper.

NOTE: The conditions of ISO/IEC 15775 are different compared to the viewing conditions for graphic arts applications (D50, 2 degree observer, 0/45, black backing instead of white paper) defined in ISO 3664:1999

The conditions specified in ISO/IEC 15775 agree with the viewing conditions for monitors to a high degree. In the television standard ITU-R BT.709-2:1995 and in the standard IEC 61966-2-1:1999 the chromaticity of D65 is recommended for achromatic colours on monitors.

Equal luminance and chromaticity of paper and monitor output in offices

The recommended illumination of 1000 lux in offices for colour comparison corresponds to a luminance of about 300 cd/m^2 (= 0.886 * 1000/3.14 = 282 cd/m^2) on the white areas of the ISO/IEC-test charts. The constant 0.886 is given by the luminance reflectance Y_W = 88.6 of the white standard reference paper of the ISO/IEC-test charts 2 to 4 according to ISO/IEC 15775.

The luminance on CRT and LCD monitors has increased a lot during recent years. Many LCD displays show a luminance around 300 cd/m^2 for the white screen. So the luminance on the white monitor and the white paper may be nearly the same as in a modern office in many cases. Additionally the chromaticity of D65 is the same as office daylight illumination chromaticity according to the International Standards ISO/IEC 15775:1999 and for example, IEC 61966-2-1:1999.

Additional standard luminance reflection Y_r=2.5 by the ambient light in offices

The viewing conditions for graphic arts applications assume an ambient light of less then 64 lux. For colour testing in offices, the standard ambient light is 1000 lux which produce large changes of the luminous colours. A luminance reflectance Y_r=2.5 of the ambient light is assumed as **standard** reflection on monitors in offices. This changes the luminance reflectance Y_{N0}=0.0 of Black N0 to the luminance reflectance Y_N=2.5 of Black N is assumed as **standard** reflection on monitors in offices. This reflection changes the lightness L^*_{N0}=0.0 of Black N0 in the dark room to the lightness L^*_N=18 of Black N for the standard office illumination of 1000 lux. In ISO/IEC 15775 a reproduction tolerance of ΔL^*=3 is recommended. In the office, the influence of the ambient light is a factor 6 higher (ΔL^*=18) and is therefore important.

NOTE: In addition the ambient light destroys the **equal spacing** of a 16 step grey scale designed for the dark room. This is discussed in Annex M for 16-step CIELAB scales. Four transparent ISO/IEC-test charts for four different luminous reflectances on the test chart surface are available.

NOTE: The reproduction tolerance of ΔL^*=3 given in ISO/IEC 15775 allows variations of the office illumination (or the luminance reflection Y_r) by about 30%. The variations due to different office lighting (or properties of the monitor surface) are small compared to the large changes which arise from a change from the dark room (or low graphic arts lighting of 64 lux) to the standard office lighting of 1000 lux.

For the Television and Offset Luminous Systems TLS and OLS, the properties of reflective and transmissive samples must be studied to produce an appropriate model. The next section will illustrate and discuss these properties.

Reflection factor of matte achromatic samples and assumed luminance reflection Y_r=2.5 of monitors

The following figures show the reflection factor (which is the luminance reflectance Y divided by 100) of the four unique hue colours RGBJ with a mate surface. There is a luminance reflectance Y_r=4.0 for all spectral colours. For

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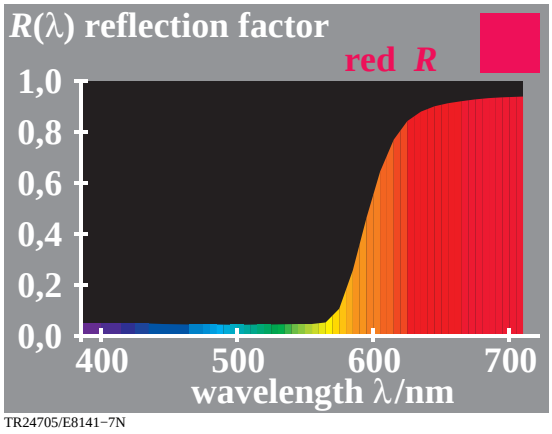
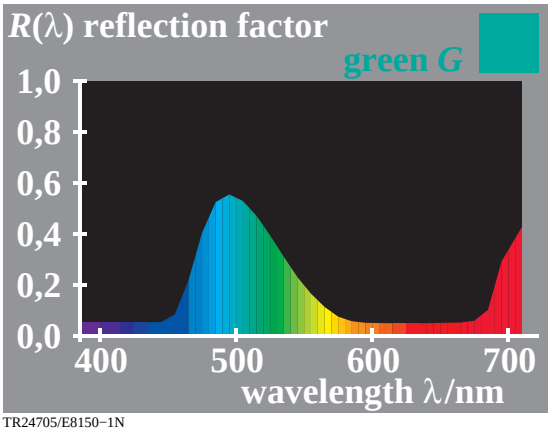
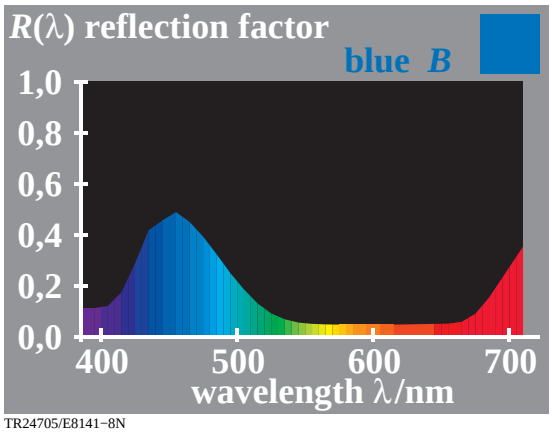
matte glossy samples there is a change to about Y_r=2.5. On monitors we can assume a similar luminance reflectance Y_r produced by the ambient light and the monitor surface properties.



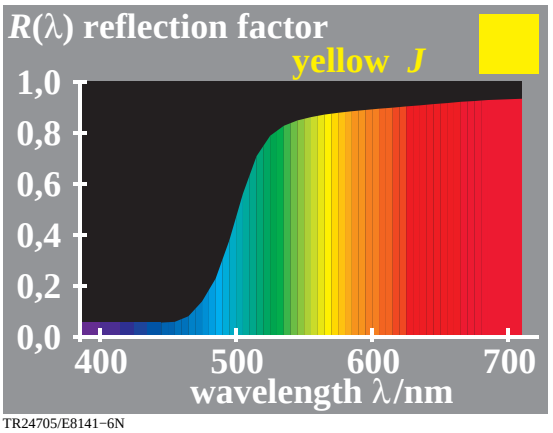
TR24705/E8141−7N



TR24705/E8150−1N



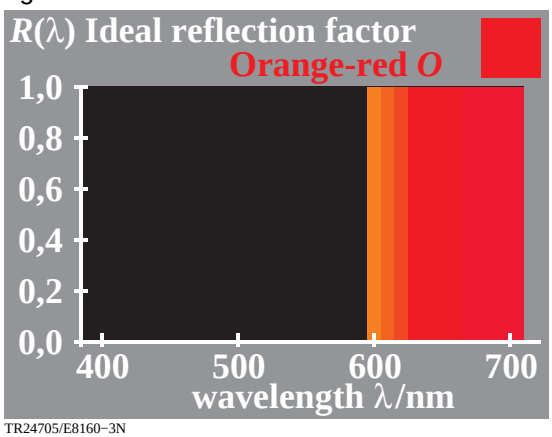
TR24705/E8141−8N



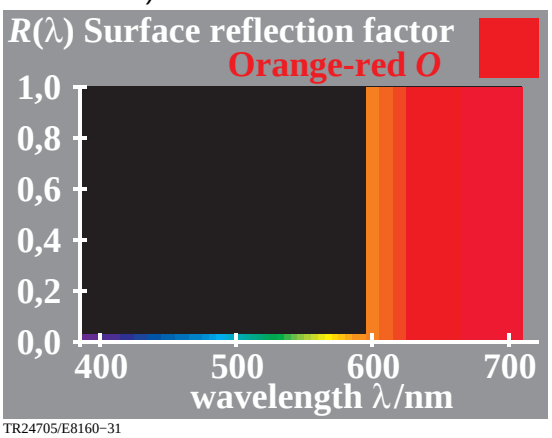
TR24705/E8141−6N

Fig. J.1: Reflection factor of the four samples RGBJ (unique hue colours)

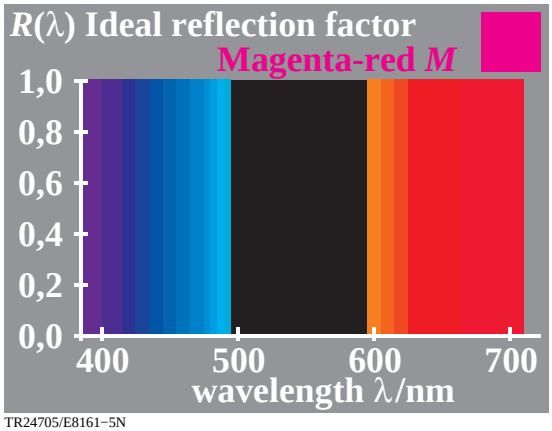
Fig. J.1 shows the reflection factor of the four samples RGBJ (unique hue colours).



TR24705/E8160−3N



TR24705/E8160−31



TR24705/E8161−5N

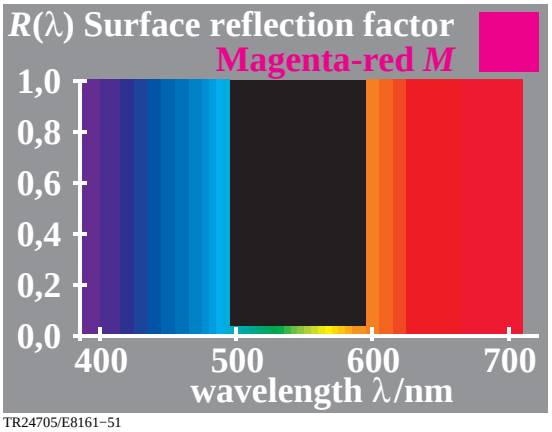


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Fig. J.2: Reflection factor of the two samples without (left) and with 2.5% surface reflection (right)

The reflection factor for matte surfaces is about 0.040 for every wavelengths and this corresponds to the luminance reflectance Y_r=4.0.

According to Fig. J.1 the tristimulus values *X, Y, Z* may vary between Y_r=4,0 for black and about Y_r=85 for yellow. In Fig. J.2 the variation is between Y_r=0,0 for black and Y_r=100.0 for white (left side) and between Y_r=2,5 for black and Y_r=100,0 for white (right side).

NOTE: The colours of Fig. J.1 show the reflection factors of four elementary colours of a symmetric unique hue circle and the colours Orange-red O and Magenta-red M of Fig. J.2 (left side) are examples of optimal colours for ideal reproduction systems.

The reflection factors and tristimulus values of the optimal colours in Fig. J.2 (left side) are changed by surface reflection (right side). The colours on the monitor vary in a similar way by the reflection of the ambient light on the monitor surface.

NOTE: According to IEC 61966-2-1 the tristimulus values on the monitor are normalized to D65 (Xn=95.00, Yn=100.00, Zn=113,00) and the ambient light in the office is not considered.

A high correlation between colorimetric calculations and visual results can only be expected if both the reflection of the standard paper and the reflection of the monitor surface are considered. The surface reflection of the black paper of the ISO/IEC-test charts according to ISO/IEC 15775 has the luminance reflectance Y_r=2.5. The surface reflection of the monitor surface is assumed to have the same luminance reflectance Y_r=2.5.

NOTE: Variations between -10% and +20% still produce an output within the intended CIELAB colour difference of ΔE^*=3.

The normalisation with the factor 0.886 for the white monitor and an assumed monitor surface reflection Y_r=2,5 lead to an equal luminance range (2.5 <= Y <= 88.6) and lightness range (18 <= L* <= 95.4) for reflective and luminous colours.

NOTE: For paper media and transparent inks, the room light is transmitted twice through the ink layers before it reaches the human visual system. If transparencies are produced for projection or back lighting then the ink layer must have twice the thickness compared to offset printing to get the same colour perception. Many colour printers produce transparent colours on transparent (overhead) material taking this into account.

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Annex K:
Offset Luminous System for L^*_N = 0, 18, 27, 33

The luminous colours of the Offset Luminous System (OLS) are calculated for luminance reflectance Y_r = 0,0, 2.52, 5.04, and 7.06 which correspond to the CIELAB lightness L^* = 0, 18, 27 and 33. The luminous colours are transparent colours, e. g. printed with the offset colorants on transparent (overhead) material. There are two applications: either the projected overhead colours are changed by the ambient light on the projection screen or the overhead colours are viewed on a flat area lamp and the overhead colours are changed by reflections of the ambient light on the overhead transparency surface.

According to the CIELAB lightness L^* = 0, 18, 27 and 33 the four systems are called OLS00a, OLS18a, OLS27a, and OLS33a. In Table 9 to Table 12 similar luminous monitor colours are defined for four luminance reflectances of the monitor surface and are called TLS00, TLS18, TLS27, and TLS33. One may apply the calculation methods also to the four luminance reflectances of data projectors and the changes of these colours on the projection screen surface due to the ambient light changes. The display colours of mobile phones which change because of the colour and the amount of ambient light is another possible application.

Table K.1: CIE data of Offset Luminous System OLS00a with Y_W = 88,6 and L^*_N = 0

Basic luminous offset or mixture colour for D65 OLS00a: Yw=88,6 + 0,0	**chromaticity** x_a	y_a	**tristimulus values** *(Y=88,6 for white D65)* X_a	Y_a	Z_a	***L*a*b*-CIELAB data*** *(Y=88,6 for white D65)* L^*_a	a^*_a	b^*_a
three subtractive basic colours: printing colours acc. to ISO 2846-1								
C cyan-blue	0,1504	0,2210	16,88	24,80	70,58	56,88	−33,11	−47,41
M magenta-red	0,4705	0,2204	31,58	14,80	20,75	45,36	81,85	−9,29
Y yellow	0,2316	0,6100	68,01	76,77	7,96	48,45	−73,19	42,21
three subtractive mixture colours: # DIN 33866-colours; ISO reference paper								
R red	0,6587	0,3376	28,57	14,64	0,16	45,14	71,37	75,54
G green	0,2316	0,6100	6,51	17,15	4,55	48,45	−73,19	42,21
B blue	0,1854	0,0834	4,88	2,19	19,24	16,48	45,94	−56,22
achromatic colours: # calculated by linear chroma extrapolation in the CIELAB colour space								
W1 (ideal white#, *D65)*	0,3127	0,3290	95,05	100,00	108,92	100,00	0,00	0,00
W (ISO paper, *D65)*	0,3127	0,3290	84,21	88,60	96,48	95,41	0,00	0,00
N (black printing colour)	–	–	0,00	0,00	0,00	0,00	0,00	0,00
N0 (ideal black#, *D65)*	–	–	0,00	0,00	0,00	0,01	0,00	0,00

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Table K.1 shows the chroma adapted (a) CIE colour data for the Offset Luminous System OLS00a normalized to Y_W = 88,6 and with the luminance reflectance Y_r = 0,0 (dark room).

The colorimetric data of the Offset Reflective System ORS18a in Table 7 are identical to OLS18a and are not repeated here.

Table K.2: CIE data of Offset Luminous System OLS27a with Y_W = 88,6 and L^*_N = 27

Basic luminous offset or mixture colour for D65 OLS27a: Yw=83,5 + 5,0	**chromaticity** x_a	y_a	**tristimulus values** *(Y=88,6 for white D65)* X_a	Y_a	Z_a	***L*a*b*-CIELAB data*** *(Y=88,6 for white D65)* L^*_a	a^*_a	b^*_a
three subtractive basic colours: printing colours acc. to ISO 2846-1								
C cyan-blue	0,1709	0,2346	20,71	28,43	72,05	60,28	−27,94	−42,75
M magenta-red	0,4398	0,2416	34,58	19,00	25,06	50,68	69,50	−7,57
Y yellow	0,4325	0,4859	68,94	77,44	13,00	90,52	−9,92	85,20
three subtractive mixture colours: # DIN 33866-colours; ISO reference paper								
O orange-red#	0,56,44	0,3353	31,73	18,85	5,64	50,51	60,17	40,13
L leaf-green#	0,2613	0,5071	10,93	21,21	9,69	53,18	−55,04	30,00
V violet-blue#	0,2340	0,1771	9,39	7,11	23,63	32,06	24,02	−37,32
achromatic colours: # calculated by linear chroma extrapolation in the CIELAB colour space								
W1 (ideal white#, *D65)*	0,3127	0,3290	95,05	100,00	108,92	100,00	0,00	0,00
W (ISO paper, *D65)*	0,3127	0,3290	84,21	88,60	96,48	95,41	0,00	0,00
N (black printing colour)	0,3127	0,3290	4,79	5,04	5,49	26,85	0,00	0,00
N0 (ideal black#, *D65)*	–	–	0,00	0,00	0,00	0,01	0,00	0,00

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Table K.2 shows the chroma adapted (a) CIE colour data for the Offset Luminous System OLS27a normalized to Y_W

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= 88,6 and with the luminance reflectance Y_r = 5,0. The calculations of Table K.2 for ambient light reflection Y_r = 5,0 are similar to the calculations for Y_r = 7,5 of the following Table K.3.

Table K.3: CIE data of Offset Luminous System OLS33a with Y_W = 88,6 and L^*_N = 33

Basic luminous offset or mixture colour for D65 OLS33a: Yw=81,1 + 7,5	**chromaticity**		**tristimulus values** *(Y=88,6 for white D65)*			***L*a*b**-CIELAB data** *(Y=88,6 for white D65)*		
	x_a	y_a	X_a	Y_a	Z_a	L^*_a	a^*_a	b^*_a
three subtractive basic colours: printing colours acc. to ISO 2846-1								
C cyan-blue	0,1800	0,2407	22,62	30,25	72,79	61,87	−25,76	−40,60
M magenta-red	0,4275	0,2500	36,07	21,10	27,21	53,05	64,36	−6,90
Y yellow	0,4266	0,4781	69,40	77,78	15,51	90,68	−9,59	79,47
three subtractive mixture colours: # DIN 33866-colours; ISO reference paper								
O orange-red#	0,5318	0,3345	33,31	30,95	8,38	52,90	55,55	33,73
L leaf-green#	0,2699	0,4774	13,14	23,25	12,31	55,33	−48,88	26,28
V violet-blue#	0,2476	0,2034	11,65	9,57	23,83	37,05	19,67	−32,32
achromatic colours: # calculated by linear chroma extrapolation in the CIELAB colour space								
W1 (ideal white#, *D65)*	0,3127	0,3290	95,05	100,00	108,92	100,00	0,00	0,00
W (ISO paper, *D65)*	0,3127	0,3290	84,21	88,60	96,48	95,41	0,00	0,00
N (black printing colour)	0,3127	0,3290	7,19	7,56	8,23	33,05	0,00	0,00
N0 (ideal black#, *D65)*	–	–	0,00	0,00	0,00	0,01	0,00	0,00

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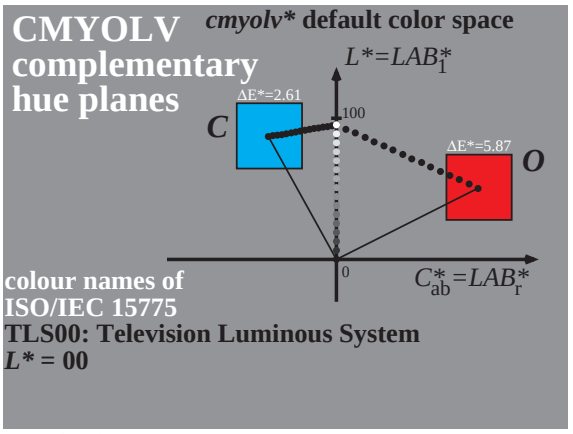
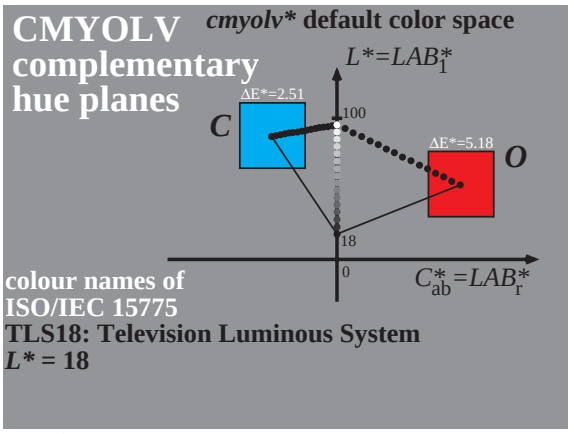
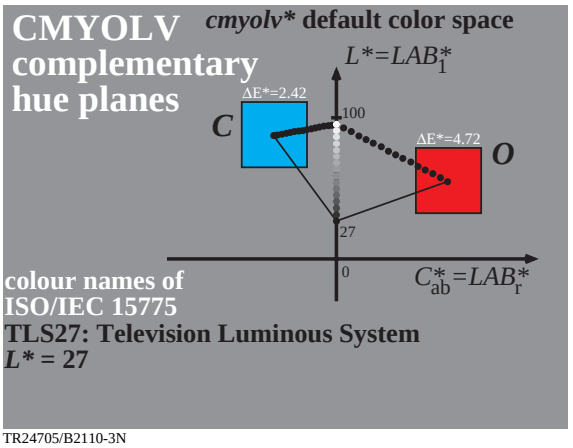
Table K.3 shows the chroma adapted (a) CIE colour data for the Offset Luminous System OLS33a normalized to Y_W = 88,6 and with the luminance reflectance Y_r = 7,5.



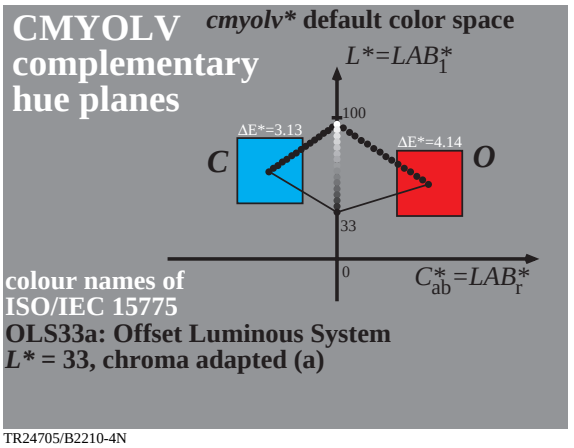
TR24705/B2110-1N



TR24705/B2110-2N



TR24705/B2110-3N



TR24705/B2210-4N

Fig. K.1: Complementary luminous printing colours O and C for L^*_N = 0, 18, 27 and 33.

Fig. K.1 shows the chroma of the offset luminous colour series Orange-red – White O – W and Cyan-blue – White C – W for four luminance reflectances Y_r = 0, 2,5, 5,0, and 7,5 which correspond to L^*=0, 18, 27, and 33. There are large changes both for achromatic and chromatic colours.

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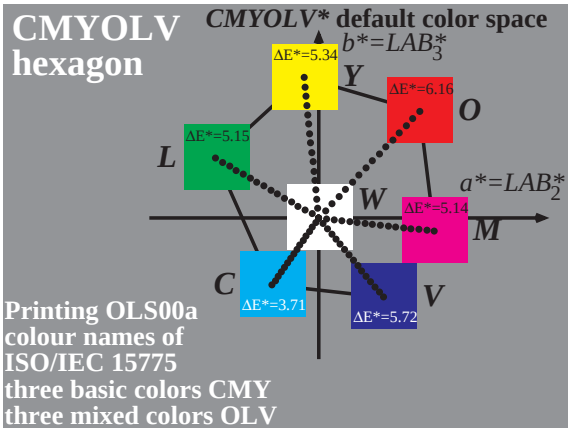
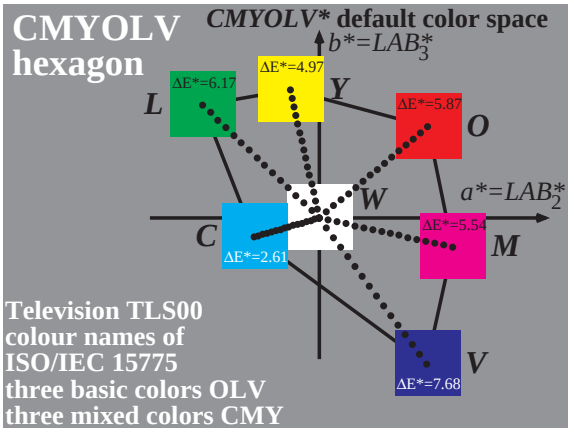
Annex L:
Colours of Offset and Television Luminous Systems

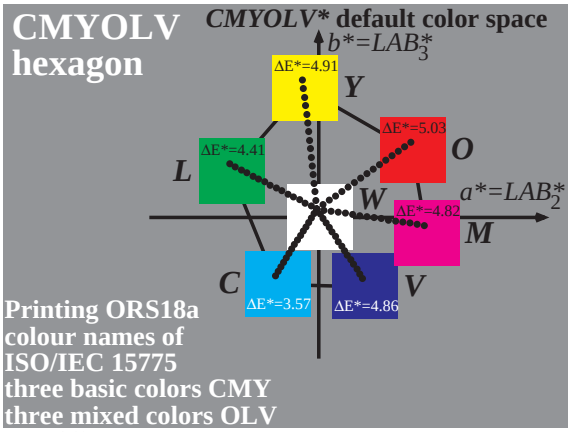
This Annex L gives the basis for the Offset and Television Luminous Systems OLS and TLS. In the four tables Table 9 to Table 12 the data for the systems TLS00, TLS18, TLS27 and TLS33 are calculated. Similar data for the Systems OLS00, OLS18, OLS27 and OLS33 are calculated in Table K.1, Table 7, Table K.2, and Table K.3.



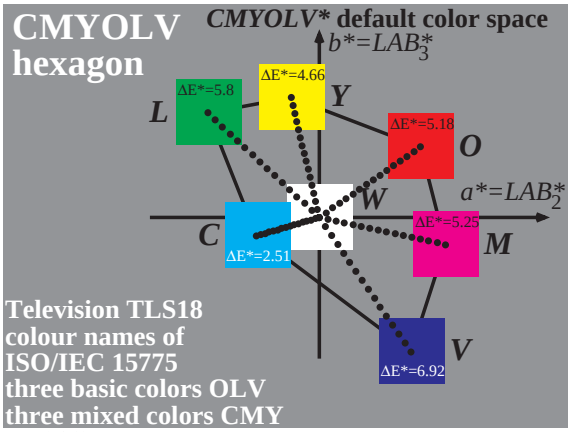
TR24705/E8370-16



TR24705/E8370-15



TR24705/E8370-14



TR24705/E8370-17

Fig. L.1: Printing colours (left) and the television colours (right) in the *a*, b chroma diagram**

Fig. L.1 shows the printing colours (left) and the television colours (right) and in the *a*, b** chroma diagram of the CIELAB colour space for the two luminance reflectance Y_r=0 (top) and Y_r=2.5 (bottom). The system ORS18a in the left bottom figure and the system TLS00 in the right top figure are the cases defined in the international standards of offset printing and television. Instead of the system TLS00 for the dark room in daylight offices, the system TLS18 in the right bottom figure is more appropriate than the system TLS00 for the dark room.

For the left figures the data of Table K.1 (System OLS00a) and Table 7 (System ORS18a = OLS18a) are used. For the right figures the data of Table 9 (Systems TLS00) and Table 10 (Systems TLS18) are used. The numbers in the figures are the colour differences ΔE^*_{ab} in the CIELAB space for every two adjacent colours of the 16 step colour series between White W and the six colours CMYOLV.

There are large colour differences between the six basic colours CMYOLV both between L^*=00 and L^*=18 and between the Systems OLS and TLS which are much larger than the CIELAB colour difference ΔE^*=3 specified in ISO/IEC 15775 as a reasonable colour difference tolerance for the field of image reproduction in offices.

These large colour differences create many difficulties for an **absolute** colorimetric colour reproduction characterization in **absolute** CIELAB units. But it seems easy and appropriate in many cases to do a colorimetric colour reproduction characterization in **relative** CIELAB units. The user may decide if the absolute or relative reproduction method is appropriate for his application.

> NOTE: For colour displays of mobile phones which are illuminated by approximately daylight D65, one of the four cases TLS00, TLS18, TLS27, and TLS33 may be the best for the recognition of the Landolt-rings and the 16-step colour scaling. It may be appropriate to have a choice between the four different reproduction methods.

In the following figure the reproduction colours will be shown in chroma – hue planes for complementary hues. One should consider which reference is appropriate. Keeping in mind that colours in nature are reflective colours, then the Offset Reflective Systems ORS18a seems more appropriate and the Television Luminance System TLS18

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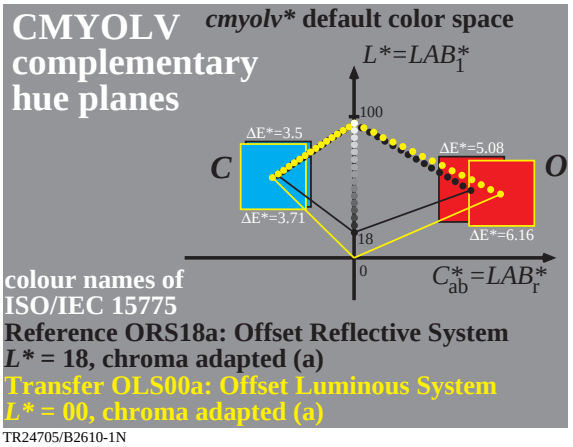
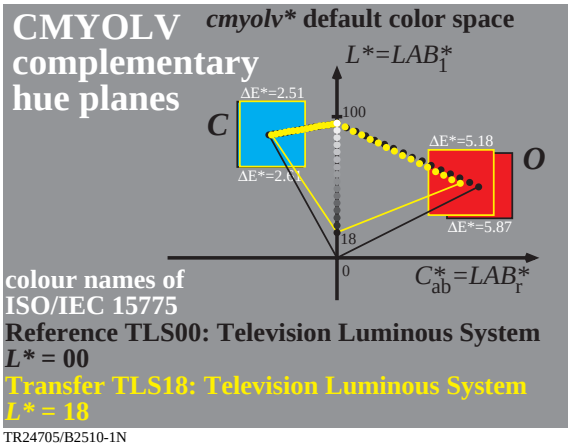
seems artificial. Again the user must decide which system is appropriate. Additionally there seem to be much larger changes in basic colours, e. g. between CRT and LCD monitors than between the reflective colours of offset printing and of office printers.



TR24705/B2610-1N



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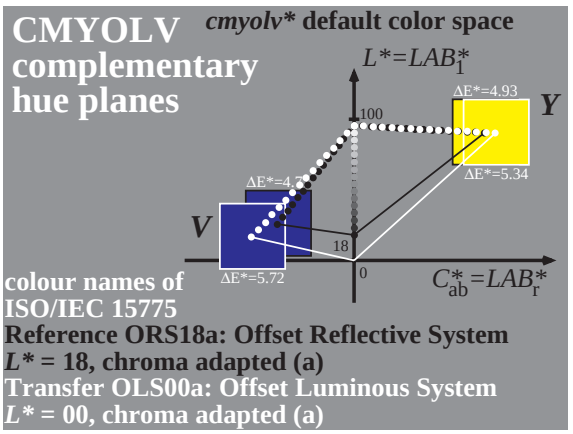
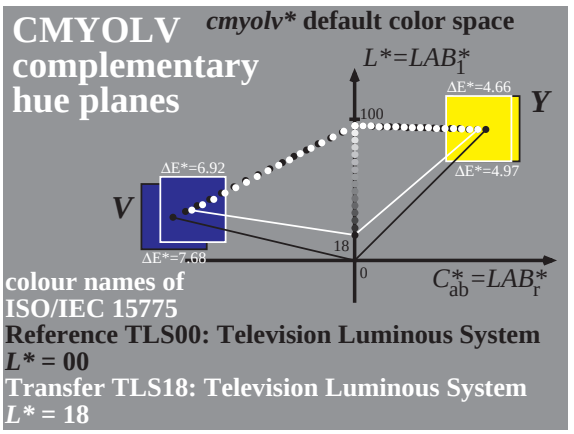
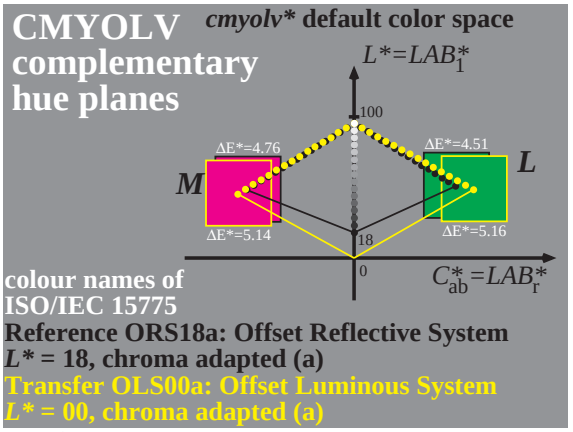


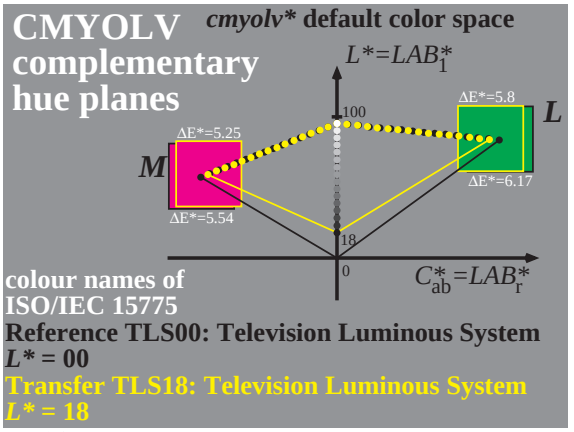
TR24705/B2610-5N



TR24705/B2510-5N



TR24705/B2611-1N



TR24705/B2511-1N

Fig. L.2: Chromatic colours of complementary hue of television and printing for L^*_N = 0 and 18

Fig. L.2 shows the Offset Reflective System ORS18a and the Television Luminous System TLS00 (black lines and balls in all the figures) as **reference**.

If one produces transparent (overhead) material by offset printing then on a white flat area lamp with a illuminant of D65 the colours of the Offset Luminous System OLS00a are seen in a dark room (yellow or white lines and balls in the figures). In offices the colours of the Offset Reflective System ORS18a = OLS18a are produced for the luminance reflectance Y_r = 2,5 of the ambient light on the overhead material.

Similarly the monitor colours change when the ambient light changes. For the luminance reflectance Y_r = 2,5 the colours of the Television Luminous System TLS00 are changed to the colours of the Television Luminous System TLS18 in the right figures and can be compared with the colours of the Offset Reflective System ORS18a.

The systems ORS18a and TLS18 have equal grey scales with the same lightness range between L^*_N = 18 and L^*_W = 95 and can be compared. The chromatic colours are much different and will be compared in the following paragraphs.

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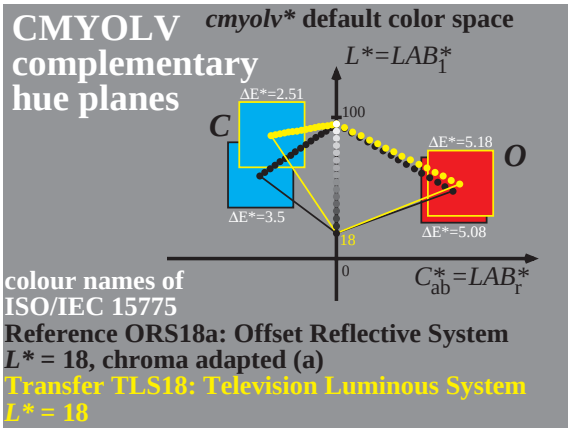
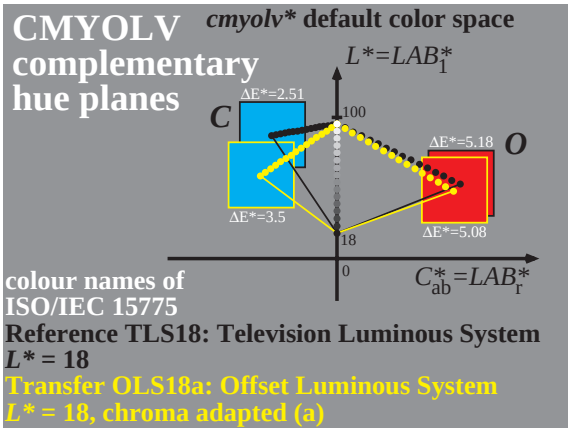
Colours of ORS18a or TLS18 as reference and comparison

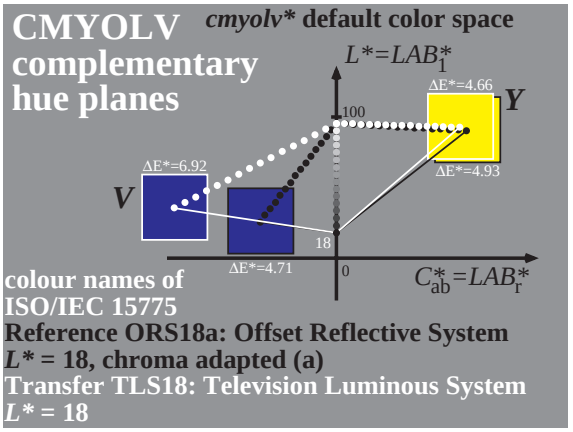
The luminance of the white and black colours on the monitor and the paper in offices may be similar. Colorimetry uses the relative luminance reflectance Y which is equal to $Y_W = 88.6$ for offset printing and normalized to the same value $Y_W = 88.6$ for the monitor in offices. This normalisation leads to the same lightness L^* for black and white and equal CIELAB lightness data for the 16-step grey colours. The chroma adaptation (a) equations lead to the CIELAB chroma $a^* = b^* = 0$ for the grey colours on both the monitor and printer.



TR24705/B2410-2N



TR24705/B2310-2N



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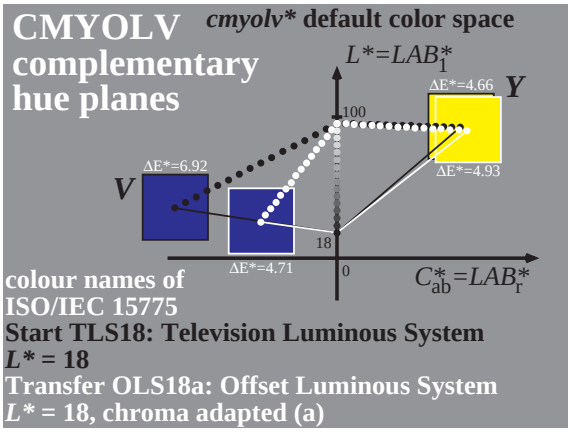
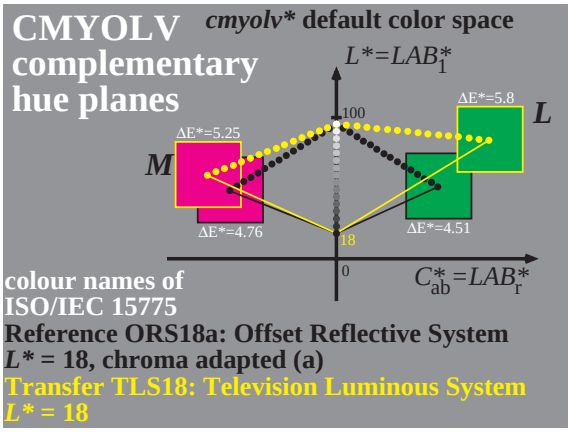


TR24705/B2310-6N



TR24705/B2411-2N

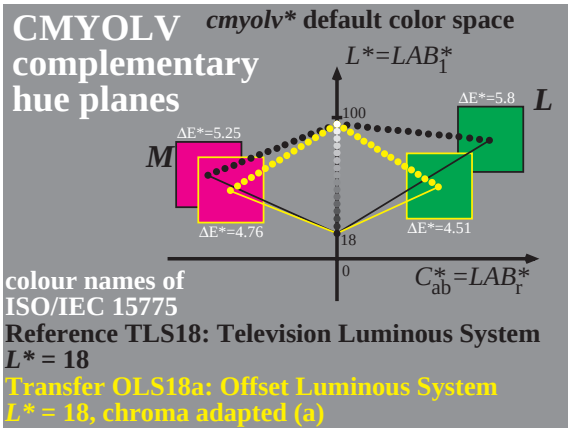


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Fig. L.3: Relative CIELAB transfer from printing to television colours

Fig. L.3 shows chroma – lightness planes in the CIELAB colour space for the three pairs of complementary colours O – C, Y – V, and L – M with the systems ORS18a and TLS18 as reference (left and right as black lines and balls). The colour differences between printing and television are large, e. g. the CIELAB colour difference between Violet-blue V in television and printing is ΔE^*=74 which is the same colour difference as between Black N and White W.

NOTE: The colour gamut for the hue Violet-blue V for monitor colours is about twice as large as for printing colours. Therefore a relative reproduction in CIELAB is usually required. For both monitors and printers the Landolt-ring test in ISO/IEC-test chart no. 2 can usually be passed only if a **relative** reproduction is made. This is shown by balls in both figures in the middle.

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Transfer of colours from paper to monitor and vice versa

The reproduction intent is usually very different if the colours of the systems ORS18a or TLS18 are taken as reference. Some examples are given in the following.

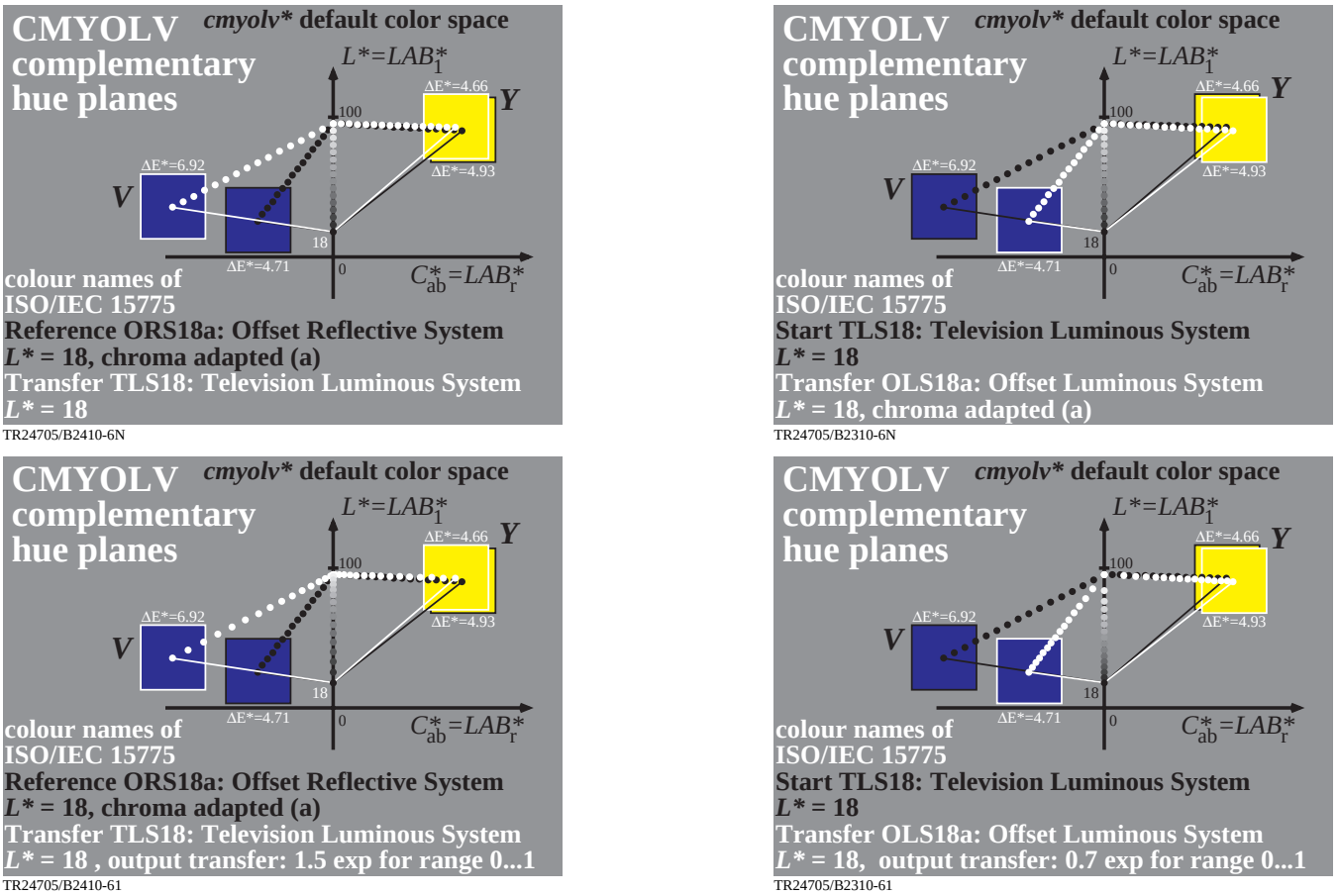

Fig. L.4: Relative CIELAB transfer methods from printing to television and vice versa

Fig. L.4 shows in the top row the colours in the complementary hue plane Y – V for the systems ORS18a and TLS18. The 16-step colour series are equally spaced in both spaces which is indicated by equally spaced balls.

For colorimetric (absolute) reproduction of the series W – V and for output of the **reference system ORS18a** on the monitor (left side) the colour differences decrease for small chroma and increase for high chroma. This is shown in the left bottom figure by a transfer function *1.5 exp of PostScript* for the device coordinate range 0 to 1. For the Landolt-rings this reproduction increases the recognition rate for high chroma and decreases the recognition rate for low chroma. Often the device system uses this kind of transfer for both the series W – CMYOLV and the series W – N. This improves the absolute spacing for the series W – V but destroys the approximately equal spacing for the series W – Y and probably for the series W – N (**not changed** in the left figure).

For colorimetric (absolute) reproduction of the series W – V and for output of the **reference system TLS18** on the printer (right side) the colour differences increase for small chroma and decrease for high chroma. This is shown by the right bottom figure. For the Landolt-rings this decreases the recognition rate for high chroma and increases the recognition rate for low chroma. Again, often the device firmware uses this kind of transfer for **any** of the series W – CMYOLV and W – N. which improves the absolute spacing for the series W – V but destroys the approximately equal spacing for the series W – Y and the series W – N (**changed** in the right figure). This reproduction is too dark. It often is impossible to recognize the Landolt-rings for high chroma colours and dark colours. Only 12 to 14 steps of the 16-step colour series can be seen. This kind of reproduction has two main disadvantages, it needs both more toner and reduces recognition.

This last reproduction strategy is used by many printer systems (printer including printer software and colour workflow). This method has the disadvantage of a low recognition of the Landolt-rings in the high chroma area. It has the advantage that it makes the output more chromatic, but has the disadvantages mentioned above.

NOTE: Examples for printer output of the six 16-step series between White W and the six chormatic colours CMYOLV and Black N are given in ISO/IEC TR 19797:2004.

In general for these printer systems the Landolt-ring test fails for the two combinations D–F and E–F near Violet-blue V. A similar failure may occur for the series W – O and W – C if there is a similar output spacing for these series compared to W – V.

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NOTE 1: In the field of digital photography the experience seem to show that images are preferred which use most of the available device output space. In addition, an output which is more chromatic than the original is preferred.

NOTE 2: It is important to avoid large hue shifts between the original and output colours, especially in the yellow-red region. The hue differences are small between the television and printing colours in this region. The hues differences are even smaller for LCD monitors hues compared to printing hues (especially for Cyan-blue C and Violet-blue V).

NOTE 3: Linear relative CIELAB reproduction is easy to achieve for monitor, printer and scanner systems using the methods of this Report. An output linearization method is described in the ISO/IEC TR 19797:2004 for printers and monitors.

NOTE 4: If the full device output space is to be used, then a very complex gamut mapping is necessary by the methods of ICC colour management. The relative reproduction method is much simpler. The output linearization method can be used as basic method in professional imaging if a device profile is to be produced. In image technology, if an output linearization method is used, then the colour outputs are by default much more filling the device output space compared to the present image technology practice.

NOTE 5: The output linearization method makes possible linear transformation equations between device coordinates *cmy0** and *olv** and CIELAB coordinates *L*a*b**. If the linear equations are applied for all the devices then the corresponding colour coordinates of the 16 step grey scales (defined in relative device spaces *cmy0*, w*, olv** and *000n**) can be transformed to CIELAB coordinates *L*a*b** and produce the same output. This can be accomplished by the *PostScript MTL (Measurement, Transfer and Linearization)* code which may be used at different places in the colour workflow (see www.ps.bam.de/BAMLIN.PDF and ISO/IEC TR 19797).

NOTE 6: Colour management may fail if the colours on one page are defined in different device colour spaces. Output linearization and the transfer of device coordinates to CIELAB coordinates reduces the measurement data of the device e. g. from 10 x 10 x 10 to e. g. 5 x 5 x 5. Additionally the number of profiling spaces is reduced from about five colour spaces (relative *lab*, 000n*, w*, cmy0* or olv**) to one device colour space (e. g. *olv**).

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Annex M:
16-step CIELAB scales and luminance reflectance

The16-step equal spacing in the CIELAB colour space is destroyed by an additional reflection of the ambient light from the monitor surface especially for dark greys and dark colours . The changes of the grey scales are shown in Fig. 4. This figure does not show that the spacing of the monitor colours must be changed to achieve equal spacing of the 16 steps for the four different conditions. This section gives basic data about the changes caused by ambient light. These are useful for the specification of the colour image reproduction of monitor systems discussed in sections 12. to 14.

The luminance transmittance Y_t of the monitor is always measured in a dark room (or with the measuring instrument touching the monitor surface) with the normalisation $Y_t = 100$ for the white monitor.

For equal spacing and in the case of a **dark** room the black monitor (hex code F) and the first grey step (hex code E) must have the luminance transmission $Y_t = 0{,}0$ and $Y_t = 0{,}7$ respectively, which corresponds to:
$Y_N = Y_{Fcode} = 0.0$ and $Y_{Ecode} = 0.7$ and lightness
$L^*_N = L^*_{Fcode} = 0$ and $L^*_E = L^*_{Ecode} = 6.6$

For equal spacing and in the case of **standard** ambient light the black monitor (hex code F) and the first grey step (hex code E) must have the luminance transmittance Y_t =0.0 and Y_t =1,33 respectively. The last is almost twice as large as the transmittance for a dark room.

In the case of **standard** ambient light the luminance reflectance Y_r=2.5 must be added. The black monitor (hex code F) and the first grey step (hex code E) must have the luminance reflectance which corresponds to
$Y_N = Y_{Fcode} = 2{,}5$ and $Y_{Ecode} = 3{,}83$ and the lightness
$L^*_N = L^*_{Fcode} = 18$ and $L^*_{Ecode} = 23{,}2$ (see Fig. M.1)

System TLSxx	Lightness L^*				Luminance reflectance Y				Luminance transmittance Y_t				Transmission factor Y_t / Y_{tmax}			
Code	L^*_N= 00	18	27	33	L^*_N= 00	18	27	33	L^*_N= 00	18	27	33	L^*_N= 00	18	27	33
00, F	0.0	18.01	26.85	33.05	0.0	2.52	5.04	7.56	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
01, E	6.36	23.17	31.42	37.21	0.7	3.85	6.83	9.65	0.7	1.33	1.79	2.09	0.008	0.015	0.021	0.026
02, D	12.72	28.33	35.99	41.36	1.52	5.58	9.0	12.09	1.52	3.06	3.96	4.53	0.017	0.036	0.047	0.056
03, C	19.08	33.49	40.56	45.52	2.77	7.77	11.59	14.92	2.77	5.25	6.55	7.36	0.031	0.061	0.078	0.091
04, B	25.44	38.65	45.13	49.68	4.56	10.46	14.64	18.15	4.56	7.94	9.6	10.59	0.051	0.092	0.115	0.131
05, A	31.8	43.81	49.7	53.84	7.0	13.71	18.17	21.82	7.0	11.19	13.13	14.26	0.079	0.13	0.157	0.176
06, 9	38.16	48.97	54.27	57.99	10.18	17.57	22.23	25.95	10.18	15.05	17.19	18.39	0.115	0.175	0.206	0.227
07, 8	44.52	54.13	58.84	62.15	14.2	22.1	26.86	30.58	14.2	19.58	21.82	23.02	0.16	0.227	0.261	0.284
08, 7	50.89	59.29	63.42	66.31	19.17	27.34	32.09	35.72	19.17	24.82	27.05	28.16	0.216	0.288	0.324	0.348
09, 6	57.25	64.45	67.99	70.47	25.18	33.36	37.95	41.42	25.18	30.84	32.91	33.86	0.284	0.358	0.394	0.418
10, 5	63.61	69.61	72.56	74.62	32.32	40.2	44.49	47.68	32.32	37.68	39.45	40.12	0.365	0.438	0.472	0.495
11, 4	69.97	74.77	77.13	78.78	40.7	47.91	51.74	54.55	40.7	45.39	46.7	46.99	0.459	0.527	0.559	0.58
12, 3	76.33	79.93	81.7	82.94	50.42	56.56	59.74	62.05	50.42	54.04	54.7	54.49	0.569	0.628	0.655	0.672
13, 2	82.69	85.09	86.27	87.1	61.58	66.18	68.53	70.2	61.58	63.66	63.49	62.64	0.695	0.74	0.76	0.773
14, 1	89.05	90.25	90.84	91.25	74.27	76.84	78.13	79.04	74.27	74.32	73.09	71.48	0.838	0.864	0.875	0.882
15, 0	95.41	95.41	95.41	95.41	88.59	88.59	88.59	88.59	88.59	86.07	83.55	81.03	1.0	1.0	1.0	1.0

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Fig. M.1: 16 step grey scales for four different ambient lighting conditions

Fig. M.1 shows the lightness L^* and other CIE data for the 16-step equally spaced grey scales and four different ambient lighting conditions. The transmission factor varies between 0 and 1. The transparent ISO/IEC-test charts are especially different for the dark grey colours. There are large changes for the grey step with the hex code E by a factor 2 for the standard situation ($L^*_N = 18$) compared to the dark room ($L^*_N = 0$).

NOTE 1: The density of the grey transparent ISO/IEC-test charts no. 3 has the value 4 which corresponds to a transmission factor of 0,0001. This corresponds to $L^*_N = 0$ in the dark room.

NOTE 2: ISO/IEC-test charts in transmission mode are available for the four luminance reflectance $Y_r = 0$, 2.5, 5.0, and 7.5.

NOTE 3: The transparent ISO/IEC-test charts serve as reference either on the surface of a monitor or a flat area lamp. It is possible to determine the reflection properties of the monitor surface in the office. Usually only one of the four transparent ISO/IEC-test charts appear approximately equally spaced in any office and this determines the luminance reflectance Y_r (=0, 2,5, 5,0 or 7,5). For the output linearization of the 16-step grey scale on the monitor a direct illuminance or luminance measurement of the 16 steps on the screen and the value of Y_r is necessary. The ISO/IEC TR 19797 describes the linearization method for the monitor output based on this visual and measurement data.

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Annex N:
Information on web sites

Organisations with Internet addresses for additional information:

ISO: International Organization for Standardization, 1 Rue de Varembé, CH–1211 Geneva, Switzerland
http://www.iso.ch

ISO/IEC JTC1 SC28: Information technology – Japan Business Machine and Information System Industries Association (JBMIA)
http://www.jbmia.or.jp/sc28

Shuuwa Dai-ni Tranomon Bldg., 8th Floor,1-21-19 Tranomon, Minato-ku, Tokyo 105
Tel.No. +81-3-3503-9821, Fax.No. +81-3-3591-3646

Sc28 documents related to this Technical Report are : N386 (DIS ISO/IEC 19839-1 to -4; 2000-04), N547 (Report of BRM on DIS 19839-1to -4; 2002-03), N564 (NWI in 2002-05), N582 (Ballot on NWI; 2003-03) and N595 (Approval of NWI; 2003-06), N607 (first draft ISO/IEC/WD1 24705; 2003-08), N656 (ISO/IEC/PDTR 24705:2004-01)

DIN: Deutsches Institut für Normung e.V., Burggrafenstrasse 6, D–10787 Berlin, Germany
http://www.din.de

DIN NI-28: Information technology – Office systems
http://www.din.de/33866 (digital DIN-test charts according to DIN 33866)

NOTE 1: Four digital DIN-test charts are available as *PostScript-(PS)* and *PDF*-files with text in english and german language and in different resolutions
NOTE 2: Four analog DIN-test charts are available as test patterns.

BAM: Federal Institute for Materials Research and Testing, Unter den Eichen 87, D–12200 Berlin, Germany
http://www.bam.de

BAM VIII.3901: Visual methods and image reproduction for NDT
http://www.ps.bam.de

NOTE 1: Four digital ISO/IEC-test charts no. 1 to 4 are available as *PostScript-(PS)* and *PDF*-files with colours defined in four device coordinates *cmy0*, w*, olv*, and 000n** and absolute CIELAB coordinates *L*a*b** with text in english or in german language and in different resolutions
NOTE 2: Four analog ISO/IEC-test charts no. 1 to 4 in reflectance mode are available as test pattern from two different manufacturers
NOTE 3: Four analog ISO/IEC-test charts no. 3 are available as transparencies which give equally spaced series for the luminance reflectances Y_r = 0, 2,5, 5,0 and 7,5.

PostScript and the *Portable Document Format* are Trademarks of *Adobe Systems Incorporated*.
For definition see:
Adobe Systems Incorporated, *PostScript* Language Reference Manual, Second edition, Addison-Wesley, 1990, ISBN 0–201–10174–2.
Adobe Systems Incorporated, *Portable Document Format*, Reference Manual, Addison-Wesley, 1993, ISBN 0–201–62628–4.

NOTE: The *PostScript*-Code of many figures used for analog and digital ISO/IEC- and DIN-test charts were taken from a book and a CD-ROM: Klaus Richter, Computergrafik und Farbmetrik, VDE-Verlag GMBH, Berlin, 1996, ISBN 3–8007–1775–1 by agreement of the publisher.

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