Analog and digital ISO/IEC-colour charts for different colour reproduction tests and for the efficient use of colour in design

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Summary

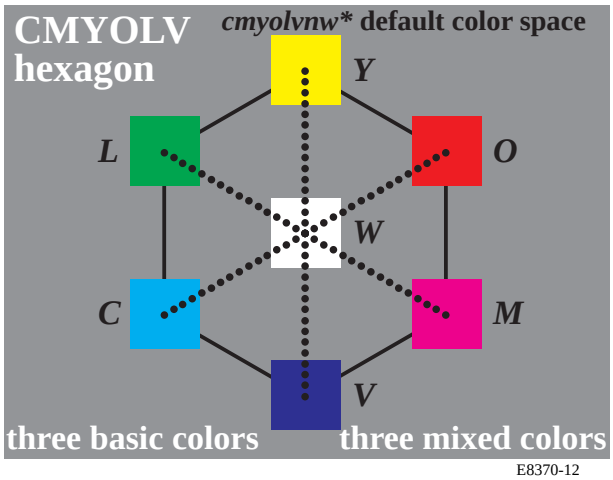
The colour reproduction properties of office devices, e. g. copiers, printers, scanners and monitors may depend on many parameters of the device system, e. g. the device properties and settings, the device driver, the file format, the computer operating system, the colour workflow, and the application software. Analog and digital ISO/IEC-colour charts allow to get a feeling about the influence of the different parameters on the output. The ISO/IEC-colour charts are an important tool to see the advantages and disadvantages of the many reproduction possibilities and to choose the appropriate one for the design application.

The reproduction of all colour elements of the ISO/IEC-test charts of ISO/IEC 15775 for colour copiers, e. g. the 5 and 16 step colour series, Siemens-stars, line screens, Landolt-rings and an image shows many reproduction properties. Most of the ISO/IEC standard tests pass if there is a linear relationship between the linear digital input data and the output data on a visual relative CIELAB scale for seven 16 step colour series of the device system.

The linear relationships are important for many applications in design.They allow to see at least 16 step colour series on any device system and with this linear property all the Landolt-rings of the test charts are recognized on every device. A draft ISO/IEC Technical Report describes how to linearize any device system for the different parameters. The output linearization method uses the measured CIELAB data of the 128 standard colours of a start output e. g. within the printer or device drive or within the startup directory of the software *Adobe Acrobat Distiller*.

1. Introduction

There is a variety of colour spaces which can be used for input and output. Any user has to spend a lot of time to learn about the different spaces and to train the relationship of the different spaces which depends on application.



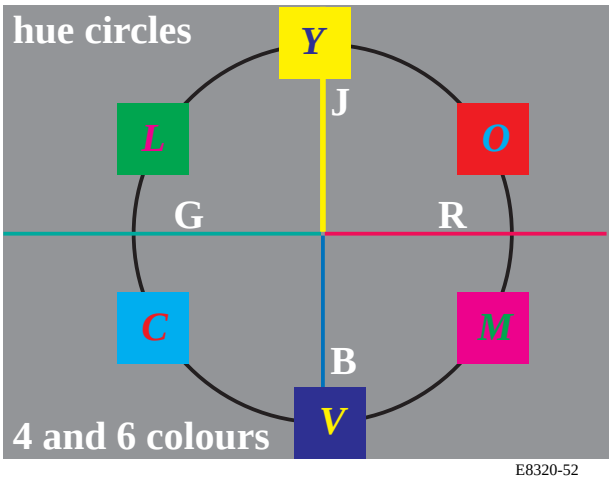


Figure 1: Six reproduction colours CMYOLV and four unique hue colours RJGB

Fig. 1 shows the six chromatic colours **CMYOLV** and Black **N** (=noir) and White **W** of standard offset printing (left). The four unique hue colours **RJGB** are different from the six reproduction colours. Standard non fluorescent offset paper was used to produce the **analog ISO/IEC-test charts which are equally spaced in CIELAB coordinates**. There are productions of DIN and JBMA (Japan Business Machines Association) in reflective and transparent mode. The German DIN production has been measured with the CIE 45/0 measuring geometry, the CIE illuminant D65 and the CIE 1931 standard observer at BAM *(Laboratory S.13)*. The mean colour difference of CMYOLV compared to the standard data is 2.5 CIELAB, see the standard DIN 33866-X and the International Standard ISO/IEC 15775.

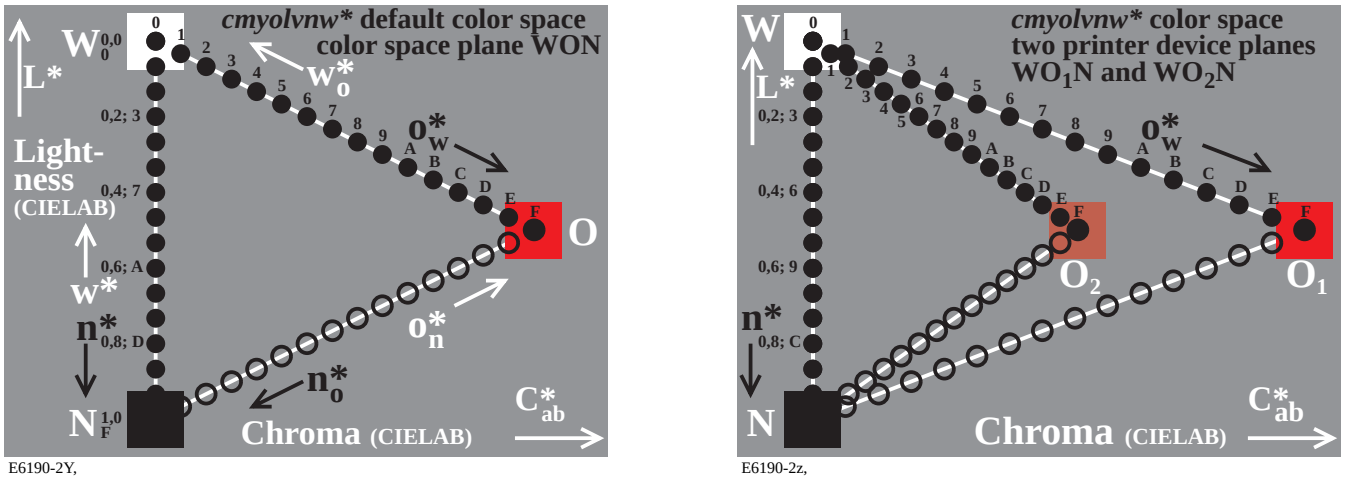
Remarks: According to the International Standard ISO/IEC 15775 the letters ***j*** (=jeanne=yellow), ***r*** (red), ***g*** (green), and ***b*** (blue) are reserved for the unique hues and the letters ***olv**** (orange red, leaf green, violet blue) are used with a star to indicate the linear relationship to CIELAB. The ***olv**** coordinates are used for the reflective colours and are used in a similar way as the coordinates ***rgb*** of the luminous television colours. The ***cmy**** coordinates are alternate coordinates compared to ***olv**** (see Fig. 1 and Table 1).

All the 16 step colour series between white and the six chromatic colours CMYOLV (see Fig. 1) and black are equally spaced in the CIELAB colour space. Laser printers produce the six chromatic colours by between 3 and 6 colorants. The result is very similar to the six colours CMYOLV of the present analog ISO/IEC-test charts which has been produced by standard offset printing.The users prefer different colour spaces for different application. In textile design and printing the CMY colour space and in web design the OLV (RGB) colour space is preferred. There are different test charts which use the different corresponding colour spaces for input, see Table 1.

Colour series Cyan blue – White (C – W) of ISO/IEC-test chart 2 (5 steps)			
Three colour spaces and **coordinates**	**CMYN (CMYK) (cmy0*)**	**OLV (RGB) (olv*)**	**CIELAB absolute (LAB*)**
Three input **PS operators**	**cmy0* setcmykcolor**	**olv* setrgbcolor**	**LAB* setcolor** see ISO/IEC 15775, Table H.2
1.00 **C** + 0.00 **W** (Cyan blue **C**)	1.00 0.00 0.00 0.00	0.00 1.00 1.00	58.62 -30.62 -42.74
0.75 **C** + 0.25 **W**	0.75 0.00 0.00 0.00	0.25 1.00 1.00	67.82 -23.21 -30.86
0.50 **C** + 0.50 **W**	0.50 0.00 0.00 0.00	0.50 1.00 1.00	77.02 -15.80 -18.98
0.25 **C** + 0.75 **W**	0.25 0.00 0.00 0.00	0.75 1.00 1.00	86.21 -08.39 -07.11
0.00 **C** + 1.00 **W** (White **W**)	0.00 0.00 0.00 0.00	1.00 1.00 1.00	95.41 -00.98 +04.76

Table 1: Colour data of 5 step colour series C – W for three input PS operators

Table 1 includes three input *PostScript* (PS) operators which define the same chromatic colour series between Cyan blue and White. There are ISO/IEC-test chart files which use the different PS operators of Table 1. If for input the corresponding CMY and OLV (RGB) data of Table 1 are used then the output of the device systems is in half of the cases equal and for the other half different. Special software uses test charts with the CIELAB input data of Table 1 and produces the intended output on many device systems.



E6190-2Y, E6190-2z,

Figure 2: Equal spacing in relative CIELAB in hue planes WO_xN of different devices x.

Fig. 2 shows the 16 step colour series **equally spaced in relative CIELAB** in the hue plane WON (left) for the default device and in the hue planes WO_1N and WO_2N for two other different devices. The CIELAB chroma C^*_{ab} of the devices 1 and 2 is larger or smaller (right) compared to the default chroma (left) but the **relative spacing** in CIELAB is equal in all cases. The dark dots show the 16 step colour series which an ISO/IEC Technical Report will produce on a printer. The coordinates used in this Technical Report are

*n** (relative blackness)

*n** changes from 0 to 1 (decimal) or from 0 to F (hexadecimal, 4bit) for the series White W to Black N (W–N)

o^*_w (relative orange redness of the whitish series w)

o^*_w changes from 0 to 1 (decimal) or from 0 to F (hexadecimal, 4bit) for the series White W to Orange red O (W–O). There are some other coordinates, e. g. relative whiteness *w** and relative orange redness of the blackish series o^*_n in Fig. 2 which have simple relationships to the above two relative coordinates and also to the CIELAB coordinates.

2. Output of the 128 standard colours in *cmy** colour space

It is within the **scope** of the draft ISO/IEC Technical Report that the **relative spacing in CIELAB is the same** for all devices as shown in Fig. 2. Then all the 16 step series W–O, W–O_1 and W–O_2 are recognized as long as the chroma of the colour O_2 is not too small.

The ISO/IEC-test charts 2 and 4 according to ISO/IEC 15775 include 8 colour series of 16 steps colours in Fig. B4 and D4. Both figures define 128 standard colours which are shown in Fig. 3.

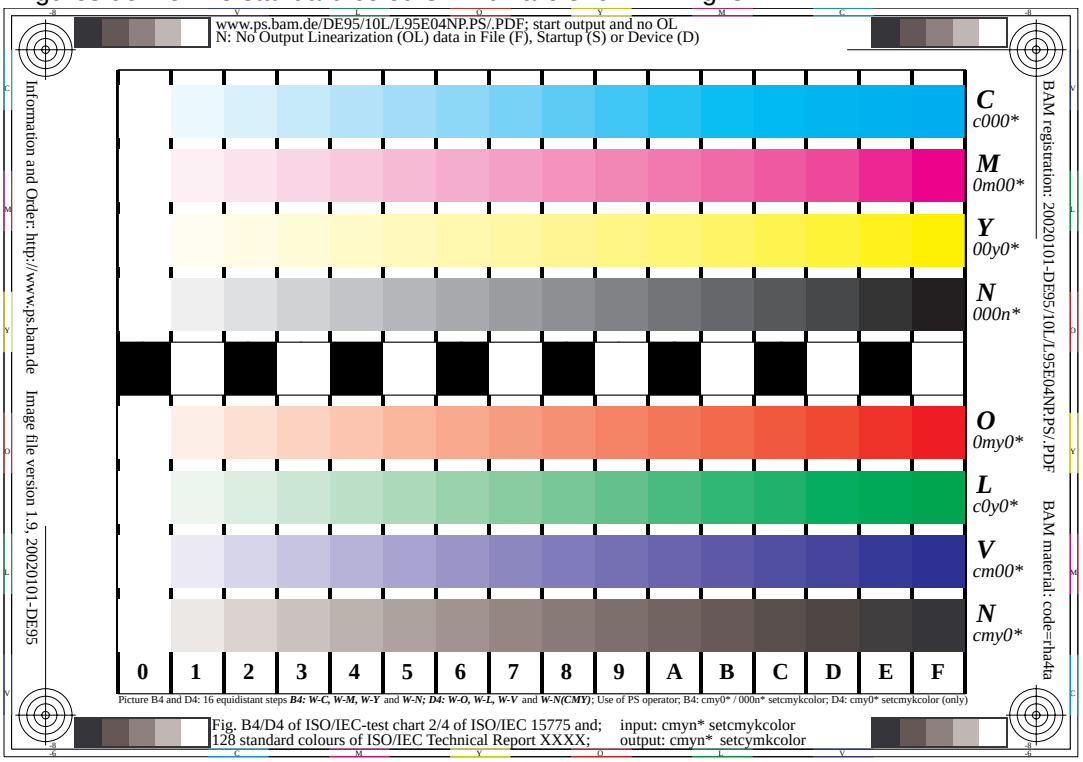


Figure 3: Start output of 128 standard colours defined in this ISO/IEC Technical Report

Fig. 3 shows the 128 standard colours which can be made equally spaced in CIELAB for hardcopy output for any device using the linearization method in the draft ISO/IEC Technical Report. Equal relative spacing of the 8 series is possible on any printer or monitor by any computer operating system, any file format, any colour workflow, and any application as far as we know. The standard digital files of the draft ISO/IEC Technical Report use relative ***cmy**** colour coordinates together with the PostScript operator *setcmykcolor* to verify this property for the different parameters.

The original files which are very useful for every printer (or monitor) system test are at the URLs:

http://www.ps.bam.de/DE95/10L/L95E04NP.PS

http://www.ps.bam.de/DE95/10L/L95E04NP.PDF

3. Output of the 128 standard colours in *different* colour spaces

The following figure shows an ISO/IEC-test chart with the 128 standard colours in two different colour spaces *cmy** and *olv** and as vector (V) and image (I) graphic.

Fig. 4 shows the 16 step series W – CMYOLV and W - N. The series W – N is produced by different PS operators. On the left side different **image operators** and on the right side different **vector operators** (to fill e. g. a square with a colour) are used. For images (left side) the PS operators **4 colorimage** and **3 colorimage** are used. For vector graphic (right side) the PS operators **setcmykcolor** and **setrgbcolor** are used.

According to colorimetry and by user desire it may be required that on printers (and on monitors) the four series W – CMYN and the four series W – OLVN (N=CMY) appear equal. But there are large differences on printers and monitors and only some combinations of software and device produce the required equal output.

With the default settings of the software *Adobe Reader* and for monitor output the **achromatic** series in part B4I4 of Fig. 4 (Image 4 component *cmy0** operator) and in part B4V4 (vector 4 component *cmy0**) operator) differ from the other gray scales (about 15 CIELAB for mean grey).

Additionally the spacing is usually different for every device system. But with the MTL code (Measurement, Transfer and Linearization) the spacing can be made equal in many cases.

The intention is to be able to get both an **equal colour** output **and an equally spaced** output for the corresponding colours in different colour spaces. An accuracy of 3 CIELAB is intended.

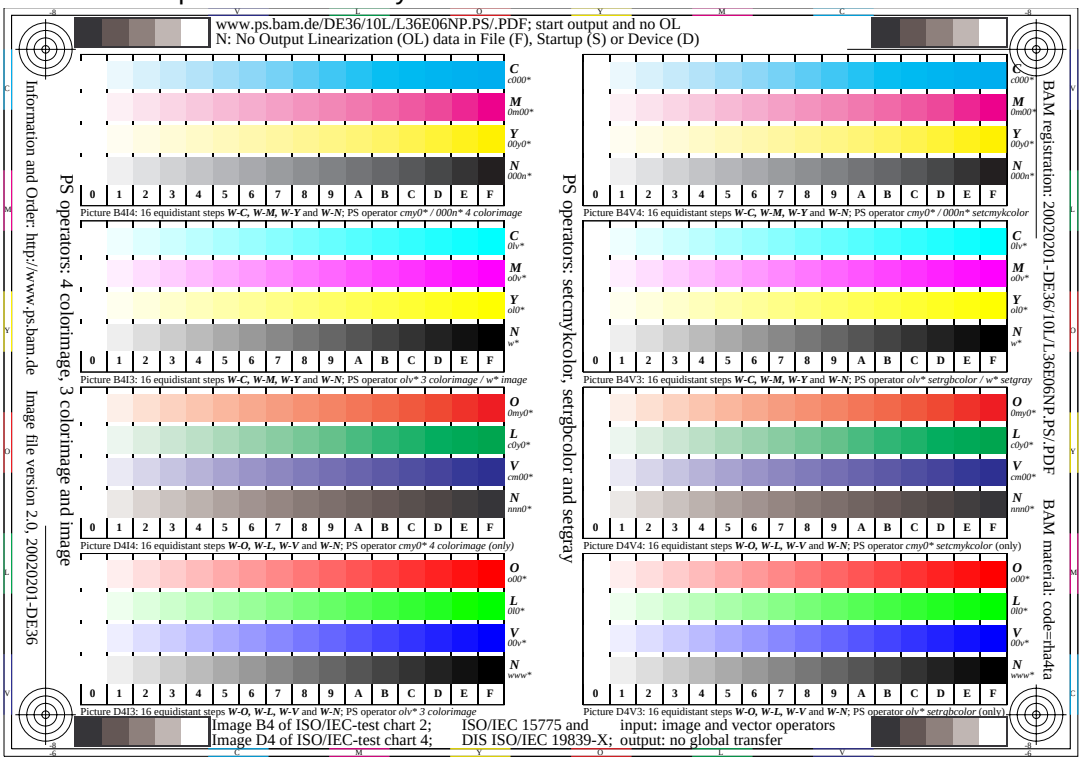


Figure 4: Test chart with vector and image PS operators for the 16 step series W – CMYOLVN.

The original files which are very useful for every printer (or monitor) system test are at the URLs:

http://www.ps.bam.de/DE36/10L/L36E06NP.PS

http://www.ps.bam.de/DE36/10L/L36E06NP.PDF

4. ISO/IEC-test charts with many different image elements in CMY space

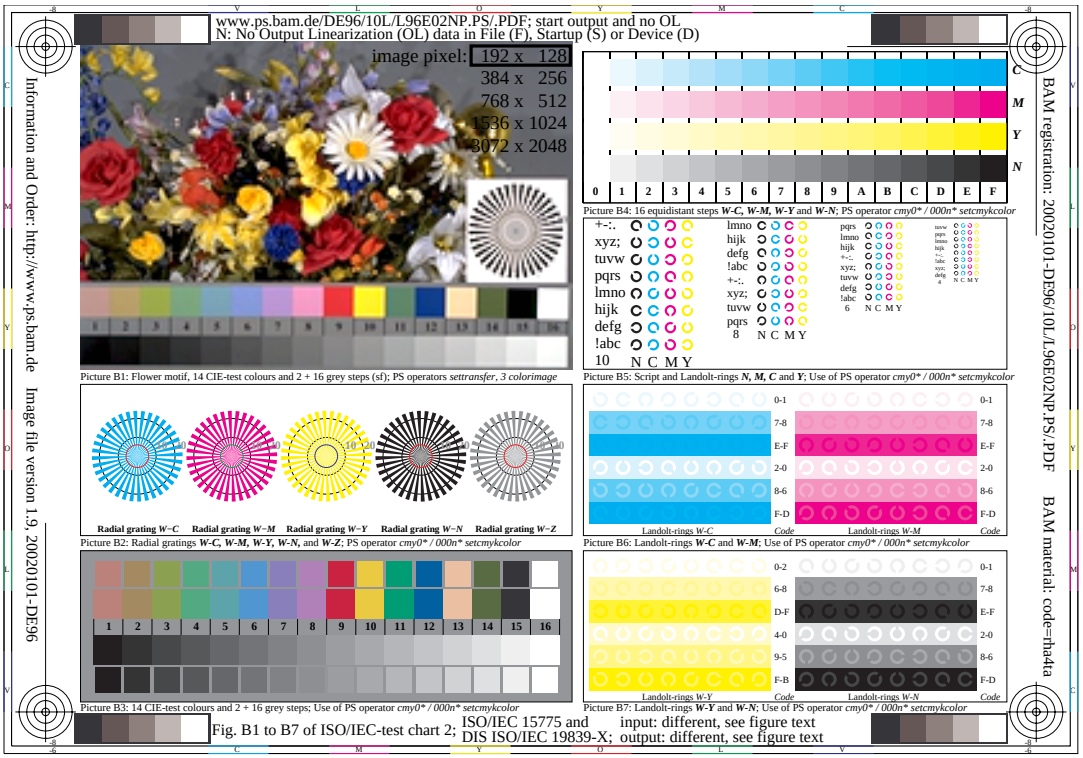


Figure 5: ISO/IEC-test chart no. 2 according to ISO/IEC 1575 with CMY colours defined in CMY colour space

Fig. 5 to 7 show the content of the ISO/IEC-test charts according to ISO/IEC 15775 for colour copiers with many different image elements.

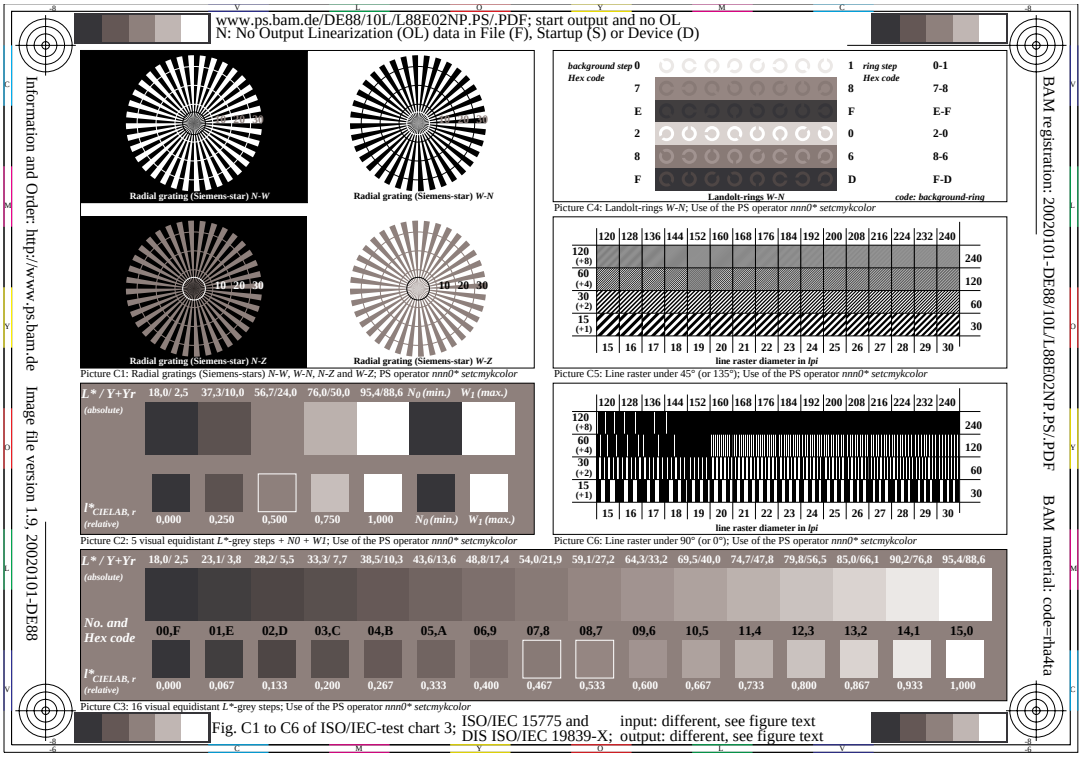


Figure 6: ISO/IEC-test chart no. 3 according to ISO/IEC 1575 with grey colours defined in CMY colour space

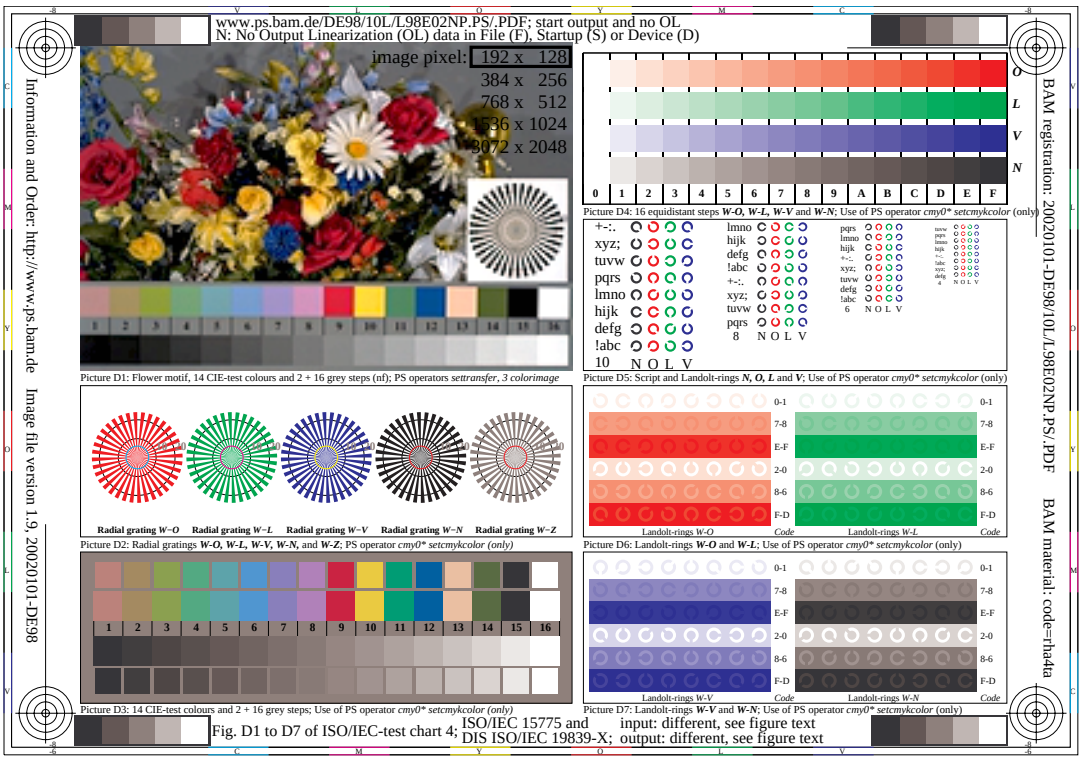


Figure 7: ISO/IEC-test chart no. 4 according to ISO/IEC 1575 with OLV colours defined in CMY colour space

There are analog ISO/IEC-test charts equally spaced in CIELAB and digital ISO/IEC-test charts with coordinates in different corresponding colour spaces (CMY, OLV, CIELAB). One may find more information on the web site given on page 1.

It was the goal of this paper to give a brief overview how analog and digital ISO/IEC-colour charts may be used for different colour reproduction tests and for the efficient use of colour in design. The ISO/IEC-test charts are freely

available on the web site. The URL is given on page 1. The original files of the ISO/IEC-test charts no. 2 to 4 which are very useful for every printer (or monitor) system test are in the PDF file format at the URLs:

http://www.ps.bam.de/DE96/10L/L96E02NP.PDF

http://www.ps.bam.de/DE88/10L/L88E02NP.PDF

http://www.ps.bam.de/DE98/10L/L98E02NP.PDF

Similar files in the PS file format are at the same URLs with the extension ".PS".

For more technical information about the different standards and draft standards see the next section "References".

5. References

[1] **DIN 33866-X**: Information technology – Office machines – Machines for colour image reproduction:
DIN 33866-1, Edition:2000-07; Part 1: Method for specifying image reproduction of colour devices by digital and analog test charts, Classification and principles; This standard includes the analog DIN-test charts no. 1 to 4
DIN 33866-2, Edition:2000-10; Part 2: Method for specifying image reproduction of colour devices by analog input and analog output for colour image reproduction devices: analog - analog (copiers) - Realisation and application
DIN 33866-3, Edition:2000-07; Part 3: Method for specifying image reproduction of colour devices by digital input and analog output as hardcopy for colour image reproduction devices: digital - analog (printers) - Realisation and application
DIN 33866-4, Edition:2000-10; Part 4: Method for specifying image reproduction of colour devices by analog input and digital output for colour image reproduction devices: analog - digital (scanners) - Realisation and application
DIN 33866-5, Edition:2000-10; Part 5: Method for specifying image reproduction of colour devices by digital input and analog output as softcopy for colour image reproduction devices: digital - analog (monitors) - Realisation and application

[2] **DIS ISO/IEC 19839-X**; Information technology - Office machines - Colour image reproduction equipment

DIS ISO/IEC 19839-1, Edition: 2000-03-Part 1: Method for specifying image reproduction of colour devices by digital and analog test charts, Classification and principles
DIS ISO/IEC 19839-2, Edition: 2000-03; Part 2: Method for specifying image reproduction of colour devices by digital input and analog output as hardcopy for colour image reproduction devices: digital - analog (printers) - Realisation and application
DIS ISO/IEC 19839-3, Edition: 2000-03; Part 3: Method for specifying image reproduction of colour devices by analog input and digital output for colour image reproduction devices: analog -digital (scanners) - Realisation and application
DIS ISO/IEC 19839-4, Edition: 2000-03; Part 4: Method for specifying image reproduction of colour devices by digital input and analog output as softcopy for colour image reproduction devices: digital - analog (monitors) - Realisation and application

[3] **ISO/IEC 15775**, Edition 1999-12; Information technology – Office machines – Machines for colour image reproduction - Method of specifying image reproduction of colour copying machines by analog test charts – Realisation and application

[4] Richter, Klaus; Computergrafik und Farbmetrik, VDE-Verlag, Berlin, 1996, with 500 colour figures in PS and PDF on CD-ROM, ISBN 3-8007-1775-12

[5] Richter, Klaus: Date, Title and Size of recent and former papers, see the URL:

http://www.ps.bam.de/INFXY91.HTM

[5.1] 010805: Linear CIELAB – cmy* colour workflow for the colour office devices and based on ISO/IEC 15775 and DIS ISO/IEC 19839-1 to -4, BAMCMY.PDF (1500 kByte, 16 pages)

[5.2] 020101: CIELAB 16 step grey scales on printers and monitors by daylight illumination based on ISO/IEC 15775 and DIS ISO/IEC 19839-1 to 4. BAMGREY.PDF (1400 kByte, 16 pages)

[5.3] 020130: Quick Introduction: ISO/IEC-test chart files which show basic problems of colour reproduction and produce equal output for corresponding colours defined in CIELAB related device spaces, DINCIE.PDF (3700 kByte, 10 pages)

[5.4] 020218: Images in ISO/IEC-test chart files which show basic problems of colour reproduction and produce equal output for corresponding colours defined in CIELAB related device spaces, BAMIMAGE.PDF (760 kByte, 14 pages)

[5.4] 020520: Analog and digital ISO/IEC-colour charts for different reproduction tests and for the efficient use of colour in design (500 kByte, 6 pages)

[6] 020510: K. Richter (Editor), 1. Draft of ISO/IEC Technical Report Type 3, Device output of 16 step colour scales, output linearization method (LM) and specification of the reproduction properties (600 kByte, 20 pages)