# Definition of extended print colour space *cmyolvnw** according to ISO/IEC 15775 or DIS ISO/IEC 19839-1 to 4 and comparison with *sRGB* and *scRGB* colour spaces according to IEC 61966-X.

Klaus RICHTER, Prof. Dr.
Federal Institute of Materials Research and Testing (BAM)
Project Leader: Visual Methods and Image Reproduction for NDT
Unter den Eichen 87
D-12200 Berlin, Germany
email: klaus.richter@bam.de
internet: **www.ps.bam.de** or http://o2.ps.bam.de/CIE2B1.PDF

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## ABSTRACT

*The International Standard series ISO/IEC 15775 [1] and DIS ISO/IEC 19839-1 to 4 [2] for specifying image reproduction properties of colour reproduction processes analog-analog (copiers), analog-digital (scanners) and digital-analog (printers, monitors) seem to overlap with the International Standard series IEC 61966-X [3] for scanners, printers and displays. But there are fundamental differences. In the ISO/IEC standards the coding of colours is based on reflective colours (defined for standard offset printing) and in the IEC series on luminous colours (defined for television).*

*Members of the standard groups ISO/IEC JTC1/ SC28 and IEC TC100 TA2 which developed the above standards try at the moment to define extended colour spaces (wide gamut colour spaces) compatible with the present spaces of the standards ISO/IEC 15775:1999-12 and IEC 61966-2-1:1999-10.The extended spaces should match the requirements of both the users and the industry for the different applications. Important advantages and disadvantages of both solutions based on coding of reflective and luminous colours are presented.*

**Keywords:** Image reproduction, ISO/IEC-test charts, copiers, printers, scanners, monitors, coding, extended colour space, wide gamut colour space.

## 1. ISO/IEC-test charts

Table 1 shows an overview of the different standards ISO/IEC 15775 and DIS ISO/IEC 19839-1 to 4.

**Table 1: Realisation and application of ISO/IEC-test charts for specifying image reproduction**

| Input | Output | Input and output media and applications<br>Input media | Output media | Application | Standard |
|---|---|---|---|---|---|
| – | – | – | – | **Basis** | **ISO/IEC 19839−1** |
| **analog** | **analog** | ISO/IEC-test chart (hardcopy) | Hardcopy | **Copier** | **ISO/IEC 15775** |
| **analog** | **digital** | ISO/IEC-test chart (hardcopy) | File | **Scanner** | **ISO/IEC 19839−3** |
| **digital** | **analog** | ISO/IEC-test chart (file) | Hardcopy<br>Softcopy | **Printer**<br>**Monitor** | **ISO/IEC 19839−2**<br>**ISO/IEC 19839−4** |

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Table 1 describes the application and realisation of ISO/IEC-test charts and the methods for the specification of reproduction properties of colour image devices **“analog - analog”** (copiers), **“analog - digital“** (scanners, Photo-CD-systems) and **“digital - analog”** (printers, monitors) and may therefore be used as a basis for the comparison and the choice of such devices.

The produced **analog** ISO/IEC-test charts are compared visually with the **analog** original. One must reproduce the **analog** ISO/IEC-test charts on copiers or the **digital** ISO/IEC-test charts on printers and monitors. There is also an ISO/IEC colorimetric method for comparison (Examples, see Annex G of ISO/IEC 15775)

For scanners the **analog** ISO/IEC-test charts are used for input. A colorimetric scanner which produces CIELAB data can use equations to transform the CIELAB data into *cmy**-data or *olv**-data of the default colour space *CMYOLVNW** of the ISO/IEC standards.

## 2. ISO/IEC colour space *CMYOLVNW**

The colour space *CMYOLVNW** is based on colours defined in the International Standard for offset printing using CIE illuminant D65, the CIE 2 degree observer and the CIE 45/0 measurement geometry.

ISO/IEC 15775 use the following colour terms shown in Fig. 1

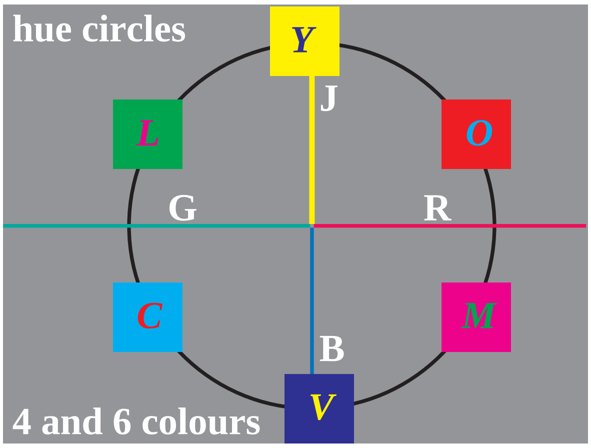


**Figure 1: Hue circles with four unitary and six reproduction colours**

The four colours terms *RGBJ* for Red, Green, Blue and Yellow (*J* = french Jeanne) are used for the unitary hues. The six colours terms *CMYOLV* are used for Cyanblue, Magentared, Yellow, Orangered, Leafgreen, Violetblue and define the reproduction colours. The terms for White and Black are *W* and *N* ( = french Noir).

The relative coordinates *nru** (Blackness *n**, Radial Chromaticness *c** and Unique Hue *u**) are based on the unitary hues of *Miescher* [4] and the six chromatic colours *CMYOLV*. This coordinate system is called the Natural Offset Reflective System (ORS). The coordinates*nru** are very user friendly.

## 3. Hexagon *CMYOLV* and 16step colour series

The 16-step colour series produced in offset printing within the **analog** ISO/IEC-test charts are defined in the CIELAB colour space, compare[1]. The accuracy of production is within the intended 3 CIELAB units. There are colour series changing only in relative *c* (Cyanblue)* between 0, 0.063, 0.133, ..., 0.933 1.000 (0/15, 1/15, ... 15/15 corresponding to the 16 steps) for constant *m**=0 and *y**=0 and similar for the series *m*, y*, o*, l*, v*,* and *n*.*

The task to calculate the relative *olv** and *cmy** coordinates from *LAB** (absolute CIELAB) coordinates has been solved by a *PostScript* (PS) and *Portable Document* (PDF) computer program. In this paper the calculated *cmy** coordinates are used to visualize the colours. The PostScript colour space *CMYK* and the PostScript parameter *setcmykcolor* are used within the PostScript source code. The visualization can use any other colour image coding like *bmp, sRGB, tiff,* and others as well but PostScript is preferred here.

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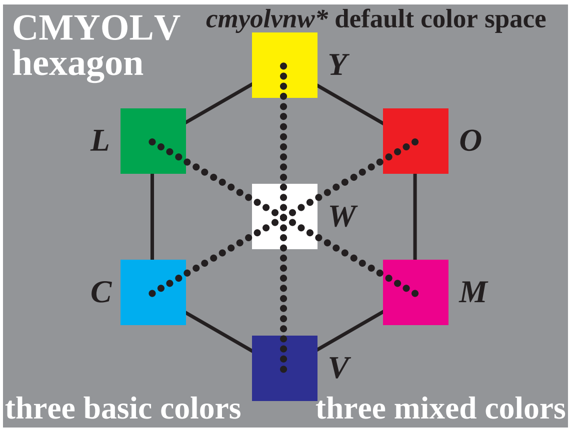
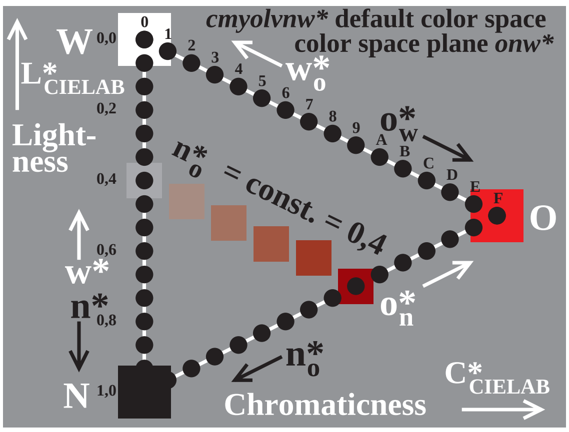



M6190−1, 16step ISO/IEC-test chart colours in hexagon

**Figure 2: Colour hexagon *CMYOLV* and 16step color series produced in ISO/IEC-test charts**

Fig. 2 shows the colour hexagon and the 16step series between White *W* and the six colours *CMYOLV* produced in ISO/IEC-test charts.




M6190−2, 16step ISO/IEC-test chart colours of hue Orangered *O*

**Figure 3: Hue plane of orangered colours with 16step colour series**

Fig. 3 shows within a hue plane the different 16step series between White *W* and Black *N* and between White *W* and Orangered *O* and between Orangered *O* and Black *N*. The colour series between *O* and *N* is not reproduced in ISO/IEC-test charts.

One can find digital files by the URL

http://o2.ps.bam.de/INFVM03/8910/A4Q8910E.PDF

http://o2.ps.bam.de/INFVM03/8920/A4Q8920E.PDF

which produce all the different colour series including the series between *CMYOLV* and N.

There are other digital files (go from page to page to see different variations)

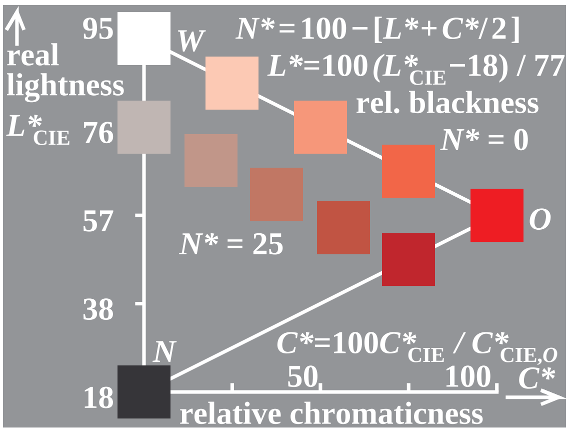
http://o2.ps.bam.de/INFVM03/8710/A4Q8710E.PDF

http://o2.ps.bam.de/INFVM03/8810/A4Q8810E.PDF

with twice as large colour patches.

One can measure the CIELAB data of the (printer) output for the 9 x 16 colours automatically, e. g. by using an instrument which measures the output colours at the different xy positions on the A4 output (see e. g. www.ColorSavvy.com)

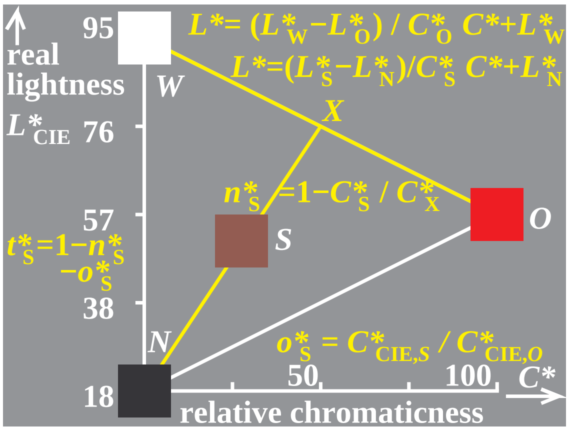
## 4. Definition and calculation of blackness




M6190−3, Colours of equal blackness $N^*$=0 and 25

**Figure 4: Colours of equal blackness $N^*$=0 and $N^*$=25 in a constant hue plane in CIELAB space.**

Fig. 4 shows the colours of equal blackness $N^*$=0 and $N^*$=25 in a constant hue plane in CIELAB space. The CIE lightness $L^*$ of the standard offset printing output between $L^*$=18 and $L^*$=95 is used on the vertical axis. Relative chromaticness of a colour (defined as ratio of CIE chroma and the CIE chroma of Orangered O) is used on the horizontal axis.




M6190−5, Calculation of triangle coordinates

**Figure 5: Calculation of relative blackness $n^*$s for a colour S in a constant hue plane in CIELAB space.**

Fig. 5 shows a colour *S* and two yellow lines. The cross point *X* of the two yellow lines defines the relative chromaticness $C^*x$ which is used to calculate relative blackness $N^*s$ = 100 x $n^*s$. Fig. 5 shows the equations for the calculations

## 5. Colour spaces and coding with capital and small letters

In Fig. 4 and Fig. 5 the **capital** and **small** letters are used for **variables and coding**. The digital coding may be in the **colorimetric range**, usually between 18 and 95 similar to the lightness $L^*$ as defined in absolute CIELAB space or between 0 (for $L^*$=18) and 100 (for $L^*$=95) in relative CIELAB space. Or the digital coding may be in the **digital 8bit range,** usually between 46 = 18 x 2,55 and 242 = 95 x 2,55 in absolute values or between 0 and 255 in relative values.

If **capital letters** *(L*, OLV*, CMY*)* are used then the range for variables is absolute, e. g. between 18 and 95 similar to lightness or for *OLV** between 46 = 18 x 2,55 and 242 = 95 x 2,55. The coding may be in the reverse direction, e. g. for *CMY** between 82 = 100 – 18 and 5 = 100 – 95. Therefore a coding proportional to lightness $L^*$ is used in the space *OLV** and the reverse coding proportional to blackness $N^*$ in the space *CMY*.*

If **small letters** are used the range of *olv** is relative between 0,0 and 1,0 for Black *N* and White *W*. The reverse coding of *cmy** leads to the range between 0,0 and 1,0 for White *W* and Black *N*

The digital coding may use 6, 7 or 8 bits for the gray series between Black *N* and White *W* either as absolute or relative coding. Table 2 includes the different possibilities.

| Coding: | relative or absolute | steps for gray scale | L* range | digital range either positive or negative for *L** = 18 to 95 (offset range) or *L** = 0 to 100 |
|---|---|---|---|---|
| **8bit for gray scale *N–W*** | | | | |
| d8+/8bit | relative | 255 | 18 to 95 | 0 to 255 for coordinates *olv** of *N* and *W* |
| d8–/8bit | relative | 255 | 18 to 95 | 0 to 255 for coordinates *cmy** of *W* and *N* |
| D8+/8bit | absolute | 255 | 0 to 100 | 46 to 242 for coordinates *olv** of *N* and *W* |
| D8–/8bit | absolute | 255 | 0 to 100 | 12 to 209 for coordinates *cmy** of *W* and *N* |
| **7bit for gray scale *N–W*** | | | | |
| d7+/8bit | relative | 128 | 18 to 95 | 63 to 191 for coordinates *olv** of *N* and *W* |
| d7–/8bit | relative | 128 | 18 to 95 | 63 to 191 for coordinates *cmy** of *W* and *N* |
| D7+/8bit | absolute | 128 | 0 to 100 | 86 to 184 for coordinates *olv** of *N* and *W* |
| D7–/8bit | absolute | 128 | 0 to 100 | 70 to 168 for coordinates *cmy** of *W* and *N* |
| **6bit for gray scale *N–W*** | | | | |
| d6+/8bit | relative | 64 | 18 to 95 | 95 to 159 for coordinates *olv** of *N* and *W* |
| d6–/8bit | relative | 64 | 18 to 95 | 95 to 159 for coordinates *cmy** of *W* and *N* |
| D6+/8bit | absolute | 64 | 0 to 100 | 106 to 155 for coordinates *olv** of *N* and *W* |
| D6–/8bit | absolute | 64 | 0 to 100 | 99 to 148 for coordinates *cmy** of *W* and *N* |

Remarks: The following numbers appear in the Table:

| | | |
|---|---|---|
| 46 = 0 + 18 x 2,55 | 86 = 63 + 18 x 2,55 x 0,5 | 106 = 95 + 18 x 2,55 x 0,25 |
| 242 = 0 + 95 x 2,55 | 184 = 63 + 95 x 2,55 x 0,5 | 148 = 95 + 95 x 2,55 x 0,25 |
| 12 = 255 – 5 x 2,55 | 70 = 191 – 5 x 2,55 x 0,5 | 99 = 159 – 5 x 2,55 x 0,25 |
| 209 = 255 – 82 x 2,55 | 168 = 191 – 82 x 2,5 x 0,5 | 148 = 159 – 82 x 2,55 x 0,25 |

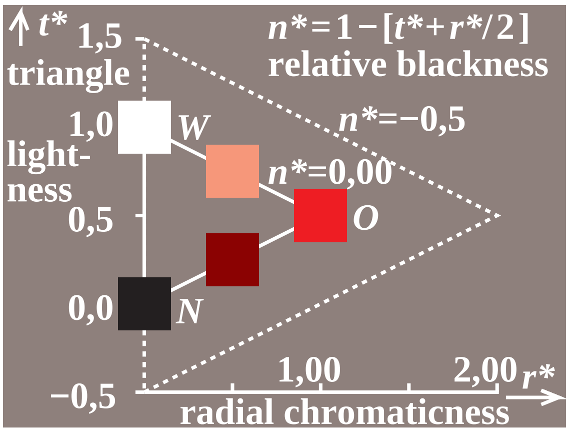
**Table 2: Examples for coding of colours using 8bit, 7bit and 6bit out of 8bit.**

Table 2 shows examples for coding of colours using 8, 7 or 6 bit for the gray scale between Black *N* and White W. The coding may use absolute or relative data and positive (proportional to lightness *L**) or negative (proportional to blackness *N**) direction. The following figures show some principles for this different digital coding.

If a **colorimetric** reproduction in CIELAB space is intended then absolute spacing must be used. If there are colours outside the offset colour range a 7bit coding may be necessary and e. g. for a fluorescent red colour a 6bit coding for the gray series between Black *N* and White *W* may be necessary.

## 6. Radial chromaticness *c** and triangle lightness *t**.

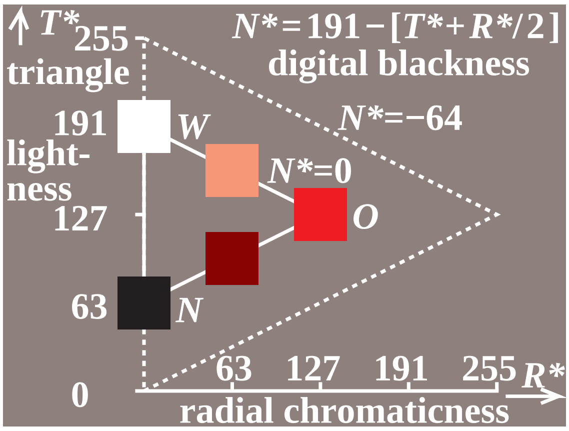
Fig. 6 to 8 show some of the principles for the relative coding. The hue plane of Fig. 5 is reproduced using different coordinates either relative between 0 and 1 or digital between 0 and 255 for N–W or between 63 and 191 for N–W (Fig. 7) or between 95 and 159 for N–W (Fig. 8)




M6190−6, Relative triangle coordinates

**Figure 6: Colours of equal blackness *n**=0 and *n**=–0,5 in a constant hue plane in relative CIELAB space *r**, *t**.**

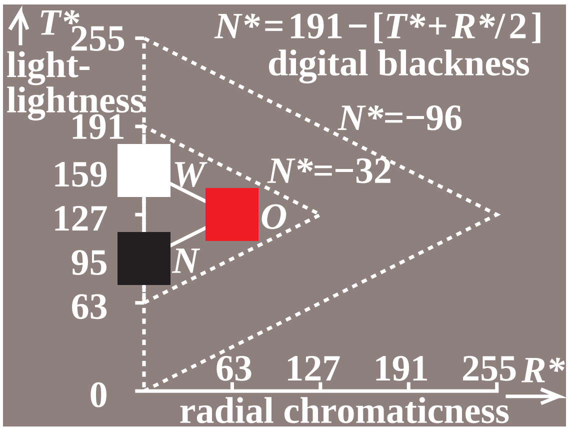
Fig. 6 shows the colours of equal blackness *n**=0 and *n**=–0,5 in a constant hue plane in relative CIELAB space with radial chromaticness *r** and triangle lightness *t**. The CIE lightness *L** of the standard offset printing output between *L**=18 and *L**=95 is transformed to the relative triangle lightness *t**=0 for black *N* and *t**=1 for white *W* shown on the vertical axis. Relative chromaticness *r** of a colour (defined as the ratio of CIE chroma and the CIE chroma of Orangered *O)* is used on the horizontal axis. Both axis are extended by a factor 2. Triangle lightness starts at *t**=-0,5 and ends at *t**=1,5.




M6190−7, Digital triangle coordinates: 7d+/8bit

**Figure 7: Colours of equal blackness *N**=0 and *N**=–64 in a constant hue plane in relative CIELAB space *R**, *T**.**

Fig. 7 shows the colours of equal blackness *N**=0 and *N**=–64 in a constant hue plane in relative CIELAB space with Radial chromaticness *R** and Triangle lightness *T**. The CIE lightness *L** of the standard offset printing output between *L**=18 and *L**=95 is transformed to the relative triangle lightness *T**=63 for black *N* and *T**=191 for white *W* shown on the vertical axis. Relative chromaticness *R** of a colour (defined as the ratio of CIE chroma and the CIE chroma of Orangered *O)* is used on the horizontal axis. Both axis are extended by a factor 2 compared to Fig. 5 and similar as in Fig. 6. Triangle lightness starts at *T**=0 and ends at *T**=255. This is a 8bit range and only a 7bit range is used for the achromatic colours between Black *N* and White *W* of offset printing.



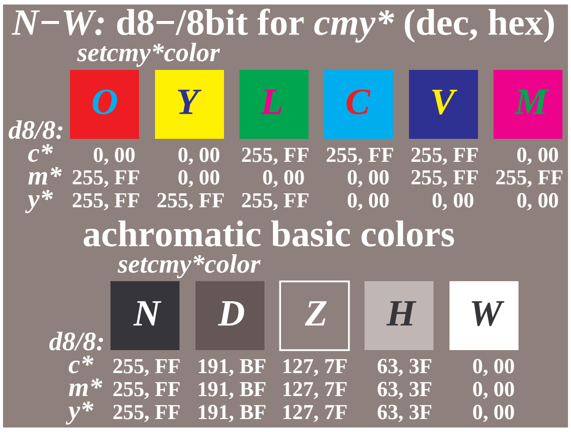

M6190−8, Digital triangle coordinates: 6d+/8bit

**Figure 8: Colours of equal blackness *N**=0, –32 and –96 in a constant hue plane in relative CIELAB space *R**, *T**.**

Fig. 8 shows the colours of equal blackness *N**=0, –32, –96 in a constant hue plane in relative CIELAB space Radial chromaticness *R** and Triangle lightness *T**. The CIE lightness *L** of the standard offset printing output between *L**=18 and *L**=95 is transformed to the relative triangle lightness *T**=95 for black *N* and *T**=159 for white *W* shown on the vertical axis. Relative chromaticness *R** of a colour (defined as the ratio of CIE chroma and the CIE chroma of Orangered *O)* is used on the horizontal axis. Both axis are extended by a factor 4 compared to Fig. 5. Triangle lightness starts at *T**=0 and ends at *T**=255. This is a 8bit range and only a 6bit range is used for the achromatic colour between Black *N* and White *W* of offset printing.

## 7. Colour space transformations from D8*CMY**/8bit, D7*CMY**/8bit, D6*CMY**/8bit to d8*cmy**/8bit

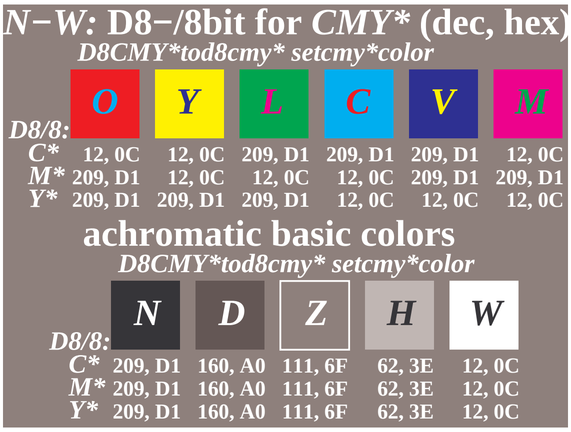
Figures 4 to 6 show the transfer from the absolute CIELAB space (Fig. 4 and 5) to the relative CIELAB space (Fig. 6). There is a digital **relative coding** d7+/8bit (=d7*olv**/8bit) and d6+/8bit in Fig. 7 and 8. There is an additional important possibility of **absolute coding** according to the CIELAB space shown in Table 2. For the lightness *L**=18 the hexadecimal data 46 = 18 x 2,55 are calculated in *OLV** coordinates. This is equivalent to the hexadecimal data of 209 = 255 – 82 x 2,55 in *CMY** coordinates. In Fig. 9 **relative coding in *cmy**** coordinates and in Fig. 10 **absolute coding in *CMY**** coordinates is used.




M6191−1, digital data d8−/8bit sgcode *cmy**

**Figure 9: Relative coding d8–/8bit for achromatic and standard colours of offset printing.**

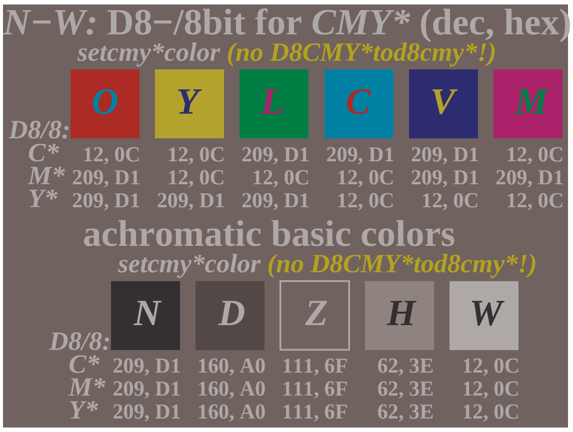
Fig. 9 shows the relative coding d8–/8bit (=d8*cmy**/ 8bit) for achromatic and standard colours of offset printing. The *cmy** coding of the achromatic series varies between 0 and 255 (hexadecimal 00 and FF) for *W* and *N* and similar for the chromatic colours.




M6191−2, Digital data D8−/8bit SGcode *CMY**

**Figure 10: Absolute coding D8–/8bit for achromatic and standard colours of offset printing including the D8*CMY**tod8*cmy** transfer.**

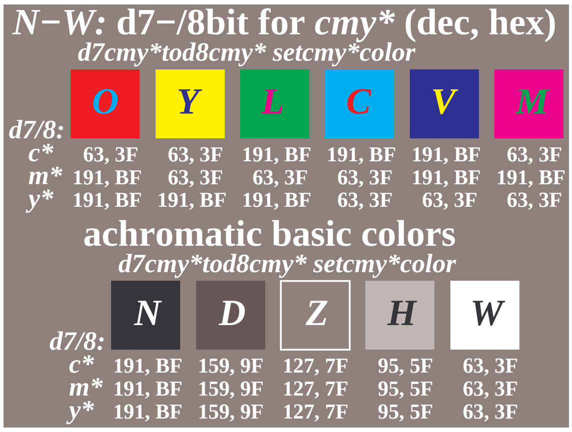
Fig. 10 shows the absolute coding D8–/8bit for achromatic and standard colours of offset printing. The *CMY** coding of the achromatic series varies between 12 = 288 – 5 x 2.55 and 209 = 255 – 82 x 2.55 (hexadecimal 0C and D1) and similar for the chromatic colours. A PostScript settransfer function is used to transfer the absolute *CMY** coordinates (between 12 and 209) to the relative *cmy** coordinates (between 0 and 255). This produce the same visual output in Fig. 10 compared to Fig. 9




M6191−3, Digital data D8−/8bit SGcode *CMY**

**Figure 11: Absolute coding D8–/8bit for achromatic and standard colours of offset printing without the D8*CMY**tod8*cmy** transfer.**

Fig. 11 uses the same data compared to Fig. 10 but the transfer from absolute coordinate D8*CMY** to relative coordinates d8*cmy** is not included. Therefore Fig. 11 appears lighter for black and darker for white compared to Fig. 10.




M6191−4, digital data d7−/8bit mgcode *cmy**

**Figure 12: Relative coding d7–/8bit for achromatic and standard colours of offset printing including d7*cmy**tod8*cmy** transfer.**

Fig. 12 shows the relative coding d7–/8bit for the achromatic and standard colours of offset printing. The d7*cmy** coding of the achromatic series varies between 63 and 191 (hexadecimal 3F and BF) and similar for the chromatic colours. A PostScript settransfer function is used to transfer the relative d7*cmy** coordinates (between 63 and 191) to the relative d8*cmy** coordinates (between 0 and 255). This produces in Fig. 12 the same visual output compared to the Fig. 9 and 10.

There is a similar possibility to transfer from D7–/8bit to d8–/8bit coding (compare Fig. 10).

There is a similar possibility to transfer from d6–/8bit to d8–/8bit coding (compare Fig. 11).

There is a similar possibility to transfer from D6–/8bit to d8–/8bit coding (compare Fig.10).

## 8. Example of 16step digital input coding *CMY**, *cmy** and output coding *cmy*´*, *olv*´*

If an equidistant offset gray scale of the ISO/IEC test chart is scanned then the output coding data vary between 0 and 255. Depending on the type of the scanner the 8bit data *cmy*´* and *olv*´* (star-dash) are produced.

The original data *CMY** and *cmy** (without dash) are known. One can transfer the three output tone scales *cmy*´* (uneven and indicating chromatic tints) back to the equidistant tone scales of the input.

The same procedure of tone transfer must be used for every pixel of the picture. If there are some samples in the original scene darker compared to the offset lightness $L^*$=18 this information is lost if one uses the relative coding *cmy**. It is important to keep this information and to use absolute spacing *CMY** to store the image information. Only the *CMY** coding will allow to produce a colorimetric reproduction of CIELAB input data. Some devices like photographic printers allow to reproduce all colours of the original scene including many outside the offset range, e. g. the lightness range *L**=8 to 95 on papers instead of only *L**=18 to 95.

| *i* | *CMY** | | | *cmy** | | | *cym*'* | | | *olv*'* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 209 | 209 | 209 | 255 | 255 | 255 | 239 | 247 | 244 | 16 | 8 | 11 |
| 2 | 196 | 196 | 196 | 238 | 238 | 238 | 238 | 246 | 244 | 17 | 9 | 11 |
| 3 | 183 | 183 | 183 | 221 | 221 | 221 | 220 | 233 | 226 | 35 | 22 | 29 |
| 4 | 170 | 170 | 170 | 204 | 204 | 204 | 207 | 215 | 214 | 48 | 40 | 41 |
| 5 | 157 | 157 | 157 | 187 | 187 | 187 | 193 | 198 | 199 | 62 | 57 | 56 |
| 6 | 144 | 144 | 144 | 170 | 170 | 170 | 181 | 186 | 187 | 74 | 69 | 68 |
| 7 | 130 | 130 | 130 | 153 | 153 | 153 | 168 | 173 | 173 | 87 | 82 | 82 |
| 8 | 117 | 117 | 117 | 136 | 136 | 136 | 155 | 160 | 158 | 100 | 95 | 97 |
| 9 | 104 | 104 | 104 | 119 | 119 | 119 | 141 | 147 | 145 | 114 | 108 | 110 |
| 10 | 91 | 91 | 91 | 102 | 102 | 102 | 129 | 132 | 129 | 126 | 123 | 126 |
| 11 | 78 | 78 | 78 | 85 | 85 | 85 | 116 | 119 | 115 | 139 | 136 | 140 |
| 12 | 65 | 65 | 65 | 68 | 68 | 68 | 102 | 106 | 99 | 153 | 149 | 156 |
| 13 | 52 | 52 | 52 | 51 | 51 | 51 | 88 | 92 | 88 | 167 | 163 | 167 |
| 14 | 39 | 39 | 39 | 34 | 34 | 34 | 76 | 80 | 76 | 179 | 175 | 179 |
| 15 | 26 | 26 | 26 | 17 | 17 | 17 | 59 | 64 | 60 | 196 | 191 | 195 |
| 16 | 13 | 13 | 13 | 0 | 0 | 0 | 48 | 51 | 47 | 207 | 204 | 208 |

E6191−61, ***CMY*, cmy*, cmy*', olv*'***: analog − digital process; slide film

**Table 3: Coordinates *CMY*, cmy*, cmy*´*, and *olv*´* for a real process analog - digital**

Table 3 shows the data of 16 equidistant gray colours with lightness between *L**=18 and *L**=95 in the original. The *cmy*´* or *olv*´* output data are not equidistant. The three output tone scales can be transferred back to the equidistant tone scales *CMY** between 13 for White *W* and 209 for black *N*. This is the way to include the colorimetric CIELAB data as *CMY** data within the image file.

Only if the coding includes the colorimetric *CMY** data the user can make a colorimetric reproduction on the output device. The user can also produce a relative reproduction within the lightness range of the output device. The transfer function of Fig. 8 D8*CMY**tod8*cmy** is a solution for this intention.


M6191−7, olv*_ad*'; slide film, exposure +0,0

**Figure 13: ISO/IEC image which must include the offset 16step colour series in the original (*L**=18 to 95).**

Fig. 13 shows an ISO/IEC image. An ISO/IEC image includes the 16step gray scale and the CIE-test colours in the original and the digital file. The 32 colours were taken by slide film. The digital file was produced by the Photo-CD process. In Table 3 the data *cmy*´* ( = 255 – *olv*´*) were taken from the digital image file.


M6191−8, olv*_ad* slide film, exposure +0,0

**Figure 14: ISO/IEC image corrected by the inverse input - output process.**

Figure 14 shows the **ISO/IEC image corrected by the inverse input - output process**. The transfer function d8*cmy*´* tod8*cmy** was used to calculate the original pixel data *cmy**.

## 9. Advantages and disadvantages of ISO/IEC and IEC Standards

The ISO/IEC standards use reflective colours and the IEC standards use luminous colours for coding. Only for reflective colours reference test colours can be produced as hardcopies. Therefore corresponding **analog** and **digital** ISO/IEC-test charts have been produced.

According to ISO/IEC 15775 the properties of the reproduction process are specified by visual and colorimetric methods using many test elements. The test charts are a powerful tool to study and to optimize the total reproduction process, e. g. the analog - digital - analog process of a colour copier or a part of it, e. g. the analog-digital part of the multifunctional copier. A multifunctional copier includes a scanner part and a printer part separately.

The coordinates ***cmyolvnw**** match in **analog** and **digital** ISO/IEC-test charts and their **spacing is proportional** to the CIELAB spacing.

The complete match for devices depends on a linear input - output relationship of the device which can be reached by special linearisation tools (which some manufacturers have already build in new devices like printers and scanners). Linearisation tools are free on the web and can be applied by users with some technical knowledge in the office environment.

For encoding and decoding the ISO/IEC standards use six chromatic colours located on a colour hexagon *CMYOLV* and the IEC standards need only three colours *sRGB* located on a colour triangle. In the ISO/IEC standards one must specify first the one of the six sectors (each a triangle) where the given colour is located. Then the calculations are similar to the calculations of the IEC standards.

In the ISO/IEC standards the transformation in both directions between the coordinates *cmyolvnw** and CIELAB requires some more time compared to the transformation in the IEC standards between *sRGB* (or extended *scRGB*) and CIELAB. The ISO/IEC-transformation method use in CIELAB colour space either the *cmyolvnw** of PR (printing) or TV (television). The result is for the TV colours an alternate coding compared to *sRGB*. This *cmyolvnw** coding is compatible to the spacing of CIELAB but the coding of *sRGB* is not compatible to CIELAB. Only for the gray scale *sRGB* is approximately compatible to the spacing of CIELAB.

A more comprehensive comparison by only four tables and one figure is given for the International standard series ISO/IEC 15775 or DIS ISO/IEC 19839-1 to -4 and the series IEC 61966-X in the field of Image Technology by K. Richter in [5].

## 10. Extended colour spaces of ISO/IEC and IEC standards

The **extended colour space *cmyolvnw**** of the ISO/IEC standards is compatible with CIELAB (compare Fig. 5 and asume that *S* is outside the triangle *NOW*) but the extended ***sRGB*** colour space is **not compatible** with **CIELAB.**

The calculation equation between CIELAB and *cmyolvnw** is described by many figures in this paper. The digital codings **d**n/8bit in relative space and **D**n/8bit in absolute space (n=8,7,6) are defined.

The capital **D** stands for **absolute** and the small **d** for **relative digital** coding. The number ***n*** describes the amount of steps used for the gray scale, either 8bit (255 steps), 7bit (128 steps) or 6bit (64 steps).

There are transfer functions, e. g. between D8*CMY** and d8*cmy** compatible with most software products like *Adobe Acrobat Distiller, Macintosh X Server Display PostScript (YAP* Application) and *Adobe Photoshop.*

The *cmyolvnw** coordinates of the ISO/IEC standards including the proposed extended color space (compare Fig. 5) are compatible with both most off the existing software and the CIELAB spacing.

The *sRGB* coordinates of the IEC standards are included in many software products. The proposed extended 16bit *scRGB* standard is incompatible to all existing software. New software is needed for *scRGB*, e. g. a new version of *Microsoft Windows*, and completely new 16bit printer drivers. Both the spacing of *sRGB* and *scRGB* is incompatible with the spacing of CIELAB.

**References**

[1] ISO/IEC 15775: 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

[2] ISO/IEC DIS 19839-1 to 4: 2000-04 „Information technology – Office machines – Machines for colour image reproduction";
*Part 1:* Method of specifying image reproduction by digital and analog DIN-test charts – Classification and principles
*Part 2:* Method of specifying image reproduction with digital input and analog output as hardcopy of colour image devices: "digital – analog" (printers) – Realisation and application
*Part 3:* Method of specifying image reproduction with analog input and digital output of colour image devices: "analog – digital" (scanners) – Realisation and application
*Part 4:* Method of specifying image reproduction with digital input and analog output as softcopy of colour image devices: "digital – analog" (monitors) – Realisation and application

[3] IEC 61966-2-1:1999-10 Multimedia systems and equipment – Colour measurement and management – Part 2-1: Colour management – Default *RGB* colour space – *sRGB*; for other standards see the URL:

http://www.iec.ch/TC100/txt/100struc-ta2.htm

[4] Miescher, K. (1948), Neuermittlung der Urfarben und deren Bedeutung für die Farbordnung, Helv. Physiol. Acta 6, C12-C13

[5] Richter, K., Comparison of properties of the International Standard series ISO/IEC 15775 or DIS ISO/IEC 19839-1 to -4 and IEC 61966-X in the field of Image Technology (4 pages), see the URL

http://o2.ps.bam.de/CIE2A1.PDF