

Technical Report BAM(7110/20/30/40/50/60/70/80/90)E

Wide Gamut colour space code (WGcode) and transformations of the absolute LAB* coordinates (CIELAB colour space) to the 8bit Standard Gamut (SG) and universal Wide Gamut (WG) *olv, *cmv**, *nru**, *rtu**, *sRGB* or *sRGB** coordinates for 16 step equidistant colour series**

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<http://o2.ps.bam.de/INFVM03/7110/BAM7110E.PDF>

<http://o2.ps.bam.de/INFVM03/7110/BAM7110E.HTM>

Remark 1: The number 7110 for the compatibility test of IEC 61966-2-1, CIELAB, and ISO/IEC 15775 has changed to 7310:

<http://o2.ps.bam.de/INFVM03/7310/BAM7310E.PDF>

<http://o2.ps.bam.de/INFVM03/7310/BAM7310E.HTM>

Remark 2: Instead of *nru** the XYZ, *sRGB* and *sRGB** coordinates (*X*, *Y*, *Z*, *RsRGB*, *GsRGB*, *BsRGB* in tristimulus value colour space and *R'sRGB*, *G'sRGB*, *B'sRGB* in perceptive *colour space) are only calculated for the Series 7180 and 7190. In the system TV18 the 8 colours *CMYOLVNW* are normalized to $L^*=18$ and $L^*=95$ for Black *N* and White *W*. In the system TV100 the 8 colours *CMYOLVNW* are normalized to $L^*=0$ and $L^*=100$ for Black *N* and White *W* which makes the 6 chromatic basic colours 5% more chromatic (by the ratio $100/95=1.05$).

In this report the **8bit codes** of the **Standard Gamut (SG)** and the **universal Wide Gamut (WG)** *colour spaces are calculated from *LAB** coordinates of the CIELAB *colour space.

Important properties of the universal Wide Gamut *colour space code (WGcode):

1. The **WGcode *olv** and *cmv**** in *colour space are for any colour of both the offset (PR) and the television (TV) *colour space **within the 8bit range 0 to 255**. In other words: **Any CIELAB *colour data of any real offset or any real television colour transforms only within this 8bit range.**
2. There is a reverse transformation between the WGcode and the CIELAB *colour data.
3. There are transformations between the WGcode and the SGcode of the PR *colour spaces *cmvolv** (CPR, PR18, PR14, PR10, PR0; definition see later)
4. There are transformations between the WGcode and the SGcode of the TV *colour spaces *cmvolv** (CTV, TV18, TV14, TV10, TV0; definition see later)
5. The most chromatic colour according to CIELAB of TV and PR is the colour Violet-blue *V* of TV. The normalization of the universal WGcode gives *olv** data $o^*=0$, $l^*=0$, $v^*=255$ or *cmv** data $c^*=255$, $m^*=255$, $y^*=0$ for the colour Violet-blue *V* of TV.
6. The WGcode range of both the offset and the television gray scale ($L^*=18$ to 85 , $L^*\text{-Range}=77$) is 6 bit ($64 = 77 * 0.82$ steps) in *colour space.
7. The intended accuracy for the office environment is 3 CIELAB units. Every two steps of the 16step gray scale defined by the L^* -range of 77 have a difference of $77/15=5.1$ CIELAB units. Therefore a 32step (5 bit) coding is sufficient and the 6bit WGcode for the gray scale defines an accuracy of only 1.3 CIELAB units.
8. Most scanner signals increase linear with the luminance *L* of the sample. CIELAB lightness L^* is a cube root function of luminance *L*. Therefore a 15bit linear scanner signal in *L* is equivalent to a 5 bit coding for L^* . Present high quality scanners have a luminance resolution of not more than 16bit per channel. Therefore it is not possible to capture more than a 32step equidistant gray scale. The 64step coding is better compared to the present scanner

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technology (and compared to the Photo-CD technology with about 14 bits / channel).

9. The WGcode of images can be transformed into the present SGcode of images by simple PostScript (or Photoshop or equivalent) settransfer functions.

10. Appropriate settransfer functions will allow to reduce the image accuracy from 6bit to 5bit, 4bit, 3bit, and 2bit per channel and to reduce image transfer time e. g. for internet mobile phone technology.

Data and URL addresses:

The Technical Reports 7110, 7120, 7130, 7140, 7150, 7160, 7170, 7180, and 7190 transform LAB^* coordinates into cmY^* , olV^* , nru^* , and rtu^* data. In most cases 16-step equally spaced colour series in *linear* LAB^* arrangement are transformed. But also the LAB^* coordinates of the CIE-test colours are transformed.

The $CMYOLVNW$ colour space of printing (PR) or television (TV) is defined by 8 CIELAB colour coordinates in a 3-dimensional space. Both spaces look like a double pyramid with White W at the top and Black N at the bottom and an colour hexagon of the 8 colours $CMYOLV$ perpendicular to the achromatic axis $N-W$. If we use absolute coordinates LAB^* (identical to the 3 coordinates $L^*a^*b^*$ of CIELAB colour space) then the space looks irregular but in relative coordinates (lab^* , small letters) the space is a regular double pyramid with a regular hexagon as basis. The following two figures show this regular spacing in two dimensions with the colours between White W and the hexagon $CMYOLV$ (the whitish colours w) or the colours between Black N and the hexagon $CMYOLV$ (the blackish colours n)

<http://o2.ps.bam.de/INFVM03/8370/E4370-2N.PDF>

<http://o2.ps.bam.de/INFVM03/8370/E4370-3N.PDF>

There are different reference systems for the calculations:

The Standard PRint system (SPR) contains the 8 colours $CMYOLVNW(PR)$ defined in ISO/IEC 15775. The lightness range is in the standard defined between $L^*=18$ and $L^*=95$. One may call this $SPR(L^*=18-95) = PR18$. The photographic test chart no. 1 in continuous tone has according to ISO/IEC 15775 a lightness range between $L^*=10$ and $L^*=94$. One may call this $DPR(L^*=10-94) = DPR10-94$ (D=Device)

Other systems used here are $DPR(L^*=14-95) = PR14$, $DPR(L^*=10-95) = PR10$, $DPR(L^*=0-95) = PR0$, and $DPR(L^*=0-100) = CPR$. The last one with the limits $L^*=0$ and $L^*=100$ is of special colorimetric interest and is called here the colorimetric print system (CPR). PR18 and CPR are the important ones here.

The Standard Television system (STV) contains the 8 colours $CMYOLVNW(TV)$ tabled in ISO/IEC 15775. The lightness L^* normalisation for White W is the same as for offset colours according to the standard. In offices with daylight illumination actual Black N on a screen is far from $L^*=0$ mainly because of the about 4% surface reflection on the screen surface which is very much depending on the device. One may choose $L^*=18$ as in SPR for simplicity of the calculations. This system is called $STV(L^*=18-95) = TV18$.

Others systems used here are $DTV(L^*=10-95) = TV10$, $DTV(L^*=0-95) = TV0$, and $DTV(L^*=0-100) = CTV$. TV18 and CTV are the important ones here.

System and device adaptation (sa and da) for the calculations.

A system adaptation (sa) and/or a device adaptation (da) to CIE illuminant D65 is used. According to ISO/IEC 15775 the 8 colours $CMYOLVNW$ defining the system output show for television (TV) zero CIELAB coordinates for both Black N and White W but not for printing (PR). Therefore for printing (PR) a chromatic adaptation is necessary for the system coordinates. Any device output may deviate from zero CIELAB coordinates for both Black N and White W . For comparison of coordinates both a system adaptation and a device adaptation may be necessary.

For the printing system (PR) then Black N ($A^*CIE=0.5$, $B^*CIE=-0.46$) and White W ($A^*CIE=-0.98$, $B^*CIE=4.76$) and all gray colours get the coordinates $A^*CIE=0.0$, $B^*CIE=0.0$

Similar for any output device then Black N ($A^*CIE=0.5$, $B^*CIE=-0.46$ or other values) and White W ($A^*CIE=-0.98$, $B^*CIE=4.76$ or other values) and all gray colours in CIELAB space linear between Black N and White W get the coordinates $A^*CIE=0.0$, $B^*CIE=0.0$. Within a tolerance of 1 of the 16 gray steps (5.2 CIELAB units) a linear shift in CIELAB space depending on lightness L^*CIE is used for the transformations.

For a 16 step gray colour series in offset printing with device colours PR18 ($L^*=18$ to 95 and Black N with $A^*CIE=0.5$, $B^*CIE=-0.46$ and White W with $A^*CIE=-0.98$, $B^*CIE=4.76$) in system PR18sa ($L^*=18$ to 95 and for both Black N and White W with $A^*CIE=0.0$, $B^*CIE=0.0$) see the simple *colour data by the URL:

<http://o2.ps.bam.de/INFVM03/7130/E3130-3N.PDF>

<http://o2.ps.bam.de/INFVM03/7130/E3130-3N.EPS>

<http://o2.ps.bam.de/INFVM03/7130/E3130-7N.PDF>

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<http://o2.ps.bam.de/INFVM03/7130/E3130-7N.EPS>

Absolute measurement or theoretical *colour data in CIELAB colour space are called L^*CIE , A^*CIE , B^*CIE and device adapted (da) *colour data are called L^*CIE_{da} , A^*CIE_{da} , B^*CIE_{da} .

Relative measurement or theoretical *colour data in CIELAB colour space are called l^*CIE , a^*CIE , b^*CIE and device adapted (sa) *colour data are called l^*CIE_{da} , a^*CIE_{da} , b^*CIE_{da} .

Calculations of olv^* , cmv^* and nru^* data are based on relative data l^*CIE_{da} , a^*CIE_{da} , b^*CIE_{da} .

For the technical basis of this transformations see the at the end of the technical report

<http://o2.ps.bam.de/INFVM03/8650/BAM8650E.PDF>

<http://o2.ps.bam.de/INFVM03/8650/BAM8650E.HTM>

Series 7110: Standard offset PR18 and television TV18 colours in systems PR18sa and TV18sa.

The PostScript files of this report include LAB^* coordinates of standard offset or television colours $CMYOLVNW$ as input. The SGcode (Standard Gamut) olv^* , cmv^* , nru^* and WGcode (Wide Gamut 86-168) olv^* , cmv^* is calculated for the device adapted coordinates L^*CIE_{da} , A^*CIE_{da} , B^*CIE_{da} .

1. Standard offset colours $CMYOLVNW$ (PR18) in system PR18sa ($L^*=18-95$) (E7110-3N.EPS)
2. Standard television colours $CMYOLVNW$ (TV18) in system PR18sa ($L^*=18-95$) (E7110-7N.EPS)
3. Standard offset colours $CMYOLVNW$ (TV18) in system TV18sa ($L^*=18-95$) (E7111-3N.EPS)
4. Standard television colours $CMYOLVNW$ (PR18) in system TV18sa ($L^*=18-95$) (E7111-7N.EPS)

All four are found in:

<http://o2.ps.bam.de/INFVM03/7110/A4Q7110E.PDF>

<http://o2.ps.bam.de/INFVM03/7110/A4Q7110E.PS>

Series 7120: Standard offset PR18 and television TV18 colours in systems CPRsa and CTVsa.

The PostScript files of this report include LAB^* coordinates of standard offset or television colours $CMYOLVNW$ as input. The SGcode (Standard Gamut) olv^* , cmv^* , nru^* and WGcode (Wide Gamut 86-168) olv^* , cmv^* is calculated for the device adapted coordinates L^*CIE_{da} , A^*CIE_{da} , B^*CIE_{da} .

1. Standard offset colours $CMYOLVNW$ (PR18) in system CPRsa ($L^*=0-100$) (E7120-3N.EPS)
2. Standard television colours $CMYOLVNW$ (TV18) in system CPRsa ($L^*=0-100$) (E7120-7N.EPS)
3. Standard offset colours $CMYOLVNW$ (TV18) in system CTVsa ($L^*=0-100$) (E7121-3N.EPS)
4. Standard television colours $CMYOLVNW$ (PR18) in system CTVsa ($L^*=0-100$) (E7121-7N.EPS)

All four are found in:

<http://o2.ps.bam.de/INFVM03/7120/A4Q7120E.PDF>

<http://o2.ps.bam.de/INFVM03/7120/A4Q7120E.PS>

Series 7130: Achromatic offset PR18 and television TV18 colours in systems PR18sa and TV18sa.

The PostScript files of this report include LAB^* coordinates of standard offset or television colours $CMYOLVNW$ as input. The SGcode (Standard Gamut) olv^* , cmv^* , nru^* and WGcode (Wide Gamut 86-168) olv^* , cmv^* is calculated for the device adapted coordinates L^*CIE_{da} , A^*CIE_{da} , B^*CIE_{da} .

1. Standard offset gray series $W-N$ ($i=0-7$) (PR18) in system PR18sa ($L^*=18-95$) (E7130-3N.EPS)
2. Standard offset gray series $W-N$ ($i=8-F$) (PR18) in system PR18sa ($L^*=18-95$) (E7130-7N.EPS)
3. Standard television gray series $W-N$ ($i=0-7$) (TV18) in system TV18sa ($L^*=18-95$) (E7131-3N.EPS)
4. Standard television gray series $W-N$ ($i=8-F$) (TV18) in system TV18sa ($L^*=18-95$) (E7131-7N.EPS)

All four are found in:

<http://o2.ps.bam.de/INFVM03/7130/A4Q7130E.PDF>

<http://o2.ps.bam.de/INFVM03/7130/A4Q7130E.PS>

Series 7140: Cyan and Magenta whitish (index w) and blackish (index n) PR18 and TV18 colours in system PR18sa.

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The PostScript files of this report include *LAB** coordinates of standard offset or television colours *CMYOLVNW* as input. The 16 steps colour series *w-c**, *n-c** and *w-m**, *n-m** of the standard are transformed. The SGcode (Standard Gamut) *olv**, *cmv**, *nru** and WGcode (Wide Gamut 86-168) *olv**, *cmv** is calculated for the device adapted coordinates *L**CIEda, *A**CIEda, *B**CIEda.

1. Colour series *C-W* and *C-N* (*i*=0 to 7, PR18 and TV18) in system PR18sa (*L**=18-95) (E7140-3N.EPS)
2. Colour series *C-W* and *C-N* (*i*=8 to F, PR18 and TV18) in system PR18sa (*L**=18-95) (E7140-7N.EPS)
3. Colour series *M-W* and *M-N* (*i*=0 to 7, PR18 and TV18) in system PR18sa (*L**=18-95) (E7141-3N.EPS)
4. Colour series *M-W* and *M-N* (*i*=8 to F, PR18 and TV18) in system PR18sa (*L**=18-95) (E7141-7N.EPS)

All 16 (multipage!) are found in:

<http://o2.ps.bam.de/INFVM03/7140/A4Q7140E.PDF>

<http://o2.ps.bam.de/INFVM03/7140/A4Q7140E.PS>

Series 7150: Yellow and Black whitish (index w) and blackish (index n) PR18 and TV18 colours in system PR18sa.

The PostScript files of this report include *LAB** coordinates of standard offset or television colours *CMYOLVNW* as input. The 16 steps colour series *w-y**, *n-y** and *w-n**, *n-w** of the standard are transformed. The SGcode (Standard Gamut) *olv**, *cmv**, *nru** and WGcode (Wide Gamut 86-168) *olv**, *cmv** is calculated for the device adapted coordinates *L**CIEda, *A**CIEda, *B**CIEda.

1. Colour series *Y-W* and *Y-N* (*i*=0 to 7, PR18 and TV18) in system PR18sa (*L**=18-95) (E7150-3N.EPS)
2. Colour series *Y-W* and *Y-N* (*i*=8 to F, PR18 and TV18) in system PR18sa (*L**=18-95) (E7150-7N.EPS)
3. Colour series *N-W* and *W-N* (*i*=0 to 7, PR18 and TV18) in system PR18sa (*L**=18-95) (E7151-3N.EPS)
4. Colour series *N-W* and *W-N* (*i*=8 to F, PR18 and TV18) in system PR18sa (*L**=18-95) (E7151-7N.EPS)

All 16 (multipage!) are found in:

<http://o2.ps.bam.de/INFVM03/7150/A4Q7150E.PDF>

<http://o2.ps.bam.de/INFVM03/7150/A4Q7150E.PS>

Series 7160: CIE-test colours (*i*=0 to F) colours in systems PR18sa and TV18sa.

The PostScript files of this report include *LAB** coordinates of standard CIE-test colours (*i*=0-F) as input. The SGcode (Standard Gamut) *olv**, *cmv**, *nru** and WGcode (Wide Gamut 86-168) *olv**, *cmv** is calculated for the device adapted coordinates *L**CIEda, *A**CIEda, *B**CIEda.

1. Standard CIE-test colours (*i*=0 to 7) in system PR18sa (*L**=18-95) (E7160-3N.EPS)
2. Standard CIE-test colours (*i*=8 to F) in system PR18sa (*L**=18-95) (E7160-7N.EPS)
3. Standard CIE-test colours (*i*=0 to 7) in system TV18sa (*L**=18-95) (E7161-3N.EPS)
4. Standard CIE-test colours (*i*=8 to F) in system TV18sa (*L**=18-95) (E7161-7N.EPS)

All four are found in:

<http://o2.ps.bam.de/INFVM03/7160/A4Q7160E.PDF>

<http://o2.ps.bam.de/INFVM03/7160/A4Q7160E.PS>

Series 7170: CIE-test colours (*i*=0 to F) colours in systems CPRsa and CTVsa.

The PostScript files of this report include *LAB** coordinates of standard CIE-test colours (*i*=0-F) as input. The SGcode (Standard Gamut) *olv**, *cmv**, *nru** and WGcode (Wide Gamut 86-168) *olv**, *cmv** is calculated for the device adapted coordinates *L**CIEda, *A**CIEda, *B**CIEda.

1. Standard CIE-test colours (*i*=0 to 7) in system CPRsa (*L**=0-100) (E7170-3N.EPS)
2. Standard CIE-test colours (*i*=8 to F) in system CPRsa (*L**=0-100) (E7170-7N.EPS)
3. Standard CIE-test colours (*i*=0 to 7) in system CTVsa (*L**=0-100) (E7171-3N.EPS)
4. Standard CIE-test colours (*i*=8 to F) in system CTVsa (*L**=0-100) (E7171-7N.EPS)

All four are found in:

<http://o2.ps.bam.de/INFVM03/7170/A4Q7170E.PDF>

<http://o2.ps.bam.de/INFVM03/7170/A4Q7170E.PS>

Series 7180: Standard television TV100, TV18 and CIE-test colours in system CTV100.

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The PostScript files of this report include *LAB** coordinates of standard television colours *CMYOLVNW* and CIE-test colours as input. The SGcode (Standard Gamut) *olv**, *cmy**, *nru** and WGcode (Wide Gamut 86-168) *olv**, *cmy** is calculated for the device adapted coordinates *L*CIEda*, *A*CIEda*, *B*CIEda*.

1. Standard television colours *CMYOLVNW* (TV100) in system CTV100 ($L^*=0-100$) (E7180-3N.EPS)
2. Standard television colours *CMYOLVNW* (TV18) in system CTV100 ($L^*=0-100$) (E7180-7N.EPS)
3. Standard CIE-test colours ($i=0$ to 7) in system CTV100 ($L^*=0-100$) (E7181-3N.EPS)
4. Standard CIE-test colours ($i=8$ to F) in system CTV100 ($L^*=0-100$) (E7181-7N.EPS)

All four are found in:

<http://o2.ps.bam.de/INFVM03/7180/A4Q7180E.PDF>

<http://o2.ps.bam.de/INFVM03/7180/A4Q7180E.PS>

Series 7190: Violet-blue and Gray whitish (index w) and blackish (index n) PR18 and TV18 colours in system CTV100.

The PostScript files of this report include *LAB** coordinates of standard television colours *CMYOLVNW* and CIE-test colours as input. The SGcode (Standard Gamut) *olv**, *cmy**, *nru** and WGcode (Wide Gamut 86-168) *olv**, *cmy** is calculated for the device adapted coordinates *L*CIEda*, *A*CIEda*, *B*CIEda*.

1. Standard television colours *CMYOLVNW* (TV100) in system TV100 ($L^*=0-100$) (E7190-3N.EPS)
2. Standard television colours *CMYOLVNW* (TV18) in system TV100 ($L^*=0-100$) (E7190-7N.EPS)
3. Standard CIE-test colours ($i=0$ to 7) in system CTV100 ($L^*=0-100$) (E7191-3N.EPS)
4. Standard CIE-test colours ($i=8$ to F) in system CTV100 ($L^*=0-100$) (E7191-7N.EPS)

All four are found in:

<http://o2.ps.bam.de/INFVM03/7190/A4Q7190E.PDF>

<http://o2.ps.bam.de/INFVM03/7190/A4Q7190E.PS>

Similar data:

The Technical Reports 8650,8750,8870,8880,8890 include similar. The SGcode (Standard Gamut) *olv**, *cmy**, *nru** and WGcode (Wide Gamut 77-177) *olv**, *cmy** is calculated for the device adapted coordinates *L*CIEda*, *A*CIEda*, *B*CIEda*. See for instance the technical report:

<http://o2.ps.bam.de/INFVM03/8650/BAM8650E.PDF>

or one example;

<http://o2.ps.bam.de/INFVM03/8650/A4Q8650E.PDF>

<http://o2.ps.bam.de/INFVM03/8600/A4Q8650E.PS>

These technical reports include transformations in colour systems PR18sa ($L^*=18-95$), PR14sa ($L^*=14-95$), PR10sa ($L^*=10-95$), PR0sa ($L^*=0-95$)

The Technical Reports 8930,8940,8950,8950,8960,8970,8980,8990 include similar data. The SGcode (Standard Gamut) *olv**, *cmy**, *nru** and WGcode (Wide Gamut 77-177) *olv**, *cmy** is calculated for the device adapted coordinates *L*CIEda*, *A*CIEda*, *B*CIEda*. See for instance the technical report:

<http://o2.ps.bam.de/INFVM03/8930/BAM8930E.PDF>

or one example;

<http://o2.ps.bam.de/INFVM03/8930/A4Q8930E.PDF>

<http://o2.ps.bam.de/INFVM03/8930/A4Q8930E.PS>

The technical report 8930 include transformations in colour system PR18sa ($L^*=18-95$)

The technical reports 8940 to 8950 include transformations in colour systems PR18sa ($L^*=18-95$) for the 16 step colour series *W-C*, *N-C*, *W-M*, *N-M*, *W-Y*, *N-Y*, *W-N*, *N-W*

The technical reports 8960 to 8990 include transformations in colour systems TV18sa ($L^*=18-95$), TV14sa ($L^*=14-95$), TV10sa ($L^*=10-95$), TV0sa ($L^*=0-95$)