Technical Report BAM(7310/20/30/40/50/60/70/80/90)E

Standard Printing (PR18) and CIELAB colors (RAL colour atlas) – Compatibility Test of IEC 61966-2-1, CIELAB and ISO/IEC 15775 colour coordinates –Standard and Wide Gamut 8bit *color code (SGcode and WGcode in CTVw and not in CPR)

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Creation date: 2000-08-04 (former numbers BAM7110E, BAM7290E)
Revision date: 2000-09-10

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

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

Data and URL addresses:
The Technical Reports 7310/20/30/40/50/50/70/80/90 transform *LAB** coordinates into coordinates *cmy*, olv** and *rtu** in Systems *CTV* and *CTVw* and calculates the data *rtu** and *RGB* and *R'G'B'* of the *sRGB* color space according to IEC 61966-2-1:1999-10.

Standard printing colours (Series 7310) and RAL colors of the four different hues green (Series 7320/30), red (7340/50), yellow (7360/70) and blue (7380/90) (CIELAB hue angle 180, 360, 90 and 270) are used. The CIELAB coordinates of real RAL colours of the RAL colour atlas are transformed to the SGcode and WGcode of both the Television (Series 7320/40/60/80) and the Printing (Series 7330/50/70/90) colour spaces.

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. Tables 1 to 6 give the basic data

basic colour or mixture colour and term	chromaticity		tristimulus values (Y=88,6 for white D65)		
	x	*y*	*X*	*Y*	*Z*
three subtractive basic colours: printing colours acc. to ISO 2846-1					
C cyan-blue	0,1645	0,2337	18,74	26,62	68,54
M magenta-red	0,4594	0,2348	33,06	16,90	22,01
Y yellow	0,4414	0,5000	68,06	77,10	9,03
three subtractive mixture colours: # DIN 33866-colours; ISO reference paper					
O orange-red#	0,6080	0,3380	30,13	16,75	2,68
L leaf-green#	0,2523	0,5559	8,71	19,18	6,62
V violet-blue#	0,2158	0,1400	7,17	4,65	21,41
D65 (ISO paper, *D65)*	0,3197	0,3384	83,69	88,60	89,47
N (black printing colour)	0,3122	0,3251	2,42	2,52	2,81

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Table 1: Chromaticity coordinates CIE *xy* and tristimulus values CIE *XYZ* of System PR18-95=PR18
Remark: In this case the normalization of White W is defined by the luminance factor*Y*=88.60 which corresponds to the lightness *L**=95.41

basic colour or mixture colour and term	*ab*-chromaticity		*L*a*b**-CIELAB data (Y=88,6 for white D65)		
	a = x/y	*b=−0,4 (z/y)*	*L**	*a**	*b**
three subtractive basic colours: printing colours acc. to ISO 2846-1					
C cyan-blue	0,7040	−1,0301	58,62	−30,63	−42,75
M magenta-red	1,9564	−0,5210	48,13	75,20	−6,80
Y yellow	0,8828	−0,0469	90,37	−11,16	96,17
three subtractive mixture colours: # DIN 33866-colours; ISO reference paper					
O orange-red#	1,7990	−0,0640	47,94	65,31	52,07
L leaf-green#	0,4540	−0,1380	50,90	−62,96	36,71
V violet-blue#	1,5415	−1,8407	25,72	31,35	−44,36
D65 (ISO paper, *D65)*	0,9446	−0,4040	95,41	−0,99	4,76
N (black printing colour)	0,9603	−0,4462	18,01	0,50	−0,47

INFIE031:IETA071.PS

Table 2: Chromaticity coordinates *a,b* and CIE *L*a*b (CIELAB) coordinates of System PR18-95=PR18**
Remark: In this case the normalization of White W is defined by the luminance factor*Y*=88.60 which corresponds to the lightness *L**=95.41

The following changes for the Black and White *color data lightness *L** are possible:

1. *L**=0 for Black *N* and *L**=100 for White *W*: System PR0-100=CPR (colorimetric range)

2. *L**=10 for Black *N* and *L**=94 for White *W*: System PR10-94=PR10 (photographic range)

basic colour or mixture colour and term	chromaticity		tristimulus values (Y=100 for white D65)		
	x	*y*	*X*	*Y*	*Z*
three additive basic colours: television colours acc. to ITU-R BT.709−2					
R red	0,6400	0,3300	41,25	21,27	1,93
G green	0,3000	0,6000	35,77	71,53	11,92
B blue	0,1500	0,0600	18,05	7,22	95,11
three additive mixture colours: television colours acc. to ITU-R BT.709−2					
C cyan-blue	0,2247	0,3287	53,80	78,73	106,96
M magenta-red	0,3209	0,1542	59,29	28,48	96,98
Y yellow	0,4193	0,5052	77,00	92,78	13,85
D65 (white, 100%)	0,3127	0,3290	95,05	100,00	108,90
N (black, (100/255)%)	0,3127	0,3290	0,37	0,39	0,43

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Table 3: Chromaticity coordinates CIE *xy* and tristimulus values CIE *XYZ* of System TV2-100=TV100
Remark: In this case the normalization of White W is defined by the luminance factor*Y*=100 which corresponds to the lightness *L**=100

basic colour or mixture colour and term	*ab*-chromaticity		*L*a*b**-CIELAB data (Y=100 for white D65)		
	a = x/y	*b=−0,4 (z/y)*	*L**	*a**	*b**
three additive basic colours: television colours acc. to ITU-R BT.709−2					
R red	1,9394	−0,0364	53,24	80,09	67,20
G green	0,5000	−0,0664	87,74	−86,18	83,19
B blue	2,5003	−5,2702	32,30	79,20	−107,9
three additive mixture colours: television colours acc. to ITU-R BT.709−2					
C cyan-blue	0,6834	−0,5434	91,11	−48,08	−14,13
M magenta-red	2,0817	−1,3620	60,32	98,24	−60,83
Y yellow	0,8299	−0,0597	97,14	−21,56	94,48
D65 (white, 100%)	0,9505	−0,4356	100,00	0,00	0,00
N (black, (100/255)%)	0,9505	−0,4356	2,29	0,00	0,00

INFIE031:IETA091.PS

Table 4: Chromaticity coordinates *a,b* and CIE *L*a*b (CIELAB) coordinates of System TV2-100=TV100**
Remark: In this case the normalization of White W is defined by the luminance factor*Y*=100 which corresponds to the lightness *L**=100

The following changes for the Black and White *color data lightness L* are possible:

1. *L**=0 for Black *N* and *L**=100 for White *W*: System TV0-100=CTVw (colorimetric range)
2. *L**=18 for Black *N* and *L**=95 for White *W*: System TV18-95=TV18 (offset range)

basic colour or mixture colour and term	chromaticity		tristimulus values (Y=88,6 for white D65)		
	x	y	X	Y	Z
three additive basic colours: television colours acc. to ITU-R BT.709−2					
R red	0,6400	0,3300	36,54	18,84	1,71
G green	0,3000	0,6000	31,68	63,36	10,56
B blue	0,1500	0,0600	15,99	6,40	84,22
three additive mixture colours: television colours acc. to ITU-R BT.709−2					
C cyan-blue	0,2246	0,3287	47,67	69,76	94,78
M magenta-red	0,3209	0,1542	52,53	25,24	85,91
Y yellow	0,4193	0,5053	68,22	82,20	12,27
D65 (white, 88,6%)	0,3127	0,3290	84,21	88,60	96,49
N (black, (88,6/255)%)	0,3127	0,3290	0,33	0,35	0,38

INFIE031:IETA101.PS 2x2

Table 5: Chromaticity coordinates CIE *xy* and tristimulus values CIE *XYZ* of System TV2-95=TV2
Remark: In this case the normalization of White W is defined by the luminance factor*Y*=88.60 which corresponds to the lightness *L**=95.41

basic colour or mixture colour and term	*ab*-chromaticity		*L*a*b**-CIELAB data (Y=88,6 for white D65)		
	a = x/y	b=−0,4 (z/y)	L*	a*	b*
three additive basic colours: television colours acc. to ITU-R BT.709−2					
R red	1,9394	−0,0364	50,50	76,92	64,55
G green	0,5000	−0,0667	83,63	−82,77	79,90
B blue	2,5000	−5,2667	30,39	76,06	−103,6
three additive mixture colours: television colours acc. to ITU-R BT.709−2					
C cyan-blue	0,6834	−0,5434	86,88	−46,18	−13,57
M magenta-red	2,0815	−1,3620	57,30	94,35	−58,42
Y yellow	0,8299	−0,0597	92,66	−20,71	90,75
D65 (white, 88,6%)	0,9505	−0,4356	95,41	0,00	0,00
N (black, (88,6/255)%)	0,9505	−0,4356	1,57	0,00	0,00

INFIE031:IETA111.PS 2x2

Table 6: Chromaticity coordinates *a,b* and CIE *L*a*b (CIELAB) coordinates of System TV2-95=TV2**
Remark: In this case the normalization of White W is defined by the luminance factor*Y*=88.60 which corresponds to the lightness *L**=95.41

The following changes for the Black and White *color data lightness *L** are possible:

1. *L**=0 for Black *N* and *L**=100 for White *W*: System TV0-100=CTV (colorimetric range)
2. *L**=18 for Black *N* and *L**=95 for White *W*: System TV18-95=TV18 (similar to PR18, offset range)

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 the colorimetric TV system 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

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**CIEda, *A**CIEda, *B**CIEda.

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**CIEda, *a**CIEda, *b**CIEda.

Calculations of *olv*, cmy** and *nru** data are based on relative data *l**CIEda, *a**CIEda, *b**CIEda.

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 7310

The colour series 7310 shows the

1. PR18 colours CMYOLVWN in the system CTVsa (colorimetric TV, normalization to Y=88.6, system adapted)

http://o2.ps.bam.de/INFVM03/7310/E3310-3N.PDF

2. PR18 colours CMYOLVWN in the system CTVwsa (colorimetric TV, normalization to Y=100, system adapted)

http://o2.ps.bam.de/INFVM03/7310/E3310-7N.PDF

3. Series White - Cyanblue (W-C) of PR18 colours CMYOLVWN (*i*=0 to 7) in the system CTVwsa (colorimetric TV, normalization to Y=100, system adapted)

http://o2.ps.bam.de/INFVM03/7310/E3311-3N.PDF

4. Series White - Cyanblue (W-C) of PR18 colours CMYOLVWN (*i*=8 to F) in the system CTVwsa (colorimetric TV, normalization to Y=100, system adapted)

http://o2.ps.bam.de/INFVM03/7310/E3311-7N.PDF

For all together see the URL

http://o2.ps.bam.de/INFVM03/7310/A4Q7310E.PDF

The following data are calculated:

1. *XCIE, YCIE, ZCIE* in linear CIE *XYZ* color space
2. *RsRGB, GsRGB, BsRGB* in linear *sRGB* color space
3. *R‘sRGB, G‘sRGB, B‘sRGB* in nonlinear *sR‘G‘B‘* *color space (perceptive color space)
4. *o*nCTV, l*nCTV, v*nCTV* in nonlinear *olv*nCTV* or *olv*nCTV*w *color space.

5. *c*wCTV, m*wCTV, y*wCTV* in nonlinear *cmy*wCTV* or *cmy*wCTV*w *color space.

For mean gray the mean coding 127 is defined in the 8bit *color space. The coding range is between 88 and 166 for all colours including Black *N* and White *W* which can be produced on the TV screen.

Other colors, for example the printing color Cyanblue *C* and its16 step mixture with White *W*, may have an 8bit *color coding below 77 and above 177.

This study tries to solve questions which of the above coordinates are useful. Colorimetry and visual assessments are used to show the differences of the coordinates and their advantages and disadvantages.

A 16step color series between White *W* and Cyanblue *C* is shown in two parts in the files:

http://o2.ps.bam.de/INFVM03/7310/E3310-3N.PDF

http://o2.ps.bam.de/INFVM03/7310/E3310-7N.PDF

http://o2.ps.bam.de/INFVM03/7310/E3310-3N.EPS

http://o2.ps.bam.de/INFVM03/7310/E3311-7N.EPS

Possible interpretation of the data:

The variation of the *o** data is between 0.96 (this value is calculated for the standard offset printing paper with some yellowish tint) for White *W* and -0.50 for Cyanblue *C*. The value -0.50 indicates that 33% (=50/150) of the 16 steps in offset printing or the last 5 steps can not be reproduced on the screen.

The variation of the *RsRGB* data is between 0.90 for White *W* and -0.16 for Cyanblue *C*. The value -0.16 indicates that 15% (=0.16/1.06) of the 16 steps in offset printing or the last 2 steps can not be reproduced on the screen.

The variation of the *R'sRGB* data is between 0.96 for White *W* and -2.0 for Cyanblue *C*. The value -2.0 indicates that 66% (=2.0/3.0) of the 16 steps in offset printing or the last 10 steps can not be reproduced on the screen.

Check of red coordinates *RsRGB, R'sRGB* and *o for compatibility to CIELAB**

According to colorimetry and the following proof there is only ***o** compatible to CIELAB**:

The ***RsRGB*** data are defined in a linear colorimetric space and the distance in this space has no meaning for perceptive color differences. If 16% is true then the change point of *RsRGB* data from positive to negative must be near step 14 but it is near step 11.

The ***R'sRGB*** data are defined in a colorimetric space incompatible with CIELAB. It seem obvious that the numbers are in conflict with visual appearance and experience. If 66% is true then the change point of *R'sRGB* data from positive to negative must be near step 5 but it is near step 11.

The ***o**** data are defined in the relative colorimetric space CIELAB. If 33% is true then the change point of the *o** data from positive to negative must be near step 11. The change point is indeed near step 11, so this is the solution.

Conclusions in case of correct calculations in the Series 7310:

RsRGB data and *R'sRGB* data are unable to describe the metric of the 16step series and the amount of colour steps by the numerical number differences of *RsRGB* or *R'sRGB* for the offset printing series W - C (White – Cyanblue) which can be reproduced on the TV screen

Only the *o data defined in the relative colorimetric space CIELAB seem to be able to describe the spacing.**

Definition of 8bit Standard and Wide Gamut code (SGcode and WGcode) in *colour space:

The SGcode *olv**nCTVw is transformed to the WGcode *olv**nCTVw88 by the equations

*o**nCTVw88 = 88 + 0.82 *o**nCTVw / 2.55 = 88 + 0.32 *o**nCTVw

*l**nCTVw88 = 88 + 0.82 *l**nCTVw / 2.55 = 88 + 0.32 *l**nCTVw

*v**nCTVw88 = 88 + 0.82 *v**nCTVw / 2.55 = 88 + 0.32 *v**nCTVw

The WGcode (Index 88) defines an 8bit Wide gamut *colour space. The transformation gives as WGcode 8bit *color data between 88 and 168 for the colorimetric gray scale between *L**=0 to *L**=100 and the numerical value 127 for mean gray with the lightness *L**=50. The numerical values 88 and 0.82 in the equations are defined by the intended WGcode *olv**nCPR88 (0, 0, 255) for the colour Violetblue V in the Colorimetric **Printing** (CPR) *color space. But we are here in the Colorimetric **Television** (CTV) space.

The **printing colour Cyanblue** C_{PR} is the colour most outside the Television colour space and the **television colour Violetblue** V_{TV} is the colour most outside the printing colour space. Other numerical values compared to 88 and 0.82 are necessary if it is intended to include the printing colour Cyanblue C_{PR} in the Colorimetric **Television** (CTVw) *color space. If this is intended one must allow more chromatic blue colours and then there is more space for more chromatic colours compared to the colour **Violetblue V of Television** (which is the most chromatic of both PR and

TV colours). This is not useful as then the **dynamic range for all colours is reduced** in the Wide Gamut CTV 8bit *colour space.

It makes only sense to extend the printing colour space CPR by the above factors 88 and 0.32 and in this case we get the smallest colorimetric Wide Gamut *colour space which includes all colours of both Printing and Television within the 8bit range of the three channels. This defines the Wide Gamut equations for all television and printing colours:

*o**nCPR88 = 88 + 0.82 *o**nCPR / 2.55 = 88 + 0.32 *o**nCPR

*l**nCPR88 = 88 + 0.82 *l**nCPR / 2.55 = 88 + 0.32 *l**nCPR

*v**nCPR88 = 88 + 0.82 *v**nCPR / 2.55 = 88 + 0.32 *v**nCPR

Color management with 8bit wide gamut color space

For Color management a settransfer function for a pixel x in hex code (00 to FF) can be used.

```
x 88 255 div le {/x 0 def} if
x 168 255 div ge {/x 255 def}
        {/x x xw xn sub div 255 mul def} ifelse
```

The 8bit values xw and xn for white and black may be 168 and 88 or any other device or process specific values. This equation transforms the linear 8bit input values (WGcode) between 88 and 168 to the 8bit output values between 0 and 255 for every pixel (SGcode). Changing the limits 88 for Black *N* and 168 for White *W* according to the input or output device can handle all device properties, e. g. can transform the WGcode for the lightness *L** range between 93=88+0.82*18 *(L*=18)* and 166=88+ 0.82 * 95 *(L*=95)* for every pixel to the SGcode with the standard range 0 to 255.

There are standard functions in PostScript for these properties which are handled for example within the *PS*-Printer, or by *Adobe Acrobat Distiller*, or by Software-RIPs, or by *Display-PS*-Systems. The functions had to be included before the image data in the file, some more information is given in the technical report:

http://o2.ps.bam.de/INFVM03/8640/BAM8640E.PDF

or

http://o2.ps.bam.de/INFVM03/8640/BAM8640E.HTM

The part for colour management is under development. Standard input and output files with Standard Gamut code (SGcode) and Wide Gamut code (WGcode) within the 8bit range are compatible with nearly all software products in the graphic area.

Variable input processes can be handled by automatic colour management if one takes an analog ISO/IEC-test chart as a first picture by a camera and assuming that the other pictures are done under the same conditions. The original colours of the first picture are known. Then the digital data can be corrected to get equally spaced digital values for *olv** digital data between 0 and 255 for the 16 colours of the gray series. A settransfer function can handle this correction for all pictures of a film, for different film materials (slide, negative), different exposures etc. Tests have shown that the *olv** digital data are nearly independent of all the parameters changed, e. g. between one stop underexposure and 2 stops overexposure for negative film. See the URL:

http://o2.ps.bam.de/CISV06.PDF

Series 7320

The colour series 7320 shows the

1. RAL colours of maximum chromaticness *C**max, *H**=180 (green) in the system CTVwsa (colorimetric TV, normalization to *Y*=100, system adapted)

http://o2.ps.bam.de/INFVM03/7320/E3320-3N.PDF

2. RAL colours of maximum chromaticness *C**max minus 5 *C** steps, *H**=180 (green) in the system CTVwsa (colorimetric TV, normalization to *Y*=100, system adapted)

http://o2.ps.bam.de/INFVM03/7320/E3320-7N.PDF

3. RAL colours of constant lightness *L**=50 and chromaticness *C**=0, 10, 20, 30, 40, 50, *H**=180 (green) and black *N (L*,C*)*=(0,0) and White *W (L*,C*)*=(100,0) in the system CTVwsa (colorimetric TV, normalization to *Y*=100, system adapted)

http://o2.ps.bam.de/INFVM03/7320/E3321-3N.PDF

4. RAL colours of constant chromaticness *C**=20 and lightness *L**=20, 30, 40, 50, 60, 70, 80, *H**=180 (green) in the system CTVwsa (colorimetric TV, normalization to *Y*=100, system adapted)

http://o2.ps.bam.de/INFVM03/7320/E3321-3N.PDF

For all together see the URL

http://o2.ps.bam.de/INFVM03/7320/A4Q7320E.PDF

Series 7330

The colour series 7330 shows the

1. RAL colours of maximum chromaticness *C**max, *H**=180 (green) in the system CPRsa (colorimetric PR, normalization to *Y*=100, system adapted)

http://o2.ps.bam.de/INFVM03/7330/E3330-3N.PDF

2. RAL colours of maximum chromaticness *C**max minus 5 *C** steps, *H**=180 (green) in the system CPRsa (colorimetric TV, normalization to *Y*=100, system adapted)

http://o2.ps.bam.de/INFVM03/7330/E3330-7N.PDF

3. RAL colours of constant lightness *L**=50 and chromaticness *C**=0, 10, 20, 30, 40, 50, *H**=180 (green) and black *N (L*,C*)*=(0,0) and White *W (L*,C*)*=(100,0) in the system CPRsa (colorimetric PR, normalization to *Y*=100, system adapted)

http://o2.ps.bam.de/INFVM03/7330/E3331-3N.PDF

4. RAL colours of constant chromaticness *C**=20 and lightness *L**=20, 30, 40, 50, 60, 70, 80, *H**=180 (green) in the system CPRsa (colorimetric PR, normalization to *Y*=100, system adapted)

http://o2.ps.bam.de/INFVM03/7330/E3331-3N.PDF

For all together see the URL

http://o2.ps.bam.de/INFVM03/7330/A4Q7330E.PDF

Purpose of the Series 7320 and 7320

The purpose is to study the SGcode and WGcode and compatibility of different coordinates with the CIELAB spacing.

The RAL color atlas includes about 1.500 color samples produced with automotive glossy paints for CIE illuminant D65, the CIE 10 degree observer (in image science the CIE 2 degree observer is used), and the CIE 45/0 measurement geometry.

The **green** samples (Hue H*=180) are chosen in the series 7320 and 7330, the **red** samples (Hue H*=360) are chosen in the series 7340 and 7350, the **yellow** samples (Hue H*=90) are chosen in the series 7360 and 7370, the **blue** samples (Hue H*=270) are chosen in the series 7380 and 7390.

A study of the *olv** coordinates shows that there are negative values for the **green** samples both in the CPR system (Series 7330, e. g. for *L**=40, *A**=-45 there is *o**=-0.09) and in the CTV system (Series 7320, e. g. for *L**=40, *A**=-45 there is *o**=-0.35). The color *L**=40, *A**=-45, H*=180 is out of the Standard Gamut of both the CPR and CTV system. The **SGcode** is given by *olv**CPR = (-22, 209, 81) and the **WGcode** is given by *olv**CPR = (81, 151, 112), compare the URL:

http://o2.ps.bam.de/INFVM03/7330/E3330-3N.PDF

The CIELAB input data by this figure and the following

http://o2.ps.bam.de/INFVM03/7330/E3330-7N.PDF

differ by only 5 steps is chromaticness C*=-A*.

This allows to look at the **spacing** of the different coordinates.

One must have in mind the perceptive spaces (*color spaces) and the CIE tristimulus value spaces. As an example the following Table 7 for a 16 step equally spaced achromatic series may be used:

Table 7: Lightness and luminance of a 16step equally spaced gray series

Step no.	Lightness *L**	Lightness *l** (relative)	Luminance *L*	Luminance *l* (relative)	
1	1	0	1	0	
2	2	0.066	4	0.066^2=0.004	
3	3	0.133	9	0.133^2=0.017	*Remark: difference=0.013*

8.5	8.5	0.500	72	0.500^2=0.250	*Remark: mean step in L* and L*
15	15	0.933	225	0.933^2=0.870	
16	16	1.000	256	1.000^2=1.000	*Remark: difference=0.130*

For a 16step lightness scale with equidistant steps in the CIELAB space the difference in relative lightness is 0.066. if we assume a square function relationship between lightness *L** and luminance *L* then in the tristimulus value space there is a luminance difference of 3=4-1 for the first two steps and 31=256-225 for the last two steps. The ratio is more than 1:10 and increases:

1. for the CIELAB system which includes the cube instead of the square function
2. if one changes or more steps from 16 to 32 steps or 64 steps.

For the **green** RAL colors the mean changes are in the **red** coordinates *o*, RsRGB, R´sRGB*. The *RsRGB* coordinate is defined in a tristimulus value space and the coordinates *o** and *R´sRGB* are defined in a *color space.

The following Table 8 lists data from the above to URLs (E3330-3N.PDF and E3330-7N.PDF):

Table 8: Relationship of the green RAL colours between CIELAB and *olv and *sRGB* coordinates**

Coordinates in CIELAB, *olv** and *sRGB* spaces					differences for chroma *C** and *C**-5		
Lightness	Chroma	SGcode	linear	*color	SGcode	linear	*color
*L**	*C**	*o**	*R*sRGB	*R´*sRGB	*o**	*R*sRGB	*R '*sRGB
90	-10	201	0.611	0.800	-13	-0.075	-0.04
80	-30	119	0.213	0.049	-13	-0.056	-0.06
70	-40	66	0.043	0.23	-13	-0.041	-0.09
60	-50	10	-0.057	-0.74	-15	-0.029	0.37
50	-50	-12	-0.065	-0.84	-12	0.021	0.27
40	-45	-22	-0.047	-0.061	-15	0.015	0.19
30	-36	-22	-0.024	-0.31	-15	0.010	0.13
20	-20	-2	-0.001	-0.01	-9	0.006	-0.07

The calculated *o** code shows variations between 9 and 15 (Factor 3:5=60%).

The calculated RsRGB code shows variations between 0.006 and -0.075 (Factor 1:12=1200%).

The calculated R´sRGB code shows variations between 0.07 and 0.37 (Factor 1:5=500%)

The change of sign has not been considered.

Conclusion from study of green RAL colors for the relationship between CIELAB, *olv and *sRGB*:**
The coordinate *o** is the only one which approximately includes a linear relationship compared to the CIELAB variation of 5 steps in chromaticness *C**. It is not only important to have a fixed relationship between chroma and the coordinate – **the spacing must be proportional for an effective coding**. This is not true for the *R*sRGB and *R´*sRGB coordinate of IEC 61966-2-1. Variations of more than a factor 10 are expected for the tristimulus value coordinate *R*sRGB for a 16step series (see Table 1 above). Here we get a variation of a factor 1:12.
It seems **not appropriate** to use the tristimulus *RGB* data or the *color data RGB´ of the sRGB colour system to code the colour in images. The *color space olv* is much more efective compared to the sRGB color spaces

Remark: New studies about e-sRGB (proposed draft IEC 61966-2-0) have not been done yet. The e-sRGB space needs more than 8 bit (12 bit) and image data in e-sRGB are therefore incompatible with nearly all software producs.

Series 7340/50 (red), Series 7360/70 (yellow), Series 7380/90 (blue)
These series are similar to the Series 7320 and 7330. The RAL green colors (hue H*=180) are changed to the RAL red colors (hue H*=360), to the RAL yellow colors (hue H*=90), and to the RAL blue colors (hue H*=270.

The Technical Reports 7110, 7120, 7130, 7140, 7150, 7160, 7170, 7180, 7190 include similar data. The SGcode (Standard Gamut) *olv*, cmy*, nru** and WGcode (Wide Gamut 88-166) *olv*, cmy** is calculated for the device adapted coordinates *L**CIEda, *A**CIEda, *B**CIEda. See for instance the technical report:

See for instance the technical report:

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

or one example;

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

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

These technical reports include all important basic transformations in colour systems PR18sa (L*=18-95), TV18sa (L*=18-95), CPR (colorimetric PR, L*=0-100), and CTV (Colorimetric TV, L*=0-100). The series 7180 and 7190 show transformations to the *sRGB* tristimulus value and the *sRGB** perceptive *colour space.

The Technical Reports 7210, 7220, 7230, 7240, 7250, 7260, 7270, 7280, 7290 include similar data. The SGcode (Standard Gamut) *olv*, cmy*, nru** and WGcode (Wide Gamut 88-166) *olv*, cmy** is calculated for the device adapted coordinates *L**CIEda, *A**CIEda, *B**CIEda. See for instance the technical report:

See for instance the technical report:

http://o2.ps.bam.de/INFVM03/7210/BAM7210E.PDF

or one example;

http://o2.ps.bam.de/INFVM03/7210/A4Q7210E.PDF

http://o2.ps.bam.de/INFVM03/7210/A4Q7210E.PS

These technical reports include all important basic transformations in colour systems PR18sa (L*=18-95), TV18sa (L*=18-95), CPR (colorimetric PR, L*=0-100), and CTV (Colorimetric TV, L*=0-100). The series 7210 to 7290 show transformations to the *sRGB* tristimulus value and the *sRGB** perceptive *colour space.

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)