



Efficient Lighting for the 21st Century, Varna (BG), 2006-6-31

Device dependent colour appearance output on printers and monitors based on *relative* CIELAB colorimetry and ISO/IEC 24705

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Efficient Lighting for the 21st Century, Varna (BG), 2006-6-31

paper presented by:

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For many ISO/IEC-test charts and other publications see the URL

<http://www.ps.bam.de>

of the Working Group “Visual methods and image reproduction”

For this paper see (18 pages, 1 Mbyte)

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Overview

- **ISO/IEC-test charts according to ISO/IEC TR 24705**
- **Colour coordinates used in Image Technology**
- **Colour coordinates of Colour Order Systems**
- **PDF Format as Colour Document Standard**
- **PDF Files for a Colour Compatibility Test**
- **Absolute and *relative* CIELAB data LAB^* and lab^***
- **Definiton of device dependent rgb^* coordinates**
- **Definiton of device independent rgb^* coordinates**
- **Applications of the rgb^* coordinates**
- **16 step equally spaced monitor and printer output**

Summary

Figure 1: ISO/IEC-test chart for the test of monitor or printer output

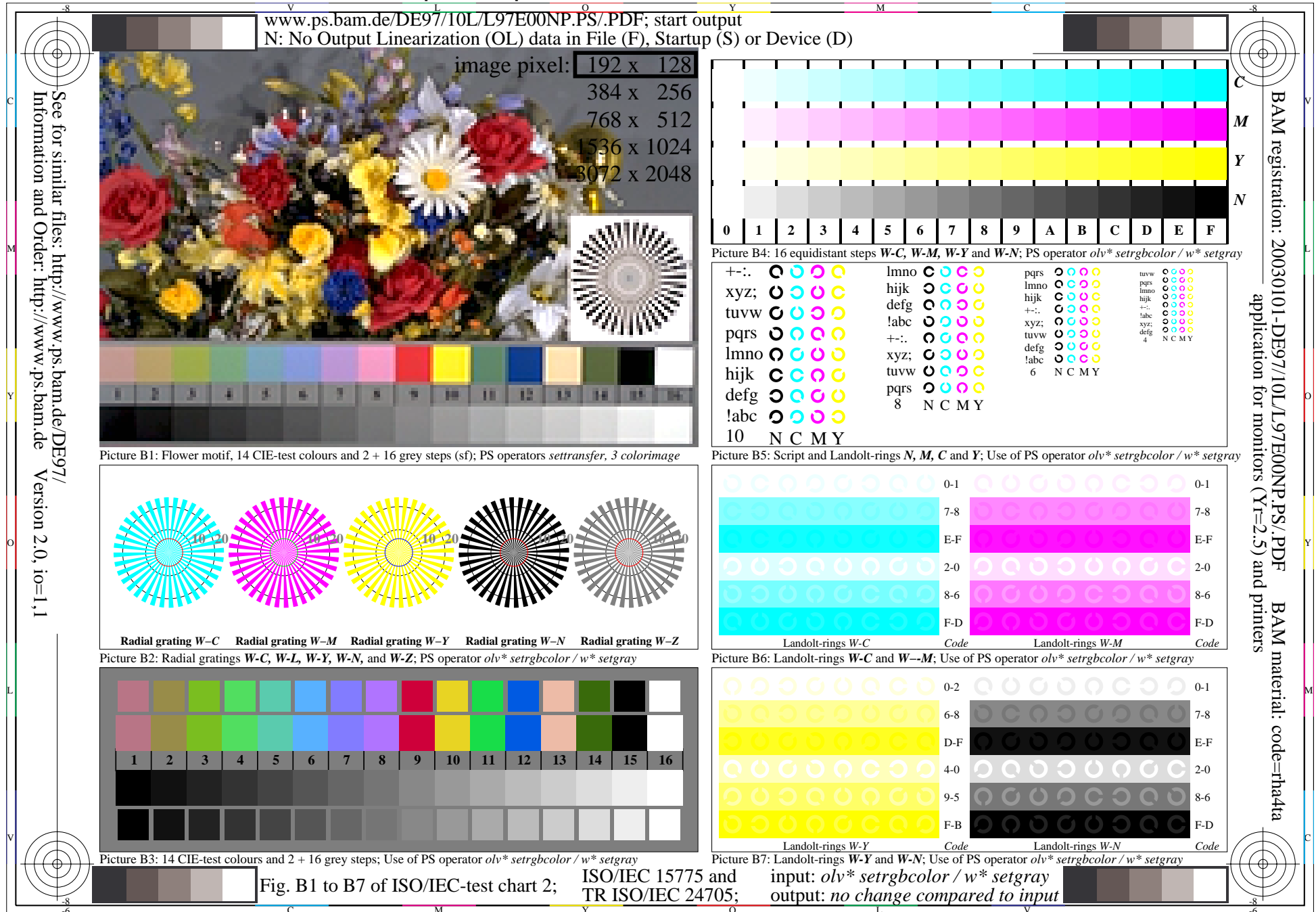
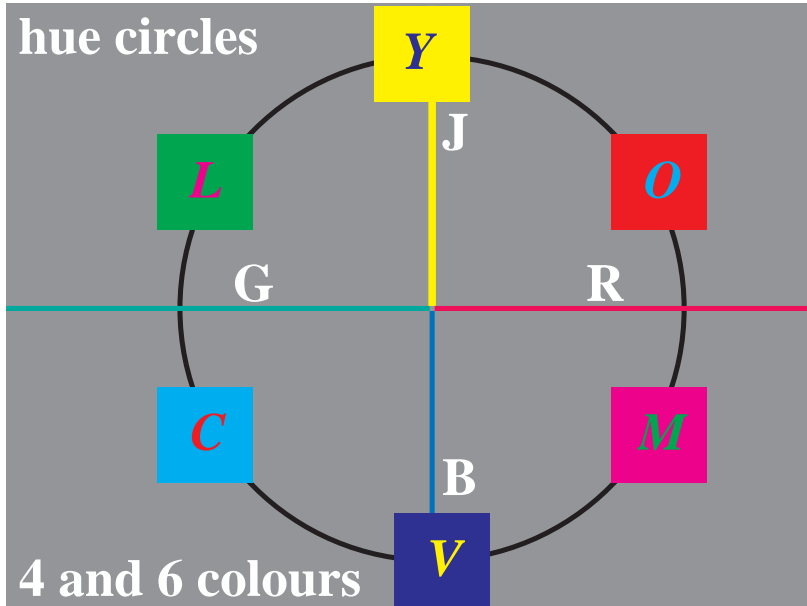
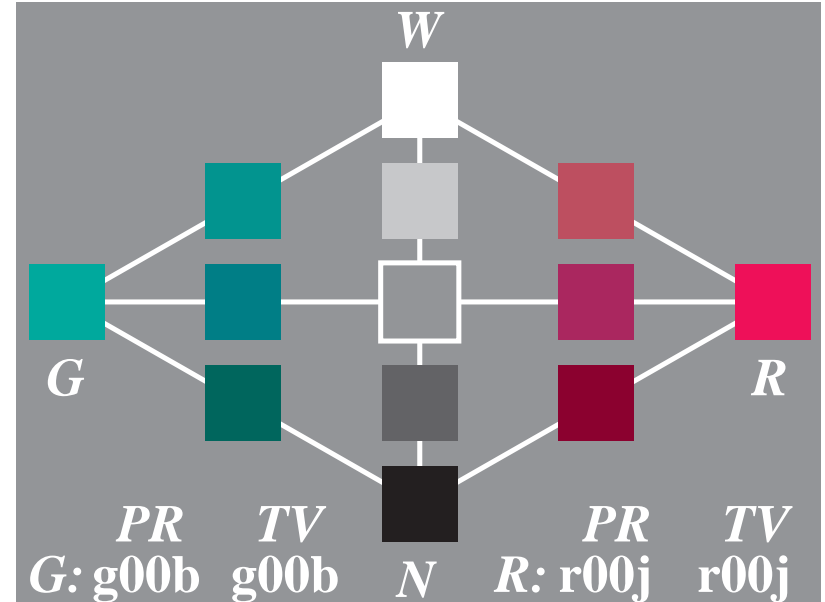


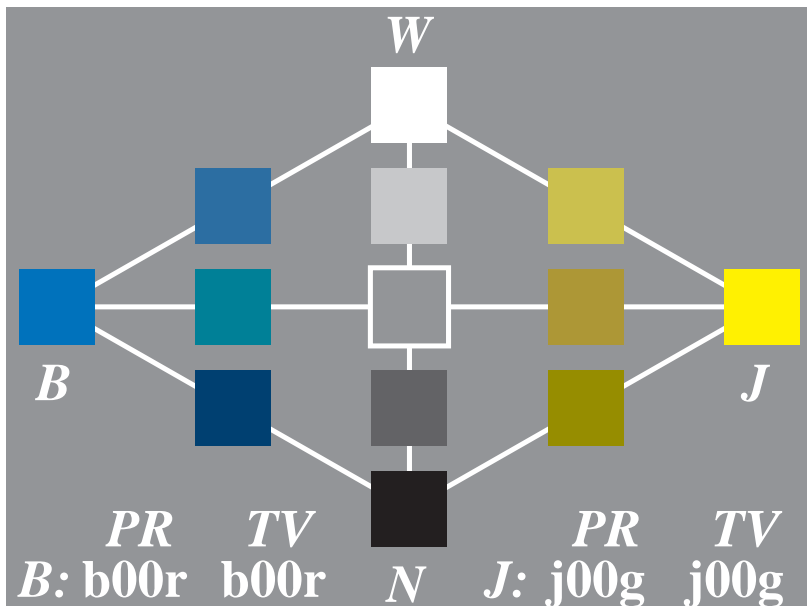
Figure 2: Colour Circle, Colour Double Cone and Colour Hexagon



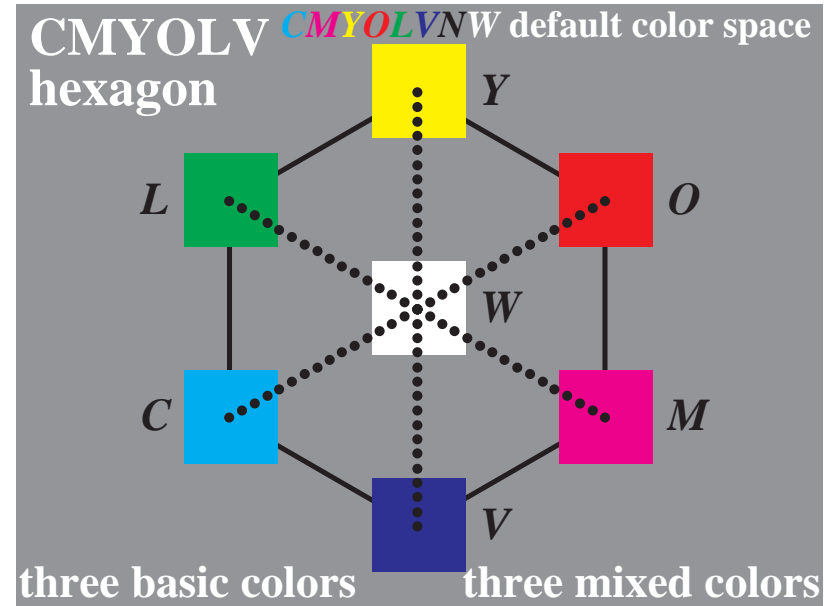
LE410-3, 4 and 6 colours in hue circle



LE410-7, Double cone: Hue planes R and G



LE410-8, Double cone: Hue planes J and B



LE410-1, 16 step colours in regular hexagon

Figure 3: Colour order Systems and Colorimetric Image Technology (CIT)

Application of colour in daily life or in Information Technology (IT):

Design, architecture, art, industrial products
Measured for CIE standard illuminant D65
colour order system: name and coordinates

RAL Design System (CIELAB):
*LCH**, lightness, chroma, hue

Munsell Colour System:
*VCH**, lightness (Value), Chroma, Hue

Natural Colour System (NCS):
*nce**: blackness, chromaticness, elementary hue

Information technology of printers
Measured for CIE illuminant D65 or D50
Device system name and coordinates:

Printer system (illuminant D65 or D50):
cmY, content of "cyan", "magenta", "yellow"

Display system (standard illuminant D65):
rgb/sRGB, content of "red", "green", "blue"

IT colour coordinates confuse the users!
Nearly no connection to colour order systems!

New: Application connection by coordinates *olv, *cmY**, *tce**, ... und linear relation to *LAB****

CIELAB: *LAB** : lightness, red-green and yellow-blue chroma; *LCH** : lightness, chroma, hue

Definition of *relative* device coordinates similar to coordinates of colour order systems

*lab*lch*: relative lightness *l**, chromaticness, Bunttheit *c**, hue *h**

*lab*lch*, *lab*tce*: triangle lightness *t**, chromaticness, Bunttheit *c**, hue or elementary hue *h**, *e**

*lab*nce*: blackness *n**, chromaticness *c**, elementary hue *e**

*lab*olv₃ = rgb**: orange-red *o₃**, leaf-green *l₃**, violet-blue *v₃**

Figure 4: Colorimetric coordinates for W – N and W – C

5 steps of grey series black - white (N - W)	Colour space, colour space coordinates and PostScript operator calculations according to ISO/IEC 15775:1999-12			
Linear mixture between black and white in CIELAB colour space	L^* CIE $w^* = l^*$ <i>setgray</i>	CMYN (CMYK) $000n^*$ <i>setcmykcolor</i>	CMYN (CMYK) $cmy0^*$ <i>setcmykcolor</i>	OLV (RGB) www^* <i>setrgbcolor</i>
1,00 N + 0,00 W (black N)	0,00	0,00 0,00 0,00 1,00	1,00 1,00 1,00 0,00	0,00 0,00 0,00
0,75 N + 0,25 W	0,25	0,00 0,00 0,00 0,75	0,75 0,75 0,75 0,00	0,25 0,25 0,25
0,50 N + 0,50 W	0,50	0,00 0,00 0,00 0,50	0,50 0,50 0,50 0,00	0,50 0,50 0,50
0,25 N + 0,75 W	0,75	0,00 0,00 0,00 0,25	0,25 0,25 0,25 0,00	0,75 0,75 0,75
0,00 N + 1,00 W (white W)	1,00	0,00 0,00 0,00 0,00	0,00 0,00 0,00 0,00	1,00 1,00 1,00

LE420–1, colorimetric relationship of w^* , $000n^*$, $cmy0^*$, www^* for a 5 step scale: black – white

5 steps of colour series cyan blue - white (C - W)	Colour space, colour space coordinates and PostScript operator calculations according to ISO/IEC 15775:1999-12		
Linear mixture between cyan blue and white in CIELAB colour space	CIELAB absolute $LAB^*LAB = LAB^*$ LAB^* <i>setcolor</i>	CIELAB relative $lab^*cmy0 = cmy0^*$ $cmy0^*$ <i>setcmykcolor</i>	CIELAB relative $lab^*olv = olv^*$ olv^* <i>setrgbcolor</i>
1,00 C + 0,00 W (cyan blue C)	58.62 -30.62 -42.74	1,00 0,00 0,00 0,00	0,00 1,00 1,00
0,75 C + 0,25 W	67.82 -23.21 -30.86	0,75 0,00 0,00 0,00	0,25 1,00 1,00
0,50 C + 0,50 W	77.02 -15.80 -18.98	0,50 0,00 0,00 0,00	0,50 1,00 1,00
0,25 C + 0,75 W	86.21 -8.39 -7.11	0,25 0,00 0,00 0,00	0,75 1,00 1,00
0,00 C + 1,00 W (white W)	95.41 -0.98 4.76	0,00 0,00 0,00 0,00	1,00 1,00 1,00

LE421–1, colorimetric relationship of LAB^*a , $cmy0^*$, olv^* for a 5 step scale: cyan blue – white

Figure 5: Compatibility test

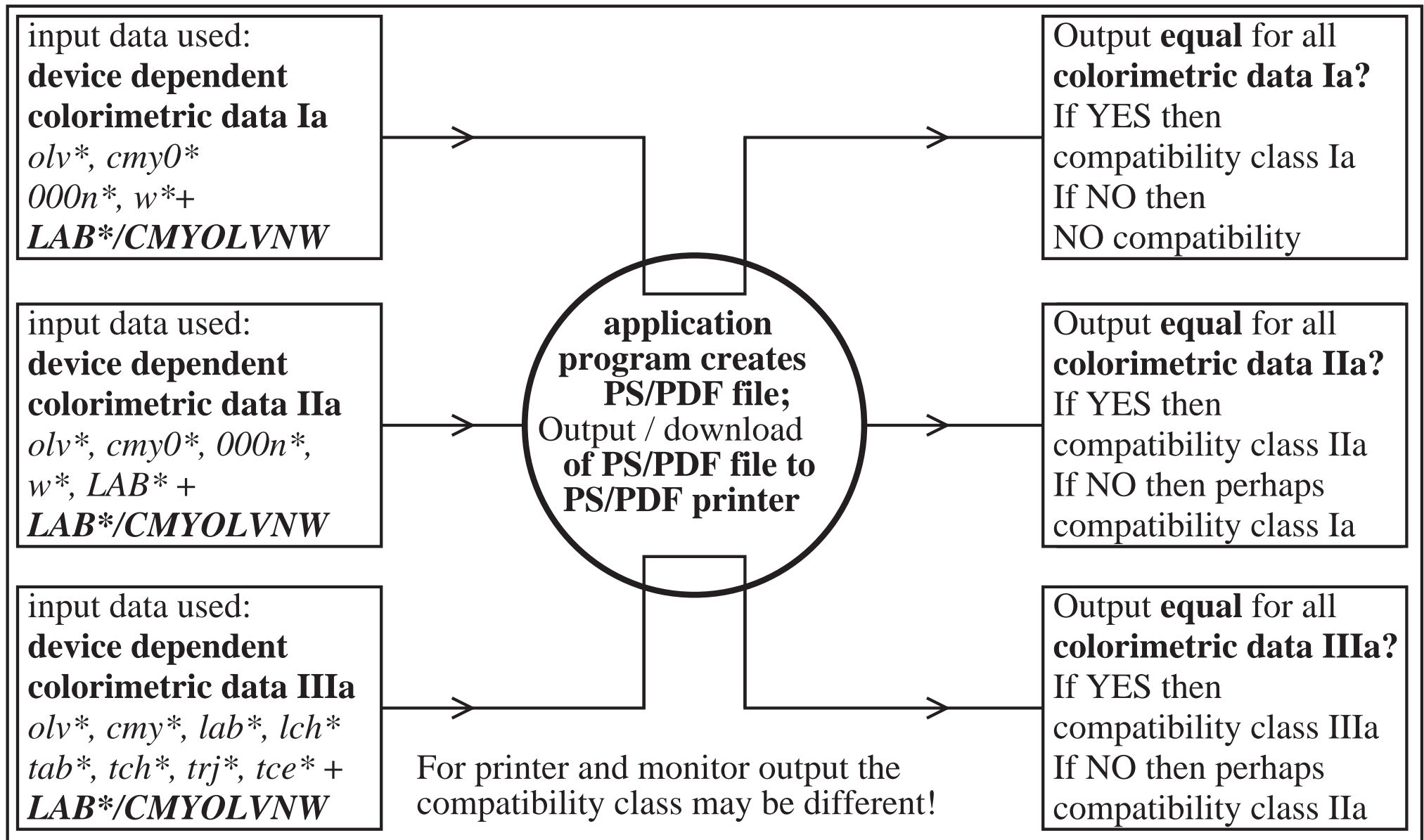


Figure 6: 16 step grey scale for compatibility test

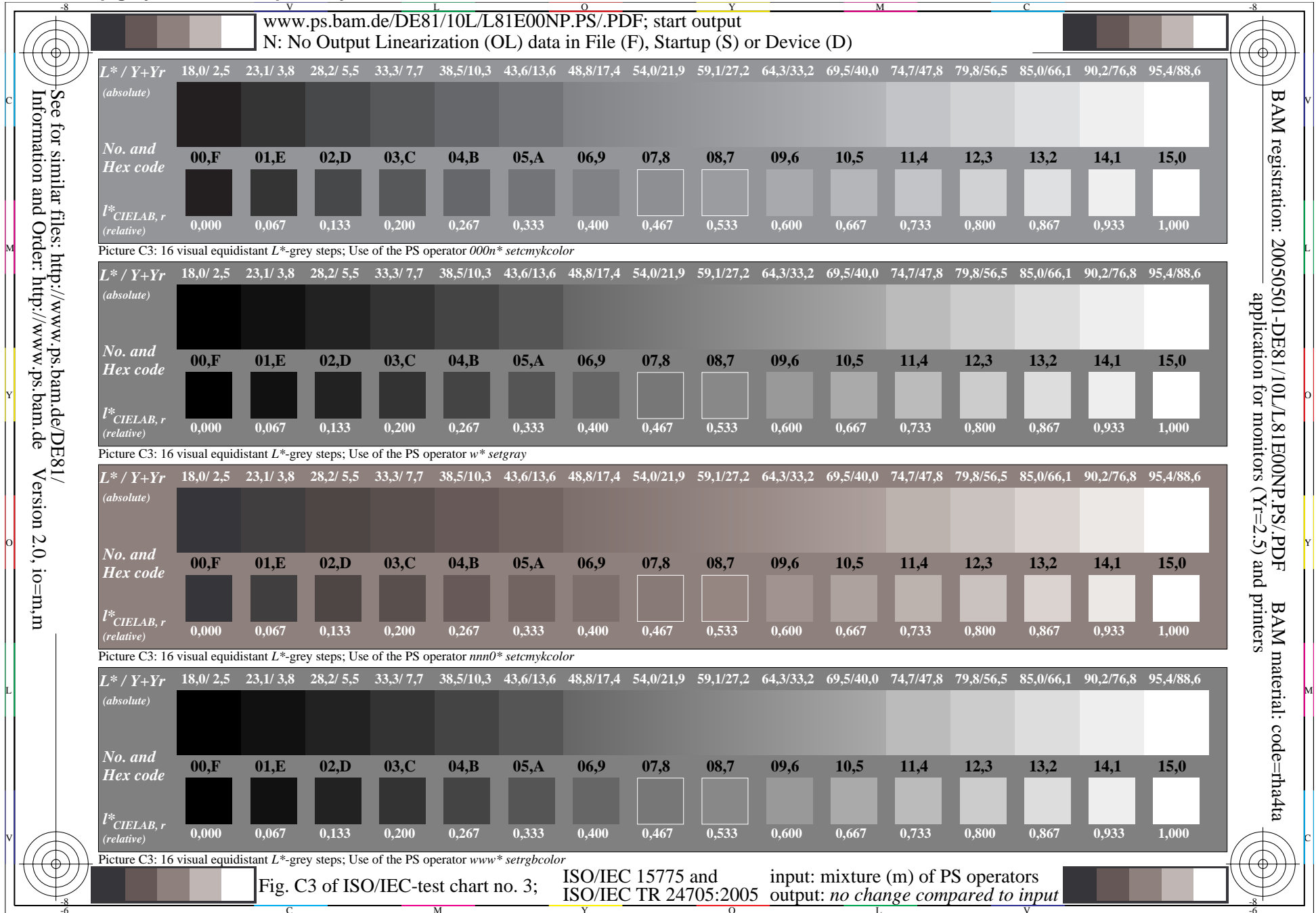
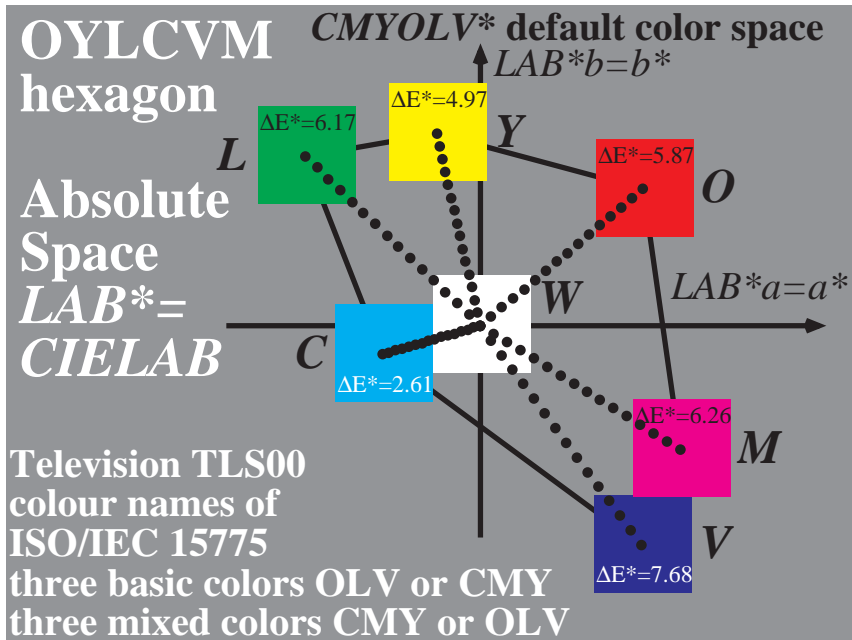
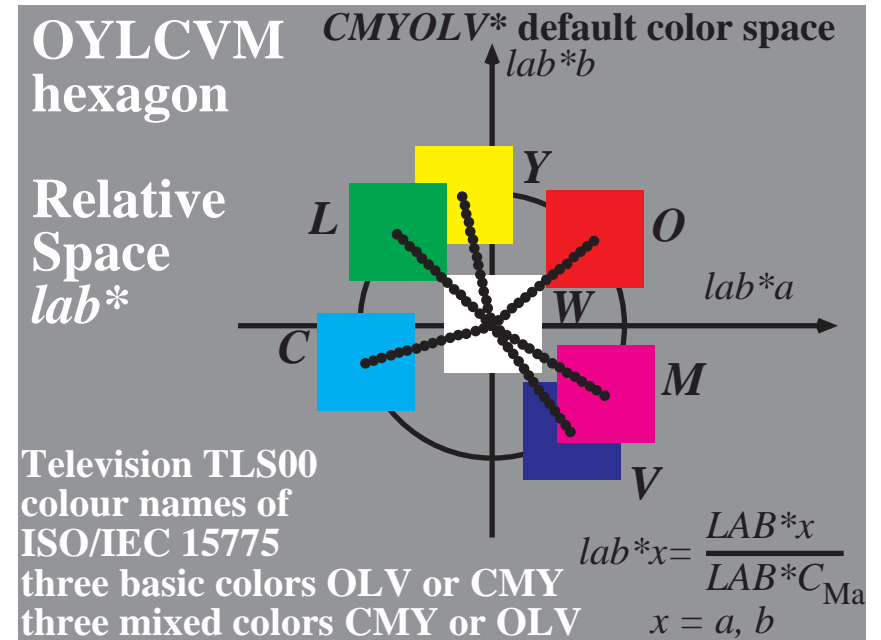


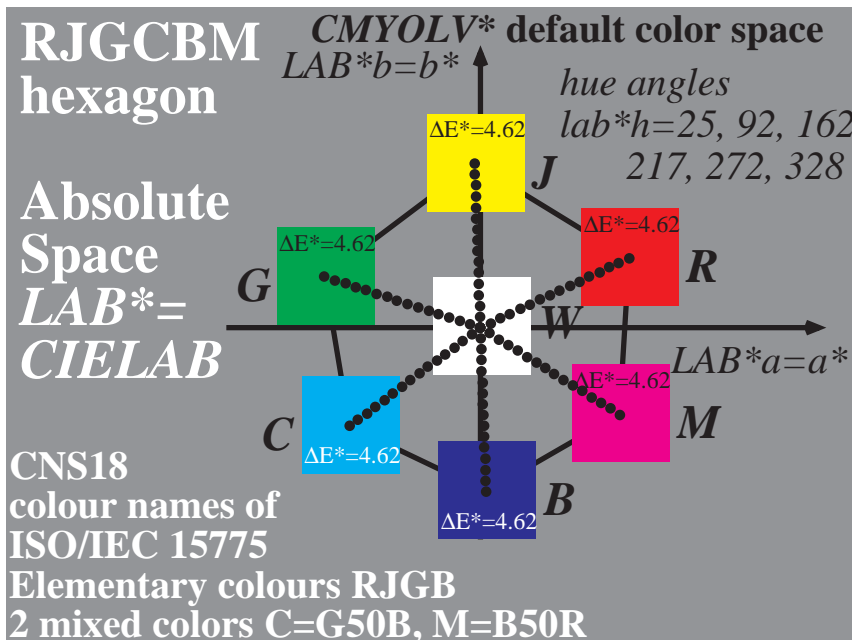
Figure 7: CIELAB (a*, b*) diagram for TLS00 and CNS18



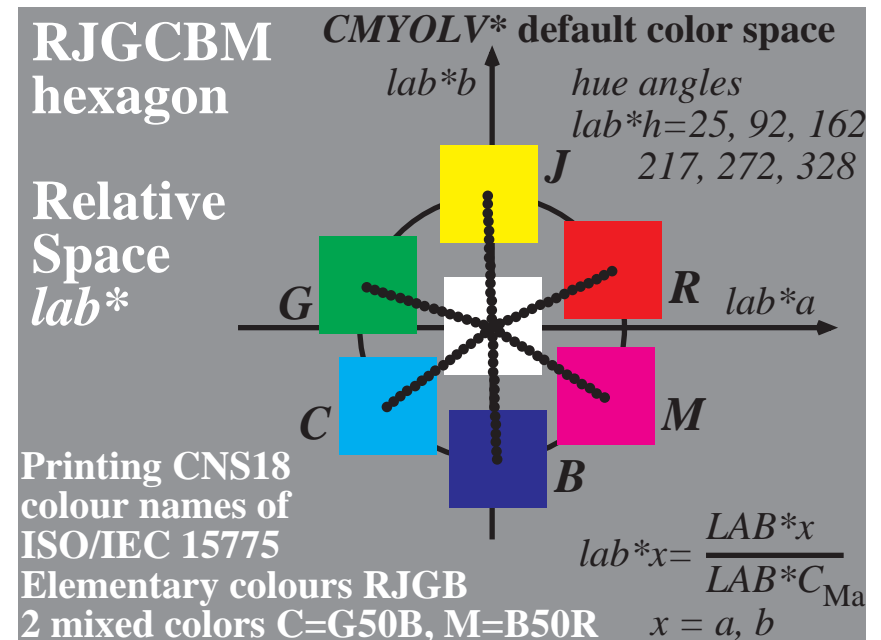
VE800-21



VE800-41

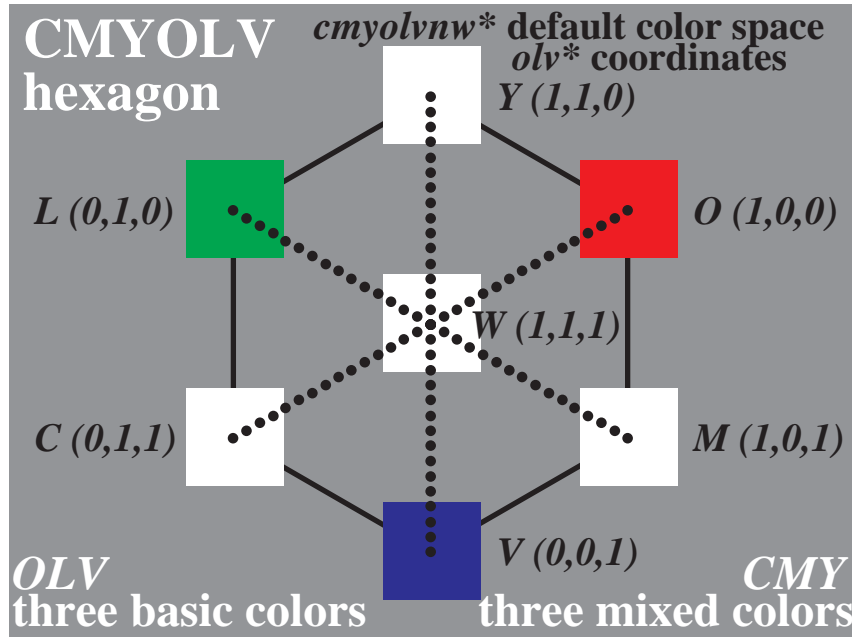


VE800-61

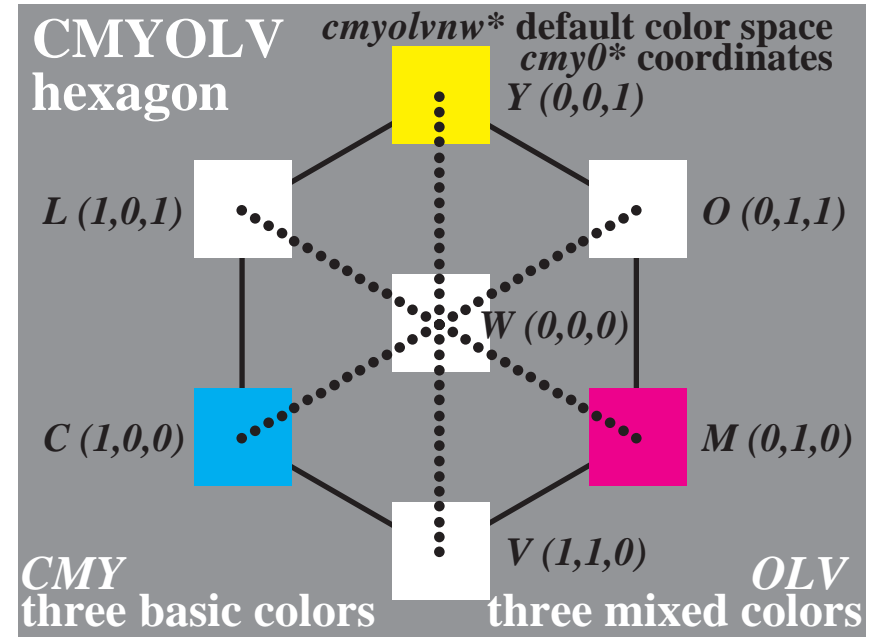


VE800-81

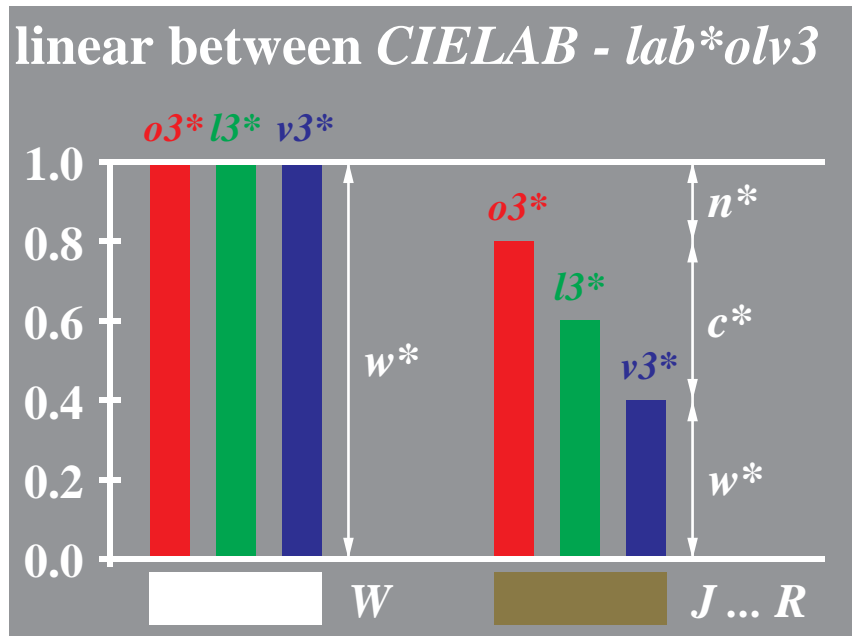
Figure 8: 1-minus relation of olv^* and cmy^* coordinates and examples



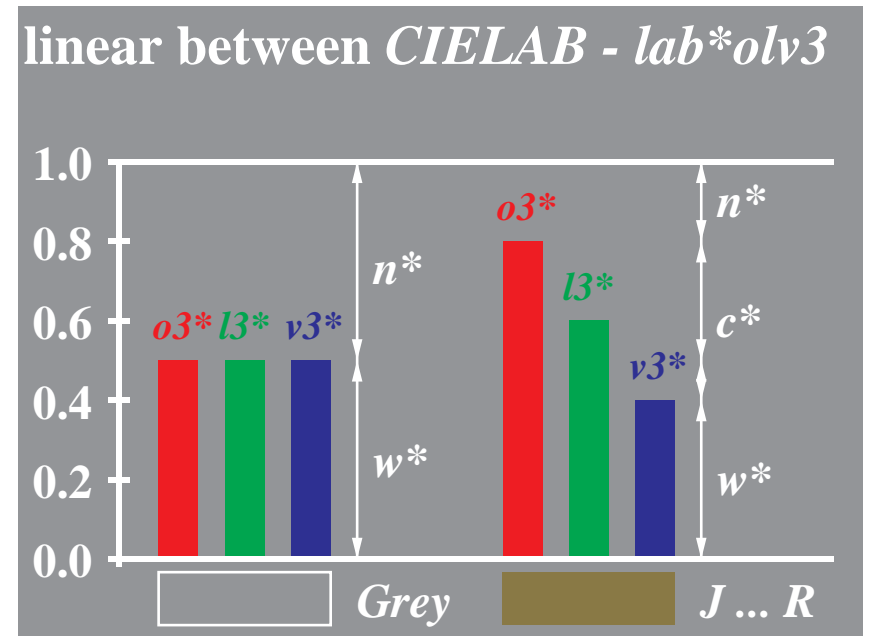
ME301-11



ME301-21



VE801-71



VE801-81

Figure 9: Regular hexagon and linear relation between CIELAB and olv*

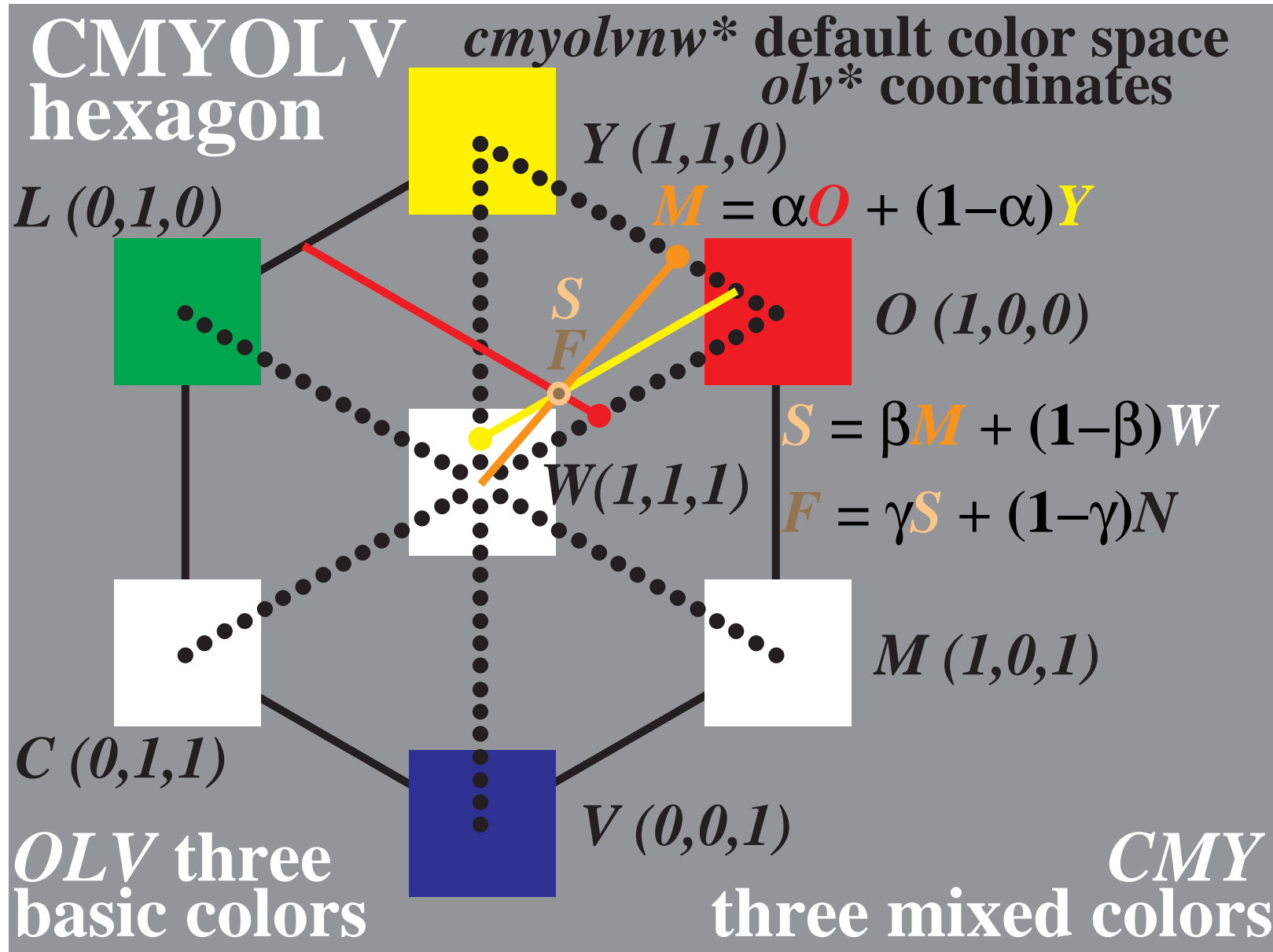
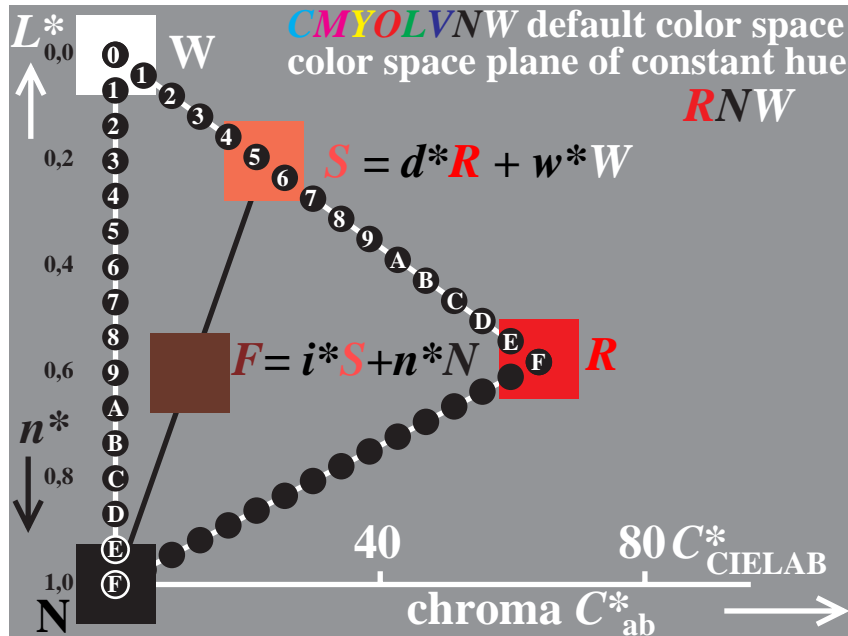
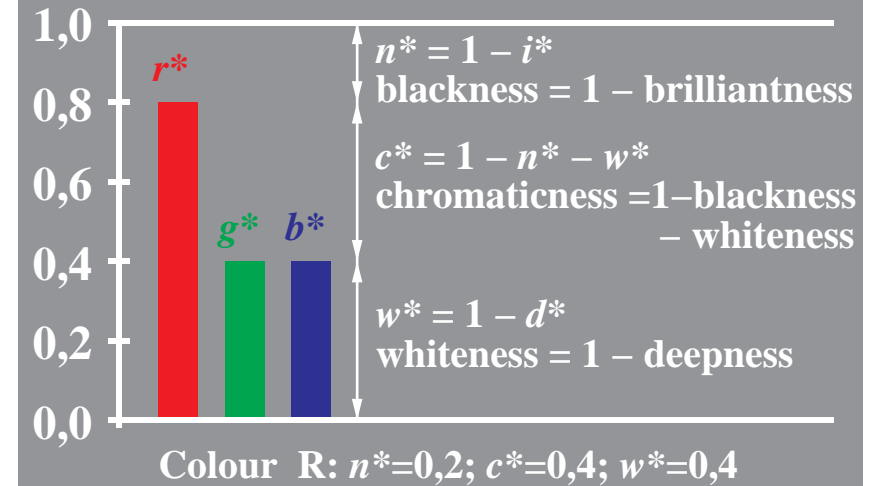


Figure 10: Mixture of Red R with White W and Black N; rgb* coordinates)



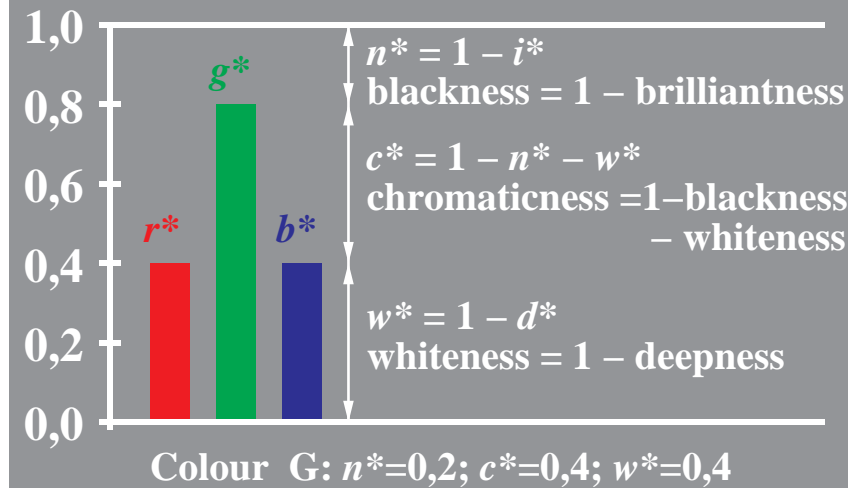
VE801-61

Elementary (unique) hue Red R: linear relation of n^* , i^* , c^* , w^* , d^*



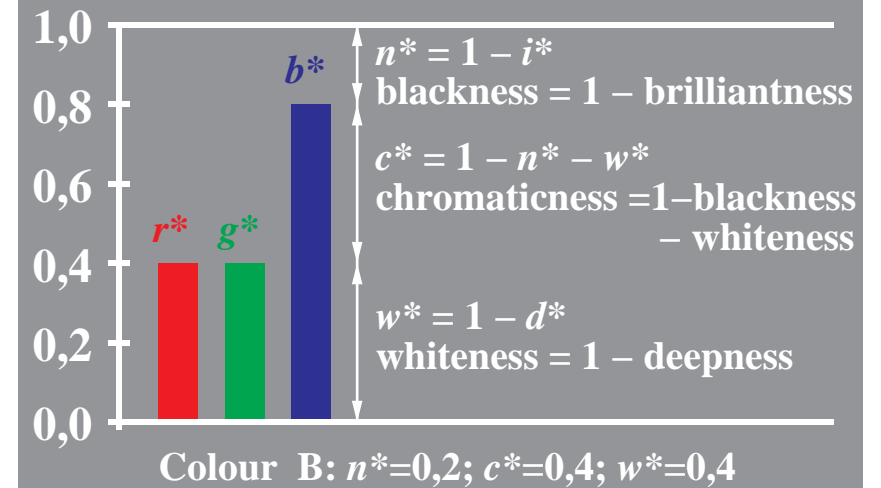
VE801-21

Elementary (unique) hue Green G: linear relation of n^* , i^* , c^* , w^* , d^*



VE801-31

Elementary (unique) hue Blue B: linear relation of n^* , i^* , c^* , w^* , d^*



VE801-41

Figure 11: Relation olv* and CIELAB data

<i>relative Inform. Technology (IT)</i>				
<i>olvi3*</i>	0.0	1.0	0.0	(1.0)
<i>cmyn3*</i>	1.0	0.0	1.0	(0.0)
<i>olvi4*</i>	0.0	1.0	0.0	1.0
<i>cmyn4*</i>	1.0	0.0	1.0	0.0
<i>standard and adapted CIELAB</i>				
<i>LAB*LAB</i>	56.7	-73.59	23.91	
<i>LAB*LABa</i>	56.7	-73.59	23.91	
<i>LAB*TCHa</i>	50.0	77.38	162.0	
<i>relative CIELAB lab*</i>				
<i>lab*lab</i>	0.5	-0.95	0.309	
<i>lab*tch</i>	0.5	1.0	0.45	
<i>lab*nch</i>	0.0	1.0	0.45	
<i>relative Natural Colour (NC)</i>				
<i>lab*lrj</i>	0.5	-0.999	0.005	
<i>lab*tce</i>	0.5	1.0	0.499	
<i>lab*ncE</i>	0.0	1.0	j99g	

Figure 12: Change of device olv^* coordinates to produce intended rgb^* colours)

<i>relative</i> Inform. Technology (IT)			
$olvi3^*$	0.0	1.0	0.375 (1.0)
$cmyn3^*$	1.0	0.0	0.625 (0.0)
$olvi3^{*'} $	0.135	0.724	0.305 (1.0)
$cmyn3^{*'} $	0.865	0.276	0.695 (0.0)
<i>standard and adapted</i> CIELAB			
LAB^*LAB	42.59	-49.68	12.65
LAB^*LABa	42.59	-48.66	15.82
LAB^*TCHa	50.0	51.18	162.0
<i>relative</i> CIELAB lab^*			
lab^*lab	0.424	-0.95	0.309
lab^*tch	0.5	1.0	0.45
lab^*nch	0.0	1.0	0.45
<i>relative</i> Natural Colour (NC)			
lab^*lrj	0.424	-0.997	-0.059
lab^*tce	0.5	1.0	0.51
lab^*ncE	0.0	1.0	g03b

Figure 13: Device hue V and Elementary hue B output

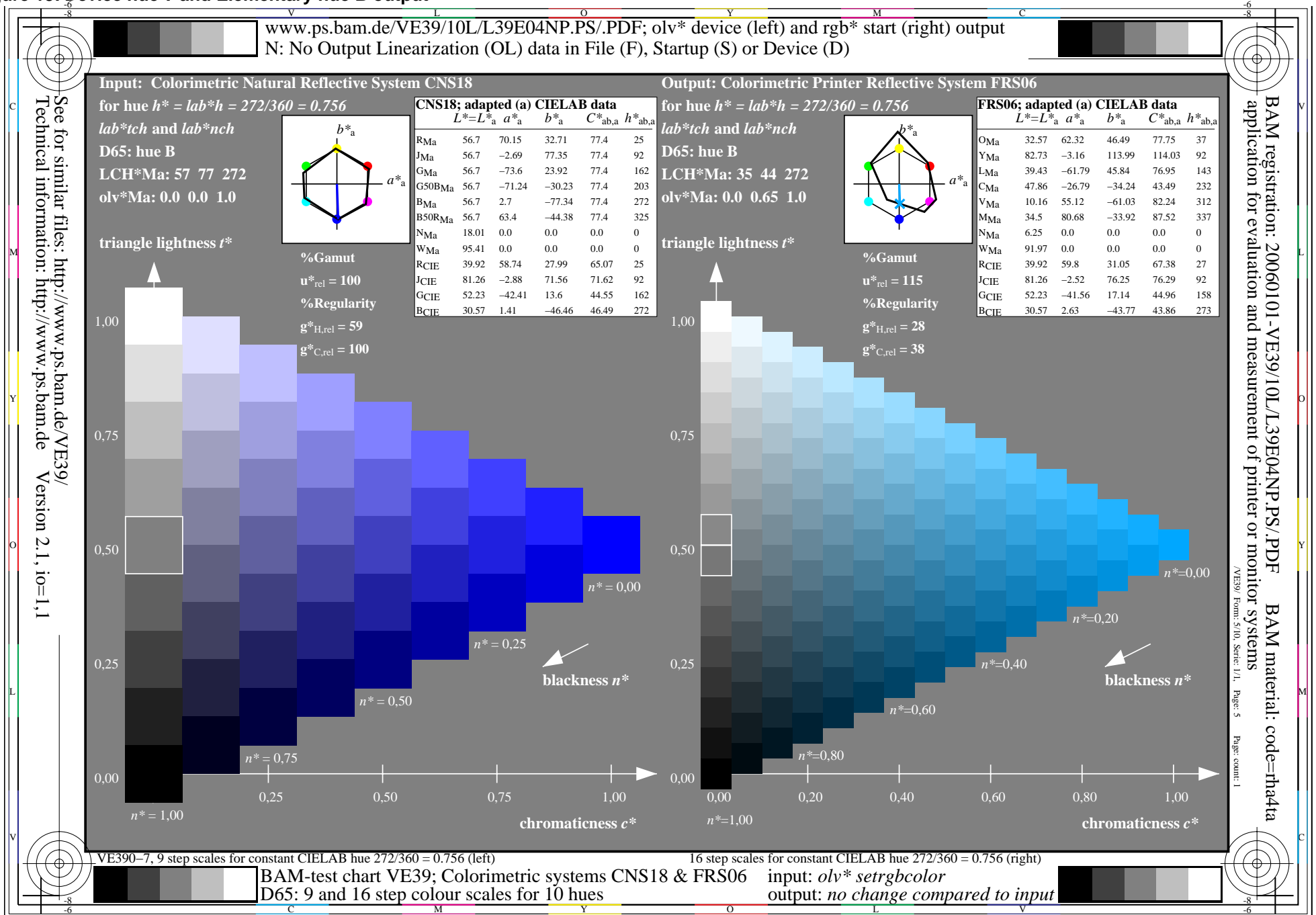
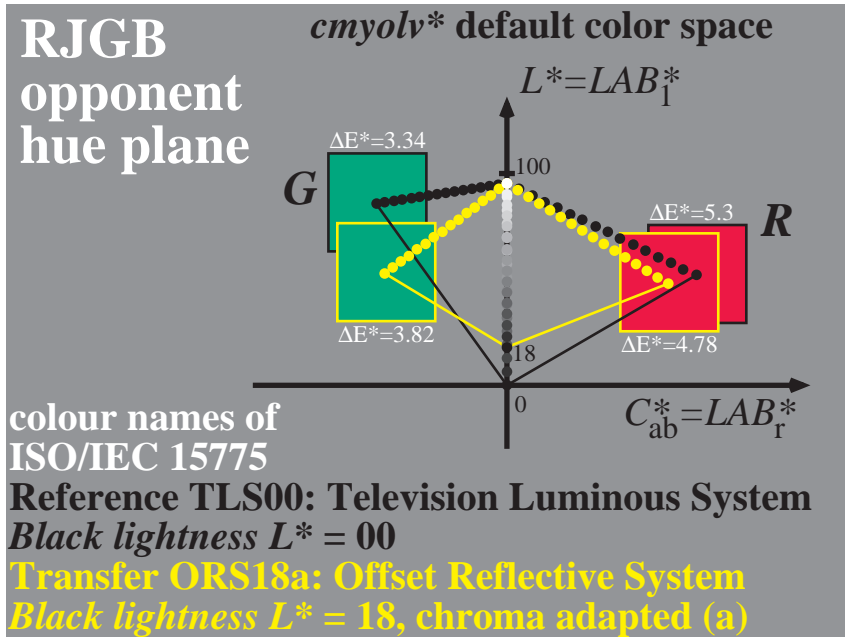
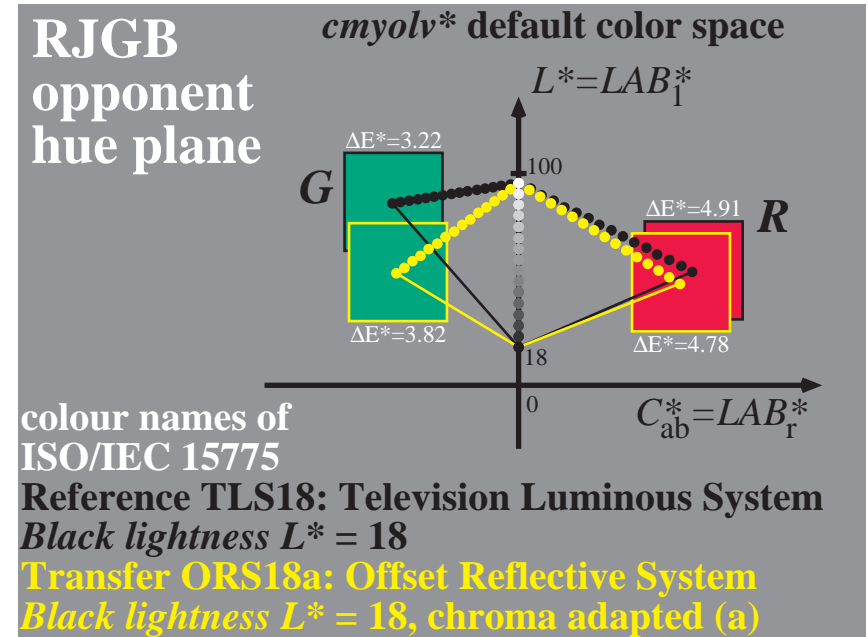


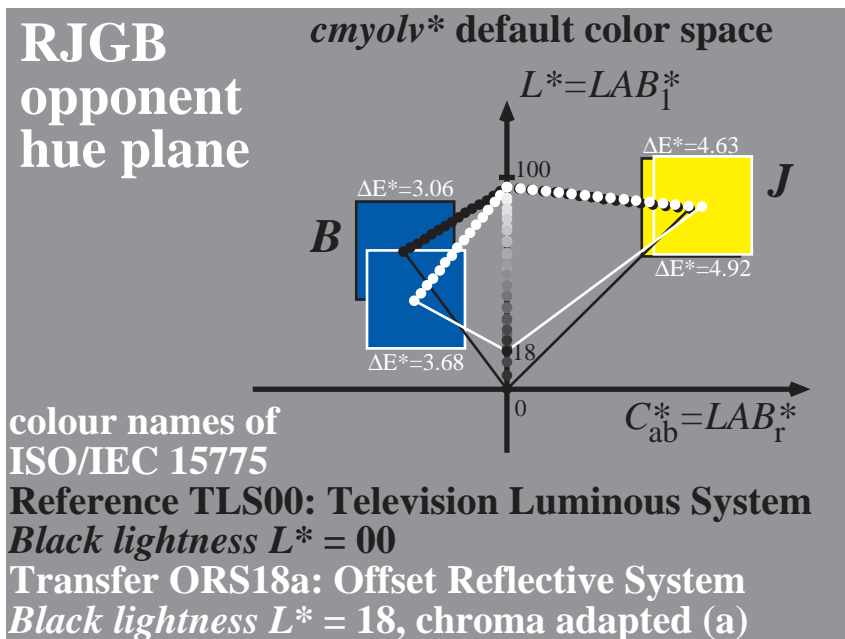
Figure 14: C*-L* diagram for output on monitors and printers)



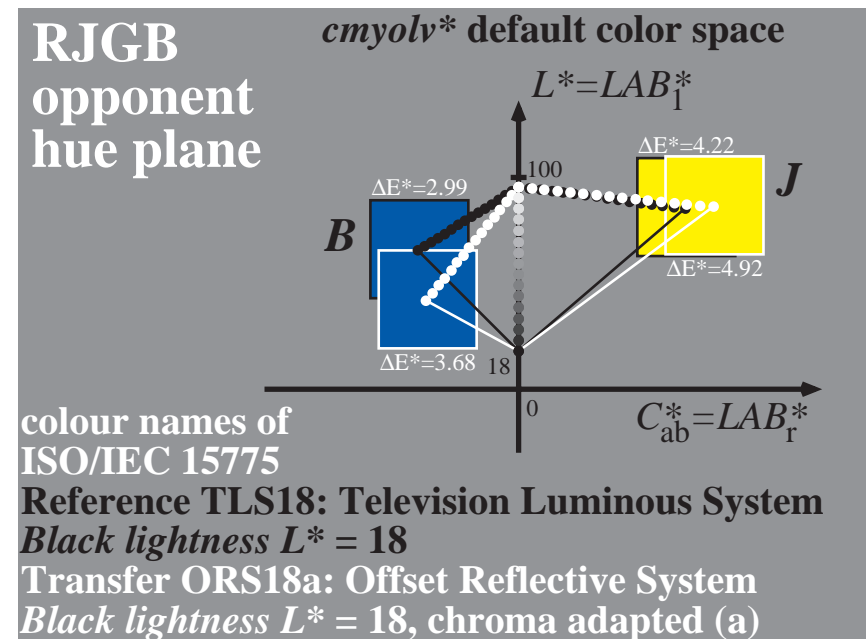
BE331-51



BE331-61



BE331-71



BE331-81

Summary

- Missing connection between *rgb/cmy* coordinates of Image Technology (IT) and colour order systems
- A Colorimetric Image Technology (CIT) is needed
- Definition of relative colorimetric data *lab**
- *lab*olv = olv** and *lab*rgb = rgb** data
- Relation of *olv** and *rgb** to CIELAB
- *olv** input and output of device dependent hues
- *rgb** input and output of device independent hues
- 16 step equal spacing in CIELAB of device output
- 16 step equal spacing on monitors and printers
- Relative device dependent colour appearance

Standards, Technical Reports and other References

The author was active as a leader for the standards [1] to [3] and was editor of the International documents [4] to [6].

[1] **DIN 33870:2000**: Requirements and tests for the remanufacturing of used toner modules black for electrophotographic printers, copiers and fax machines (Anforderungen und Prüfungen für die Aufbereitung von gebrauchten Tonermodulen schwarz für electrophotographische Drucker, Kopierer und Fernkopierer)

[2] **DIN 33871-1:2003**: Requirements for remanufacturing of used inkjet heads and inkjet tanks of inkjet printers (Aufbereitung von gebrauchten Tintendruckköpfen und Tintentanks für Tintenstrahldrucker)

[3] **DIN 33866-1 bis 5:2000**: Information technology – Office machines – Machines for colour image reproduction: Method for specifying image reproduction of colour devices by digital and analog test charts, This standard includes analog DIN-test charts no. 1 to 4.

[4] **ISO/IEC 15775:1999**; 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

[5] **ISO/IEC TR 19797:2004**, Information technology - Device output of 16-step colour scales, output linearization method (LM) and specification of the reproduction properties, ISO/IEC JTC1/SC28 (21pages)

[6] **ISO/IEC TR 24705:2005**, Method of specifying image reproduction of colour devices by digital and analog test charts, (79 pages)

[7] Richter, K. (2004), Natural colour connection space (NCCS) between input and output for office systems, International Semina on Information Office Equipment Standardization, Korean Agency for Technology and Standards, pages 71-92, see the URL (1.4 MByte, 27 pages)

<http://www.ps.bam.de/BAMAG1.PDF>

[8] Richter, K. (2005), Linear relationship between CIELAB and device coordinates for Colorimetric Image Technology (CIT), see the URL (140 kByte, 6 pages)

<http://www.ps.bam.de/CIE05.PDF>

[9] Richter, K. (2005), Material efficiency for image output on colour printers. For an English version see the URL (6 pages, 88 kByte)

<http://www.ps.bam.de/UBAE05.PDF>

[10] Richter, K. (2005), Visual efficiency for image output on colour monitors, For an English version see the URL (10 pages, 1..4 MByte)

<http://www.ps.bam.de/VISE05.PDF>

[11] Richter, K. (2006), CIELAB definition and application of device independent *rgb** colour coordinates for output of elementary colours, see the URL (1 page, 20 kByte)

<http://www.ps.bam.de/ISCC06.PDF>

[12] Richter, K. (2005), Relative Colour Image Technology (RCIT) and RLAB lab* (2005) Colour Image Encoding, see (73 pages, 900 kByte)

<http://www.ps.bam.de/RLABE05.PDF>

Remark: For further publications and analog and digital BAM-, DIN-, CEN- and ISO/IEC-test charts, see (> 1 Million connections / year since 2002) and many similar figures compared to the figures used in this paper:

<http://www.ps.bam.de/WE.HTM>