Trends for CIE-ISO-colour standards for input and output of all colour devices with relative CIELAB colour coordinates *rgb**

for this publication see: http://130.149.60.45/~farbmetrik/CIE_TC42_DFWG_14.PDF

Summary

DIN 33872-1 to 6 was published in 2010 and comes with test charts on CD for part 1 to 6, and in internet, see http://www.ps.bam.de/33872E. The output properties of these test charts are tested visually for the *softcopy* (display, projector) and the *hardcopy* (printer, offset, photographic) output.

For example the ISO committees TC159/SC4/WG2 *Visual display requirements* and ISO/IEC SC28 *Office systems* have asked the standard bodies CIE Division 1 and 8 by different resolutions between 2009 and 2014 to work on a visual human *RGB* colour space. The trends in standardization to such a colour space for example by different the CIE Reportership Reports R1-47, R1-57 and R8-09 are described. The advantages for example to solve the visual user wishes of DIN 33872-1 to -6 by colorimetry are given and may influence this CIE development.

DIN 33872-1 to -6 and ouput dependence on colour workflow

In the DIN standard series DIN 33872-1 to -6 there is **no** statement that the output properties according to DIN-user wishes are **required**. However, many companies may consider how to *solve* the DIN-user wishes as an ***option*** for applications.

If one studies the user whishes then it is realized soon, that the *workflow* between the file and the output has at least four sources which usually support and sometimes block the user whishes. For example:

- the computer operating system
- the application software
- the device driver
- the hard- and software of the device

Therefore the workflow output of the test charts of DIN 33871-1 to -6 can either support the user wishes or block them.
The individual source of the problem may not be detected, because only the final output of a workflow with different components is studied.

For the output, the main questions and user wishes are:

- Is the output visually *equally spaced* for equally spaced *rgb* data *(Y/N)?* *(compare Fig. 1)*
- Are the *elementary* hues produced for the given *rgb* values *(Y/N)?* *(compare Fig. 2)*

Example outputs of test charts and trends for CIE-ISO standards

The following pages show two output examples of two DIN-test charts according to DIN 33872-2 and -5.

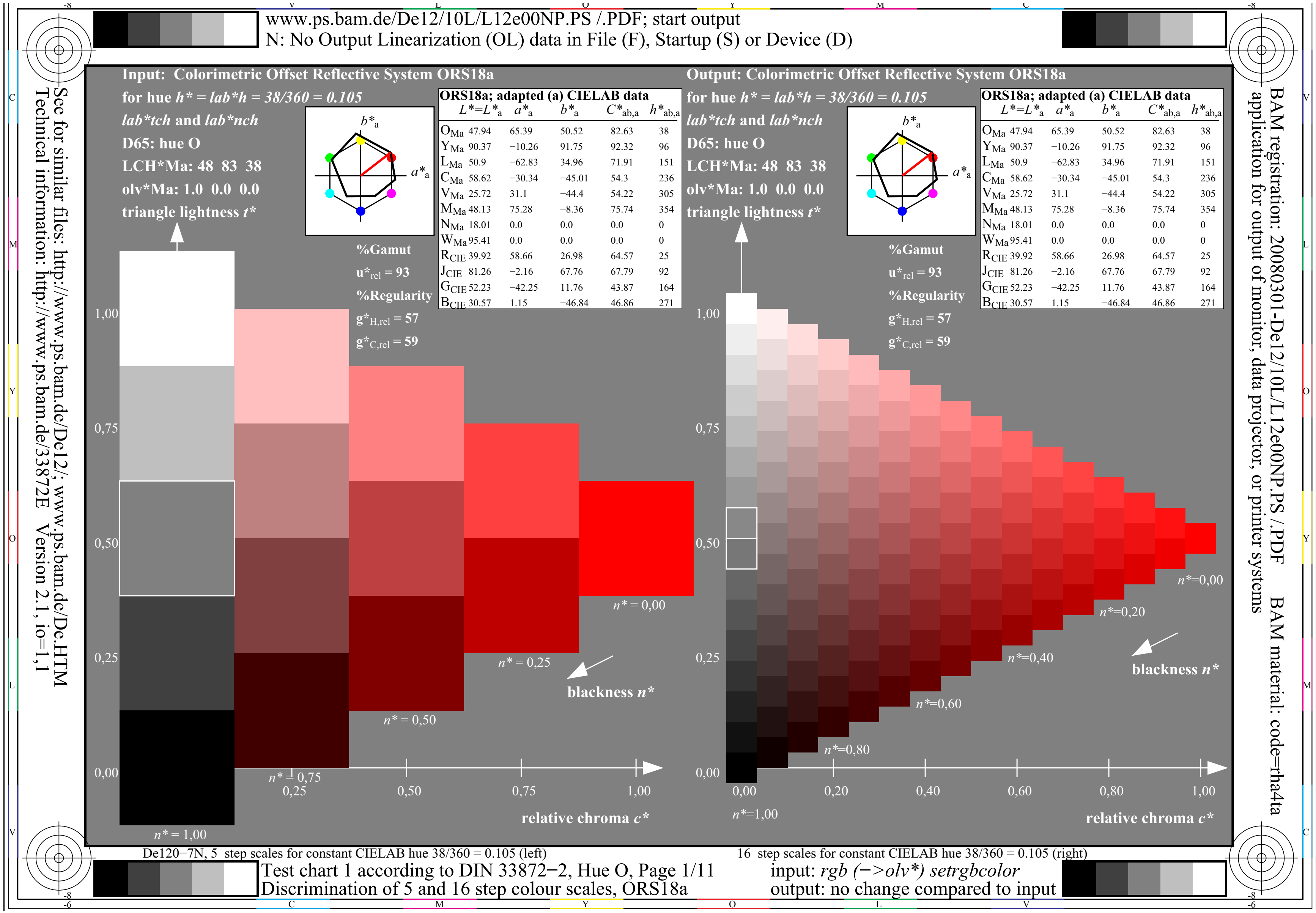
In addition each output example produces questions, see

http://www.ps.bam.de/33872E

in a DIN-form to be answered by the user.

Only visual evaluation is necessary to answer the DIN-questions.

The use of colour measurement equipment is an *option* to support colorimetric answers, for example in real office colour applications. More standardization is needed for these colorimetric *option*.



ORS18a; adapted (a) CIELAB data

	$L^*=L^*_a$	a^*_a	b^*_a	$C^*_{ab,a}$	$h^*_{ab,a}$
O_{Ma}	47.94	65.39	50.52	82.63	38
Y_{Ma}	90.37	−10.26	91.75	92.32	96
L_{Ma}	50.9	−62.83	34.96	71.91	151
C_{Ma}	58.62	−30.34	−45.01	54.3	236
V_{Ma}	25.72	31.1	−44.4	54.22	305
M_{Ma}	48.13	75.28	−8.36	75.74	354
N_{Ma}	18.01	0.0	0.0	0.0	0
W_{Ma}	95.41	0.0	0.0	0.0	0
R_{CIE}	39.92	58.66	26.98	64.57	25
J_{CIE}	81.26	−2.16	67.76	67.79	92
G_{CIE}	52.23	−42.25	11.76	43.87	164
B_{CIE}	30.57	1.15	−46.84	46.86	271

ORS18a; adapted (a) CIELAB data

	$L^*=L^*_a$	a^*_a	b^*_a	$C^*_{ab,a}$	$h^*_{ab,a}$
O_{Ma}	47.94	65.39	50.52	82.63	38
Y_{Ma}	90.37	−10.26	91.75	92.32	96
L_{Ma}	50.9	−62.83	34.96	71.91	151
C_{Ma}	58.62	−30.34	−45.01	54.3	236
V_{Ma}	25.72	31.1	−44.4	54.22	305
M_{Ma}	48.13	75.28	−8.36	75.74	354
N_{Ma}	18.01	0.0	0.0	0.0	0
W_{Ma}	95.41	0.0	0.0	0.0	0
R_{CIE}	39.92	58.66	26.98	64.57	25
J_{CIE}	81.26	−2.16	67.76	67.79	92
G_{CIE}	52.23	−42.25	11.76	43.87	164
B_{CIE}	30.57	1.15	−46.84	46.86	271

Fig 1: *Equally spaced colour test* with test chart according to DIN 33872-2
Question: Produce the equally spaced *rgb* values equally spaced output series (Y/N) ?

Trends for CIE-ISO-colour standards for input and output of all colour devices

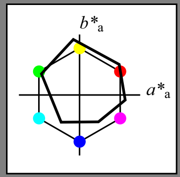
www.ps.bam.de/De15/10L/L15e00NP.PS /.PDF; start output
N: No Output Linearization (OL) data in File (F), Startup (S) or Device (D)

See for similar files: http://www.ps.bam.de/De15/; www.ps.bam.de/De.HTM
Technical information: http://www.ps.bam.de/33872E Version 2.1, io=1,1

BAM registration: 20080301-De15/10L/L15e00NP.PS /.PDF
application for output of monitor, data projector, or printer systems
BAM material: code=rha4ta

Input: Colorimetric Offset Reflective System ORS18a

with *rgb* data of the four elementary hues
1 0 0 = Red *R*
1 1 0 = Yellow *J*
0 1 0 = Green *G*
0 0 1 = Blue *B*

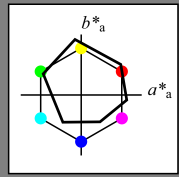


ORS18a; adapted (a) CIELAB data

	$L^*=L^*_a$	a^*_a	b^*_a	$C^*_{ab,a}$	$h^*_{ab,a}$
O_{Ma}	47.94	65.39	50.52	82.63	38
Y_{Ma}	90.37	−10.26	91.75	92.32	96
L_{Ma}	50.9	−62.83	34.96	71.91	151
C_{Ma}	58.62	−30.34	−45.01	54.3	236
V_{Ma}	25.72	31.1	−44.4	54.22	305
M_{Ma}	48.13	75.28	−8.36	75.74	354
N_{Ma}	18.01	0.0	0.0	0.0	0
W_{Ma}	95.41	0.0	0.0	0.0	0
R_{CIE}	39.92	58.66	26.98	64.57	25
J_{CIE}	81.26	−2.16	67.76	67.79	92
G_{CIE}	52.23	−42.25	11.76	43.87	164
B_{CIE}	30.57	1.15	−46.84	46.86	271

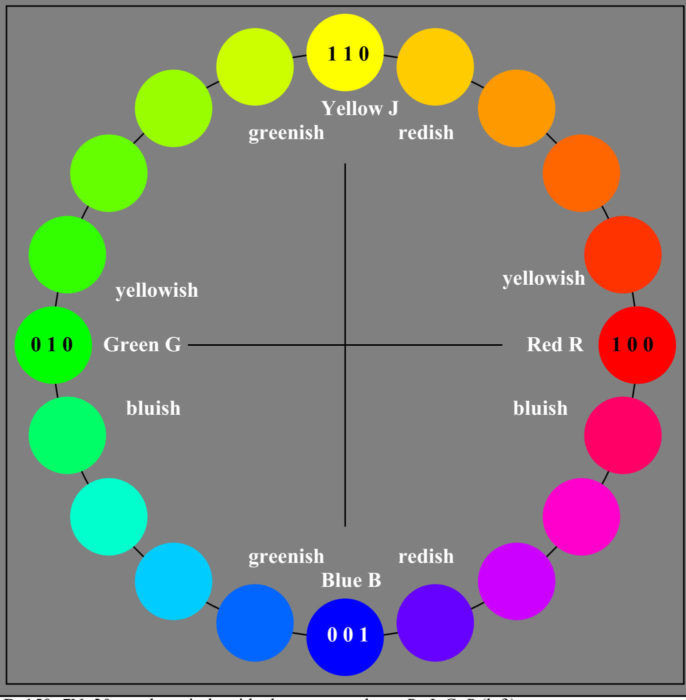
Output: Colorimetric Offset Reflective System ORS18a

with hue number
***n*= 00 to 19**
00 = Red *R*
05 = Yellow *J*
10 = Green *G*
15 = Blue *B*

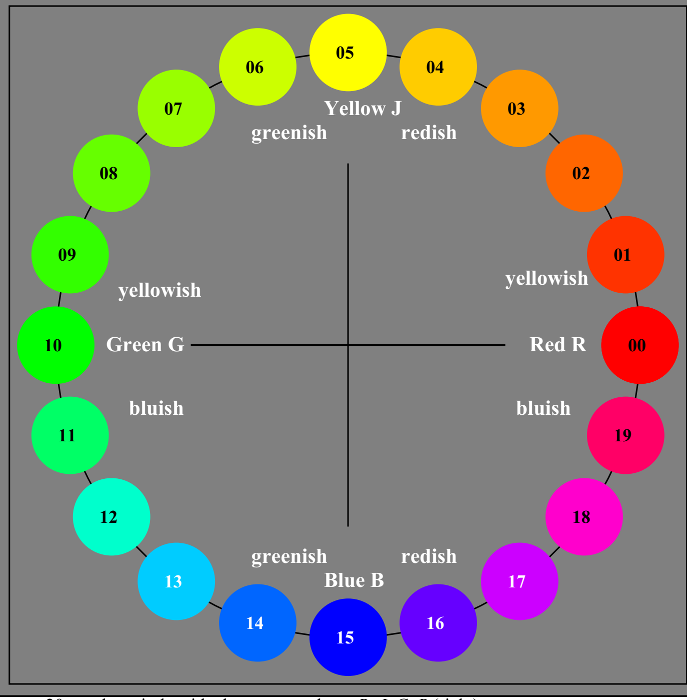


ORS18a; adapted (a) CIELAB data

	$L^*=L^*_a$	a^*_a	b^*_a	$C^*_{ab,a}$	$h^*_{ab,a}$
O_{Ma}	47.94	65.39	50.52	82.63	38
Y_{Ma}	90.37	−10.26	91.75	92.32	96
L_{Ma}	50.9	−62.83	34.96	71.91	151
C_{Ma}	58.62	−30.34	−45.01	54.3	236
V_{Ma}	25.72	31.1	−44.4	54.22	305
M_{Ma}	48.13	75.28	−8.36	75.74	354
N_{Ma}	18.01	0.0	0.0	0.0	0
W_{Ma}	95.41	0.0	0.0	0.0	0
R_{CIE}	39.92	58.66	26.98	64.57	25
J_{CIE}	81.26	−2.16	67.76	67.79	92
G_{CIE}	52.23	−42.25	11.76	43.87	164
B_{CIE}	30.57	1.15	−46.84	46.86	271



De150−7N, 20 step hue circle with elementary colours *R, J, G, B* (left)



20 step hue circle with elementary colours *R, J, G, B* (right)

Test chart 1 according to DIN 33872−5, Page 1/2
Elementary hue agreement and discrimination, ORS18a

input: *rgb (−>olv*) setrgbcolor*
output: no change compared to input

Fig 2: *Elementary hue output test* with test chart according to DIN 33872-5

Question: Produce the *rgb* values the elementary hues according to visual criteria (Y/N)?

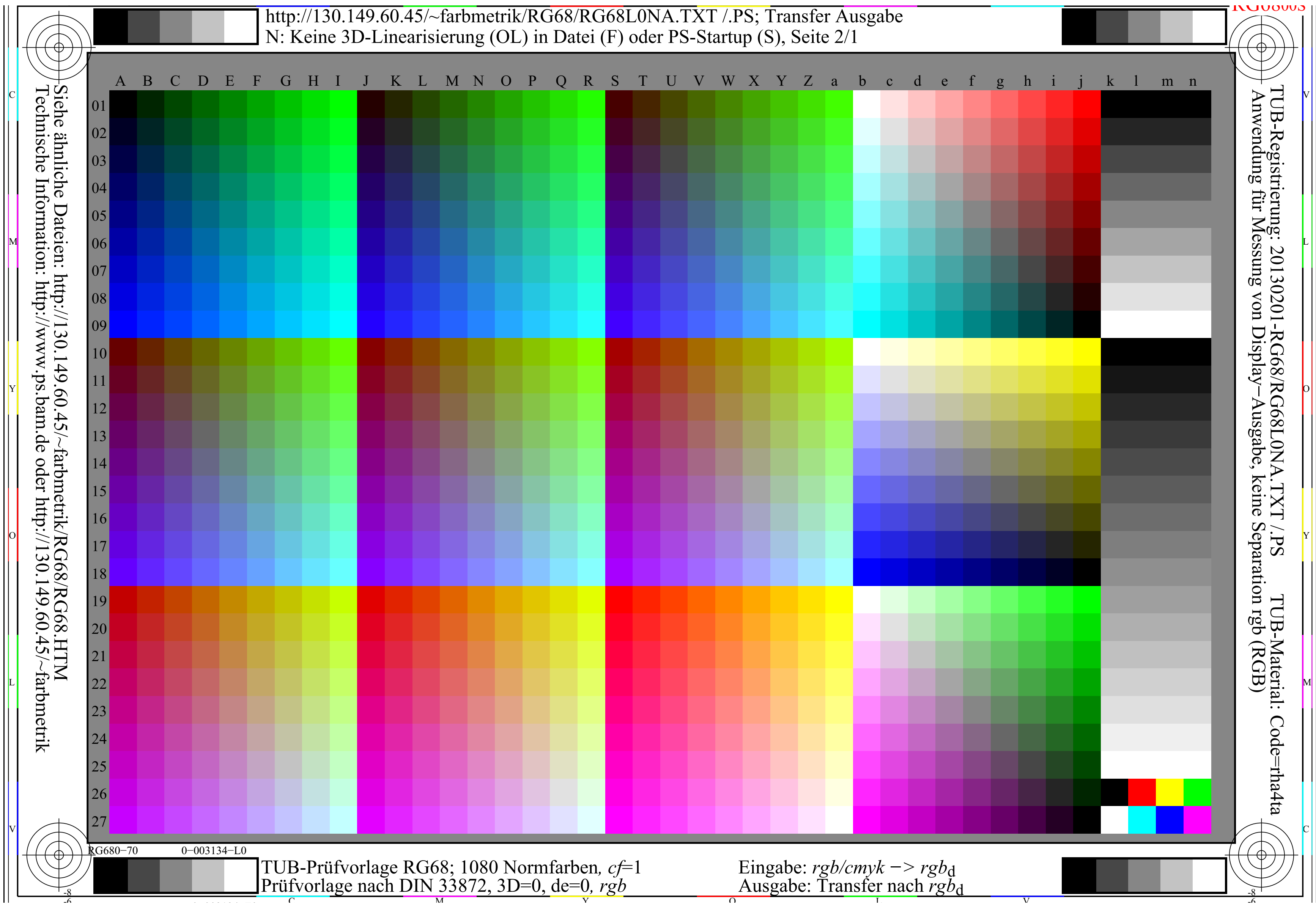


Fig. 3: Test chart according to CIE R8-09 with 1080 colours defined by *rgb* values in file

Fig. 3 includes 1080 colours. A *rgb* colour cube is defined by 729=9x9x9 colours. There is a 48 step hue circle within the 729 colours. In addition oponent hue planes and greys are shown.

Trends for CIE-ISO-colour standards for input and output of all colour devices

Input	Output	Input and output media and applications: Input media	Output media	Application	Technical Report (TR) or Standard	Method & Test: Linearization
–	–	–	–	**Basis**	**ISO/IEC TR 24705**	**DIN 33866−1** **DIN 33872−1**
analog	**analog**	ISO/IEC-file series equally spaced in *rgb* + ISO/IEC-test chart (hardcopy) series equally spaced in *LCh**	Hardcopy	**Copier**	**ISO/IEC 15775**	**DIN 33866−2** **JIS X 6933**
analog	**digital**	ISO/IEC-test chart (hardcopy) series equally spaced in *Lch**	File	**Scanner**	**ISO/IEC TR 24705**	**DIN 33866−4**
digital	**analog**	ISO/IEC-test chart (File) series equally spaced in *rgb*	Hardcopy	**Printer**	**ISO/IEC TR 24705**	**DIN 33866−3** **DIN 33872−2,4**
			Softcopy	**Display**	**ISO/IEC TR 24705** **ISO 9241−306**	**DIN 33866−5** **DIN 33872−2,4**

The ISO/IEC-input linearisation method produces an ISO/IEC-file from an ISO/IEC-original scene:
Flower motiv with 16 equidistant grey steps, and 14 CIE-test colours according to CIE 13.3

The ISO/IEC-output linearisation method produces from an ISO/IEC-file a linearized display, offset or printer output:

ISO/IEC-input linearisation method

Input	Output	Application	Technical Report (TR) or Standard
Original scene + CIE colours	ISO/IEC Image File	Reference Image File	**ISO/IEC 15775** **ISO/IEC TR 24705**

ISO/IEC-output linearisation method

Input	Output media	Application	Technical Report (TR) or Standard
ISO/IEC File	Hardcopy	Printer	**ISO/IEC TR 19797**
ISO/IEC File	Softcopy	Display	**ISO 9241−306** 8 viewing conditions
ISO/IEC File	Softcopy Hardcopy Hardcopy	Display Offset Printer	**CIE R8−09: 2014** device space + device-independent visual RGB* space

SE200−7N

Fig. 4: Standard documents with equally spaced *rgb* and *LCh data for 16-step series**

Fig. 4 includes the connection between many International and National Standard documents.
The colour series have equal spacing in *rgb* in the file and equal spacing in *LCh** in the hardcopy.

Output linearization according to CIE R8-09 and user test according to DIN 33872-1 to -6

Colour device company which produces:
display, data projector, printer, offset machine, ...

Device output of colour test chart according to DIN 33872-X or CIE R8-09 by two options:
option 1: automatic company device output
option 2: output according to CIE R8-09

Linearization company:
Measures 1080 user colours and produces ***linearization code according to CIE R8-09*** in driver or profile for user device

For the test charts of DIN 33872-1 to -6 see
http://www.ps.bam.de/33872E

For english text of DIN 33872 see
http://www.iso.org/scit (docum. N183−189)

For test chart with 1080 colours of CIE R8-09 see
http://130.49.60.45/~farbmetrik/RE68/RE68L0NP.PDF

For more technical information about CIE R8-09 see
http://130.49.60.45/~farbmetrik/outlin

Visual output test for option 1 or 2
with Y/N user questions of DIN 33872-2 to -6
(no colour measurement necessary)

Agrees the output with the user wishes (Y/N)?
If the answer is Yes (Y) then finish.
If No (N) agreement to the user wishes then:
look for a device with properties according to R8-09
or send (printed) output to a **linearization company.**
Get back a device driver or profile which produces an output according to CIE R8-09.

Advantages of Output Linearization:
- Device-independent hue output (CIE R1-47).
- Linear relation between *rgb** and CIELAB data.
- No loss of visual information for 16 step colour series on different colour devices.
- remark: for *rgb** colour specification in device-independent *RGB** colour space see CIE R1-57 & http://www.iso.org/scit (open document N275).

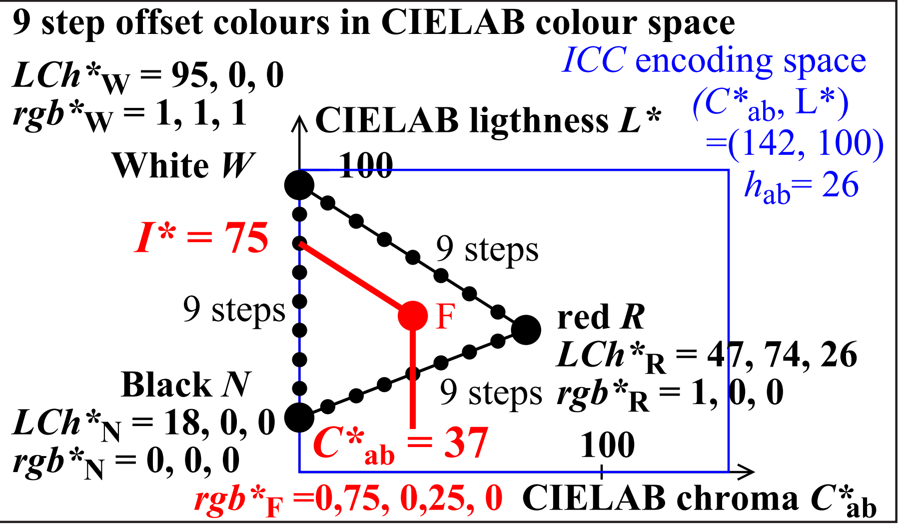
1−003030−L0 TE211−3N

Fig. 5: Output Linearization according to CIE R8-09 to realize user wishes of DIN 33872-X
An automatic device company output, for example by the method of CIE R8-09, or profiles produced for users by *linearization companies* may solve the user wishes of DIN 33872-X.

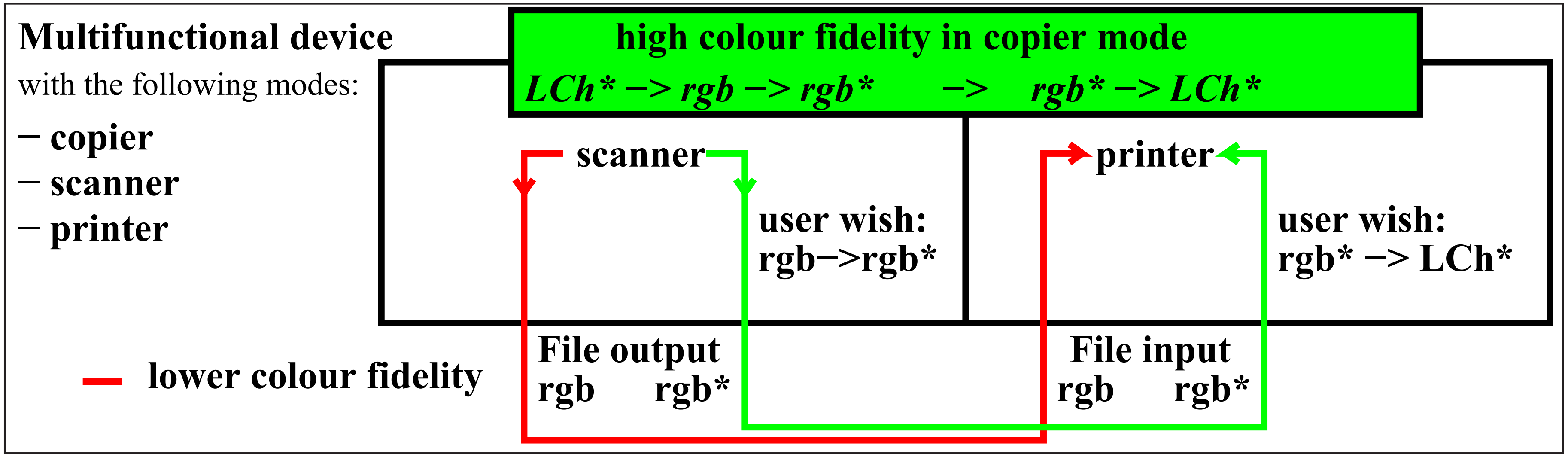
Offset *rgb input data and *LCh** output data**

Color	*rgb**	*LCh**
R_e elementary red	**1 0 0**	47, 74, **26**
Y_e elementary yellow	**1 1 0**	86, 88, **92**
G_e elementary green	**0 1 0**	53, 57, **164**
B_e elementary blue	**0 0 1**	42, 45, **271**
N black	**0 0 0**	18, **0, 0**
W white	**1 1 1**	95, **0, 0**

(data according to test chart DIN 33872-2, p. 9-12)
(CIELAB hue angles according to CIE R1−47)



UE190−7



UE190−3

Fig. 6: *ICC* rectangle and *rgb triangle coding (top) and *rgb->rgb** transfer for scan devices**
Fig. 6 compares the *ICC* rectangle with the *rgb** triangle coding. According to CIE 168 the *sRGB* triangle space fills 20% of the ICC coding space. The coding accuracy increases by *rgb** by a factor 5 which for example increases colour fidelity of multifunctional devices in scanning mode.

Development of relative device and visual colour spaces *sRGB* & *RGB**		
Time scale	**IEC: Display manufacturers and standard documents**	**CIE: Visual observers and standard documents**
1950−1999	**Colour television and colour CRT devices** 4 display device colours $RYGB_d$ CIELAB hue angles = 40, 102, 136, 306	**Visual colour space CIELAB 1976** $L^*, C^*_{ab}, h_{ab} = \mathbf{g_n}(XYZ)$ (CIE metric) ($\mathbf{g_n}$ = nonlinear function) Color rendering CIE 13 Test colours no. 9 to 12 = *RYGB* CIELAB hue angles = 26, 92, 162, 272
2000−2009	***sRGB* (display) standard** $rgb = \mathbf{f_n}(XYZ, L^*)$ (sRGB metric?) ($\mathbf{f_n}$ = nonlinear function) (the sRGB metric allows much freedom) IEC 61966−2−1 (sRGB standard) IEC 61966−X	***relative device* CIELAB space** $rgb^*_d = \mathbf{f_l}(L^*, C^*_{ab}, h_{ab,d})$ (CIE metric) ($\mathbf{f_l}$ = linear function, d = any device) DIN 33866−1 to 5, JIS 6933 ISO/IEC 15775, ISO/IEC TR 24705 ISO 9241−306:2009 Linearized display output for 8 room light reflections
2010−20??	IEC 61966−1 to 12	***relative elementary* CIELAB space** CIE R1−47: CIE 13, no. 9 to 12 = $RYGB_e$ $rgb^*_e = \mathbf{g_l}(L^*, C^*_{ab}, h_{ab,e})$ (CIE metric) ($\mathbf{g_l}$ = linear function, e = elementary) DIN 33872−1 to 6 −> ISO/CIE ?

1−003030−L0 UE170−3N

Fig. 7: Development of *relative device* space *sRGB* and *visual* colour space *RGB**

Fig. 7 shows that only the *RGB** metric is visual, in contrast to *sRGB*. Output linearization for office displays is allready used at work places in ISO 9241-306:2009 and not a new requirement

Posible time scale related to international standardization of DIN 33872−X
possible standard and market developments between 2009 and 2024

Time scale for Standard Development

2009	2014	2019	2024	
●				DIN 33872−1 to −6:2009 User wish satisfied (Yes/No)?
●				CIE R1−47:2009 with the four hue angles $h_{ab,e}$ = 26, 92, 162, and 271.
	●			CIE R1−57:2013 with *rgb** coordinates for *Ostwald* colours.
	●			CIE R8−09:2014? (long version) for output linearization of devices.
		●		CIE Technical Report with four elementary hue angles $h_{ab,e}$ of $RYGB_e$.
		●		CIE Technical Report with definition of visual *rgb** colour coordinates.
			●	ISO/CIE Standard with four elementary hue angles $h_{ab,e}$ of $RYGB_e$.
			●	ISO/CIE Standard with definition of the visual *RGB** colour space.
			●	ISO/CIE Standards: Output Linearization for displays, offset, printers.
			●	ISO/CIE Standards: Input Linearization for scanners and cameras.

Time scale for Market Development with the motivation of fast solutions for user wishes

1. Use of DIN-test charts and the above CIE documents within new *rgb** workflow.
2. Production of *reference* test charts with CIE R8−09 for many output devices.
3. Use of *reference* test charts for colour calibration of scanners and cameras.
4. Optimizing the output-input-output linearization loop for *rgb** colour management.
5. 5-fold higher accuracy (triangle coding) for *Profile Connection Space RGB** instead of *CIELAB*.

2009	2014	2016	2018	
	●			Device Output Linearization, and production of test charts *rgb−>rgb**.
		●		Linearized *reference* test charts for calibration of scanners & cameras.
		●		Colour workflow loop output-input-output and calculation of accuracy.
			●	Advantages & disadvantages of *rgb**; smooth transfer rgb_{sRGB}−>*rgb**.

1−003030−L0 UE161−7N

Fig. 8: Possible time scale related to international standardization of DIN 33872-X
Fig. 8 include a possible time scale for a standard and market development. The market demand may not wait for new standards. Some mouse clicks seem to solve the user wishes.

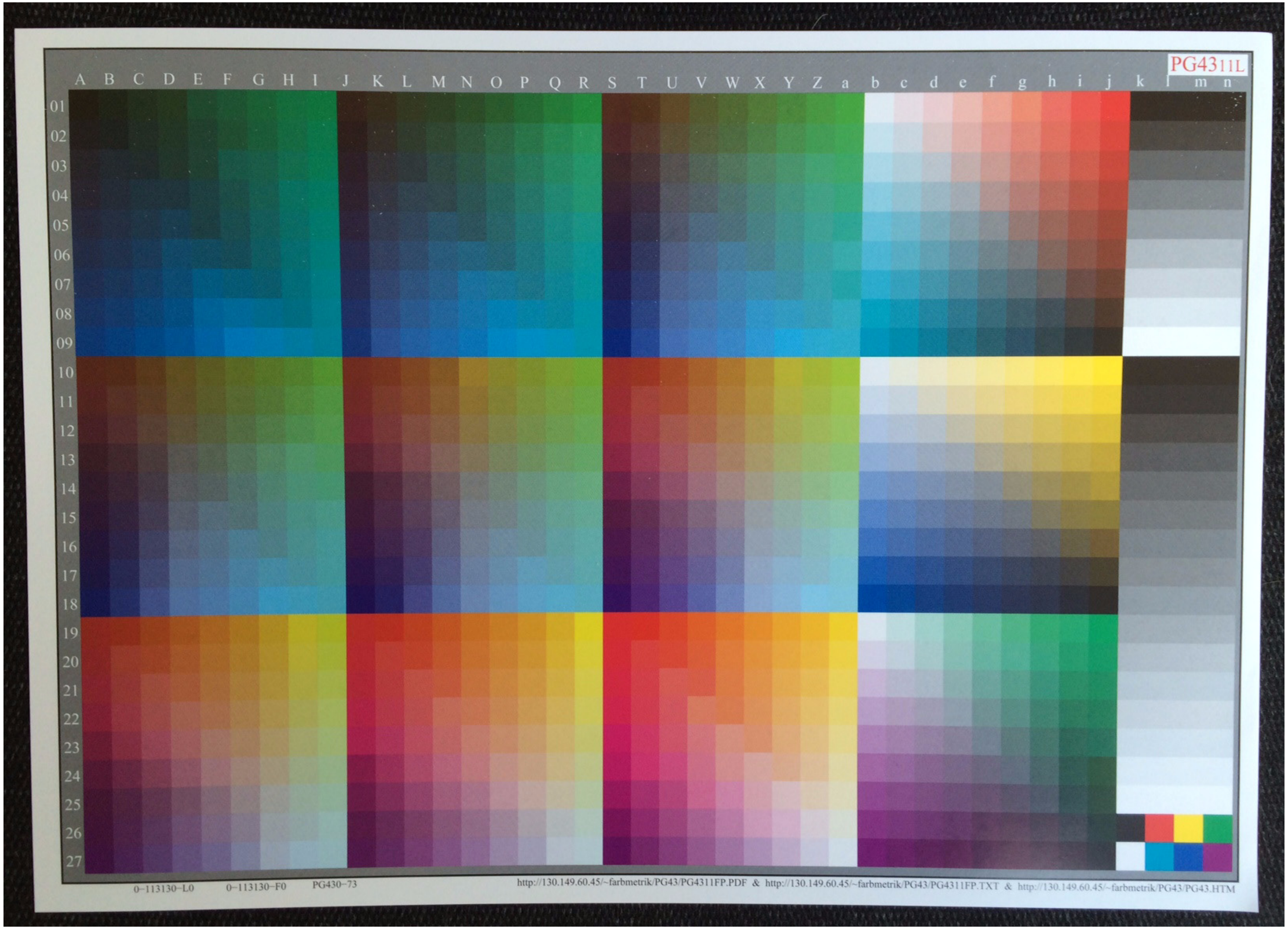


Fig. 9: *iPhone* foto of the *rgb linearized output in offset, Plate PG4311L, German edition**

Fig. 9 includes the 729 colours with known *rgb** and $L^*C^*_{ab}h_{ab}$ values in CIELAB. One can get 729 foto *rgb* data by many software. Use of a profile *rgb* -> *rgb** produces the original file colours.

Output − Input − Output: A loop for colour fidelity with the visual *rgb and *LCh** CIELAB data**

Produce a reference test chart with 729 CIELAB colours
or buy one, or use PG4311L of *Colour and Colour Vision,*
see http://130.149.60.45/~farbmetrik/color

Example: Linearized output in offset print

Output linearization produces for 729=9·9·9 *rgb* input data the 729 *LCh** CIELAB output colours.

Produce the linearized output of page 2 of the file
http://130.149.60.45/~farbmetrik/RE68/RE68L0NP.PDF

Use document CIE R8−09 for output linearization, see for more information
http://130.149.60.45/~farbmetrik/outlin or
http://farbe.li.tu−berlin.de/outlin

Offset *rgb data input and *LCh** data output**

Color	***rgb****	***LCh****
R_e elementary red	**1 0 0**	47, 74, **26**
Y_e elementary yellow	**1 1 0**	86, 88, **92**
G_e elementary green	**0 1 0**	53, 57, **164**
B_e elementary blue	**0 0 1**	42, 45, **271**
N black	**0 0 0**	18, **0, 0**
W white	**1 1 1**	95, **0, 0**

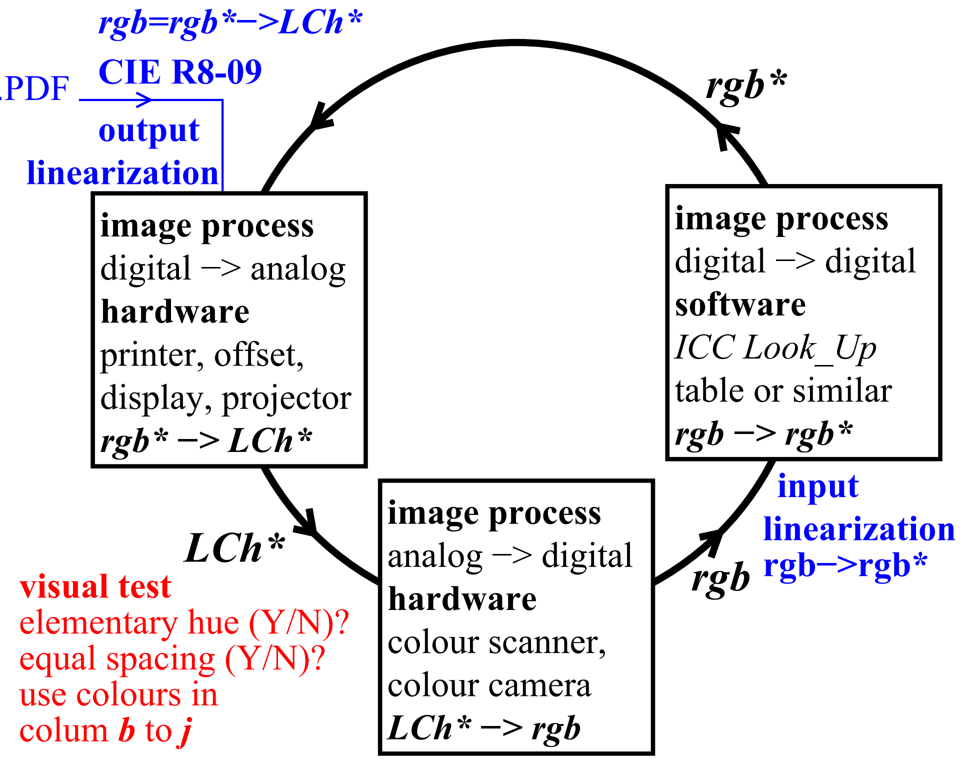
(data according to test chart DIN 33872-2, p. 9-12)

Use reference test chart with 729 CIELAB colours

Colour scanners or cameras produce 729 *rgb* data.

Transfer the 729 *rgb* data to the 729 *rgb** data.

After the linearized input the 729 colour data *rgb** may be used again for the linearized output.



UE201−7

Fig. 10: Output - Input - Output: A loop for colour fidelity with the visual *rgb** and *LCh** data
Fig. 10 includes available information for the *calibration* of colour *scanners* and *cameras*. A reference test chart in offset (PG4311L) is in the German version of an available booklet.

Agreement *(Y/N)* of CIELAB h_{ab} with IEC 61966-2-1 and CIE R1-47					
	reference: device colours				**NOTES**
	$R_{d,sRGB}$	$Y_{d,sRGB}$	$G_{d,sRGB}$	$B_{d,sRGB}$	**visual standard deviation v_{SD}**
definition for display output in IEC 61966−2−1	40 +/− 4 40 +/− 8	103 +/− 4 103 +/− 8	136 +/− 4 136 +/− 8	306 +/− 8 306 +/− 16	1 x v_{SD} 2 x v_{SD} data see [1], Tab. B.2
measurement of printer output *rgb* in file	34 *N*(−2) 34 ***Y***	100 ***Y*** 100 ***Y***	146 *N*(+8) 146 *N*(+2)	264 *N*(−34) 264 *N*(−26)	1 x v_{SD}; 1 x ***Y*** **2 x v_{SD}; 2 x *Y*** data see [1], Fig. 32
measurement of printer output *cmy0* in file	34 *N*(−2) 34 ***Y***	100 ***Y*** 100 ***Y***	153 *N*(+15) 153 *N*(+9)	300 ***Y*** 300 ***Y***	1 x v_{SD}; 2 x ***Y*** 2 x v_{SD}; 3 x ***Y*** data see [1], Fig. 33
	reference: elementary colours				**NOTES**
	R_e	Y_e	G_e	B_e	**visual standard deviation v_{SD}**
definition for any output in CIE R1−47	26 +/− 4 26 +/− 8	92 +/− 4 92 +/− 8	162 +/− 4 162 +/− 8	272 +/− 8 272 +/− 16	1 x v_{SD} 2 x v_{SD} data see CIE R1−47
measurement of printer output *rgb* in file	34 *N*(+4) 34 ***Y***	100 *N*(+4) 100 ***Y***	146 *N*(−12) 146 *N*(−8)	264 *N*(−4) 264 ***Y***	1 x v_{SD}; 0 x ***Y*** **2 x v_{SD}; 3 x *Y*** data see [1], Fig. 32
measurement of printer output *cmy0* in file	34 *N*(+4) 34 ***Y***	100 *N*(+4) 100 ***Y***	153 *N*(−5) 153 *N*(−1)	300 *N*(+20) 300 *N*(+12)	1 x v_{SD}; 0 x ***Y*** 2 x v_{SD}; 2 x ***Y*** data see [1], Fig. 33

1−003030−L0 UE191−3N

Fig. 11: Agreement (Y/N) of CIELAB hue angle h_{ab} with IEC 61966-2-1 and CIE R1-47
If *rgb* data are in the file, then the output of an example printer of a leading printer company agrees for blue more with the hue angle of CIE R1-47 (h_{ab}=272) compared to IEC 61966-2-1.

References

CIE 15:2008, Colorimetry

CIE 168:2005: Criteria for the Evaluation of Extended-Gamut Colour Encodings

CIE R1-47:2009, Hue angles of elementary colours, and CIE R1-57:2012, Border between luminous and blackish colours, see for download under MINUTES & REPORTS http://div1.cie.co.at

CIE R8-09:2014, Output Linearization for printers and displays - Reportership Report, under CIE processing (Sept. 2014), for CIE Division 8 members see CIE COLLTOOL

ISO EN DIN 9241-306:2009, Ergonomics of human system interaction – Part 306: Field Assessment methods for electronic visual displays

ISO 11664-4:2008(E)/CIE S 014-4/E:2007: Joint ISO/CIE Standard: CIE Colorimetry — Part 4: 1976 *L*a*b** Colour Space (CIELAB)

ISO 15076-1:2011, Image technology colour management -- Architecture, profile format and data structure -- Part 1: Based on ICC.1:2004-10

ISO/IEC 15775:2006, Information Technology – Office machines – Method of specifying image reproduction of colour copying machines by analog test charts – Realization and application, for accuracy of the test chart see *Ito, Takashi* (2004), JBMIA, Introduction of JIS X 6933 & ISO/IEC 15775-compliant Color Test Charts for Copying Machines of ISO/IEC JTC1/SC28, see the URL (2.1 MByte, 35 pages), http://www.ps.bam.de/info04/ITO04.PDF

ISO/IEC TR 19797:2004, Information technology – Office machines – Machines for colour image reproduction – Device output for 16-step colour scales, output linearization method (LM) and specification of the reproduction properties

ISO 22028-1:2007, Photography and graphic technology -- Extended colour encodings for digital image storage, manipulation and interchange -- Part 1: Architecture and requirements (see in addition NWI proposal ISO 17231-3:Consideration scene referred imaging applications)

ISO/IEC TR 24705:2005, Information technology – Office machines – Machines for colour image reproduction – Method of specifying image reproduction of colour devices by digital and analog test charts

DIN 33872-1 to -6:2010, Information technology - Office machines - Method of specifying relative colour reproduction with YES/NO criteria - Part 1: Classification, terms and principles - Part 2: Test charts for output properties - Testing of discriminability of 5 and 16 step colour series - Part 3: Test charts for output properties - Testing of equality for four equivalent grey definitions and discriminability of the 16 grey steps - Part 4: Test charts for output properties - Testing of equality for two equivalent colour definitions with 5 and 16 step colour series- Part 5: Test charts for output properties - Testing of elementary hue agreement and hue discriminability - Part 6: Test charts for output properties - Testing of the equivalent spacing and of the regular chromatic spacing. For the test charts according to DIN 33872-1 to -6 see http://www.ps.bam.de/33872E, For an english version of all parts, see http://www.iso.org/scit, download documents N 183 to 189.

Richter, Klaus (2008), Ergonomic color image technology with high visual and material efficiency based on elementary (unique) hues, pages 259-264, Sixteenth Color Imaging Conference, Final Program and Proceedings 2008, Nov. 10-15, Portland, Oregon, USA

Richter, Klaus (2009), Output Linearization in CIELAB for visual displays with 8 different Luminance reflections of indoor illuminants, Light and Lighting Conference with special emphasis on LEDs and Solid state lighting, Proceedings, Budapest 2009, 10 pages, no. PwDaS-39 on CD

Wagenknecht, Hans (2005), Colour Management Method (CMM) which maintains CIELAB hue and relative lightness and chroma for analog and digital ISO/IEC-test charts, see the URL (PDF, 15 pages, 18 MB), http://www.ps.bam.de/WAG05.PDF

Jaeger, Stefan (2005), Multispectral CIELAB camera for the evaluation of colored automobile coatings, see the URL (PDF, 18 pages, 2MB), http://www.ps.bam.de/JAE05.PDF

Witt, Jens (2004), Production method for analog ISO/IEC-test charts according to ISO/IEC 15775, see the URL (PDF, 13 pages, 2.7 MByte), http://www.ps.bam.de/info04/WIT04.PDF

Witt, Jens (2005), Production method for analog ISO/IEC-test charts according to ISO/IEC 15775, see the URL (PDF, 13 pages, 2.7 MByte), http://www.ps.bam.de/WIT05.PDF

Witt, Jens (2006), Jens Witt (2006) Colorimetric methods for the production of test charts for colour copiers, colour scanners and colour monitors, PhD thesis, TU Berlin (8 MB, in German, Table 6.3, page 138), see http://opus4.kobv.de/opus4-tuberlin/frontdoor/index/index/docId/1320

Author: Klaus Richter, email: klaus.richter@mac.com Internet: Berlin University of Technology (TUB): http://130.149.60.45/~farbmetrik or http://farbe.li.tu-berlin.de
For recent publications of the TUB group see: http://130.149.60.45/~farbmetrik/XY91FEN.html