see similar files of the whole serie: http://farbe.li.tu-berlin.de/heps.htm
technical information: http://farbe.li.tu-berlin.de or http://color.li.tu-berlin.de

TUB registration: 20241101-hep1/hep1l0np.pdf /.ps
application for evaluation and measurement of display or print output
TUB material: code=rha4ta

Relationship between brightness B^*_T and luminance L_T as function of viewing angle φ for surround luminance L_n=300 cd/m²

$B^*(L_T, L_n, \varphi) = [C_T(\varphi) L_n^n - B_0(L_n, \varphi)]\, L_{rn}^n \quad (L_{rn}^n = (L_{300}/L_n)^n)$ [1]

$B_0(L_n, \varphi) = C_T(\varphi)[S_0(\varphi) + S_1(\varphi) L_n^n]$ (n=0,31, here $L_T^n = L_n^n$) [2]

$L_s(L_n, \varphi) = [S_0(\varphi) + S_1(\varphi) L_n^n]^{1/n}$ (s=black threshold) [3]

L_n	φ	$C_T(\varphi)$	$S_0(\varphi)$	$S_1(\varphi)$	$B_0(\varphi)$	B^*	L_s	L_n/L_s
cd/m²	degree					=100?	cd/m²	
300	10	30,747	0,2730	0,3984	80,18	99,99	22,02	13,62
300	20	27,971	0,2013	0,3555	63,91	99,99	14,37	20,86
300	30	26,235	0,1797	0,3188	53,74	100,00	10,10	29,68
300	60	23,973	0,1313	0,2657	40,48	99,99	5,42	55,33
300	90	23,415	0,1083	0,2526	37,20	100,00	4,45	67,35
300	100	23,128	0,0747	0,2494	35,53	99,99	3,99	75,07
300	120	22,969	0,0718	0,2448	34,60	99,99	3,75	79,99

hep10−1a

Relationship between brightness B^*_T and luminance L_T as function of viewing angle φ for surround luminance L_n=1000 cd/m²

$B^*(L_T, L_n, \varphi) = [C_T(\varphi) L_n^n - B_0(L_n, \varphi)]\, L_{rn}^n \quad (L_{rn}^n = (L_{300}/L_n)^n)$ [1]

$B_0(L_n, \varphi) = C_T(\varphi)[S_0(\varphi) + S_1(\varphi) L_n^n]$ (n=0,31, here $L_T^n = L_n^n$) [2]

$L_s(L_n, \varphi) = [S_0(\varphi) + S_1(\varphi) L_n^n]^{1/n}$ (s=black threshold) [3]

L_n	φ	$C_T(\varphi)$	$S_0(\varphi)$	$S_1(\varphi)$	$B_0(\varphi)$	B^*	L_s	L_n/L_s
cd/m²	degree					=100?	cd/m²	
1000	10	30,747	0,2730	0,3984	112,66	102,61	65,96	15,16
1000	20	27,971	0,2013	0,3555	90,28	101,75	43,81	22,82
1000	30	26,235	0,1797	0,3188	75,92	101,46	30,80	32,46
1000	60	23,973	0,1313	0,2657	57,37	100,97	16,69	59,88
1000	90	23,415	0,1083	0,2526	52,88	100,80	13,85	72,18
1000	100	23,128	0,0747	0,2494	50,82	100,53	12,68	78,86
1000	120	22,969	0,0718	0,2448	49,51	100,51	11,91	83,94

hep10−2a

Relationship between brightness B^*_T and luminance L_T as function of viewing angle φ for surround luminance L_n=200 cd/m²

$B^*(L_T, L_n, \varphi) = [C_T(\varphi) L_n^n - B_0(L_n, \varphi)]\, L_{rn}^n \quad (L_{rn}^n = (L_{300}/L_n)^n)$ [1]

$B_0(L_n, \varphi) = C_T(\varphi)[S_0(\varphi) + S_1(\varphi) L_n^n]$ (n=0,31, here $L_T^n = L_n^n$) [2]

$L_s(L_n, \varphi) = [S_0(\varphi) + S_1(\varphi) L_n^n]^{1/n}$ (s=black threshold) [3]

L_n	φ	$C_T(\varphi)$	$S_0(\varphi)$	$S_1(\varphi)$	$B_0(\varphi)$	B^*	L_s	L_n/L_s
cd/m²	degree					=100?	cd/m²	
200	10	30,747	0,2730	0,3984	71,70	98,87	15,35	13,02
200	20	27,971	0,2013	0,3555	57,02	99,24	9,95	20,09
200	30	26,235	0,1797	0,3188	47,94	99,36	6,99	28,58
200	60	23,973	0,1313	0,2657	36,07	99,57	3,73	53,51
200	90	23,415	0,1083	0,2526	33,11	99,67	3,05	65,41
200	100	23,128	0,0747	0,2494	31,54	99,76	2,72	73,51
200	120	22,969	0,0718	0,2448	30,71	99,77	2,55	78,36

hep10−3a

Relationship between brightness B^*_T and luminance L_T as function of viewing angle φ for surround luminance L_n=40 cd/m²

$B^*(L_T, L_n, \varphi) = [C_T(\varphi) L_n^n - B_0(L_n, \varphi)]\, L_{rn}^n \quad (L_{rn}^n = (L_{300}/L_n)^n)$ [1]

$B_0(L_n, \varphi) = C_T(\varphi)[S_0(\varphi) + S_1(\varphi) L_n^n]$ (n=0,31, here $L_T^n = L_n^n$) [2]

$L_s(L_n, \varphi) = [S_0(\varphi) + S_1(\varphi) L_n^n]^{1/n}$ (s=black threshold) [3]

L_n	φ	$C_T(\varphi)$	$S_0(\varphi)$	$S_1(\varphi)$	$B_0(\varphi)$	B^*	L_s	L_n/L_s
cd/m²	degree					=100?	cd/m²	
40	10	30,747	0,2730	0,3984	46,83	92,71	3,88	10,29
40	20	27,971	0,2013	0,3555	36,83	95,11	2,43	16,45
40	30	26,235	0,1797	0,3188	30,96	95,90	1,70	23,42
40	60	23,973	0,1313	0,2657	23,14	97,26	0,89	44,82
40	90	23,415	0,1083	0,2526	21,10	97,80	0,71	55,95
40	100	23,128	0,0747	0,2494	19,83	98,49	0,60	65,70
40	120	22,969	0,0718	0,2448	19,29	98,56	0,56	70,18

hep10−4a

hep10−3R_R

Relationship between brightness B^*_T and luminance L_T as function of viewing angle φ for surround luminance L_n=300 cd/m²

$B^*(L_T, L_n, \varphi) = s(L_n, \varphi) L_n^n - d(L_n, \varphi) \quad (L_{rn}^n = (L_{300}/L_n)^n)$ [1]

$B_0(L_n, \varphi) = C_T(\varphi)[S_0(\varphi) + S_1(\varphi) L_n^n]$ (n=0,31, here $L_T^n = L_n^n$) [2]

$s_x = C_T(L_r / L_n)^n \quad d = B_0(L_n, \varphi) L_r / L_n)^n$ (s=scaling factor) [3]

L_n	φ	$C_T(\varphi)$	$S_0(\varphi)$	$S_1(\varphi)$	$B_0(\varphi)$	B^*	$s_x(\varphi)$	$d(\varphi)$
cd/m²	degree					=100?		
300	10	30,747	0,2730	0,3984	80,18	99,99	30,74	80,18
300	20	27,971	0,2013	0,3555	63,91	99,99	27,97	63,91
300	30	26,235	0,1797	0,3188	53,74	100,00	26,23	53,74
300	60	23,973	0,1313	0,2657	40,48	99,99	23,97	40,48
300	90	23,415	0,1083	0,2526	37,20	100,00	23,41	37,20
300	100	23,128	0,0747	0,2494	35,53	99,99	23,12	35,53
300	120	22,969	0,0718	0,2448	34,60	99,99	22,96	34,60

hep10−5a

Relationship between brightness B^*_T and luminance L_T as function of viewing angle φ for surround luminance L_n=1000 cd/m²

$B^*(L_T, L_n, \varphi) = s_x(L_n, \varphi) L_n^n - d(L_n, \varphi) \quad (L_{rn}^n = (L_{300}/L_n)^n)$ [1]

$B_0(L_n, \varphi) = C_T(\varphi)[S_0(\varphi) + S_1(\varphi) L_n^n]$ (n=0,31, here $L_T^n = L_n^n$) [2]

$s_x = C_T(L_r / L_n)^n \quad d = B_0(L_n, \varphi) L_r / L_n)^n$ (s=scaling factor) [3]

L_n	φ	$C_T(\varphi)$	$S_0(\varphi)$	$S_1(\varphi)$	$B_0(\varphi)$	B^*	$s_x(\varphi)$	$d(\varphi)$
cd/m²	degree					=100?		
1000	10	30,747	0,2730	0,3984	112,66	102,61	21,16	77,56
1000	20	27,971	0,2013	0,3555	90,28	101,75	19,25	62,15
1000	30	26,235	0,1797	0,3188	75,92	101,46	18,06	52,27
1000	60	23,973	0,1313	0,2657	57,37	100,97	16,50	39,50
1000	90	23,415	0,1083	0,2526	52,88	100,80	16,12	36,41
1000	100	23,128	0,0747	0,2494	50,82	100,53	15,92	34,99
1000	120	22,969	0,0718	0,2448	49,51	100,51	15,81	34,08

hep10−6a

Relationship between brightness B^*_T and luminance L_T as function of viewing angle φ for surround luminance L_n=200 cd/m²

$B^*(L_T, L_n, \varphi) = s_x(L_n, \varphi) L_n^n - d(L_n, \varphi) \quad (L_{rn}^n = (L_{300}/L_n)^n)$ [1]

$B_0(L_n, \varphi) = C_T(\varphi)[S_0(\varphi) + S_1(\varphi) L_n^n]$ (n=0,31, here $L_T^n = L_n^n$) [2]

$s_x = C_T(L_r / L_n)^n \quad d = B_0(L_n, \varphi) L_r / L_n)^n$ (s=scaling factor) [3]

L_n	φ	$C_T(\varphi)$	$S_0(\varphi)$	$S_1(\varphi)$	$B_0(\varphi)$	B^*	$s_x(\varphi)$	$d(\varphi)$
cd/m²	degree					=100?		
200	10	30,747	0,2730	0,3984	71,70	98,87	34,86	81,30
200	20	27,971	0,2013	0,3555	57,02	99,24	31,71	64,66
200	30	26,235	0,1797	0,3188	47,94	99,36	29,74	54,37
200	60	23,973	0,1313	0,2657	36,07	99,57	27,18	40,90
200	90	23,415	0,1083	0,2526	33,11	99,67	26,55	37,54
200	100	23,128	0,0747	0,2494	31,54	99,76	26,22	35,76
200	120	22,969	0,0718	0,2448	30,71	99,77	26,04	34,82

hep10−7a

Relationship between brightness B^*_T and luminance L_T as function of viewing angle φ for surround luminance L_n=40 cd/m²

$B^*(L_T, L_n, \varphi) = s_x(L_n, \varphi) L_n^n - d(L_n, \varphi) \quad (L_{rn}^n = (L_{300}/L_n)^n)$ [1]

$B_0(L_n, \varphi) = C_T(\varphi)[S_0(\varphi) + S_1(\varphi) L_n^n]$ (n=0,31, here $L_T^n = L_n^n$) [2]

$s_x = C_T(L_r / L_n)^n \quad d = B_0(L_n, \varphi) L_r / L_n)^n$ (s=scaling factor) [3]

L_n	φ	$C_T(\varphi)$	$S_0(\varphi)$	$S_1(\varphi)$	$B_0(\varphi)$	B^*	$s_x(\varphi)$	$d(\varphi)$
cd/m²	degree					=100?		
40	10	30,747	0,2730	0,3984	46,83	92,71	57,42	87,46
40	20	27,971	0,2013	0,3555	36,83	95,11	52,23	68,79
40	30	26,235	0,1797	0,3188	30,96	95,90	48,99	57,83
40	60	23,973	0,1313	0,2657	23,14	97,26	44,77	43,21
40	90	23,415	0,1083	0,2526	21,10	97,80	43,72	39,40
40	100	23,128	0,0747	0,2494	19,83	98,49	43,19	37,03
40	120	22,969	0,0718	0,2448	19,29	98,56	42,89	36,03

hep10−8a

hep10−7R_R

Relationship between brightness B^*_T and luminance L_T as function of viewing angle φ for surround luminance L_n=300 cd/m²

$B^*(L_T, L_n, \varphi) = s(L_n, \varphi) L_n^n - d(L_n, \varphi) \quad (L_{rn}^n = (L_{300}/L_n)^n)$ [1]

$B_0(L_n, \varphi) = C_T(\varphi)[S_0(\varphi) + S_1(\varphi) L_n^n]$ (n=0,31, here $L_T^n = L_n^n$) [2]

$L_s(L_n, \varphi) = [S_0(\varphi) + S_1(\varphi) L_n^n]^{1/n}$ (s=scaling factor) [3]

L_n	φ	$C_T(\varphi)$	$S_0(\varphi)$	$S_1(\varphi)$	$B_0(\varphi)$	B^*	s(φ)	d(φ)
cd/m²	degree					=100?		
300	10	30,747	0,2730	0,3984	80,18	99,99	180,18	80,18
300	20	27,971	0,2013	0,3555	63,91	99,99	163,91	63,91
300	30	26,235	0,1797	0,3188	53,74	100,00	153,74	53,74
300	60	23,973	0,1313	0,2657	40,48	99,99	140,48	40,48
300	90	23,415	0,1083	0,2526	37,20	100,00	137,21	37,20
300	100	23,128	0,0747	0,2494	35,53	99,99	135,53	35,53
300	120	22,969	0,0718	0,2448	34,60	99,99	134,60	34,60

hep11−1a

Relationship between brightness B^*_T and luminance L_T as function of viewing angle φ for surround luminance L_n=1000 cd/m²

$B^*(L_T, L_n, \varphi) = s(L_n, \varphi) L_n^n - d(L_n, \varphi) \quad (L_{rn}^n = (L_{300}/L_n)^n)$ [1]

$B_0(L_n, \varphi) = C_T(\varphi)[S_0(\varphi) + S_1(\varphi) L_n^n]$ (n=0,31, here $L_T^n = L_n^n$) [2]

$L_s(L_n, \varphi) = [S_0(\varphi) + S_1(\varphi) L_n^n]^{1/n}$ (s=scaling factor) [3]

L_n	φ	$C_T(\varphi)$	$S_0(\varphi)$	$S_1(\varphi)$	$B_0(\varphi)$	B^*	s(φ)	d(φ)
cd/m²	degree					=100?		
1000	10	30,747	0,2730	0,3984	112,66	102,61	124,05	77,56
1000	20	27,971	0,2013	0,3555	90,28	101,75	112,85	62,15
1000	30	26,235	0,1797	0,3188	75,92	101,46	105,85	52,27
1000	60	23,973	0,1313	0,2657	57,37	100,97	96,72	39,50
1000	90	23,415	0,1083	0,2526	52,88	100,80	94,47	36,41
1000	100	23,128	0,0747	0,2494	50,82	100,53	93,31	34,99
1000	120	22,969	0,0718	0,2448	49,51	100,51	92,67	34,08

hep11−2a

Relationship between brightness B^*_T and luminance L_T as function of viewing angle φ for surround luminance L_n=200 cd/m²

$B^*(L_T, L_n, \varphi) = s(L_n, \varphi) L_n^n - d(L_n, \varphi) \quad (L_{rn}^n = (L_{300}/L_n)^n)$ [1]

$B_0(L_n, \varphi) = C_T(\varphi)[S_0(\varphi) + S_1(\varphi) L_n^n]$ (n=0,31, here $L_T^n = L_n^n$) [2]

$L_s(L_n, \varphi) = [S_0(\varphi) + S_1(\varphi) L_n^n]^{1/n}$ (s=scaling factor) [3]

L_n	φ	$C_T(\varphi)$	$S_0(\varphi)$	$S_1(\varphi)$	$B_0(\varphi)$	B^*	s(φ)	d(φ)
cd/m²	degree					=100?		
200	10	30,747	0,2730	0,3984	71,70	98,87	204,31	81,30
200	20	27,971	0,2013	0,3555	57,02	99,24	185,86	64,66
200	30	26,235	0,1797	0,3188	47,94	99,36	174,33	54,37
200	60	23,973	0,1313	0,2657	36,07	99,57	159,30	40,90
200	90	23,415	0,1083	0,2526	33,11	99,67	155,59	37,54
200	100	23,128	0,0747	0,2494	31,54	99,76	153,68	35,76
200	120	22,969	0,0718	0,2448	30,71	99,77	152,62	34,82

hep11−3a

Relationship between brightness B^*_T and luminance L_T as function of viewing angle φ for surround luminance L_n=40 cd/m²

$B^*(L_T, L_n, \varphi) = s(L_n, \varphi) L_n^n - d(L_n, \varphi) \quad (L_{rn}^n = (L_{300}/L_n)^n)$ [1]

$B_0(L_n, \varphi) = C_T(\varphi)[S_0(\varphi) + S_1(\varphi) L_n^n]$ (n=0,31, here $L_T^n = L_n^n$) [2]

$L_s(L_n, \varphi) = [S_0(\varphi) + S_1(\varphi) L_n^n]^{1/n}$ (s=scaling factor) [3]

L_n	φ	$C_T(\varphi)$	$S_0(\varphi)$	$S_1(\varphi)$	$B_0(\varphi)$	B^*	s(φ)	d(φ)
cd/m²	degree					=100?		
40	10	30,747	0,2730	0,3984	46,83	92,71	336,49	87,46
40	20	27,971	0,2013	0,3555	36,83	95,11	306,11	68,79
40	30	26,235	0,1797	0,3188	30,96	95,90	287,11	57,83
40	60	23,973	0,1313	0,2657	23,14	97,26	262,36	43,21
40	90	23,415	0,1083	0,2526	21,10	97,80	256,25	39,40
40	100	23,128	0,0747	0,2494	19,83	98,49	253,11	37,03
40	120	22,969	0,0718	0,2448	19,29	98,56	251,37	36,03

hep11−4a

hep10−3N_R

CIELAB lightness L^*, tristimulus value discrimination dY, contrast (Y/dY), and sensitivity(dY/Y)

CIELAB lightness for all colours, L^*_u=50 for Y_u=18

$L^* = 66\,(Y/Y_u)^{1/3} - 16 \quad (Y_u = 18,\ Y > 1)$

For the grey discrimination we get:

$dL^*/dY = (66/Y_u)\,(1/3)\,(Y/Y_u)^{-2/3}$

and for dL^*=1 (about 3 thresholds) we can write:

$dY = 3\,(Y_u/66)\,(Y/Y_u)^{2/3}$

or $\log(dY) = \log(\,3\,(Y_u/66)\,) + (2/3)\,\log(Y/Y_u)$

therefore in a log-log diagram the slope is (2/3).

for the CIE contrast sensitivity, and for dL^* = 1 it is valid:

$Y/dY = (1/3)\,(66/Y_u)\,(Y/Y_u)^{1/3}$

or $\log(Y/dY) = \log(\,(1/3)\,(66/Y_u)\,) + (1/3)\,\log(Y/Y_u)$

hep11−5a, eer30−1n

CIELAB lightness L^*, CIE tristimulus value discrimination $dY$and CIE contrast sensitivity (Y/dY)

CIELAB lightness for all colours, L^*_w=100 for Y_w=100

$L^* = 116\,(Y/Y_n)^{1/3} - 16 \quad (Y_n = 100,\ Y > 1)$

For the grey discrimination we get:

$dL^*/dY = (116/Y_n)\,(1/3)\,(Y/Y_n)^{-2/3}$

and for dL^*=1 (about 3 thresholds) we can write:

$dY = (3(Y_n^{1/3})/116)\,(Y)^{2/3}$

or $\log(dY) = \log(3(Y_n^{1/3})/116) + (2/3)\,\log(Y)$

therefore in a log-log diagram the slope is (2/3).

for the CIE contrast sensitivity, and for dL^* = 1 it is valid:

$Y/dY = (1/3)\,(116/(Y_n^{1/3}))\,Y^{1/3}$

or $\log(Y/dY) = \log(\,(1/3)\,(116/(Y_n^{1/3}))\,) + (1/3)\,\log(Y)$

hep11−6a, eer30−2n

IECsRGB-triangle lightness T^*, CIE tristimulus value discrimination dY and CIE contrast (Y/dY) sRGB: see IEC 61966-2-1

$T^*_{sRGB,100} = 100\,(Y/Y_n)^{1/2,4}$ is an approximation of L^*_{CIELAB}

sRGB-triangle lightness for *achromatic* colours: W

$T^*_{sRGB,100} = 100\,(Y/Y_n)^{1/2,4} \quad (Y_n{=}100)$

For the grey discrimination we get:

$dT^*_{sRGB,100}/dY = (1/2,4)\,(Y/Y_n)^{-1,4/2,4} = 0,42\,(Y/Y_n)^{-0,58}$

and for $dT^*_{sRGB,100}$=1 (about 3 thresholds) we can write:

$dY = 2,4\,(Y/Y_n)^{1,4/2,4}$

or $\log(dY) = \log(2,4) + (1,4/2,4)\,\log(Y/Y_n)$

therefore in a log-log diagram the slope is 1,4/2,4.

for the CIE contrast sensitivity, and for $dT^*_{sRGB,100}$=1:

$Y/dY = (Y_n^{1,4/2,4}/2,4)\,(Y/Y_n)^{1/2,4}$

or $\log(Y/dY) = \log(Y_n^{1,4/2,4}/2,4) + 1/2,4\,\log(Y/Y_n)$

hep11−7a, eer31−1n

IECsRGB-triangle lightness T^*, CIE tristimulus value discrimination dY and CIE contrast (Y/dY) sRGB: see IEC 61966-2-1

$T^*_{sRGB,100} = 100\,(Y/Y_n)^{1/2,4}$ is an approximation of L^*_{CIELAB}

sRGB-triangle lightness for *chromatic* colours: RGB

$T^*_{sRGB,100} = 100\,(Y/Y_n)^{1/2,4}$ (Y_n=22(R), =71(G), =07(B))

For the discrimination we get:

$dT^*_{sRGB,100}/dY = (1/2,4)\,(Y/Y_n)^{-1,4/2,4} = 0,42\,(Y/Y_n)^{-0,58}$

and for $dT^*_{sRGB,100}$=1 (about 3 thresholds) we can write:

$dY = 2,4\,(Y/Y_n)^{1,4/2,4}$

or $\log(dY) = \log(2,4) + (1,4/2,4)\,\log(Y/Y_n)$

therefore in a log-log diagram the slope is 1,4/2,4.

for the CIE contrast sensitivity, and for $dT^*_{sRGB,100}$=1:

$Y/dY = (Y_n^{1,4/2,4}/2,4)\,(Y/Y_n)^{1/2,4}$

or $\log(Y/dY) = \log(Y_n^{1,4/2,4}/2,4) + 1/2,4\,\log(Y/Y_n)$

hep11−8a, eer31−2n

hep11−7n

TUB-test chart hep1; Relationship between brightness B*T and luminance LT as function of sample viewing angle phi for adaptation luminances La=(300, 1000, 200, 40)cd/m^2