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TUB registration: 20240201-feo4/feo410na.txt /ps  
 application for evaluation and measurement of display or print output  
 TUB material: code=rh4ta

**Weber-Fechner law in CIE 230:2019 for threshold colour differences of surface colours; relations between tristimulus value, luminance, and lightness**

The Weber-Fechner law describes the lightness  $L^*_{rW}$  as *logarithmic* function of  $L_{rW}$ .  
 The Stevens law describes the lightness  $L^*_{CIELAB}$  as *potential* function of  $L_{rW}=Y/90$ .  
 $L^*_{CIELAB} = 116 L_{rW}^{1/3} - 16 = 66 L_{rU}^{1/3} - 16$ , Approximation:  $L^*_{IEC,sRGB} = 100 L_{rW}^{1/2,4}$  [1]  
 The Weber-Fechner law is equivalent to the equation:  $\Delta L_{rW} = c_W L_{rW}$  [2]  
 Integration leads to the logarithmic equation:  $L^*_{rW} = t_W \log(L_{rW})$ . [3]  
 Derivation leads for  $\Delta L^*_{rW}=1$  to the linear equation:  $L_{rW}/\Delta L_{rW} = t_W = 57$ . [4]  
 For *adjacent* Colours in offices the standard contrast range is 25:1=90:3,6.

**Table 1: CIE tristimulus value Y, luminance L, and lightness L\***

Colour (matte paper)	tristimulus values	SDR office luminance	relative luminance		CIELAB <sub>W</sub> lightness	TUBLOG <sub>U</sub> lightness
			$L_{rU}$ =L/L <sub>U</sub>	$L_{rW}$ =L/L <sub>W</sub>		
Contrast W:N (25:1=90:3,6)	Y	L [cd/m <sup>2</sup> ]	$L_{rU}$ =L/L <sub>U</sub>	$L_{rW}$ =L/L <sub>W</sub>	$L^*_{CIELAB,W}$ =c <sub>W</sub> L <sub>rW</sub> <sup>1/3</sup> -16	$L^*_{TUBLOG,U}$ =t <sub>U</sub> log(L <sub>rU</sub> )+50
White W (paper)	90 =18*5	142 =28,2*5	5	1	96=50+46 =c(1) <sup>1/3</sup> -16	100=50+50 =tlog(5)+50
Grey U (paper)	18	28,2	1	0,2	49=50-1 =c(0,2) <sup>1/3</sup> -16	50=50+0 =tlog(1)+50
Black N (paper)	3,6 =18/5	5,6 28,2/5	0,2	0,04	22=50-28 =c(0,04) <sup>1/3</sup> -16	0=50-50 =tlog(0,2)+50

It is valid: CIELAB<sub>W</sub>: c<sub>W</sub>=c=116, TUBLOG<sub>U</sub>: t<sub>U</sub>=t=50/log(5)=57

feo40-3n

**Colourimetric scaling of achromatic colours between peak white and black. Relations between tristimulus value Y, luminance L, and lightness L\* of ISO-standards**

Colour (light or paper)	tristimulus values	HDR display luminance	relative luminance		CIELAB <sub>U</sub> lightness	TUBLOG <sub>U</sub> lightness
			$L_{rU}$ =L/L <sub>U</sub>	$L_{rW}$ =L/L <sub>W</sub>		
Contrast W:N (25:1=90:3,6)	Y (50,5=2,24)	L [cd/m <sup>2</sup> ]	$L_{rU}$ =L/L <sub>U</sub>	$L_{rW}$ =L/L <sub>W</sub>	$L^*_{CIELAB,U}$ =d <sub>U</sub> L <sub>rU</sub> <sup>1/3</sup> -16	$L^*_{TUBLOG,U}$ =t <sub>U</sub> log(L <sub>rU</sub> )+50
White P2 (light)	360 =18*20	800 =40*20	25	2,24	161=50+111 =d(11,2) <sup>1/3</sup> -16	121=50+71 =tlog(20)+50
White P1 (light)	180 =18*10	400 =40*10	20	1,00	125=50+75 =d(5,00) <sup>1/3</sup> -16	104=50+54 =tlog(10)+50
White W (fluorescent paper)	90 =18*5	200 =40*5	5	0,45	95=50+45 =d(2,24) <sup>1/3</sup> -16	87=50+37 =tlog(5,0)+50
Grey U (paper)	18 =18*1	40 40*1	1	0,20	49=50-0 =d(1,00) <sup>1/3</sup> -16	47=50-2 =tlog(1)+50
Black N (paper)	3,6 =18/5	8 40/5	0,20	0,09	22=50-27 =d(0,45) <sup>1/3</sup> -16	7=50-42 =tlog(0,20)+50
Black p1 (glossy paper)	2,5 =18/7	5,7 40/7	0,14	0,04	17=50-32 =d(0,20) <sup>1/3</sup> -16	-1=50-51 =tlog(0,14)+50
Black p2 (glossy paper)	1,8 =18/10	4 40/10	0,10	0,022	14=50-35 =d(0,09) <sup>1/3</sup> -16	-9=50-59 =tlog(0,10)+50

It is valid: CIELAB<sub>U</sub>: d<sub>U</sub>=d=66, TUBLOG<sub>U</sub>: t<sub>U</sub>=t=40/log(5)=57

feo41-3n

**Colourimetric scaling of achromatic colours between peak white and black. Relations between tristimulus value Y, luminance L, and lightness L\* of ISO-standards**

Colour (light or paper)	tristimulus values	HDR display luminance	relative luminance		CIELAB <sub>W</sub> lightness	TUBLOG <sub>U</sub> lightness
			$L_{rU}$ =L/L <sub>U</sub>	$L_{rW}$ =L/L <sub>W</sub>		
Contrast W:N (25:1=90:3,6)	Y	L [cd/m <sup>2</sup> ]	$L_{rU}$ =L/L <sub>U</sub>	$L_{rW}$ =L/L <sub>W</sub>	$L^*_{CIELAB,W}$ =c <sub>W</sub> L <sub>rW</sub> <sup>1/3</sup> -16	$L^*_{TUBLOG,U}$ =t <sub>U</sub> log(L <sub>rU</sub> )+50
White P2 (light)	360 =18*20	800 =40*20	25	2,24	100=50+50 =c(2,00) <sup>1/3</sup> -16	100=50+52 =tlog(10,00)+50
White P1 (light)	180 =18*10	400 =40*10	20	1,00	76=50+26 =c(1,00) <sup>1/3</sup> -16	78=50+30 =tlog(5,00)+50
White W (fluorescent paper)	90 =18*5	200 =40*5	5	0,45	54=50+4 =c(0,45) <sup>1/3</sup> -16	53=50+5 =tlog(2,24)+50
Grey U (paper)	18 =18*1	40 40*1	1	0,20	37=50-12 =c(0,20) <sup>1/3</sup> -16	28=50-19 =tlog(1,00)+50
Black N (paper)	3,6 =18/5	8 40/5	0,20	0,09	25=50-24 =c(0,09) <sup>1/3</sup> -16	3=50-44 =tlog(0,45)+50
Black p1 (glossy paper)	2,5 =18/7	5,7 40/7	0,14	0,04	15=50-34 =c(0,04) <sup>1/3</sup> -16	-21=50-69 =tlog(0,20)+50
Black p2 (glossy paper)	1,8 =18/10	4 40/10	0,10	0,022	8=50-41 =c(0,02) <sup>1/3</sup> -16	-43=50-91 =tlog(0,10)+50

It is valid: CIELAB<sub>W</sub>: c<sub>W</sub>=c=116, TUBLOG<sub>U</sub>: t<sub>U</sub>=t=50/log(5)=72

feo40-7n

**Colourimetric scaling of achromatic colours between peak white and black. Relations between tristimulus value Y, luminance L, and lightness L\* of ISO-standards**

Colour (light or paper)	tristimulus values	HDR display luminance	relative luminance		IECsRGB <sub>W</sub> lightness	TUBLOG <sub>U</sub> lightness
			$L_{rU}$ =L/L <sub>U</sub>	$L_{rW}$ =L/L <sub>W</sub>		
Contrast W:N (25:1=90:3,6)	Y (50,5=2,24)	L [cd/m <sup>2</sup> ]	$L_{rU}$ =L/L <sub>U</sub>	$L_{rW}$ =L/L <sub>W</sub>	$L^*_{IECsRGB,W}$ =s <sub>W</sub> L <sub>rW</sub> <sup>1/2,4</sup>	$L^*_{TUBLOG,U}$ =t <sub>U</sub> log(L <sub>rU</sub> )+50
White P2 (light)	360 =18*20	800 =40*20	25	2,24	170=50+120 =s(2,24) <sup>1/2,4</sup>	121=50+71 =tlog(20)+50
White P1 (light)	180 =18*10	400 =40*10	20	1,00	127=50+77 =s(1,00) <sup>1/2,4</sup>	104=50+54 =tlog(10)+50
White W (fluorescent paper)	90 =18*5	200 =40*5	5	0,45	95=50+45 =s(0,45) <sup>1/2,4</sup>	87=50+37 =tlog(5,0)+50
Grey U (paper)	18 =18*1	40 40*1	1	0,20	48=50-1 =s(0,20) <sup>1/2,4</sup>	47=50-2 =tlog(1)+50
Black N (paper)	3,6 =18/5	8 40/5	0,20	0,09	25=50-24 =s(0,09) <sup>1/2,4</sup>	7=50-42 =tlog(0,20)+50
Black p1 (glossy paper)	2,5 =18/7	5,7 40/7	0,14	0,04	21=50-28 =s(0,04) <sup>1/2,4</sup>	-1=50-51 =tlog(0,14)+50
Black p2 (glossy paper)	1,8 =18/10	4 40/10	0,10	0,022	18=50-31 =s(0,02) <sup>1/2,4</sup>	-9=50-59 =tlog(0,10)+50

It is valid: IECsRGB<sub>W</sub>: s<sub>W</sub>=s=100, TUBLOG<sub>U</sub>: t<sub>U</sub>=t=40/log(5)=57

feo41-7n