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: 20241001-hep3/hep3l0np.pdf /.ps
application for evaluation and measurement of display or print output

TUB material: code=rha4ta



**HAULAB lightness $L^*_{80}$ normalized to the background lightness $L^*_{80,u}$**

$L^* = s (Y/Y_n)^n - d$   $(Y_n=100, Y_u=18, s=22, n=0,31, d=30)$   [1a]
$L^* = r (Y/Y_u)^n - d$   $(r = s (Y_u/Y_n)^n=13,49, L^*_u= r - d)$   [1b]
$L^*/L^*_u = g(Y/Y_u)^n - h$  $(g=r/(r-d)=-0,78, h=d/(r-d)=-1,78)$   [1c]
$\log [(L^*/L^*_u + h) / g] = n \log (Y/Y_u)$   [1d]
$10 \ln [(L^*/L^*_u + h) / g] = \ln(10) n \log (Y/Y_u)$   [1e]
$(L^*/L^*_u + h) / g = e^{\ln(10) n \log (Y/Y_u)}$   [1f]

$m_{nu} = n = 0,310$
$m_u = 0,544$

0,301
−0,968

**HAULAB tristimulus value difference $\Delta Y$ normalized to $\Delta Y_u$**

$L^* = s (Y/Y_n)^n - d$   $(Y_n=100, Y_u=18, s=22, n=0,31, d=30)$   [1a]
$L^* = r (Y/Y_u)^n - d$   $(r = s (Y_u/Y_n)^n=13,49, L^*_u= r - d)$   [1b]
$dY = [Y_n/ (n s)] (Y/Y_n)^{1-n}$   [2c]
$dY_u = [Y_n/ (n s)] (Y_u/Y_n)^{1-n} = 8,2533$   [2d]
$dY/dY_u = (Y/Y_u)^{1-n}$   [2e]
$\log(dY/dY_u) = (1-n) \log(Y/Y_u)$   [2f]

$m_{nu} = 1-n = 0,690$
$m_u = 0,689$

0,448
−0,723

**HAULAB lightness $L^*_{80}$ normalized to the background lightness $L^*_{80,u}$**

$L^* = s (Y/Y_n)^n - d$   $(Y_n=100, Y_u=18, s=22, n=0,31, d=30)$   [1a]
$L^* = r (Y/Y_u)^n - d$   $(r = s (Y_u/Y_n)^n=13,49, L^*_u= r - d)$   [1b]
$dY = [Y_n/ (n s)] (Y/Y_n)^{1-n}$   [2c]
$dY_u = [Y_n/ (n s)] (Y_u/Y_n)^{1-n} = 8,2533$   [2d]
$dY/dY_u = (Y/Y_u)^{1-n}$   [2e]

$m_{u90\_4} = 0,937, f_{90}=95, f_4=15$
$m_u=1,313$

2,000
0,105

**HAULAB tristimulus value difference $\Delta Y$ normalized to $\Delta Y_u$**

$L^* = s (Y/Y_n)^n - d$   $(Y_n=100, Y_u=18, s=22, n=0,31, d=30)$   [1a]
$L^* = r (Y/Y_u)^n - d$   $(r = s (Y_u/Y_n)^n=13,49, L^*_u= r - d)$   [1b]
$dY = [Y_n/ (n s)] (Y/Y_n)^{1-n}$   [2c]
$dY_u = [Y_n/ (n s)] (Y_u/Y_n)^{1-n} = 8,2533$   [2d]
$dY/dY_u = (Y/Y_u)^{1-n}$   [2e]

$m_{u90\_4} = 0,022, f_{90}=2, f_4=0$
$m_u = 0,027$

2,811
−0,189

hep30−1a   hep30−2a   hep31−1a   hep31−2a

**HAULAB-$Y$ sensitivity normalized to $(\Delta Y/Y)_u$**

$S_r/S_{ru}=(\Delta Y/Y)/(\Delta Y/Y)_u$
$L^* = s (Y/Y_n)^n - d$   $(Y_n=100, Y_u=18, s=22, n=0,31, d=30)$   [1a]
$L^* = r (Y/Y_u)^n - d$   $(r = s (Y_u/Y_n)^n=13,49, L^*_u= r - d)$   [1b]
$dY/Y = [(Y_n/ (n s)) (Y/Y_n)^{1-n}] / Y$   [3c]
$(dY/Y)_u = [(Y_n/ (n s)) (Y_u/Y_n)^{1-n}] / Y_u$   [3d]
$(dY/Y) / (dY/Y)_u = (Y/Y_u)^{-n}$   [3e]
$\log [(dY/Y) / (dY/Y)_u] = (-n) \log (Y/Y_u)$   [3f]

$m_{nu} = -n = -0,310$
$m_u = -0,310$

0,325
−0,201

**HAULAB-$Y$ contrast normalized to $(Y/\Delta Y)_u$**

$C_r/C_{ru}=(Y/\Delta Y)/(Y/\Delta Y)_u$
$L^* = s (Y/Y_n)^n - d$   $(Y_n=100, Y_u=18, s=22, n=0,31, d=30)$   [1a]
$L^* = r (Y/Y_u)^n - d$   $(r = s (Y_u/Y_n)^n=13,49, L^*_u= r - d)$   [1b]
$Y/dY = Y / \{ [(Y_n/ (n s)) (Y/Y_n)^{1-n}] \}$   [4c]
$(Y/Y)_u = Y_u / \{ [(Y_n/ (n s)) (Y_u/Y_n)^{1-n}] \}$   [4d]
$(Y/dY) / (Y/dY)_u = (Y/Y_u)^n$   [4e]
$\log [(Y/dY) / (Y/dY)_u] = (n) \log (Y/Y_u)$   [4f]

$m_{nu} = n = 0,310$
$m_u = 0,310$

0,201
−0,325

**HAULAB-$Y$ sensitivity normalized to $(\Delta Y/Y)_u$**

$S_r/S_{ru}=(\Delta Y/Y)/(\Delta Y/Y)_u$
$L^* = s (Y/Y_n)^n - d$   $(Y_n=100, Y_u=18, s=22, n=0,31, d=30)$   [1a]
$L^* = r (Y/Y_u)^n - d$   $(r = s (Y_u/Y_n)^n=13,49, L^*_u= r - d)$   [1b]
$dY/Y = [(Y_n/ (n s)) (Y/Y_n)^{1-n}] / Y$   [3c]
$(dY/Y)_u = [(Y_n/ (n s)) (Y_u/Y_n)^{1-n}] / Y_u$   [3d]
$(dY/Y) / (dY/Y)_u = (Y/Y_u)^{-n}$   [3e]

$m_{u90\_4} = -0,000, f_{90}=0, f_4=0$
$m_u = -0,000$

2,113
0,628

**HAULAB-$Y$ contrast normalized to $(Y/\Delta Y)_u$**

$C_r/C_{ru}=(Y/\Delta Y)/(Y/\Delta Y)_u$
$L^* = s (Y/Y_n)^n - d$   $(Y_n=100, Y_u=18, s=22, n=0,31, d=30)$   [1a]
$L^* = r (Y/Y_u)^n - d$   $(r = s (Y_u/Y_n)^n=13,49, L^*_u= r - d)$   [1b]
$Y/dY = Y / \{ [(Y_n/ (n s)) (Y/Y_n)^{1-n}] \}$   [4c]
$(Y/Y)_u = Y_u / \{ [(Y_n/ (n s)) (Y_u/Y_n)^{1-n}] \}$   [4d]
$(Y/dY) / (Y/dY)_u = (Y/Y_u)^n$   [4e]

$m_{u90\_4} = 0,290, f_{90}=40, f_4=15$
$m_u = 0,407$

1,591
−0,473

hep30−3n   hep30−3a   hep30−4a   hep31−3n   hep31−3a   hep31−4a

**CIELAB lightness $L^*$ normalized to the background lightness $L^*_u$**

$L^* = s (Y/Y_n)^n - d$   $(Y_n=100, Y_u=18, s=116, n=1/3, d=16)$   [1a]
$L^* = r (Y/Y_u)^n - d$   $(r = s (Y_u/Y_n)^n=65,49, L^*_u= r - d)$   [1b]
$L^*/L^*_u = g(Y/Y_u)^n - h$   $(g=r/(r-d)=1,32, h=d/(r-d)=0,32)$   [1c]
$\log [(L^*/L^*_u + h) / g] = n \log (Y/Y_u)$   [1d]
$10 \ln [(L^*/L^*_u + h) / g] = \ln(10) n \log (Y/Y_u)$   [1e]
$(L^*/L^*_u + h) / g = e^{\ln(10) n \log (Y/Y_u)}$   [1f]

$m_{nu} = n = 0,333$
$m_u = 0,438$

0,301
−0,508

**CIELAB tristimulus value difference $\Delta Y$ normalized to $\Delta Y_u$**

$L^* = s (Y/Y_n)^n - d$   $(Y_n=100, Y_u=18, s=116, n=1/3, d=16)$   [1a]
$L^* = r (Y/Y_u)^n - d$   $(r = s (Y_u/Y_n)^n=65,49, L^*_u= r - d)$   [1b]
$dY = [Y_n/ (n s)] (Y/Y_n)^{1-n}$   [2c]
$dY_u = [Y_n/ (n s)] (Y_u/Y_n)^{1-n} = 1,4602$   [2d]
$dY/dY_u = (Y/Y_u)^{1-n}$   [2e]
$\log(dY/dY_u) = (1-n) \log(Y/Y_u)$   [2f]

$m_{nu} = 1-n = 0,666$
$m_u = 0,666$

0,489
−0,642

**CIELAB lightness $L^*$ normalized to the background lightness $L^*_u$**

$L^* = s (Y/Y_n)^n - d$   $(Y_n=100, Y_u=18, s=116, n=1/3, d=16)$   [1a]
$L^* = r (Y/Y_u)^n - d$   $(r = s (Y_u/Y_n)^n=65,49, L^*_u= r - d)$   [1b]
$L^*/L^*_u = g(Y/Y_u)^n - h$   $(g=r/(r-d)=1,32, h=d/(r-d)=0,32)$   [1c]
$dY = [Y_n/ (n s)] (Y/Y_n)^{1-n}$   [2c]
$dY_u = [Y_n/ (n s)] (Y_u/Y_n)^{1-n} = 1,4602$   [2d]

$m_{u90\_4} = 0,840, f_{90}=95, f_4=23$
$m_u = 1,170$

2,000
0,309

**CIELAB tristimulus value difference $\Delta Y$ normalized to $\Delta Y_u$**

$L^* = s (Y/Y_n)^n - d$   $(Y_n=100, Y_u=18, s=116, n=1/3, d=16)$   [1a]
$L^* = r (Y/Y_u)^n - d$   $(r = s (Y_u/Y_n)^n=65,49, L^*_u= r - d)$   [1b]
$dY = [Y_n/ (n s)] (Y/Y_n)^{1-n}$   [2c]
$dY_u = [Y_n/ (n s)] (Y_u/Y_n)^{1-n} = 1,4602$   [2d]
$dY/dY_u = (Y/Y_u)^{1-n}$   [2e]

$m_{u90\_4} = 0,024, f_{90}=2, f_4=0$
$m_u = 0,029$

3,089
−0,227

hep30−5a   hep30−6a   hep31−5a   hep31−6a

**CIELAB-$Y$ sensitivity normalized to $(\Delta Y/Y)_u$**

$S_r/S_{ru}=(\Delta Y/Y)/(\Delta Y/Y)_u$
$L^* = s (Y/Y_n)^n - d$   $(Y_n=100, Y_u=18, s=116, n=1/3, d=16)$   [1a]
$L^* = r (Y/Y_u)^n - d$   $(r = s (Y_u/Y_n)^n=65,49, L^*_u= r - d)$   [1b]
$dY/Y = [(Y_n/ (n s)) (Y/Y_n)^{1-n}] / Y$   [3c]
$(dY/Y)_u = [(Y_n/ (n s)) (Y_u/Y_n)^{1-n}] / Y_u$   [3d]
$(dY/Y) / (dY/Y)_u = (Y/Y_u)^{-n}$   [3e]
$\log [(dY/Y) / (dY/Y)_u] = (-n) \log (Y/Y_u)$   [3f]

$m_{nu} = -n = -0,333$
$m_u = -0,333$

0,321
−0,244

**CIELAB-$Y$ contrast normalized to $(Y/\Delta Y)_u$**

$C_r/C_{ru}=(Y/\Delta Y)/(Y/\Delta Y)_u$
$L^* = s (Y/Y_n)^n - d$   $(Y_n=100, Y_u=18, s=116, n=1/3, d=16)$   [1a]
$L^* = r (Y/Y_u)^n - d$   $(r = s (Y_u/Y_n)^n=65,49, L^*_u= r - d)$   [1b]
$Y/dY = Y / \{ [(Y_n/ (n s)) (Y/Y_n)^{1-n}] \}$   [4c]
$(Y/Y)_u = Y_u / \{ [(Y_n/ (n s)) (Y_u/Y_n)^{1-n}] \}$   [4d]
$(Y/dY) / (Y/dY)_u = (Y/Y_u)^n$   [4e]
$\log [(Y/dY) / (Y/dY)_u] = (n) \log (Y/Y_u)$   [4f]

$m_{nu} = n = 0,333$
$m_u = 0,333$

0,244
−0,321

**CIELAB-$Y$ sensitivity normalized to $(\Delta Y/Y)_u$**

$S_r/S_{ru}=(\Delta Y/Y)/(\Delta Y/Y)_u$
$L^* = s (Y/Y_n)^n - d$   $(Y_n=100, Y_u=18, s=116, n=1/3, d=16)$   [1a]
$L^* = r (Y/Y_u)^n - d$   $(r = s (Y_u/Y_n)^n=65,49, L^*_u= r - d)$   [1b]
$dY/Y = [(Y_n/ (n s)) (Y/Y_n)^{1-n}] / Y$   [3c]
$(dY/Y)_u = [(Y_n/ (n s)) (Y_u/Y_n)^{1-n}] / Y_u$   [3d]
$(dY/Y) / (dY/Y)_u = (Y/Y_u)^{-n}$   [3e]

$m_{u90\_4} = -0,000, f_{90}=0, f_4=0$
$m_u = -0,000$

2,096
0,568

**CIELAB-$Y$ contrast normalized to $(Y/\Delta Y)_u$**

$C_r/C_{ru}=(Y/\Delta Y)/(Y/\Delta Y)_u$
$L^* = s (Y/Y_n)^n - d$   $(Y_n=100, Y_u=18, s=116, n=1/3, d=16)$   [1a]
$L^* = r (Y/Y_u)^n - d$   $(r = s (Y_u/Y_n)^n=65,49, L^*_u= r - d)$   [1b]
$Y/dY = Y / \{ [(Y_n/ (n s)) (Y/Y_n)^{1-n}] \}$   [4c]
$(Y/Y)_u = Y_u / \{ [(Y_n/ (n s)) (Y_u/Y_n)^{1-n}] \}$   [4d]
$(Y/dY) / (Y/dY)_u = (Y/Y_u)^n$   [4e]

$m_{u90\_4} = 0,280, f_{90}=37, f_4=13$
$m_u = 0,390$

1,757
−0,477

hep30−7n   hep30−7a   hep30−8a   hep31−7n   hep31−7a   hep31−8a

**TUB-test chart hep3; HAULAB & CIELAB colour-difference, Haubner (1980) & ISO/CIE 11664-4**
**log & lin[lightness $L^*$, threshold $\Delta Y$, sensitivity $\Delta Y / Y$, contrast $Y / \Delta Y$, normalized for grey U]**