

Contrast step  $C_{Yi}$  ( $i=1$  to 8), CIE tristimulus values  $Y_W$  and  $Y_N$  according to ISO 9241-306<sup>1)</sup>

| Contrast step<br>$C_{Yi}$ and Y<br>-ratio<br>( $i=1 \dots 8$ ) | CIE tristi-<br>mulus value;<br>ratio<br>$Y_W : Y_N$<br>White W<br>and Black N | CIE tristi-<br>mulus value;<br>range<br>$Y_{N1} \dots Y_{N2}$ | Display (E)<br>illumi-<br>nance <sup>2)</sup> ;<br>ratio<br>lux<br>$E_{WE} : E_{NE}$ | Display (P)<br>lumi-<br>nance <sup>2)</sup> ;<br>ratio<br>[cd/m <sup>2</sup> ]<br>$L_{WE} : L_{NE}$ | application and<br>colour mode<br>at work place;<br>illuminance<br>on display 500 lux<br>or 250/125/62 lux |
|----------------------------------------------------------------|-------------------------------------------------------------------------------|---------------------------------------------------------------|--------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|
| $C_{Y8}$ 288:1                                                 | 88,9 : 0,31                                                                   | 0,00 ... <0,46                                                | 445 : 1,55                                                                           | 142 : 0,50                                                                                          | display, only 062 lux                                                                                      |
| $C_{Y7}$ 144:1                                                 | 88,9 : 0,62                                                                   | 0,46 ... <0,93                                                | 445 : 3,1                                                                            | 142 : 1,00                                                                                          | display, only 125 lux                                                                                      |
| $C_{Y6}$ 72:1                                                  | 88,9 : 1,25                                                                   | 0,93 ... <1,87                                                | 445 : 6,2                                                                            | 142 : 2,00                                                                                          | display, only 250 lux                                                                                      |
| $C_{Y5}$ 36:1                                                  | <b>88,9 : 2,50</b>                                                            | <b>1,87 ... &lt;3,75</b>                                      | <b>445 : 12,4</b>                                                                    | <b>142 : 4,00</b>                                                                                   | <b>display and surface</b>                                                                                 |
| $C_{Y4}$ 18:1                                                  | 88,9 : 5,00                                                                   | 3,75 ... <7,50                                                | 445 : 24,8                                                                           | 142 : 8,00                                                                                          | display and surface                                                                                        |
| $C_{Y3}$ 9:1                                                   | 88,9 : 10,0                                                                   | 7,50 ... <15,0                                                | 445 : 49,6                                                                           | 142 : 16,0                                                                                          | display and surface                                                                                        |
| $C_{Y2}$ 4,5:1                                                 | 88,9 : 20,0                                                                   | 15,0 ... <30,0                                                | 445 : 99,2                                                                           | 142 : 32,0                                                                                          | display and surface                                                                                        |
| $C_{Y1}$ 2,25:1 <sup>3)</sup>                                  | 88,9 : 40,0                                                                   | 30,0 ... <60,0                                                | 445 : 198                                                                            | 142 : 64,0                                                                                          | display and surface                                                                                        |

1) The example shows data for emissive displays (E). The standard contrast step (bold) with  $L_{NE} = 4 \text{ cd/m}^2$  may be reached.

2) Measurement of 445 (= 500\*0,889) lux corresponds to the viewing luminance  $L_V = 142 \text{ cd/m}^2$  for an emissive display (E).

3) For the contrast  $C_Y = 36:1$  the viewing luminances of both the black paper and the black on the screen are equal.

Also the viewing luminances of all colours at the screen and the paper are equal, for example for a 16 step grey scale.

A visual fatigue based on an adaptation changes between paper and display is impossible.

For all black surfaces it is valid  $Y_N > 2,5$ . Therefore high contrast steps are only possible at the displays by reduced reflection.

AE950-3N

Contrast step  $C_{Yi}$  ( $i=1$  to 8), CIE tristimulus values  $Y_W$  and  $Y_N$  according to ISO 9241-306<sup>1)</sup>

| Contrast step<br>$C_{Yi}$ and Y<br>-ratio<br>( $i=1 \dots 8$ ) | CIE tristi-<br>mulus value;<br>ratio<br>$Y_W : Y_N$<br>White W<br>and Black N | CIE tristi-<br>mulus value;<br>range<br>$Y_{N1} \dots Y_{N2}$ | Paper (S)<br>lumi-<br>nance <sup>2)</sup> ;<br>ratio<br>[cd/m <sup>2</sup> ]<br>$L_{WS} : L_{NS}$ | Display (E)<br>lumi-<br>nance <sup>2)</sup> ;<br>ratio<br>[cd/m <sup>2</sup> ]<br>$L_{WE} : L_{NE}$ | application and<br>colour mode<br>at work place;<br>illuminance<br>on display 500 lux<br>or 250/125/62 lux |
|----------------------------------------------------------------|-------------------------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|
| $C_{Y8}$ 288:1                                                 | 88,9 : 0,31                                                                   | 0,00 ... <0,46                                                | 142 : 0,50                                                                                        | 142 : 0,50                                                                                          | display, only 062 lux                                                                                      |
| $C_{Y7}$ 144:1                                                 | 88,9 : 0,62                                                                   | 0,46 ... <0,93                                                | 142 : 1,00                                                                                        | 142 : 1,00                                                                                          | display, only 125 lux                                                                                      |
| $C_{Y6}$ 72:1                                                  | 88,9 : 1,25                                                                   | 0,93 ... <1,87                                                | 142 : 2,00                                                                                        | 142 : 2,00                                                                                          | display, only 250 lux                                                                                      |
| $C_{Y5}$ 36:1                                                  | <b>88,9 : 2,50</b>                                                            | <b>1,87 ... &lt;3,75</b>                                      | <b>142 : 4,00</b>                                                                                 | <b>142 : 4,00</b>                                                                                   | <b>display and surface</b>                                                                                 |
| $C_{Y4}$ 18:1                                                  | 88,9 : 5,00                                                                   | 3,75 ... <7,50                                                | 142 : 8,00                                                                                        | 142 : 8,00                                                                                          | display and surface                                                                                        |
| $C_{Y3}$ 9:1                                                   | 88,9 : 10,0                                                                   | 7,50 ... <15,0                                                | 142 : 16,0                                                                                        | 142 : 16,0                                                                                          | display and surface                                                                                        |
| $C_{Y2}$ 4,5:1                                                 | 88,9 : 20,0                                                                   | 15,0 ... <30,0                                                | 142 : 32,0                                                                                        | 142 : 32,0                                                                                          | display and surface                                                                                        |
| $C_{Y1}$ 2,25:1 <sup>3)</sup>                                  | 88,9 : 40,0                                                                   | 30,0 ... <60,0                                                | 142 : 64,0                                                                                        | 142 : 64,0                                                                                          | display and surface                                                                                        |

1) The example shows data for emissive displays (E). The standard contrast step (bold) with  $L_{NE} = 4 \text{ cd/m}^2$  may be reached.

2) 500 lux corresponds to the viewing luminance  $L_V = 142 \text{ cd/m}^2$  for the standard offset paper (S) with the tristimulus value  $Y_W = 88,9$ .

3) Measurement of 445 (= 500\*0,889) lux corresponds to the viewing luminance  $L_V = 142 \text{ cd/m}^2$  for an emissive display (E).

4) For the contrast  $C_Y = 36:1$  the viewing luminances of both the black paper and the black on the screen are equal.

Also the viewing luminances of all colours at the screen and the paper are equal, for example for a 16 step grey scale.

For all black surfaces it is valid  $Y_N > 2,5$ . Therefore high contrast steps are only possible at the displays by reduced reflection.

AE950-7N

TUB test chart AE95; Contrast steps of emissive displays  
Eight contrast steps, and illuminances 500 lux of displays

Contrast step  $C_{Yi}$  ( $i=1$  to 8), CIE tristimulus values  $Y_W$  and  $Y_N$  according to ISO 9241-306<sup>1)</sup>

| Contrast step<br>$C_{Yi}$ and Y<br>-ratio<br>( $i=1 \dots 8$ ) | CIE tristi-<br>mulus value;<br>ratio<br>$Y_W : Y_N$<br>White W<br>and Black N | CIE tristi-<br>mulus value;<br>range<br>$Y_{N1} \dots Y_{N2}$ | Paper (S)<br>lumi-<br>nance <sup>2)</sup> ;<br>ratio<br>[cd/m <sup>2</sup> ]<br>$L_{WS} : L_{NS}$ | Display (E)<br>lumi-<br>nance <sup>2)</sup> ;<br>ratio<br>[cd/m <sup>2</sup> ]<br>$L_{WE} : L_{NE}$ | application and<br>colour mode<br>at work place;<br>illuminance<br>on display 500 lux<br>or 250/125/62 lux |
|----------------------------------------------------------------|-------------------------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|
| $C_{Y8}$ 288:1                                                 | 88,9 : 0,31                                                                   | 0,00 ... <0,46                                                | 142 : 142/288                                                                                     | 142*36 : 018                                                                                        | display, only 062 lux                                                                                      |
| $C_{Y7}$ 144:1                                                 | 88,9 : 0,62                                                                   | 0,46 ... <0,93                                                | 142 : 142/144                                                                                     | 142*36 : 035                                                                                        | display, only 125 lux                                                                                      |
| $C_{Y6}$ 72:1                                                  | 88,9 : 1,25                                                                   | 0,93 ... <1,87                                                | 142 : 142/72                                                                                      | 142*36 : 071                                                                                        | display, only 250 lux                                                                                      |
| $C_{Y5}$ 36:1                                                  | <b>88,9 : 2,50</b>                                                            | <b>1,87 ... &lt;3,75</b>                                      | <b>142 : 142/36</b>                                                                               | <b>142*36 : 142</b>                                                                                 | <b>display and surface</b>                                                                                 |
| $C_{Y4}$ 18:1                                                  | 88,9 : 5,00                                                                   | 3,75 ... <7,50                                                | 142 : 142/18                                                                                      | 142*18 : 142                                                                                        | display and surface                                                                                        |
| $C_{Y3}$ 9:1                                                   | 88,9 : 10,0                                                                   | 7,50 ... <15,0                                                | 142 : 142/9                                                                                       | 142*09 : 142                                                                                        | display and surface                                                                                        |
| $C_{Y2}$ 4,5:1                                                 | 88,9 : 20,0                                                                   | 15,0 ... <30,0                                                | 142 : 142/4,5                                                                                     | 142*4,5 : 142                                                                                       | display and surface                                                                                        |
| $C_{Y1}$ 2,25:1 <sup>3)</sup>                                  | 88,9 : 40,0                                                                   | 30,0 ... <60,0                                                | 142 : 142/2,25                                                                                    | 142*2,25 : 142                                                                                      | display and surface                                                                                        |

1) The example is intended for data projectors (P). The standard contrast step (bold)  $L_{WP} = 142*36 \text{ cd/m}^2$  is hard to reach.

2) 500 lux corresponds to the viewing luminance  $L_V = 142 \text{ cd/m}^2$  for the standard offset paper (S) with the tristimulus value  $Y_W = 88,9$ .

3) For the contrast  $C_Y = 2:1$  the viewing luminances of both the black in the projection and the white standard offset paper are equal (!).

Visual fatigue caused by the adaptation luminance ratio 36:1 of the black at the screen and the black at the paper shall be reduced.

If for example a grey screen with the CIE tristimulus value  $Y_Z = 22,2$  (= 0,25\*88,9) is used the contrast step  $C_{Yi}$  remains constant.

Then the luminance ratio of all colours at the screen and the paper has reduced to 9:1. This reduces visual fatigue.

AE951-3N

Contrast step  $C_{Yi}$  ( $i=1$  to 8), CIE tristimulus values  $Y_W$  and  $Y_N$  according to ISO 9241-306<sup>1)</sup>

| Contrast step<br>$C_{Yi}$ and Y<br>-ratio<br>( $i=1 \dots 8$ ) | CIE tristi-<br>mulus value;<br>ratio<br>$Y_W : Y_N$<br>White W<br>and Black N | CIE tristi-<br>mulus value;<br>range<br>$Y_{N1} \dots Y_{N2}$ | Display (E)<br>illumi-<br>nance <sup>2)</sup> ;<br>ratio<br>lux<br>$E_{WE} : E_{NE}$ | Display (P)<br>lumi-<br>nance <sup>2)</sup> ;<br>ratio<br>[cd/m <sup>2</sup> ]<br>$L_{WP} : L_{NP}$ | application and<br>colour mode<br>at work place;<br>illuminance<br>on display 500 lux<br>or 250/125/62 lux |
|----------------------------------------------------------------|-------------------------------------------------------------------------------|---------------------------------------------------------------|--------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|
| $C_{Y8}$ 288:1                                                 | 88,9 : 0,31                                                                   | 0,00 ... <0,46                                                | 125*36 : 015                                                                         | 36*36 : 4,5                                                                                         | display, only 062 lux                                                                                      |
| $C_{Y7}$ 144:1                                                 | 88,9 : 0,62                                                                   | 0,46 ... <0,93                                                | 125*36 : 031                                                                         | 36*36 : 09                                                                                          | display, only 125 lux                                                                                      |
| $C_{Y6}$ 72:1                                                  | 88,9 : 1,25                                                                   | 0,93 ... <1,87                                                | 125*36 : 062                                                                         | 36*36 : 18                                                                                          | display, only 250 lux                                                                                      |
| $C_{Y5}$ 36:1                                                  | <b>88,9 : 2,50</b>                                                            | <b>1,87 ... &lt;3,75</b>                                      | <b>125*36 : 125</b>                                                                  | <b>36*36 : 36</b>                                                                                   | <b>display and surface</b>                                                                                 |
| $C_{Y4}$ 18:1                                                  | 88,9 : 5,00                                                                   | 3,75 ... <7,50                                                | 125*18 : 125                                                                         | 36*18 : 36                                                                                          | display and surface                                                                                        |
| $C_{Y3}$ 9:1                                                   | 88,9 : 10,0                                                                   | 7,50 ... <15,0                                                | 125*09 : 125                                                                         | 36*09 : 36                                                                                          | display and surface                                                                                        |
| $C_{Y2}$ 4,5:1                                                 | 88,9 : 20,0                                                                   | 15,0 ... <30,0                                                | 125*4,5 : 125                                                                        | 36*4,5 : 36                                                                                         | display and surface                                                                                        |
| $C_{Y1}$ 2,25:1 <sup>3)</sup>                                  | 88,9 : 40,0                                                                   | 30,0 ... <60,0                                                | 125*2,25 : 125                                                                       | 36*2,25 : 36                                                                                        | display and surface                                                                                        |

1) The example is intended for data projectors (P). The standard contrast step (bold)  $L_{WP} = 36*36 \text{ cd/m}^2$  is hard to reach.

2) 500 lux corresponds to the viewing luminance  $L_V = 36 \text{ cd/m}^2$  for the standard offset paper (S) with the tristimulus value  $Y_W = 88,9$ .

3) For the contrast  $C_Y = 2:1$  the viewing luminances of both the black in the projection and the white standard offset paper are equal (!).

Visual fatigue caused by the adaptation luminance ratio 36:1 of the black at the screen and the black at the paper shall be reduced.

If for example a grey screen with the CIE tristimulus value  $Y_Z = 22,2$  (= 0,25\*88,9) is used the contrast step  $C_{Yi}$  remains constant.

Then the luminance ratio of all colours at the screen and the paper has reduced to 9:1. This reduces visual fatigue.

AE951-7N

input: w/rgb/cmyk -> rgb-  
output: no change