

| Contrast step $C_{Yi}$ ( $i=1$ to 8), CIE tristimulus value $Y_N$ , grey steps according to ISO 9241-306 <sup>1)</sup> |                                                                |                                                                 |                                                                      |                                                              |                                                                       |                                                                    |
|------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|-----------------------------------------------------------------|----------------------------------------------------------------------|--------------------------------------------------------------|-----------------------------------------------------------------------|--------------------------------------------------------------------|
| Contrast step $C_{Yi}$ and Y-ratio ( $i=1 \dots 8$ )                                                                   | CIE tristimulus value $Y_N$ and CIE lightness $L_N^*$ of black | total viewing display illuminance $E_{p+R}$ [lux] <sup>3)</sup> | measured projector (P) display illuminance $E_p$ [lux] <sup>3)</sup> | room light (R) display illuminance $E_R$ [lux] <sup>3)</sup> | grey steps without output linearisation delta $L^*=1$ amount $a_N^2)$ | grey steps with output linearisation delta $L^*=1$ amount $a_N^2)$ |
| $C_{Y8}$ 288:1                                                                                                         | 0,31 / 1                                                       | 80000+64000                                                     | 143500                                                               | 500                                                          | 47 (max)                                                              | 94 (max)                                                           |
| $C_{Y7}$ 144:1                                                                                                         | 0,62 / 6                                                       | 40000+32000                                                     | 61500                                                                | 500                                                          | 44                                                                    | 88                                                                 |
| $C_{Y6}$ 72:1                                                                                                          | 1,25 / 11                                                      | 20000+16000                                                     | 35500                                                                | 500                                                          | 42                                                                    | 84                                                                 |
| $C_{Y5}$ 36:1                                                                                                          | 2,5 / 18                                                       | 10000+8000                                                      | 17500                                                                | 500                                                          | 38                                                                    | 77                                                                 |
| $C_{Y4}$ 18:1                                                                                                          | 5,0 / 27                                                       | 5000+4000                                                       | 8500                                                                 | 500                                                          | 34                                                                    | 68                                                                 |
| $C_{Y3}$ 9:1                                                                                                           | 10 / 38                                                        | 2500+2000                                                       | 4000                                                                 | 500                                                          | 28                                                                    | 57                                                                 |
| $C_{Y2}$ 4,5:1                                                                                                         | 20 / 52                                                        | 1250+1000                                                       | 1750                                                                 | 500                                                          | 21                                                                    | 43                                                                 |
| $C_{Y1}$ 2,25:1                                                                                                        | 40 / 70                                                        | 625+500                                                         | 625                                                                  | 500                                                          | 12                                                                    | 25                                                                 |

- 1) The example is intended for data projectors (P). The standard contrast step (bold)  $C_{Y5} = 36:1$  is hard to reach.  
2) For the amount of discriminable colour steps use the equations:  $c_N = a_N^2$  or  $c_N = c_N^2$ , for example  $c_N = 4096$  for  $a_N = 16$ .  
3) For the contrast  $C_N \geq 2:1$  the viewing luminances of both the black in the projection and the white standard offset paper are equal (1). 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  $Y_N = 22,2 (=0,25 \cdot 88,9)$  is used the contrast step  $C_{Y5}$  remains constant. Then the luminance ratio of all colours at the screen and the paper has reduced to 9:1. This reduces visual fatigue.

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| Contrast step $C_{Yi}$ ( $i=1$ to 8), CIE tristimulus value $Y_N$ , grey steps according to ISO 9241-306 <sup>1)</sup> |                                                                |                                                                 |                                                                      |                                                              |                                                                       |                                                                    |
|------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|-----------------------------------------------------------------|----------------------------------------------------------------------|--------------------------------------------------------------|-----------------------------------------------------------------------|--------------------------------------------------------------------|
| Contrast step $C_{Yi}$ and Y-ratio ( $i=1 \dots 8$ )                                                                   | CIE tristimulus value $Y_N$ and CIE lightness $L_N^*$ of black | total viewing display illuminance $E_{p+R}$ [lux] <sup>2)</sup> | measured projector (P) display illuminance $E_p$ [lux] <sup>2)</sup> | room light (R) display illuminance $E_R$ [lux] <sup>2)</sup> | grey steps without output linearisation delta $L^*=1$ amount $a_N^3)$ | grey steps with output linearisation delta $L^*=1$ amount $a_N^3)$ |
| $C_{Y8}$ 288:1                                                                                                         | 0,31 / 1                                                       | 80000+64000                                                     | 143500                                                               | 500                                                          | 47 (max)                                                              | 94 (max)                                                           |
| $C_{Y7}$ 144:1                                                                                                         | 0,62 / 6                                                       | 40000+32000                                                     | 61500                                                                | 500                                                          | 44                                                                    | 88                                                                 |
| $C_{Y6}$ 72:1                                                                                                          | 1,25 / 11                                                      | 20000+16000                                                     | 35500                                                                | 500                                                          | 42                                                                    | 84                                                                 |
| $C_{Y5}$ 36:1                                                                                                          | 2,5 / 18                                                       | 10000+8000                                                      | 17500                                                                | 500                                                          | 38                                                                    | 77                                                                 |
| $C_{Y4}$ 18:1                                                                                                          | 5,0 / 27                                                       | 5000+4000                                                       | 8500                                                                 | 500                                                          | 34                                                                    | 68                                                                 |
| $C_{Y3}$ 9:1                                                                                                           | 10 / 38                                                        | 2500+2000                                                       | 4000                                                                 | 500                                                          | 28                                                                    | 57                                                                 |
| $C_{Y2}$ 4,5:1                                                                                                         | 20 / 52                                                        | 1250+1000                                                       | 1750                                                                 | 500                                                          | 21                                                                    | 43                                                                 |
| $C_{Y1}$ 2,25:1                                                                                                        | 40 / 70                                                        | 625+500                                                         | 625                                                                  | 500                                                          | 12                                                                    | 25                                                                 |

The following example assumes that a projector produces the contrast step  $C_{Y3}$  for the illuminances measured for 5 times the horizontal A4 direction (149 cm):

|                 |         |           |      |     |    |    |
|-----------------|---------|-----------|------|-----|----|----|
| $C_{Y3}$ 9:1    | 10 / 38 | 2500+2000 | 4000 | 500 | 28 | 57 |
| $C_{Y2}$ 4,5:1  | 20 / 52 | 1250+1000 | 1750 | 500 | 21 | 43 |
| $C_{Y1}$ 2,25:1 | 40 / 70 | 625+500   | 625  | 500 | 12 | 25 |

The illuminances  $E_p$  are by the factor 4 less for 10 times the A4-direction (298 cm):

|                              |         |          |      |     |    |    |
|------------------------------|---------|----------|------|-----|----|----|
| $C_{Y3}$ 3:1 <sup>4)</sup>   | 30 / 61 | 1000+500 | 1000 | 500 | 17 | 34 |
| $C_{Y2}$ 1,9:1 <sup>5)</sup> | 45 / 74 | 438+500  | 438  | 500 | 10 | 21 |

- 1) The example is intended for data projectors (P). The standard contrast step (bold)  $C_{Y5} = 36:1$  is not reached.  
2) 500 lux corresponds to the viewing luminance  $L_N = 142 \text{ cd/m}^2$  for a standard white paper with the tristimulus value  $Y_N = 88,9$ .  
3) For the amount of discriminable colour steps use the equations:  $c_N = a_N^2$  or  $c_N = c_N^2$ , for example  $c_N = 4096$  for  $a_N = 16$ .  
4) The viewing contrast  $C_{Y31} = 1500:500 = 3:1$  is larger compared to the contrast  $C_{Y1} = 2,25:1$ . The contrast step is  $C_{Y1} = 2,25:1$ .  
5) The viewing contrast  $C_{Y42} = 938:500 = 1,9:1$  is smaller compared to the contrast  $C_{Y1} = 2,25:1$ . A contrast step is not defined.

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test chart PE04; Contrast steps of data projectors  
Eight contrast steps, and illuminances of displays for 500 lux output: no change

| Contrast step $C_{Yi}$ ( $i=1$ to 8), CIE tristimulus value $Y_N$ , grey steps according to ISO 9241-306 <sup>1)</sup> |                                                                |                                                                 |                                                                      |                                                              |                                                                       |                                                                    |
|------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|-----------------------------------------------------------------|----------------------------------------------------------------------|--------------------------------------------------------------|-----------------------------------------------------------------------|--------------------------------------------------------------------|
| Contrast step $C_{Yi}$ and Y-ratio ( $i=1 \dots 8$ )                                                                   | CIE tristimulus value $Y_N$ and CIE lightness $L_N^*$ of black | total viewing display illuminance $E_{p+R}$ [lux] <sup>2)</sup> | measured projector (P) display illuminance $E_p$ [lux] <sup>2)</sup> | room light (R) display illuminance $E_R$ [lux] <sup>2)</sup> | grey steps without output linearisation delta $L^*=1$ amount $a_N^2)$ | grey steps with output linearisation delta $L^*=1$ amount $a_N^2)$ |
| $C_{Y8}$ 288:1                                                                                                         | 0,31 / 1                                                       | 19200+16000                                                     | 35075                                                                | 125                                                          | 47 (max)                                                              | 94 (max)                                                           |
| $C_{Y7}$ 144:1                                                                                                         | 0,62 / 6                                                       | 9600+8000                                                       | 17475                                                                | 125                                                          | 44                                                                    | 88                                                                 |
| $C_{Y6}$ 72:1                                                                                                          | 1,25 / 11                                                      | 4800+4000                                                       | 8675                                                                 | 125                                                          | 42                                                                    | 84                                                                 |
| $C_{Y5}$ 36:1                                                                                                          | 2,5 / 18                                                       | 2400+2000                                                       | 4275                                                                 | 125                                                          | 38                                                                    | 77                                                                 |
| $C_{Y4}$ 18:1                                                                                                          | 5,0 / 27                                                       | 1200+1000                                                       | 2075                                                                 | 125                                                          | 34                                                                    | 68                                                                 |
| $C_{Y3}$ 9:1                                                                                                           | 10 / 38                                                        | 600+500                                                         | 975                                                                  | 125                                                          | 28                                                                    | 57                                                                 |
| $C_{Y2}$ 4,5:1                                                                                                         | 20 / 52                                                        | 300+250                                                         | 425                                                                  | 125                                                          | 21                                                                    | 43                                                                 |
| $C_{Y1}$ 2,25:1                                                                                                        | 40 / 70                                                        | 150+125                                                         | 150                                                                  | 125                                                          | 12                                                                    | 25                                                                 |

- 1) The example is intended for data projectors (P). The standard contrast step (bold)  $C_{Y5} = 36:1$  is hard to reach.  
2) For the amount of discriminable colour steps use the equations:  $c_N = a_N^2$  or  $c_N = c_N^2$ , for example  $c_N = 4096$  for  $a_N = 16$ .  
3) For the contrast  $C_N \geq 2:1$  the viewing luminances of both the black in the projection and the white standard offset paper are equal (1). 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  $Y_N = 22,2 (=0,25 \cdot 88,9)$  is used the contrast step  $C_{Y5}$  remains constant. Then the luminance ratio of all colours at the screen and the paper has reduced to 9:1. This reduces visual fatigue.

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| Contrast step $C_{Yi}$ ( $i=1$ to 8), CIE tristimulus value $Y_N$ , grey steps according to ISO 9241-306 <sup>1)</sup> |                                                                |                                                                 |                                                                      |                                                              |                                                                       |                                                                    |
|------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|-----------------------------------------------------------------|----------------------------------------------------------------------|--------------------------------------------------------------|-----------------------------------------------------------------------|--------------------------------------------------------------------|
| Contrast step $C_{Yi}$ and Y-ratio ( $i=1 \dots 8$ )                                                                   | CIE tristimulus value $Y_N$ and CIE lightness $L_N^*$ of black | total viewing display illuminance $E_{p+R}$ [lux] <sup>2)</sup> | measured projector (P) display illuminance $E_p$ [lux] <sup>2)</sup> | room light (R) display illuminance $E_R$ [lux] <sup>2)</sup> | grey steps without output linearisation delta $L^*=1$ amount $a_N^3)$ | grey steps with output linearisation delta $L^*=1$ amount $a_N^3)$ |
| $C_{Y8}$ 288:1                                                                                                         | 0,31 / 1                                                       | 19200+16000                                                     | 35075                                                                | 125                                                          | 47 (max)                                                              | 94 (max)                                                           |
| $C_{Y7}$ 144:1                                                                                                         | 0,62 / 6                                                       | 9600+8000                                                       | 17475                                                                | 125                                                          | 44                                                                    | 88                                                                 |
| $C_{Y6}$ 72:1                                                                                                          | 1,25 / 11                                                      | 4800+4000                                                       | 8675                                                                 | 125                                                          | 42                                                                    | 84                                                                 |
| $C_{Y5}$ 36:1                                                                                                          | 2,5 / 18                                                       | 2400+2000                                                       | 4275                                                                 | 125                                                          | 38                                                                    | 77                                                                 |
| $C_{Y4}$ 18:1                                                                                                          | 5,0 / 27                                                       | 1200+1000                                                       | 2075                                                                 | 125                                                          | 34                                                                    | 68                                                                 |
| $C_{Y3}$ 9:1                                                                                                           | 10 / 38                                                        | 600+500                                                         | 975                                                                  | 125                                                          | 28                                                                    | 57                                                                 |
| $C_{Y2}$ 4,5:1                                                                                                         | 20 / 52                                                        | 300+250                                                         | 425                                                                  | 125                                                          | 21                                                                    | 43                                                                 |
| $C_{Y1}$ 2,25:1                                                                                                        | 40 / 70                                                        | 150+125                                                         | 150                                                                  | 125                                                          | 12                                                                    | 25                                                                 |

The following example assumes that a projector produces the contrast step  $C_{Y3}$  for the illuminances measured for 5 times the horizontal A4 direction (149 cm):

|                 |         |           |      |     |    |    |
|-----------------|---------|-----------|------|-----|----|----|
| $C_{Y3}$ 9:1    | 10 / 38 | 2400+2000 | 4275 | 125 | 38 | 77 |
| $C_{Y2}$ 4,5:1  | 20 / 52 | 1200+1000 | 2075 | 125 | 34 | 68 |
| $C_{Y1}$ 2,25:1 | 40 / 70 | 600+500   | 975  | 125 | 28 | 57 |

The illuminances  $E_p$  are by the factor 4 less for 10 times the A4-direction (298 cm):

|                            |         |          |      |     |    |    |
|----------------------------|---------|----------|------|-----|----|----|
| $C_{Y3}$ 3:1 <sup>4)</sup> | 30 / 61 | 1069+125 | 1069 | 125 | 17 | 34 |
| $C_{Y2}$ 2:1 <sup>5)</sup> | 45 / 74 | 518+125  | 518  | 125 | 10 | 21 |

- 1) The example is intended for data projectors (P). The standard contrast step (bold)  $C_{Y5} = 36:1$  is not reached.  
2) 125 lux corresponds to the viewing luminance  $L_N = 35 \text{ cd/m}^2$  for a standard white paper with the tristimulus value  $Y_N = 88,9$ .  
3) For the amount of discriminable colour steps use the equations:  $c_N = a_N^2$  or  $c_N = c_N^2$ , for example  $c_N = 4096$  for  $a_N = 16$ .  
4) The viewing contrast  $C_{Y31} = 1194:125 = 8,5:1$  is larger compared to the contrast  $C_{Y1} = 2,25:1$ . The contrast step is  $C_{Y1} = 2,25:1$ .  
5) The viewing contrast  $C_{Y42} = 643:125 = 5,1:1$  is larger compared to the contrast  $C_{Y1} = 2,25:1$ . The contrast step is  $C_{Y1} = 2,25:1$ .

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input: w/rgb/cmyk -> rgb-