

Contrast step C_{Y_i} (i=1 to 8), CIE tristimulus value Y_N , grey steps according to ISO 9241-306¹⁾

Contrast step C_{Y_i} and Y-ratio (i=1 .. 8)	CIE tristimulus value Y_N and CIE lightness L_N^* of black	total viewing display illuminance E_{P+R} [lux] ³⁾	measured projector (P) display illuminance E_P [lux] ³⁾	room light (R) display illuminance E_R [lux] ³⁾	grey steps without output linearisation delta $L^*=1$ amount a_n ²⁾	grey steps with output linearisation delta $L^*=1$ amount a_l ²⁾
C_{Y_8} 288:1	0,31 / 1	80000+64000	143500	500	47 (max)	94 (max)
C_{Y_7} 144:1	0,62 / 6	40000+32000	61500	500	44	88
C_{Y_6} 72:1	1,25 / 11	20000+16000	35500	500	42	84
C_{Y_5} 36:1	2,5 / 18	10000+8000	17500	500	38	77
C_{Y_4} 18:1	5,0 / 27	5000+4000	8500	500	34	68
C_{Y_3} 9:1	10 / 38	2500+2000	4000	500	28	57
C_{Y_2} 4,5:1	20 / 52	1250+1000	1750	500	21	43
C_{Y_1} 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) $C_{Y_5} = 36:1$ is hard to reach.
- 2) For the amount of discriminable colour steps use the equations: $c_n = a_n^3$ or $c_l = a_l^3$, for example $c_n = 4096$ for $a_n = 16$.
- 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 $Y_Z = 22,2$ ($= 0,25 \cdot 88,9$) is used the contrast step C_{Y_i} remains constant. Then the luminance ratio of all colours at the screen and the paper has reduced to 9:1. This reduces visual fatigue.

Contrast step C_{Yi} ($i=1$ to 8), CIE tristimulus value Y_N , grey steps according to ISO 9241-306¹⁾

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] ²⁾	measured projector (P) display illuminance E_P [lux] ²⁾	room light (R) display illuminance E_R [lux] ²⁾	grey steps without output linearisation delta $L^*=1$ amount a_n ³⁾	grey steps with output linearisation delta $L^*=1$ amount a_l ³⁾
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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_{Yx1} 3:1 ⁴⁾	30 / 61	1000+500	1000	500	17	34
C_{Yx2} 1,9:1 ⁵⁾	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 $L_v = 142 \text{ cd/m}^2$ for a standard white paper with the tristimulus value $Y_w = 88,9$.
- 3) For the amount of discriminable colour steps use the equations: $c_n = a_n^3$ or $c_l = a_l^3$, for example $c_n = 4096$ for $a_n = 16$.
- 4) The viewing contrast $C_{Yx1} = 1500:500 = 3:1$ is larger compared to the contrast $C_{Y1} = 2,25:1$. The contrast step is $C_{Y1} = 2,25:1$.
- 5) The viewing contrast $C_{Yx2} = 938:500 = 1,9:1$ is smaller compared to the contrast $C_{Y1} = 2,25:1$. A contrast step is not defined.

Contrast step C_{Y_i} ($i=1$ to 8), CIE tristimulus value Y_N , grey steps according to ISO 9241-306¹⁾

Contrast step C_{Y_i} 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] ²⁾	measured projector (P) display illuminance E_P [lux] ²⁾	room light (R) display illuminance E_R [lux] ²⁾	grey steps without output linearisation delta $L^*=1$ amount a_n ²⁾	grey steps with output linearisation delta $L^*=1$ amount a_l ²⁾
C_{Y_8} 288:1	0,31 / 1	19200+16000	35075	125	47 (max)	94 (max)
C_{Y_7} 144:1	0,62 / 6	9600+8000	17475	125	44	88
C_{Y_6} 72:1	1,25 / 11	4800+4000	8675	125	42	84
C_{Y_5} 36:1	2,5 / 18	2400+2000	4275	125	38	77
C_{Y_4} 18:1	5,0 / 27	1200+1000	2075	125	34	68
C_{Y_3} 9:1	10 / 38	600+500	975	125	28	57
C_{Y_2} 4,5:1	20 / 52	300+250	425	125	21	43
C_{Y_1} 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) $C_{Y_5} = 36:1$ is hard to reach.
- 2) For the amount of discriminable colour steps use the equations: $c_n = a_n^3$ or $c_l = a_l^3$, for example $c_n = 4096$ for $a_n = 16$.
- 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 $Y_Z = 22,2$ ($= 0,25 \cdot 88,9$) is used the contrast step C_{Y_i} remains constant. Then the luminance ratio of all colours at the screen and the paper has reduced to 9:1. This reduces visual fatigue.

Contrast step C_{Yi} ($i=1$ to 8), CIE tristimulus value Y_N , grey steps according to ISO 9241-306¹⁾

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] ²⁾	measured projector (P) display illuminance E_P [lux] ²⁾	room light (R) display illuminance E_R [lux] ²⁾	grey steps without output linearisation delta $L^*=1$ amount a_n ³⁾	grey steps with output linearisation delta $L^*=1$ amount a_l ³⁾
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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_{Y4} 36:1	10 / 38	2400+2000	4275	125	38	77
C_{Y3} 9:1	20 / 52	1200+1000	2075	125	34	68
C_{Y2} 4,5:1	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_{Yx1} 4:1⁴⁾	30 / 61	1069+125	1069	125		34
C_{Yx2} 2:1⁵⁾	45 / 74	518+125	518	125		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 $L_v = 35 \text{ cd/m}^2$ for a standard white paper with the tristimulus value $Y_w = 88,9$.
- 3) For the amount of discriminable colour steps use the equations: $c_n = a_n^3$ or $c_l = a_l^3$, for example $c_n = 4096$ for $a_n = 16$.
- 4) The viewing contrast $C_{Yx1} = 1194:125 = 8,5:1$ is larger compared to the contrast $C_{Y2} = 4,5:1$. The contrast step is $C_{Y2} = 4,5:1$.
- 5) The viewing contrast $C_{Yx2} = 643:125 = 5,1:1$ is larger compared to the contrast $C_{Y2} = 4,5:1$. The contrast step is $C_{Y2} = 4,5:1$.