BS EN ISO 24502:2010

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Ergonomics — Accessible design — Specification of age-related luminance contrast for coloured light (ISO 24502:2010)

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National foreword

This British Standard is the UK implementation of EN ISO 24502:2010.

The UK participation in its preparation was entrusted to Technical Committee PH/9/1, Ergonomics of the physical environment.

A list of organizations represented on this committee can be obtained on request to its secretary.

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ISBN 978 0 580 68947 5

ICS 11.180.30; 13.180

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 January 2011.

Amendments issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN ISO 24502

December 2010

ICS 11.180.30; 13.180

English Version

Ergonomics - Accessible design - Specification of age-related luminance contrast for coloured light (ISO 24502:2010)

Ergonomie - Conception accessible - Spécification du contraste de luminance lié à l'âge pour la lumière colorée (ISO 24502:2010)

Ergonomie - Zugängliche Gestaltung - Leitlinien für die Spezifikation des altersbezogenen Leuchtdichte-Kontrastes für farbiges Licht (ISO 24502:2010)

This European Standard was approved by CEN on 14 December 2010.

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Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN ISO 24502:2010: E

Foreword

This document (EN ISO 24502:2010) has been prepared by Technical Committee ISO/TC 159 “Ergonomics” in collaboration with Technical Committee CEN/TC 122 “Ergonomics” the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2011, and conflicting national standards shall be withdrawn at the latest by June 2011.

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Endorsement notice

The text of ISO 24502:2010 has been approved by CEN as a EN ISO 24502:2010 without any modification.

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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ISO 24502 was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 5, *Ergonomics of the physical environment*.

Introduction

Although the proportion of older people is increasing in many countries, the care for better visibility of signs and displays is not sufficiently taken for those older people. This prevents older people from actively being involved in social activities, as well as from living their life safely and comfortably. This International Standard provides a method of calculating age-related luminance contrast that can be used for assessing and designing signs and displays in our visual environment, so that they are clearly visible to older people. This method calculates age-related luminance contrast for people aged from 10 to 79 years based on age-related photopic spectral luminous efficiency of the eye.

This International Standard adopts the principles of accessible design given in ISO/IEC Guide 71 and amplified in ISO/TR 22411.

Ergonomics — Accessible design — Specification of age-related luminance contrast for coloured light

1 Scope

This International Standard specifies the age-related luminance contrast of any two lights of different colour seen by a person at any age, by taking into account the age-related change of spectral luminous efficiency of the eye.

This International Standard provides a basic method of calculation that can be applied to the design of lighting, visual signs and displays. It applies to light, self-luminous or reflected, in visual signs and displays seen under moderately bright conditions called photopic vision and whose spectral radiance is known or measurable. It does not apply to light seen under darker conditions called mesopic or scotopic vision.

This International Standard specifies the luminance contrast for people aged from 10 to 79 years who have had no medical treatment or surgery on their eyes that may affect their spectral luminous efficiency.

This International Standard does not apply to visual signs and displays seen by people with colour defects whose spectral luminous efficiency is different from those with normal colour vision, nor those seen by people with low vision.

2 Normative references

The following refererenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3864-1:—[1)], *Graphical symbols — Safety colours and safety signs — Part 1: Design principles for safety signs and safety markings*

ISO 3864-4:—[2)], *Graphical symbols — Safety colours and safety signs — Part 4: Colorimetric and photometric properties of safety sign materials*

ISO 9241-302:2008, *Ergonomics of human-system interaction — Part 302: Terminology for electronic visual displays*

ISO 9241-303:2008, *Ergonomics of human-system interaction — Part 303: Requirements for electronic visual displays*

ISO 23539/CIE S 010, *Photometry — The CIE system of physical photometry*

CIE 15, *Colorimetry*

CIE 17.4-1987, *International lighting vocabulary*

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1) To be published. (Revision of ISO 3864-1:2002)

2) To be published.

3 Terms and definitions

3.1
luminous efficiency
ratio of radiant flux weighted according to $V(\lambda)$ to the corresponding radiant flux

[CIE 17.4-1987]

3.2
spectral luminous efficiency
⟨of a monochromatic radiation of wavelength λ ($V(\lambda)$ for photopic vision; $V'(\lambda)$ for scotopic vision⟩ ratio of the radiant flux at wavelength λ_m to that at wavelength λ, such that both radiations produce equally intense luminous sensations under specified photometric conditions and λ_m is chosen so that the maximum value of this ratio is equal to 1

NOTE 1 Adapted from CIE 17.4-1987.

NOTE 2 The values for spectral luminous efficiency in photopic vision are given in ISO 23539/CIE S 010.

3.3
radiant flux
power emitted, transformed or received in the form of radiation

NOTE The radiant flux is expressed in watts (W).

[CIE 17.4-1987]

3.4
age-related photopic spectral luminous efficiency
$V_a(\lambda)$
spectral luminous efficiency defined as a function of age, a

3.5
luminance contrast
ratio between the higher luminance, L_H, and lower luminance, L_L, that defines the feature to be detected

NOTE 1 If measured by contrast modulation (or Michelson contrast) it is defined as:

$$C_m = \frac{L_H - L_L}{L_H + L_L} \quad (1)$$

or, if measured by contrast ratio (CR), it is defined as:

$$CR = \frac{L_H}{L_L} \quad (2)$$

NOTE 2 Contrast ratio, CR, is often used for high luminances. When near the luminance-detection threshold, some use the following form (also known as Weber contrast):

$$C_w = \frac{L_H - L_L}{L_L} \quad (3)$$

NOTE 3 For some but not all displays, area-luminance targets can be used to approximate the luminances that define the feature to be detected because pixels are discrete and near-area luminance is sufficiently uniform.

[ISO 9241-302:2008]

NOTE 4 Equation (2) is used in this International Standard. Equations (1) and (3) may also be used to calculate age-related luminance contrast.

3.6
age-related luminance contrast
$C_a(\lambda)$
luminance contrast defined as a function of age, a

NOTE The formula is given in Equation (4).

3.7
photopic vision
vision by the normal eye when it is adapted to levels of luminance of at least several candelas per square metre

[CIE 17.4-1987]

3.8
CIE standard photometric observer
ideal observer having a relative spectral responsivity curve that conforms to the $V(\lambda)$ function for photopic vision or to the $V'(\lambda)$ function for scotopic vision, and that complies with the summation law implied in the definition of luminous flux

[CIE 17.4-1987]

4 Age-related luminance contrast

The equation for age-related luminance contrast, C_a, is derived from the luminance contrast equation in which the luminance term is accommodated to the value that takes into account the age-related change of spectral luminous efficiency. See Table 1. Equation (4) shall be applied when age-related luminance contrast is calculated for light P_1 and light P_2 with spectral radiance of $L_{e,\lambda,1}$ and $L_{e,\lambda,2}$, respectively.

$$C_a = \frac{\sum_{380}^{780} L_{e,\lambda,1} V_a(\lambda) \Delta\lambda}{\sum_{380}^{780} L_{e,\lambda,2} V_a(\lambda) \Delta\lambda} \tag{4}$$

for $\sum_{380}^{780} L_{e,\lambda,1} V_a(\lambda) \Delta\lambda > \sum_{380}^{780} L_{e,\lambda,2} V_a(\lambda) \Delta\lambda$

where

C_a is the age-related luminance contrast for age, a;

$L_{e,\lambda,1}$ is the spectral radiance of light P_1, expressed in $W \cdot m^{-2} \cdot sr^{-1} \cdot nm^{-1}$;

$L_{e,\lambda,2}$ is the spectral radiance of light P_2, expressed in $W \cdot m^{-2} \cdot sr^{-1} \cdot nm^{-1}$;

$V_a(\lambda)$ is the age-related photopic spectral luminous efficiency of age, a, in years (values given in Table 1 in decade steps);

$\Delta\lambda$ is the wavelength width (5 nm).

NOTE 1 Age, a, is expressed in years but specified in decade steps such as 10-19 or 20-29 years, as indicated in Table 1. For example, C_{20} and $V_{20}(\lambda)$ mean the age-related luminance contrast and age-related photopic spectral luminous efficiency function, respectively, averaged for people in their twenties.

NOTE 2 $L_{e,\lambda,1}$ and $L_{e,\lambda,2}$, as well as $V_a(\lambda)$, are tabulated in the range of 380 nm to 780 nm in 5 nm steps as shown in Table 1. $\Delta\lambda$ in Equation (4) is therefore 5 nm. For more accurate calculation, the 1 nm width is applied by using interpolation. There are a few methods for interpolation recommended by the CIE depending on the spectral composition (see CIE 15).

NOTE 3 The quantity $\sum_{380}^{780} L_{e,\lambda,1} V_a(\lambda)\Delta\lambda$ is analogous to the luminance defined by the CIE, in which the standard luminous efficiency, $V(\lambda)$, and the maximum luminous efficacy, K_m (683 lm/W), are used.

NOTE 4 In the definition of luminance by the CIE, the continuous integral equation is used to avoid the effect of the wavelength width. In practice, summation of spectral radiance weighted by spectral luminous efficiency in 5 nm steps is adequate.

NOTE 5 Equation (4) is derived from one of the definitions for luminance contrast using $\sum_{380}^{780} L_{e,\lambda,1} V_a(\lambda)\Delta\lambda$ as a luminance component. Other definitions such as Michelson contrast (ISO 9241-302) may also be applied for the calculation of age-related luminance contrast.

NOTE 6 Age-related change in $V_a(\lambda)$ and its implication to the visual efficiency of light are described in ISO/TR 22411.

Table 1 — Age-related photopic spectral luminous efficiency

Wavelength nm	Photopic luminous efficiency						
	10-19 years	20-29 years	30-39 years	40-49 years	50-59 years	60-69 years	70-79 years
380	0,002 723	0,001 567	0,000 861 0	0,000 493 2	0,000 275 4	0,000 154 9	0,000 088 10
385	0,004 295	0,002 523	0,001 435	0,000 843 3	0,000 485 3	0,000 281 8	0,000 164 4
390	0,006 730	0,004 055	0,002 382	0,001 439	0,000 859 0	0,000 512 9	0,000 306 9
395	0,010 12	0,006 237	0,003 784	0,002 371	0,001 455	0,000 891 3	0,000 547 0
400	0,015 12	0,009 546	0,006 026	0,003 804	0,002 401	0,001 516	0,000 956 9
405	0,021 59	0,014 00	0,009 076	0,005 885	0,003 816	0,002 474	0,001 604
410	0,029 43	0,019 59	0,013 03	0,008 67	0,005 772	0,003 841	0,002 556
415	0,038 33	0,026 16	0,017 85	0,012 18	0,008 313	0,005 673	0,003 872
420	0,047 67	0,033 33	0,023 31	0,016 30	0,011 40	0,007 97	0,005 574
425	0,056 62	0,040 54	0,029 02	0,020 78	0,014 88	0,010 65	0,007 627
430	0,064 23	0,047 05	0,034 46	0,025 24	0,018 49	0,013 54	0,009 920
435	0,070 56	0,052 83	0,039 56	0,029 62	0,022 18	0,016 61	0,012 43
440	0,076 09	0,058 19	0,044 51	0,034 04	0,026 03	0,019 91	0,015 23
445	0,080 55	0,062 87	0,049 08	0,038 31	0,029 90	0,023 34	0,018 22
450	0,084 91	0,067 59	0,053 81	0,042 83	0,034 10	0,027 14	0,021 61
455	0,090 40	0,073 33	0,059 48	0,048 25	0,039 14	0,031 75	0,025 75
460	0,097 20	0,080 28	0,066 30	0,054 76	0,045 23	0,037 35	0,030 85
465	0,105 5	0,088 69	0,074 52	0,062 62	0,052 62	0,044 21	0,037 15
470	0,115 8	0,098 95	0,084 52	0,072 20	0,061 67	0,052 68	0,045 00
475	0,128 6	0,111 6	0,096 81	0,084 00	0,072 88	0,063 23	0,054 86
480	0,144 4	0,127 1	0,112 0	0,098 60	0,086 83	0,076 46	0,067 34
485	0,164 0	0,146 4	0,130 8	0,116 8	0,104 3	0,093 15	0,083 19
490	0,191 0	0,172 9	0,156 5	0,141 6	0,128 1	0,116 0	0,104 9
495	0,231 6	0,212 3	0,194 5	0,178 2	0,163 3	0,149 6	0,137 1
500	0,292 3	0,271 0	0,251 2	0,232 9	0,215 9	0,200 2	0,185 6
505	0,383 9	0,359 8	0,337 2	0,316 0	0,296 2	0,277 6	0,260 2
510	0,501 1	0,474 4	0,449 1	0,425 1	0,402 5	0,381 0	0,360 7
515	0,620 6	0,593 0	0,566 6	0,541 4	0,517 3	0,494 3	0,472 3
520	0,729 3	0,702 8	0,677 2	0,652 6	0,628 9	0,606 0	0,584 0
525	0,813 3	0,789 8	0,766 9	0,744 7	0,723 2	0,702 2	0,681 9
530	0,876 3	0,856 8	0,837 8	0,819 2	0,801 0	0,783 1	0,765 7
535	0,929 0	0,913 9	0,899 0	0,884 4	0,870 0	0,855 8	0,841 9
540	0,968 9	0,958 2	0,947 6	0,937 1	0,926 8	0,916 5	0,906 4
545	0,994 2	0,987 6	0,981 1	0,974 6	0,968 2	0,961 8	0,955 5

Table 1 (*continued*)

Wavelength nm	Photopic luminous efficiency						
	10-19 years	**20-29 years**	**30-39 years**	**40-49 years**	**50-59 years**	**60-69 years**	**70-79 years**
550	1,003 6	1,000 7	0,997 8	0,994 9	0,992 0	0,989 1	0,986 3
555	1,000 0	1,000 0	1,000 0	1,000 0	1,000 0	1,000 0	1,000 0
560	0,986 6	0,988 7	0,990 8	0,992 9	0,995 0	0,997 1	0,999 2
565	0,963 8	0,967 1	0,970 4	0,973 7	0,977 1	0,980 4	0,983 8
570	0,932 2	0,935 9	0,939 6	0,943 3	0,947 1	0,950 8	0,954 6
575	0,892 3	0,895 7	0,899 1	0,902 5	0,905 9	0,909 4	0,912 8
580	0,820 2	0,828 3	0,836 4	0,844 7	0,853 0	0,861 4	0,869 8
585	0,750 6	0,762 4	0,774 3	0,786 5	0,798 8	0,811 3	0,824 0
590	0,683 8	0,698 4	0,713 2	0,728 5	0,744 0	0,7599	0,7761
595	0,620 1	0,636 7	0,653 7	0,671 2	0,689 2	0,707 7	0,726 6
600	0,559 7	0,577 7	0,596 2	0,615 3	0,635 0	0,655 4	0,676 4
605	0,500 1	0,518 7	0,538 0	0,557 9	0,578 7	0,600 2	0,622 4
610	0,439 9	0,458 4	0,477 6	0,497 7	0,518 61	0,540 4	0,563 1
615	0,380 9	0,398 6	0,417 3	0,436 7	0,457 1	0,478 5	0,500 8
620	0,324 6	0,341 2	0,358 6	0,377 0	0,396 3	0,416 5	0,437 8
625	0,272 3	0,287 4	0,303 3	0,320 1	0,337 84	0,356 6	0,376 3
630	0,224 8	0,238 2	0,252 4	0,267 4	0,283 3	0,300 1	0,318 0
635	0,182 8	0,194 3	0,206 6	0,219 7	0,233 6	0,284 0	0,264 1
640	0,146 2	0,156 0	0,166 5	0,177 6	0,189 5	0,202 1	0,215 7
645	0,115 2	0,123 3	0,131 9	0,141 2	0,151 1	0,161 8	0,173 1
650	0,089 28	0,095 85	0,102 9	0,110 4	0,118 6	0,127 3	0,136 6
655	0,068 39	0,073 62	0,079 25	0,085 31	0,091 83	0,098 85	0,106 4
660	0,051 96	0,056 08	0,060 52	0,065 31	0,070 48	0,076 06	0,082 08
665	0,039 16	0,042 36	0,045 82	0,049 56	0,053 61	0,057 98	0,062 72
670	0,029 27	0,031 73	0,034 39	0,037 28	0,040 41	0,043 80	0,047 47
675	0,021 70	0,023 56	0,025 59	0,027 79	0,030 18	0,032 78	0,035 60
680	0,015 95	0,017 36	0,018 88	0,020 54	0,022 34	0,024 30	0,026 44
685	0,011 64	0,012 68	0,013 81	0,015 04	0,016 39	0,017 85	0,019 45
690	0,008 417	0,009 180	0,010 01	0,010 92	0,011 91	0,012 99	0,014 17
695	0,006 039	0,006 593	0,007 199	0,007 861	0,008 583	0,009 371	0,010 23
700	0,004 297	0,004 696	0,005 131	0,005 607	0,006 127	0,006 696	0,007 317
705	0,003 036	0,003 319	0,003 628	0,003 967	0,004 338	0,004 750	0,005 192
710	0,002 144	0,002 346	0,002 565	0,002 807	0,003 072	0,003 370	0,003 684
715	0,001 515	0,001 658	0,001 813	0,001 986	0,002 175	0,002 390	0,002 614
720	0,001 070	0,001 172	0,001 282	0,001 405	0,001 540	0,001 696	0,001 855
725	0,000 755 9	0,000 828 0	0,000 906 4	0,000 994 4	0,001 090	0,001 203	0,001 316
730	0,000 533 9	0,000 585 2	0,000 640 9	0,000 703 6	0,000 771 9	0,000 853 3	0,000 933 7
735	0,000 377 2	0,000 413 6	0,000 453 1	0,000 497 9	0,000 546 5	0,000 605 4	0,000 662 5
740	0,000 266 4	0,000 292 3	0,000 320 3	0,000 352 3	0,000 386 9	0,000 429 4	0,000 470 1
745	0,000 188 2	0,000 206 6	0,000 226 5	0,000 249 3	0,000 274 0	0,000 304 6	0,000 333 5
750	0,000 133 0	0,000 146 0	0,000 160 1	0,000 176 4	0,000 194 0	0,000 216 1	0,000 236 7
755	0,000 093 92	0,000 103 2	0,000 113 2	0,000 124 8	0,000 137 3	0,000 153 3	0,000 167 9
760	0,000 066 34	0,000 072 93	0,000 080 04	0,000 088 30	0,000 097 23	0,000 108 8	0,000 119 1
765	0,000 046 86	0,000 051 55	0,000 056 59	0,000 062 47	0,000 068 84	0,000 077 15	0,000 084 54
770	0,000 033 11	0,000 036 43	0,000 040 01	0,000 044 20	0,000 048 74	0,000 054 73	0,000 059 98
775	0,000 023 39	0,000 025 75	0,000 028 29	0,000 031 28	0,000 034 51	0,000 038 83	0,000 042 56
780	0,000 016 52	0,000 018 20	0,000 020 00	0,000 022 13	0,000 024 43	0,000 027 54	0,000 030 20
NOTE Data from Reference [2] in the Bibliography							

5 Using age-related luminance contrast

5.1 Age-related luminance contrast shall be used as an equivalent value to the luminance contrast in assessing visibility, visual performance, and visual appearance in signs and displays. The quantitative evaluation of the luminance contrast depends on the context of use and shall be carried out by taking account of the following factors:

— spatial and temporal configuration of the lights;

NOTE 1 The contrast sensitivity function of the eye for a spatial and temporal grating pattern is referred to for the evaluation of contrast values.

— viewing conditions;

NOTE 2 Among the factors defining viewing conditions, the luminance level of the light mostly affects the visibility of the contrast.

— visual tasks.

NOTE 3 Evaluation of the contrast value depends on the task being performed, e.g. detecting objects, reading characters, and evaluating visual impressions such as a legibility-ranking test.

5.2 For some application fields, such as electronic visual displays and graphical symbols (safety signs), specific values of luminance contrast are required (ISO 9241-303:2008, 5.5.2; ISO 3864-1:—[1)], Table 6; and ISO 3864-4:—[2)], Table 3). Age-related luminance contrast shall comply with those values.

Annex A
(informative)

An example of calculation and application of age-related luminance contrast

A.1 Purpose

This annex presents an example of calculation of the age-related luminance contrast for persons of different age to demonstrate contrast difference with age for the same visual sign. Additional examples for lighting design and implication of age-related photopic spectral luminous efficiency are also presented.

A.2 Example of calculation

According to the method described in Clause 4, the age-related luminance contrast for a person in his/her twenties and that for a person in his/her seventies can be calculated respectively for a given visual sign as shown in Figure A.1 a). The spectral radiance data of a sign and its background are provided in Figure A.1 b).

Applying the spectral luminous efficiency of a person in his/her twenties, $V_{20}(\lambda)$, in Table 1, Equation (4) in Clause 4 is used to calculate the age-related luminance contrast of a person in his/her twenties, C_{20}, for the sign presented in Figure A.1 a) as follows:

$$C_{20} = \frac{\sum_{380}^{780} L_{e,\lambda,1} V_{20}(\lambda)\Delta\lambda}{\sum_{380}^{780} L_{e,\lambda,2} V_{20}(\lambda)\Delta\lambda}$$

$$= \frac{0{,}003\,1}{0{,}001\,5}$$

$$= 2{,}07$$

The age-related luminance contrast is also calculated by using the same formula, but for a person in his/her seventies where $V_{70}(\lambda)$ applies, as follows:

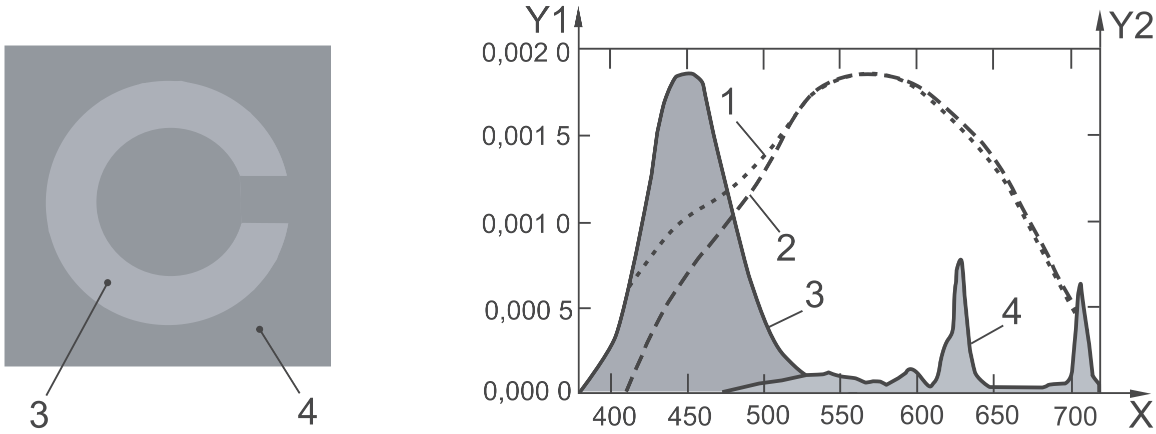
$$C_{70} = \frac{\sum_{380}^{780} L_{e,\lambda,1} V_{70}(\lambda)\Delta\lambda}{\sum_{380}^{780} L_{e,\lambda,2} V_{70}(\lambda)\Delta\lambda}$$

$$= \frac{0{,}001\,8}{0{,}001\,6}$$

$$= 1{,}13$$

The age-related luminance contrast of the sign shown in Figure A.1 a) (for example, a blue letter on a dark brown background) is 2,07 for a person in his/her twenties and is 1,13 for a person in his/her seventies. It is assessed that the visibility of the sign is much lower for the older person. If the contrast to the older person should be kept at least at the same level as that achieved for the younger person ($C_a = 2{,}07$), the radiance of the blue letter should be raised by a factor of 1,83.

NOTE The determination of the limit values for luminance contrast depends upon the context of design.



a) Example of a letter and background

b) Spectral radiance of a letter and background

Key

X wavelength, nm
Y1 spectral radiance, $W \cdot m^{-2} \cdot sr^{-1} \cdot nm^{-1}$
Y2 luminous efficiency

1 $V_{20}(\lambda)$
2 $V_{70}(\lambda)$
3 a blue letter
4 dark-brown background

Figure A.1 — Example of a letter and backgroud used for the calculation of age-related luminance contrast

A.3 Examples of application of age-related luminance contrast to lighting design

The following are examples of the use of age-related luminance contrast for better lighting design.

— Evaluation of visual efficiency for a newly developed light source for older people

With a standard lamp as a comparison, calculation of age-related luminance contrast for two areas (of the same sample), one being illuminated by a new lamp and the other by a comparison lamp, provides quantitative evaluation of visual efficiency of the new lamp for older people.

— Lighting design for better visibility for older people

An adequate light source for lighting can be selected and evaluated by calculating age-related luminance contrast of objects or visual signs so that they are designed to be more visible by older people.

A.4 Implication of age-related photopic spectral luminous efficiency function in application

The age-related photopic spectral luminous efficiency function $V_a(\lambda)$ is measured by the method of flicker photometry and can be used for assessment of light in terms of visual tasks that concern spatial and temporal discrimination, such as visual acuity and flicker. This function is different from another type of photopic spectral luminous efficiency function, which is measured by the method of direct-brightness matching and can be used for assessment of light in terms of visual tasks that concern detectability or apparent brightness of coloured light.

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