BRITISH STANDARD

BS ISO 23539:2005

Photometry — The CIE system of physical photometry

ICS 17.180.01

British Standards

National foreword

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The UK participation in its preparation was entrusted by Technical Committee CPL/34, Lamps and related equipment, to Subcommittee CPL/34/5, Photometry and light classifications, which has the responsibility to:

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Summary of pages

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INTERNATIONAL STANDARD

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CIE S 010/E

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Photometry — The CIE system of physical photometry

Photométrie — Le système CIE de photométrie physique

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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.

ISO 23539 was prepared as Standard CIE S 010/E by the International Commission on Illumination, which has been recognized by the ISO Council as an international standardizing body. It was adopted by ISO under a special procedure which requires approval by at least 75 % of the member bodes casting a vote, and is published as a joint ISO/CIE edition.

The International Commission on Illumination (abbreviated as CIE from its French title) is an organization devoted to international cooperation and exchange of information among its member countries on all matters relating to the science and art of lighting.

ISO 23539 was prepared by CIE Technical Committee 2-35 *CIE Standard for* $V(\lambda)$ *and* $V'(\lambda)$.

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PHOTOMETRY - THE CIE SYSTEM OF PHYSICAL PHOTOMETRY

INTRODUCTION

The visual brightness of a light source depends not only on the amount of radiation it emits but also on its spectral composition and on the visual response function of the observer viewing it. Because human visual response varies at different light levels and from person to person, precise photometry requires the definition of representative standard observers. The CIE system of physical photometry specifies procedures for the quantitative evaluation of optical radiation in terms of the spectral luminous efficiency functions of two such standard observers. One, $V(\lambda)$, represents photopic vision and the other, $V'(\lambda)$, scotopic vision. Used in conjunction with the SI photometric base unit, the candela, these functions constitute a system that enables the values of photometric quantities for all types of luminous source to be precisely determined, regardless of the spectral composition of the radiation emitted.

1. SCOPE

This international Standard specifies the characteristics of the system of physical photometry established by the CIE and accepted as the basis for the measurement of light. It defines the photometric quantities, units and standards that make up the CIE system of physical photometry and that have been officially accepted by the Comité International des Poids et Mesures (CIPM). They comprise:

– the definition of photometric quantities and units,
– the definition of CIE standard spectral luminous efficiency functions for photopic and scotopic vision,
– the definition of a CIE standard photometric observer that conforms to these functions,
– the definition of maximum luminous efficacies for photopic and scotopic vision.

An informative annex provides a vocabulary of related terms.

2. PHOTOMETRIC QUANTITIES

Photometric quantities are defined in the International Lighting Vocabulary (ILV) (CIE, 1987a).

2.1 Luminous flux

The fundamental physical quantity used in optical radiometry is the radiant flux or radiant power, Φ_e, measured in watts, which is emitted by a source of radiation, transmitted by a medium of propagation, or received at a surface. The corresponding photometric quantity is:

luminous flux (Φ_v) (see ILV 845-01-25)

quantity derived from radiant flux Φ_e by evaluating the radiation according to its action upon the CIE standard photometric observer

The procedure for deriving Φ_v from Φ_e is defined in 4.3, below.

2.2 Other quantities

The following are the photometric quantities that correspond to the most important radiometric quantities defined in the International Lighting Vocabulary.

luminous energy (also known as **quantity of light**) **(Q_v)** (see ILV 845-01-28)

time integral of the luminous flux Φ_v over a given duration Δt

$$Q_v = \int_{\Delta t} \Phi_v \mathrm{d}t$$

luminous intensity (of a source in a given direction) **(I_v)** (see ILV 845-01-31)

quotient of the luminous flux $\mathrm{d}\Phi_v$ leaving the source and propagated in the element of solid angle $\mathrm{d}\Omega$ containing the given direction, by the element of solid angle

$$I_v = \frac{d\Phi_v}{d\Omega}$$

luminance (in a given direction, at a given point of a real or imaginary surface) **(L_v)** (see ILV 845-01-35)

quantity defined by the formula

$$L_v = \frac{d\Phi_v}{dA \cdot \cos\theta \cdot d\Omega}$$

where $d\Phi_v$ is the luminous flux transmitted by an elementary beam passing through the given point and propagating in the solid angle $d\Omega$ containing the given direction; dA is the area of a section of that beam containing the given point; θ is the angle between the normal to that section and the direction of the beam

illuminance (at a point of a surface) **(E_v)** (see ILV 845-01-38)

quotient of the luminous flux $d\Phi_v$ incident on an element of the surface containing the point, by the area dA of that element

$$E_v = \frac{d\Phi_v}{dA}$$

luminous exitance (at a point of a surface) **(M_v)** (see ILV 845-01-48)

quotient of the luminous flux $d\Phi_v$ leaving an element of the surface containing the point, by the area dA of that element

$$M_v = \frac{d\Phi_v}{dA}$$

3. PHOTOMETRIC UNITS

3.1 Candela

The SI photometric base unit is the candela (cd), the unit of luminous intensity. It was defined by the Conférence Générale des Poids et Mesures (CGPM) in 1979 (CGPM, 1979), as follows:

The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540 x 10^{12} hertz and that has a radiant intensity in that direction of (1/683) watt per steradian.

This definition of the candela applies equally to photopic, scotopic, and mesopic vision.

3.2 Other units

The SI units of other photometric quantities can be derived from the candela and the SI units of length (m), solid angle (sr) and time (s). Thus:

Quantity	Symbol	SI Unit
Luminous flux	Φ_v	lm = cd·sr
Luminous energy	Q_v	cd·sr·s
Luminance	L_v	cd·m^{-2}
Illuminance	E_v	lx = cd·sr·m^{-2}
Luminous exitance	M_v	cd·sr·m^{-2}

4. PHOTOMETRIC STANDARDS

4.1 CIE Standard spectral luminous efficiency functions for photopic and scotopic vision

This Standard defines two spectral luminous efficiency functions for photometric measurements:

- The $V(\lambda)$ function, which applies to photopic vision and should be used for measurements at luminance levels of at least several candelas per square metre. It is defined by the numerical values given in Table 1 of this Standard, the wavelength being measured in standard air (Birch, 1994). For numerical computations, the peak value of the $V(\lambda)$ function should be evaluated at 555 nm exactly. Linear interpolation should be used exclusively to evaluate $V(\lambda)$ at wavelengths intermediate to those given in Table 1;

- The $V'(\lambda)$ function, which applies to scotopic vision and should be used for measurements at luminance levels less than some hundredths of a candela per square metre. This function is defined by the numerical values in Table 2 of this Standard, the wavelength λ again being measured in standard air. For numerical computations, the peak value of the $V'(\lambda)$ function should be evaluated at 507 nm exactly. Linear interpolation should be used exclusively to evaluate $V'(\lambda)$ at wavelengths intermediate to those given in Table 2.

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

The CIE has not, so far, defined standard spectral luminous efficiency functions for the mesopic region, intermediate between the ranges of photopic and scotopic vision.

4.2 Maximum luminous efficacies for photopic and scotopic vision

The $V(\lambda)$ and $V'(\lambda)$ functions defined in this Standard supplement the 1979 candela definition in a manner that, taken together, these definitions constitute a rational system of physical photometry which

- correlates the radiant power of broadband radiation acting upon the human visual system with the physiological characteristics of the latter,
- is consistent with visual experience for photopic and scotopic vision,
- establishes precisely defined numerical relationships between radiometric and photometric quantities.

Based on the following definitions and considerations, these numerical relationships are defined by equations (1) to (4), below.

luminous efficacy (for monochromatic radiation of wavelength λ) ***K*(λ) *and K'*(λ)**

Quotient of the luminous flux Φ_v by the corresponding radiant flux Φ_e

$$K(\lambda) = K_m \cdot V(\lambda) = \frac{\Phi_v}{\Phi_e} \quad \left[\mathrm{lm} \cdot \mathrm{W}^{-1}\right] \qquad \text{(for photopic vision)} \qquad (1)$$

$$K'(\lambda) = K'_m \cdot V'(\lambda) = \frac{\Phi'_v}{\Phi_e} \quad \left[\mathrm{lm} \cdot \mathrm{W}^{-1}\right] \qquad \text{(for scotopic vision)} \qquad (2)$$

where the maximum values of $K(\lambda)$ and $K'(\lambda)$ are denoted by K_m and K'_m so that K_m = K(555 nm) and K'_m = K'(507 nm). The frequency 540 x 10^{12} Hz corresponds to a wavelength of 555,016 nm in standard air and it follows from the candela definition that K(555,016 nm) = K'(555,016 nm) = 683 $\mathrm{lm \cdot W^{-1}}$. Therefore, according to equations 1 and 2,

$$K_m = 683\ [\mathrm{lm \cdot W^{-1}}]\ /\ V(555{,}016\ \mathrm{nm}) = 683{,}002\ \mathrm{lm \cdot W^{-1}} \qquad (3)$$

$$K'_m = 683\ [\mathrm{lm \cdot W^{-1}}]\ /\ V'(555{,}016\ \mathrm{nm}) = 1700{,}05\ \mathrm{lm \cdot W^{-1}} \qquad (4)$$

For all practical photometric applications, K_m can be taken as equal to 683 $\mathrm{lm \cdot W^{-1}}$ and K'_m as equal to 1700 $\mathrm{lm \cdot W^{-1}}$.

4.3 Fundamental equations relating photometric and radiometric quantities

The method for implementing the definition of luminous flux given in 2.1 is based on equations (1) to (4), above.

If the luminous flux in question pertains to photopic vision, it is related to the corresponding spectral concentration of radiant flux by the equation

$$\Phi_v = K_m \cdot \int_0^\infty \Phi_{e,\lambda} \cdot V(\lambda) d\lambda \qquad (5)$$

and the corresponding relation for scotopic vision is

$$\Phi'_v = K'_m \cdot \int_0^\infty \Phi_{e,\lambda} \cdot V'(\lambda) d\lambda \qquad (6)$$

In these equations K_m and K'_m are defined by equations (3) and (4) above and $V(\lambda)$ and $V'(\lambda)$ are defined by Tables 1 and 2 of this Standard.

Equations (5) and (6) are fundamental to the CIE system of physical photometry.

4.4 Measurement procedures

In practice, the spectral weighting required by equations (5) and (6) can be realized by means of absolutely calibrated, $V(\lambda)$ or $V'(\lambda)$ corrected detectors that conform to the definition of the CIE standard photometric observer. In such cases, the integrations specified are performed by the detector itself. The evaluation of photometers designed to measure light is dealt with in the Publication CIE 69 – 1987, *Methods of Characterizing Illuminance Meters and Luminance Meters* (CIE, 1987b).

Alternatively, it is possible to make spectroradiometric measurements (CIE, 1984) and obtain the required integrals by numerical computation from the spectroradiometric data. In this case, the integrations usually take the form of numerical summations over the visible spectrum. The tabulated values of $V(\lambda)$ and $V'(\lambda)$ at 1 nm intervals are normally sufficient for this purpose, but if intermediate values are required, these should be obtained from the tabulated values by linear interpolation.

In this Standard, values are given for the photopic standard observer $V(\lambda)$ over the spectral range from 360 nm to 830 nm (Table 1) and for the scotopic standard observer $V'(\lambda)$ over the spectral range from 380 nm to 780 nm (Table 2). The CIE does not define values for the standard observers outside these spectral ranges, because, for all practical photometric purposes, the visual contribution at longer or shorter wavelength is negligible.

Definitive values of the photometric quantities will be obtained if the summation is carried out at 1 nm intervals and the limits set to 360 nm and 830 nm in equation (5) and to 380 nm and 780 nm in equation (6).

The above equations and measurement procedures can be applied to any of the photometric quantities defined in 2.2. For example, luminance (for photopic vision) may be evaluated as

$$L_v = K_m \cdot \int_0^\infty L_{e,\lambda} \cdot V(\lambda) d\lambda$$

where $L_{e,\lambda}$ is the corresponding spectral concentration of radiance.

TABLES

Table 1. Definitive values of the spectral luminous efficiency function for photopic vision *V*(λ)

Wave length [nm]	Spectral luminous efficiency	Wave length [nm]	Spectral luminous efficiency	Wave length [nm]	Spectral luminous efficiency
360	0,000 003 917 000	393	0,000 170 208 0	426	0,008 086 507
361	0,000 004 393 581	394	0,000 191 816 0	427	0,008 908 720
362	0,000 004 929 604	395	0,000 217 000 0	428	0,009 767 680
363	0,000 005 532 136	396	0,000 246 906 7	429	0,010 664 43
364	0,000 006 208 245	397	0,000 281 240 0	430	0,011 600 00
365	0,000 006 965 000	398	0,000 318 520 0	431	0,012 573 17
366	0,000 007 813 219	399	0,000 357 266 7	432	0,013 582 72
367	0,000 008 767 336	400	0,000 396 000 0	433	0,014 629 68
368	0,000 009 839 844	401	0,000 433 714 7	434	0,015 715 09
369	0,000 011 043 23	402	0,000 473 024 0	435	0,016 840 00
370	0,000 012 390 00	403	0,000 517 876 0	436	0,018 007 36
371	0,000 013 886 41	404	0,000 572 218 7	437	0,019 214 48
372	0,000 015 557 28	405	0,000 640 000 0	438	0,020 453 92
373	0,000 017 442 96	406	0,000 724 560 0	439	0,021 718 24
374	0,000 019 583 75	407	0,000 825 500 0	440	0,023 000 00
375	0,000 022 020 00	408	0,000 941 160 0	441	0,024 294 61
376	0,000 024 839 65	409	0,001 069 880	442	0,025 610 24
377	0,000 028 041 26	410	0,001 210 000	443	0,026 958 57
378	0,000 031 531 04	411	0,001 362 091	444	0,028 351 25
379	0,000 035 215 21	412	0,001 530 752	445	0,029 800 00
380	0,000 039 000 00	413	0,001 720 368	446	0,031 310 83
381	0,000 042 826 40	414	0,001 935 323	447	0,032 883 68
382	0,000 046 914 60	415	0,002 180 000	448	0,034 521 12
383	0,000 051 589 60	416	0,002 454 800	449	0,036 225 71
384	0,000 057 176 40	417	0,002 764 000	450	0,038 000 00
385	0,000 064 000 00	418	0,003 117 800	451	0,039 846 67
386	0,000 072 344 21	419	0,003 526 400	452	0,041 768 00
387	0,000 082 212 24	420	0,004 000 000	453	0,043 766 00
388	0,000 093 508 16	421	0,004 546 240	454	0,045 842 67
389	0,000 106 136 1	422	0,005 159 320	455	0,048 000 00
390	0,000 120 000 0	423	0,005 829 280	456	0,050 243 68
391	0,000 134 984 0	424	0,006 546 160	457	0,052 573 04
392	0,000 151 492 0	425	0,007 300 000	458	0,054 980 56

Wave length [nm]	Spectral luminous efficiency
459	0,057 458 72
460	0,060 000 00
461	0,062 601 97
462	0,065 277 52
463	0,068 042 08
464	0,070 911 09
465	0,073 900 00
466	0,077 016 00
467	0,080 266 40
468	0,083 666 80
469	0,087 232 80
470	0,090 980 00
471	0,094 917 55
472	0,099 045 84
473	0,103 367 4
474	0,107 884 6
475	0,112 600 0
476	0,117 532 0
477	0,122 674 4
478	0,127 992 8
479	0,133 452 8
480	0,139 020 0
481	0,144 676 4
482	0,150 469 3
483	0,156 461 9
484	0,162 717 7
485	0,169 300 0
486	0,176 243 1
487	0,183 558 1
488	0,191 273 5
489	0,199 418 0
490	0,208 020 0
491	0,217 119 9
492	0,226 734 5
493	0,236 857 1
494	0,247 481 2

Wave length [nm]	Spectral luminous efficiency
495	0,258 600 0
496	0,270 184 9
497	0,282 293 9
498	0,295 050 5
499	0,308 578 0
500	0,323 000 0
501	0,338 402 1
502	0,354 685 8
503	0,371 698 6
504	0,389 287 5
505	0,407 300 0
506	0,425 629 9
507	0,444 309 6
508	0,463 394 4
509	0,482 939 5
510	0,503 000 0
511	0,523 569 3
512	0,544 512 0
513	0,565 690 0
514	0,586 965 3
515	0,608 200 0
516	0,629 345 6
517	0,650 306 8
518	0,670 875 2
519	0,690 842 4
520	0,710 000 0
521	0,728 185 2
522	0,745 463 6
523	0,761 969 4
524	0,777 836 8
525	0,793 200 0
526	0,808 110 4
527	0,822 496 2
528	0,836 306 8
529	0,849 491 6
530	0,862 000 0

Wave length [nm]	Spectral luminous efficiency
531	0,873 810 8
532	0,884 962 4
533	0,895 493 6
534	0,905 443 2
535	0,914 850 1
536	0,923 734 8
537	0,932 092 4
538	0,939 922 6
539	0,947 225 2
540	0,954 000 0
541	0,960 256 1
542	0,966 007 4
543	0,971 260 6
544	0,976 022 5
545	0,980 300 0
546	0,984 092 4
547	0,987 418 2
548	0,990 312 8
549	0,992 811 6
550	0,994 950 1
551	0,996 710 8
552	0,998 098 3
553	0,999 112 0
554	0,999 748 2
555	1,000 000 0
556	0,999 856 7
557	0,999 304 6
558	0,998 325 5
559	0,996 898 7
560	0,995 000 0
561	0,992 600 5
562	0,989 742 6
563	0,986 444 4
564	0,982 724 1
565	0,978 600 0
566	0,974 083 7

Wave length [nm]	Spectral luminous efficiency
567	0,969 171 2
568	0,963 856 8
569	0,958 134 9
570	0,952 000 0
571	0,945 450 4
572	0,938 499 2
573	0,931 162 8
574	0,923 457 6
575	0,915 400 0
576	0,907 006 4
577	0,898 277 2
578	0,889 204 8
579	0,879 781 6
580	0,870 000 0
581	0,859 861 3
582	0,849 392 0
583	0,838 622 0
584	0,827 581 3
585	0,816 300 0
586	0,804 794 7
587	0,793 082 0
588	0,781 192 0
589	0,769 154 7
590	0,757 000 0
591	0,744 754 1
592	0,732 422 4
593	0,720 003 6
594	0,707 496 5
595	0,694 900 0
596	0,682 219 2
597	0,669 471 6
598	0,656 674 4
599	0,643 844 8
600	0,631 000 0
601	0,618 155 5
602	0,605 314 4

Wave length [nm]	Spectral luminous efficiency
603	0,592 475 6
604	0,579 637 9
605	0,566 800 0
606	0,553 961 1
607	0,541 137 2
608	0,528 352 8
609	0,515 632 3
610	0,503 000 0
611	0,490 468 8
612	0,478 030 4
613	0,465 677 6
614	0,453 403 2
615	0,441 200 0
616	0,429 080 0
617	0,417 036 0
618	0,405 032 0
619	0,393 032 0
620	0,381 000 0
621	0,368 918 4
622	0,356 827 2
623	0,344 776 8
624	0,332 817 6
625	0,321 000 0
626	0,309 338 1
627	0,297 850 4
628	0,286 593 6
629	0,275 624 5
630	0,265 000 0
631	0,25 476 32
632	0,244 889 6
633	0,235 334 4
634	0,226 052 8
635	0,217 000 0
636	0,208 161 6
637	0,199 548 8
638	0,191 155 2

Wave length [nm]	Spectral luminous efficiency
639	0,182 974 4
640	0,175 000 0
641	0,167 223 5
642	0,159 646 4
643	0,152 277 6
644	0,145 125 9
645	0,138 200 0
646	0,131 500 3
647	0,125 024 8
648	0,118 779 2
649	0,112 769 1
650	0,107 000 0
651	0,101 476 2
652	0,096 188 64
653	0,091 122 96
654	0,086 264 85
655	0,081 600 00
656	0,077 120 64
657	0,072 825 52
658	0,068 710 08
659	0,064 769 76
660	0,061 000 00
661	0,057 396 21
662	0,053 955 04
663	0,050 673 76
664	0,047 549 65
665	0,044 580 00
666	0,041 758 72
667	0,039 084 96
668	0,036 563 84
669	0,034 200 48
670	0,032 000 00
671	0,029 962 61
672	0,028 076 64
673	0,026 329 36
674	0,024 708 05

Wave length [nm]	Spectral luminous efficiency
675	0,023 200 00
676	0,021 800 77
677	0,020 501 12
678	0,019 281 08
679	0,018 120 69
680	0,017 000 00
681	0,015 903 79
682	0,014 837 18
683	0,013 810 68
684	0,012 834 78
685	0,011 920 00
686	0,011 068 31
687	0,010 273 39
688	0,009 533 311
689	0,008 846 157
690	0,008 210 000
691	0,007 623 781
692	0,007 085 424
693	0,006 591 476
694	0,006 138 485
695	0,005 723 000
696	0,005 343 059
697	0,004 995 796
698	0,004 676 404
699	0,004 380 075
700	0,004 102 000
701	0,003 838 453
702	0,003 589 099
703	0,003 354 219
704	0,003 134 093
705	0,002 929 000
706	0,002 738 139
707	0,002 559 876
708	0,002 393 244
709	0,002 237 275
710	0,002 091 000

Wave length [nm]	Spectral luminous efficiency
711	0,001 953 587
712	0,001 824 580
713	0,001 703 580
714	0,001 590 187
715	0,001 484 000
716	0,001 384 496
717	0,001 291 268
718	0,001 204 092
719	0,001 122 744
720	0,001 047 000
721	0,000 976 589 6
722	0,000 911 108 8
723	0,000 850 133 2
724	0,000 793 238 4
725	0,000 740 000 0
726	0,000 690 082 7
727	0,000 643 310 0
728	0,000 599 496 0
729	0,000 558 454 7
730	0,000 520 000 0
731	0,000 483 913 6
732	0,000 450 052 8
733	0,000 418 345 2
734	0,000 388 718 4
735	0,000 361 100 0
736	0,000 335 383 5
737	0,000 311 440 4
738	0,000 289 165 6
739	0,000 268 453 9
740	0,000 249 200 0
741	0,000 231 301 9
742	0,000 214 685 6
743	0,000 199 288 4
744	0,000 185 047 5
745	0,000 171 900 0
746	0,000 159 778 1

Wave length [nm]	Spectral luminous efficiency
747	0,000 148 604 4
748	0,000 138 301 6
749	0,000 128 792 5
750	0,000 120 000 0
751	0,000 111 859 5
752	0,000 104 322 4
753	0,000 097 335 60
754	0,000 090 845 87
755	0,000 084 800 00
756	0,000 079 146 67
757	0,000 073 858 00
758	0,000 068 916 00
759	0,000 064 302 67
760	0,000 060 000 00
761	0,000 055 981 87
762	0,000 052 225 60
763	0,000 048 718 40
764	0,000 045 447 47
765	0,000 042 400 00
766	0,000 039 561 04
767	0,000 036 915 12
768	0,000 034 448 68
769	0,000 032 148 16
770	0,000 030 000 00
771	0,000 027 991 25
772	0,000 026 113 56
773	0,000 024 360 24
774	0,000 022 724 61
775	0,000 021 200 00
776	0,000 019 778 55
777	0,000 018 452 85
778	0,000 017 216 87
779	0,000 016 064 59
780	0,000 014 990 00
781	0,000 013 987 28
782	0,000 013 051 55

Wave length [nm]	Spectral luminous efficiency
783	0,000 012 178 18
784	0,000 011 362 54
785	0,000 010 600 00
786	0,000 009 885 877
787	0,000 009 217 304
788	0,000 008 592 362
789	0,000 008 009 133
790	0,000 007 465 700
791	0,000 006 959 567
792	0,000 006 487 995
793	0,000 006 048 699
794	0,000 005 639 396
795	0,000 005 257 800
796	0,000 004 901 771
797	0,000 004 569 720
798	0,000 004 260 194

Wave length [nm]	Spectral luminous efficiency
799	0,000 003 971 739
800	0,000 003 702 900
801	0,000 003 452 163
802	0,000 003 218 302
803	0,000 003 000 300
804	0,000 002 797 139
805	0,000 002 607 800
806	0,000 002 431 220
807	0,000 002 266 531
808	0,000 002 113 013
809	0,000 001 969 943
810	0,000 001 836 600
811	0,000 001 712 230
812	0,000 001 596 228
813	0,000 001 488 090
814	0,000 001 387 314

Wave length [nm]	Spectral luminous efficiency
815	0,000 001 293 400
816	0,000 001 205 820
817	0,000 001 124 143
818	0,000 001 048 009
819	0,000 000 977 057 8
820	0,000 000 910 930 0
821	0,000 000 849 251 3
822	0,000 000 791 721 2
823	0,000 000 738 090 4
824	0,000 000 688 109 8
825	0,000 000 641 530 0
826	0,000 000 598 089 5
827	0,000 000 557 574 6
828	0,000 000 519 808 0
829	0,000 000 484 612 3
830	0,000 000 451 810 0

Table 2. Definitive values of the spectral luminous efficiency function for scotopic vision *V′*(λ)

Wave length [nm]	Spectral luminous efficiency
380	0,000 589
381	0,000 665
382	0,000 752
383	0,000 854
384	0,000 972
385	0,001 108
386	0,001 268
387	0,001 453
388	0,001 668
389	0,001 918
390	0,002 209
391	0,002 547
392	0,002 939
393	0,003 394
394	0,003 921
395	0,004 53
396	0,005 24
397	0,006 05
398	0,006 98
399	0,008 06
400	0,009 29
401	0,010 70
402	0,012 31
403	0,014 13
404	0,016 19
405	0,018 52
406	0,021 13
407	0,024 05
408	0,027 30
409	0,030 89
410	0,034 84
411	0,039 16
412	0,043 9
413	0,049 0

Wave length [nm]	Spectral luminous efficiency
414	0,054 5
415	0,060 4
416	0,066 8
417	0,073 6
418	0,080 8
419	0,088 5
420	0,096 6
421	0,105 2
422	0,114 1
423	0,123 5
424	0,133 4
425	0,143 6
426	0,154 1
427	0,165 1
428	0,176 4
429	0,187 9
430	0,199 8
431	0,211 9
432	0,224 3
433	0,236 9
434	0,249 6
435	0,262 5
436	0,275 5
437	0,288 6
438	0,301 7
439	0,314 9
440	0,328 1
441	0,341 2
442	0,354 3
443	0,367 3
444	0,380 3
445	0,393 1
446	0,406
447	0,418

Wave length [nm]	Spectral luminous efficiency
448	0,431
449	0,443
450	0,455
451	0,467
452	0,479
453	0,490
454	0,502
455	0,513
456	0,524
457	0,535
458	0,546
459	0,557
460	0,567
461	0,578
462	0,588
463	0,599
464	0,610
465	0,620
466	0,631
467	0,642
468	0,653
469	0,664
470	0,676
471	0,687
472	0,699
473	0,710
474	0,722
475	0,734
476	0,745
477	0,757
478	0,769
479	0,781
480	0,793
481	0,805

Wave length [nm]	Spectral luminous efficiency
482	0,817
483	0,828
484	0,840
485	0,851
486	0,862
487	0,873
488	0,884
489	0,894
490	0,904
491	0,914
492	0,923
493	0,932
494	0,941
495	0,949
496	0,957
497	0,964
498	0,970
499	0,976
500	0,982
501	0,986
502	0,990
503	0,994
504	0,997
505	0,998
506	1,000
507	1,000
508	1,000
509	0,998
510	0,997
511	0,994
512	0,990
513	0,986
514	0,981
515	0,975
516	0,968
517	0,961

Wave length [nm]	Spectral luminous efficiency
518	0,953
519	0,944
520	0,935
521	0,925
522	0,915
523	0,904
524	0,892
525	0,880
526	0,867
527	0,854
528	0,840
529	0,826
530	0,811
531	0,796
532	0,781
533	0,765
534	0,749
535	0,733
536	0,717
537	0,700
538	0,683
539	0,667
540	0,650
541	0,633
542	0,616
543	0,599
544	0,581
545	0,564
546	0,548
547	0,531
548	0,514
549	0,497
550	0,481
551	0,465
552	0,448
553	0,433

Wave length [nm]	Spectral luminous efficiency
554	0,417
555	0,402
556	0,386 4
557	0,371 5
558	0,356 9
559	0,342 7
560	0,328 8
561	0,315 1
562	0,301 8
563	0,288 8
564	0,276 2
565	0,263 9
566	0,251 9
567	0,240 3
568	0,229 1
569	0,218 2
570	0,207 6
571	0,197 4
572	0,187 6
573	0,178 2
574	0,169 0
575	0,160 2
576	0,151 7
577	0,143 6
578	0,135 8
579	0,128 4
580	0,121 2
581	0,114 3
582	0,107 8
583	0,101 5
584	0,095 6
585	0,089 9
586	0,084 5
587	0,079 3
588	0,074 5
589	0,069 9

Wave length [nm]	Spectral luminous efficiency
590	0,065 5
591	0,061 3
592	0,057 4
593	0,053 7
594	0,050 2
595	0,046 9
596	0,043 8
597	0,040 9
598	0,038 16
599	0,035 58
600	0,033 15
601	0,030 87
602	0,028 74
603	0,026 74
604	0,024 87
605	0,023 12
606	0,021 47
607	0,019 94
608	0,018 51
609	0,017 18
610	0,015 93
611	0,014 77
612	0,013 69
613	0,012 69
614	0,011 75
615	0,010 88
616	0,010 07
617	0,009 32
618	0,008 62
619	0,007 97
620	0,007 37
621	0,006 82
622	0,006 30
623	0,005 82
624	0,005 38
625	0,004 97

Wave length [nm]	Spectral luminous efficiency
626	0,004 59
627	0,004 24
628	0,003 913
629	0,003 613
630	0,003 335
631	0,003 079
632	0,002 842
633	0,002 623
634	0,002 421
635	0,002 235
636	0,002 062
637	0,001 903
638	0,001 757
639	0,001 621
640	0,001 497
641	0,001 382
642	0,001 276
643	0,001 178
644	0,001 088
645	0,001 005
646	0,000 928
647	0,000 857
648	0,000 792
649	0,000 732
650	0,000 677
651	0,000 626
652	0,000 579
653	0,000 536
654	0,000 496
655	0,000 459
656	0,000 425
657	0,000 393 5
658	0,000 364 5
659	0,000 337 7
660	0,000 312 9
661	0,000 290 1

Wave length [nm]	Spectral luminous efficiency
662	0,000 268 9
663	0,000 249 3
644	0,000 231 3
665	0,000 214 6
666	0,000 199 1
667	0,000 184 8
668	0,000 171 6
669	0,000 159 3
670	0,000 148 0
671	0,000 137 5
672	0,000 127 7
673	0,000 118 7
674	0,000 110 4
675	0,000 102 6
676	0,000 095 4
677	0,000 088 8
678	0,000 082 6
679	0,000 076 9
680	0,000 071 5
681	0,000 066 6
682	0,000 062 0
683	0,000 057 8
684	0,000 053 8
685	0,000 050 1
686	0,000 046 7
687	0,000 043 6
688	0,000 040 6
689	0,000 037 89
690	0,000 035 33
691	0,000 032 95
692	0,000 030 75
693	0,000 028 70
694	0,000 026 79
695	0,000 025 01
696	0,000 023 36
697	0,000 021 82

Wave length [nm]	Spectral luminous efficiency
698	0,000 020 38
699	0,000 019 05
700	0,000 017 80
701	0,000 016 64
702	0,000 015 56
703	0,000 014 54
704	0,000 013 60
705	0,000 012 73
706	0,000 011 91
707	0,000 011 14
708	0,000 010 43
709	0,000 009 76
710	0,000 009 14
711	0,000 008 56
712	0,000 008 02
713	0,000 007 51
714	0,000 007 04
715	0,000 006 60
716	0,000 006 18
717	0,000 005 80
718	0,000 005 44
719	0,000 005 10
720	0,000 004 78
721	0,000 004 49
722	0,000 004 21
723	0,000 003 951
724	0,000 003 709
725	0,000 003 482
726	0,000 003 270
727	0,000 003 070
728	0,000 002 884
729	0,000 002 710
730	0,000 002 546
731	0,000 002 393
732	0,000 002 250
733	0,000 002 115
734	0,000 001 989
735	0,000 001 870
736	0,000 001 759
737	0,000 001 655
738	0,000 001 557
739	0,000 001 466
740	0,000 001 379
741	0,000 001 299
742	0,000 001 223
743	0,000 001 151
744	0,000 001 084
745	0,000 001 022
746	0,000 000 962
747	0,000 000 907
748	0,000 000 855
749	0,000 000 806
750	0,000 000 760
751	0,000 000 716
752	0,000 000 675
753	0,000 000 637
754	0,000 000 601
755	0,000 000 567
756	0,000 000 535
757	0,000 000 505
758	0,000 000 477
759	0,000 000 450
760	0,000 000 425
761	0,000 000 401
762	0,000 000 379 0
763	0,000 000 358 0
764	0,000 000 338 2
765	0,000 000 319 6
766	0,000 000 302 1
767	0,000 000 285 5
768	0,000 000 269 9
769	0,000 000 255 2
770	0,000 000 241 3
771	0,000 000 228 2
772	0,000 000 215 9
773	0,000 000 204 2
774	0,000 000 193 2
775	0,000 000 182 9
776	0,000 000 173 1
777	0,000 000 163 8
778	0,000 000 155 1
779	0,000 000 146 8
780	0,000 000 139 0

ANNEX A (INFORMATIVE)

Vocabulary of related terms

The following list of terms which are not defined in the main body of this Standard is consistent with the definitions in the International Lighting Vocabulary (CIE, 1987a).

brightness (see ILV 845-02-28)

attribute of a visual sensation according to which an area appears to emit more or less light

cones (see ILV 845-02-02)

photoreceptors in the retina containing light-sensitive pigments capable of initiating the process of photopic vision (see photopic vision)

detector (of optical radiation)

device in which incident optical radiation produces a measurable physical effect

light

1. (perceived) light: universal and essential attribute of all perceptions and sensations that are peculiar to the visual system (see ILV 845-02-17)

2. visible radiation: See below.

mesopic vision (see ILV 845-02-11)

vision intermediate between photopic and scotopic vision

Note: In mesopic vision both the cones and rods are active.

photometric quantity

physical quantity evaluated by means of a standard photometric observer. See: radiometric and photometric quantities

photometry (see ILV 845-05-09)

measurement of quantities referring to radiation as evaluated according to a given spectral luminous efficiency function, e.g. $V(\lambda)$ or $V'(\lambda)$

photopic vision (see ILV 845-02-09)

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

Note: The cones are the principal active photoreceptors in photopic vision.

Under these conditions the spectrum appears coloured.

physical photometry (see ILV 845-05-13)

photometry in which physical detectors are used to make the measurements

radiometric and photometric quantities

Pure physical quantities for which radiation is evaluated in terms of energy are called radiometric quantities. For each of these there is a corresponding photometric quantity for which the radiation is evaluated by means of a standard photometric observer. The two kinds of quantities are represented by the same principal symbol, distinguished by the subscript "e" (energy) in the case of radiometric quantities, and the subscript "v" (visual) in the case of photometric quantities. For example; Φ_e represents radiant flux (measured in watts), Φ_v represents luminous flux (measured in lumens).

rods (see ILV 845-02-03)

photoreceptors in the retina containing a light-sensitive pigment capable of initiating the process of scotopic vision (see scotopic vision)

scotopic vision (see ILV 845-02-10)

vision by the normal eye when it is adapted to levels of luminance less than some hundredths of a candela per square metre

Note: The rods are the principal active photoreceptors in scotopic vision.

Under these conditions the spectrum appears uncoloured and the maximum spectral luminous efficiency is shifted to a shorter wavelength than in photopic vision.

spectral concentration (of a radiant, luminous or photon quantity) (see ILV 845-01-17)

quotient of the radiant, luminous or photon quantity $\mathrm{d}X(\lambda)$ contained in an elementary range $\mathrm{d}\lambda$ of wavelength at the wavelength λ, by that range

$$X_\lambda = \frac{\mathrm{d}X(\lambda)}{\mathrm{d}\lambda}$$

unit: $[X]\cdot\mathrm{m}^{-1}$, e.g. $\mathrm{W}\cdot\mathrm{m}^{-1}$, $\mathrm{lm}\cdot\mathrm{m}^{-1}$, etc.

Note1: The term spectral distribution is to be preferred when dealing with the function $X_\lambda(\lambda)$ over a wide range of wavelengths, not at a particular wavelength.

Note2: The quantity X can also be expressed as a function of frequency ν, wavenumber σ, etc.; the corresponding symbols are $X(\nu)$, $X(\sigma)$, etc. and X_ν, X_σ, etc.

If there is any risk of ambiguity resulting from the use of spectral coordinates other than wavelength, this should be avoided by means of the wording "spectral concentration of …………..... in terms of frequency", etc.

spectral luminous efficiency (of monochromatic radiation of wavelength λ) (see ILV 845-01-22)

ratio of the radiant flux at wavelength λ_m by 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

visible radiation (see ILV 845-01-03)

any optical radiation capable of causing a visual sensation directly

Note: There are no precise limits for the spectral range of visible radiation since they depend upon the amount of power reaching the retina and on the responsivity of the observer. The lower limit is generally taken between 360 nm and 400 nm and the upper limit between 760 nm and 830 nm.

visual photometry (see ILV 845-05-11)

photometry in which the eye is used to make quantitative comparisons between light stimuli

The methods of comparison chiefly employed are: brightness match of two adjacent surfaces, adjustment to equality of contrast, or adjustment to minimum flicker.

wavelength (λ) (see ILV 845-01-14)

distance in the direction of propagation of a periodic wave between two successive points at which the phase is the same

Note: The wavelength in a medium is equal to the wavelength in vacuo divided by the refractive index of the medium. The refractive index of standard air (for spectroscopy t = 15 °C, p = 101 325 Pa) lies between 1,000 27 and 1,000 29 for visible radiation.

ANNEX B (INFORMATIVE)

Background to the CIE system of physical photometry

More detailed descriptions of this photometric system may be found in the BIPM monograph, *Principles Governing Photometry* (Wyszecky et al., 1983) and in the CIE publication, *The Basis of Physical Photometry* (CIE, 1983).

B.1 Evolution of the photometric base unit

From its beginnings until about 1950, photometry was chiefly concerned with the visual comparison of light sources, so that the luminous intensity of a light source has traditionally been regarded as the fundamental photometric quantity. The earliest standards were candles, and the name *candela* has been preserved for the photometric base unit in the International System of Units (SI) (CGPM, 1948). The candela has been a base unit of the International System of Units (SI) since the inception of that system. It remained a base unit even after it was linked to the (derived) SI unit of power, the watt (radiant flux), in 1979.

The definition of the candela in terms of monochromatic radiation (rather than broadband radiation of the kind usually encountered in photometry) resulted from an astute analysis of the state of the art in photometry and radiometry at the time of the redefinition by members of the Comité Consultatif de Photométrie et Radiométrie (CCPR) of the Conférence Générale des Poids et Mesures (CGPM) (Blevin, 1979). The constant 683 $cd \cdot sr \cdot W^{-1}$ represented the best 1979 estimate of the maximum luminous efficacy for photopic vision, K_m, required to maintain the photopic candela at its previous level, and it is now the defined constant that links physical photometry and optical radiometry. The definition applies to both photopic and scotopic vision. At the fixed reference point corresponding to the specified frequency 540 x 10^{12} Hz, the values of the luminous efficacy functions $K(\lambda)$ and $K'(\lambda)$ are both equal to 683 $cd \cdot sr \cdot W^{-1}$ (683 $lm \cdot W^{-1}$). It was realized at the time that the new definition would increase the size of the existing scotopic candela by some 3%, but this small change was felt to be acceptable.

Owing to the choice of a defining frequency (rather than a wavelength) the candela is independent of the medium of light propagation.

These features allow for further advances in photometry without necessitating a redefinition of the SI base unit.

B.2 Spectral response of the human eye

The spectral response of the human eye depends on the wavelength of the light. Equal amounts of radiant flux from different parts of the visible spectrum produce different visual stimuli. Measurements of the spectral luminous efficiencies of different observers were performed early on, beginning with the work of Coblentz and Emerson in 1918 (Coblentz and Emerson, 1918). It was soon recognized that the eye response varies from observer to observer. These variations cause errors in visual photometry that can be avoided if measurements are made photoelectrically and are based on internationally accepted average spectral luminous efficiency functions that give unambiguous and consistent photometric scales for worldwide use. By 1924, additional measurements of the spectral luminous efficiency of individual observers had been performed, three by the flicker method and two by direct comparison of light from adjacent portions of the spectrum ("step-by-step method") (Walsh, 1958). This enabled the CIE to adopt a standardized response function.

The first of the standard functions so defined, $V(\lambda)$, applies to photopic vision at luminance levels of at least several candelas per square metre.-

Further studies revealed that the spectral response of the human eye changes as the luminance of objects is reduced. Because the principal active elements for scotopic vision (the rod receptors of the retina) are less sensitive to red light, the response for scotopic vision is blue-shifted by approximately 50 nm with respect to the $V(\lambda)$ curve that applies to photopic (cone) vision. In 1951, the CIE adopted the supplementary standard spectral luminous efficiency function, $V'(\lambda)$, for scotopic vision at luminance levels less than some hundredths of a candela per square metre.

The CIE standard spectral luminous efficiency functions, $V(\lambda)$ and $V'(\lambda)$ have been officially ratified by the Comité International des Poids et Mesures (CIPM) (CIPM, 1972; CIPM, 1976).

B.3 Supplementary remarks

Although the CIE system of physical photometry is a universally accepted, proven system that is unlikely to be changed in the near future, it should be noted that it is based on conventions which are supported by only a limited number of measurements made a fairly long time ago. The human visual response to optical radiation of different wavelengths is complex and not yet fully understood. For example:

- It is known that sources having the same luminance or luminous intensity but different colours are generally not perceived as equally bright. The brightness difference of lights of equal luminance depends on their colour. This may require a different system of photometry to predict the relative luminosity of heterochromatic sources (CIE, 1978; CIE, 1988a; CIE, 1988b).
- There is currently no officially recommended CIE system for measuring light at mesopic levels. Photopic photometers are frequently used at these levels, resulting in measurements that do not match visual perception, especially with modern discharge sources. Several different methods of mesopic photometry have been proposed, and these are being evaluated (CIE, 1989).
- An alternative form of $V(\lambda)$, commonly referred to as Judd's modification and denoted by $V_M(\lambda)$, has been proposed. This modified function is intended to supplement, not to replace, the $V(\lambda)$ function defined in this Standard. The two functions differ only below 460 nm, where $V(\lambda)$ is too insensitive with respect to observers with normal colour vision (CIE, 1990).

ANNEX C (INFORMATIVE)

Bibliography

BIRCH J., 1994. Correction to the updated Edlèn equation for the refractive index of air. *Metrologia*, **31**, 315, 1994.

BLEVIN, W.R., 1979. The candela and the watt. in CIE 50-1979. *Proceedings of the CIE Session in Kyoto*, 11, 1979.

CGPM, 1948. *Comptes rendus des séances de la 9e Conférence Générale des Poids et Mesures (CGPM)*, 54. Bureau International de Poids et Mesures, Paris, 1948.

CGPM, 1979. *Comptes Rendus des séances de la 16e Conférence Générale des Poids et Mesures (CGPM)*, 100. Bureau International de Poids et Mesures, Paris, 1979.

CIE, 1978. CIE 41-1978. *Light as a True Visual Quantity: Principles of Measurement*. 1978.

CIE, 1983. CIE 18.2-1983. *The Basis of Physical Photometry*. 1983.

CIE, 1984. CIE 63-1984. *The Spectroradiometric Measurement of Light Sources*. 1984.

CIE, 1987a. CIE 17.4-1987. *International Lighting Vocabulary*. 1987.

CIE, 1987b. CIE 69-1987. *Methods of Characterizing Illuminance Meters and Luminance Meters*. 1987.

CIE, 1988a. CIE 75-1988. *Spectral Luminous Efficiency Functions Based upon Brightness Matching for Monochromatic Point Sources, 2° and 10° Fields*. 1988.

CIE, 1988b. CIE 78-1988. *Brightness-Luminance Relations - Classified Bibliography.* 1988.

CIE, 1989. CIE 81-1989. *Mesopic Photometry: History, Special Problems, and Practical Solutions*. 1989.

CIE, 1990. CIE 86-1990. *CIE 1988 2° Spectral Luminous Efficiency Function for Photopic Vision*. 1990.

CIPM, 1972. Procès-Verbaux des séances du Comité International des Poids et Mesures (CIPM), **40**, 145. Bureau International de Poids et Mesures, Paris, 1972.

CIPM, 1976. Procès-Verbaux des séances du Comité International des Poids et Mesures (CIPM), **44**, 4. Bureau International de Poids et Mesures, Paris, 1976.

COBLENTZ, W. and EMERSON, W.B., 1918. *Bull. Bur. Stds. (USA)*, **14**, 167, 1918.

WALSH, J.W.T., 1958. *Photometry*. 73. Constable & Co., London, 1958.

WYSZECKI, G., BLEVIN, W.R., KESSLER, K.G. and MIELENZ, K.D., 1983. *Principles Governing Photometry.* Bureau International de Poids et Mesures Monograph, Sèvres, 1983.

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