IEC TR 62778

Edition 2.0 2014-06

TECHNICAL REPORT

colour inside

Application of IEC 62471 for the assessment of blue light hazard to light sources and luminaires



IEC TR 62778:2014-05(en)



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2014 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in 14 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

More than 55 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

IEC TR 62778

Edition 2.0 2014-06

TECHNICAL REPORT

colour inside

Application of IEC 62471 for the assessment of blue light hazard to light sources and luminaires

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PRICE CODE W

ICS 29.140

ISBN 978-2-8322-1615-6

Warning! Make sure that you obtained this publication from an authorized distributor.

® Registered trademark of the International Electrotechnical Commission

CONTENTS

FOREWORD 4
1 Scope 6
2 Normative references 6
3 Terms and definitions 6
4 General 11
5 Spectrum, colour temperature, and blue light hazard 12
5.1 Calculation of blue light hazard quantities and photometric quantities from emission spectra 12
5.2 Luminance and illuminance regimes that give rise to t_{max} values below 100 s 15
6 LED packages, LED modules, lamps and luminaires 17
7 Measurement information flow 18
7.1 Basic flow 18
7.2 Conditions for the radiance measurement 20
7.3 Special cases (I): Replacement by a lamp or LED module of another type 22
7.4 Special cases (II): Arrays and clusters of primary light sources 22
8 Risk group classification 22
Annex A (informative) Geometrical relations between radiance, irradiance and radiant intensity 23
Annex B (informative) Distance dependence of t_{max} for a certain light source 25
Annex C (informative) Summary of recommendations to assist the consistent application of IEC 62471 for the assessment of blue light hazard to light sources and luminaires 27
C.1 General 27
C.2 Situation of RG0 or RG1 classification not requiring radiance or irradiance measurement 27
C.2.1 Boundary conditions 27
C.2.2 True luminance values giving risk group not greater than RG1 27
C.2.3 Illuminance values giving risk group not greater than RG1 28
C.3 Situation for the classification of light sources larger than 2,2 mm and luminaires using these light sources 29
C.4 Situation for the classification of light sources smaller than 2,2 mm and luminaires using these light sources 30
C.5 Situation for the classification of light sources that pose practical difficulties in measurements at 200 mm 30
Annex D (informative) Detailed assessment of arrays and clusters of primary light sources, comprised of LED packages 31
D.1 General 31
D.2 Approach 31
D.2.1 Step by step assessment 31
D.2.2 Type of arrays and additional steps 32
D.2.3 Complete flowchart 34
D.3 Derivation of the formula for average radiance of the full array 35
Bibliography 37

Figure 1 – Blue light hazard efficacy of luminous radiation, $K_{B,V}$, for a range of light sources from different technologies, and for a few typical daylight spectra 13

Figure 2 – Comparison between the curves involved in calculating $K_{B,V}$ (the photopic eye sensitivity curve and the blue light spectral weighting function) and the CIE 1931 *Y* and *Z* curves involved in calculating the CIE 1931 *x*, *y* colour coordinates 14

Figure 3 – Correlation plot between the quantity $(1 – x – y)/y$, calculated from the CIE 1931 *x*, *y* colour coordinates, and the value of $K_{B,V}$, for all the spectra analysed to generate Figure 1 15

Figure 4 – Estimate of the luminance level where L_B = 10 000 W/(m^2·sr), border between RG1 ($t_{max} > 100$ s) and RG2 ($t_{max} < 100$ s) in the large source regime, as a function of CCT 16

Figure 5 – Estimate of the illuminance level where E_B = 1 W/m^2, border between RG1 ($t_{max} > 100$ s) and RG2 ($t_{max} < 100$ s) in the small source regime, as a function of CCT 16

Figure 6 – Relation of illuminance *E*, distance *d* and intensity *I* 20

Figure 7 – Flow chart from the primary light source (in blue) to the luminaire based on this light source (in amber) 21

Figure A.1 – Schematic image of the situation considered in Annex A 23

Figure B.1 – General appearance of t_{max} as a function of viewing distance *d*, for any light source with homogeneous luminance *L* and diameter *D* 26

Figure C.1 – Luminance values from Table C.1 in relation to the RG1/RG2 border as function of correlated colour temperature 28

Figure C.2 – Illuminance values from Table C.2 in relation to the RG1/RG2 border as function of correlated colour temperature 29

Figure D.1 – Examples of secondary lenses with identical light distribution and alignment 32

Figure D.2 – Examples of LED arrays with bare LED packages 33

Figure D.3 – Evaluation whether one or more LED elements fall in 11 mrad field of view at distance d_1 33

Figure D.4 – Complete flowchart of the detailed assessment of arrays and clusters of primary light sources 35

Table 1 – Correlation between exposure time and risk group 10

Table C.1 – Luminance values giving risk group not greater than RG1 28

Table C.2 – Illuminance values giving risk group not greater than RG1 29

Table D.1 – Applicability of steps 1 to 6 31

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

APPLICATION OF IEC 62471 FOR THE ASSESSMENT OF BLUE LIGHT HAZARD TO LIGHT SOURCES AND LUMINAIRES

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC TR 62778, which is a technical report, has been prepared by subcommittee 34A: Lamps, of IEC technical committee 34: Lamps and related equipment.

This second edition cancels and replaces the first edition published in 2012. This edition constitutes a technical revision.

This edition includes the following significant technical change with respect to the previous edition: inclusion of the photobiological assessment of LED arrays (Annex D).

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
34A/1737/DTR	34A/1758/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

APPLICATION OF IEC 62471 FOR THE ASSESSMENT OF BLUE LIGHT HAZARD TO LIGHT SOURCES AND LUMINAIRES

1 Scope

This Technical Report brings clarification and guidance concerning the assessment of blue light hazard of all lighting products which have the main emission in the visible spectrum (380 nm to 780 nm). By optical and spectral calculations, it is shown what the photobiological safety measurements as described in IEC 62471 tell us about the product and, if this product is intended to be a component in a higher level lighting product, how this information can be transferred from the component product (e.g. the LED package, the LED module, or the lamp) to the higher level lighting product (e.g. the luminaire).

A summary of recommendations to assist the consistent application of IEC 62471 to light sources and luminaires for the assessment of blue light hazard is given in Annex C.

NOTE It is expected that HID and LED product safety standards will make reference to this Technical Report.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050 (all parts), *International Electrotechnical Vocabulary* (available at <http://www.electropedia.org>).

IEC 62471:2006, *Photobiological safety of lamps and lamp systems*

CIE S 017/E:2011, *ILV: International Lighting Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62471:2006, CIE S 017/E:2011 and IEC 60050-845 as well as the following apply.

3.1
blue light hazard efficacy of luminous radiation
$K_{B,v}$
quotient of blue light hazard quantity to the corresponding photometric quantity

Note 1 to entry: Blue light hazard efficacy of luminous radiation is expressed in W/lm.

Note 2 to entry: The quantity $\Phi_\lambda(\lambda)$ in the formula below can be replaced by $L_\lambda(\lambda)$ or $E_\lambda(\lambda)$.

$$K_{B,v} = \frac{\int \Phi_\lambda(\lambda) \cdot B(\lambda) \cdot d\lambda}{K_m \cdot \int \Phi_\lambda(\lambda) \cdot V(\lambda) \cdot d\lambda}$$

where K_m= 683 lm/W.

Note 3 to entry: $K_{B,v} = L_B/L = E_B/E$.

3.2
blue light hazard efficiency of radiation
η_B
ratio of blue light hazard quantity to the corresponding radiometric quantity

Note 1 to entry: The quantity $\Phi_\lambda(\lambda)$ in the formula below can be replaced by $L_\lambda(\lambda)$ or $E_\lambda(\lambda)$.

$$\eta_B = \frac{\int \Phi_\lambda(\lambda) \cdot B(\lambda) \cdot \mathrm{d}\lambda}{\int \Phi_\lambda(\lambda) \cdot \mathrm{d}\lambda}$$

3.3
correlated colour temperature
CCT
temperature of the Planckian radiator having the chromaticity nearest the chromaticity associated with the given spectral distribution on a diagram where the (CIE 1931 standard observer based) *u*', 2/3 *v*' coordinates of the Planckian locus and the test stimulus are depicted

Note 1 to entry: Correlated colour temperature is expressed in kelvin (K).

Note 2 to entry: The concept of correlated colour temperature should not be used if the chromaticity of the test source differs more than $\Delta C = [(u'_t - u'_p)^2 + \frac{4}{9}(v'_t - v'_p)^2]^{1/2} = 5 \times 10^{-2}$ from the Planckian radiator, where

u'_t, v'_t refer to the test source, u'_p, v'_p to the Planckian radiator.

Note 3 to entry: Correlated colour temperature can be calculated by a simple minimum search computer program that searches for that Planckian temperature that provides the smallest chromaticity difference between the test chromaticity and the Planckian locus, or e.g. by a method recommended by Robertson, A. R. "Computation of correlated color temperature and distribution temperature", J. Opt. Soc. Am. 58, 1528-1535, 1968. (Note that the values in some of the tables in this reference are not up-to-date).

[SOURCE: CIE S 017/E:2011, 17-258, modified — T_{cp} is not referenced.]

3.4
illuminance <at a point of a surface>
E
quotient of the luminous flux dΦ incident on an element of the surface containing the point, by the area d*A* of that element

Note 1 to entry: Illuminance is expressed in lm/m^2 or lx.

[SOURCE: IEC 60050-845:1987, 845.01.38, modified — The second half of the definition is omitted.]

3.5
blue light weighted irradiance
E_B
irradiance spectrally weighted with the blue light spectral weighting function as defined in IEC 62471

Note 1 to entry: Blue light weighted irradiance is expressed in W/m^2.

3.6
threshold illuminance
E_{thr}
threshold illuminance value, below which the light source can never give rise to an exposure time $t_{max} < 100$ s, regardless of the light source's L_B value

Note 1 to entry: The threshold illuminance can be calculated by taking the E_B value for t_{max} = 100 s, which is E_B = 1 W/m^2, and dividing E_B by the $K_{B,v}$ value corresponding to the spectrum of the light source.