COMPARISON BETWEEN THE CIE AND LITG METHOD FOR MINIMIZING OBTRUSIVE GLARE CAUSED BY BRIGHT LUMINAIRES IN THE FIELD

Walkling, A.[1], Schierz, Ch.[1]

[1]Technical University of Ilmenau, Department of Lighting Technology, Prof.-Schmidt-Straße 26, 98693 Ilmenau, Germany,

andreas.walkling@tu-ilmenau.de

Abstract

The aim of the paper is to check the validity of the CIE 150 method for the limitation of bright luminaires in the field based on using the luminous intensity as photometric parameter. We have compared the CIE method with the LiTG method by transforming the luminance based LiTG values into comparable luminous intensity values. There is a significant difference between both methods. It was found impossible to find any matching results. This paper, therefore, is suggested as the basis of revising the current CIE method by utilizing the luminance as photometric parameter instead.

Keywords: obtrusive light, luminous intensity, luminance, glare

1 Introduction

Since the mid 1970s, lighting engineers have dealt with the effects of obtrusive light from outdoor lighting installations in Germany (TÜV, 1978; Hartmann, 1984). In 1991, the first edition of the LiTG guide on the limitation of those effects was published (LiTG, 1991). The latest revision of this guide was recently published (LiTG, 2011). The general principles of assessing the light trespass into windows and the glare effect on residents have been proved successful and stayed the same in the 3rd edition.

2 CIE limitation of bright luminaires in the field

The view of bright luminaires can cause distraction and discomfort. The effect on residents can be described by using luminance values of the luminaire. The CIE Guide, however, does not recommend the luminance as photometric parameter because it claims that luminance data from manufacturers are infrequent and the luminance of luminaire is difficult to measure (CIE, 2003). Hence, the limiting values recommended for the limitation of bright luminaires in the field are expressed by the simplifying luminous intensity value. In terms of the tolerable maximum values for luminous intensity of luminaires in designated directions, the ambient lighting (i.e. environmental zones E1 - E4) and the time of day (i.e. pre-curfew and post-curfew hours) are relevant.

Table 1. Maximum values for luminous intensity (CIE, 2003).

Light technical parameter	Application condition	Environmental zones			
		E1	E2	E3	E4
Luminous intensity emitted by luminaires	Pre-curfew	2500 cd	7500 cd	10000 cd	25000 cd
	Post-curfew hours:	0 cd	500 cd	1000 cd	2500 cd

The environmental zones are defined as follows (Table 2):

Table 2. Environmental lighting zone (CIE, 2003).

Zone	Surrounding	Lighting environment	Examples
E1	Natural	Intrinsically dark	National parks or protected sites
E2	Rural	Low district brightness	Industrial or residential rural areas
E3	Suburban	Medium district brightness	Industrial or residential suburbs
E4	Urban	High district brightness	Town centres and commercial areas

3 LiTG limitation of bright luminaires in the field

The obtrusive glare is determined by the following equation (LiTG, 2011):

$$k = \overline{L}_{\max} \times \sqrt{\frac{\Omega_S}{L_b}} \tag{1}$$

where

k = limiting value
$\overline{L}_{\max}$ = the maximum tolerable average luminance of the bright source in cd/m^2
Ω_s = the size of the source in sr
L_b = the background luminance of the bright luminaire in cd/m^2

This equation is applied to 0,1 cd/m^2 ≤ L_b ≤ 10 cd/m^2 and 10^{-6} sr < Ω_s < 10^{-2} sr. The application also implies that the bright part of the luminaire is visible from the particular position (i.e. Guth's position index for a glare source being p = 1). Any further light technical parameters such as the shape of the bright part of the luminaire or the light colour are not taken into account.

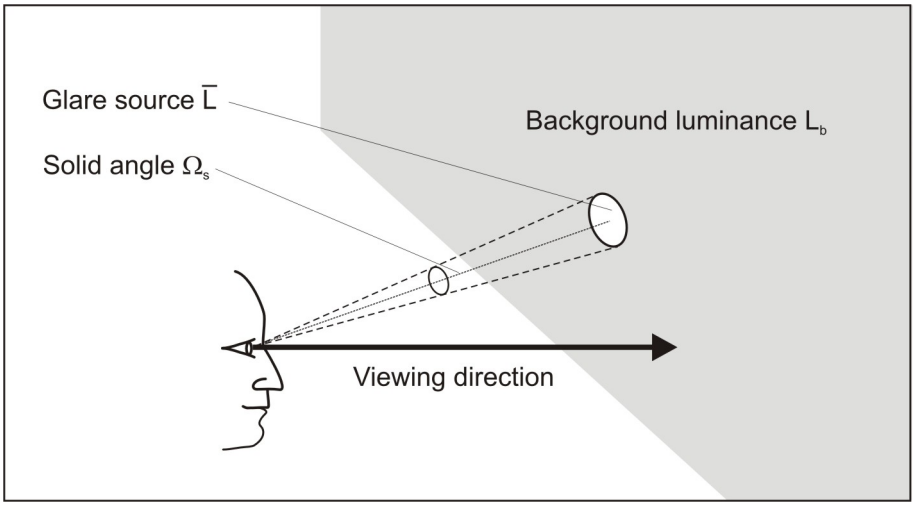

Figure 1. Example for describing relevant photometric parameters.

From past experiments where the subjective glare evaluation was investigated, the borderline between comfort and discomfort glare was derived as shown in Figure 2.

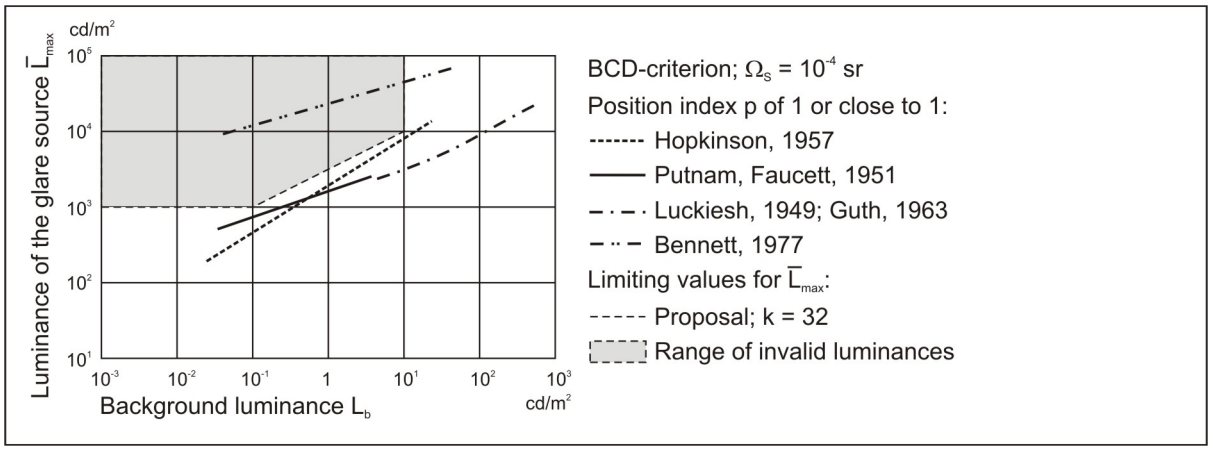

Figure 2. Comparison between glare equations: the dependence of luminance L_{max} of the background luminance L_b.

The basis for the limiting value k is the maximum tolerable luminance of 1000 cd/m² referring to Ω_s = 10^{-6} sr and L_b = 0,1 cd/m² which gives a value for k of 32. From this, the limiting values can be derived depending on the environment and the time of day (LiTG, 2011):

Table 3. Maximum values for k.

	Place of immission	limiting value for k		
		6.00 hrs – 20.00 hrs	**20.00 hrs – 22.00 hrs**	**22.00 hrs – 6.00 hrs**
1	Spa areas, hospitals, mental hospitals	32	32	32
2	Residential-only areas General residential areas Special residential areas Small residential estate areas Recreational areas	96	64	32
3	Village areas Mixed used areas	160	96	32
4	Business zones Commercial areas Industrial areas	-	-	160

4 Comparison between CIE and LiTG limitation of bright luminaires in the field

To compare the maximum luminance values of the LiTG method with the maximum luminous intensity values of the CIE method, the following equation

$$k = \bar{L}_{\max} \times \sqrt{\frac{\Omega_s}{L_b}} \tag{2}$$

can be written as

$$\bar{L}_{\max} = k \times \sqrt{\frac{L_b}{\Omega_s}} \tag{3}$$

This leads to the following equations (Eberbach, 2002):

$$I_{\max} = \overline{L}_{\max} \times A \tag{4}$$

$$I_{\max} = k \times \sqrt{\frac{L_b}{\Omega_s}} \times A \tag{5}$$

$$I_{\max} = k \times \sqrt{L_b} \times \sqrt{A} \times R \tag{6}$$

where

A = apparent size of the glare source

R = distance between the glare source and the resident

Figure 3 shows the calculated results based on using equation no. 6 and A = 0,1 m² and L_b = 1 cd/m². It can be seen that the maximum values for intensity are independent on the distance between the glare source and the observer if the CIE method is considered.

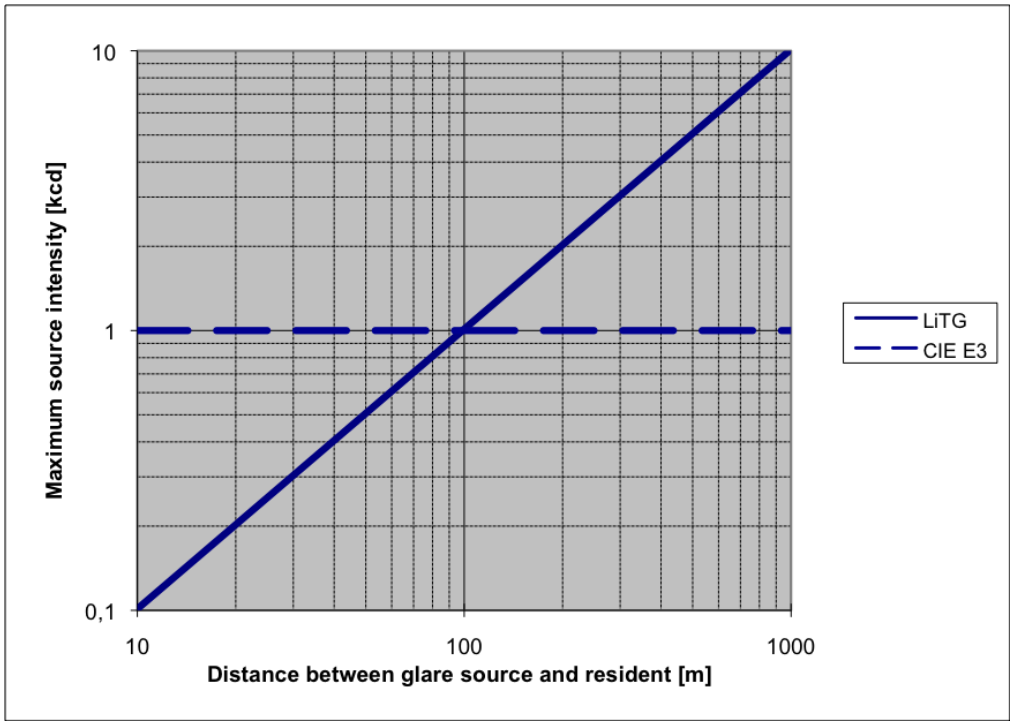

Figure 3. Comparison between the CIE and LiTG method.

The maximum values, however, are dependent on the distance if the LiTG method is used. It can be seen that the wider the distance, the higher is the tolerable limit for the glare source intensity.

5 Conclusion

To summarise, a principal effect associated with the CIE method is that the limiting values are too high in the near field and too low in the far field. This implies that lighting installations designed with the CIE method are too glaring if they are situated within the near field (e.g. < 100 m distance). Moreover, they are too expensive (because of over shielding) if they are situated within the far field. We suggest, therefore, that the current CIE method for limiting bright luminaires in the field should be withdrawn from the CIE Guide 150 and it should be replaced with the luminance based LiTG method.

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