Lab Notes

Issue 10

Disability Glare in the Outdoor Workplace

1.00 Introduction :

This Lab Note is one of several which discusses the matter of glare in the workplace. They have been issued as a series of short and easily digestible articles rather than one long and heavy text book.

This Issue 10 Lab Note attempts to address the subject of "Disability Glare in the Outdoor Workplace," and it is suggested that Lab Notes 7, 8 and 9 be read before proceeding with this document.

Other Issue numbers and titles are as follows:

Issue 2 : *The Unified Glare Rating System as a Productivity Tool*

Issue 7 *: What is Glare ?*

Issue 8 : *The Control of Glare by the AS1680 Systems*

Issue 9 : *Dealing with Discomfort Glare in the Interior Workplace*

As discussed in Lab Note No. 7, there was considerable research into glare in the 1920's. Holladay published his classic paper in 1926, and W. S. Stiles presented his paper to the British Illuminating Engineering Society in 1929. It was in this 1929 paper that Stiles made the distinction between "Discomfort Glare" and "Disability Glare" when he said -

> " In one's own home "Discomfort Glare" is the more vital, in a factory both forms are perhaps equally important, in a street "Disability Glare" is usually considered the most serious."

Holladay's prime interest was the effect of glare on visibility, and not the study of the phenomena of glare itself. Out of his investigations into what he called, "blinding glare," came the famous Holladay Formula, which is often and incorrectly called the Stiles - Holladay Formula. However in recognition of both researchers, the fundamental theory of Disability Glare is often referred to as the Stiles - Holladay Principle.

LightLab International Pty Ltd
Unit 1 56 Smith Road
Springvale, Vic. 3171
Phone : + 61 3 9546 2188
Fax : + 61 3 9562 3717
Email : lightlab@lsa.com.au
Web Page : www.lsa.com.au

1.1 The Holladay Formula

The general form of the Holladay Formula is :

$$L_v = \frac{E}{K \cdot \theta^n}$$

where L_v = equivalent veiling luminance (cd/sq.m.)

E = illuminance of the plane of the eye (lux)

θ = angle between the observer's line of sight and the glare source

K+n = Constants

Since the 1920's many researchers such as, Adrian, 1961 and 1975; Fisher and Christie, 1957; Fry, 1955; Hartman, 1963 and 1968, have investigated the value of the constants K and n.

It is generally accepted for most practical applications K is taken as 10 and n as 2. Therefore the formula is usually taken as for the total number (n) of luminaires.

$$L = \sum_{1}^{n} \frac{E}{10 \ \theta^2}$$

2.00 Glare in Outdoors :

Glare is often encountered in the outdoor situation, and it is generally Disability rather than Discomfort Glare. However in outdoor workplaces Discomfort Glare can be experienced by operators working for long periods of time in difficult circumstances.

2.1 Glare Evaluation Methods :

The glare evaluation methods of the "Threshold Increment", TI and the "Glare Control Mark," G, which are used as quality of light parameters in road lighting are not applicable to an area lighting situation. This is because the direction of viewing by the observer is variable and not fixed. In addition, the lighting points are not usually positioned in a regular line array, and the mounting heights and illuminance values used are usually well outside the accepted range of road lighting.

The "Glare Rating" or GR system which is outlined in Section 2.2 of this Lab Note is based on the assumption that the viewing directions are usually below eye level. It is recognised that the observer will experience intolerable glare when looking up and straight into a luminaire. It is therefore important that the highest possible mounting height be used, and the spacing to pole height ratio should not exceed 5 : 1.

It is also recognised that the lighting designer must pay very careful attention to the aiming and siting of the luminaires relative to the main directions of viewing. This matter is particularly important in areas such as container wharves and storage areas, where pedestrians and large transporters share a common traffic route.

2.2 The Glare Rating System

This system is described in detail in the CIE Publication No. 112.

In general the lower the value of GR the better will be the glare restriction. The following Table compares the GR Scale, nominally from 10 to 90, with descriptive criteria of glare evaluation.

Descriptive Criteria	Glare Rating
Unbearable - - - - - - -→	90
	80
Disturbing - - - - - - - -→	70
	60
Just admissible - - - - →	50
	40
Noticeable - - - - - - - -→	30
	20
Unnoticeable - - - - - - →	10

This scale is not given as a means of specifying glare restriction limits but rather as a means of comparing glare ratings of different lighting installations. For practical reasons GR values should only be given between 10 and 90 with two significant digits.

In the following table of Recommended Glare Rating Limits, the limits shown should be regarded as **maximum values not average values.**

Likewise for important or difficult visual tasks in an outdoor working area it is strongly suggested that the maximum glare rating used should be **5 units lower** than those shown in the Table.

2.3 Recommended Glare Rating Limits :

Area Lighting

Lighting Application	Risk Factor	GR max
Safety & Security	Low Risk	55
	Medium Risk	50
	High Risk	45
Movement and Safety	Pedestrians Only	55
	Slow Moving Traffic	50
	Normal Traffic	45
Work	Very Rough	55
	Rough - Medium	50
	Fine	45

2.4 Glare Control Mark and Threshold Increment :

These two parameters are used in fixed road lighting installations as methods of quantifying glare. The Glare Control Mark (G) is a method of describing discomfort from glare and the Threshold Increment (TI) as a method of evaluating Disability Glare.

2.4.1 The Glare Control Mark (G) :

The Glare Control Mark Scale uses the same descriptive criteria as the Glare Rating System but in reverse order, for example;

G = 1 “Unbearable” glare
G = 3 “Disturbing” glare
G = 5 “Just admissible” glare
G = 7 “Satisfactory” glare
G = 9 “Unnoticeable” glare

The method of calculating the Glare Control Mark (G) is fully described in the CIE Publication No. 31-1976 “Glare and Uniformity in Road Lighting Installations.”

As a general statement the Glare Control Mark is based on an empirical formula which was derived from experimental work done in the Netherlands in the 1960’s.

One of the controversial parameters of this particular formula is the “F” term the flashed area of the luminaire.

This term is very difficult to determine for a luminaire which has a non-uniform luminance distribution over it surface area.

It must also be noted that the formula should only apply to straight sections of roadway which have a regular luminaire arrangement.

2.4.2 Threshold Increment :

In principle the values of the Threshold Increment (TI) should be related to road safety. While the relationship between Threshold Increment and road safety is unknown, there is a known relationship between visual performance and road safety.

Thus a TI value can be specified for a level of road safety for a given class of road.

TI is usually expressed as a percentage figure. A 2% TI is generally regarded as the onset of Disability Glare.

In single terms TI might be regarded as the relationship between the equivalent veiling luminance as calculated by the Holladay Formula, refer Section 1.0, and the average road luminance for a given angular size of object.

3.00 Induction of Disability Glare :

The influence of one part of the visual field upon another is sometimes called “Induction” or “Simultaneous Contrast”. This phenomena is best illustrated by the apparent change in the lightness of the two halves of the square shown in Figure 1.

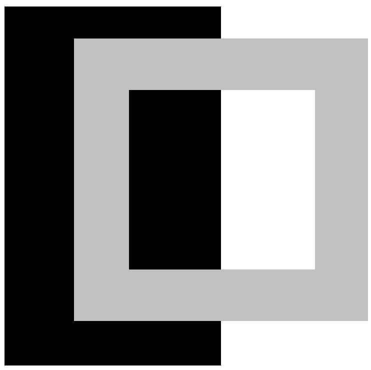

Figure 1.

If you were to place a fine line or a pencil along the right hand edge of the black rectangle, the right hand half of the square would appear to be darker than the left hand half.

This is because the induction effect is believed to originate within the retina of the eye.

However, when the square is divided it would appear that a mechanism within the visual cortex takes place. ie. When the square is divided, we perceive that the two halves have different shades of grey, but when it is not divided, we perceive it to be one shade only.

3.1 The Possible Consequence of Induction :

One possible consequence of this induction phenomena is that our central vision, ie. our foveal or cone vision capacity, is reduced.

This is because the brighter light source, in this case the white right hand background of Figure 1, is in our peripheral, ie. our parafoveal or rod vision field.

In an extreme situation when this phenomena occurs, ie. an extremely bright light source appears in our peripheral field of vision, we experience Disability Glare.

Any enquiries should be directed to :

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