Lab Notes

Issue 8

The Control of Glare by the AS1680 Systems

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 8 Lab Note reviews the three methods of limiting Discomfort Glare included in AS 1680.1, and it is suggested that Lab Note 7 should 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 9 : *Dealing with Discomfort Glare in the Interior Workplace*

Issue 10 : *Disability Glare in the Outdoor Workplace*

2.00 Glare Control Methods :

Before considering these three methods it is worthwhile to look at the classification of luminance distributions of luminaires, because the luminance of the glare source is the dominant factor in the determination of Discomfort Glare.

When the luminance of the bare lamp exceeds an appropriate limit, it can be controlled with three types of devices. These are translucent diffusers, prismatic panels and reflectors or louvres. Ignoring for the moment special cases such as that of louvres made of translucent rather than opaque material, it is convenient to classify the luminance distribution of luminaires, employing each of these three types of devices as **constant, non-constant, and cut-off.**

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2.1 Constant Distributions :

Luminaires employing diffusing plastic or glass panels and enclosures, normally have a moderate luminance not exceeding about 15 kilo candelas per square metre, and the luminance (L_s) usually remains reasonably constant throughout the critical angular range. This is 45° to 90° in the gamma angles of the luminaire. It therefore becomes possible to determine a suitable luminaire limit L_s for this type of luminaire.

However since the direct application of a glare formula is tedious and unwieldy, it is preferable to convert the data into the form of precalculated tables such as Tables 8.2 and 8.3 of AS1680.1. With Tables of this type available, the user needs to no longer calculate the parameters for the individual luminaires, but merely to be concerned with the room dimensions and the orientation of the luminaires.

2.2 Non-Constant Distributions :

Luminaires employing prismatic panels and enclosures have a varying luminance throughout the critical angular range of 45° to 90° .

Well designed devices of this type progressively reduce the luminance (L_s) from the 45° angle to a lower value, as it approaches the horizontal 90° angle. These devices are extensively used in recessed luminaires mounted flush with the ceiling in large rooms. This is because as in the case of cut-off luminaires, the effective region causing glare is determined by the shape of the light distribution of the luminaire, rather than by the actual room size.

The surface mounted luminaire with a prismatic panel and refractor side panels also has a non-constant distribution, since these luminaires can also effectively limit the luminance at the larger gamma angles.

2.3 Cut-off Distributions :

This is often referred to as “control by shielding.” The lamp is completely concealed whenever θ becomes less than a pre-determined shielding angle S which is controlled by the mechanical construction of the luminaire.

This principle is illustrated in Figure 1, and the method depends on two assumptions:-

(a) the worker’s normal line of sight is not above the horizontal
(b) extremely powerful lamps will not be mounted too low or too close to the head of the worker.

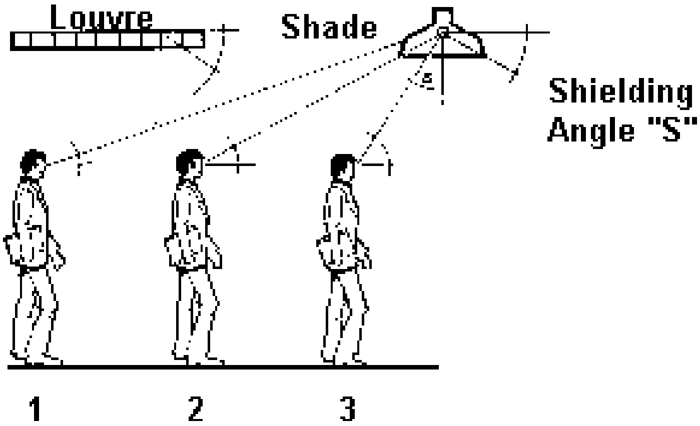

Figure 1

In Position 1 - Angle θ is less than S. In Position 2 - Angle θ = S. In Position 3 - Angle θ is greater than S. The principal of Cut-off (shielding angle) is that when the angle θ, as shown is less than S, the observer has no direct view of the light source.

This method has great practical advantages. For one thing the shielding angle is a simple concept readily defined and measured, as shown in Figure 1. Moreover, once cut-off has occurred, the luminance of the visible parts of the luminaire is usually low (about $1kcd.m^{-2}$) in the case of luminaires using ordinary tubular fluorescent lamps.

Hence the degree of glare becomes virtually independent of room size. In addition, by employing suitably shaped specular finished louvres, the luminance after cut-off can be made extremely low, and well under the threshold value where Discomfort Glare is not likely to occur.

3.00 Glare Control by a Glare Evaluation System :

The most popular Glare Evaluation System currently being used is the Glare Index System, originally developed by the British Illuminating Engineering Society in the 1960's.

Another form is the American Visual Comfort Probability Method (VCP), which was developed by Dr. Sylvester Guth, also in the 1960's.

As discussed in Lab Note Issue 2, the Glare Index System tends to be a more sensitive indicator of a glare situation. It can be used to **identify troublesome locations and viewing directions in a particular workplace,** rather than condemning the entire installation as does the Luminance Limiting System. As one wit once said, "If there is one troublesome spot in the office, that's a good place to put a pot plant !"

4.00 AS1680.1 Section 8 :

There are three currently recognised methods of controlling Discomfort Glare.

These are - :

- by limiting the Luminance of the luminaire
- by hiding the glare source behind an opaque shield – cut off angles
- by using a glare evaluation system

Section 8, of AS1680.1 includes all of these three methods. This is because there are differing situations where each method is quite appropriate. For example, while the Luminance Limiting System can be used in a factory, the cut-off system is probably more appropriate, and the Glare Index System should be used in screen based task areas.

4.1 The Luminance Limiting System :

Between 1937 and 1942 Standards Association of Australia (SAA) had sub-committees in both Melbourne and Sydney working on a number of draft documents which became CA.501-1942. This Code was gazetted by the Australian Commonwealth Government on July 8th, 1942, as the "National Security (Industrial Lighting) Regulations," and was known as (E) CA.501-1942.

This document was unique as it was the first to contain recommendations for both the quality and quantity of illumination.

In addition the glare recommendations differentiated between diffusing luminaires and open reflector type luminaires, ie. luminance limits and cut off angles.

During the period 1951 to 1954 there was considerable activity in glare research in Australia, America and Europe. As a result of this work CA 30-1957 was published in that year with a considerably refined Luminance Limiting System which is very similar to the method currently used in AS1680.1.

The CA 30-1957 Table of Luminance Limits consisted of only single values because at that time most of the luminaires were of the Constant Luminance distribution, refer Section 2.1 above, ie. luminaires employing diffusing plastic or glass panels and enclosures.

By 1976, the prismatic panel was the most commonly used commercial luminaire. Because of this the structure of the Table of Luminance Limits was changed to accommodate the Non-Constant Luminance Distribution luminaires. Recessed troffers with K12, K15 or K19 prismatic panels come into this category. To fully describe their luminance limiting curve, a minimum of four gamma angles are required. These are 55, 65, 75 and 85 degrees, in both the C0 and C90 planes.

Tables 8.2 and 8.3 AS1680.1, Pages 40 and 41, show these limits, and the Notes describe some of the conditions under which they apply. Other assumptions not stated include - :

- the maximum panel size is 1500 x 600 mm.
- the room reflectances are ceiling, 0.7 ; walls, 0.5 ; floor, 0.2
- the luminaires are set out in a regular array
- that the optical axis is for reading and writing tasks, and not for screen based tasks

It must be stressed that this is a very simplistic method and that there are many weaknesses with the Luminance Limiting System. It is a methodology which belongs to the 1950's and 1960's, but not to the 1990' and beyond. It is not applicable in installations which have multiple luminaire types or irregular arrays.

The primary weakness of the Luminance Limiting System is that when the luminaire limits are converted to a Glare Index value, they equate to a GI value of approximately 20 GI units. Many appraisals confirm that this value is too high for screen based tasks. The recommended value of 16 GI units appears to be acceptable for the majority of the working population.

4.2 Cut Off Angles

As discussed in Section 2.3, "Cut-off Distributions," this method of glare control shields the glare source from the observer. It is assumed that the glare source is always the lamp, but as we will see later this is not always the case.

In the early editions of CA 30 and AS1680 the Standard specified a minimum Shielding Angle. This was changed to a maximum Cut-Off Angle in the 1990 edition of AS1680.

It was found that the Cut-Off Angle concept was much more easily understood than that of the Shielding Angle. Refer Figure 2.

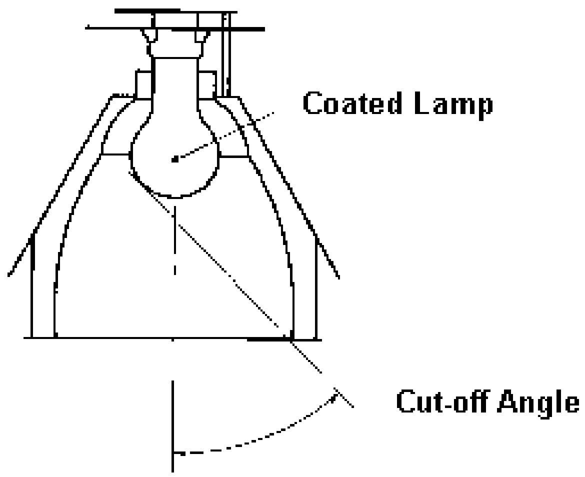

Figure 2

Example of luminaire with tungsten filament lamp showing cut-off angle.

Tables 8.4 of AS1680.1, Page 43, specifies maximum cut-off angles for a wide range of lamps including fluorescent and high intensity discharge lamps. The cut-off angle is related to the lamp lumen output and the mounting height.

Although cut-off angles are specified for offices and school classrooms, the primary application of this system is in industrial premises. which is not controlled by the cut-off angle is nearly as bright as the lamp itself.

While this system works well for most lamp luminaire combinations, it does not work when the lamp is a small arc high intensity lamp, or when the luminaire has highly specular reflectors. This is because the brightness of the image of the lamp in the reflector which is not controlled by the cut-off angle, is nearly as bright as the lamp itself.

4.3 Glare Index System :

One of the prolific glare researchers was Dr. R. G. Hopkinson of the Building Research Station in England. He published papers on glare in 1940, 1950 and 1960. In his 1960 paper he proposed a scaling system which became known as The British IES Glare Index, or BGI for short.

This system was adopted by the British Illuminating Engineering Society in the British Lighting Code in 1963, and later in a number of Scandinavian and other countries.

Until the advent of the personal computer, the calculation of Glare Index values (GI) for an installation was complex and tedious, with a high probability of error.

To overcome this problem the British IES developed a system of standardised tables, with a number of correction factors. This system was not adopted in Australia, as it was thought that it was no better than our Luminance Limiting System used at that time. It also meant additional work and cost for Manufacturers, and took Lighting Designers more time to perform.

The 1990 edition of AS1680.1 adopted for use in Australia the British IES method of calculating GI values. Later, in February 1997, Standards Australia decided to adopt the new Commission Internationale De L'Eclairage (CIE) Unified Glare Rating System, (UGR). Because this UGR system effectively gives the same results as the British IES method and overcomes some of the short comings of the BGI formula, it really replaces the British system.

The UGR Glare Index System is more accurately known as a Glare Evaluation System. This is because it evaluates the suitability of a lighting system for a particular work space, without the restrictive assumptions of the Luminance Limiting System. It also allows a higher or lower value of GI to be calculated. Section 8.4.2.3. of AS1680.1, Page 37, describes the conditions in which the UGR System should be used.

Always remember that the Luminance Limits in Tables 8.2 and 8.3 equate to a GI of 20.

A large number of appraisals in many parts of the world have found the maximum GI value for screen based tasks to be 16 GI units. However, investigations carried out in Australia have led us to believe that a tolerance of plus one and one half, (1½) GI values is quite tolerable. Therefore a calculated Glare Index of up to 17.4 GI units is considered to be acceptable in Australia.

This figure can only be reliably ascertained by the use of a dependable personal computer program. The use of luminance limits one or two steps lower has never been validated as being as reliable as a Glare Evaluation System.

Likewise the practice of using Tables of uncorrected GI values and correction factors has not been validated as being sufficiently accurate for screen based tasks. There are two reasons for this. Firstly, the table of uncorrected values is based on only two viewing positions, crosswise and endwise, that is, the C0 and C90 planes, yet we know for ULB luminaires the C45 produces much more glare than the C0 or C90 planes.

Secondly, it is based on the standard room surface reflectance of ceiling; 0.7, walls; 0.5, floor; 0.2. Again experience has shown that in contemporary work places where light coloured work stations are installed the average reflectance of the **floor cavity** is closer to 0.3 than 0.2.

Similarly the practice of using Tables of uncorrected GI values and correction factors has not been validated as being sufficiently accurate for screen based tasks, and there are two reasons for this - :

- The Tables are based on only two viewing positions, crosswise and endwise, ie. the C0 and C90 planes. However we know that for ULB luminaires, the C45 plane produces much more glare than do the C0 or C90 planes

- The Tables are based on the standard room reflectance of ceiling, 0.7; walls, 0.5; and floor, 0.2. However we again know from experience that in contemporary work places where light coloured work stations are installed, the average reflectance of the **floor cavity** is closer to 0.3 rather than 0.2.

This relatively small change in reflectance can have a significant effect on the calculated GI values in an installation which uses ULB luminaires.

Lab Note, Issue 2 : The Unified Glare Rating System UGR as a Productivity Tool, discusses the various attributes of the Australian Glare Index program, and it is recommended as further helpful reading on this matter.

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