Lab Notes

Issue 13

Emergency Evacuation Lighting in Buildings

1.00 Introduction :

In the early 1970s there had been a number of serious fires in commercial buildings which resulted in significant loss of life as well as of property. These occurred mainly in Europe, but the most famous, or infamous here in Australia occurred at the Whiskey Au Go Go night club in Brisbane on March 8th 1973.

In almost every case it was established after investigations, that the main cause of death was either by people being trampled underfoot while trying to escape, or by the effects of smoke inhalation as they tried in vain to find the exits from the buildings.

In 1976 Standards Australia (then SAA) formed a committee known as LG/7 which was formed to examine the possibility of developing an Australian Code of Practice for Evacuation Lighting.

The role of this committee was to develop means by which people could escape from any building under threat from fire. It was not intended to directly assist firemen or rescue workers, nor to allow work processes to continue, even on a limited basis.

This is why the Foreword of AS2293 spells out quite clearly the difference between Standby, Safety, and Evacuation Lighting.

1.1 The Function of the LG/7 Committee :

Initially LG/7 had three working groups.

- to investigate the proposed lighting
- to investigate the electrical aspects, especially battery types
- to determine how and where the new Standard was to be applied

This third group was made up from local government representatives from each State, and was soon disbanded as it became impossible to gain agreement between the States on the legal standing of such a Code.

2.00 Performance of the Lighting System :

Working Group 1 first considered the fundamental questions of how much light would be needed to safely evacuate people from a building, and how the system would be assessed for compliance.

This latter question had to address assessment both in the design stage, and when the project was completed.

At that time in the late 1970s, there were three major international proposals which had been adopted, or were about to be adopted, in various countries.

The British had a recommended minimum level of 0.2 lux, the American proposal had an average of one foot candle, (approximately 10 lux), and the Russians required one tenth of the normal average illuminance. ie. If the room average was 400 lux, then the average emergency lighting required would be 40 lux.

These three countries' requirements meant not only a wide variation in illuminance values, but also and obviously, a wide difference in the costs of the emergency lighting installations and battery capacities.

3.00 The Australian Situation :

Perhaps it is not too hard to imagine that the 0.2 lux proposition was the most attractive for the Australian committee to consider, BUT, it was realised that it would be very difficult to measure with accuracy, or to design an 0.2 lux system.

It was further realised that perhaps a person could not visually adapt to such a wide change of lighting levels eg. from a 400 lux level to an 0.2 lux level in just an instant, and the committee was concerned that this visual adaptation would probably not happen without a panic condition being created, which could in turn end in disaster.

Another matter of concern was how people would react in those few seconds after being suddenly plunged into darkness. How would they feel, and how would they respond both as individuals and as a group?

To test these questions, a number of trials were carried out in Melbourne with the co-operation of a group of members of the Illuminating Engineering Society as participants and observers.

These people came from a wide variety of ages and experience, but unfortunately the results of these experiments were never formally documented, and the data was lost when the Commonwealth Department of Productivity was disbanded in 1981.

3.1 Experimental Results :

The results of these experiments can be summarised as follows :
1) People of all ages could adapt from 400 lux to 0.2 lux levels in a few seconds without undue difficulty.
2) It is important that vertical surfaces such as walls and doors be recognisable to assist in orientation.
3) Emergency lighting must be integrated with Exit signs, and there must be a direct line of sight to either the actual Exit sign or to directional signs pointing to the Exit signs.
4) Using conventional measuring instruments, it is almost impossible to accurately measure illuminance values in the order of one lux or less.
5) It is important that the emergency lighting is activated within 1 second of the failure of the mains power lighting, and to at least 50% capacity within 5 seconds.

The Committee was most impressed with the experimental work done at the Jules Thorn Lighting Laboratory in the United Kingdom. The conclusions which they reached were that 0.28 lux was a safe minimum illuminance , and that the diversity in illuminance along an escape route approaching 50 :1 had no effect on the ability to see.

4.00 Peoples' Reactions :

It was found that the onset of panic within a crowd situation was caused by a number of factors which included :

- loss of orientation
- a feeling of isolation, even though surrounded by a crowd of people
- an awareness that mere seconds in time seemed to be interminable

All of these effects will be heightened if there is a presence or even the smell of smoke, and it can be easily understood that the first question to enter a person's mind is “How do I get out of here ?"

4.1 Presence of Smoke :

Working Group 1 struggled with the problem of the presence of smoke and how to compensate for it, or alternatively how to quantify the level or density of smoke, but these problems proved to be too difficult and complex.

In the end it was left to a comment in the Foreword of the Standard which states

> “It is recognised that the presence of smoke will have a detrimental effect on the visual conditions provided by emergency lighting. The Committee is of the view that there is no practical way of ensuring that the lighting system will continue to be effective under smoke conditions, and that dependence must be placed on other measures such as in the building construction and ventilation, to keep the escape paths as free as possible from smoke."

5.00 Structure of the Code :

It was realised in the very early deliberations of Working Group 1 that there was a need to check the design for compliance in both the planning stage and after the project was finally completed. It was also appreciated that the primary group of people doing the checking would be the Building Surveyors and Inspectors who have little or no Lighting knowledge, and so it was thought that the only reliable measuring equipment which these people could skilfully use, would be a scale rule and a 5 metre measuring tape.

From this philosophy was born the Tables of Maximum Spacing for a given mounting height and given luminaire classification.

In the latest edition of AS/NZS 2293-1995 illuminance calculations by either a computer aided design program or conventional point by point calculations are permissible. This design process is closely defined in Clause 5.3.2.4 as to how these calculations may be carried out.

6.00 The System of Classification :

As explained in Appendix C of ASINZS 2293.3-1995, the classification of emergency luminaires is based on an alpha-numeric system.

The alphabetic component is in the form of the letters A, B, C, D or E, and these define the general shape of the Intensity Distribution Curve in both the C0 and C90 planes. Figure 1 illustrates these generalised Intensity Distribution Curves.

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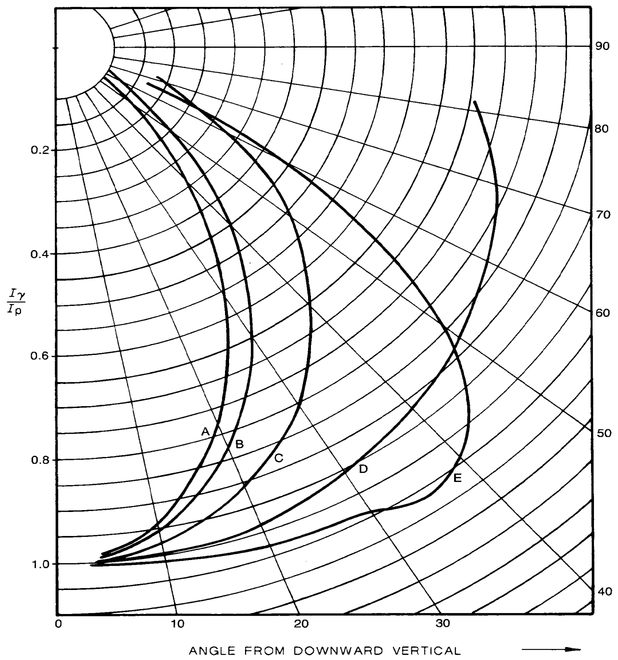

Figure 1.

The AS/NZS 2293-1995 edition also includes a set of formulae by which the luminous intensity (I_p) at any particular angle may be calculated, relative to the assigned luminous intensity (I_o) in the downwards vertical direction. The formulae for the five classifications are as follows :

(a) For Class A emergency luminaires

$I_p = I_o \cos^4 \gamma$ (for $\gamma < 70°$)

(b) For Class B emergency luminaires

$I_p = I_o \cos^3 \gamma$ (for $\gamma \leq 70°$)

(c) For Class C emergency luminaires

$I_p = I_o \cos^{1.5} \gamma$ (for $\gamma \leq 70°$)

(d) For Class D emergency luminaires

$I_p = I_o$ (2+cos *y)/* 3 (for $\gamma \leq 70°$)

(e) For Class E emergency luminaires

$I_p = I_o (1 +[0.04 \gamma / 30])$ (for $\gamma \leq 70°$)

$I_p = 1.07 I_o \cos 2.6 (\gamma - 35)$ (for $30° < \gamma \leq 65°$)

Where I_p = luminous intensity emitted at the angle, in candelas (cd)

I_o = luminous intensity in the downward vertical direction, assigned in accordance with Paragraph C3.2.3, in candelas (cd).

6.1 Numerical Component of the Classification :

This section of the Standard has never been very well understood, and it is hoped that the following examples will be helpful.

The actual numbers used in the Tables 5.1 to 5.5 of AS/NZS 2293.1-1995 are based on the R1O series of preferred numbers which are described in AS2752.

Using this R1O series of preferred numbers, the Table commencing at 1.0 is as follows :

1.0, 1.25, 1.6, 2.0, 2.5, 3.2, 4.0, 5.0, 6.3, 8.0, and 10.0

The series can also go up or down a decade as shown :

0.1, 0.125, 0.16, 0.2, 0.25, 0.32, 0.4, 0.5, 0.63, 0.8, 1.0
or
10, 12.5, 16, 20, 25, 32, 40, 50, 63, 50, 100
or
100, 125, 160, 200, 250, 320, 400, 500, 630, 800, 1000

As can be seen the series layout depends upon where the decimal point is placed in the first number of the series.

The actual number which relates to the downward vertical Intensity value is an **assigned** or selected number within this R1O series. This number must be equal to or less than the actual luminous Intensity in the downward vertical direction.

This has been done for two reasons :

The actual I_0 downward vertical Intensity value plays little or no part in the calculation

The shape of the polar curve in the upper zones, ie. 60° to 90° is much more influential than the I_0 value

7.00 Illustration of the Classification Method :

To illustrate the classification method and the result of the assignment process, consider the following example. The actual measured Intensity values in the C0 and C90 zones are as follows :

Gamma Angles	C0 Plane (cd)	C90 Plane (cd)
0	128	128
10	126	125
20	115	118
30	86	107
40	54	90
50	27	49
60	9	15
70	4	6
80	2	4
90	0	0

If we assume a mounting height of **2.7 m**, the spacing for the various assigned values would be as follows :

Assigned Value	Classification C0 Plane	Spacing (m)	Classification C90 Plane	Spacing (m)
125	A125	9.9	A125	9.9
100			B100	11.0
63	B63	10.0		
40				
32			E 32	11.2
25			C 25	10.5
20	E20	10.4		
16	C16	9.3		
12.5				
6.3			D6.3	9.0
5.0	D5	8.1		

The above Table shows that even though the I_0 value of 128 candelas is fairly high, by assuming or assigning a value of only 20 candelas it is possible to gain an E Classification. This classification allows a 10.4 metre spacing in the C0 Plane and an 11.2 metre spacing in the C90 Plane.

If the I_0 value was adjusted to the nearest preferred number of 125 candelas, the classification would only be A125 with a maximum spacing of only 9.9 metres.

However if a lower assigned number of 20 cds is used, a fewer total number of emergency luminaires will be required for an installation with a 2.7 metre mounting height.

This also shows how by careful assessment of the Intensity data, it is possible to maximise the spacings for a particular luminaire.

LightLab Sciences has a computer program which automatically reviews all of the possible combinations of classifications and assigned numbers, and then highlights the classification which gives the most advantageous spacing as shown above.

This program is utilised within any Emergency Lighting Test Report which is undertaken at our Laboratory, and we would be happy to further discuss its application with any Client.

8.0 Emergency Lighting Spacing Calculator :

This program is another helpful tool which is available for purchase from LightLab International. The Emergency Lighting Spacing Calculator is a design calculation tool for use with Windows. The program allows the determination of the maximum allowable spacing of emergency luminaires in accordance with the Australian Standard AS2293.3 - 1995.

8.1 Outputs :

The program produces a simple Plan view of the layout indicating the relevant maximum spacing distances in each direction. This may be printed, and includes the following details :

- Photometric Test Report Number
- Mounting orientation - ceiling or wall
- Classifications from the Photometric Test
- Mounting height
- Summary of maximum permissible spacings
- Indications on layout Plan of which maximum spacings apply in each direction

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