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EMERGENCY LIGHTING AND EXIT SIGNS

Emergency lighting and Exit signs are a critical element for the safe evacuation of persons from a building in an emergency. Most people only associate the word “emergency” to that of a fire but an emergency may include a bomb threat, flood, earthquake or even a toxic hazard.

Regulatory Requirements

The requirements for emergency lighting and Exit signs are contained in the Building Code of Australia (BCA) Section E4 and the technical requirements in AS2293.1. This paper does not intend to further address the requirements of two documents because competent designers and Certifiers should be able to interpret and apply them.

The Deemed to Satisfy (DtS) provisions in the BCA are deemed to provide an adequate level of life safety to occupants and any building which is designed to fully meet the DtS provisions need not undergo any further fire safety analysis.

What this paper does intend to do is highlight the shortfalls in both of the BCA and AS2293.1 when it comes to fire related emergencies.

The Shortfalls of the BCA

The principal shortfall in the BCA is that the DtS design of emergency lighting and Exit signage is based on the fact that there is no impairment of visibility within the building.

This, in a fire situation, a DtS design is patently deficient because in any fire situation, the smoke evolved from a fire is critical to life safety and will certainly:-

1. Obscure the effect of the emergency lights which are generally installed at ceiling level, see Figure 1; and
2. Obscure the visibility of the Exit signs which are generally installed at high level for intermediate signage and above the intermediate (see Figures 2 and 3) and final exit doors.

Figure 1 – Factory Smoke Testing – Emergency Lighting at Roof

Figure 2 – Intermediate Exit sign in Shopping Centre

Figure 3 – Intermediate Exit sign in Warehouse

The Shortfalls of the AS2293.1

AS2293.1 is undoubtedly a very good design guide and enables designers to design the required emergency lighting and Exit signs in order to meet Clause E4 of the BCA.

For emergency lighting systems, Section 5 of AS2293.1 provides a scheme for classifying emergency luminaries according to their light output distribution was evolved together with associated requirements governing the maximum spacings which may be used. This approach was adopted in preference to stating requirements directly in terms of illuminance values for the following reasons:

- The very low illuminance values which are involved cannot be measured with any degree of accuracy by conventional measuring instruments.
- To obviate the necessity for inspection personnel to have the training and skills required to take illuminance measurements.

This approach also has the advantage of simplifying the design of emergency lighting installations since it should be possible to more readily predict compliance at the design and certification stage.

In the formulating of requirements for the spacing of emergency luminaries, cognisance was taken of investigations conducted in the United Kingdom which led to the adoption in BS 5266, Part 1 of a recommended minimum illuminance of 0.2 lux along the escape route and throughout the specified operating period. Appraisals of emergency lighting installations which have been conducted in Australia generally confirm the adequacy of this recommendation. The spacing tables given in AS 2293.1 have therefore been computed on the basis of the provision of an illuminance at floor level of not less than 0.2 lux between adjacent luminaries, with reference to operation of the luminaries at a voltage equivalent to that which may apply at the end of the prescribed duration of operation.

The issue with this approach is that the only reference to smoke is in a note to Section 5.2 in AS2293.1 where Note 2 says – *"In the installation of emergency luminaries (with respect to both mounting height and location) consideration shall be given to the possible effects of smoke within the space reducing the effectiveness of the emergency lighting".* With the availability of considerable International research into the effects of smoke, it would seem appropriate that Standards Australia would have provided additional advice and design requirements. This should include a Performance Requirement to provide the necessary illuminance at floor level by either increased lighting levels at high level or by specifying low level emergency lighting – after all, Standards Australia would be aware of the acceptance criteria of the 2.1m high tenability height for safe egress (see later section on Fire Modelling).

For Exit signs, Section 6 of AS2293.1 provides only for the technical requirements of the signs and Section 6.2 leaves the locations up to the BCA. Again Standards Australia should be aware of the reduction in visibility due to smoke obscuration.

AS2293.1 Clause 6.8.1 limits the mounting heights of EXIT signs to be between 2.0m and 2.7m above FFL based on the normal field of view. This would normally take care of smoke layer heights.

International Research

M.J. Ouellette from the National Research Council Canada (NRCC) and others have published many papers on the subject. One particular paper reproduced two good examples of the visibility of an Exit sign in both normal and fire conditions. These are reproduced below as Figures 4 and 5.

Figure 4 – Exit sign in normal circumstances

Figure 5 – Same Exit sign in fire conditions

Oullette went on to say:-

Smoke seriously reduces sign visibility. It reduces brightness, contrast and clarity or distinctness of individual characters and symbols. Rea, Clark and Ouellette observed that quite often, in experiments, otherwise adequate signs become completely obscured in minimal amounts of smoke. The signs all conformed to code requirements. Should we have been surprised? No.

The reason is that code requirements for exit signs are written for conditions of clear air. They imply that no one will experience smoke if the building conforms to the other requirements in the codes. These might include ventilation requirements and limits on the smoke-generating potential of materials.

Some argue that because smoke builds up so quickly in fires, we cannot possibly expect anyone to be alive to read the signs just minutes after a fire starts. So, they contend, "why bother making signs visible in smoke?" There is some logic to this reasoning, at least for the rooms where the fire starts. On the other hand, smoke growth in neighbouring rooms and exit routes throughout the building may not necessarily be as rapid.

The reality is that people do encounter smoke. Firefighters and rescuers are obvious examples. They are often unfamiliar with the building and they require as many visual cues as possible for orientation. Some say that an extra metre or two of exit sign visibility can sometimes make a large difference for these people - and the people they rescue.

Bryan reported that 53% of survivors from fires in institutions admitted to travelling through smoke. Similar findings were reported by P.G. Wood in the United Kingdom. Some people went only short distances through the smoke, but many of them advanced farther than they could see. Knowing that people do navigate through smoke, we have a responsibility to provide evacuation systems that are visible in smoke, wherever feasible. Exit signs are essential components of evacuation systems. Our research identifies simple ways for making exit signs more visible in smoke.

Oullette then discussed the luminance and colours of Exit signs before addressing placement:-

Some argue that signs should be placed low on walls because the smoke density is lowest at floor level during the early stages of fire. As a bonus, low signs might be less affected by overhead luminaries which tend to obscure the signs when smoke is present.

While there is merit to low signs, they are usually recommended as supplements rather than alternatives to conventionally placed overhead ones. Supplemental low signs are now required in some jurisdictions, such as California.

Fire and Smoke Modelling

As Fire Engineers, FSCS frequently prepares Alternative Solutions addressing extended egress travel distances within buildings. To justify the extended travel distances FSCS conducts fire and smoke modelling using the Zone Model BranzFire. It is a multi-compartment fire model accommodating multiple vents and burning objects. The model predicts various phenomena in the upper and lower layers including temperature, species concentrations, plume and vent flows, smoke (hot) layer interface height, fractional effective dose, visibility and sprinkler / smoke detector actuation.

Typically the model produces a timeline of layer (smoke and hot layer) heights in the various interconnected compartments. Figure 6 below shows the results from a factory and warehouse where the ceiling heights in the various compartments varied from 6.2 to 8.8m and there were extended travel distances. This model showed that the smoke layer had dropped to the minimum tenable height of 2.1m at 670 seconds in Room 4 and 735 seconds in Room 5.

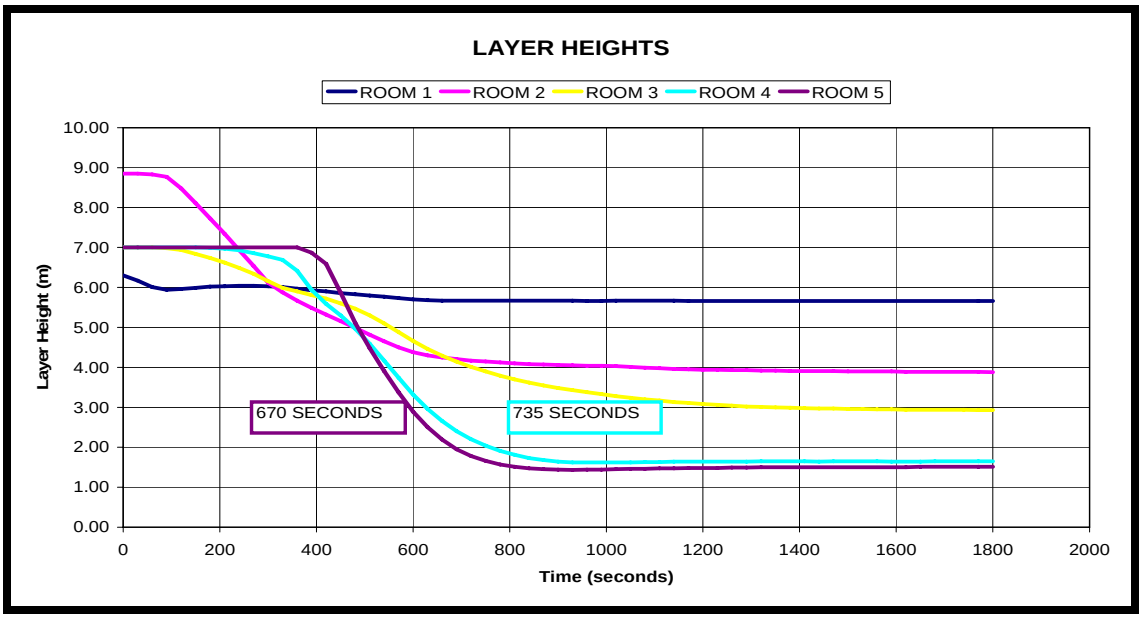

Figure 6 – Typical Computer Model results

Of more importance however, is the observation that at about 4 to 5 minutes, the smoke layer had dropped below the ceilings to such a degree that the ceiling mounted emergency lighting had become obscured – see also Figure 1 for a picture of this.

For an Alternative Solution to be acceptable, occupants should be able to complete safe evacuation prior to the development of untenable conditions from smoke, heat or toxicity. The key design aspect for occupant egress is to ensure that the time taken for occupant evacuation is less than the time taken for untenable conditions to occur. Definitions of tenability criteria include the requirement that if the smoke layer falls below 2.1m, the optical density of the smoke should not exceed $0.1m^{-1}$ (i.e., 10 m visibility).

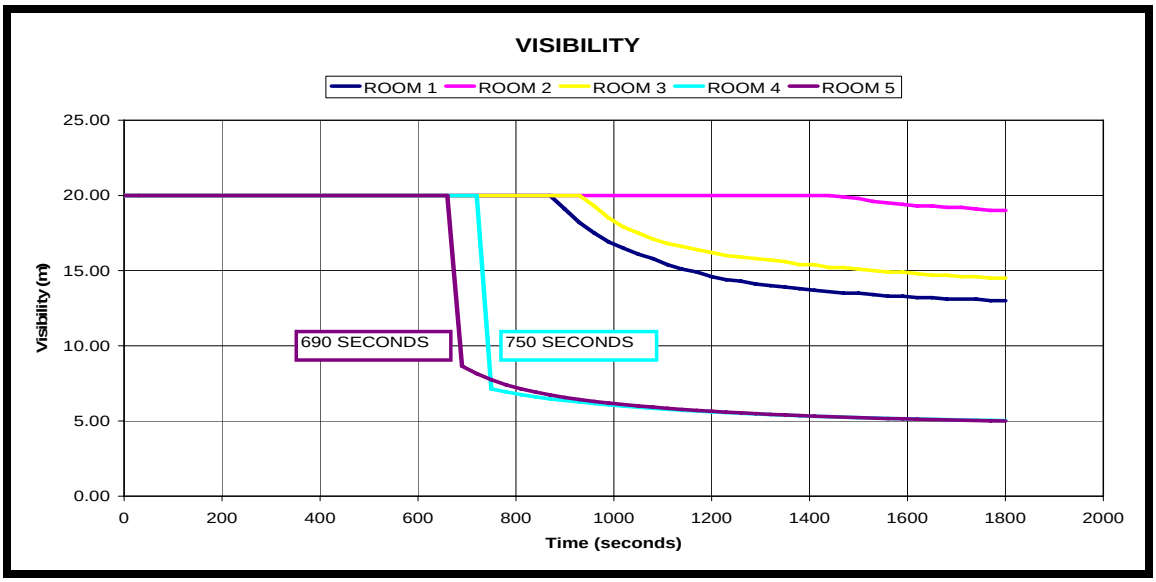

Figure 7 – Visibility

Figure 7 shows the visibility from the same model where the visibility has fallen below 10m in Rooms 4 and 5.

Clearly, and considering the requirement for occupants to be provided with an alarm, to respond to that alarm and to egress the building with an appropriate safety factor, the analysis failed to demonstrate compliance with the Performance Requirements of the BCA.

What is disturbing is that if this building did not have extended travel distances, the design would have been DtS (Deemed to Satisfy) – or in other words – deemed to be safe!

Whilst this example highlights the issues generally with DtS buildings, further analysis showed that the ceiling mounted emergency lighting would be ineffective and the Exit signs generally obscured.

Where to Now?

Whilst DtS buildings do not come under its remit, FSCS can only advise building designers and Certifiers of the note to AS2293.1, Section 5.2 **requiring the emergency lighting system designers to consider the effects of smoke**. To date FSCS has not seen this consideration given!

Fire and Security Consulting Services provides Performance Based Alternative Solutions under Sections A0.04 to A0.10 of the BCA. In particular Section A0.10 states:-

When an "Alternative Solution" is proposed, that the Fire Engineer is obliged to -

- *"Identify Performance Requirements from other sections and parts that are relevant to any aspects of the Alternative Solution proposed or that are affected by the application of the Deemed-to Satisfy Provisions that are the subject of the Alternative Solution."*

FSCS is required under this section of the BCA to assess the effects of smoke in buildings and particularly in paths of travel to an exit. This is performed in several ways as follows:-

1. In residential, aged care, hospitals and retail buildings, supplementary Exit signs may be useful at low level. Photo luminescent EXIT signage at low level is shown in Figure 8.

Figure 8 – Low level signage

This low level signage should be next to all exit doors and at appropriate locations as supplementary directional signs wherever there is a requirement for an AS2293.1 required directional sign. The specified photoluminescent signage complies with UL924 (Underwriters' Laboratories USA), recognised in Australia as an acceptable testing facility for fire products. Note that the International Fire Code recognises the use of photoluminescent exit signage. Clause 1003.2.10.4 of that code states *"Exit signs shall be internally or externally illuminated….Exceptions – Approved self luminous exit signs that provide evenly illuminated letters…"*

This photo luminescent signage is available in Australia from the following Companies:-

BRADY; SETON; LUNAGLOW; ECOGLOW and ENVIROFIRE

2. For large buildings such as factories and warehouses, egress travel paths are determined; Figure 9 below shows a project where the principal egress paths have been identified. In this instance Exit signs are provided at intermediate points and at the final exits. The principle adopted is "*Wherever you are, you can turn around and see an Exit sign. You follow that sign to where either an intermediate sign is provided or the final exit can be seen*". This path of

travel is also required to be provided with emergency lighting – see Section 3 below. Using the smoke layer heights from Figures 6 and 7, the heights of the emergency lights and Exit signs are determined.

Note that AS2293.1 Table 6.1 provides for varying pictorial element heights where viewing distances exceed 16m, 24m and 32m; this should be considered in the design.

Where the building fit out contemplates mid level obstructions such as retail displays, storage or machinery, the provision of dual Exit signs is often desirable, one at high level to be seen from a distance and another above the exit door for closer identification. Figure 10 shows typical dual Exit signs in a retail occupancy.

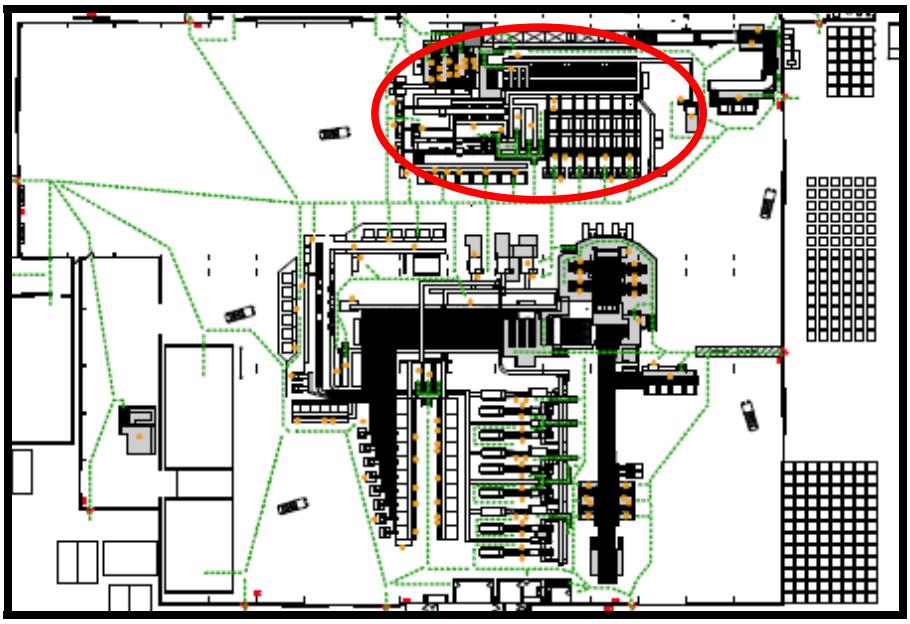

Figure 9 – Identification of Egress paths

Figure 10 – Dual Level Exit Signs

3. For all buildings, occupant egress is identified as the path to be followed to the final exit from the building. Figure 9 above shows the identified egress paths from various work stations in the building identified by green dotted lines.

   Accordingly emergency lighting should be provided to illuminate these paths of travel. The normal design would be to provide emergency lights at the ceiling spaced in accordance with AS2293.1. However as discussed, in a fire situation smoke will rapidly obscure the lighting output. Additionally the high level luminaries tend to be covered in dust and are difficult to clean and maintain.

   Installation of emergency lights (battens) in a vertical configuration at low level (mid point at about 2.0m above the floor) can provide a half or full circle of illumination above the egress paths. Figure 11 below shows the layout in the same building as Figure 9.

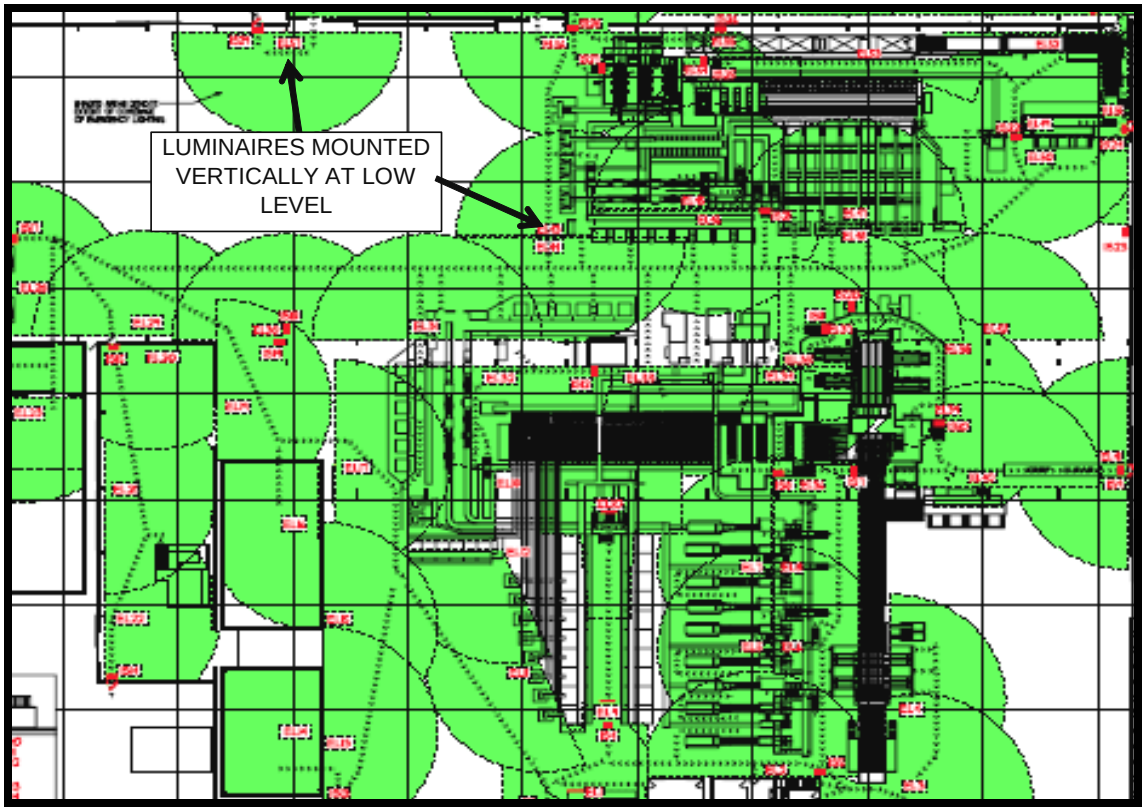

Figure 11 – Low Level Emergency Lighting

Alternatively the use of spot lights as shown in Figure 12 can be used.

Figure 12 – Emergency Spotlight

4. In some circumstances, occupants are at work stations accessed by stairs alongside assembly or packing lines or have to cross over process lines – the area within the red circle in Figure 9 shows such a circumstance. Accordingly additional Exit signage and local emergency lighting should be provided at these points. Figure 13 shows a typical conveyor cross over with these features.

Figure 13 – Local Exit signs and emergency lighting

2012 BCA Provisions

BCA Performance Requirement EP4.1 provides for emergency illumination "to the degree necessary" in buildings. The 2012 edition of the BCA now has a useful Verification Method EV4.1 which allows for the design of the system to provide ***"0.2 lux at floor level in the path of travel to an exit"*** and, ***"1 lux at each floor level or tread in fire isolated stairways, passageways and ramps."***

This is now consistent with notes and advice provided earlier in this paper.

I trust that this paper provides timely and sensible advice as to the required and "sensible" design for emergency lighting and Exit signs.

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Version 4 – July 2012