Discussion

Design and Cost Implications

for

The Provision of Occupant Warning

for

Hearing Disabilities.

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1.0 INTRODUCTION

This document seeks to consider the design changes necessary for additional facilities to provide occupant warning for the deaf and hearing impaired. It will look at the typical system designs used in residential applications, both within sole occupancy units as well as the common usage areas within the building. The design considerations will be based on the Deemed to Satisfy provisions contained in the Building Code of Australia Part E2 – Smoke Hazard Management. Particular regard will be given to obtaining an outcome that is no less in performance than that provided to a person of normal hearing.

2.0 MEASURES FOR THE HEARING IMPAIRED

There are three measures identified in research conducted by Bruck et al. These being the use of a visual warning device VAD, a pillow or bed shaker and the selection of a 520Hz square wave pulsing (on/off) warning tone.

2.1 Visual Alarm Device (VAD).

To ensure a consistency of technical requirements to which a product can be assessed and thereby certified, the VAD is considered as one that meets the requirements of ISO7240.23; this standard being based on the EN54.23 standard. A gap analysis conducted between the ISO and EN standards indicates that a VAD complying with the EN standard would also meet the technical requirements of the ISO variant.

Currently it is proposed to adopt ISO7240.23 as an Australian Standard via direct adoption, with the new AS/ISO standard to be referenced within the current revision of AS1670 - Fire detection, warning, control and intercom systems—System design, installation and commissioning Part 1 Fire. With the exception of some of the electrical testing unique to Australia, products currently meeting both the EN and ISO standards would meet the proposed AS/ISO 7240.23. This ensures the availability of suitable products.

2.2 Pillow shaker.

Bed shakers will not be considered as part of this review, the tactile response will be limited to pillow shakers only. To ensure a consistency of technical requirements to which a product can be assessed and thereby certified, the pillow shaker is considered as one that meets the requirements of AS1603.17; which reflects many of the technical requirements in BS 5446 Fire detection and fire alarm devices for dwellings — Part 3: Specification for smoke alarm kits for deaf and hard of hearing people.

In the research conducted by Bruck et al the Bellman Symfon pillow shaker was used. Bellman Symfon have confirmed that their pillow shaker has been assessed under BS5446.3 and complies. It is assumed this device is representative of the standard devices of this type currently available and in general use. It is noted in the Bruck report the pillow shaker produced an intensity at just below level 3, at this level some 84% of those with hearing impairment were aroused by the pillow shaker.

The current requirements of BS5446.3 are being review, in particular the assessment of the pillow shaker. From discussions with European colleagues it is believed this is more to do with the appropriateness and reproducibility of the test method than the effectiveness of the vibration unit. The findings of the Bruck et al research are being fed back to the Bsi technical committee. A number of pillow shaker products are available.

2.3 The pulsed 520Hz square wave.

The low frequency alarm signal has been shown to be 6 to 10 times more effective at waking children, young and adults with upper frequency hearing loss than the standard 3 to 5 KHz audible fire alarm signal from a standard smoke alarm (Bruck et al). The implementation of this warning signal is dependent upon detection system selection.

Systems employing smoke alarms, complying with Specification E2.2a clause 3, utilising the inbuilt piezo sounder as the occupant warning are unlikely to provide the 520Hz square wave signal. Discussions with Dr Michael Byrne, Technical Director Ei Electronics, a major smoke alarm design and manufacturing company based in Ireland indicates that smoke alarm manufacturers are currently working toward providing a supplementary sounder producing the 520Hz square wave alarm signal. These remote sounders will be interconnectable to the standard smoke alarm. Cost of implementation therefore will relate to the number of sounders required for the system design.

A smoke detection system utilising smoke detectors, complying with Specification E2.2a clause 4, can provide the 520Hz signal. Systems utilising 24Vdc electronic sounders to provide occupant warning under AS1670.1 Clause 3.22(b), can simple source those that produce the low frequency output. There are products currently available that will connect directly to the existing 24Vdc alarm bus. Systems utilising a tone generator, amplifier and speakers to meet the same requirements, will require a simple reprogramming of the tone generator to provide the required 520Hz signal and tonal pattern. Therefore the implementation of this additional measure is not about additional costs but about choosing the correct device from a supplier's product range.

The current draft of the proposed AS4428.16 Fire detection and alarm systems — Part 16: Emergency warning control and indicating equipment, mandates that the control panel must as a minimum produce the 520Hz square wave signal. This facility therefore would be a standard feature in future emergency warning systems of this type

It is noted that the 520Hz signal may be of little use to those with severe hearing disability and certainly the deaf.

3.0 SYSTEM OPTIONS

3.1 Building Code Requirements

Building Code of Australia Specification E2.2a Clause 2 permits as a deemed to satisfy option three categories of smoke detection and alarm system;

1. A smoke alarm system:

2. A smoke detection system:

3. A combination of both smoke detection system and smoke alarm system.

The choice of system is dependent on the size, class and specific needs of the building. There are performance and cost implications dependent upon the system option chosen.

A smoke alarm system is one that utilises smoke alarm(s) complying with AS3786. Each smoke alarm has an integral sounder which when activated provides the necessary occupant warning. Smoke alarms can be either standalone or interconnected to provide simultaneous activation of all sounders.

A smoke detection system comprises Control and Indicating Equipment (CIE) and suitable smoke detectors complying with the relevant product standard. These are referenced in the AS7240 suit of standards. The detection circuits are wired around the building from the CIE to suit the building design.

Wired separately from the CIE is the building occupant warning system (BOWS) which is activated when the CIE detects a fire condition. To provide system integrity detection and BOWS circuitry is supervised to ensure that any fault within the system will be identified at the CIE.

A combination smoke detection system usually occurs where smoke alarms are installed within the SOU and a smoke detection system throughout the remainder of the building.

In this discussion paper we will address both smoke alarm systems and smoke detection systems. Also it is assumed the inclusion of facilities and products for the disabled will produce the same technical outcomes as those provided to a normal hearing person. To do less may in itself be considered a form of discrimination.

3.2 Smoke Alarm System

Smoke alarm systems can vary in design, from individual standalone smoke alarms, to multiple smoke alarms interconnected providing a common alarm throughout the dwelling or building. The power source for the smoke alarm system may be internal within each smoke alarm, from an external power source or a combination of the two.

The standard smoke alarm utilises the interconnect facility of each device to enable alarm signals to be communicated between devices. The smoke alarm entering the alarm state applies a small dc voltage to the interconnect line. This voltage then initiates the piezo sounder contained in all other non-alarm state smoke alarms. It is this interconnection that would be used to initiate the required VAD and/or pillow shaker when any smoke alarm senses smoke.

However the interconnect facility on standard smoke alarms is not a supervised connection. Resultantly where the occupant warning is supplementary to the smoke alarm, if the interconnection between smoke alarms is broken there is no external warning provided to advise the occupants. Under these circumstances the smoke alarm will detect smoke, will sound but the VAD /pillow shaker may not operate. Such a fault condition would only be identified when the system was actually tested into full alarm as part of a test and maintenance regime.

The risk to the occupant from this non supervised condition is less for the normal hearing occupant as the piezo sounder is integral to the device and acts as the occupant warning. If interconnection is not present the occupant warning will be provided, as a worst case, at each smoke alarm location as the smoke plume migrates to it. Occupant warning is provided in the area of fire origin and all areas to which smoke has migrated.

With respect to the mains powered VADs capable of interconnection to the required mains powered smoke alarm, the VAD would require both a standby supply as per AS3786 and meet ISO7240.23. No such VAD has been identified. Even if such a product did exist there would again be no supervision of the interconnection.

There are currently two options that address the supervision issue.

3.2.1 Deaf Alarm

The “deaf alarm” system is typically designed to meet the requirements of AS1603.17. This type of system provides a small control panel which acts as the controller and power source for the system. The smoke alarm(s), VAD and pillow shaker connected to the controller. These systems are currently being supplied as part of the NSW Smoke Alarm Subsidy Scheme, a joint initiative between the Deaf Society of NSW and Fire and Rescue NSW, made possible with funding from the NSW Department of Family and Community Services; Ageing, Disability and Home Care.

This type of system is limited in capacity, due to power supply limitations and is a one SOU/one bedroom system. The controller is placed beside the bed, the pillow shaker (2) placed under the pillow, the VAD and smoke alarm(s) wired back to the controller. The controller supervises the connections. Should there be a fault with the wiring connections the fault condition is indicated at the controller. Both the Deaf alarm controller and associated smoke alarm will be required to meet the AS3786 requirements.

3.2.2 External Power Supply (AS3786).

Smoke alarm systems are permitted, under the AS3768 standard, to use an external power supply. This external power supply provides both the primary and secondary power requirements for the number of smoke alarms connected. The external power supply is typically connected to consumer mains as its primary power source and has an internal rechargeable battery(s) as the standby supply.

The smoke alarm(s) are wired to the power supply which provides both the power and interconnection facility. Under these circumstances the power supply supervises the wiring and provides a fault signal at the power supply should a fault condition occur? The external power supply may also provide other control functionality in addition to the basic supervision required.

This specific format is covered in the proposed revision of AS3786. In terms of the BCA performance requirements, the smoke alarm system is connected to consumer mains (typically hardwired) and the individual smoke alarms are certified to AS3786. This format is therefore considered to be compliant as a “deemed to satisfy” building solution for a required smoke alarm system. Equally it would also be compliant with AS1603.17.

The ability to size the external power supply allows for greater systems capacity than the deaf alarm, this allows for a system of multiple smoke alarms, VADs and pillow shakers. The VAD and pillow shaker would be connected to the power supply and be supervised in the same manner as the smoke alarms. This type of system could be designed to cover the VADs in the communal areas as well as the VAD and pillow shaker within the SOU(s).

3.3 Smoke Detection System

The design and functionality of these systems has two formats, addressable and collective (conventional). The implementation of the disability measures may vary between system types dependent on building design. In both cases the CIE provides the required power and component supervision. All buildings are divided into detection zones, each covering a defined search area. AS1670.1 prescribes the zonal requirements of the system.

A collective system is one where individual detection circuits are hard wired from the CIE to the area within the building intended to be covered. In an alarm condition the CIE will only identify the specific zone in alarm (the area), not the specific detector or room. These systems are typically used for smaller buildings due to the cost, both cable and labour, in running separate wiring around the building. With these systems the circuitry to the VADs and pillow shakers will be a common 24Vdc alarm bus. This makes it difficult to provide independent control of the alarm devices in the SOUs; it is possible but again requires significant cabling. The additional VADs and pillow shakers will be connected to this alarm bus. This circuitry provides all of the necessary power, supervision and control functionality for both the VADs and pillow shakers.

An addressable system is one where a loop cable is installed throughout the building. Detectors are added to the loop in the required locations and the zones (areas) are defined in software. This type of system is therefore more cost effective in larger application. The cable run and labour cost are both reduced. The loop cable also provides the power, supervision and control for the devices connected to it. A limitation is however the loop has limited power capability. It does allow addressable VAD or pillow shakers to be connected directly to the loop, but only in small numbers. With an addressable/analogue system each device is identified at the panel. Where VADs or pillow shaker are connected to the loop they can be individually control via programming.

This provides greater flexibility in system functionality and may provide for separate control of disability devices within individual SOUs separate from the common accessible areas.

Where the power requirements cannot be supplied by the loop a separate 24Vdc alarm bus is required, most likely only where the additional disability devices are required. Input/output modules on the loop can be programmed to control the VADs and pillow shakers. All CIE can provide the 24Vdc output but there are potentially additional costs associated with the alarm bus cabling.

VADs are typically used in these systems where the ambient background noise level is high and the audible warning would not be heard. The addition of VADs for the hearing disabled would simply be an extension of current practice

The additional load of the VADs and pillow shakers will be part of the CIE power supply calculations which may require upgrading. However unless there are significant loads this, in most cases, would be covered by standard power supply capacities.

4.0 VISUAL ALARM DEVICE (VAD)

ISO7240.23 sets out the test requirement for VADs as producing 0.4 Lux in the coverage volume. VADs can be wall or ceiling mounted.

Fulleon is a specialist manufacturer of audio/visual alarm devices and their EN54.23 products will be used as a guide for typical volume coverage. Two products will be used to provide typical volume applications;

> Solista LX Ceiling: Rated as C-3-7.5. The shape of the coverage is conical downward from the ceiling. If converted this provides a cubical coverage of 5.3m.
>
> Squashni G4 LX Ceiling: Rated as C-3-15.

The shape of the coverage is conical downward from the ceiling. However with the height fixed effective coverage can be converted to a cubical volume, this provides the maximum length and width to be applied to a single VAD. This being 5.3m and 10m for the Solista LX and Squashni G4 LX respectively.

These ratings can now be applied to the floor layout of the building. Assuming a ceiling mounting height is between 2.1m and 3.0m, the maximum length and width can be used to determine the number of VADs required to maintain 0.4Lux.

A room of 2.4m x 5.3m x 5.3m will require only one Solista LX VAD. A 2.4 x 1.5 x 15m hallway would require two Squashni G4 LX or 3 Solista LX. These areas presume no interposing structure blocking the coverage. Where hallways tee off a VAD may be required in each direction. In addition, dependant on the type and number of VADs the 24Vdc alarm bus may require upgrading due to the alarm load of the VADs and pillow shakers.

Whether a smoke alarm system (deaf alarm and external power supply options) or smoke detection system, equipment used within the SOU will require compliance with AS1603.17. With the revision of AS1670.1 and subsequent publishing of AS/ISO 7240.23 it is intended all VADs whether within the SOU or located in the common areas will require compliance with BS5446.3 (AS/ISO7240.23 when published). This part 23 standard provides a consistent technical requirement for 0.4Lux within the coverage volume therefore providing a consistent technical datum for compliance assessment during commissioning of a system.

5.0 COSTING

In determining the additional cost of introducing measure for the deaf the building class and locations requiring either a VAD or pillow shaker were referenced to BCA Part D3 Table D3.1 Requirements for access for people with disability,

5.1 Assumptions:

- The installation will be for new construction with the additional components required for the hearing impaired to be installed simultaneously with the required system components.
- Cost variance between smoke alarms required is based upon the standard smoke alarm being a 230Vac model with replaceable battery and includes a 15% mark up by the contractor.
- Labour Rate will be at the upper end of rates ($55 - $80) and will be $80.00 per hour.
- Labour for preparation and fit out system components, including VADs, is 0.75 hours per unit.
- For additional components, such as the VAD, 10m of additional cable has been added.
- Cable rate will be $1.50 per metre, which includes an allowance for fittings.
- Due to the current load of the additional components either local power will be supplied, typically within the SOU, or a separate 24Vdc alarm bus will be provided to the required areas.

- Labour for running additional cable for the 24Vdc alarm bus – 0.5 hours per 20m.
- The VAD is at an average price of $130.00 per unit.
- The cost variance for smoke alarms fitted to a Deaf Alarm System is $25.00 per unit
- The cost variance for smoke alarms fitted to an External power supply is $45.00 per unit
- The costs can be expressed in unit rates for both individual components and small systems. These costs are reflected in Table 1.

Table 1: System components and unit rates

Smoke Alarm System Options

Deaf Alarm System

Component	Unit Cost	Installation	Unite Rate	Required	Total
Deaf alarm controller	$310.00	$60.00	$370.00	1	$370.00
Photoelectric Smoke Alarm (upgrade)	$15.00	$0.00	$15.00	1	$15.00
VAD (compatible with controller)	$90.00	$75.00	$165.00	1	$165.00
Pillow shaker	$60.00	$0.00	$60.00	1	$0.00
				Total	$550.00

Note 1: First pillow shaker comes with the controller kit
Note 2: One additional pillow shaker and one additional VAD can be connected to the controller at additional cost (Max distance 10m)

External Power Supply System

Component	Unit Cost	Installation	Unite Rate	Required	Total
Deaf alarm controller	$480.00	$75.00	$555.00	1	$555.00
Photoelectric Smoke Alarm (upgrade)	$45.00	$0.00	$45.00	1	$45.00
VAD (compatible with controller)	$130.00	$75.00	$205.00	1	$205.00
Pillow shaker	$120.00	$75.00	$195.00	1	$0.00
				Total	$805.00

Note 1: Multiple VADs and pillow shakers can be added.

Smoke Detection System Options

Component	Unit Cost	Installation	Unite Rate
24Vdc VAD	$130.00	$75.00	$205.00
24Vdc Pillow shaker	$90.00	$75.00	$165.00

5.2 Class 1b (a)

It is assumed the dwelling layout consists of main open area and separate bedroom(s) and bathroom; similar to the "cabin" accommodation found in caravan and tourist parks. As such the system will vary dependent upon the number of bedrooms.

For the single bedroom style either the deaf alarm system or external power supply system in their basic format is applicable, $550.00 or $805.00 respectively.

Where multiple bedrooms are required the external power supply system provides for the additional VADs and pillow shakers at the rates shown in table 1. For a three bedroom, bathroom and open area, assuming the bedrooms open directly to the common area, an additional 2 pillow shakers would be required (see table 2).

Table 2: Three bedroom Class 1b

External Power Supply System

Component	**Unit Cost**	**Installation**	**Unite Rate**	**Required**	**Total**
Power supply/controller	$480.00	$75.00	$555.00	1	$555.00
Photoelectric Smoke Alarm (upgrade)	$45.00	$0.00	$45.00	1	$45.00
VAD	$130.00	$75.00	$205.00	1	$205.00
Pillow shaker	$120.00	$75.00	$195.00	3	$585.00
				Total	$1390.00

5.3 Class 1b (b)

This building is assumed to be typical of a converted large dwelling consisting of multiple bedrooms, communal bathroom facilities, lounge, dining, kitchen and games area. Given the load requirements an external power supply system would be required. To apply the disability additions and maintain the interconnectability of the system all smoke alarms used in the building will need to be upgraded to ensure compatible with and connection to the external power supply.

As a Class 1b requires the interconnection of all smoke alarms, the unit rate taken from the system cost to allow for the costs that would have already been required by the installation of a non-disabilities system per smoke alarm is increased from $120.00 to $135.00.

Assuming the maximum number of residents – 12 the required system components and cost are as per Tables 3 & 4.

Table 3: Class 1b (b) systems components

Location	**Smoke alarm**	**VAD**	**Pillow shaker**
Standard Bedrooms	11	0	0
Disability Bedroom	1	1	1
Hallway 1	1	1	0
Hallway 2	1	1	0
Communal bathroom	0	1	0
Lounge Room	1	1	0
Dining Room	1	1	0
Games room	1	1	0
Kitchen	0	1	0
	17	8	1

Table 4: Class 1b (b) system cost.

External Power Supply System

Component	Unit Cost	Installation	Unite Rate	Required	Total
Power supply/controller	$480.00	$75.00	$555.00	1	$555.00
Photoelectric Smoke Alarm (upgrade)	$45.00	$0.00	$45.00	17	$765.00
VAD	$130.00	$75.00	$205.00	2	$410.00
Pillow shaker	$120.00	$75.00	$195.00	1	$195.00
				Total	$1925.00

5.4 Class 2 – Common Areas

The requirement will be dependent on the type of system installed, this can be either a smoke alarm system or smoke detection system.

If a smoke alarm system is installed within the SOU the requirement would be as per clause 5.2. Within the common areas, the external power supply system would be required.

If a smoke detection system is installed the additional VADs and pillow shakers can be connected directly to the 24Vdc alarm bus of the detection system. Where the system is addressable the VADs may be connected to the addressable loop and be powered by the loop. In this case there is no need for a separate 24Vdc alarm bus.

The costs would be dependent upon the specific design requirements using the unit rates of Table 1. For example: A 15m corridor will require 2 x Squashni G4 TX ceiling mounted VADs at $205.00 each.

The number of VADs required will depend on the rating of the model chosen. This would be selected giving regard to the volumetric coverage required for the corridor or room. The cost of running a separate alarm bus cable is 0.5 hours ($40.00) per 20m.

5.5 Class 3

A class 3 building not subject to BCA Specification E2.2a Clause 2(a) (ii) may install a smoke alarm system. Where the class 3 building is subject to Specification E2.2a Clause 2(a) (ii) a smoke detection system must be installed. The provisions of 5.4 apply. The rates within table 1 apply.

Where the SOU is connected to a smoke detection system, the VAD and pillow shaker can be connected to the 24V alarm bus. The required VADs and pillow shakers will be dependent upon layout and number of bedrooms.

For example an SOU with a common open area and two bedrooms requires a single VAD, two pillow shakers and 30m of additional alarm bus circuitry. If the SOU is served by a 15m corridor, two VADs will be required, see table 5.

Table 5: Class 3

Accessible area	Required	Unit cost	Cost
Common area within SOU	1	$205.00	$205.00
Bedrooms	2	$165.00	$330.00
Alarm Bus labour	30	$2.00	$60.00
Corridor	2	$165.00	$330.00
		Total	$925.00

5.6 Classes 5 to 9

For these classes of building connection to a smoke detection system would be required. The cost therefore is directly related to the number of VADs required and the alarm bus. This being dependent upon the required number of rooms and their size, corridors and their length. The additional costs can be assessed using the unit rates within Table 5.

6.0 CONCLUSION

There are both techniques and products, which when correctly added to the required automatic smoke detection and alarm system, will provide effective warning for those with hearing loss of the presence of a developing fire within a building or dwelling.

In looking at these measures technical standards have been specifically referenced. This is to ensure that a consistent technical assessment is provided across all products of each type thereby providing a means of product certification and a confidence that across all manufacturers a minimum product performance will be provided. This also provides for a consistent design approach for deemed to satisfy solutions and provides a datum for system commissioning and continued maintenance.

Whilst unit costing has been assessed based upon generalised assumptions the adequacy of these and the final cost per building will be dependent on the building layout itself.