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The Research Director
Legal Affairs and Community Safety Committee
Parliament House,
Brisbane QLD 4000.
Emailed to: lacsc@parliament.qld.gov.au

Fire and Emergency Services (Smoke Alarms) Amendment Bill 2015.

Dear Sir/Madam,

Thank you for the opportunity for Fire & Safety Technologies Pty. Ltd. to submit comment to the committee on the proposed Smoke Alarm Amendment Bill.

My name is David Isaac; I am a 44 year industry veteran. I am the owner of Fire and Safety Technologies Pty Ltd. a fire protection consulting company that provides advice to corporations on the application of appropriate fire detection, warning systems and smoke control technologies. I am a member of the Australian Standards Committee FP-002 'Fire Detection, Warning, Control & Intercom Systems', which writes the suite of Australian Standards on fire detection and alarm systems which includes Smoke Alarms.

My credentials are listed at the end of this submission.

This is my preliminary submission. I would like to offer further data and information as debate progresses.

I also offer to appear personally before the committee to present, and answer questions arising from this Bill at the proposed public hearing on Wednesday the 24th February, 2016 in Brisbane.

I am writing to you out of my industry involvement and concern for public safety around the issue of smoke alarm applications. I or my company do not sell smoke alarms or contract to any company that sells smoke alarms. I have no commercial interests that are affected in any way by the proposed Bill.

The intention in this submission is to move away from academic theory and repetitive analysis to present the challenge issues before the Government. Hopefully this submission will be in simple language that describes the real issues in the homes of Australians today that an educated, knowledgeable and experienced Fire Practitioner faces.

Summary:

This submission reinforces the following:

1. The greatest risk of fire to occupants is when they are sleeping which is statistically between the hours of 8-00pm and 8-00am. Occupants who are awake and intimate with a fire (have caused the fire by their actions) do not need a smoke alarm to tell them there is a fire.

2. It is imperative to have multiple smoke alarms in residences. Single smoke alarms that are not primarily located in the typical room of fire origin typically respond too slowly to fires remote from the smoke alarm and often fail to wake sleeping occupants in a timely manner to allow them to escape before the fire becomes unsurvivable.

3. Smoke alarms must be of the photoelectric or combination photoelectric / heat type in order to respond to the early stages of a typical night time fire that statistically has a significant smouldering stage. Ionisation type alarms are NOT fit for purpose because they do not activate to smoke from a smouldering fire in a timely manner.

4. We know from research conducted by the Victorian University of technology that the waking effectiveness of smoke alarms is significantly reduced when smoke alarms are not installed in bedrooms and not interconnected so that all alarm sounders activate. We acknowledge that the cost of multiple smoke alarms is significant to the community and if this is ultimately a limiting factor, legislation MUST require a smoke alarm in the primary carers bedroom (typically the master bedroom) as well as in corridors connecting sleeping areas to exits and in living rooms, with at least one smoke alarm in every storey including a basement.

5. In order to reduce cost to the consumer, the option of <u>10 year Lithium battery powered</u> smoke alarms MUST be permitted in the legislation as an alternative to mains powered hard wired alarms. Many of the 10 year Lithium battery powered type of smoke alarms have a wireless interconnectivity facility which significantly reduces installation costs.

6. Rental residential properties must have either hardwired or 10 year Lithium powered smoke alarms as these premises are used to derive profit for the owners. If cost is an issue for legislators, privately owned and occupied existing built premises, could be permitted to install 9V battery powered photoelectric smoke alarms. However, the number and location of smoke alarms should be consistent for all residences whether existing, owned, rental or new construction.

7. The timing for the legislation effective date should be based on effective affordability with priority to immediate effect on new residential construction, a limited introductory window for rental premises and perhaps a more flexible introductory window for owner occupied existing residential construction.

Submission Objective:

In essence the thrust of our submission is to implore the Government to act to ensure that Legislation is adopted to require multiple interconnected smoke alarms in every habitable room and room connecting sleeping areas to living areas on every storey in all homes. Most importantly the smoke alarm type MUST be legislated as photoelectric or photoelectric / heat combination alarms.

It defies all common sense in fire engineering terms that we require smoke detection in all habitable rooms and paths of travel to exits in commercial buildings where statistically the death rate from structural fires is very low; yet in the residential structures where statistically the death rate from structural fires is high, we only legislate to require as little as one or two smoke alarms for the whole residence.

The Research Committee may not be aware that after substantial research and international enquiry, in August 2008 the Australian Standards Committee FP-002 published a draft revision of Australia's smoke alarm Standard AS 3786 for public comment. In essence the new draft standard required all smoke alarms, regardless of their technology, to pass a visible smoke test. As profoundly obvious as one would think; what is staggering is that the ionisation alarm that is installed in almost all Australian homes was NOT required to pass a visible smoke test in the then current Australian Standard testing conducted by the CSIRO.

Committee FP-002s multiple attempts to have the Australian Buildings Code Board (The ABCB) adopt the revised Standard were met with rejections. It therefore behoves the Queensland Government to act in the interests of public safety.

A response to Fire industry rhetoric on the effectiveness of Smoke Alarms

For more than 40 years the Fire Protection industry has held to statements regarding residential smoke alarms and their effectiveness.

In this section I will show in ***bold black text*** the typical industry statements and comment on each from a technical and life safety perspective. My response comments are in blue text.

Industry statement 1:
There are two types of smoke alarm: photoelectric and ionisation. Both types comply with Australian Standard AS 3786. Either type will provide sufficient time to escape from fire.
There are two principle types of smoke alarm technology, ionisation and photoelectric. Ionisation smoke alarms predominantly detect the presence of extremely small sub-micron sized particles of combustion (invisible to the human eye) whilst photoelectric smoke alarms predominantly detect visible smoke.

Both types are tested to separate and distinct pass criteria in the Australian Standard. The public and most of the fire industry are not aware that in Australian Standard 2362.17 – 'Smoke sensitivity testing' (a required test for approval to AS 3786), the typical photoelectric smoke alarm activates at around 8% to 12% light obscuration per lineal metre. These tests have been conducted by the CSIRO and formerly Scientific Services Laboratories (SSL) since 1993. What is not readily known is that under the same AS 2362.17 smoke sensitivity test, ionisation alarms are not required to meet light obscuration (visible smoke) pass criteria; they are measured on sub-micron particle density pass criteria. This is designated at a maximum of 0.6 MIC (Measuring Ionisation Chamber) level. When typical ionisation alarms are tested at the CSIRO and activate within the approved MIC-X range, the actual light obscuration level measured and recorded in the test room at the time of alarm activation is typically in the range of 48% to 62% light obscuration per metre (up to 5 times the maximum safe level allowed for photoelectric smoke alarms under the light obscuration pass criteria). This very high level is recorded on the test certificate of every manufacturer's ionisation smoke alarms. To put those obscurations levels in perspective, the average person would have difficulty in seeing and breathing in a room at 12% obscuration per metre and would be running for the exit. It can be reasonably argued that smoke alarms that do not activate till up to four times the safe smoke obscuration level set for photoelectric type smoke alarms are NOT fit for purpose.

To those who understand the residential application of smoke alarms and the significance of this high obscuration level for ionisation alarms, it should be of major concern.

We simply must not promote ionisation alarms as fit for purpose; we must promote the use of photoelectric smoke alarms and warn the consumers of the known limitations of ionisation alarms. There is a profound legal argument the industry has a 'duty of care' to do so, especially since any court may regard the industry as experts and that if the industry didn't know the industry ought to have known.

Unfortunately manufacturing company's marketing and sales divisions typically don't know or understand the safety implications of this and simply sell ionisation alarms on the claimed basis *"it complies with the Standard"*. Given what 'we know or ought to know' we must promote the use of photoelectric smoke alarms and to do so we should more importantly warn the consumer of the known limitations of ionisation alarms.

<u>Industry Statement 2:</u>
There are two types of fires, smouldering fires and flaming fires. Photoelectric smoke alarms are more effective at detecting smouldering fires and Ionisation smoke alarms are more effective at detecting flaming fires.

This statement completely lacks integrity and is misleading; it is what has been said for more than 30 years. With what we know today we should no longer perpetuate this misinformation.

There are not two types of fires, all smouldering fires will become flaming fires if allowed to develop and all fires have a smouldering phase, in some cases the smouldering phase may as little as a second or as long as several hours.

We now know from readily available industry and CSIRO test data that a more accurate credible statement would be:

Photoelectric smoke alarms are very effective at detecting fires when they are at the early smouldering phase, this can provide warning many minutes to several hours in advance of the fire reaching the flaming stage.
For both flaming fires and smouldering fires, photo-electric smoke alarms are likely to alert occupants in time to escape safely.

Photoelectric smoke alarms are less likely to be disconnected by the consumer as they have a low nuisance alarm rate compared to ionisation alarms.

Photoelectric smoke alarms are effective at detecting fires when they are some distance from the fire provided there is no physical barrier to prevent smoke reaching them.

Ionisation alarms detect flaming fires marginally earlier than photoelectric smoke alarms, but only when the ionisation alarm is located in the room of fire origin or close to the flaming fire. The more remote an ionisation alarm is from the fire source the less likely it is to activate.

Ionisation smoke alarms do not detect fires at the early smouldering phase.

Ionisation smoke alarms are highly likely to be disconnected by occupants due to their propensity to nuisance activations.

Ionisation alarms may not operate in time to alert occupants early enough to escape from fires that start from a smouldering phase."

<u>Industry statement 3:</u>
A more serious issue than the type of alarm is whether it is in working order. With 9v replaceable battery alarms, the battery is frequently flat or has been removed due to false alarms.

The Canadian Kemano study showed that the high disconnection rate of ionisation alarms is due to their propensity to nuisance alarms. Photoelectric smoke alarms in the same study were not disconnected by the consumer.

Australian data indicates that as many as 30% of ionisation smoke alarms are disconnected within two years of the original installation. From practical experience we know that number is closer to 50% in lower socio economic rental properties. When disconnection occurs, the consumer has elected to have no smoke alarm whatsoever.

Given statistically we know the nuisance alarm rate is the sole cause of disconnection, why have we not legislated for the photoelectric technology that is statistically NOT disconnected by the consumer?

<u>Industry Statement 4:</u>
The move to hard-wired smoke alarms may be more critical in saving lives than the move from ionisation to photoelectric.

This last sentence is completely inaccurate; hardwiring ionisation alarms does not solve the problem, moving to photoelectric smoke alarms or photoelectric / heat combination alarms significantly lessens the chances of disconnection and more importantly significantly improves the range of detection capability and therefore gives the occupants significantly more time to escape in the type of fire that is statistically likely to kill; fires that occur at night while occupants sleep.

We should ask ourselves why is it in hotels, accommodation buildings, and shopping centres the Australian Standard 1670.1, which is called up by the BCA, requires photoelectric smoke detectors and alarms to be installed in sleeping areas and paths of travel to exits. The BCA also specifies that photoelectric detection must be installed in patient care areas in hospitals and buildings with atria. Yet we continue to sell ionisation alarms into private homes where the death rate in Australasia as in the rest of the world is at an unacceptable level. We continually fail to warn the public of the 'known limitations of ionisation alarms'. Why do we require a higher quality of detection in hotels and hospitals than our homes?

Industry Statement 5:
There is clearly still a market for battery operated ionisation alarms because they are cheaper and require no skill for installation.

Is the smoke alarm manufacturing industry prepared to accept 'duty of care' issues here and still sell ionisation smoke alarms purely on the basis of revenue and margin when we know ionisation alarms may not warn occupants in time to escape from a fire that develops from a smouldering phase while they sleep? If the industry fails to adequately warn the public, is the industry not culpably liable? There have been a number of USA law examples of recent years where courts of appeal have upheld that the manufacturer was liable because they failed their duty of care to warn the consumer their ionisation alarms may fail to warn in time for them to escape. In a recent New York case, Hackert versus BRK, the court of appeal upheld that the "ionisation smoke alarm was the legal cause of death". The industry is travelling down a slippery slope if they blindly continue to promote ionisation alarms without warning consumers that ionisation alarms may not provide adequate warning to escape fires in their own homes.

Industry statement 6:
On the basis that any alarm is better than no alarm, and the battery operated ionisation alarms comply with the Australian Standard, we should ensure that we are educating the consumer about the relative benefits of photoelectric smoke alarms and warning them of the limitations of ionisation alarms

This notion is admirable but we should ask ourselves why this should even be necessary. If we don't require warnings on ionization alarm packaging, how can the public be expected to know the difference in performance.

If a device carries an Australian Standard mark, the public have a right to expect the product is fit for purpose. The public do not need to understand the difference if legislation specified the safest type to protect the lives of the consumers.

Industry Statement 7:
The average consumer does not understand the difference and therefore buys the cheapest alarm which is typically the ionisation type.

This is absolutely correct, which is why the legislative position should be to legislate for the safer alternative and the public education of types is not required.

Industry statement 8:
The USA National Institute of Standards and Testing (NIST) estimates that the safe exit time in a fire today is 3 minutes, compared with 17 minutes in their previous research, AFAC have similar data. Australian Fire Brigades acknowledge there is typically less than three minutes to untenability once a fire reaches the flaming stage in a typical residence.

Do we fully understand this; a fire that smoulders and develops for a significant period undetected will travel at approximately 8 metres per second through the home when the fire reaches 'flashover'.

At this point if the home is still occupied, the fire is likely unsurvivable. Even if the fire does not reach 'flashover' it is particularly dangerous when the occupants are asleep. The 3 minutes to untenability (which means unsurvivability) is all the occupants have once the fire reaches the flaming stage.

An ionisation alarm will typically only detect the fire at the flaming stage, and that is only if the ionisation alarm is in the location of fire origin. To have the full 3 minutes the smoke alarm must activate and wake the occupant immediately at the flaming stage. Under these circumstances the ionisation alarm will only activate if it is close to the fire and then it must wake the occupant immediately. If bedroom doors are closed or the alarms are not interconnected, the probability of waking is reduced. If the fire has had a long smouldering phase (which is typical of night time fires), the occupants may not waken quickly due to toxic gas and smoke build up. In these circumstances if the occupant does wake immediately they may not have sufficient time to arouse the household so they can all escape.

This is the critical issue and why photoelectric technology can give far superior early detection and warning. In some circumstances 20 minutes to several hours early warning of a fire that starts with a smouldering phase. These smouldering fires are the typical fires that start while occupants are sleeping between the hours of 8-00 pm and 8-00 am and the fires that statistically kill.

Industry Statement 9:
It is important to have a sufficient numbers of smoke alarms and in the appropriate location.

This is why we promote photoelectric smoke alarms in every bedroom, living room and hallways (paths of escape from bedrooms) and all interconnected. The current building regulations only require one smoke alarm of any type on each level of a home and until recently did not require interconnection.

I have copied the Australasian Fire and Emergency Services Authorities Council Smoke Alarm position statement below in full. This position statement was originally published in June 2006, about the same time that Standards committee FP-002 moved to amend AS 3786. I have highlighted the notable sections.

Australasian Fire and Emergency Services Authorities Council
Position on Smoke Alarms in Residential Accommodation

Preamble
The Australasian Fire Authorities Council (AFAC) believes that smoke alarms save lives and that the correct type and number should be installed in all residential accommodation.

This paper expresses AFAC's position on a number of issues related to domestic smoke alarms installed in residential accommodation. Residential accommodation includes buildings defined by the Building Code of Australia as Class 1 buildings and sole occupancy units in class 2, 3 & 4 buildings.

This position is based on emerging knowledge about smoke alarm performance. This position may change following further research into the performance of smoke alarms in the Australasian environment.

AFAC encourages further research into the performance of smoke detection devices in the Australasian residential environment and supports the need for ongoing review, development and testing through the Australian Standards review process.

For the purposes of this paper:

- A smoke alarm is a device that contains a means of detecting smoke or products of combustion and for sounding an alarm; and
- A domestic smoke alarm is one manufactured principally for use in the home.

Purpose
The purpose of this paper is to support AFAC's efforts to inform and educate home owners and occupiers about best practice in regard to domestic smoke alarms and to influence Government to adopt consistent and effective smoke alarm provisions across Australia.

Position

1. Compliance
That all domestic smoke alarms installed in residential accommodation comply with Australian Standard (AS) 3786.

2. Power supply
That smoke alarms installed in permanent residential accommodation shall comply with the power supply requirements of AS 3786, including that they:
— be hard-wired direct to a 240 volt AC power supply; or
— be hard-wired to a 12/24 volt DC system powered by a 240 volt supply; or
— be powered by an integral, non-removable battery with a life span at least equal to that of the smoke alarm.

That hard-wired smoke alarms be wired to the un-switched active side of a light circuit.

That hard-wired smoke alarms be equipped with an integral battery back-up so that power is still available to the smoke alarm in the event of failure of the 240 volt supply.

3. Type
That all residential accommodation be fitted with photo-electric smoke alarms.

Note 1: There are two principle types of smoke alarms, ionisation and photo-electric smoke alarms. Ionisation smoke alarms predominantly detect the presence of extremely small particles of smoke whilst photo-electric smoke alarms predominantly detect visible smoke.

Note 2: Some research indicates that both ionisation and photo-electric smoke alarms provide occupants time to escape. AFAC's position however is based on current knowledge about smoke alarm performance; that is, that photo-electric alarms are generally more effective than ionisation alarms across the broader range of fire experienced in homes, and should be promoted as the technology of choice.

Note 3: Current research indicates that:

- *ionisation smoke alarms detect flaming fires marginally earlier than photo-electric smoke alarms.*
- *photo-electric smoke alarms detect smouldering fires and fires starting in areas remote from smoke alarms significantly earlier than ionisation smoke alarms.*

- *ionisation smoke alarms may not operate in time to alert occupants early enough to escape from smouldering fires.*

- *for both flaming fires and smouldering fires, photo-electric smoke alarms are likely to alert occupants in time to escape safely.*

Note 4: As many fires in residential accommodation begin as smouldering fires, photoelectric smoke alarms provide more effective all-round detection and alarm than ionisation alarms.

Note 5: Householders may choose to maintain ionisation smoke alarms until the end of their service life. However, householders should also install photo-electric smoke alarms in accordance with the locations described below.

Note 6: Smoke alarms fitted with dual photo-electric / ionisation detectors are available. Householders may choose to install such alarms in lieu of photo-electric alarms. However, research indicates that they are more costly and prone to more false alarms than photo-electric alarms, and the benefits are marginal.

4. Location

That smoke alarms in single dwellings (Class 1 buildings) be located in all sleeping areas and in all paths of travel between sleeping areas and exits to the open air.

That smoke alarms in buildings containing 2 or more separate dwellings (Class 2 and Class 4 buildings) be located in all sleeping areas and in all paths of travel between sleeping areas and exits to common corridors.

That smoke alarms in multi-level dwellings, in addition to the above provisions, be located in the path of travel between each level in such dwellings.

That due consideration be given to the effect on smoke alarm performance of air conditioners, heaters, fans and other temperature control devices, and that smoke alarms
be located where these devices will not compromise the effectiveness of the smoke alarms.

That, whenever possible, smoke alarms not be installed in close proximity to kitchens and bathrooms.

Note 7: Research indicates that a primary reason why smoke alarms do not operate when needed is because batteries have been removed after repeated false alarms. False alarms are often caused by steam from bathrooms or by cooking fumes. Research indicates that photo-electric alarms are less prone to false alarms from cooking fumes.

5. Installation
That smoke alarms be installed with reference to manufacturers' instructions, and located in accordance with the *Building Code of Australia* and AS 1670 parts 1 or 6.

That the responsibility for installation rests with the building owner, including, in the case of rental accommodation, the landlord.

That 240 volt smoke alarms be installed by a licenced electrician.

Note 8: AFAC is satisfied that smoke alarms with a DC power source may be installed by competent persons who are not qualified electricians.

6. Temporary accommodation
That battery-powered smoke alarms be used for temporary accommodation if 240 volt power is unavailable or impractical (eg. tents, boats, caravans).

That in temporary accommodation, smoke alarms be installed in all sleeping areas.

7. Sound levels
That the minimum smoke alarm sound pressure level at the bed head in all sleeping areas be 75 decibels.

Note 9: While this will not guarantee that all sleeping persons (particularly children under the age of 16, elderly people and the hard of hearing) will be woken by a smoke alarm, research indicates that adults with normal hearing are likely to be woken.

8. Smoke alarms for the deaf and hard of hearing
That smoke alarms with sensory stimulation devices other than standard audible devices be installed in residential accommodation occupied by

The Deaf or people who are hard of hearing.

Note 10: Alternative alarm methods may include alarm tones of varying frequency, vibrating pads and strobe lights.

9. Interconnection
That all smoke alarms in single dwellings (Class 1 buildings) be interconnected.

Note 11: Interconnection of smoke alarms ensures that regardless of where a fire starts, all smoke alarms in a dwelling will sound to alert occupants at the earliest possible time.

Conclusion:

The regulators (the ABCB), have been provided with ample information and proof of the issues with Ionisation alarms by the Australian Standards committee of expert fire practitioners. FP-002 represents a broad range of stake holder organizations.

This information was included in the Preliminary Impact Assessment (PIA), [See attached Appendix A] which included Pen Chart recorder data from the CSIRO laboratory testing of smoke alarms that demonstrated very clearly the poor performance of Ionisation alarms in the presence of high obscuration visible smoke.

In spite of the data produced by FP-002 in the two submitted PIAs, the ABCB prevented adoption of the proposed amendment to AS 3786 at the time. The reasons given by the ABCB in the rejection of the proposal by FP-002 to amend the smoke alarm standard were based on an incomplete analysis of the 2004 USA National Institute of Standards and Testing (NIST) 1455 study on smoke alarms. The ABCB was in contact with the author of the report a Mr Dick Bukowski who put forward a 'Statistical Average' argument (the basis of the extract and executive summary of the NIST report) when discussing the performance comparisons between Photoelectric and Ionisation smoke alarms. However, the data within the report clearly showed multiple incidences where Ionisation alarms failed to operate at all and many instances where they operated too late for occupants to escape to safety.

It is somewhat concerning that Mr. Bukowski acknowledged that he did not advise the ABCB (Videotaped and Video Conference Deposition Of Richard Bukowski San Francisco, California, Wednesday, September 17, 2014, Volume I) at the time that NIST had concluded otherwise and that later NIST in their "Statement for the Record. National Institute of Standards and Technology, to the Boston City Council Committee on Public Safety on August 6, 2007. [See highlighted sections in the attached Appendix B] stated that:

" **….** In the NIST experiments the photoelectric detectors sensed smoldering fires on average 30 minutes earlier than the ionization detectors….''; and

"… However, ionization detectors have been shown to sometimes fail to alarm in a smoldering fire even when visibility in the room is significantly degraded by smoke. Most photoelectric detectors alarm substantially sooner in these situations…"; and

"An important conclusion from the 2004 NIST study was that the available safe egress time provided by a smoke alarm would be sufficient, in many cases, only if households follow the requirements in NFPA's National Fire Alarm Code (NFPA 72) for new construction, which requires the installation of fire alarms at more locations in order to improve audibility in bedrooms where occupants sleep with the door closed, and to provide warning to the occupants of bedrooms with closed doors when the fire starts in that bedroom. NFPA 72 also requires two ways out of a sleeping room, one of which is generally a window. With the bedroom door closed there is more time in which to use the window exit should the primary exit be blocked."

The last paragraph is critical in understanding the NIST basis for claiming "No statistical difference in the performance between Ionisation and photoelectric smoke alarms". This claim is made on the basis of a fully installed NFPA 72 system. Nothing like what is currently required in Australia.

The regulations could have been changed at that point and we would have been 10 years into a regime of photoelectric smoke alarms in Australian residences.

I do not say that photoelectric smoke alarms are the panacea to fire detection; they are not. I allege the ionisation alarm is a dangerous device; its frequent false alarming is the reason people disable them, leaving them with no smoke alarm at all. There is now statistical data that establishes this is the case.

A worrying consequence of the ionisation alarms' propensity to frequent false alarming causes people to think it is extremely sensitive; they think it will provide them with plenty of warning to escape, after all *"It goes off when I cook the toast, it must be sensitive"*. The reality is that in a real fire situation, the highest probability is that the ionisation alarm may not activate in a timely manner. By the time an ionisation alarm activates from a fire, the fire is well past the auto ignition stage and established and more often than not the available safe egress time is negative. The real travesty is that the public are not being actively told to install photoelectric smoke alarms, the National Construction Code does not require them. The Northern Territory Legislation is the only State/territory in Australia at the present time that requires photoelectric smoke alarms in residential accommodation in spite of the AFAC June 2006 policy that states that "all residential accommodation be fitted with photoelectric smoke alarms. The Fire Services and industry are not being educated by their management and administration to this industry information.

This we do know:

1. The response time of an alarm, amongst other factors, depends on the character of the particulate (smoke), distance of detector from fire, size of the room of fire origin, character of the fire, drafts, the open / closed status of windows and doors, speed of growth and the burning materials;

2. Laboratory tests and pass criteria for both flaming and smouldering fires used to evaluate smoke alarms for approval are not representative of real-life fires in residential structures;

3. Effective residential fire detection is fundamentally dependent on there being smoke/heat alarms in all rooms of potential fire origin. This would require nothing less than inter-connected photoelectric smoke alarms in all bedrooms, living rooms, hallways and escape paths and heat alarms in kitchens on every level of a home. Photoelectric /heat combination alarms are ideal for this purpose;

4. Building regulations requiring smoke alarms across Australia and New Zealand are totally inadequate at the time of writing. Typically the regulations only require one smoke alarm in the escape paths adjoining sleeping areas. Virtually nothing in the regulations requires photoelectric technology (excluding the NT) or adequate detection of fire developing at its earliest stage in bedrooms, living rooms and kitchens and attached garages and worse still the regulations until this year did not require inter-connection of alarms to ensure that when one alarm sounds, they all sound;

5. When a fire is in its smouldering phase it will not produce high energy particulate and the ionisation alarm will not respond until the fire develops to the auto-ignition stage and in the worst case auto ignition may be close to flashover (see below). This smouldering could conceivably go on for hours filling the residence with toxic smoke;

6. From full scale smouldering fire tests the smoke increases much faster than the toxicity. That is, smoke will nearly always precede the creation of debilitating toxicity by a large margin. Usually (not always) the toxicity will not become a serious deterrent to escape for up to 30 minutes (depending on the smouldering material). In other words, the right type of smoke detector that detects visible smoke gives a very adequate warning of the smouldering fire;

7. When a fire develops to flaming from little or no smouldering, it is small and may initially produce little visible smoke; however, flaming fires in residential structures involve surrounding materials within seconds and rapidly produce large volumes of visible smoke. Flaming fires in residential structures are typically caused by those who are intimate with the fire, and a smoke alarm is not needed to tell them there is a fire. A notable exception is where flaming fires start from candles left burning when occupants are sleeping.

8. There is no such thing as a clean burning smokeless fire in a residential structure. Such smokeless flaming fires are created in the laboratory.

9. That a photoelectric smoke alarm responds typically 15 to 30 seconds behind an ionisation alarm in a flaming residential fire but only if the ionisation smoke alarms are in the room of fire origin. When the smoke alarms are remote from the room of fire origin, the photoelectric smoke alarms will typically operate

before ionisation alarms. Detecting any fire using the current smoke alarm regulatory regime at the flaming stage is typically too late for sleeping occupants to escape to safety;

10. A fire becomes most dangerous when the ceiling temperature in the fire affected room approaches flashover, somewhere in the region of a 540 degrees C., sometimes less. If the fire is not detected before this stage there is virtually no opportunity for escape. It is not possible for such a fire to develop in a residential structure without developing sufficient smoke to activate a photoelectric smoke alarm and/or a heat alarm. A heat alarm will usually respond at a ceiling temperature around 60-70 degrees Celsius. This is significantly below the most dangerous flashover temperature. Nearly always, when a photoelectric smoke alarm and a heat alarm activate in the room of fire origin of a flaming fire there will be time to escape to safety and often an opportunity for the home occupant to extinguish the fire promptly with the right equipment. Again this is dependent on alarms being in the room of fire origin and interconnected to ensure the occupants waken immediately on alarm activation. This is nothing like the current building regulations require;

11. That once a fire develops to the flaming stage in a residential structure there is typically less than 3 minutes to untenability; so detection at the pre-flaming stage in the room of fire origin is critical to allow time to escape particularly when occupants are sleeping;

12. The reality is that fire has infinite behavioral variations and it is not possible to predict a precise response time for any detector. When a fire is slow to develop the detector is slower to respond; but if the smoke alarm responds early enough to allow escape, or control of the fire, before the fire grows to a deadly stage, it meets the public performance expectation. However, when more than one in five occupants disable ionisation alarms, others ignore ionisation alarms due to frequent false alarms and ionization alarms are unreliable in response to slow smouldering fires; the ionisation alarm cannot provide what the public expect and becomes a threat to life. Life safety devices should reliably stimulate appropriate human response; they should not require human response to conform to their deficiencies;

The best solution available at time of writing this article is good quality true smoke detectors which at this time employ photoelectric technology combined with reliable heat sensing technology. They should be installed in all habitable rooms and inter-connected to activate a common audible alarm throughout the residence. Whether the detection is hardwired to the mains power or operates from 10 year Lithium batteries is a matter of debate. The author prefers long life Lithium battery powered alarms as they are immune to spikes in the mains power. Such spikes are known to destroy the operation of mains powered smoke alarms. Ideally the detection would be in conjunction with a home sprinkler system. But what about homeowners and occupiers who cannot afford to install this level of protection and what about the regulatory authorities who refuse to regulate anything more than one smoke alarm in the escape path from sleeping areas and one in every other level of a residence on the basis that the cost of a better installation cannot be justified against any perceived benefit? What value do the regulators place on human life and the lives of children and the elderly who rely on us for their protection?

Please feel free to contact me to discuss any points of this submission.

Yours sincerely,

David P Isaac.
[redacted]

About David Isaac:
David Isaac is the business Principal and Director of Fire and Safety Technologies Pty. Ltd.
David has more than 44 years' experience in electrical systems design installation and commissioning for building services, heavy industrial installations and essential services systems including fire detection, smoke hazard management systems and warning systems.
David is a systems application specialist in his field, a registered Electrician and a Licensed Electrical Contractor.
David holds Post Trade electrical engineering Certificates in Building Services and Heavy Industrial installations.
David is an Australian Communications and Media Authority (ACMA) Registered communications cabler.
David has been trained and certified in numerous electrical detection and PLC and SCADA

products over the last 40 years.
David was a member of the NSW Rural Fire Service from 1978 to 1989.
David is a member of the Australian Standards Committee FP-002 – 'Fire Detection, Warning, Control & Intercom Systems'. FP-002 writes the suite of Australian Standards on fire detection and alarm systems. David is also a member of Standards Sub-Committee ME-062 advising the committee on the electrical performance and compliance issues for AS 1668.1 'The use of ventilation and air-conditioning in buildings Part 1: Fire and smoke control in multi-compartment buildings' and AS 4428.7 'Fire detection, warning, control and intercom systems—Control and indicating equipment Part 7: Air-handling fire mode control panel'.
David is also a member of the Fire Protection Association Australia (FPAA) Technical Advisory Committee TAC/2, a former FPAA representative to Australian Communications Industry Forum Cabling Advisory Group (ACIF/CAG) which writes the communications industry cabling Standards and a member of the Audio Engineering Society.
In the last 30 years David has worked in private consulting, advising corporations on fire safety measures and held senior management roles for major international fire detection system manufacturers.
In the last 18 years David has been an active participant in Fire Industry Associations and the Standards writing processes in Australia.
David is a consumer advocate and has published several articles on the imperative of uniformity and Code compliance of life safety systems.
E-mail: [redacted]

Attachments:

Appendix A: AS 3786 Preliminary Impact Assessment
Appendix B: NIST Official Statement for the Record

Australian Building Codes Board

PRELIMINARY IMPACT ASSESSMENT FOR BCA VOLUME 1 & 2 REVISION OF PRODUCT STANDARD AS 3786 —1993 *Smoke alarms*

Version 2: 1 February 2007

Nature and Extent of the Problem:

Standards Australia on behalf of committee FP-002 *Fire Detection, Warning, Control and Intercom Systems*, proposes to revise AS 3786 because of an identified anomaly in the current edition of the Standard. The current edition allows two pass criteria for the same product (i.e. smoke alarms), resulting in different performance outcomes. Table 3.1 of AS 3786 shows a light obscuration pass criteria for photoelectric type and a MIC-X value for ionization type. Australia is the only country that uses two different pass criteria, all other regional and international Standards use an acceptance criteria based on light obscuration.

Standards Australia technical committee FP-002 identified that the design fire within residential accommodation is statistically a smouldering fire. This, coupled with maintaining tenability within paths of travel to an exit, is a function of the level of light obscuration and toxic species.

CSIRO have reported to FP-002 that the different criteria result in significant differences in the performance of smoke alarms. Photoelectric smoke alarms, when tested in accordance with the requirements of AS 3786—1993, typically respond between 8% and 16% obscuration per metre (Obs/m) whilst ionization smoke alarms typically respond between 40% and 60% light Obs/m (0.25 to 0.6 MICX), with the majority of ionization smoke alarms operating at the least sensitive end of this range (See Appendix A, CSIRO test graph and explanation).

Under the current Standard, ionization smoke alarms are permitted to have a lesser response to obscuration, which results in a significant negative impact on the Available Safe Evacuation Time (ASET).

Australian and international research demonstrates that the highest number of fatalities in residential fires occurs between the hours of 8.00 p.m. and 8.00 a.m. when occupants are typically sleeping and these fires typically begin with a smouldering phase. Of principle concern is the impact of resultant smoke obscuration and toxic species on the occupants' ability to escape.

The Standards Committee FP-002 cites the following three points in support of the revision of AS 3786.

ONE
Australian and international research that indicates ionization smoke alarms have performance limitations in adequately detecting smouldering fires in time to provide adequate ASET before untenable conditions exist.

- The Australasian Fire Authorities Council report titled *Accidental Fire Fatalities in Residential Structures; Who's at risk*? (Oct 2005), gives the three major causes of fatal fires in Australia as, heater/open fire/lamp (27%), smoking materials/equipment (25%), and electrical fault (23%). These fires typically have an extended smouldering phase.

- Tom Chaplan, Head of UL's fire protection division – CBS News (July 24 2006), stated,

  "In today's homes, the tendency for synthetics – like nylon and polyester in furnishings, fabrics and carpeting – is to smoulder for a long time, then burn faster than natural materials like wood and cotton which char as they burn. Synthetics melt and pool, then give off substantially more energy when they burn".

- From, *Fire Safety of Upholstered Furniture* – the final report on the CBUF research programme, edited by Bjom Sundstrom, European Commission Measurement and testing Report:

Page 64

Time Between Ignition and Discovery

(UK Statistics for 314 Fire Casualties*)

Time	# Casualties	% of Total
At ignition	**14**	**4.4%**
Under 5 minutes	**23**	**7.3%**
5-30 minutes	**78**	**24,8%**
More than 30 minutes	**194**	**61.8%**
Not Known	**5**	**1.5%**

<u>The table demonstrates that 88.3% of fatalities occur when the discovery time is more than 5 minutes. This is particularly relevant for sleeping occupants.</u>

- *Building Fire Statistics* 88-97 Norway, Directorate for Fire and Explosion Prevention, states,

  "It is recognized that deadly fires and fires doing the most damage typically have a substantial undetected incipient stage while flame-ignited fires are typically intimate with awake people and connected to their activities. Hence, detection in order to alert is less important (in flaming fires)".

- The NIST Study *Technical Note 145*, suggests that the ASET may only be 3 minutes for an ultra-fast fire involving upholstery furniture. It concludes, "the placement of either alarm type on every level of the house provided the necessary escape time for the different types of fires examined". However, this is not supported by data from within the NIST report (pgs 242, 243), which shows that for smouldering fires in the living area, the ionization device provided less than the required safe evacuation time in two of the tests (-43s and -54s) or barely adequate time (+16s) in another test. This fire scenario i.e. smouldering fire in the living area was identified as the most common fatal fire scenario (pg. 60).

- Meland, Oysten, and Lonuik, Lars, "Detection of Smoke—Full Scale Tests with Flaming and Smouldering Fires", *Fire Safety Science, Proceedings of the Third International Symposium*, July, 1991, pp. 975-984, states the following,

  "The ionization detectors detected smoke from a smoldering fire much later than optical (photoelectric) detectors. When the particular conditions during the fire development are taken into consideration there are reasons to indicate that this detection principle would not provide adequate safety during this type of fire."

- The "Residential Smoke Alarm Report" - Prepared by Special Automatic Detection Committee of the International Association of Fire Chiefs, *The International Fire Chief*, (September 1980) states,

  "This test will show that most photoelectric detectors, operated by battery will detect smoke at about 1.5 - 3% smoke (*4.8 - 9.5% Obs/m*), which is good. The test will show that the photoelectric detectors operated by household current will activate between 2 and 4 %, (*6.4 – 12.5% Obs/m*) which is still

good. But, the test also will show that many ionization detectors will not activate until the smoke obscuration reaches 10-20% (*29 – 52% Obs/m*) and sometimes 25% (*61% Obs/m*). Therefore, because of the present state of the art in detecting smoke, the Subcommittee on Smoke Detectors can take no other course but to recommend the installation of photoelectric detectors."
(Note: Italics added by editor)

- R. Riley, K., and Rogers, S. in *A Study of the Operation and Effectiveness of Fire Detectors Installed in the Bedrooms and Corridors of Residential Institutions*, Fire Research Station, Fire Research Current Paper 26/78, Borehamwood, England, April 1978, concluded,

  "Ionization chamber type detectors, in the room of origin and the corridor, did not, in the smoldering fire tests, provide adequate warning that the escape route was impassable or that conditions in the room were potentially hazardous to life".

- The case of Jeanna Rodgers reported by consumer.org.nz illustrates the concern with the ability of ionization alarms to detect visibly dense smoke. On August 2 2006 a clothes dryer failed filling the house with smoke. There were three ionization alarms installed within the house and all failed to alarm. Whilst the report does not state that smoke was observed to have reached the ionization alarms it would be reasonable to assume with three installed it would have been the case. The alarm was raised by Jeanna's five year old son, Samuel, who sleeping on the top bunk was awoken when he started to cough from the smoke layer which had now descended to where Samuel was sleeping. When the three ionization smoke alarms were tested in situ by the attending fire service all three operated correctly.

- In 1988 UL, as a result of high level of nuisance alarms from ionization smoke alarms, decreased the sensitivity requirements from 7%obs/ft (*21.2% Obs/m*) to 10%Obs/ft (*29.2% Obs/m*) as a means of mitigating the problem. However as ionization detectors respond to fast flaming fires this potentially meant the detection of the fire at a more advanced flaming stage than previously. This may explain the significant changes in the number of fire fatalities that occur in fires where the smoke detector has operated. Detection at a later stage must impact on the ASET. The table below shows a disproportionate increase in the number of post alarm fatalities compared to the home coverage and number of fires.

	% OF FATAL FIRES WITH WORKING DETECTORS	% OF HOMES WITH DETECTORS	% OF FIRES WITH WORKING DETECTORS
1988	9%	81%	38%
1990	19%	86%	42%
1994	19%	93%	49%
1996	21%	93%	52%
1998	29%	94%	55%
2001	39%	95%	55%

Source: Joseph M. Flemming, Deputy Chief, Boston Fire Department, *Photoelectric and Ionization Detectors; A Review of the Literature Revisited.*

- A search of published studies and papers has produced no document that concluded that photoelectric detectors, with current "open" design, were inadequate for flaming or smouldering. This would appear to constitute "compelling evidence" that ionization detectors are not suitable for residential occupancies as stand alone devices, since a reasonable alternative is available as a Deemed to Satisfy solution. While it may be true that no single study is enough proof of this problem the totality of all of the studies provided considerable evidence that this problem is real.
  Source: Joseph M. Flemming, Deputy Chief, Boston Fire Department, *Photoelectric and Ionization Detectors; A Review of the Literature Revisited*

TWO

The critical *Performance Requirement* P2.3.2 of the BCA are not satisfied by ionization smoke alarms, on the basis of their inability to activate early enough in smouldering fires, before untenable conditions prevent the escape of occupants to a safe place.

THREE

Up to 31% of installed smoke alarms no longer operate.
This is shown in AFAC, *Accidental Fire Fatalities in Residential Structures Who's at Risk?,* October 2005.

Other international research, (NIST Technical Note 1455, *Performance of Home Smoke Alarms*, *Ionization and Photoelectric smoke alarms in Rural Alaskan Homes,* August 2000; Fleming, J.M., *Photoelectric v. Ionization Detectors - A Review of the Literature—Revisited*), .indicates that a major factor in the disablement of ionization smoke alarms by consumers is their demonstrated high incidence of 'false' activation due to cooking fumes, gas heaters and the like. The implementation of smoke detection based upon light obscuration provides the additional benefit of mitigating the incidence of 'false' activation due to the above causes. This potentially leads to a reduction in disablement by consumers thereby increasing the number of functional installed smoke alarms with a proportional increase in life safety.

Objectives:

The FP-002 committee seeks to:

1. Assure that smoke alarms when applied as a deemed to satisfy solution, meet the critical *Performance Requirement* P2.3.2 Volume 2 and EP2.1 and EP2.2 of Volume 1 of the BCA.
2. Establish a single acceptance criteria for AS 3786 based on light obscuration regardless of technology type.
3. Align AS 3786 with international practice of acceptance criteria based on obscuration.

Options:

1. Do nothing.
2. Amend the BCA to specify photoelectric smoke alarms in all areas where AS 3786 smoke alarms are required.
3. Amend AS 3786 to provide for smoke alarms suitable for general use, i.e. adequate for both smouldering and flaming fires, with performance criteria independent of technology type.

Impact Analysis:

1. **Do nothing:**
    - The research presented indicates that the installation of current ionization products will not meet the critical *Performance Requirement* P2.3.2 of the BCA.
    - Consumers will continue to be unaware of the significant difference in sensitivity and performance (i.e., life safety) of the two technologies complying with AS 3786.
    - There is a greater potential for litigation due to the lack of performance in providing life safety in real residential fires. (Litigation against manufacturers of ionization smoke alarms have been successful in the USA and further litigation is in progress).
    - This option will not address the identified shortcoming of the current product Standard.

2. **Amend the BCA to specify photoelectric smoke alarms in all areas where AS 3786 smoke alarms are required**
    - The mandating of photoelectric smoke alarms provides a detection technology suited to a broader range of fires experienced in residential applications and therefore provides the most suitable deemed to satisfy solution.
    - A review of the ActivFire listing and discussions with smoke alarms suppliers and manufacturers at a meeting called by the FPAA on the 31 March 2006, identified one Australian manufacturer that currently does not provide a photoelectric option. From data provided at the meeting, it is estimated this manufacturer provides less than 0.2% of the product supplied to the Australian market.
    - Currently photoelectric technology based smoke alarms are typically 10% to 15% more expensive than their ionization technology alternatives. Discussions with product manufacturers indicate that an increased manufacturing volume will see this price differential decrease. Some manufacturers have indicated that the increased volumes will result in no price differential.

3. **Amend AS 3786 to provide for smoke alarms suitable for general use, i.e. adequate for both smouldering and flaming fires, with performance criteria independent of technology type**
    - Amending AS 3786 to ensure products meet the acceptance criteria based on obscuration would result in the use of smoke alarms suited to a broader range of fires experienced in residential applications and would provide a deemed to satisfy solution that meets the performance requirements.
    - A review of the ActivFire listing and discussions with smoke alarms suppliers and manufacturers at a meeting called by the FPAA on the 31 March 2006, identified one Australian manufacturer that provides only products that might not meet the acceptance criteria of the revised Standard. From data provided at the meeting, it is estimated this manufacturer provides less than 0.2% of the product supplied to the Australian market.
    - Currently photoelectric smoke alarms (obscuration based technology) are typically 10% to 15% more expensive than their ionization technology alternatives. Discussions with product manufacturers indicate that an increased manufacturing volume will see this price differential decrease. Some manufacturers have indicated that the increased volumes will result in no price differential.
    - The revision of the Standard opens up the compliance of smoke alarms to any technology that meets the single acceptance criteria.
    - The acceptance criteria for smoke detectors installed in sleeping areas and paths of travel to an exit as part of an AS 1670.1 system required by Clause 4 Spec. E2.2a of the BCA is based solely upon obscuration. The amendment of AS 3786 will bring the acceptance criteria for smoke alarm products installed to Clause 3 of Spec. E2.2a into line with the acceptance criteria for products in Clause 4.

- To reflect the identified changes in fire behaviour in modern dwellings, Option 3 would provide product performance criteria suitable for general use in both the smouldering and flaming stages of fire development. The revision of AS 3786 seeks a single sensitivity criteria for smoke alarms based on the measurement of light obscuration resulting from a developing fire to evaluate the ability of smoke alarms to facilitate sufficient evacuation time to meet the critical Performance Requirement P2.3.2 of the BCA. All devices that meet the obscuration criteria, independent of technology, may be referred to as smoke alarms. The likely outcome of the AS 3786 revision is that photoelectric detection technology will meet the revised requirements and become the technology of choice over ionization technology.
- As an example of this pricing trend, smoke detection systems have, over the last decade, moved towards photoelectric technology. Today they typically employ 98% photoelectric technology, resulting in photoelectric smoke detector pricing reducing to the same or less than ionization.

Consultation:

- Audio Engineering Society
- Fire Services through representation of Australasian Fire Authorities Council
- Australian Chamber of Commerce and Industry
- Australian Electrical and Electronic Manufacturers Association
- Australian Industry Group
- Australian Institute of Building Surveyors
- Deafness Forum of Australia
- Department of Defence (Australia)
- Fire Protection Association Australia
- Institute of Security Executives
- National Electrical and Communications Association
- CSIRO Manufacturing & Infrastructure Technology division.

In addition to the above, formal discussions on the proposed changes have taken place with the Department of Planning NSW and all smoke alarm suppliers / manufacturers through an FPAA residential smoke alarm forum conducted on the 31st March 2006

Conclusion and Recommended Option:

Standards Australia identified an anomaly in the current edition of AS 3786 Smoke alarms. The current edition allows two acceptance criteria for the same product (i.e. smoke alarms), resulting in different performance outcomes. Research shows that the application of smoke alarms where the acceptance criteria is not based upon the detection of obscuration levels, will not provide an adequate level of life safety in residential occupancies and thereby does not meet the performance requirements set down in the BCA.

The provision of smoke alarms typically follows the deemed to satisfy path. The lack of awareness of the general community to the performance limitations of smoke alarms requires that AS 3786 be revised, to ensure that consumers are automatically provided with a product that is fit-for-purpose and the most appropriate deemed to satisfy solution.

Options 2 and 3 are credible options. Both options result in:

- the installation of smoke alarms suitable for general use i.e. adequate for both smouldering and flaming fires;
- the closing of current price gap between photoelectric and ionization due to increased usage of photoelectric;
- mitigation of nuisance alarms;
- decrease in disablement by consumers; and
- positive increase in life safety.

Option 2 would address the anomaly with respect to the BCA but does not address those situations where AS 3786 is directly referenced by other State or Territory legislation.

Option 3 would address both the anomaly with respect to the BCA and where AS 3786 is directly referenced by other State or Territory legislation.

Standards Australia committee FP-002 recognises that there will be fatalities within residential occupancies irrespective of the detection technology employed. However there is the inescapable responsibility, as the peak technical standards body, to provide an Australian Standard that results in the most appropriate product giving due regard to the end user and the application.

Implementation and Review:

If accepted, the Standard is planned for referencing in BCA 2008, which is to be adopted on 1 May 2008.

As a matter of policy, proposed changes to the BCA are released three months in advance of implementation to allow time for familiarisation and education and for industry to modify its practices as required accommodating the changes.

Within this context the ABCB remains committed to regular review of all the aspects of the Building Code of Australia and to amending and updating the Code as needed to ensure that building regulations meet changing community standards. The ABCB maintains regular and extensive consultative relationships with a wide range of stakeholders. In particular, a continuous feedback mechanism exists and is maintained through State and Territory building control administrations, industry and the Building Codes Committee. This constitutes an important means of ensuring that opportunities for regulatory reform are identified and assessed for implementation in a timely manner.

APPENDIX A

Explanation of attached CSIRO Pen recorder test chart for Ionization Smoke Alarms.

In AS 3786 photoelectric smoke alarms are tested for acceptance to light obscuration levels and ionization smoke alarms are tested for acceptance to a MIC X value.

IN CSIRO acceptance testing, photoelectric smoke alarms typically activate between 8 to 16% light obscuration per metre (2.5 to 5.2% per foot). However, ionization smoke alarms typically activate between 0.2 and 0.5 MIC X (a different property to light obscuration level). Light beam obscuration is about 40 to 60 % light obscuration per metre (14.4 to 24.4% per foot) when the MIC X value reaches between 0.2 and 0.6. The majority of ionisation smoke alarms operate towards the least sensitive end of the acceptance range as indicated on the attached Pen recorder test chart.

The attached document is a pen recorder test chart from a typical smoke sensitivity test undertaken on five ionisation smoke alarms tested in accordance with Clause 3.2 of AS 3786 (sensitivity). The data is confirmed by Peter Haggar a Materials Scientist from CSIRO, that the results on the attached copy of the pen recorder chart are typical of a large number of tests over many years on a range of ionisation smoke alarms in Australia.

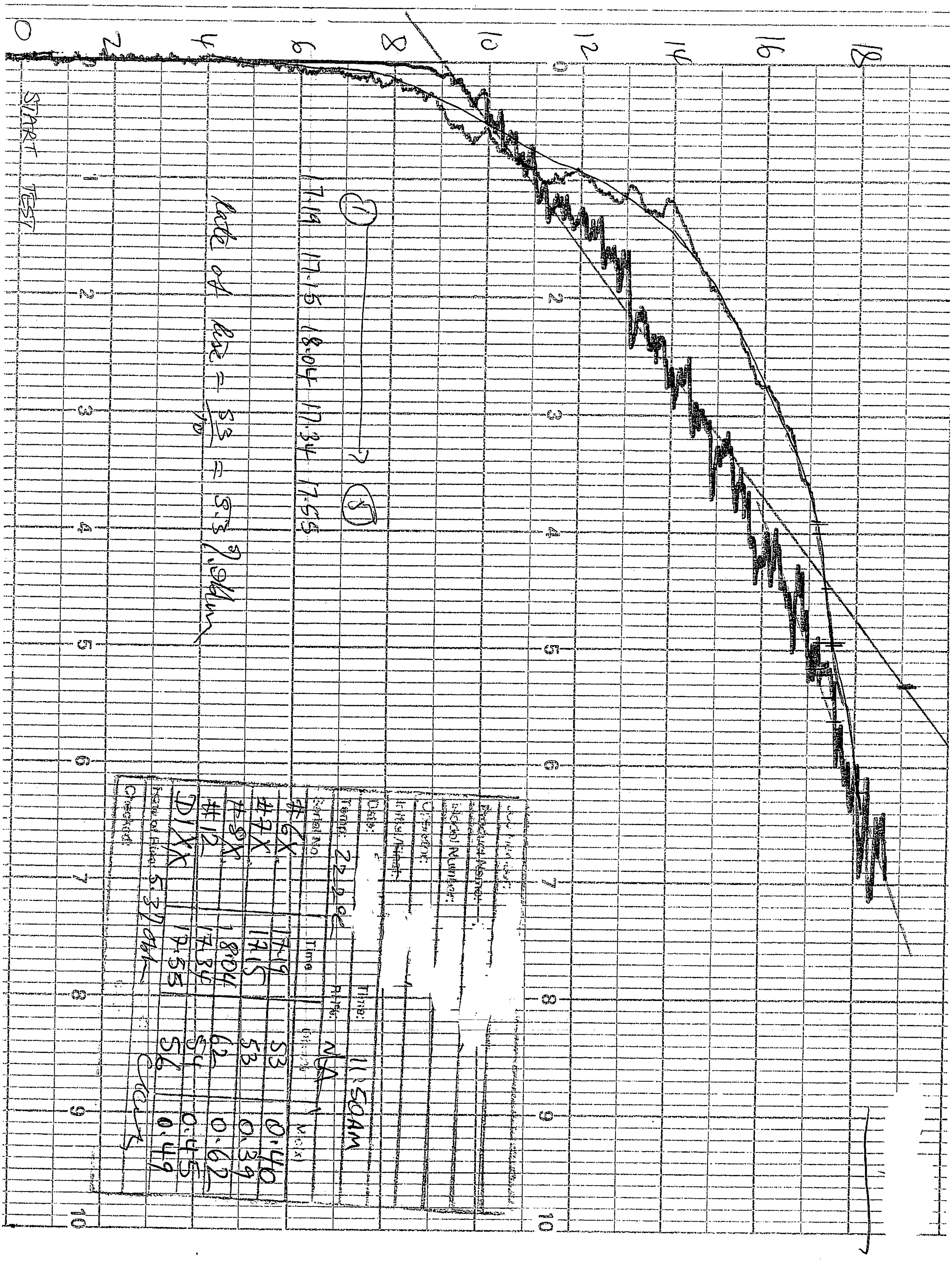
Please note that the test fire specified by the standard is a slowly developing smouldering fire which will inherently favour detection devices that detect visible smoke over ionisation type smoke alarms that do not detect smoke.

About the chart

- The rate of rise of smoke obscuration per metre is calculated over the first 30 % obscuration per metre and is represented by the straight line drawn on the chart dissecting the obscuration curve and in this case is calculated at 5.3% obscuration per metre per minute.
- The vertical axis represents the time of the test in minutes.
- The span 0 to 10 across the horizontal axis corresponds to 0 to 100% obscuration/metre and 0.00 to 1.00 MIC-X.
- The fuzzy line which approximates a straight line drawn on the chart represents obscuration per metre in the test room.
- The less fuzzy line which curves above the obscuration line represents the MIC-X level in the test room.
- Being a pen chart recorder, the obscuration lines and ion lines are offset by about ½ a minute.
- The smoke test started at 0% obscuration per metre and was stopped at 70% obscuration per metre.
- The smoke test started at 0.00 MIC X and finished at 0.64 MIC X.
- MIC-X in the test room is measured using a standard measuring ionisation chamber which is typically an ionisation detector chamber with air being drawn through it to measure the MIC X level.
- The obscuration in the test room is measured using an obscuration light beam.

For further information, please contact Peter Haggar at CSIRO on (03) 9252 6361.

APPENDIX A



Statement for the Record
National Institute of Standards and Technology
to the
Boston City Council Committee on Public Safety
August 6, 2007

This statement provides technical information on smoke detector technology based on research conducted by the U.S. Commerce Department's National Institute of Standards and Technology (NIST), especially on the differences between ionization and photoelectric technology.

NIST is a non-regulatory federal research agency that specializes in measurement and basic standards, and has been engaged in fire research for more than a century. Our mission is to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life.

Prior to 1988 NIST was known as the National Bureau of Standards (NBS). NIST staff has been involved in research and standards development related to smoke detectors and fire alarms for approximately four decades. We interact with the National Fire Protection Association (NFPA), Underwriters Laboratories (UL), the U.S. Fire Administration (USFA), the Consumer Product Safety Commission (CPSC), and other federal agencies on technical matters concerning fire sensing and fire alarm technologies. The output of NIST research on smoke alarms is freely available for downloading from the NIST web site (http://smokealarm.nist.gov/).

Smoldering fires are inherently different from flaming fires, and the operating principle for a photoelectric detector is distinct from the operating principle of an ionization detector . Smoldering can occur only in a porous solid; for example, polyurethane foam, shredded paper, or cotton. The rate of smoldering is limited by the ability of air to penetrate the porous fuel, and hence the rate at which heat is released from a smoldering fire is low, as is the rate of carbon monoxide (CO) production. The smoke layer from a smoldering fire grows slowly and smoke can accumulate well below the ceiling, especially in rooms other than the room of fire origin.

Another important aspect of a smoldering fire is that it produces smoke particles that are relatively large (greater than one micrometer). Flaming fires can occur in all types of fuels, including porous and non-porous solids, liquids, and gases. Air has easy access to a flaming fire, which means that the rate at which heat is released is high. Smoke and fire gases, including CO, can be produced at a higher rate in a flaming fire than in a smoldering fire. The smoke layer is hotter and can build up near the ceiling of the room of fire origin as well as elsewhere in a building. Flaming fires produce a very large number of smoke particles that can be relatively small (less than one micrometer).

The above discussion distinguishes between smoldering and flaming fires; the following describes the different characteristics of photoelectric and ionization detectors, and why they react the way they do in smoldering and flaming fires. The bottom line is that each type of detector has its advantages and disadvantages. An ionization detector responds to the movement through an electric field of ions produced by a small radioactive source in the smoke alarm chamber. When smoke particles move into the chamber they inhibit the motion of the ions, altering the electrical current. Fires that produce a large number of particles (i.e., flaming fires) are sensed more easily with an ion detector. A photoelectric detector operates on the principle of light scattered from the surface of particles. Because large particles have much more surface area than small particles, a photoelectric detector is more sensitive to the large particles produced in a smoldering fire. The sensitivity requirements of the UL standard are identical for both types of detectors, and neither detector responds to carbon monoxide or heat.

The general trends from a 2004 NIST experimental study into the behavior of smoke alarms are consistent with several previous scientific studies showing that properly installed and maintained ionization and photoelectric alarms provide enough time to save lives for most of the population under many fire scenarios. **However, ionization detectors have been shown to sometimes fail to alarm in a smoldering fire even when visibility in the room is significantly degraded by smoke. Most photoelectric detectors alarm substantially sooner in these situations.**

In the NIST experiments the photoelectric detectors sensed smoldering fires on average 30 minutes earlier than the ionization detectors. The same study demonstrated that ionization detectors responded, on average, 50 seconds earlier than photoelectric detectors during flaming fire experiments. The relative margins of safety associated with a 30 minute earlier warning in a slow growing smoldering fire compared to a 50 second earlier warning for a fast growing flaming fire is difficult to determine.

In the 2004 NIST study, average times to untenable conditions for flaming and smoldering furniture fires were found to be shorter by 17% and 47%, respectively, than those found in the 1975 NBS study (also known as the Indiana Dunes study). On the other hand, the average time for the cooking fires to reach untenable conditions was 120% longer in the current study. Since the cooking materials were similar in the two studies, NIST concluded—on the basis of the shorter time to untenable conditions in the furniture fires—that a major factor in the increase in fire growth rate is due to differences in modern furniture materials and construction compared to furniture manufactured four decades ago. The reduction in time to untenable conditions from a fire (either flaming or smoldering) in modern, synthetic materials indicates the need to determine the ability of standard test methods to ensure safe performance of modern (and legacy) residential fire alarms. Both NIST and UL are involved in research that will assess whether or not modifications are required in the standard to accommodate the changing threat.

An important conclusion from the 2004 NIST study was that the available safe egress time provided by a smoke alarm would be sufficient, in many cases, only if households follow the requirements in NFPA's National Fire Alarm Code (NFPA 72) for new construction, which requires the installation of fire alarms at more locations in order to improve audibility in bedrooms where occupants sleep with the door closed, and to provide warning to the occupants of bedrooms with closed doors when the fire starts in that bedroom. NFPA 72 also requires two ways out of a sleeping room, one of which is generally a window. With the bedroom door closed there is more time in which to use the window exit should the primary exit be blocked.

Audibility of smoke alarms remains an issue, particularly for sleeping children and adults impaired with alcohol or other drugs. For existing residences that do not fall under the "new construction" requirements of NFPA 72, or for new residences where the state or local building regulatory agency has not adopted the requirements, the following approaches are suggested to reduce problems associated with inaudibility: placing smoke alarms in bedrooms, interconnecting smoke alarms, changing alarm tones, and providing better home fire escape planning. Interconnection of the smoke alarms ensures all alarms respond to a fire event. **Nationally-collected data on fire incidents do not specifically classify fire sources as smoldering and/or flaming; however, NFPA estimates that more than one-fourth of home fire deaths involve fires with an extended period of initial smoldering.**

In NIST's smoke alarm research, and in applications in the field, it is documented that most common ionization detectors have a propensity to produce nuisance alarms during cooking activities. NIST examined a broad range of activities (including cooking) that yield nuisance alarms. The published field observations guided the nuisance alarm scenarios studied. Specifically, the sensitivity to alarm threshold, distance from the source, background air flows, and alarm sensor (photoelectric or ionization) were examined. Additional measurements were made with aerosol instrumentation to provide a more fundamental understanding of nuisance alarm sources than has been previously published. Given the scenarios examined, **both photoelectric and ionization alarms produced nuisance alarms, but NIST does not mean to imply that they are equally susceptible to such nuisance alarms. Most field data suggest that ionization alarms have a greater propensity to nuisance alarm than photoelectric alarms, possibly indicating that certain activities such as cooking dominate reported nuisance alarms in the field.**

To reduce the impact of nuisance alarms, NFPA 72 requires that smoke alarms not be located directly in cooking areas, and that any alarm located within 20 feet of a cooking appliance be photoelectric. Studies have shown that this should be reasonably effective except where some cooking techniques (blackening, deep frying, and broiling especially in a broiler that is not clean) are employed. However, photoelectric detectors may also alarm to these more egregious cooking styles. The second biggest nuisance alarm culprit is steam from showers where both detector types are equally susceptible.

In summary, the research conducted by NIST staff leads to the conclusion that both ionization and photoelectric alarms provide enough time to save lives for most of the population under many fire scenarios**; however, ionization alarms may not always alarm even when a room is filled with smoke from a smoldering fire, exposing the most sensitive populations with mobility limitations to an undetermined risk. Photoelectric detectors can provide a lot more warning time than ionization detectors in a smoldering fire;** at the same time a smoldering fires can take a longer period to become dangerous. Ionization detectors can provide a little more time than photoelectric detectors in a flaming fire; in this case there can be little time to spare. Changes in furnishing materials and construction over the past decades have reduced the time available for safe egress in any fire. NIST is currently conducting research to assess whether or not modifications may be needed in the standard test method for certifying residential smoke alarms to accommodate the changing threat.