BRANZ

ISSUE 639 BULLETIN

DOMESTIC ACTIVE FIRE PROTECTION

June 2019

Almost all deaths in fires result from smoke inhalation. Detection and notification of a fire as early as possible provides the most time to escape.

Stand-alone smoke alarms are required as a minimum for domestic applications, and sprinklers are a worthwhile upgrade because they control fire spread and growth.

This bulletin contains updated smoke alarm and domestic sprinkler information and discusses new regulations for residential rental properties. It replaces Bulletin 458 *Domestic fire protection*.

1 INTRODUCTION

1.0.1 Domestic smoke alarms are designed for use in private dwellings to detect and give warning of the presence of smoke, indicating that a fire is developing. They are small units, easily attached to the ceiling (preferably) or high up a wall.

1.0.2 Single 9 volt battery-powered smoke alarms are the most common and the cheapest but are not recommended. Better options are mains powered with battery back-up or units with a long-life battery.

1.0.3 Interconnected smoke alarms are a worthwhile upgrade. They improve the chances of early notification, because they all make noise when the first alarm detects smoke.

1.0.4 The best protection is provided by a sprinkler system incorporated into the domestic plumbing. When the thermal element of a sprinkler head senses sufficient heat, it automatically sprays water, wetting and cooling the area directly below.

1.0.5 Since 2003, the New Zealand Building Code has required smoke alarms to be installed in all new dwellings and existing houses undergoing building work where a building consent is required. Legislation was introduced in 2016 making the installation of smoke alarms mandatory in all residential rental properties, and stand-alone photoelectric smoke alarms with at least 8-year batteries are now required.

1.0.6 This bulletin contains updated smoke alarm and domestic sprinkler information and discusses the new regulations for New Zealand residential rental properties. It replaces Bulletin 458 *Domestic fire protection*.

1.0.7 This bulletin does not consider the risk of external fire spread or additional measures required if more than one household unit is included (such as granny flats). External fire spread becomes important when a house is close to a property boundary or in an area prone to high wildfire risk.

2 FIRE AND SMOKE

2.1 WHY DETECT SMOKE, NOT HEAT?

2.1.1 Death from fire is usually caused by the effects of smoke rather than from heat or flames, particularly when people are asleep and remote from the source of fire. The combined effects of carbon monoxide and other toxic gases in the smoke and a lack of oxygen will either kill a person or render them unconscious, preventing escape from the flames.

2.1.2 Tests in real fire situations show that smoke and other combustion products are detected earlier than heat in nearly all fires. Smoke alarms therefore provide earlier warning of a fire and give more time for escape than heat detectors.

2.1.3 Smoke alarms can be sensitive to small amounts of smoke, aerosols and steam produced during cooking, spraying deodorant and showering. Smoke alarms near kitchen or bathroom areas can produce nuisance false alarms. This can be managed by:

- locating smoke alarms away from kitchen and bathroom areas
- installing smoke alarms with hush functionality, which temporarily silences the alarm during these activities
- specifying photoelectric smoke alarms, which tend to be more resistant to cooking, steam and sprays but are more susceptible to dust and small insects
- regular cleaning and maintenance
- taking an 'upspec' approach to the quality and location of alarms.

2.2 SPREAD OF SMOKE

2.2.1 Smoke and flammable gases are hot, so they will rise until they reach a roof or ceiling. Where the ceiling is level, they will then spread out in all directions until they reach a wall or obstacle.

2.2.2 Accumulating smoke fills the room from the ceiling down. Where a door in the room containing the fire is open, the smoke will fill the room down to the top of the doorway, then spread through the doorway and continue spreading close to the ceiling of the adjacent space. Where the ceiling is sloping, the smoke will first tend to rise to the high part or apex of the room before accumulating and spreading.

2.2.3 Where the door to the room containing the fire is closed, smoke will build up within the room (except for small amounts escaping from any openings, mainly between the door and the frame). Until the door is opened, smoke continues to accumulate within the room, steadily reducing the height of the layer of clear air close to the floor. As the closed door contains the fire within the room, the temperature within the room rises. The closed door may also delay occupants becoming aware of the fire.

2.2.4 Smoke from an uncontained fire located in the lower storey of a 2-storey dwelling will quickly rise up the stairway and continue to spread in the upper storey before spreading through the lower floor. If this stair is the only escape route, occupants can be trapped if there is no warning of the early stages of smoke spread.

2.2.5 Closing the doors to each room reduces the risk of fire spread, even if the fire does build up more in the room of origin. Closed doors also reduce the sound volume of smoke alarms and they may not be heard as quickly. Features such as a mezzanine floor or balcony may create dead spaces that prevent the passage of smoke to the highest point (Figure 1).

2.3 FIRE DEVELOPMENT

2.3.1 All fires start small but may grow rapidly and spread if the right conditions are present. For a fire to start and grow, it needs three essential elements (Figure 2):

- Fuel – materials that burn such as furnishings, fittings and surface finishes.
- Heat – electrical equipment (such as charging batteries if they malfunction), room heaters, open fires, matches, cigarettes, candles or other naked flames.
- Oxygen – present in the air.

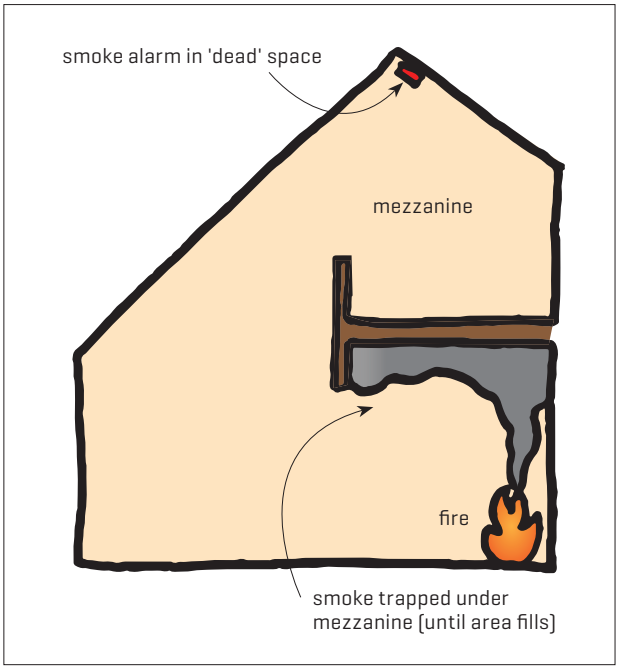

Figure 1. Example of a smoke alarm located in a dead space.

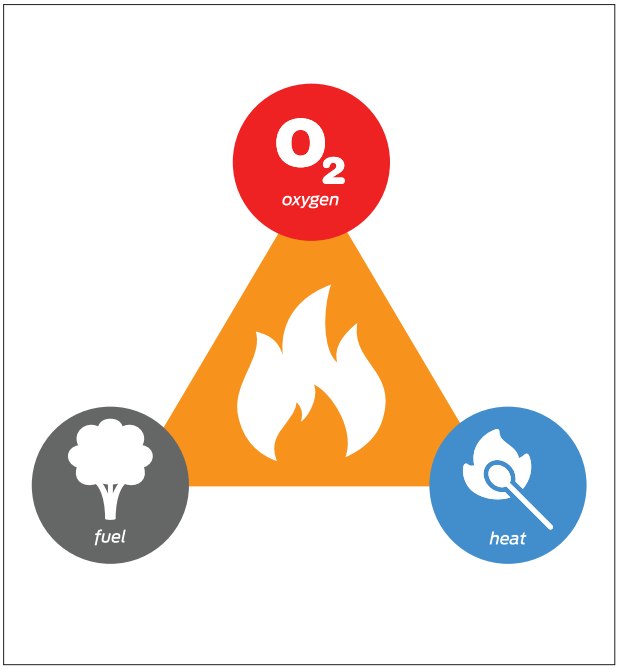

Figure 2. The fire triangle.

2.3.2 Heat causes combustible material surfaces to degrade, producing flammable vapours that will ignite if sufficient heat and oxygen are available. If any of the essential elements are removed or significantly reduced, the fire cannot sustain itself and will die down.

2.3.3 If the fire is not extinguished, it may continue to grow and spread by convection and radiation:

- Convection occurs because the hot gases rise in a plume above the heat source until they reach an obstacle like a ceiling, which will spread the plume horizontally. This transfers the heat to other surfaces it touches.
- Radiation transfers heat energy through the air to heat other surfaces.

2.3.4 If there is sufficient heat transferred to surfaces, they will start to degrade and produce flammable vapours. Once they achieve sufficient concentrations and enough energy is present for ignition, they will start to burn.

2.3.5 As the heat increases, flammable gases emitted from objects within the room can ignite simultaneously and may engulf the whole room. This action is called flashover. At this point, the conditions in the room will not be survivable.

2.3.6 A room fire that is left to grow can reach flashover in less than 3 minutes from when the fire first ignites. The increased use of plastics in modern home furniture and furnishings tends to promote faster fire growth. This means that there may be less time available to escape, and therefore early detection and notification becomes even more critical.

3 SMOKE ALARMS

3.0.1 Modern smoke alarms contain:

- a smoke detector
- an audible alarm
- control equipment
- a power supply – either battery only (long-life recommended) or mains power with a battery back-up
- a test button
- a hush button.

3.0.2 When smoke is detected, the alarm emits an intermittent high-frequency tone loud enough to wake a sleeping person so they can escape to a safe place.

3.0.3 When smoke alarms are interconnected, they will all sound the alarm if any one of them detects smoke. This feature provides improved notification, particularly to sleeping occupants remote from the fire, and they will be much more likely to hear the alarm with enough time to escape. Older interconnected alarms required wiring for the connection, which increased the cost and made retrofitting difficult. Modern wireless interconnected alarms provide this functionality without any additional installation cost.

3.1 TYPES OF ALARMS

3.1.1 Two types of smoke alarms have been available in New Zealand – optical/photoelectric and ionisation.

3.1.2 Optical or photoelectric type alarms use a small light beam housed in a chamber. When smoke particles from a fire enter the chamber, some of the light is deflected onto a photocell, and this creates a small electrical current that activates the alarm. This can be thought of as 'seeing' the smoke. These types of detectors are most sensitive to smoke particles that are easily seen, such as the dark, large particles from smouldering fires. These detectors are less likely to react to less-visible particles like shower steam.

3.1.3 Ionisation type alarms use a tiny radioactive source to ionise the air in the chamber and turn it into a conductor of electric current. When smoke particles enter the chamber, they mix with the ionised air and slow the

ionisation process, reducing the current flow and starting the alarm. This can be thought of as 'smelling' the smoke. Alarms that only use ionisation detection are generally not recommended and are being phased out by many retailers.

3.1.4 Models are available that combine ionisation and photoelectric detection methods, and some photoelectric models use long-life and low-power light-emitting diodes as the light source. These units can provide the most effective early detection of both smouldering and rapidly developing fires.

3.1.5 Most existing domestic smoke alarms installed tend to be cheaper 9 V battery-powered units. Provided the battery is regularly replaced, they will provide a reliable means of detecting fire early.

3.1.6 Long-life 9 V lithium batteries can be fitted to standard 9 V battery smoke alarms. However, they aren't generally recommended. The difference in battery capacity decay between alkaline and lithium batteries means that there may be less warning before the lithium battery dies.

3.1.7 When the alarm needs to be replaced, an upgrade should be considered. The detector should be replaced after about 10 years, due to dust and residue build-up, possible degradation of the detection electrical components and to upgrade to the latest detection technology. New smoke alarms should be interconnected and have long-life batteries that last 5–10 years.

3.1.8 New detectors in rental properties must be:
- photoelectric
- hard-wired or have a battery life of at least 8 years
- installed according to the manufacturer's instructions
- manufactured to international standards.

3.2 NUMBER OF ALARMS

3.2.1 Skimping on the number of installed smoke alarms is not considered prudent. The general principle is that an alarm must be given before any part of the escape route from any bedroom in the house is blocked by smoke.

3.2.2 As a minimum, smoke alarms must be installed on each level of a household unit. There must be a smoke alarm within every sleeping space or within 3 m of every bedroom door. While a single alarm (Figure 3) may be permitted for small to medium-sized dwellings if it is within 3 m of every bedroom door in the unit, it is better practice to install an alarm in each sleeping area and in the main living area.

3.2.3 For a single-level dwelling, install two alarms as a minimum where:
- the distance between the living area and sleeping area is more than 10 m (Figure 4)
- the living area is located between sleeping areas (Figure 5).

3.2.4 Dwellings of more than 1 storey should have a smoke alarm on each level typically located as shown in Figure 6 in addition to those in each bedroom. On the lower level, one should be in the living area near the stairs, and the other should be at the head of the stairs outside the sleeping area.

3.2.5 Where doors to living and sleeping areas are regularly closed, enough smoke should escape around most closed doors to activate a smoke alarm outside the room. For optimum safety, an interconnected alarm should be fitted within each sleeping area as well as in any corridor or stairwell to ensure the alarms will be heard by all occupants.

3.2.6 Fire and Emergency New Zealand can be consulted if in doubt about how many alarms to install or where to position them.

3.3 AUDIBILITY OF SMOKE ALARMS

3.3.1 A smoke alarm should produce a sound level of 85 dBA at 3 m distance. At this level, most sleeping people would be woken and escape before enough smoke accumulates to block the escape route. A sound level of 75 dBA is required where a sleeping person's head would be located.

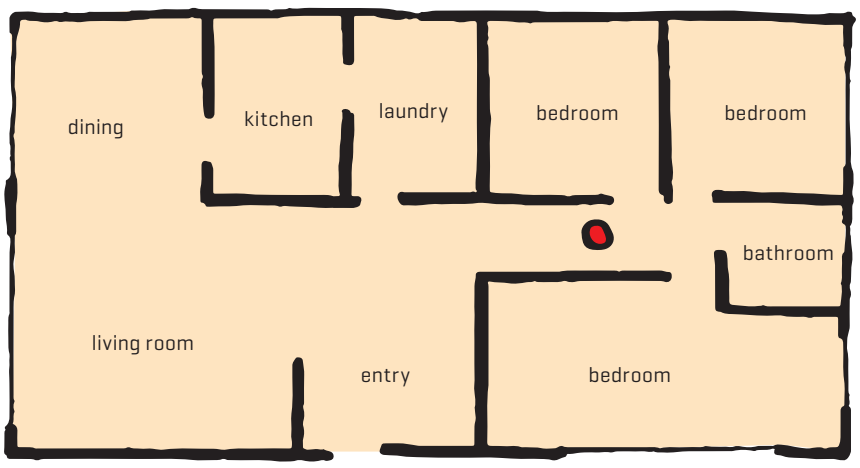

Figure 3. A smoke alarm in a small dwelling should be placed between the sleeping area and living area.

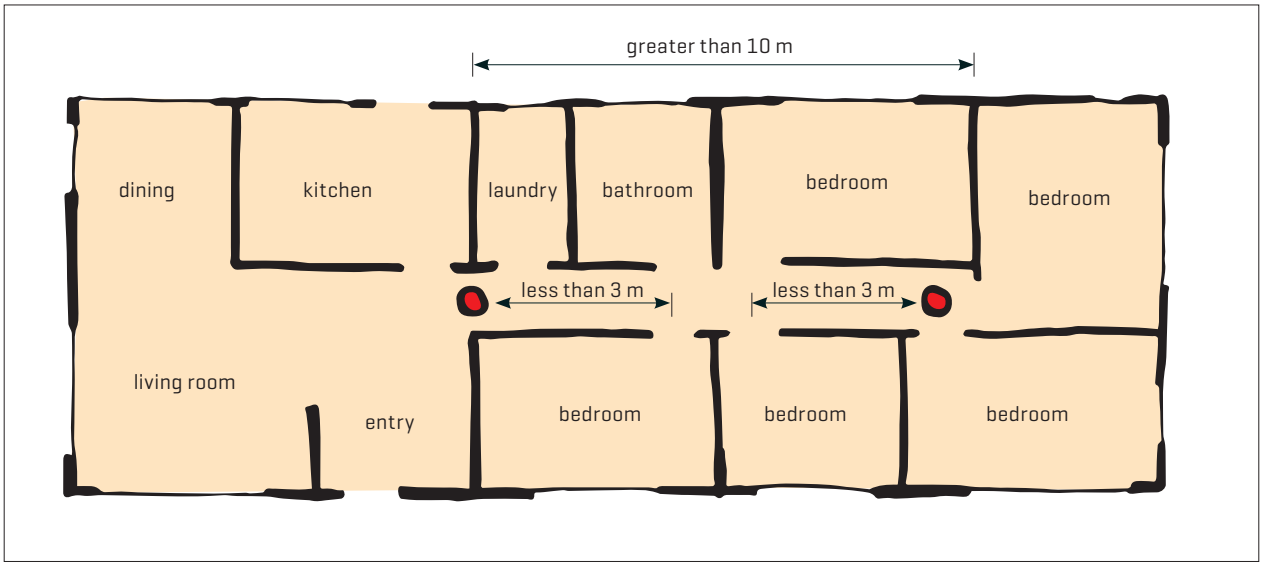

Figure 4. Two smoke alarms are needed in extended plan houses. A smoke alarm must be within 3 m of each bedroom door.

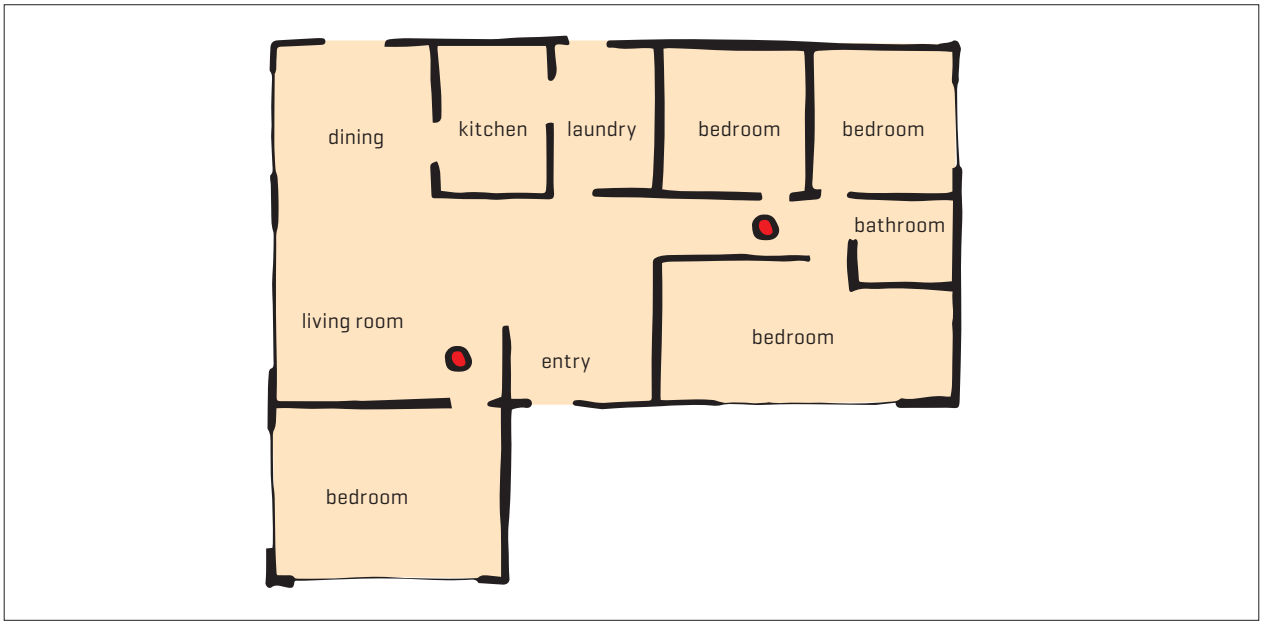

Figure 5. Two smoke alarms are needed where there are two sleeping areas separated by the living area.

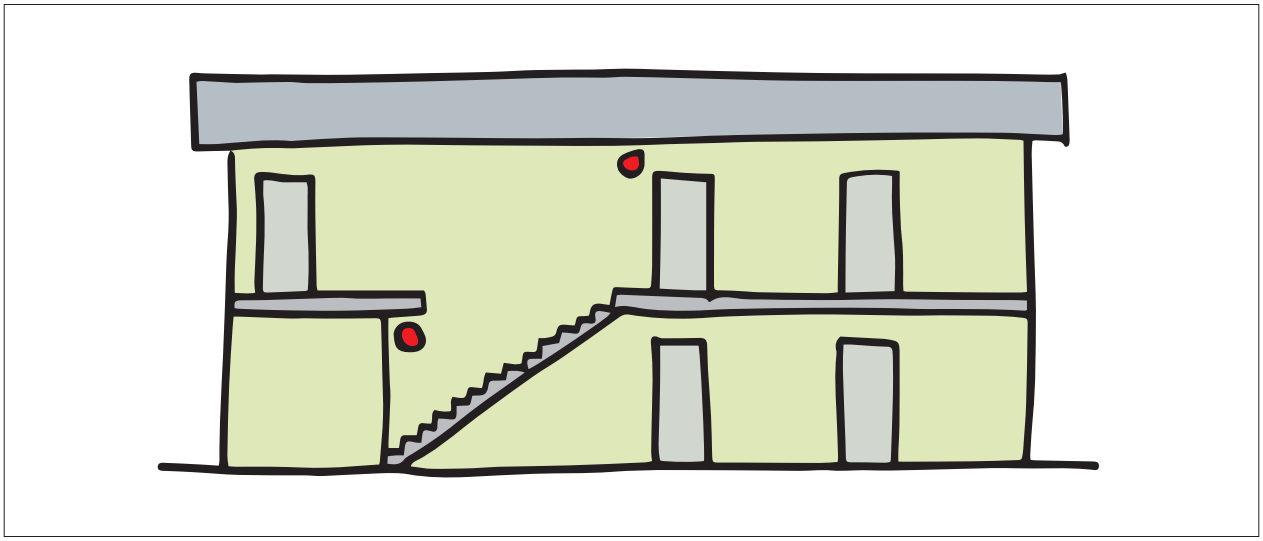

Figure 6. Where a house has more than 1 storey, there should be a smoke alarm on each level.

3.3.2 A closed door between the alarm and a sleeper reduces the level of sound heard (at the pillow) by about 15 dBA. Ambient noise levels (such as from a dehumidifier or air conditioner, which produce about 55 dBA at close range) also interfere with the ability of occupants to recognise and respond to the alarm. An alarm sound level of 15 dBA above ambient noise sources is considered just enough to wake the 'average' sleeper. This may not be sufficient to quickly wake children, people in deep sleep or people affected by alcohol or drugs.

3.3.3 It may be desirable to leave bedroom doors open to improve alarm audibility, but if this is not acceptable, additional smoke alarms within the sleeping area interconnected with those outside the bedroom are desirable. It should also be noted that open bedroom doors will allow more smoke to enter the bedroom from fires in other rooms of the house.

3.3.4 Alarm effectiveness will be reduced by:
- ambient noise levels above 55 dBA
- having a closed solid-core door between the alarm and the occupant
- locating a detector a significant distance away from the occupants – effectiveness is directly related to the proximity of the alarm to the occupants.

3.4 SMOKE ALARM MAINTENANCE

3.4.1 Smoke alarms must be maintained correctly to protect lives.

3.4.2 NZS 4514:2009 *Interconnected smoke alarms for houses* requires monthly testing of smoke alarms because the most likely cause of a smoke alarm failing to respond is a flat battery. Smoke alarms with long-life batteries reduce this failure risk. Testing is done by pressing the test button to activate the alarm. This simple check ensures that the circuits are operating and the battery voltage is adequate.

3.4.3 Some international standards also require that smoke alarms have a monitoring system that detects a drop in battery voltage and emits a warning sound for at least 7 days. The warning must be persistent enough to make the householder replace the battery. For smoke detectors without long-life batteries, use the summer change to daylight saving as the time to do a yearly change of alarm batteries.

3.4.4 Over time, smoke alarms accumulate dust that will create false alarms or inhibit correct response. Manufacturers recommend occasional cleaning with a vacuum cleaner, taking care not to damage the components. If necessary, seek the advice of the supplier.

3.5 SMOKE ALARM COMPLIANCE

3.5.1 To rely on smoke alarms to give effective early warning of a fire, there must be careful control and quality checks during manufacture. NZS 4514:2009 requires that smoke alarms used in New Zealand comply with the latest revision of one of the following standards:
- UL 217 *Standard for smoke alarms* (US).
- ULC S531 *Standard for smoke alarms* (Canada).
- BS 5446 *Part 1 Fire detection and fire alarm devices for dwellings: Specification for smoke alarms*.
- EN 14604 *Smoke alarm devices*.
- ISO 12239 *Smoke alarms using scattered light, transmitted light or ionization*.
- AS 3786 *Smoke alarms using scattered light, transmitted light or ionization*.

3.5.2 Alarms must be labelled to show compliance with one of the above standards.

3.6 FALSE ALARMS

3.6.1 On the positive side, false alarms are useful indications that the alarm is operating, but if they are too frequent, they can be irritating, leading to battery removal or the disconnection of alarms from the mains. Currently available models are sensitive to small quantities of smoke – burnt toast is a common cause of false alarms. Correct location can usually avoid false alarms, so alarms shouldn't be installed in kitchens or bathrooms. Heat alarms may be considered in these locations as an alternative. Strong winds or air currents may also falsely activate the detector.

3.6.2 One of the benefits of new smoke alarm technology and test standards is fewer false alarms. For instance, United States standards organisation UL updated its alarm and detector standards in 2018 with new requirements designed to better test how well smoke alarms can distinguish between fires and nuisance cooking activations.

3.7 SMOKE ALARM LIMITATIONS

3.7.1 Limitations of smoke alarms include that they:
- are only an aid to gaining valuable time to escape
- are not a substitute for the planned escape procedures that every household should have
- can give a false sense of safety
- are not a life saver for the very young or very old, those confined to a bed or wheelchair or those under the influence of alcohol or drugs – these people will need assistance from others who are alert and able.

3.7.2 Smoke alarms cannot protect occupants in the following situations:
- Alarms have been disabled.
- Alarms are ignored by people delaying their escape to collect valuables.
- An escape route is blocked by fire. Escape route alternatives (windows, other doors) should be considered before a fire occurs. Escape routes need to be kept clear at all times.
- The small amount of time available for escape after the alarm sounds is not adequate. The time from the first smoke generated to the time when escape routes may be obscured can be less than 2 minutes.
- The fire has been contained within a room without an alarm. The intensity of a confined fire is much greater at the stage when an alarm outside the room is sounded, which reduces the escape time available.
- There are hearing-impaired occupants. If a deaf person is alone in a dwelling, special attention needs to be given to providing an alternative means of warning such as a strobe light located in the person's bedroom.
- Sleeping, intoxicated or drug-influenced occupants may sleep through an alarm or lose valuable time for escape by responding too slowly. This situation can be mitigated only by having others present who may

respond more readily to the alarm and subsequently wake and assist with evacuation.

3.8 MULTI-OCCUPANCY DWELLINGS

3.8.1 Stand-alone alarms are not suitable for multiple-occupancy buildings such as hotels, rest homes and the like, where it is important to have all occupants made aware of the fire with the minimum of delay.

4 LOCATION OF SMOKE ALARMS

4.0.1 Alarms should be fixed to the ceiling (as high as possible for sloped ceilings).

4.0.2 Fixing to the wall is acceptable if mounting to the ceiling is not possible or the ceiling temperature will be significantly colder than the space below (for example, the space above the ceiling lining is open to the outside with little or no insulation). Alarms should be:

- mounted 100–300 mm below the ceiling (Figure 7)
- located on an internal wall rather than on an uninsulated external wall.

4.0.3 If it will not affect operation, locations that allow safer access to the smoke alarms may be considered. For instance, a location that can be reached from a mezzanine walkway may be preferable to a location only accessible from the lower floor in a tall room.

4.0.4 Unsuitable locations are:

- dead spaces where smoke won't reach the detector, such as in an internal corner or in a room that has a mezzanine floor and a high-pitched ceiling (Figure 1)
- adjacent to airflows from open windows, fans or doors, fixed ventilation systems and air conditioning system outlets, as they may prevent the smoke reaching and activating the detector
- in or near kitchens and bathrooms, as false alarms may occur.

4.0.5 Installation and operating instructions for each alarm should be followed.

5 DOMESTIC SPRINKLERS

5.0.1 A domestic fire sprinkler system works by discharging water automatically on a fire when sufficient heat is sensed by a nearby sprinkler head. The heat required to cause activation of the sprinkler head occurs when the flame is approximately the height of a standing adult. This means discharge of water generally occurs over a growing fire, thus slowing its growth and in many cases putting it out.

5.0.2 The sprinkler heads are designed to evenly apply water spray over the area directly below and up the walls to both wet and cool the room on fire. The coverage area of a sprinkler head can be as much as 6 x 6 m (36 m²), provided there is sufficient pressure and flow.

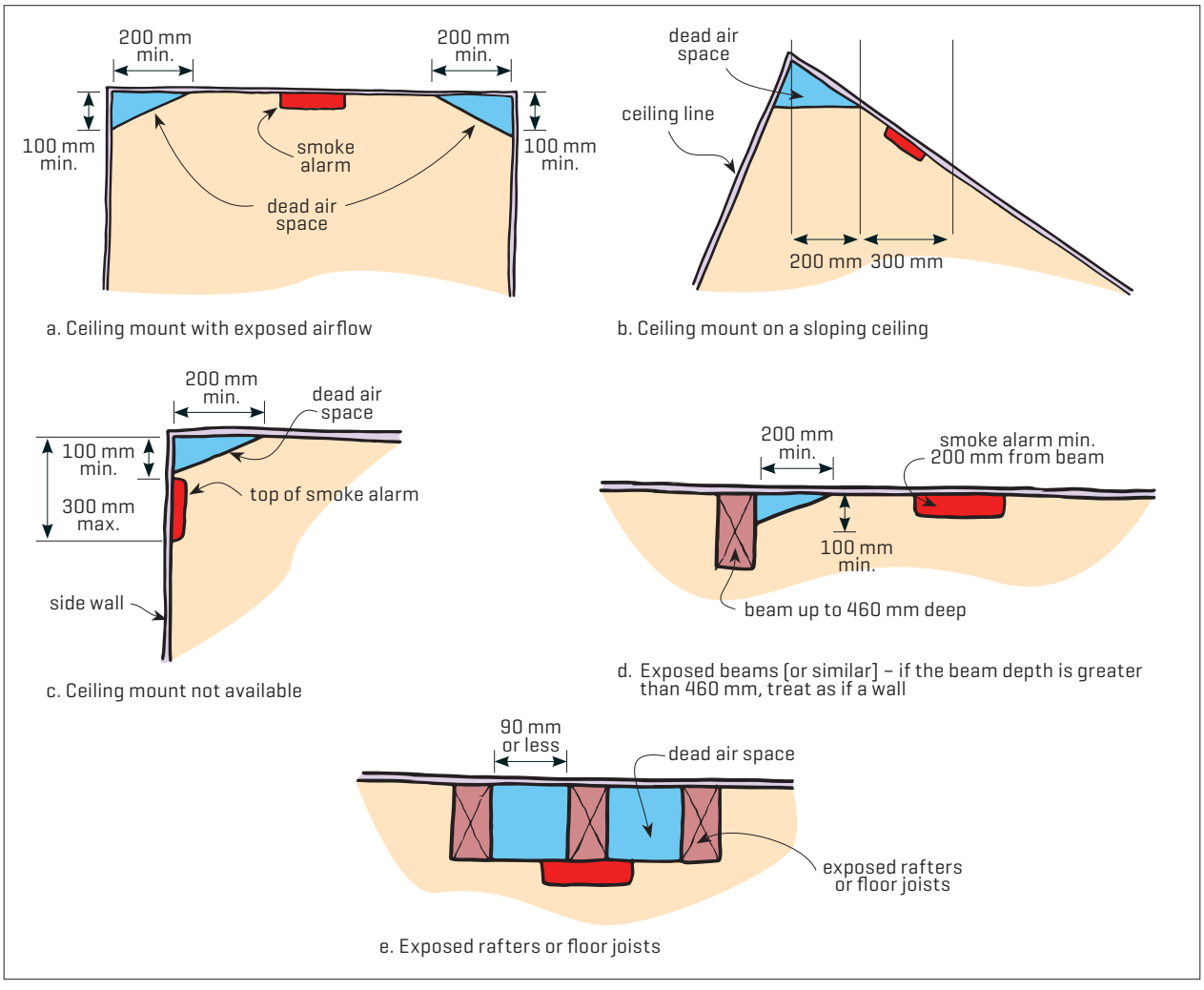

Figure 7. Acceptable locations for smoke alarms to ensure proper operation as per NZS 4514:2009.

5.0.3 Only the sprinklers necessary to control the fire will activate, and they will usually activate later than smoke alarms, which reduces the potential for unintended water damage.

5.1 SPRINKLER INSTALLATIONS

5.1.1 Sprinkler systems should be designed by a specialist and, if incorporated as part of the potable domestic plumbing, can only be installed by a registered plumber in accordance with NZS 4517:2010 *Fire sprinkler systems for houses*.

5.1.2 They are predominantly considered a life safety system. Installed to the minimum requirements of NZS 4517:2010, they are generally accepted as being at least 75% reliable in sufficiently controlling a fire's growth to delay the onset of flashover for 10 minutes, allowing more time to escape.

5.1.3 Sprinklers work best in smaller rooms such as bedrooms. They tend to operate faster and the water spray discharge is maximised in the space, extinguishing the fire in most cases.

5.1.4 Sprinkler systems are designed to apply water directly to the fire as it develops. Only the sprinkler head nearest the fire will activate at first, and because it will activate quickly, the damage caused by the fire is reduced. Fire sprinkler systems for houses are designed to have a maximum of two sprinkler heads operating at any one time.

5.1.5 A sprinkler head will release approximately 1 litre of water per second and will operate when the fire is relatively small. Without sprinklers, Fire and Emergency New Zealand may need up to 40 litres of water per second to control a fire that has continued to grow until their arrival, resulting in considerable water damage as well as significant heat damage.

5.2 SPRINKLER OPERATION

5.2.1 Sprinklers operate by using heat-detecting elements that will react to an increase in the temperature of the air surrounding them.

5.2.2 For domestic systems, the heat-sensitive element is most likely to be the glass bulb type (Figure 8). Fusible-link heat-sensitive elements can be used in other types of fire sprinkler systems but are rare in domestic systems.

5.2.3 Sprinkler sensors with differing temperature sensitivities are available, so sprinklers close to a known heat source can be selected to operate at a higher activation level. The activating temperature of the head is indicated by the colour of the liquid in the bulb. The most common activating temperature for domestic sprinklers is 68°C, which is indicated by a red liquid in glass-bulb sprinklers.

5.2.4 The activation time of a sprinkler is also determined by how fast heat is transferred from the hot fire gases to the sprinkler sensor. Domestic sprinkler heads usually use quick-response sensors and will respond more quickly than sprinklers with standard-response sensors. Earlier activation while the fire is smaller increases the chances that the sprinkler will control the fire. For domestic sprinklers, a 3 mm diameter glass bulb indicates quick response, while a 5 mm diameter bulb indicates standard response.

5.2.5 The spray pattern for domestic sprinklers is flat and wide. Water spray must impinge upon the surrounding walls to within 700 mm of the ceiling.

5.2.6 Critical components such as sprinkler heads should be listed by a sprinkler system certifier as defined in NZS 4517:2010.

5.3 MOUNTING OPTIONS

5.3.1 Domestic sprinkler heads available include:

- Concealed – the sprinkler head is mounted above the ceiling with only the deflector protruding below. These will usually have a decorative cover plate held in place by a low-temperature melting solder, which allows the cover to drop away before the sprinkler activates (Figure 9).
- Flush-mounted – similar to a concealed sprinkler head but not covered by a plate, the deflector protrudes slightly below the ceiling.

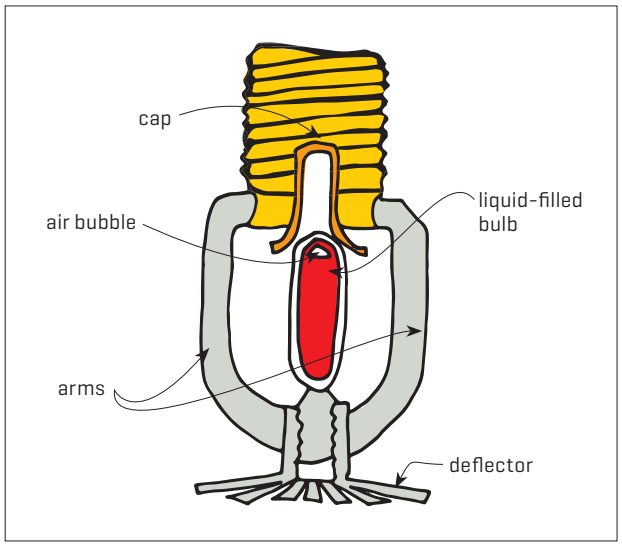

Figure 8. Glass bulb type sprinkler.

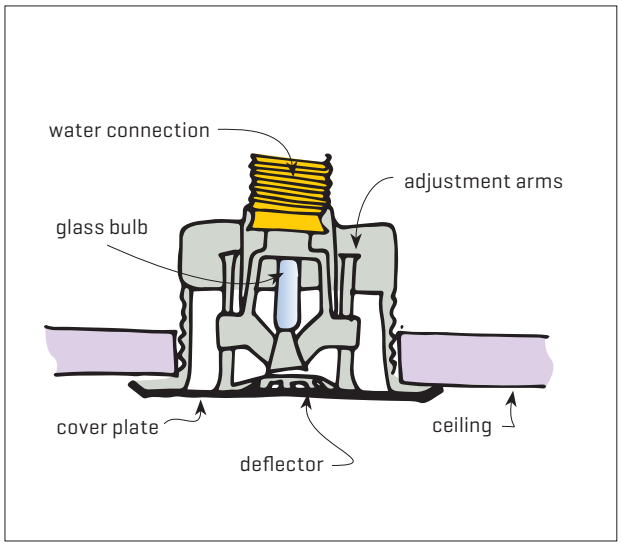

Figure 9. Concealed sprinkler head.

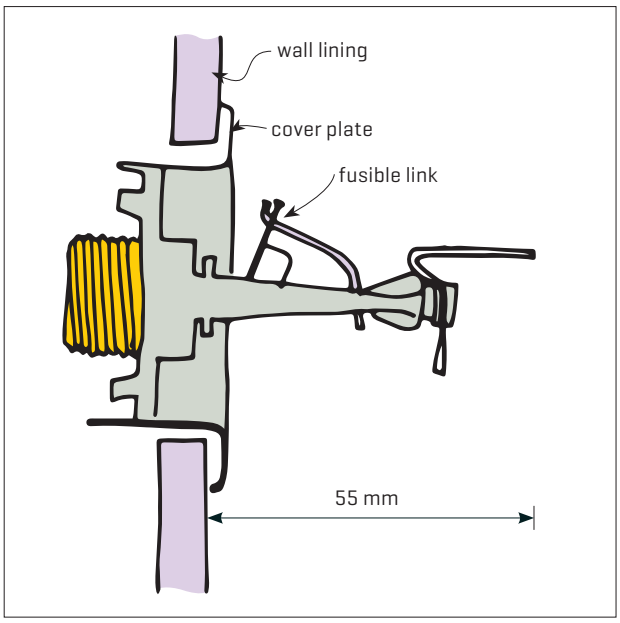

Figure 10. Horizontal sidewall sprinkler head.

- Sidewall – designed to be mounted high on a wall, these are suitable if pipework in a roofspace is not feasible (Figure 10).
- Pendant – hung from a supply pipe or short dropper to place the deflector a maximum of 100 mm below the ceiling.

5.3.2 Concealed and flush-mounted sprinkler heads will take slightly longer to activate than sidewall or pendant sprinkler heads. They may also be less susceptible to mechanical damage, which could cause inadvertent water discharge and subsequent damage.

5.4 WATER SUPPLIES

5.4.1 A 25 mm internal diameter pipe connection to the water supply should be suitable for a home sprinkler system. If the water supply is metered, it should be fitted with a low friction loss 25 mm meter to limit the pressure loss.

5.4.2 Every valve within the system capable of interrupting the sprinkler flow must be marked as follows: "Supply to domestic and fire sprinkler system – sprinkler protection not available if turned off."

5.4.3 Although the water pressure supplied by the local authority will normally be sufficient, the actual pressure at the supply point must be measured for the purposes of calculating the pressures and flows for the sprinkler system.

5.4.4 The additional cost of a domestic sprinkler system above the domestic potable water supply plumbing can be minimised with careful thought around piping layout. Figure 11 shows a simple cold water supply loop that can be installed in the ceiling plane, supplying all household cold potable water and fire sprinkler water needs. An interconnected and hard-wired smoke detection system is shown as well.

6 FURTHER INFORMATION

STANDARDS NEW ZEALAND

NZS 4512:2010 *Fire detection and alarm systems in buildings*
NZS 4514:2009 *Interconnected smoke alarms for houses*
NZS 4517:2010 *Fire sprinkler systems for houses*
NZS 4541:2013 *Automatic fire sprinkler systems*

WEB RESOURCES

- Fire and Emergency New Zealand smoke alarm advice – www.fireandemergency.nz/at-home/smoke-alarms
- Tenancy Service information on 2016 changes to smoke alarm requirements for rental properties – www.tenancy.govt.nz/maintenance-and-inspections/smoke-alarms
- *Build* 121 'Bringing fire sprinklers into homes' – www.buildmagazine.org.nz/articles/show/bringing-fire-sprinklers-into-homes

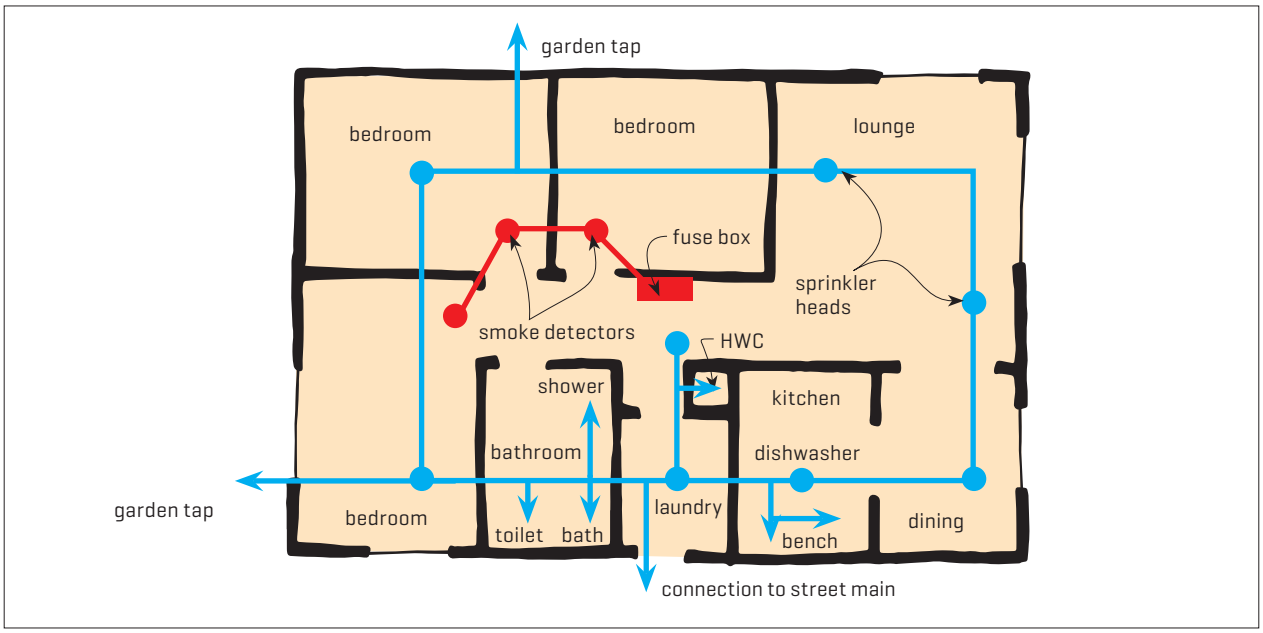

Figure 11. Cold water supply loop and interconnected and hard-wired smoke detection system.

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