BRANZ

ISSUE606 BULLETIN

RESIDENTIAL FIRE SAFETY

February 2017

- This bulletin outlines for building designers a number of easily incorporated design tools that can increase occupants' safety within a building.
- Minimum statutory fire safety requirements are given in New Zealand Building Code clauses C1 to C6.
- This bulletin updates and replaces Bulletin 420 *Designing for fire safety.*

1.0 INTRODUCTION

1.0.1 For greater occupant safety, buildings should be designed to minimise the risk and spread of fire. Minimum statutory fire safety requirements are given in New Zealand Building Code (NZBC) clauses C1–C6 *Protection from fire*.

1.0.2 This bulletin is aimed primarily at building designers and outlines a number of easily incorporated design tools that can increase occupants' safety within a residential building. It also describes a number of terms used in the NZBC *Protection from fire* clauses and Acceptable Solutions.

1.0.3 This bulletin:
- provides a brief outline of the key statutory fire safety requirements
- outlines the common causes of fires and their locations in residential buildings
- describes the developmental stages of a fire and its effects on occupants
- outlines simple good fire safety design practice, with a focus primarily on residential buildings
- while aimed at building designers, provides useful information for residential building managers, IQPs and risk assessors.

1.0.4 This bulletin updates and replaces Bulletin 420 *Designing for fire safety*.

2.0 NEW ZEALAND BUILDING CODE

2.0.1 NZBC clauses *Protection from fire* focus on the safety of the people occupying buildings and on facilitating their evacuation to a safe area in the event of a fire. The objectives of the clauses are to:
- safeguard people from an unacceptable risk of injury or illness caused by fire
- protect other property from damage caused by fire
- facilitate fire-fighting and rescue operations.

2.0.2 The NZBC also includes functional requirements and performance criteria. There are three ways to comply with the NZBC requirements: Acceptable Solutions, Verification Methods and Alternative Solutions.

2.1 WHAT THE ACCEPTABLE SOLUTIONS REQUIRE

2.1.1 Buildings are categorised by seven different risk groups, and each risk group has different requirements in the Acceptable Solutions. Generally, the requirements are under the following parts:
- Firecells, fire safety systems and fire resistance ratings
- Means of escape
- Control of internal fire and smoke spread
- Control of external fire spread
- Fire-fighting
- Prevention of fire occurring.

2.1.2 A single-unit detached dwelling, for instance, belongs to the risk group SH. In this case, there are no requirements relating to creating firecells, but smoke alarms are required to be installed. The maximum distance of travel to an exit is limited. To control external fire spread, external walls close to a boundary require a fire resistance rating. In the same way for the other risk groups, the specific requirements are included in each part.

2.1.3 A fire resistance rating (FRR) may be required either to protect the means of escape and limit internal fire and smoke spread or to control external fire spread. An example of an FRR is:
- 30/30/30 indicating structural adequacy 30 minutes, integrity 30 minutes and insulation 30 minutes, respectively.

2.1.4 It should be noted that the durations are measured for a construction when subjected to a given fire condition in a test furnace as specified in the relevant fire test standard. Therefore, it does not mean that building elements can survive for the listed time period in an actual fire condition different from the standard fire condition. FRRs only indicate comparative performance among different products exposed to the same fire condition.

2.1.5 Within a residential building, FRRs are required for building elements that provide separation between attached household units.

2.1.6 Specific FRRs are also required for elements that:
- provide protection to defined protected (escape) paths to allow all residential (apartment) building occupants to reach a place of safety in the event of a fire
- are structural elements of the building (defined by the performance requirements of NZBC clause B1 *Structure*) where collapse of such elements would constitute a loss of the FRR of the element or a risk to occupant safety or cause damage to an adjacent property.

2.1.7 Select materials and surface finishes to minimise the possibility of, and to control, fire development and fire spread in buildings. Meeting reaction to fire criteria is a statutory requirement in areas such as protected exit routes.

3.0 CHARACTERISTICS OF RESIDENTIAL BUILDING FIRES

3.0.1 There are many causes of fire in residential buildings. Typically, they result from human behaviour. The most common examples, taken from New Zealand Fire Service Statistics from 2005 to 2013, are:
- carelessness with a heat source
- electrical fault or mechanical malfunction
- deliberately lit.

3.0.2 More specific causes may include:
- inattention when cooking, particularly when using cooking oils or fats – risk is higher when the user has consumed too much alcohol
- the use of candles as a primary or secondary light source, particularly in dwellings occupied by

Careless use of a cooking appliance can easily start a fire.

teenagers and young children
- not using heat sources carefully – for example, clothes being dried too close to a source of heat or candles burning next to curtains
- children playing with matches or lighters
- chimney fires
- electrical malfunction, usually from wiring in a poor or unsafe condition, overloaded electrical circuits or faulty appliances
- unattended cooktops or ovens, portable or fixed heating and open fires
- careless use or disposal of cigarettes
- unsafe solid fuel heating appliances
- wilful damage
- faulty electric blankets or clothes driers.

3.0.3 The most common rooms/spaces of fire origin in residential buildings are:
- kitchen or cooking area
- lounge, common room, TV room, sitting room or music room
- bedroom or sleeping area
- garage, carport, vehicle storage or storage shed.

3.0.4 Fire in residential buildings is more common in the evening, especially around dinner time and early evening.

4.0 RISK TO OCCUPANTS

4.0.1 Based on the fatality data from New Zealand Fire Service statistics from 2005 to 2013 and New Zealand demographics for 2013, the groups that showed the highest death ratio per capita, in descending order, were:
- those over 70
- males aged 50–59
- males aged 20–29
- males aged 30–39.

4.0.2 The risk of death from a fire is greater when the occupants are sleeping. This is because the occupants' level of alertness is significantly reduced, so the fire often develops and spreads significantly before they are aware of it. This is especially true if the fire starts in a room away from the sleeping area.

5.0 WHEN A FIRE OCCURS

5.1 REACTION TO FIRE

5.1.1 A person's reaction to a fire emergency is affected (and potentially slowed) by:
- their age (the elderly are at particular risk)
- their physical or mental condition
- how much alcohol they have consumed
- the amount of warning given
- their level of activity – whether awake or asleep
- the people around them (in crowd situations).

5.1.2 Other important influences are:
- how quickly they are made aware of the fire – for example, if they become aware of a fire immediately after it has started, the air is likely to contain less smoke and toxic gases and they will have more time to escape
- the clarity of clues given by the building (signage, layout) to aid escape
- their familiarity with the building
- how prepared they are for an emergency.

5.2 CAUSES OF FIRE INJURIES AND FATALITIES

5.2.1 Smoke and toxic gases produced when room contents, surfaces or other building materials burn cause most fire injuries and deaths:
- Smoke is gaseous, toxic and hotter than its surroundings and is very buoyant, so it can rapidly move through a residential building. It can overcome occupants or block their means of escape before they can reach a safe place.
- Dense smoke reduces the distance people can see and obscures the path to an exit. If occupants' escape from the building is obscured, it may cause them to become disoriented and confused. This, in turn, may lead to irrational behaviour.
- Smoke can also be a narcotic (oxygen depletion in the brain can affect reasoning), an asphyxiant (lowering the ability to concentrate) and a respiratory irritant.
- The release of adrenalin and increased physical activity when a person is caught in a fire increases heart and breathing rates and therefore the amount of smoke inhaled.

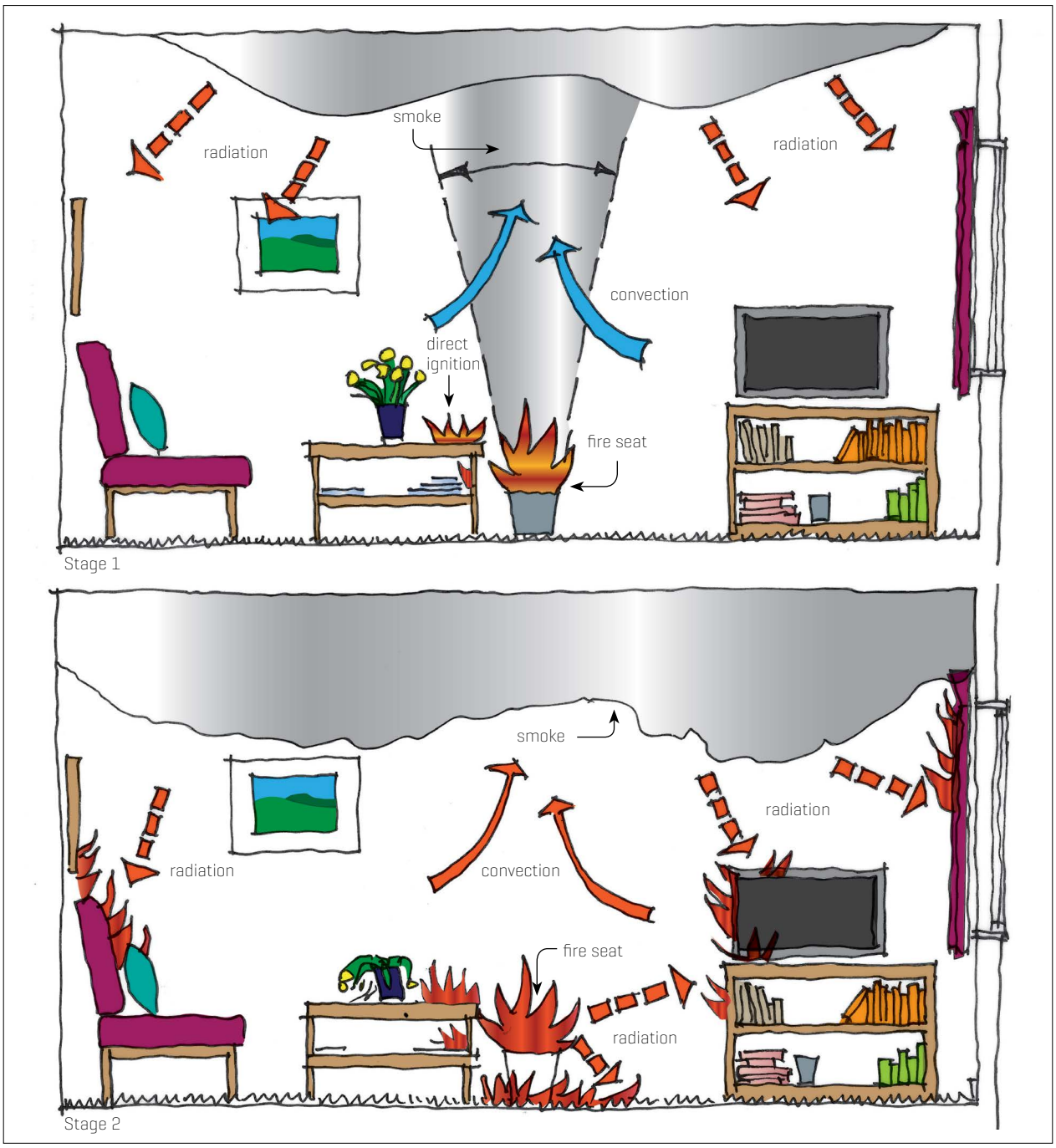

Figure 1. Development of fire.

6.0 FIRE DEVELOPMENT

6.1 IGNITION

6.1.1 Whatever the cause, a fire almost always has small beginnings. The rate of fire growth can vary from very slow to extremely rapid. The rate depends on the combustibility of the building's contents, how the contents are arranged and the amount of ventilation (oxygen) provided.

6.2 FIRE GROWTH

6.2.1 All fires develop through a number of stages, provided that oxygen, fuel and heat are available (Figure 1):

- Initial ignition.
- Fire growth and spread – this is initially upwards, then outwards from the point of origin. Radiation may ignite adjacent combustible materials such as chairs or curtains.
- Ignition at ceiling level.
- Flashover, which is when the whole room or space suddenly catches fire. This is when oxygen levels within the room begin to drop and the levels of toxic gases such as carbon monoxide increase rapidly.

6.2.2 Depending on the materials being burnt, a fire may give off invisible smoke, a gas that is dangerous to the occupants or a thick choking smoke.

6.2.3 At night, the time available for a person to wake up and safely escape from smoke is relatively short – estimated to be 2–3 minutes.

6.3 SMOKE SPREAD

6.3.1 Smoke generated by a fire will migrate through all but the smallest of gaps in construction from the point of origin to other spaces. Hot smoke in particular will easily move to the upper levels of a building.

6.3.2 Hot smoke will continue rising until one of these situations occurs:

- It is halted by an obstruction such as a ceiling. As further smoke is generated, it spreads horizontally across the ceiling until it reaches the walls. It then begins to fill the room from the ceiling down and will escape through openings and gaps.
- It cools down enough to stop rising and begins to fall.
- It is cooled by water from sprinklers or fire-fighting operations.

6.4 FIRE SPREAD

6.4.1 Initially, fire spreads as a result of flames impacting on adjacent materials, then spreads through larger gaps and open doors or breaking windows to other spaces in the building. Further spread occurs, often rapidly, as a result of unburnt gases in the smoke where sufficient air or oxygen is present. If this occurs in close proximity to combustible materials, this radiant heat causes further ignition (of ceiling linings, curtains or adjacent furniture). Subsequent spread occurs after the fire has burnt through elements such as the walls and ceilings containing it, or radiated heat has ignited combustible materials on the other side of a wall.

6.4.2 The amount of fire damage caused is directly related to the maximum temperature reached during the fire and the extent of fire spread. Smoke and water damage (from sprinklers or Fire Service intervention) may extend well beyond the area of direct burn damage. This damage may be less significant than the burn damage, but with water, the damage may spread to other lower floors in multi-level residential buildings.

6.5 FIRE SEVERITY

6.5.1 The severity of a particular fire is influenced by fuel and compartment characteristics.

6.5.2 Fuel characteristics include:

- the combustibility of fuel
- the amount of fuel
- the arrangement of fuel.

6.5.3 Compartment characteristics include:

- interior finishes (combustible ceiling and wall linings)
- the size and shape of the area containing the fire
- the area and shape of the openings (windows and doors)
- whether windows are open or break during a fire.

7.0 FIRE DETECTION/SUPPRESSION

7.1 WARNING TIME

7.1.1 Occupants of a building should be alerted to the presence of a fire as soon as possible so they can escape safely. The time available for escape can be as little as 2 minutes depending on the fire's speed of development and where the fire is located in relation to means of escape.

7.1.2 The Fire Service should be called as soon as possible, and if it is safe to do so, fire hose reels or fire extinguishers can be used by trained building occupants.

7.2 FIRE DETECTION EQUIPMENT

7.2.1 Common options for automatically detecting residential fire are:

- photoelectric smoke detectors (more responsive to smouldering fires and less prone to false alarm)
- ionisation smoke detectors (more responsive to flaming fires)
- combined ionisation/photoelectric smoke detectors (recommended)
- fixed-temperature heat detectors (recommended where frequent false alarms are likely to occur with smoke detectors or where rapid fire growth is likely).

7.2.2 Fires can be detected and almost always controlled by properly designed, installed and maintained automatic fire sprinkler systems. This will stop fires before they develop sufficiently to cause major damage. Sprinklers, particularly those with fast-response heads, suppress the fire, enhance the safety of occupants (and facilitate their escape) and will protect property.

7.2.3 In multi-unit developments, the smoke or heat detection in each dwelling unit can be stand-alone battery units or be a component of a centralised system.

7.3 AUTOMATIC FIRE SPRINKLER SYSTEMS

7.3.1 Automatic fire sprinkler systems installed in multi-unit apartment buildings may be largely categorised into four types: wet-pipe, dry-pipe, deluge and pre-action.

- Wet-pipe: Pipes are charged with water. When a sprinkler head operates, water flows immediately through it. This type is the most commonly used.
- Dry-pipe: Pipes are filled with air or nitrogen. When a sprinkler head operates, water flows through the head after air or nitrogen is released first. This type is often used when risk of pipes freezing is high.
- Deluge: Sprinkler heads are open. Water flows into the pipes after an activation of a separate detection system. This type is often used for high hazard areas.
- Pre-action: Sprinkler heads are closed. Water flows into pipes after an activation of a separate fire detection. This type is often used where preventing accidental discharge is critical.

7.3.2 An automatic wet-pipe fire sprinkler system for stand-alone houses is also available. It may be easily integrated into the domestic water pipe network or can have its own dedicated pipework originating from the main house water supply. Integration into the plumbing network only requires a simple valve system.

8.0 FIRE-SAFE BUILDING DESIGN

8.0.1 The layout, materials, use and contents within a residential building can have a significant effect on the rate of fire growth.

8.1 DESIGNING TO REDUCE FIRE HAZARD

8.1.1 Simple measures to reduce fire hazard include the following:

- Use furniture that is shaped so that there are no traps for discarded cigarettes or matches.
- Use flame-resistant fabrics. Plastic furnishing materials, particularly foam plastics, polyurethanes and nylons, should be used with caution because they rapidly release heat and can give off toxic fumes when burnt. Fires in furniture made by traditional methods (such as sofas or chairs that have a spring interior with hair or felt filling) generally develop more slowly than those in modern furniture, but they will burn for longer.

8.1.2 The building designer or interior designer can directly influence fire safety by taking into account the following:

- The size of the space and what it is to be used for. Well furnished rooms can contain greater amounts of combustible materials and finishes.
- The height of the ceiling. The lower the ceiling, the greater the potential for faster fire development as radiant heat feedback (from the ceiling) onto combustible surfaces increases.
- The amount of permanent ventilation to be provided and the area of openings in walls such as open doors and windows or when windows break. Small openings will fuel a developing fire because of the air supply provided.
- The type of fuel in the spaces and their rate of burning. With our increasing use of synthetically based furnishings (derived from the oil industry), the development of a fire to flashover can be fuelled by a single item of furnishing, such as an upholstered foam chair cushion or foam mattress within a bedroom.)
- The way a material is used and its weight. Lightweight fabrics, particularly those hanging loosely in long lengths, can ignite more easily and burn faster.
- The materials and finishes used on ceilings, walls and floors. Designers should determine the reaction to fire properties of materials and finishes and choose those that will be less likely to ignite or to generate smoke if ignited. This should not be compromised by aesthetic or acoustic aspects of the finishes.

8.2 FIRE-SAFE HOUSE DESIGN

8.2.1 Ways to enhance fire safety in new or remodelled residential units:

- Consider the installation of domestic fire sprinklers.
- Install interconnected mains-powered smoke alarms or devices that cover all areas of the house – smoke alarms are mandatory in all new dwellings and in buildings being renovated under a building consent.
- Ensure there are more than enough electrical circuits so individual outlets do not become overloaded through the use of adaptors and multi-boxes.
- Ensure that the areas of the house where it is most likely for a fire to start (kitchen and living rooms) can be closed off from the rest of the dwelling (particularly the sleeping areas).
- Ensure bedrooms have more than one means of escape so that occupants do not pass through the higher-risk areas such as living rooms and kitchens.
- Choose finishes that will be less likely to ignite or to generate smoke if ignited.
- If possible, provide two means of escape from upper floors – windows may be considered as a means of emergency escape provided the occupants can readily and safely use them.
- Locate cooktops where they would not block an exit from the kitchen if there were a fire on the cooktop.

Occupants need to be alerted to a fire as soon as possible.

- Specify solid core doors (because they resist fire better than hollow core doors) between bedrooms and the higher fire risk areas of the home.
- Ensure the travel distance to the nearest exit is minimised – it may only take 2–3 minutes for a fire to become life-threatening.
- Line walls next to cooktops with a fire-resistant material.
- Vent rangehoods through the roof or wall to the outside.
- Ensure appliances, particularly solid fuel stoves, are properly installed (and regularly checked).
- Don't locate mirrors directly above heaters and fireplaces because they attract people to stand directly in front of them, increasing the risk of setting clothing alight.
- Provide night or emergency lights – locate emergency lighting near the floor or at stair-tread level in corridors and stairwells to provide better light for escape routes.
- Avoid the use of combustible roofing material next to chimneys or flues.
- Ensure ceiling luminaires are installed appropriately and will not overheat due to placement of insulation.
- Advise owners of the risk of poor housekeeping – they should avoid clutter, keep escape paths clear, not remove alarm batteries and so on.

8.2.2 Ways to improve fire safety in existing homes:
- Install interconnected smoke alarms in each bedroom and at changes in level – it is a mandatory requirement to install smoke alarms in all new buildings and also when a building consent for alterations is issued.
- Ensure doors with deadlocks can be opened easily from the inside (leave the key in the lock).
- Ensure wiring is kept in good condition – provide additional power outlets if possible to prevent overloading or use overload-protected multi-boxes.
- Have the following fire safety equipment readily accessible:
  - One or more portable fire extinguishers (a 1.8 kg capacity multi-purpose dry powder type) with one located beside an exit door.
  - A fire blanket (in the kitchen).
  - A permanently connected garden hose capable of reaching all areas of the home.
- Provide safe childproof storage for matches and lighters.
- Clean flues and chimneys yearly.
- Work out an escape plan in advance, and make sure all dwelling occupants know what to do.
- Keep heaters and candles away from materials that will burn.
- Use fire guards on traditional open fires.

8.3 MULTI-UNIT DWELLINGS

8.3.1 Ways to enhance occupant safety in multi-unit residential buildings:
- Provide a centralised early warning system to alert building occupants to any fire that may develop anywhere in the complex.
- Install fire sprinklers to contain or quickly extinguish fire.
- Use finishes and materials that do not generate or that minimise the generation of heat and smoke.
- Pressurise spaces such as exitways in apartments to keep them clear of smoke.
- Ensure fire separations between dwelling units are not compromised by incorrectly installed penetrations or gaps.
- In apartment buildings, install automatically activated smoke control doors, and damper or shutter systems to openings between compartments.
- Install quality signage and emergency lighting where required.
- Provide information through pattern or texture – for example, by using a different material to define exit routes.
- Provide strong clues (signage, indicating travel paths in floor finishes) to the location of exits because people usually (and especially in an emergency) try to leave a building by the way they came in.
- Avoid ambiguity in building layouts and finishes that might give people the wrong signals and may direct them away from an exit.
- Provide sufficient safe (secure) storage for combustible materials to prevent them obstructing traffic routes or being accidentally (or purposefully) ignited.
- Do not paint the exit door the same colour as the surrounding wall.
- Provide adequate lighting levels, both ordinary and emergency (in accordance with the fire safety Acceptable Solution).
- Use luminous signs.
- Locate signage in a consistent manner so it is easier to find in an emergency.
- Provide signs at a high level (so they can be seen in a crowd situation) and at a low level near the floor (so they can be seen in a smoke-filled building).
- Organise signs in a consistent hierarchy with a descending order of importance (Figure 2):
  1. Mandatory signs.
  2. Direction signs.
  3. Signs to identify places and persons.
  4. Advertising signs.
- Use simple graphic symbols as these can convey information more efficiently than text.
- Provide vision panels in doors to allow occupants to see through and confirm that the space behind the door is safe.
- Locate emergency lighting at a high level and close to the floor to improve lighting in smoke conditions.

8.4 CONSTRUCTION AND SUPERVISION PRACTICES

8.4.1 A building that has been designed to be fire safe will not be successful unless construction practices, particularly for buildings with specific NZBC fire safety requirements, follow the same standards.

8.4.2 Maintaining the integrity of the fire stopping around the perimeter of fire and smoke separations is extremely important, particularly in multi-unit residential developments. Particular attention should

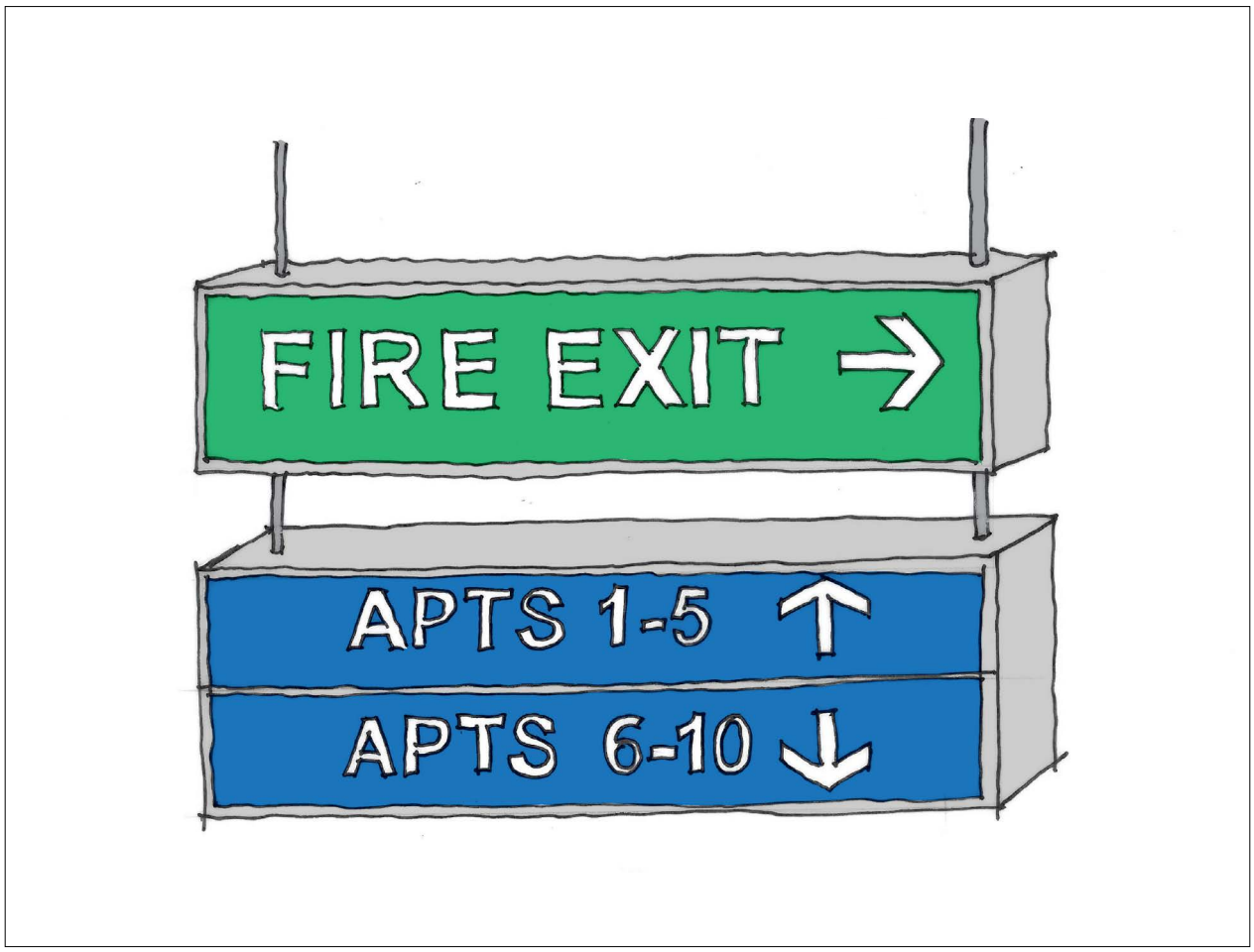

Figure 2. Establishing a hierarchy of signage.

be paid to:

- ducts, vertical shafts and other voids
- penetrations through fire separations
- gaps that occur between the floor structure and the external cladding
- seismic gaps, particularly where they change direction or plane
- services and ducts crossing seismic gaps or penetrating fire separations
- gaps occurring within ceiling voids or hidden spaces, such as ventilation ducts or refuse chutes
- junctions between fire separations and ceilings
- junctions of fire separations and curtain wall systems
- service outlets (electrical outlets) located in hollow fire separations
- penetrations that have been made through fire separations by services installers after most of the work was finished
- ensuring that hidden voids and chambers do not inadvertently link spaces (close inspection of likely trouble areas should be carried out before they are built in)
- filling shrinkage gaps that may appear during construction before the offending crack or gap is hidden from view.

8.4.3 It is also important to ensure that:

- fire separations extend up to the underside of the floor above and do not stop at the suspended ceiling level
- smoke-control and fire-rated door sets are as specified and tested (for their given performance rating) and that they are installed to the manufacturer's printed instructions
- materials used in fire separations are the correct type and thickness and are correctly fixed
- the specified concrete cover over reinforcing steel in concrete-framed buildings has been achieved
- where finishes or materials are applied to steel to provide resistance to fire, the correct thickness of protective cover is provided to give the designed fire rating.

8.4.4 During the construction of a building, take care to prevent work operations (welding, grinding, overloaded temporary power circuits) and general site activities (especially smoking) causing a fire. It is not usual for fire protection systems to be activated until the building is nearly complete, and the building is vulnerable to fire damage until then. Care is also needed when storing and dealing with:

- combustible materials not yet built in or properly protected
- solvents and paint
- rubbish (always keep the site tidy and remove rubbish regularly).

8.4.5 During housekeeping maintenance such as changing carpets or interior finishes, automatic door closers should not be compromised by a door stopper or door wedge for traffic convenience.

9.0 CODES AND STANDARDS

9.1 STANDARDS NEW ZEALAND

AS/NZS 2918:2001 *Domestic solid fuel burning appliances – Installation*
AS/NZS 60598.2:2016 *Luminaires – Part 2.2: Particular requirements – Recessed luminaires*
NZS 4512:2010 *Fire detection and alarm systems in buildings*
NZS 4514:2009 *Interconnected smoke alarms for houses*
NZS 4515:2009 *Fire sprinkler systems for life safety in sleeping occupancies (up to 2000 square metres)*
NZS 4517:2010 *Fire sprinkler systems for houses*
NZS 4520:2010 *Fire-resistant doorsets*
NZS 4541:2013 *Automatic fire sprinkler systems*
SNZ HB 4525:2006 *Fire risk management handbook*

9.2 MINISTRY OF BUSINESS, INNOVATION AND EMPLOYMENT (MBIE)

New Zealand Building Code Handbook
New Zealand Building Code clauses C1–C6 *Protection from fire*, clause F6 *Visibility in escape routes* and clause F7 *Warning systems*

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