DESIGNER'S GUIDE

# Firefighting operations on evacuation of high rise buildings

F5-10 GD

## Introduction

**When to use**

Use this chapter to provide a consistent Fire and Emergency New Zealand position on evacuation during an emergency incident in the building.

**Scope**

The scope of this chapter outlines the possible actions to extinguish a fire in tall buildings while simultaneously seeking to protect and evacuate persons remaining in the building.

Fire and Emergency NZ acknowledges that it is likely that an evacuation in tall buildings may not be completed by the time that operational fire crews enter the building to begin firefighting operations.

While Fire and Emergency is likely to take on a coordinating role and may be required to assist with the evacuation, this document cannot be taken to imply that Fire and Emergency takes on responsibility for the evacuation. Furthermore, nothing in this document removes the responsibility of the owner or operator of the building or a Person Conducting a Business or Undertaking (PCBU - as defined by Section 17 of the Health and Safety at Work Act 2015) from taking all necessary or reasonable measures to protect 'workers and other persons against harm to their health, safety and welfare'.

Users of this document should be aware that this document is an informative guideline and does not replace any statutory requirements.

**Context**

Given the probability of an extended evacuation period in a fire involving a tall building, there is likely to be a potential conflict between the progress of the evacuation and the need for firefighters to access the building to control and extinguish the fire and, if necessary, to conduct rescue operations.

Generally, this conflict can be adequately managed by pre-planning an appropriate provision of systems to support and control the evacuation and by training of the occupants and those who will coordinate the evacuation arrangements.

Experience in past incidents indicates that occupants' capabilities are likely to vary greatly. Factors such as age and disability may have a disproportionate effect on the evacuation unless provision is made to accommodate these factors. Given that the primary objective of the Fire and Emergency activities will be to ensure the safety of as many occupants as possible, such factors are likely to challenge the broad assumptions made in the New Zealand Building Code (NZBC) as to the time that effective firefighting begins.

This guide assumes the provision of required fire safety systems and firefighting facilities.

# NZ Building code performance requirements

**Standards**

Fire Safety C Protection from fire clauses C1 – C6 define NZBC performance requirements of the Building Act 2004. C4 is the performance requirement on movement to a place of safety.

The guidance provided is based around compliance with the NZBC, Clause C1, C4.1, C4.2, C4.5, C5.1, C5.2, C5.6 and C5.7 that address warning, egress and safety for the occupants and the Fire and Emergency NZ ability to identify and access the area of the fire to conduct firefighting and rescue operations. More specifically, Clauses C5.3 and C5.4 of the building code describe the performance requirements relating to fire appliance access:

Tall high-rise buildings (THRBs) will, almost certainly, be likely to require preparation and submission of a valid Evacuation Scheme under the 'Fire Safety and Evacuation of Buildings Regulations 2006'.

# Definitions

**Firefighting lift**

A lift or elevator provided with all (or an adequate number) of the following features as per alternative solution design such as BS 9999 (the building will have a fully compliant building sprinkler system):

- pressurised elevator (lift) shafts (either smoke or fire rated)
- elevator lobby enclosures on all floors
- pressurised elevator lobbies
- air intakes for pressurisation systems located in a smoke free area
- smoke detectors in elevator lobbies, water-resistive elevator systems
- elevator recall when power fails
- dedicated emergency power for all elevators
- pressurised stairways for all elevator lobbies
- a means of two-way voice communication between all elevator cars and fire command location
- a means of two-way voice communication between all elevator lobbies and fire command location
- a program for the priority response of elevators during fire emergencies.

**Fire floor**

The floor of the building on which the fire is reported by automatic systems or observed by occupants or other persons. The fire floor may change in the light of new information and the initial reports by occupants may be inaccurate if the observation is of the effects of fire (e.g. smoke spread) rather than the fire itself.

**Fire sector**

An area of the building that includes the fire floor and at least the two floors immediately above the fire floor and the floor below. These areas may be extended above and/or below the fire floor according to the nature of the incident, the circumstances, and of the building and the progress of the fire. This area is comparable to the 'hot zone' in a conventional fire.

**Forward control point**

The control point for operations in the fire sector. This will usually be located between one and three levels below the fire floor. The forward control point would be the location of the Fire Sector Commander and the BA entry control. The location would also be provided with a buffer stock of operational equipment and personnel awaiting deployment.

**Command system**

The process and procedures adopted by Fire and Emergency to achieve the operational objectives of a particular incident. The system is a framework to support the making of good operational and situational decisions by the officers attending, rather than a method to determine the decision made.

**Lobby control**

The primary control point for the incident in the THRB. Fires on or below the main entry level will be considered in terms of a conventional (low-rise) building. It is assumed that a fire that requires tactics applicable to a THRB will occur at least three floors above the lobby.

The control point is located at the main entry level and will act as the primary marshalling and logistics area for the firefighting effort and the processing/receiving area for persons evacuating the building. Although, typically, the location would be considered to be the main control point, in larger incidents this may be the location of the Incident Command Unit.

**Lobby sector**

The floors below the fire sector including the lobby control. This area could be likened to the inner cordon of a conventional fire.

**Search sector**

The floors above the fire sector that are potentially at risk from vertical fire spread.

**Sectorisation**

The notional division of a building for operational firefighting purposes. The purpose of sectorisation is to prevent the incident commander(s) from being overburdened with information and to promote good decision making during firefighting operations. Sectorisation may be defined in terms of the physical building, e.g. by the location of entry points into and/or firefighting operations within and/or levels of, the building or by the nature of the operations undertaken (e.g. firefighting, search activities, logistical support or other functions deemed to be necessary).

## General approach to evacuations

**Approach**

Fire and Emergency's approach to evacuation in high-rise buildings is based on international good practice and acknowledges the probability of some vertical fire spread from the room of origin. The severity of the fire will determine the extent of actions however, in general, Fire and Emergency will seek to ensure that the fire floor together with two or three floors above and one or two floors below are cleared as soon as possible after the first firefighting crews reach the fire floor. Further evacuations may be necessary if the fire spreads.

**Safety arrangements**

The evacuation should have commenced shortly after the fire was detected by the building's systems. The safety arrangements within the building should include a robust method for indicating which of the occupants have been accounted for outside the building. This has been identified as an issue with occupants leaving the scene having not indicated that they were out. This places a further strain on Fire and Emergency crews as they may decide to remain searching inside even though the people have evacuated.

Occupants who cannot self-evacuate should have been identified prior to the incident and, where appropriate, specific management and other measures implemented to support the evacuation of those occupants.

**Use of lifts for evacuation**

Currently, the use of lifts for evacuation is not recommended in most buildings. However, there is growing international recognition that firefighting lifts may become an important element of evacuation strategies in new buildings subject to specific, additional safeguards. Increased fire protection for lift shafts and power supplies that are both independent of other systems and are highly unlikely to be affected by a fire.

This approach requires a number of supporting systems. These provisions, and the scope and extent of these systems will depend on the nature, height and complexity of the building. They may include a:

- means to communicate from a secure coordination point to all floors and, preferably, to all occupied areas
- facilities management system that includes monitoring and control of the building's safety systems from a secure coordination point
- personnel management system that involves:
  - training of those who are likely to control the initial phases of the evacuation and who will cooperate with Fire and Emergency personnel
  - the provision of information and/or training to employees, guests and occupants according to their needs and length of stay in the building.

The following sections will expand on the issues outlined above.

## Classification of tall high-rise buildings

This document conforms to the classification of high-rise buildings as buildings greater than 25 m and notes the specific requirements for buildings that range between 60 m and 100 m and those for buildings that exceed 100 m in height.

## Firefighting response structure

**Firefighting response in THRB**

A response in a THRB is necessarily different to that in a low-rise building. Generally, there will be one means of access and egress. This means that all resources will be channelled along a single route and, in a building with a single stairway, there will inevitably be potential for conflict between the firefighting effort and an extended evacuation. The strategies for addressing this issue will be dealt with in a later section.

**Firefighting effort in THRB**

The firefighting effort can be seen viewed as a pyramid with the tip being the crews engaged in firefighting and rescue operations on or close to the fire floor. The base is the lobby control area. This is the logistical core and marshalling area of the operation. Below the tip is the forward control point from where operations on the floor or floors above are directed.

The base of the pyramid can be seen as representative of the resources required to support the firefighting operations. Generally, the higher the building, the greater the demand. This demand can also be influenced by the systems within the buildings. For example, the presence of firefighting lifts means that comparatively fewer resources may be needed because crews can travel to the forward control point quickly and without fatigue. Without these lifts, many more crews would be required because all necessary equipment would have to be carried up to the forward control level and then to the fire floor.

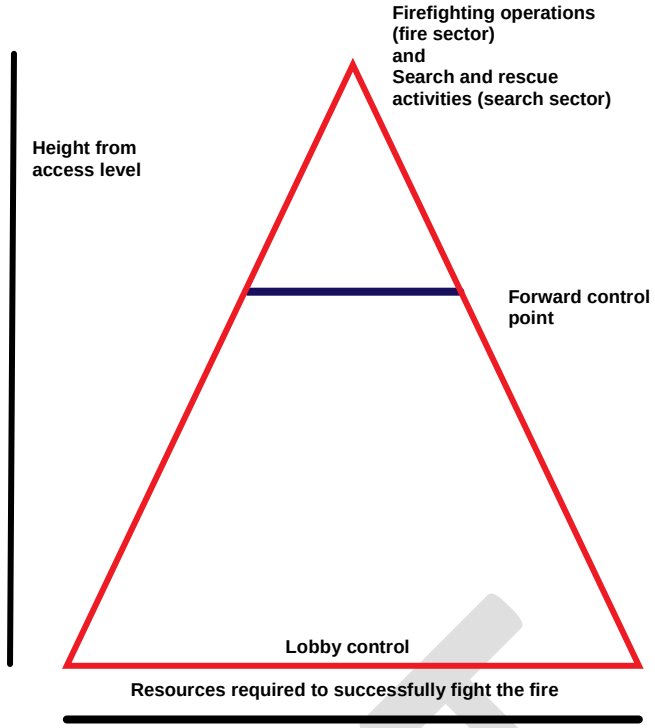


**Figure 1: Firefighting in high-rise buildings**

**Sector divisions and initial priorities**

The THRB is likely to be divided into three sectors for ease of command and control See Fire and Rescue Manual – Volume 2. Fire Service Operations - Incident Command, 3rd Ed (2008). These sectors are:

- fire sector – the fire floor, the two or three floors above and one or two floors below
- search sector – the floors above the fire sector
- lobby sector – the floors below the fire sector.

Fire and Emergency's initial priorities will be to:

- establish the location and extent of the fire
- assess and request the resources needed to support the firefighting and rescue activities
- send an initial response to the fire sector, establish the forward control point, confirm the nature of the incident and evacuate occupants at immediate risk
- establish lobby control to support and supply activities in the fire sector and the search sector.

**Potential consequences of evacuation**

While the above is not directly relevant to the evacuation, it does have an effect on the ability to involve operational personnel in an evacuation. If Fire and Emergency is required to assist in the evacuation, either the evacuation or the firefighting efforts will be slowed because of the time taken to amass the necessary personnel and equipment to set up safe systems of work and the time taken to reach the fire floor and the levels to be evacuated.

Unlike in low-rise buildings, interim evacuation measures (e.g. evacuating persons via aerial appliances or ladders pitched against the outside of the building) cannot be undertaken because of the limited reach of the appliance equipment. Therefore, the evacuation may be both delayed until after effective firefighting has commenced and, afterwards, impeded by the need to supply that effort.

# Avoiding the challenges

**Multiple stairways**

The most obvious way of avoiding delays in the evacuation is to have an alternative escape route by which escaping occupants can avoid those involved in the firefighting effort, i.e. to have at least two available stairways in the building. While this may not allow others on the fire floor to evacuate, it would allow those on other floors to escape unimpeded. It has been evident from past high-rise fires that delay of both the firefighting operations and evacuation has been a factor in fire growth and evacuation times due to limited space in stairwells.

**Stairway management**

If an alternative route is not provided, the later stages of an evacuation will require close management and, necessarily, be slower because, as with traffic control after a lane closure on a road, the greatest efficiency of the route will be achieved by allocating time between those ascending the building and those descending.

The use of lifts may also be a valid way of decreasing the burden on the stairways. This may mean that lifts may be used for evacuation prior to Fire and Emergency arriving and taking control of the lifts. The firefighting effort is then prioritized until the immediate needs have been met at the forward control. Finally, the evacuation of the upper levels can be prioritized.

**Use of firefighting lifts**

This approach requires the provision of specifically equipped firefighting lifts. This may not be viable in existing buildings. It is possible for such lifts to double as service lifts. This has the advantage that faults are likely to be detected (and rapidly corrected) in normal use and, therefore, they would not be unexpectedly out of use when they are needed.

E.F. Chapman (Elevator design for the 21st century: design criteria for elevators when used as the primary means of evacuation during fire emergencies) identified a number of criteria for safe operation of fire evacuation lifts. These include:

- complete building sprinkler protection
- pressurized elevator shafts
- elevator lobby enclosures on all floors
- pressurized elevator lobbies
- air intakes for pressurization systems located in a smoke free area
- smoke detectors in elevator lobbies, water-resistive elevator systems
- elevator recall when power fails
- dedicated emergency power for all elevators
- pressurized stairways for all elevator lobbies
- a means of two-way voice communication between all elevator cars and fire command location
- a means of two-way voice communication between all elevator lobbies and fire command location
- a program for the priority response of elevators during fire emergencies.

Each element of the above list is considered to remain valid. This subject is considered in greater detail in Firefighting response structure earlier in this guide. However, the provision and use of properly specified and equipped firefighting lifts could have a significantly beneficial effect on the speed of firefighting interventions and to the evacuation. An investigation 'To analyse evacuation methods from high-rise buildings and identify fire and life safety improvements for this vertical world' has also been conducted by Justin Francis, under the Churchill Memorial Trust of Australia.

# Staged evacuation

**Staged evacuation elements**

The principle of staged evacuation is well known and, implicitly acknowledged by the Fire and Emergency's procedure of clearing the fire floor and those immediately above and below.

However, a more general adoption of the principle within a building is likely to require careful management and an adequate provision of 'hardened' escape routes with adequate internal communications system. It is implicit that the evacuation arrangements should not prevent anyone who wishes to make their way from the building from being able to do so, to stop an occupant from doing this could be construed as unlawful detention.

The essential elements for staged evacuation include, but are not limited to:

- fully compliant sprinkler protection of the building
- fire separation of the spaces where people would be expected to travel and to wait
- at least one available, protected escape route
- a fixed, secure means of voice communication between the holding area and the evacuation controller
- potential places of refuge at intervals of pre-determined floor levels
- pre-determined space for Fire and Emergency crews to set-up and store equipment to ensure that escape routes are kept clear for occupants egressing.

The effect of a staged evacuation is likely to be a 'pulsing' of occupants as the various areas are progressively asked to enter the escape route.

# Specific occupant needs

**Provision of refuge safe places in high-rise buildings**

With the changes to the Verification Method C/VM2 high-rise buildings now fall outside the scope of that document and therefore should be designed to an alternative method. In a high-rise building, an obstruction to the escape flow is likely to lead to a disproportionate effect on the occupants behind that obstruction.

In order to facilitate the evacuation of those who are capable of meeting the assumed occupant capabilities, it may be appropriate to hold those requiring assisted evacuation in a safe place until the 'pulse' of occupants has passed.

If it is assumed that the temporary refuge is safe enough for those with mobility or sensory impairments to wait, it follows that those places are necessarily safe enough for those providing assistance to remain as well. Therefore, there is no reason why each person requiring assistance should be left alone at any time.

The building's operator or PCBU should make arrangements for the necessary assistance to be provided as part of the building's management arrangements. It is not considered viable or appropriate to rely solely on the intervention of Fire and Emergency personnel to effect the building's safety strategy.

The above arrangements are likely to require the provision of refuge spaces (that neither impede the occupant flow down the stairway nor impede the flow of occupants from the relevant floor into the stairway). These should be provided at regular intervals throughout the stairway's height and, preferably, at each floor level.

One approach that is being investigated in very high-rise buildings is the provision of public spaces at regular height intervals that may double as refuge spaces from the floors above. If such an approach is adopted, the 'acute' phase of the evacuation (i.e. to the point where all occupants are at least one floor below the fire floor) may be accelerated and the immediate physical demands on those assisting the impaired occupants are likely to be mitigated.

# Evacuation strategy using elevators

**Evacuation strategy**

The elevators are very important vertical transportation methods in either a normal situation or emergency situation. In the event of fire, all elevators will be recalled to a primary floor – usually ground floor. If the fire occurs on the ground floor, the alternate recall floor will be either second floor or the basement level just one floor below the ground floor.

Once the firefighter arrives at the fire control centre, the firefighter will control all elevator operations and communication systems via a two-way communication system.

The people located below the fire sector will use a stairway for an egress and all firefighters will use a dedicated firefighting elevator to reach the fire floor to avoid the traffic congestion which occurred in World Trade Centre. There are a lot of time delays for firefighters to ascend to the fire floor because of the traffic descending for an egress. The people using stairways as an egress will be monitored by a video camera in the fire control centre.

While people below the fire floor are egressing using stairways, the firefighter controlling the elevators will send elevator cabs to the fire floors to evacuate people in the fire floors first. All elevators will be operated by a shuttle mode (skipping all other floors).

Once the occupants in fire floors are evacuated, the elevator will move to the search sectors to evacuate people. Those people will keep communicating with firefighters in the fire control centre using the two-way communication system provided in the elevator lobby.

All evacuation elevators will be protected by a two-hour fire rated shaft wall. The firefighting elevator shall egress directly to outside protected by a two-hour fire rated safe path.

# Conclusion

**Delays likely in evacuation affecting firefighting activities**

It is highly probable that any evacuation from THRBs in the event of a fire will interact with the firefighting activities. This interaction should be managed so that the effects of each on the other are minimized.

Furthermore, any expected involvement of Fire and Emergency personnel in the evacuation is likely to delay both the evacuation and firefighting activities because of the time taken for fire crews to arrive at the building and to be deployed.

**Building's facilities management function**

Emphasis is to be placed on the building's facilities management function to identify the location and extent of a fire and to manage the initial phases of the evacuation so that those in the immediate area (the fire floor, two or three floors above and one or two floors below) can be moved to a place of relative safety without delay. The needs of people who require assistance to escape should be considered and appropriate measures taken to assist them prior to the arrival of Fire and Emergency NZ.

After this is achieved, those involved in the evacuation will liaise with the attending emergency services to achieve the safe evacuation of those who may be affected by subsequent fire spread.

**Scope of firefighters response**

Pre-planning is considered to be essential because of the limited scope for access and egress in a THRB. Those involved in making the plans work should be trained and tested in applying the arrangements. The scope of Fire and Emergency's response is likely to be influenced by the size of the building (particularly its height) and by the availability and number of properly-specified and equipped firefighting lifts.