The Fundamentals of Residential Fire Engineering

And an introduction to smoke ventilation

GROUP SCS

Module Overview

This course is designed to cover the legislative requirements necessary for those involved with the design of residential smoke ventilation systems.

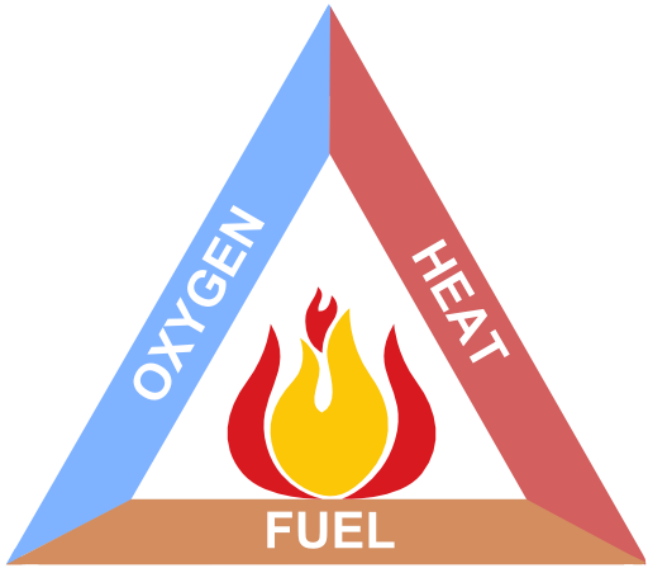
GROUP SCS

What is fire?

Fire is a process in which substances combine chemically with oxygen from the air and typically give out bright light, heat, and smoke

What is fire?

Fire requires HEAT, FUEL and OXYGEN to burn successfully.

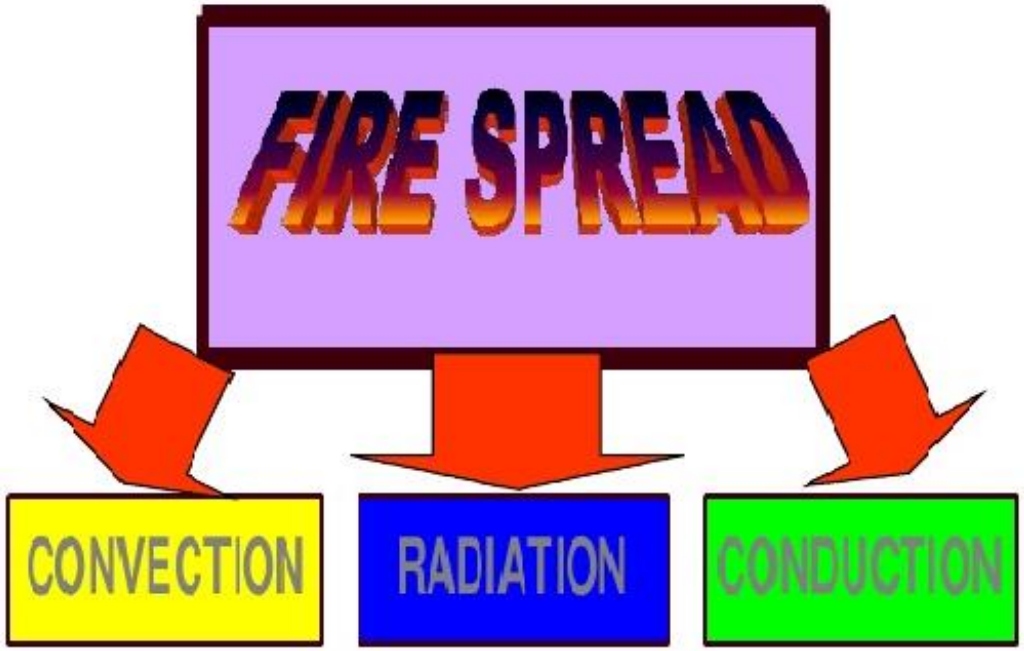


A designer should be aware of this and must try to separate heat sources from fire load [fuel] in building wherever possible

How does fire spread?

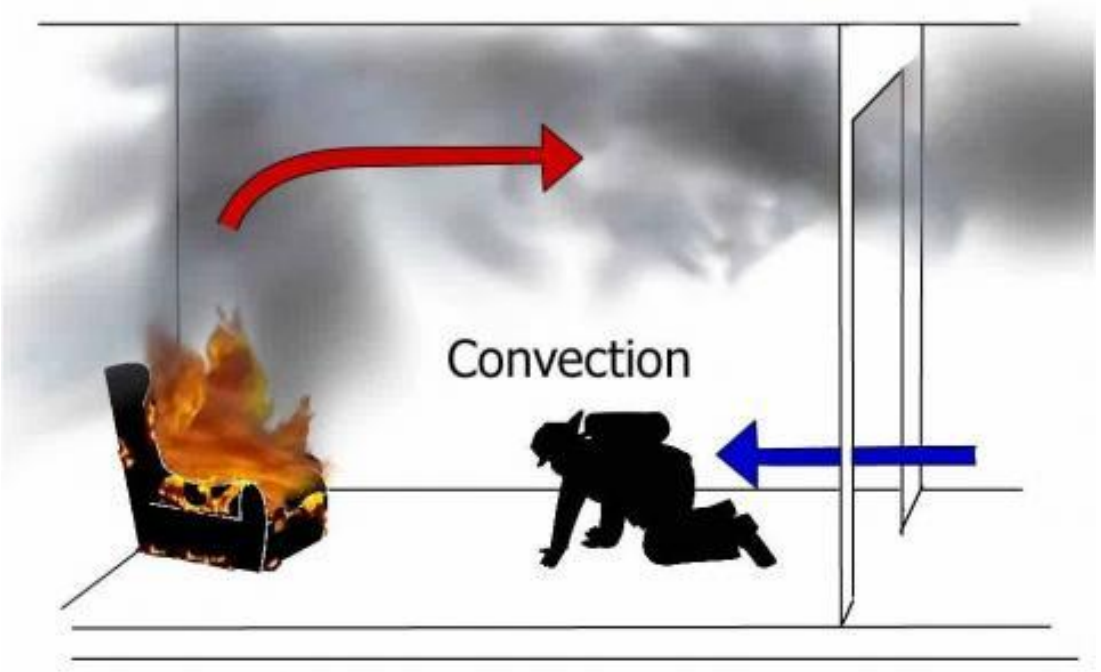
Type of Transfer	Name of Transfer
Heat transfer through the air	*Convection*
Heat transfer through solid objects	*Conduction*
Heat transfer as an infra red wave	*Radiation*

Fire Spread



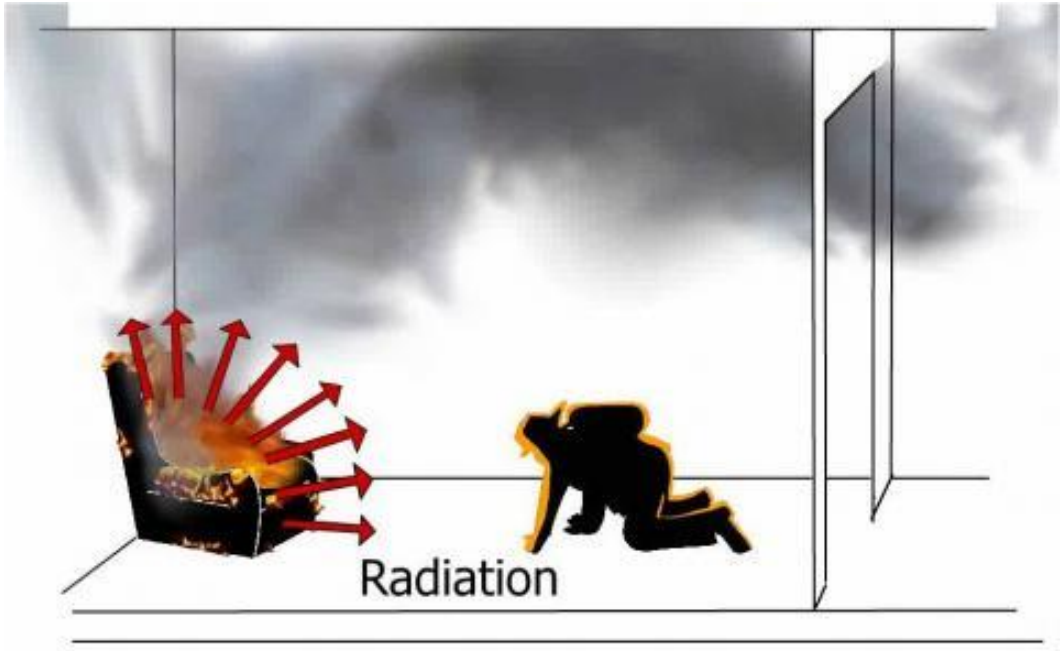
Convection currents account for around two thirds of the heat transferred from a fire

Convection



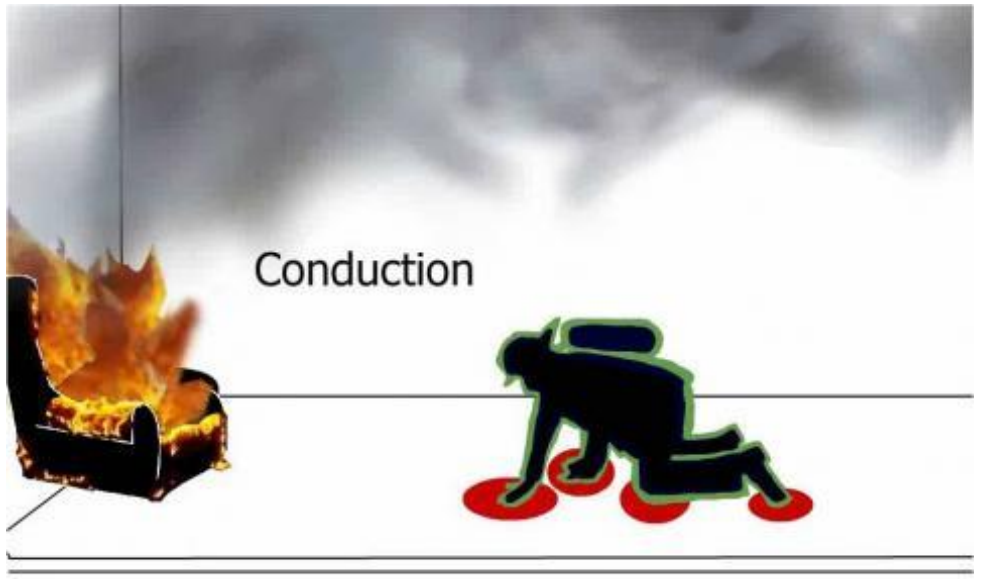
Convection is responsible for smoke transfer around a building and so convection currents can affect areas of the building remote from the room of fire origin. This is a primary concern for smoke vent engineers

Radiation



Radiation is part of the EM spectrum and can travel through a vacuum, however its main affects are only felt close to the fire location and so radiation is not a primary concern for smoke vent engineers

Conduction



Conduction generally does not affect remote areas of a building away from the room of fire origin, unless there are unprotected services such as HVAC ductwork running between areas.

Sources of ignition

Sources of Ignition

Faulty electrical equipment, heat generating equipment and overloaded sockets are the biggest source of accidental fire ignition in U.K. homes.

Sources of fuel
[Fire load]

Fire load

Polyurethane foam sofas and mattresses are the most ready source of fire load in residential buildings.

Hoarding Risk

Hoarding creates fire loading above the standard design limits and restricts Fire Service access

Cramming risk

Multiple occupation of small premises above accepted limits is common in urban areas.

Combustion Equation

$$\text{Hydrocarbon} + O_2 \longrightarrow CO_2 + H_2O$$

Fuel	Oxygen	Carbon Dioxide	Water

When combustion occurs in well ventilated environments with an abundance of oxygen, the combustion is *clean* and no smoke or soot are produced.

Incomplete Combustion

If combustion occurs and there is an *insufficient* amount of oxygen available, then the fuel is <u>not</u> completely converted into carbon dioxide and water

Products of incomplete combustion include water vapour [H_2O] as well as a combination of the following:

- CO [carbon monoxide]
- CO_2 [carbon dioxide]
- C [carbon particulates]

This is the Soot present in smoke

GROUP SCS

Smoke Inhalation

Smoke inhalation is the number one cause of death from fire. It damages the body by asphyxiation (lack of oxygen) and a combination of chemical and thermal irritation

How are building occupants protected from fire?

Structural Protection

- Fire resisting walls and floors
- Fire Doors
- Fire resisting facade

Engineered Systems

- Fire alarm
- Sprinklers
- Smoke ventilation

Structural [passive] Fire Protection

Structural Fire Protection

Also known as *passive* protection, structural fire protection is designed to contain a fire within it's room of origin and postpone building structural collapse long enough for occupant escape and firefighting operations.

Structural Steam Beams

Structural steel beams must be coated in a fire resisting material

to prevent them from deforming at high temperatures.

Fire Doors

Fire doors are provided to prevent the spread of fire and smoke to critical escape routes.

Fire doors must have spring closers *and* smoke seals

Fire Resisting Facades

A building facade should be fire resisting to prevent a fire from spreading externally. Combustible cladding can have a devastating effect in a fire situation.

Tamweel Tower, Dubai

Grenfell Tower, London

Active Fire Protection [Engineered Systems]

Early Warning Systems

Smoke/Heat detection systems are provided to give the building occupants an early warning of a fire to allow them to escape while the fire is still small.

Fire Suppression Systems

Sprinkler and water mist systems can be provided to control fire growth and limit smoke and heat production.

Smoke Ventilation

Smoke vents and smoke extract systems are installed to protect escape routes from smoke ingress.

Introduction to Fire engineering

The aim of fire engineering

The aim of Fire Engineering is:

1. To protect the occupants of a building from the effects of fire during the ***means of escape*** period

2. To protect the fire service during ***fire fighting*** operations

GROUP SCS

Means of Escape

In a fire situation, the occupants of a building must be afforded

at least **one** of the following **four** options during the

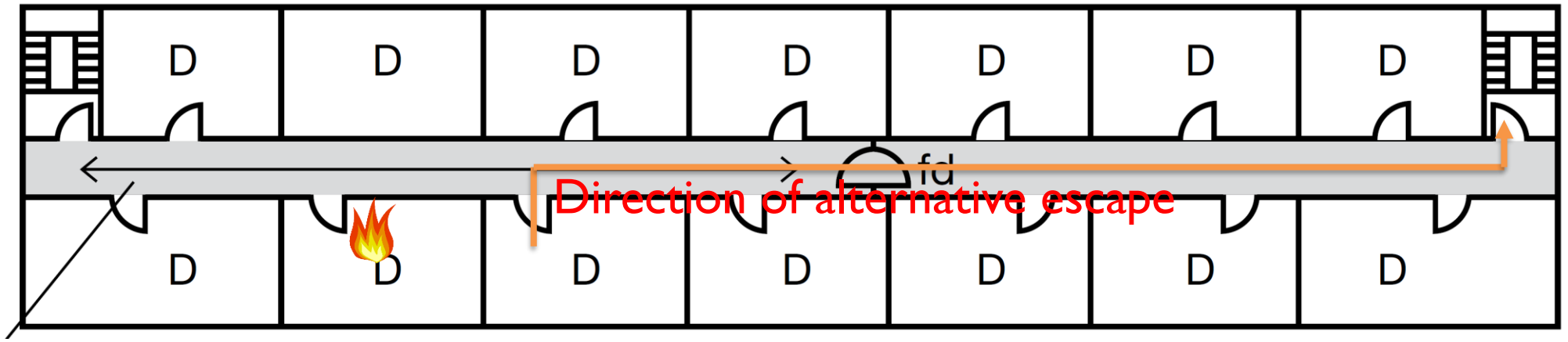
Means of Escape period

Means of Escape – Option 1

The ability to turn their back on a fire and escape in another direction.

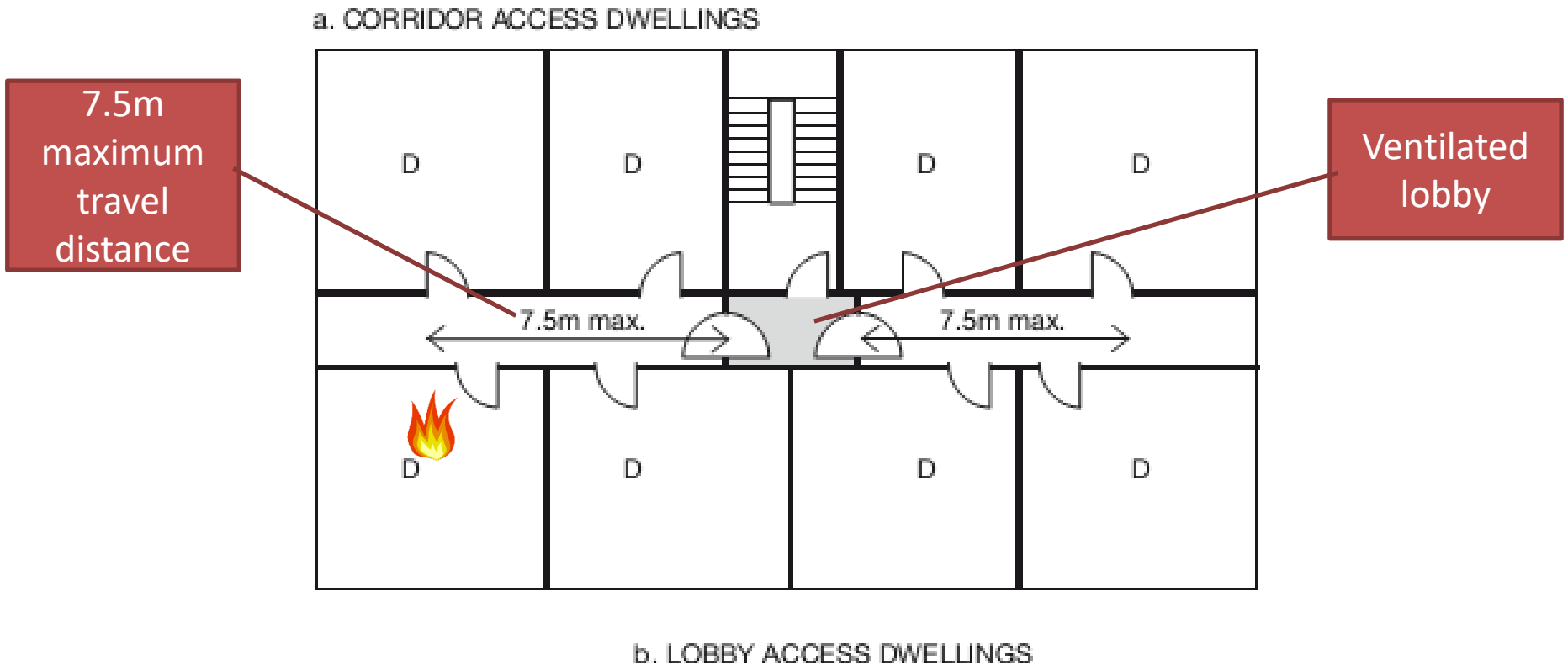
By providing more than one escape stairwell.

a. CORRIDOR ACCESS WITHOUT DEAD ENDS



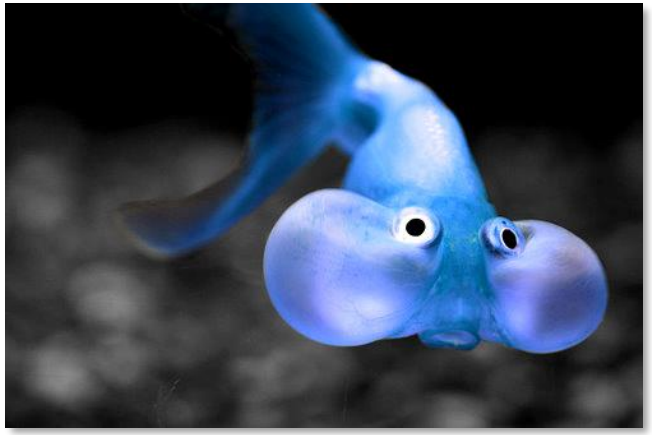
Means of Escape – Option 2

The ability to escape to a place of safety through a protected (i.e. smoke ventilated) compartment with limits on travel distance



7.5m travel distance

The distance of 7.5m is chosen as the maximum escape travel distance in a single direction because it is considered acceptable to travel 7.5m on a single breath of air if the corridor is smoke logged.



Means of Escape – Option 3

The ability to escape past a small incipient [i.e. recently started] fire.

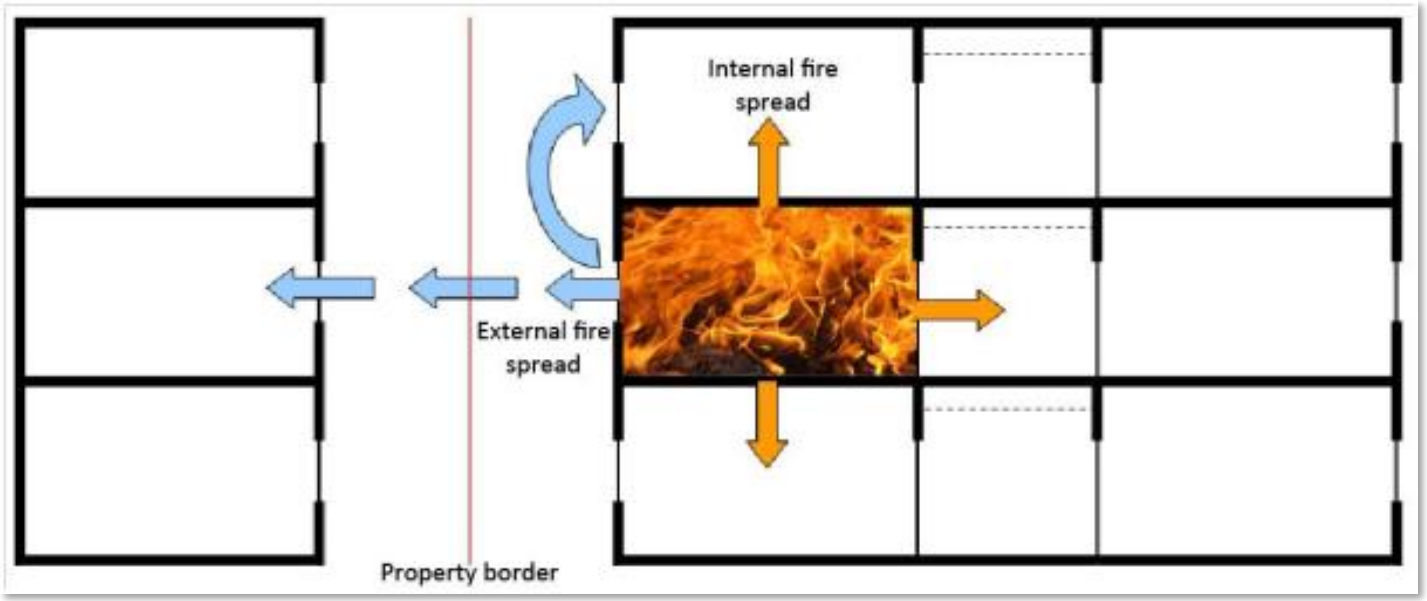
Smoke/Heat detection systems provide early warning to the occupants

of the fire affected apartment.

Means of Escape – Option 4

The ability to escape via a protected escape route separated from the

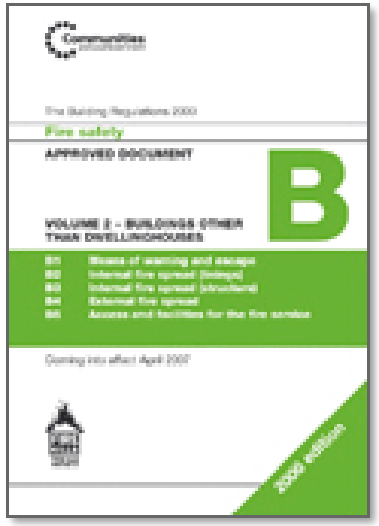
fire by ‘fire resisting’ (FR) materials



Codes of Practice

Codes of practice

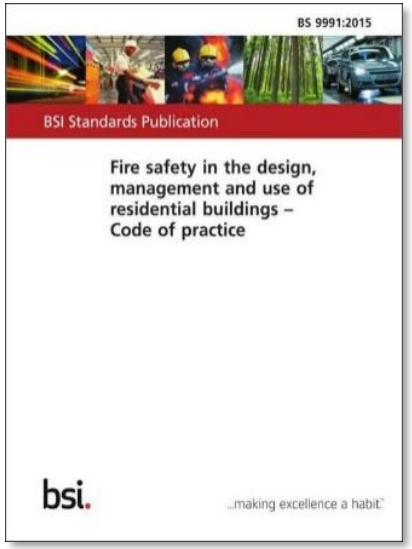
Approved Document B Volume 1: Dwellings 2019 is the legislative document that governs Fire Safety in all high rise residential buildings



This document MUST be followed under U.K. law

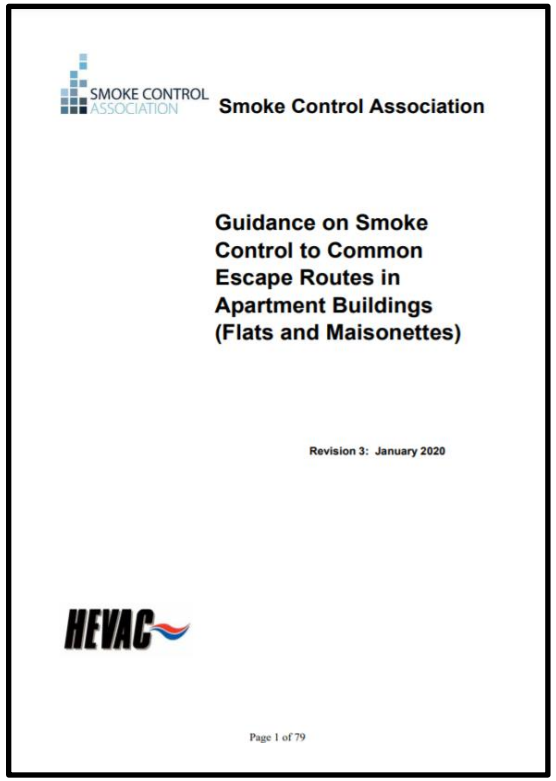
Codes of practice

BS 9991: 2015 is the British code of *best practice* for fire safety in residential buildings.



Codes of practice

The Smoke Control Association published the following free guidance on smoke control in apartment buildings. This guide was revised in January 2020 and is often referenced by Building Control Officers



Codes of practice

The following standards are also note worthy and smoke vent system designers should be familiar with them.

- BS EN12101-2: 2003 Specification for natural smoke and heat exhaust ventilators
- BS EN12101-3:2002 Specification for powered smoke and heat exhaust ventilators
- BS EN12101-6 (2005) Smoke control using pressure differentials

GROUP SCS

Introduction to Approved Document B

Means of warning and escape

B1. The building shall be designed and constructed so that there are appropriate provisions for the early warning of fire, and appropriate means of escape in case of fire from the building to a place of safety outside the building capable of being safely and effectively used at all material times.

ADB Design Assumptions

Approved Document B introduces two fundamental design assumptions that outline the approach to smoke ventilation design

ADB design assumption 1

A fire will usually start ***inside*** an apartment

Communal areas – corridors, lobbies & stairwells are inert areas and will not contribute to fire ignition or fire spread

ADB design assumption 2

Only ***one*** fire will occur in a building at any given time

Multiple fires are classed as acts of arson and cannot be legislated for

The Defend in Place Evacuation strategy

Also known as ‘Stay Put’

Defend in place strategy for means of escape

- Only the occupants of the fire affected flat are encouraged to leave the building

They are alerted by smoke detection within their apartment

- Everyone else *should* be safe to stay in their flat until the fire service arrive

Fire separation between apartments should protect the occupants for a minimum of 60 minutes

ADB: Defend in Place strategy

"Private residential flats adopt the 'defend in place / stay put' evacuation procedure; meaning that only the fire flat is evacuated by means of automatic alarm. Therefore it is necessary to ensure that smoke generated within the fire flat does not inhibit evacuation from any other premises, should the occupants choose to evacuate on their own accord without assistance from the fire service."

NOTE: Defend in Place strategy – Grenfell Tower

Grenfell Tower adopted a 'Defend in Place' evacuation strategy.

The Fire Brigade reportedly told people to stay in their apartments when they arrived on scene.

This would have been the correct advice had the structural fire protection enclosing the fire flat prevented the spread of fire internally as it was intended to, and had the cladding not contributed to fire spread externally.

The occupants of the non fire affected flats should have been safe for a minimum of 60 minutes.

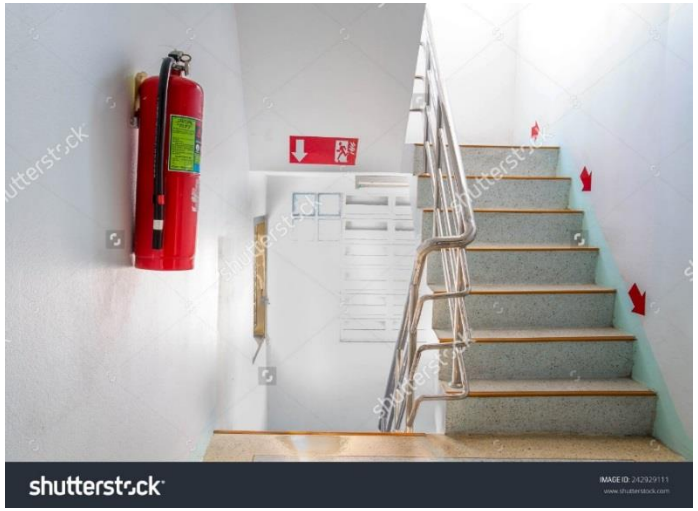
Once it became clear that the fire had spread beyond the flat of fire origin, the building residents should have been told to evacuate immediately.

The Primary Aim of Smoke Ventilation

To protect the common escape routes

Primary aim of smoke ventilation

Smoke ventilation is provided in buildings to prevent smoke from entering the common escape stairwells



The stairs provide access and egress to all storeys above ground and must be kept clear to allow occupants to escape safely and to allow Fire Service access

Primary aim of smoke ventilation

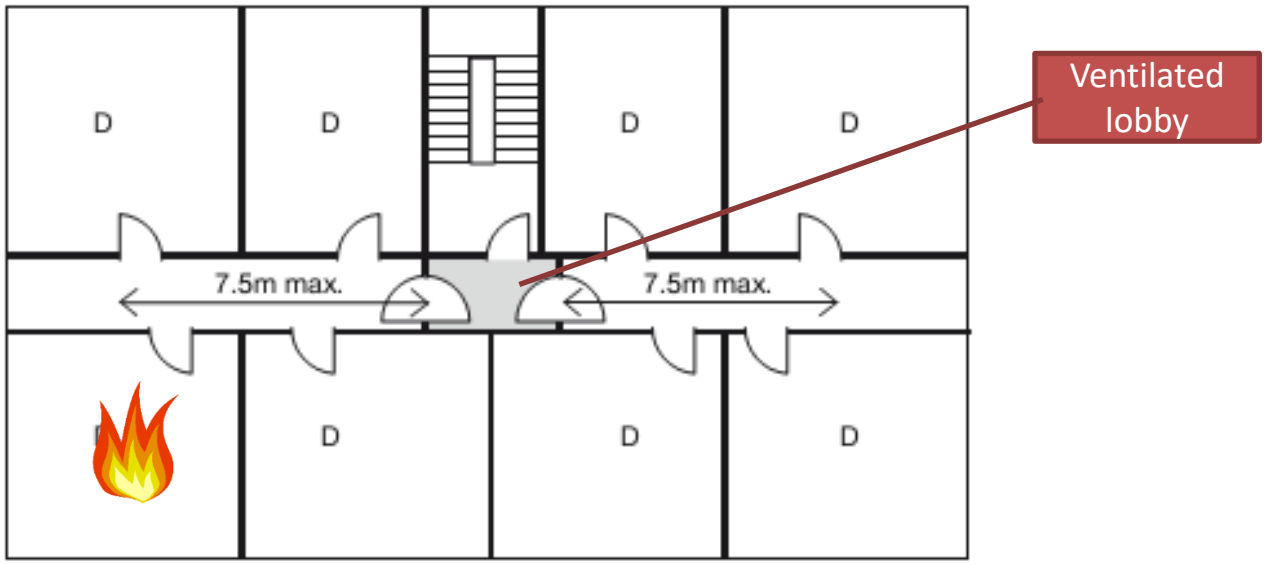
It may not be possible to keep the communal corridors completely clear of smoke due to the fact that some smoke will escape as the occupants of the fire flat leave.

Some smoke will also leak into the corridor via gaps around the fire flat door due to the pressure and buoyancy created by the fire.

We can tolerate this because there is a limit on travel of 7.5m in one direction [or more if sprinklers are provided]

ADB - Protected Lobby Example

a. CORRIDOR ACCESS DWELLINGS

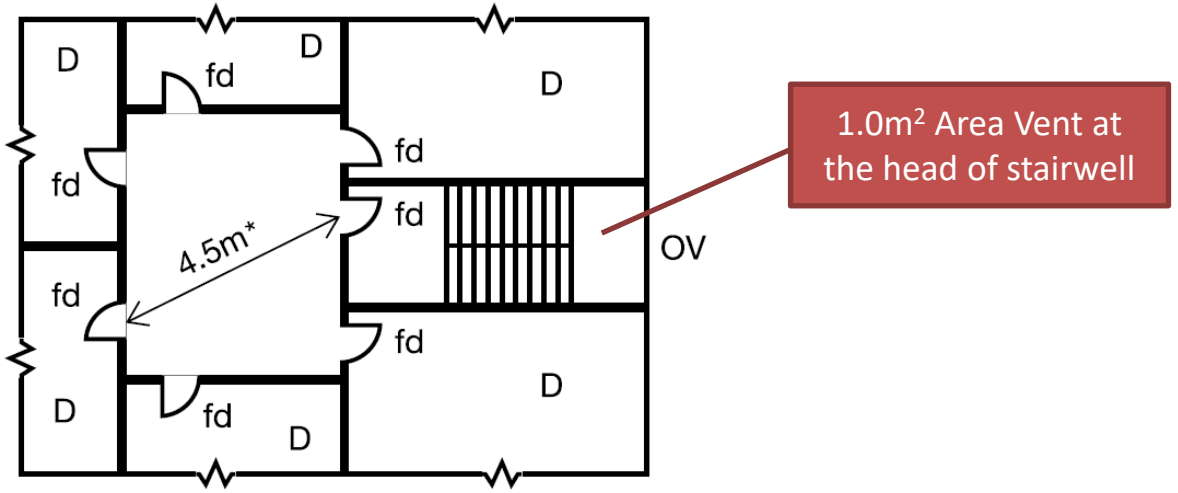


b. LOBBY ACCESS DWELLINGS

We protect the stairs by introducing ventilated lobbies to separate the stairs from the apartments providing a barrier to smoke ingress

ADB Compliant Building Layouts

ADB ‘Small Single Stair’

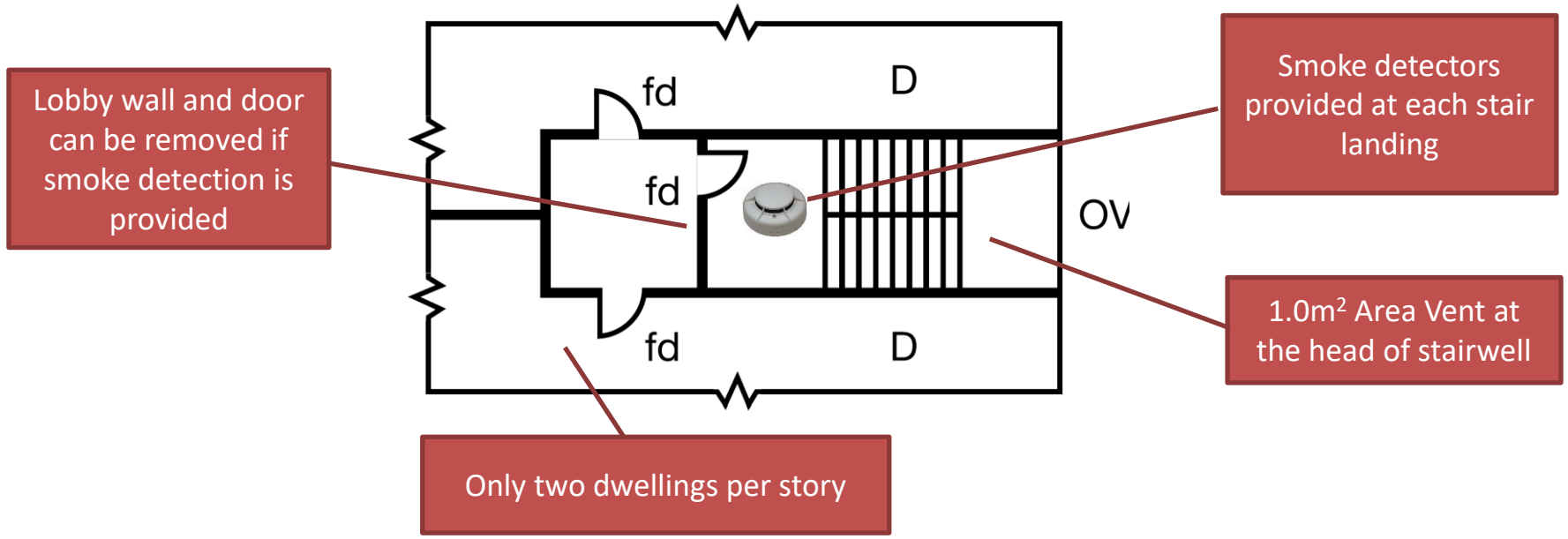


The ‘***small single stair’*** is the simplest compliant ADB layout.

Small single stair buildings are:

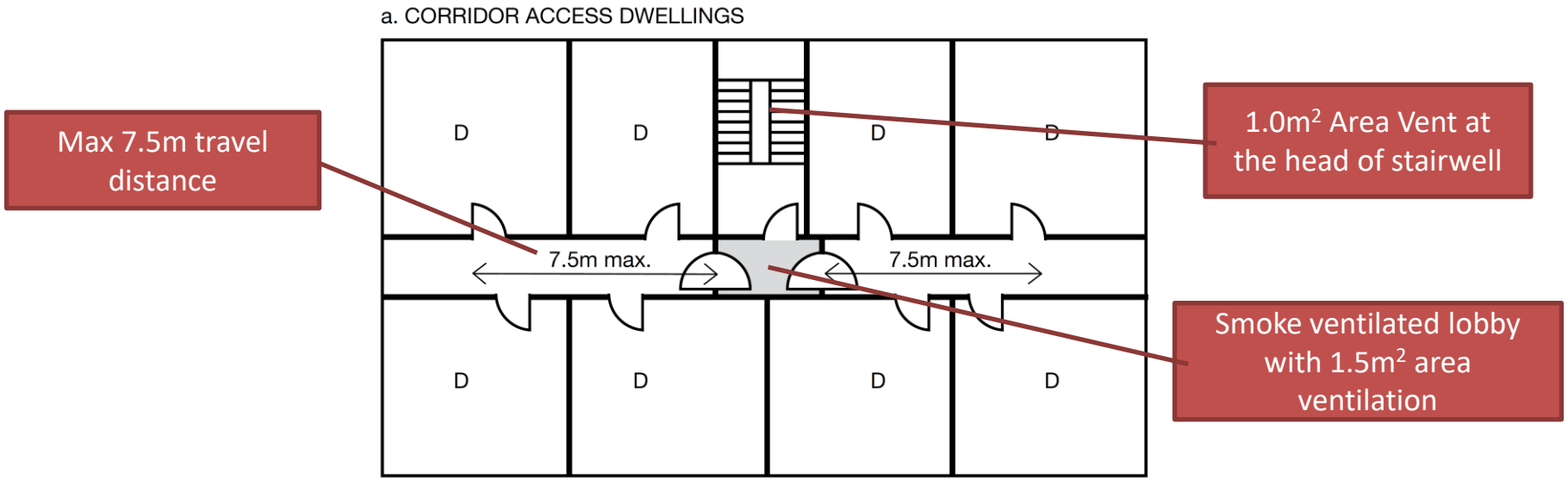
- Up to 11m in height, or 3 storeys above ground
- Have a maximum escape travel distance of 4.5m
- No lobby smoke ventilation is required
- A 1.0m² smoke vent is required at the head of the communal stairwell

ADB ‘Small Single Stair’



A ***small single stair*** building with only ***two*** dwellings per storey is a special case. The apartments can open directly onto the stairwell with no common lobby required, providing that smoke detectors are installed within the stairwell at each landing level to automatically open the 1.0m² head of stair AOV on detection of smoke.

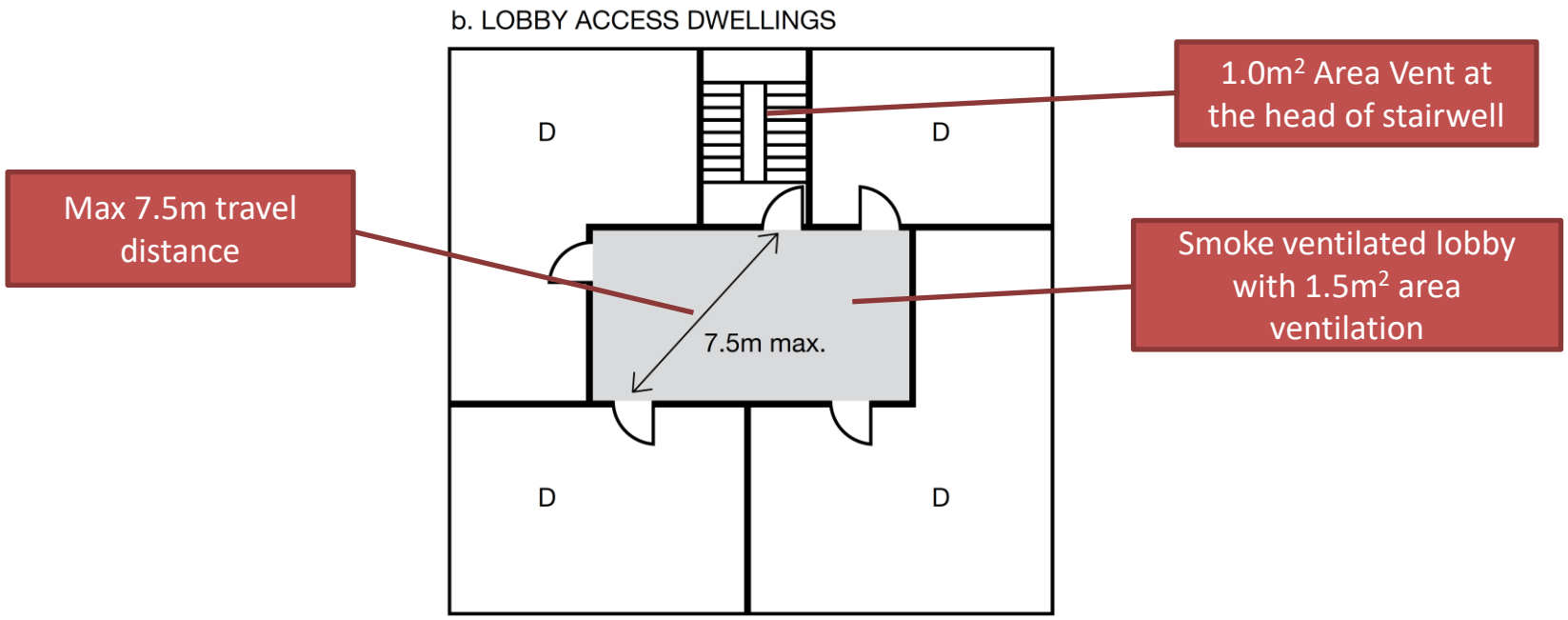
ADB ‘Single Stair’ – Corridor access



If the building is taller than 3 storeys above ground, or if travel distances exceed 4.5m, then a protected (i.e. ventilated) lobby is required to protect the stairs. 1.5m^2 ventilation is required within the protected lobby with a 1.0m^2 vent at the head of stairwell. The maximum permitted travel distance is 7.5m [this may be increased with the inclusion of sprinklers to the apartments]

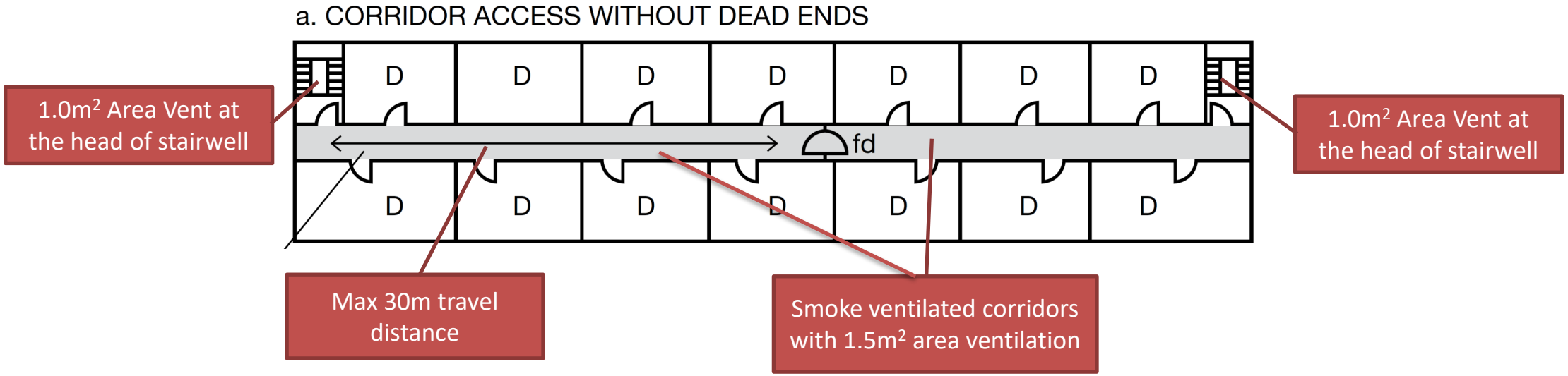
ADB Diagram 3.7a

ADB ‘Single Stair’ – Lobby access



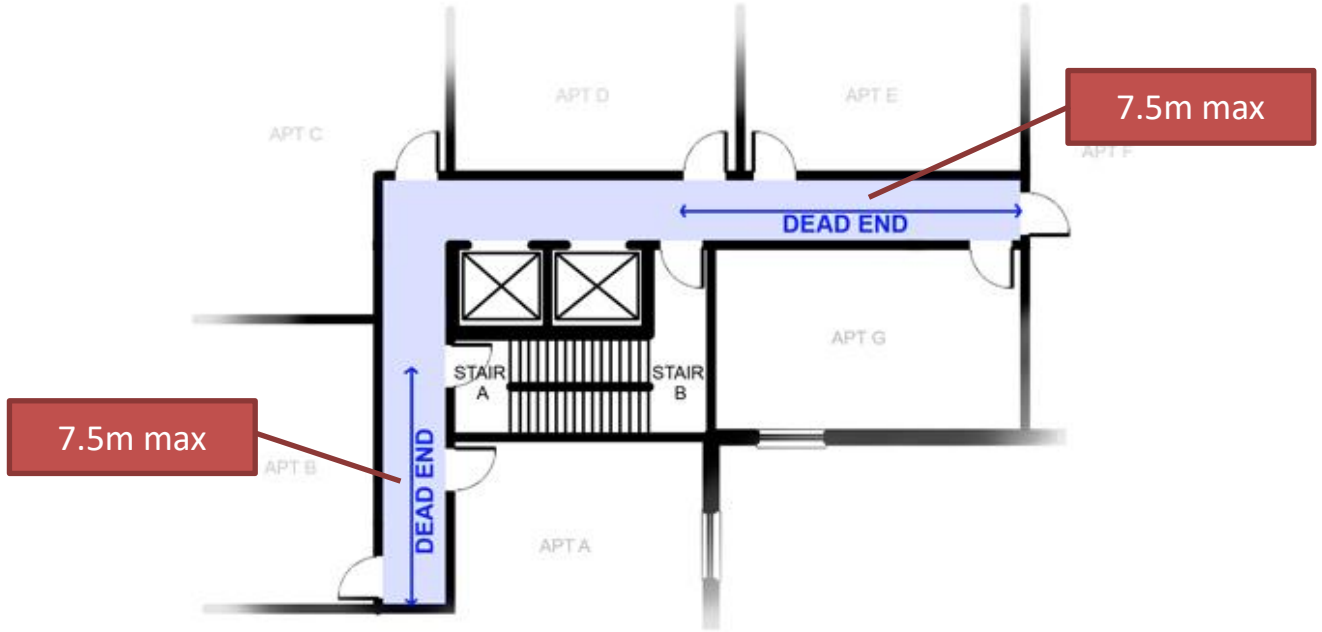
This is an alternative version of the previous layout with the apartments accessed directly from a central ventilated lobby. As before, the maximum travel permitted travel distance is 7.5m [which may be increased with the inclusion of sprinklered apartments]

ADB – Two Stairwell Layouts



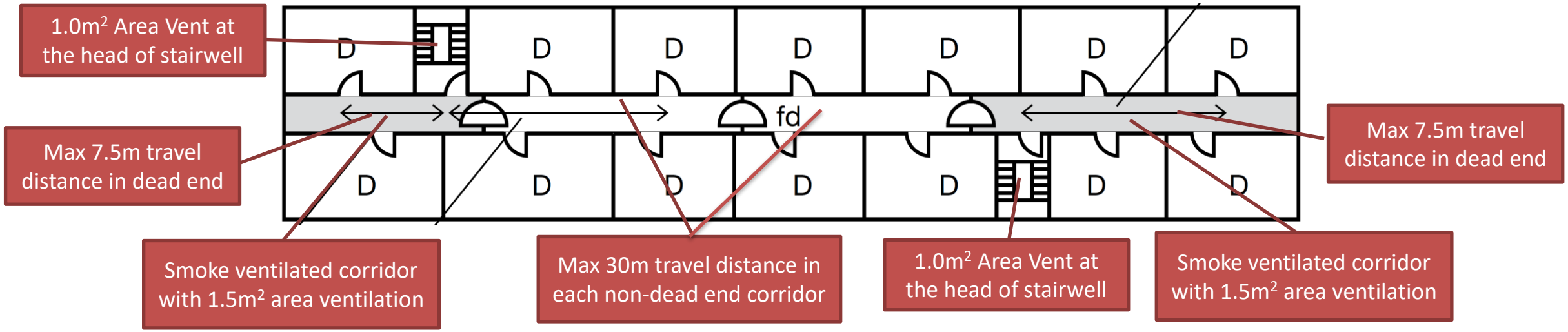
The inclusion of an additional stairwell affords the occupants two directions of escape and therefore travel distances up to 30m per corridor are permitted in this arrangement. 1.5m² ventilation is required in ***each*** corridor and a1.0m² vent is required at the head each communal stairwell

Dead End sections of Corridors



A dead end portion of a corridor is one that does not lead directly to an exit. Travel distance in dead ends is limited to 7.5m to ensure occupants can escape through them on a single breath of air.

ADB – Two Stairwell Layouts



In a two stairwell layout with dead ends, the maximum permitted travel distance within the dead ends is 7.5m, with 30m travel permitted in the non-dead end corridors. The shaded stairwell lobbies above must be provided with 1.5m² ventilation and 1.0m² ventilation is required at the head of each stairwell.

Sprinklers

The use of residential sprinklers has become more prevalent in recent years. It is a mandatory requirement to install sprinklers in apartments in any building above 30m in height (i.e. 10 storeys).

Sprinklers control fire growth and reduce smoke production and so they reduce the amount smoke that spills into the common corridors.

Sprinklered buildings are therefore permitted to have longer corridors than non-sprinklered buildings

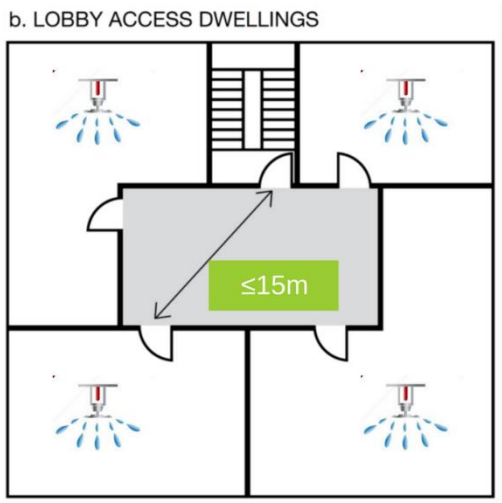
BS9991: 2015 - Sprinklers

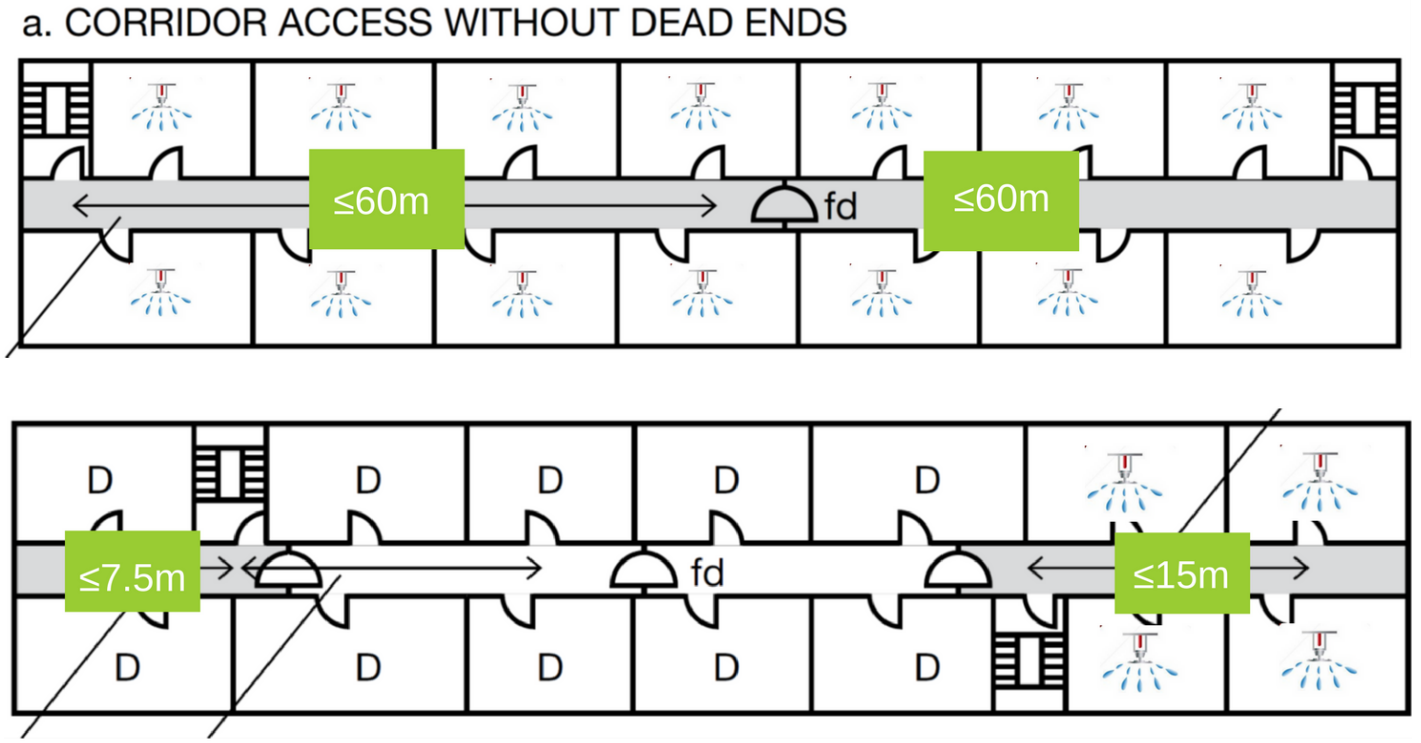
BS 9991 Travel Distances	No Sprinklers	With Sprinklers
Single stair travel	7.5m	15m
Escape in two directions	30m	60m
Dead end travel	7.5m	15m

BS 9991:2015 quantifies the permitted extension of travel distance for sprinklered buildings and states that sprinklered buildings can have *double* the escape travel distance of non sprinklered buildings

GROUP SCS

BS9991: 2015 - Sprinklers





The diagrams above illustrate the permitted travel distance in a sprinklered building. In the two stairwell 'dead end' corridor layout the sprinklered dead end has a travel distance of 15m, while the non-sprinklered dead end has a maximum travel distance of 7.5m

Fire Fighting Provisions

Access and facilities for the fire service

B5. (1) The building shall be designed and constructed so as to provide reasonable facilities to assist firefighters in the protection of life.

B5. (2) Reasonable provision shall be made within the site of the building to enable fire appliances to gain access to the building.

Firefighter External Rescue

In low rise buildings with clear external access, firefighters can perform a ‘window rescue’ using ladders to save endangered occupants without having to enter the building. This allows the firefighters to perform their duty without risking their own personal safety.

Firefighter External Rescue

A standard Fire Service turntable ladder can reach up to a maximum height of 18m. Therefore building occupants who live in apartments on storey heights of 18m or less [i.e. up to 6 storeys above ground] can conceivably be rescued externally through a window or balcony door.

This means that for tall buildings greater than 18m [or 6 storeys above ground] external rescue is **not** possible for all building occupants. Firefighters must enter the building and travel up to the fire floor via stairs or lifts to reach endangered occupants

Firefighter Internal Rescue > 18m

Tall buildings >18m must be designed with firefighter access in mind. These buildings must have a number of standard provisions for the Fire Service to aid safe access/egress and assist firefighting operations.

Firefighting Provisions

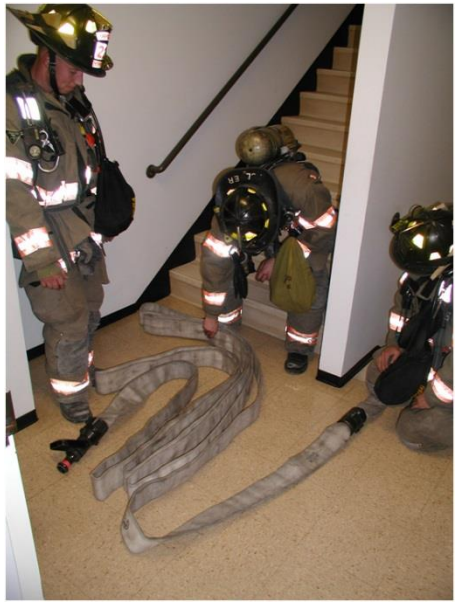
Firefighters require the following provisions to assist internal firefighting and rescue operations in tall buildings >18m.

1. Firefighting Stairwell
2. Firefighting Lift
3. Dry Riser System
4. Firefighting corridor

Firefighting Stairwells

A firefighting stair must satisfy all of the requirements listed below.

1. It must serve all intermediate storeys between the lowest and highest storeys it serves.
2. It must be a minimum of 1100mm wide
3. It must be enclosed in 120min fire resisting construction

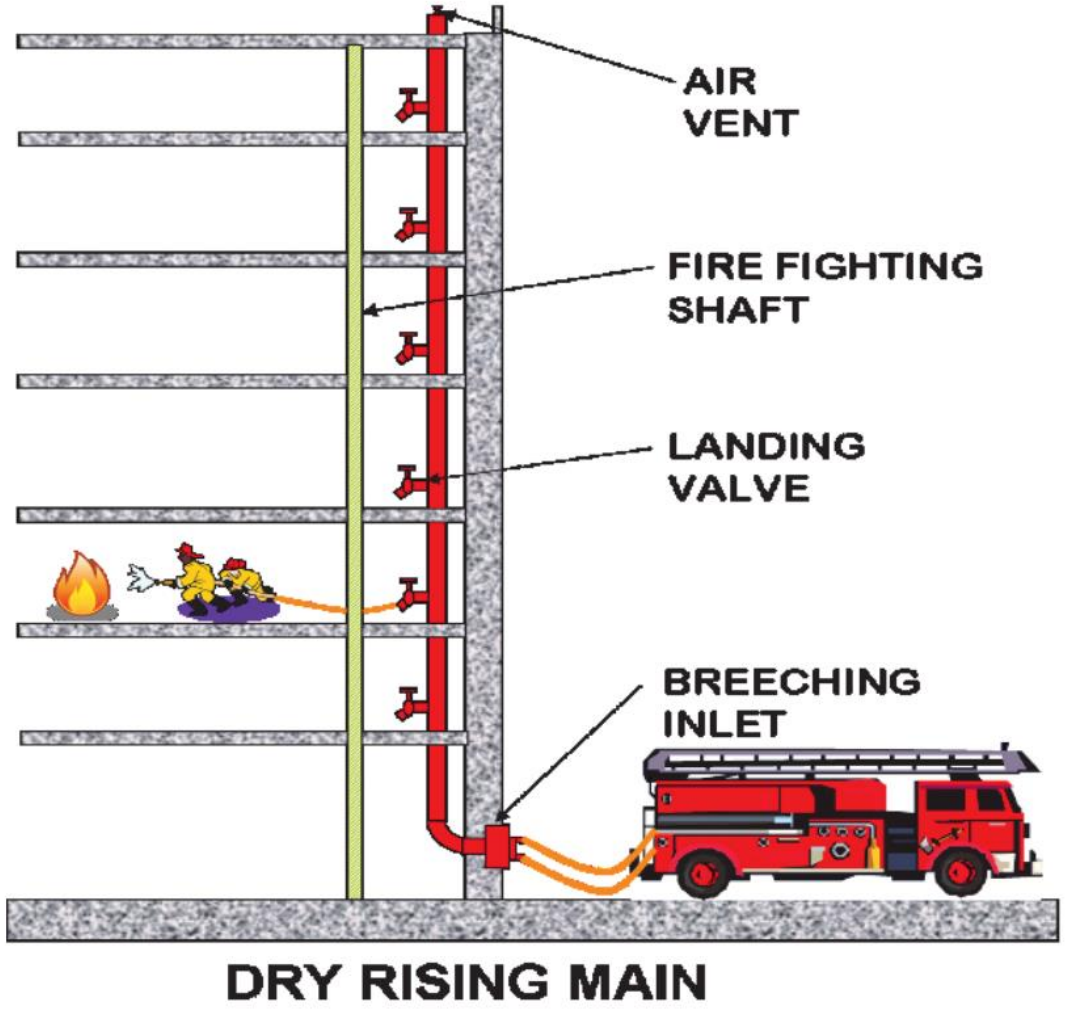


Firefighting Lifts

A firefighting lift must satisfy all of the requirements listed below.

1. It must have a back-up power supply that will remain operational during a mains failure.
2. It must have Fire Service override controls at the Fire Service entrance level
3. The lift shaft must be enclosed in 120min fire resisting construction
4. The lift must be located within 7.5m of the firefighting stairwell

Dry Risers

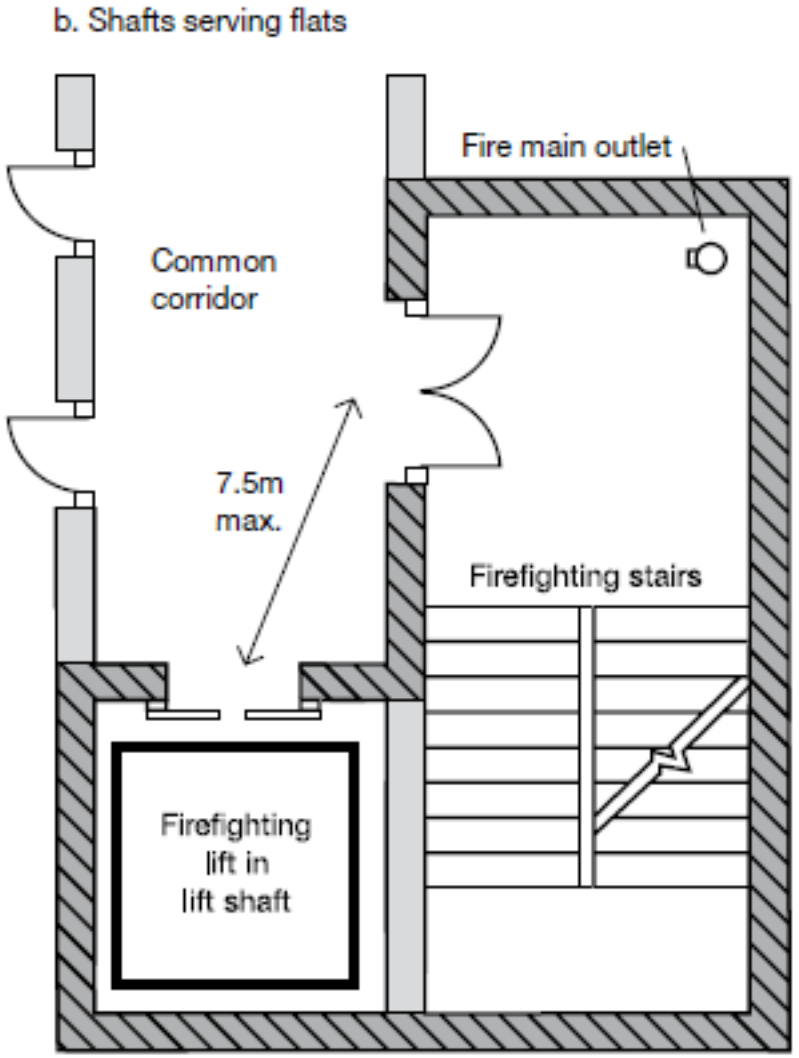


A dry riser is a vertical pipe used by Fire officers to transport pressurised water from street level to the fire affected floor level.

Firefighting Corridors

A firefighting corridor must have 1.5m^2 free area smoke ventilation and contain the firefighting lift.

The firefighting lift must be located within 7.5m of the firefighting stairwell door.



Take the Exam