



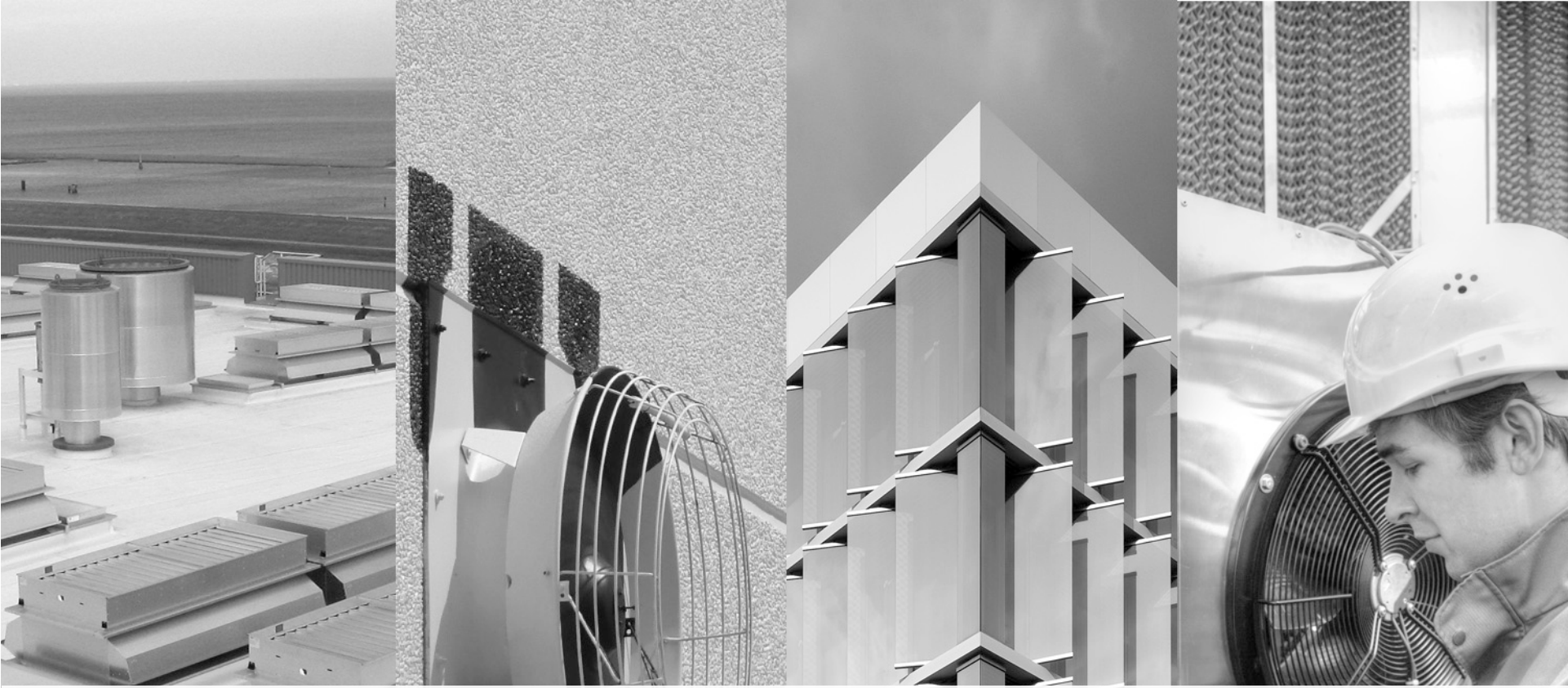
AMCA International

# General Principles of Smoke Control

**Patrick Janssens, Sales Manager**  
**Colt International**  
*[www.coltinco.co.uk](http://www.coltinco.co.uk) or*  
*[www.coltinco.be](http://www.coltinco.be)*



Air System Engineering & Technology (ASET) Conference–Europe  
Lyon, France • L'Espace Tête d'Or • 20 February 2018



**Colt International**  
General Principles of Smoke Control  
2018 ASET-Europe conference

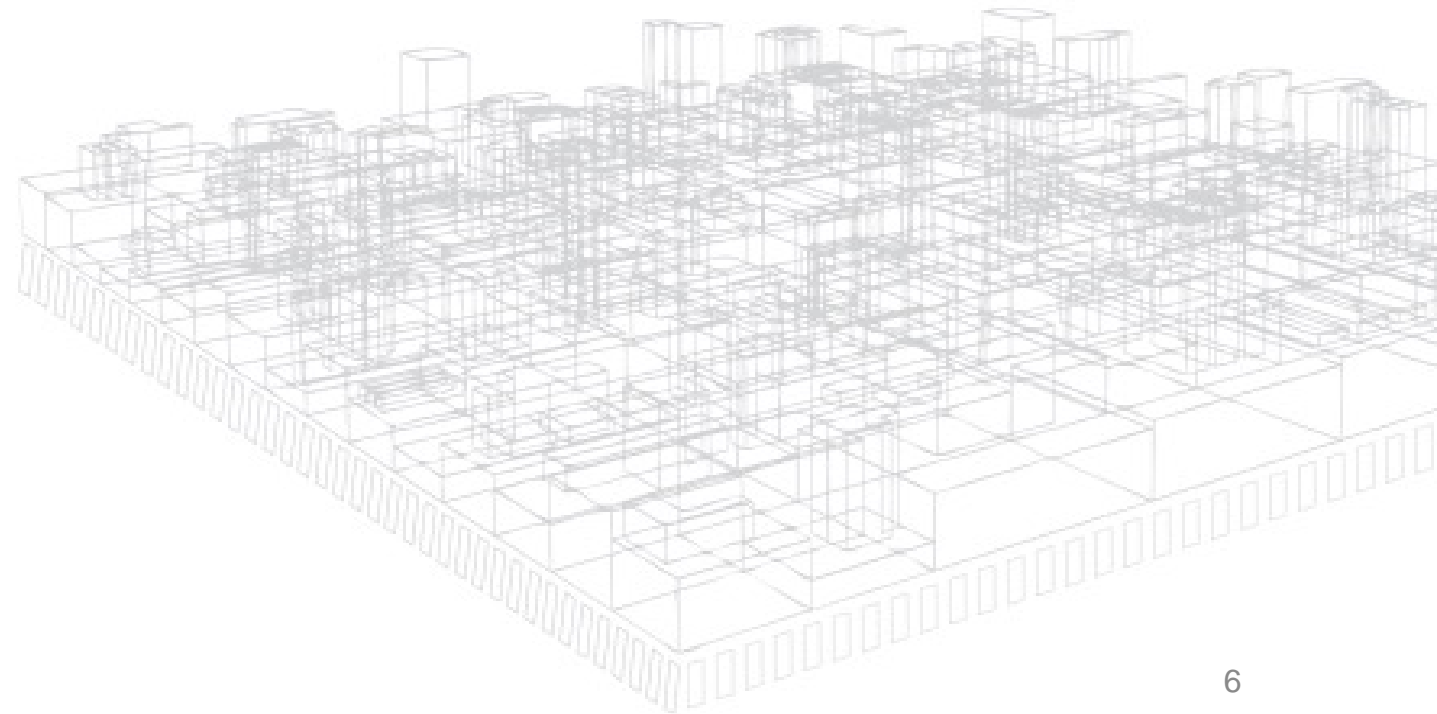


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# A brief history of Colt



- A private company founded in 1931
- I J O'Hea OBE (1897 - 1984)
- 2016 Group turnover +/-171 million EUR (2017 not known yet)
- Manufactures in the UK, Holland, Germany and China

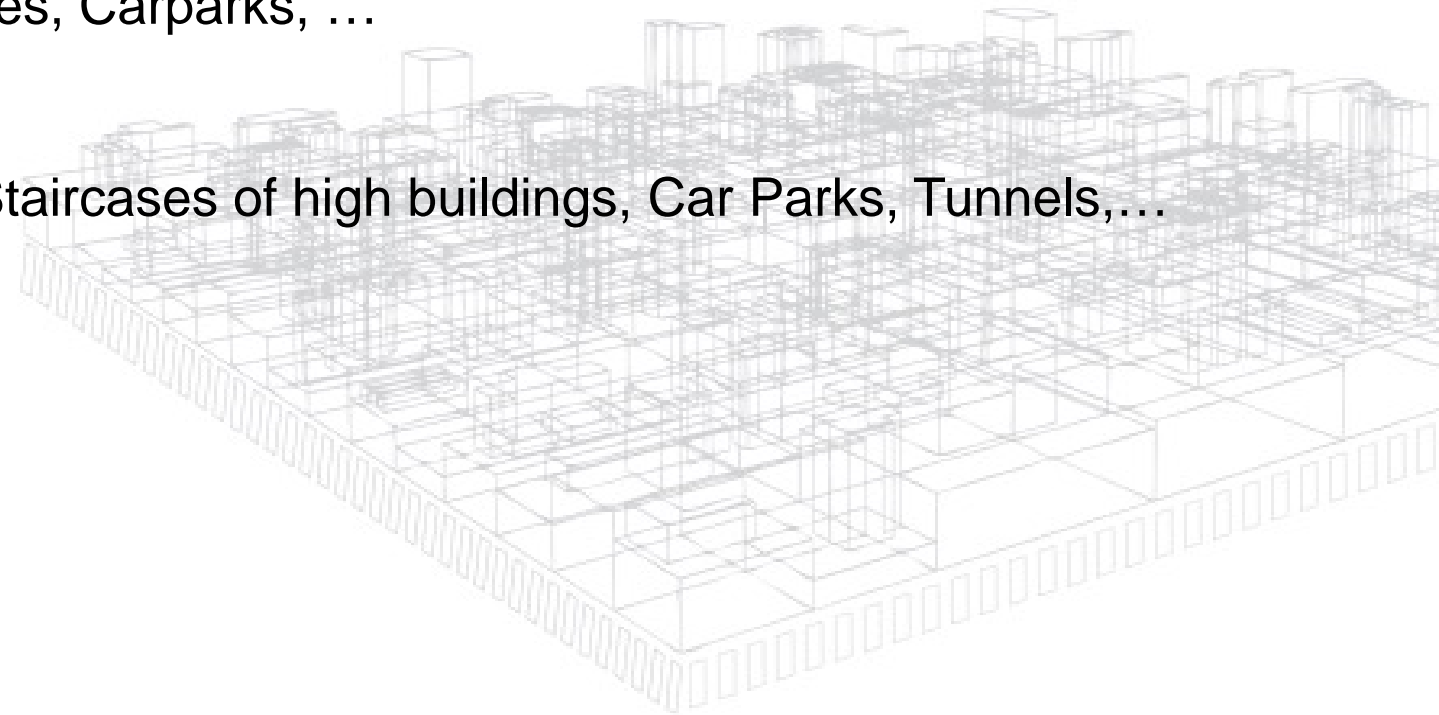


I J O'Hea  
Colt Founder



# Current UK & Belgian Business Markets for SHEV's

- Smoke Control Static 
  - SHEVS – Shopping Centres, Atria, Warehouses, Factories, etc
  - Smoke Curtains - Shopping Centres, Atria, Warehouses, Factories, Carparks, ...
- Smoke Control Mechanical 
  - Atria, Staircases of high buildings, Car Parks, Tunnels,...



# General Principles of Smoke Control

Some Notable Recent Fires:

- King's Cross
- B&Q - Leicester
- Dusseldorf Airport
- Heathrow Airport
- Bradford City Football stadium
- York Minster
- Sainsbury's – Chichester
- Windsor Castle
- Warehouse, Atherstone



# General Principles of Smoke Control



Sainsbury's  
Chichester  
Shopping Mall

Arsonist set fire to this unsprinklered and unvented store, shortly before Christmas. £14.5 million worth of damage including loss of building, loss of all stock and loss of business for many months to follow.



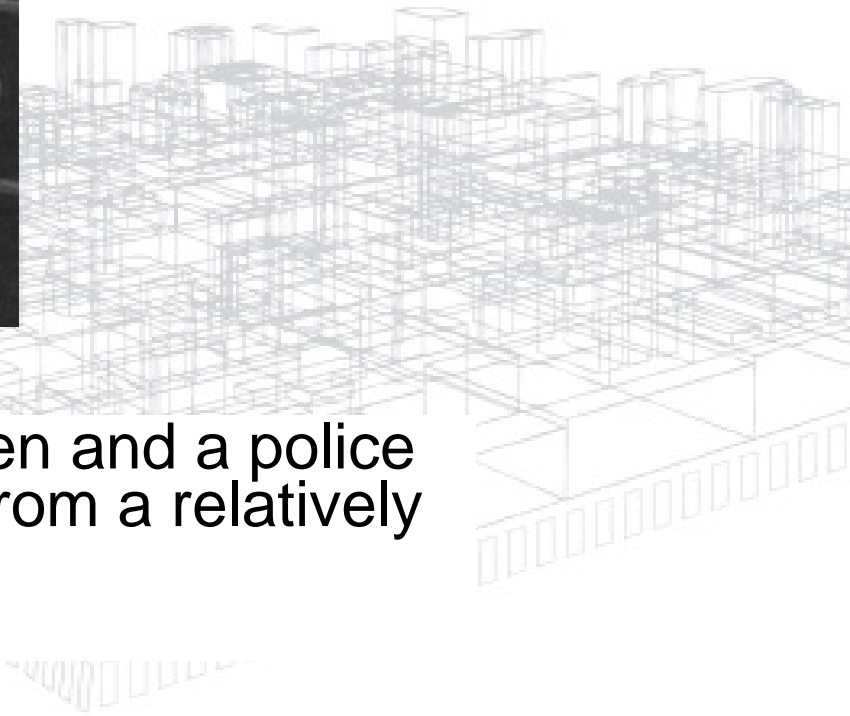


# General Principles of Smoke Control



Dusseldorf Airport  
Germany

17 people killed including a child, several women and a police officer. Over 60 injured due to smoke logging from a relatively small fire spreading throughout the Terminal.

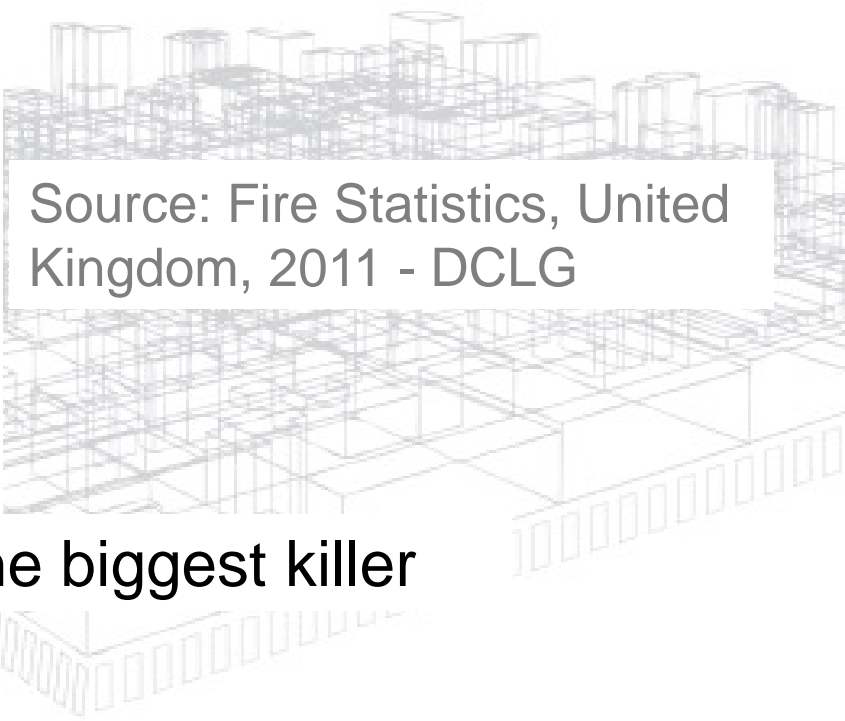
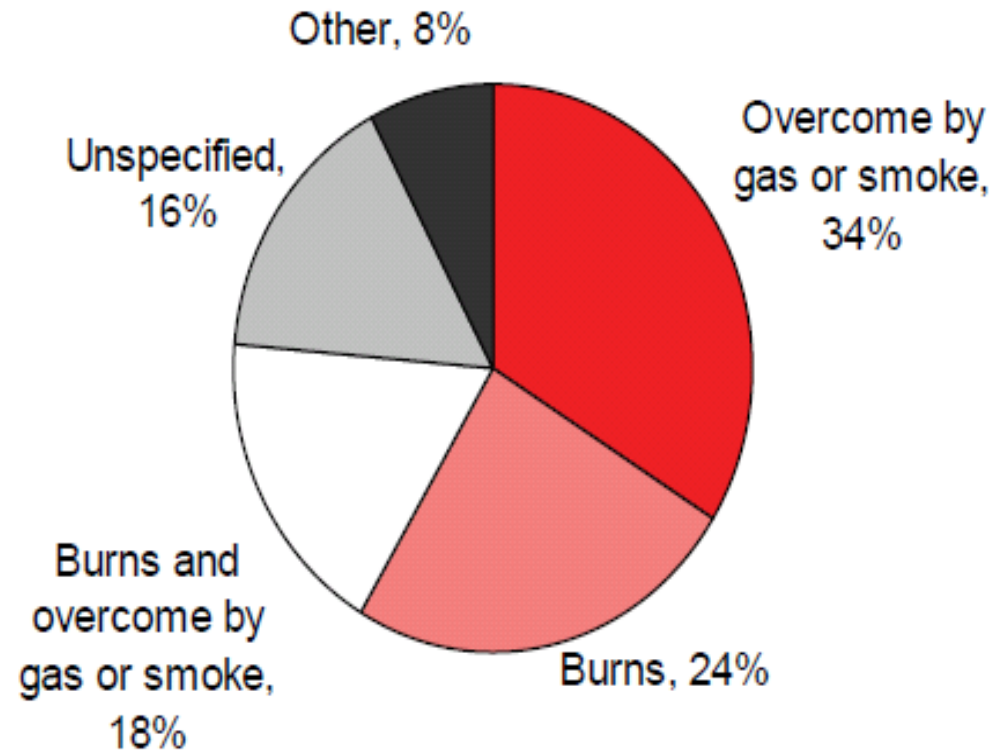




# General Principles of Smoke Control

Great Britain

388 Deaths

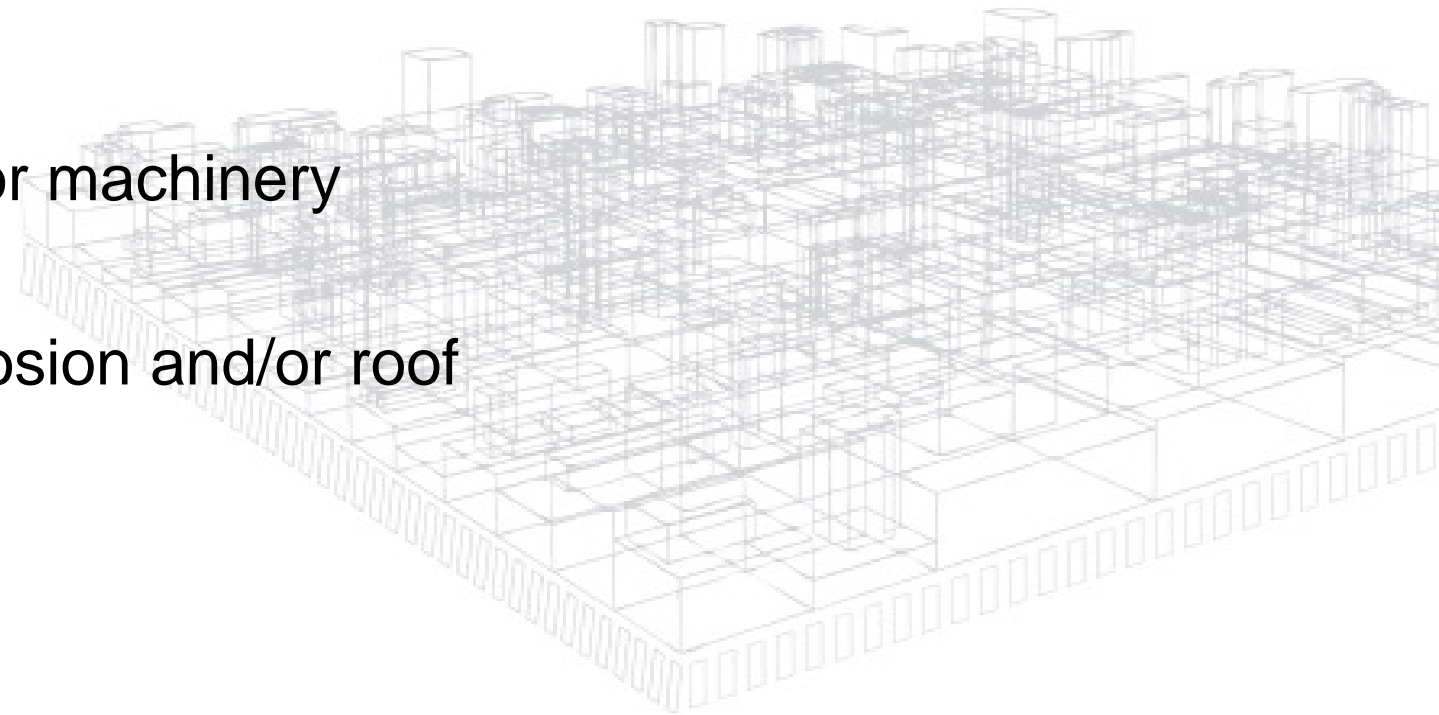


Source: Fire Statistics, United Kingdom, 2011 - DCLG

Smoke is by far the biggest killer

# Why Provide Smoke Control?

- Protect escape routes
- Assist fire fighting
- Protect valuable stock or machinery
- Reduce the risk of explosion and/or roof collapse



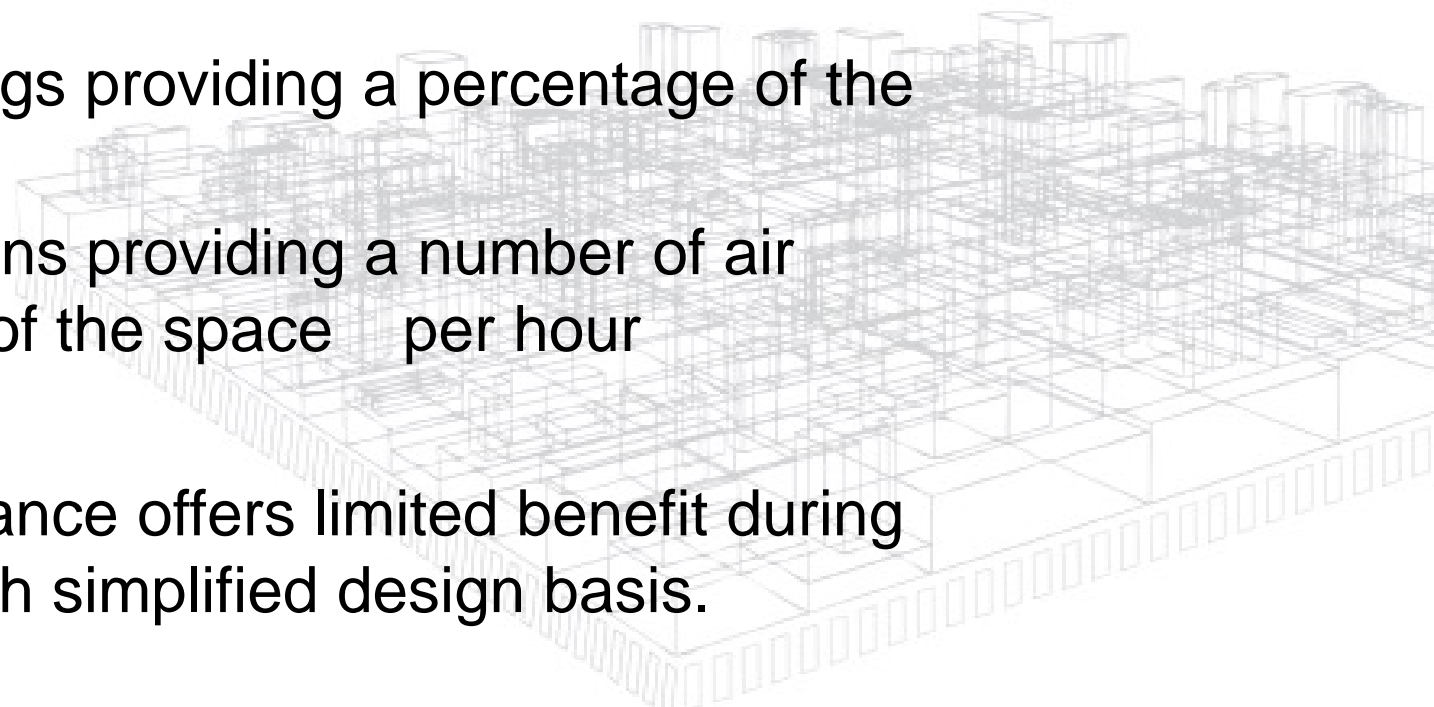
# Smoke Clearance –vSmoke Control

## Smoke Clearance Ventilation

Uses a notional amount of ventilation to assist fire fighting operations, allowing fire fighters to clear smoke from the relevant building or part of building often after the fire has been extinguished.

- Natural: Natural openings providing a percentage of the plan area of the space
- Mechanical: Extract fans providing a number of air changes of the volume of the space per hour

By definition, smoke clearance offers limited benefit during evacuation and has a much simplified design basis.



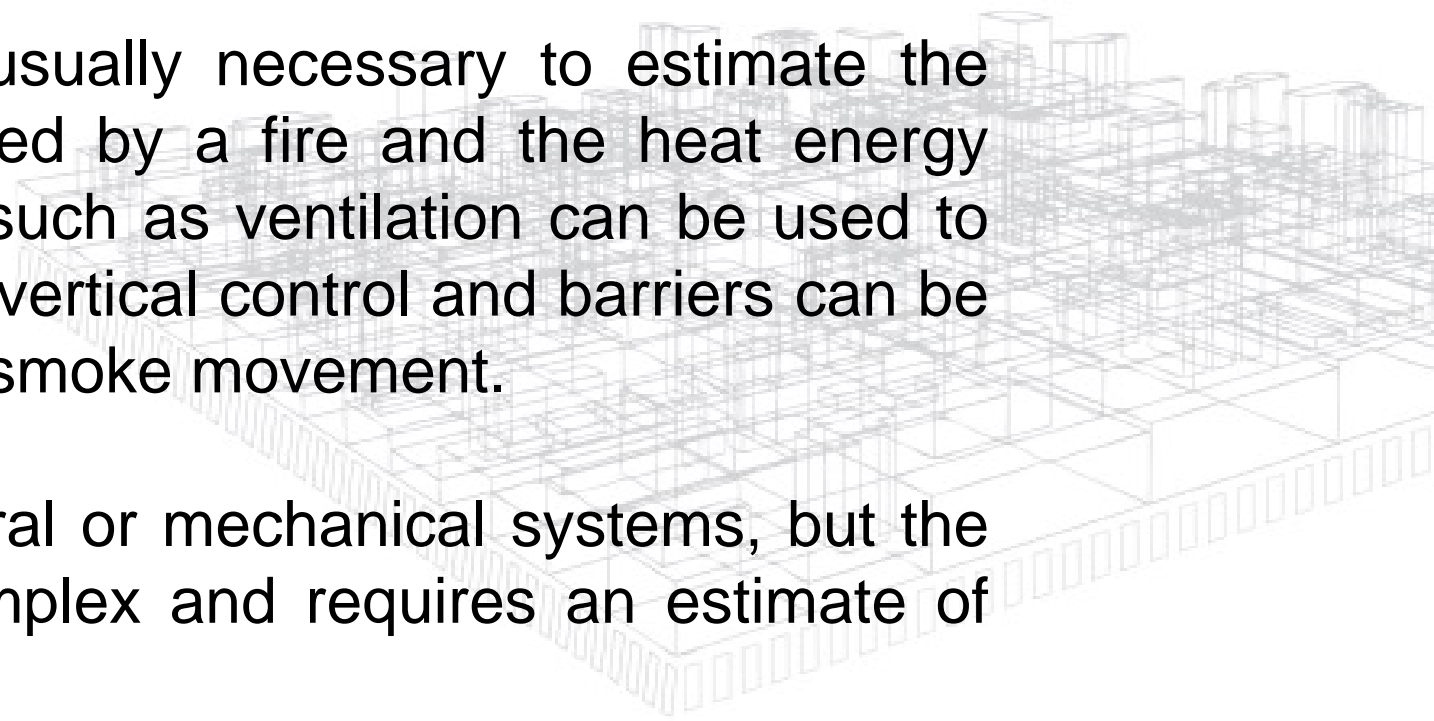
# Smoke Clearance –v- Smoke Control

## Smoke Control Ventilation

Smoke Control Systems are designed to control or restrict the movement of smoke within the building.

In order to do this it is usually necessary to estimate the amount of smoke produced by a fire and the heat energy present. Then measures such as ventilation can be used to remove smoke to provide vertical control and barriers can be used to control horizontal smoke movement.

Again, these can be natural or mechanical systems, but the design is much more complex and requires an estimate of the fire size.





# Interaction Between Sprinklers and Vents

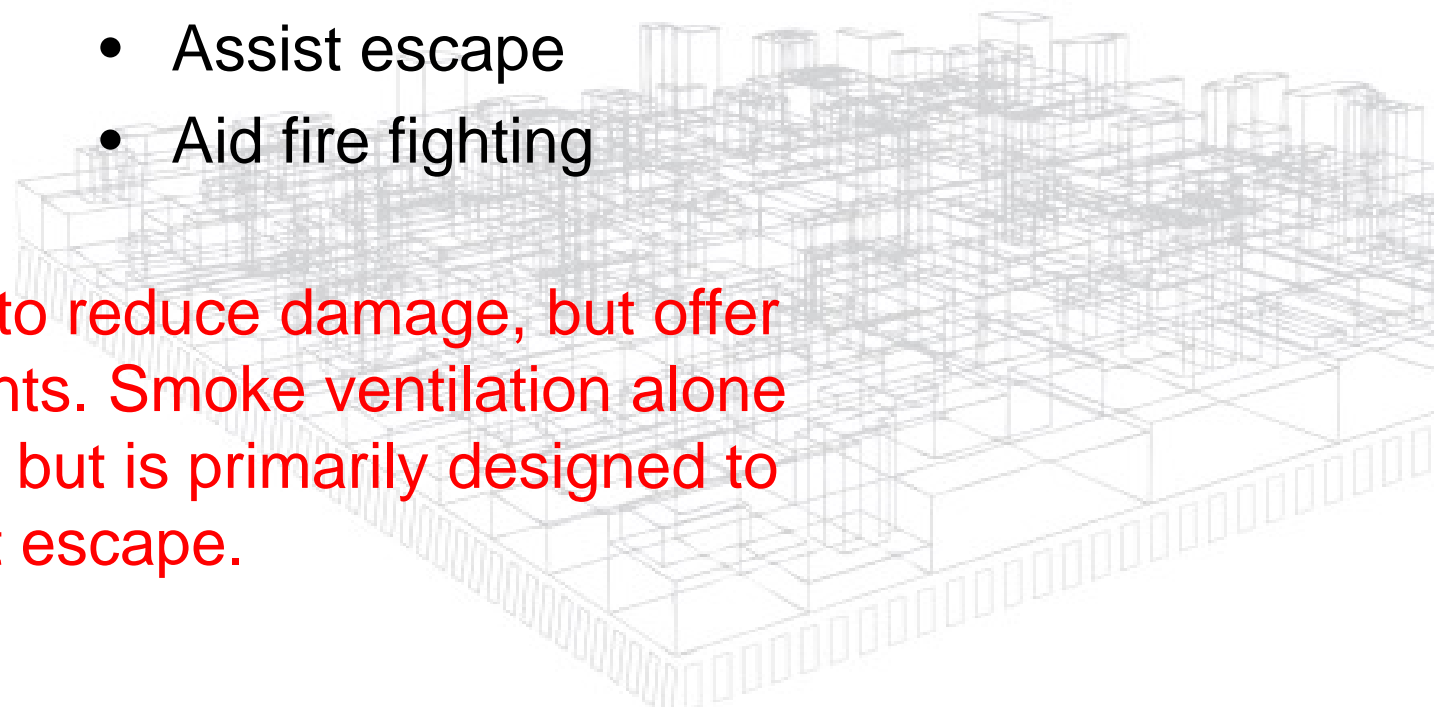
## Sprinklers

- Will limit fire spread and control growth
- Will not reduce smoke damage

## Ventilation

- Will prevent smoke logging
- Assist escape
- Aid fire fighting

Sprinklers are designed to reduce damage, but offer limited benefit to occupants. Smoke ventilation alone will not save the building but is primarily designed to assist escape.



# History and Development

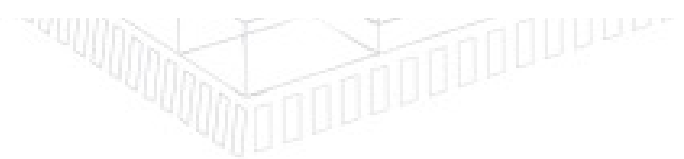


1881 – Ring Theatre, Vienna – 800 dead

1887 – Theatre Royal, Exeter – 187 dead

1887 – Paris Opera – 200 dead

1903 – Iroquois Theatre, Chicago – 602  
dead



# History and Development



General Motors Factory, Michigan  
1953

6 dead

140,000 m<sup>2</sup> plant destroyed

Loss of production of automatic  
gearboxes for 5 major car  
manufacturers

# History and Development

Current Documents:

The Building Regulations 2000: Approved Document B (2006)

Codes of Practice: BS 5588-1 to 12, BS 9999, BS 9991

Specifications: EN 12101-1, 2, 3, 7, 8 & 10

Design Guidance:

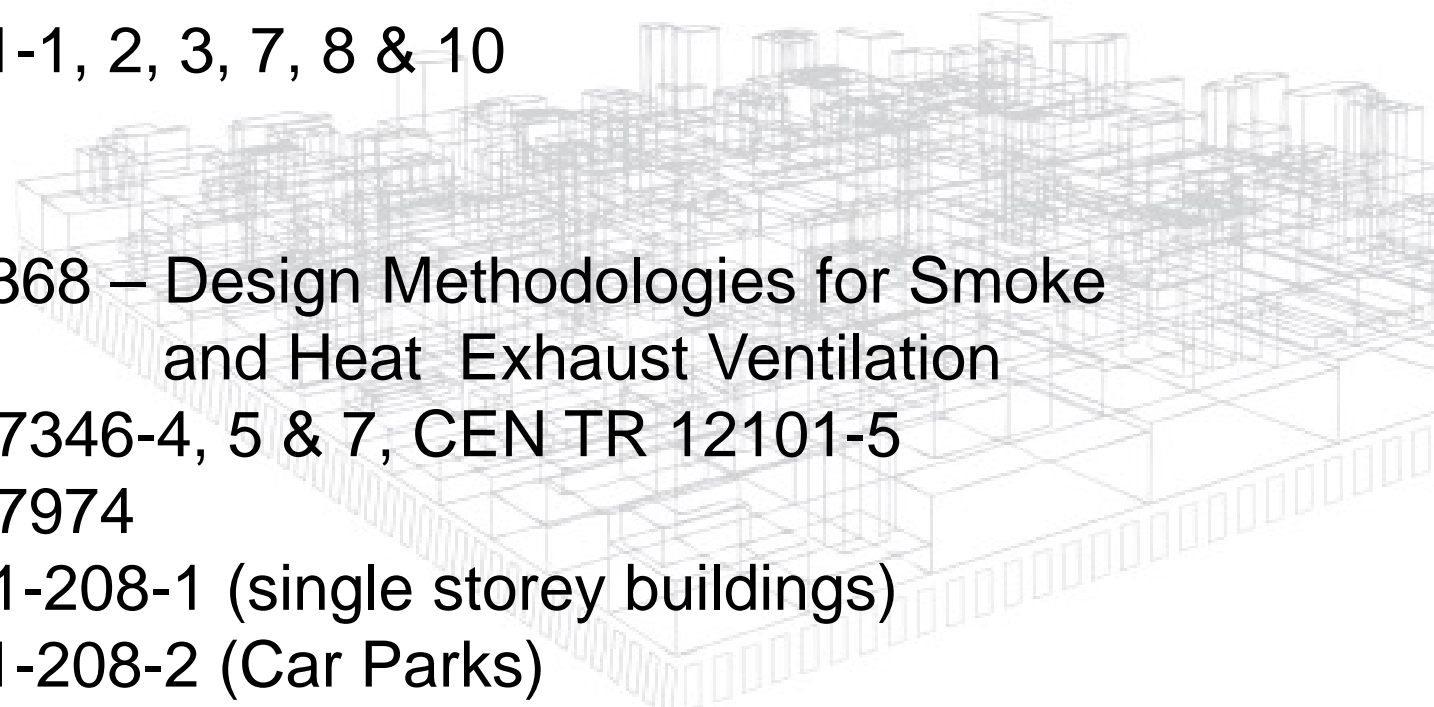
Great-Britain: BR 368 – Design Methodologies for Smoke  
and Heat Exhaust Ventilation

BS 7346-4, 5 & 7, CEN TR 12101-5

BS 7974

Belgium: NBN-S-21-208-1 (single storey buildings)

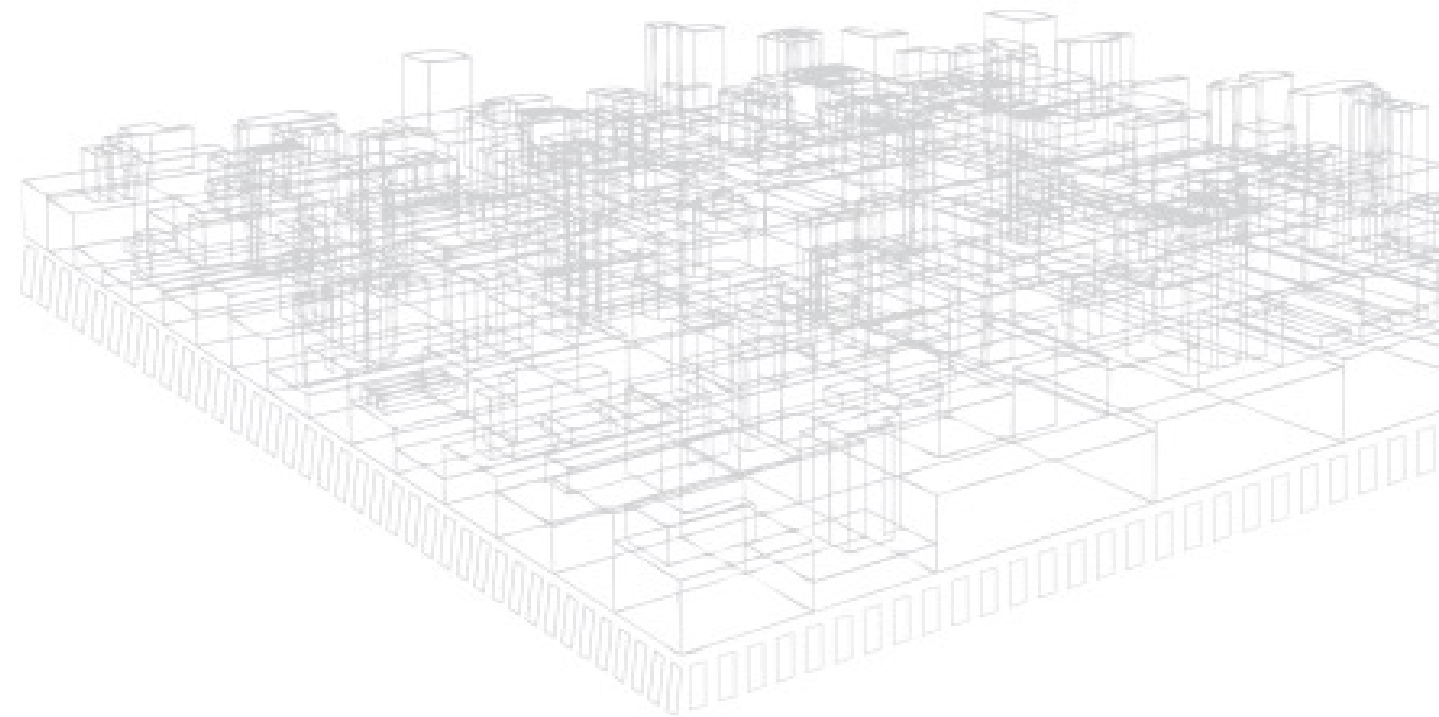
NBN-S-21-208-2 (Car Parks)





# Breakdown of Smoke Control Applications

- Factories/Warehouses/Retail Sheds
- Shopping Centres
- Atria
- Car Parks



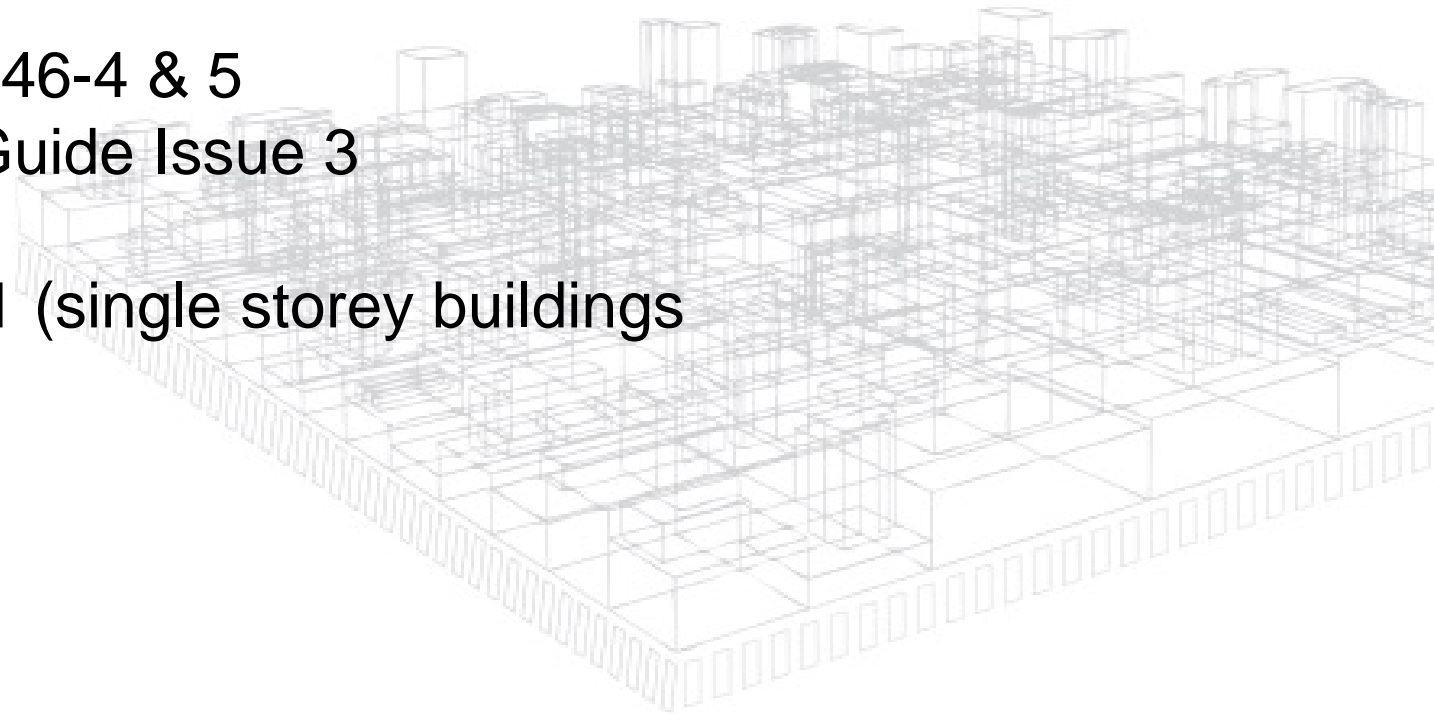
# Factories/Warehouses/Retail Sheds – Large Single Storey Buildings

Control of the temperature of the smoke layer (max. 300° C)

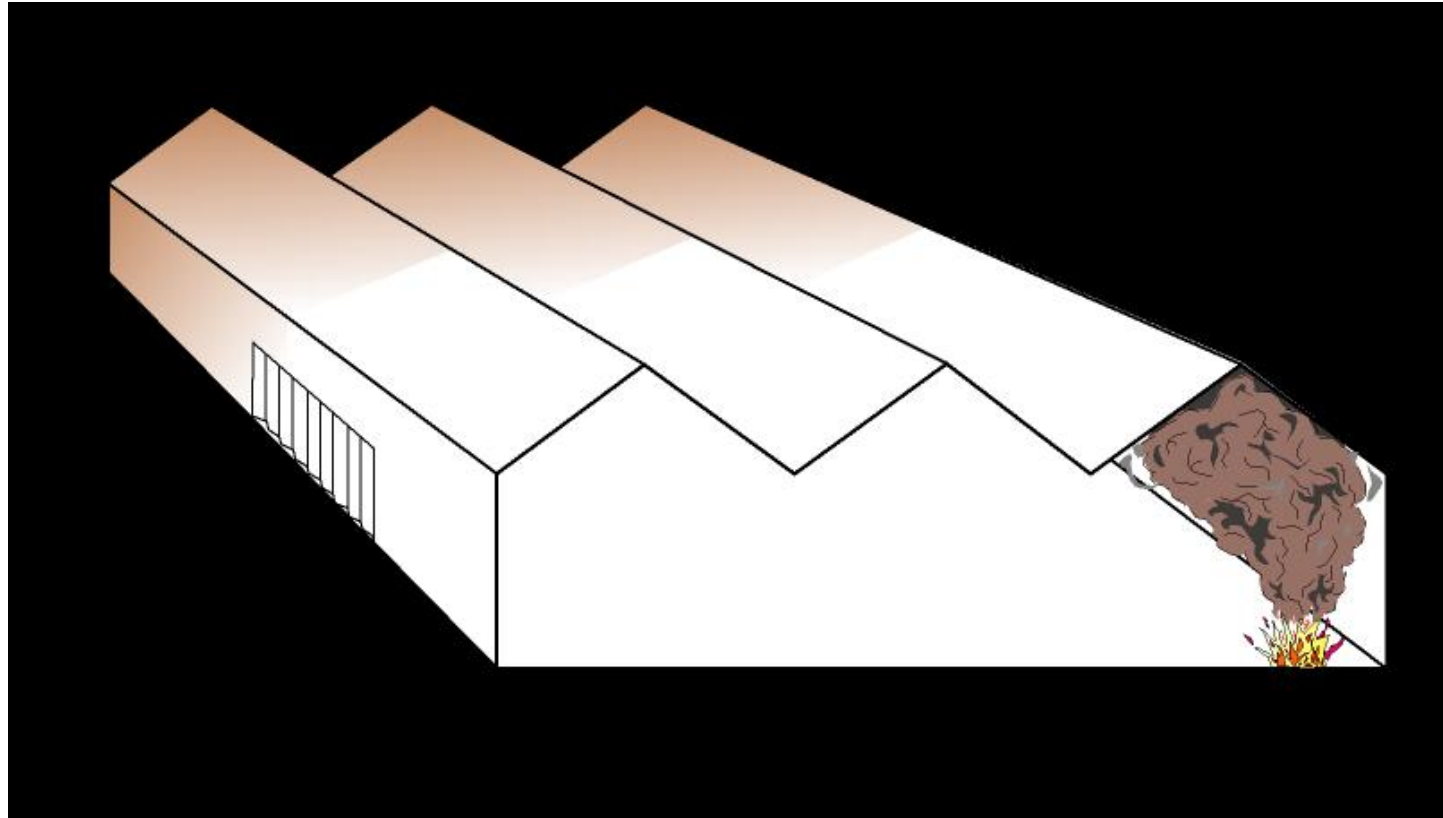
Control of the height between the floor and the smoke layer (min. 3m)

Design Guidance: BS 7346-4 & 5  
Great-Britain SVA Guide Issue 3

Belgium: NBN-S-21-208-1 (single storey buildings)

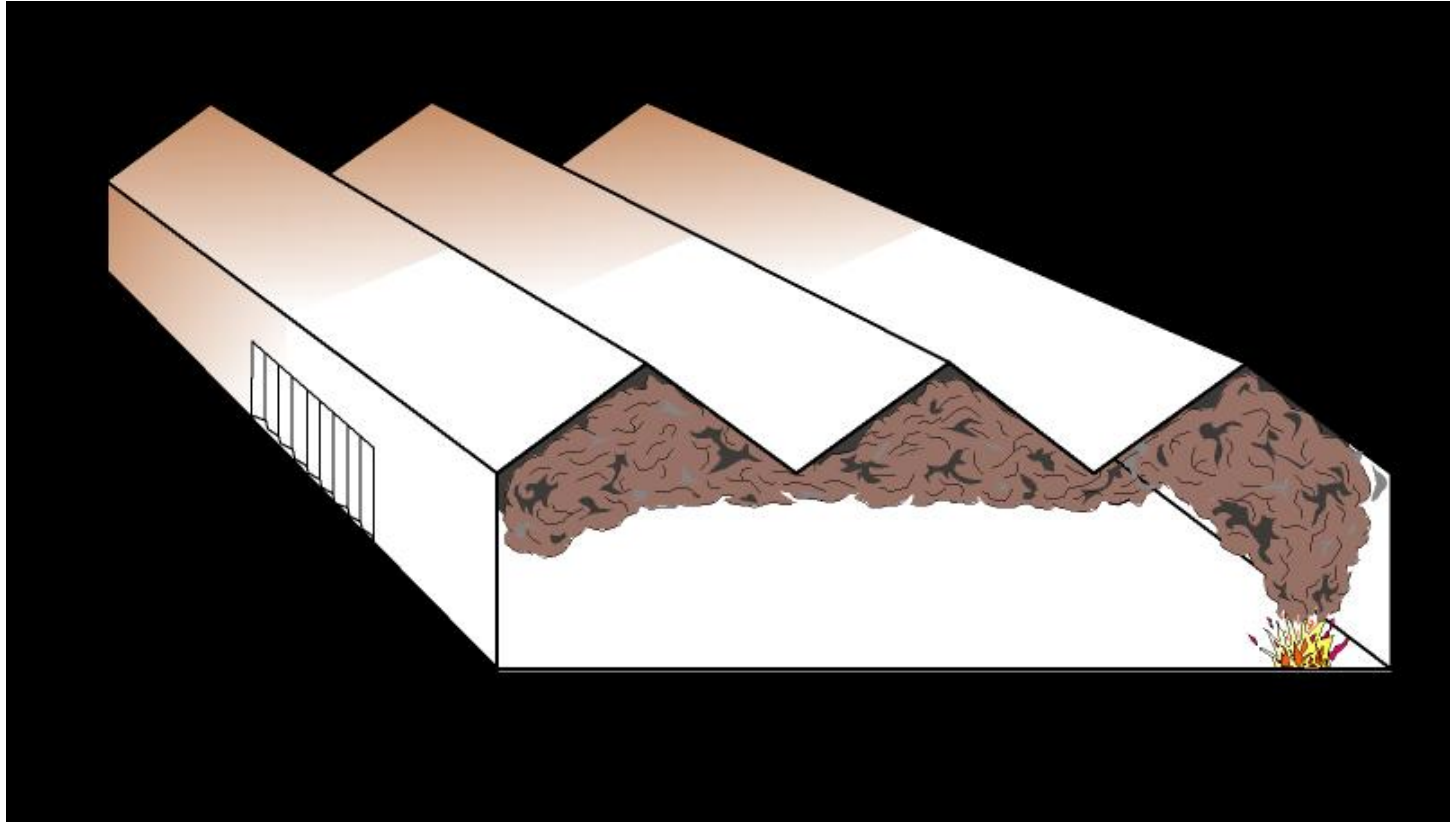


# Applications: Large Single Storey Buildings



In the early stages of fire, smoke quickly rises into roof space

# General Principles of Smoke Control

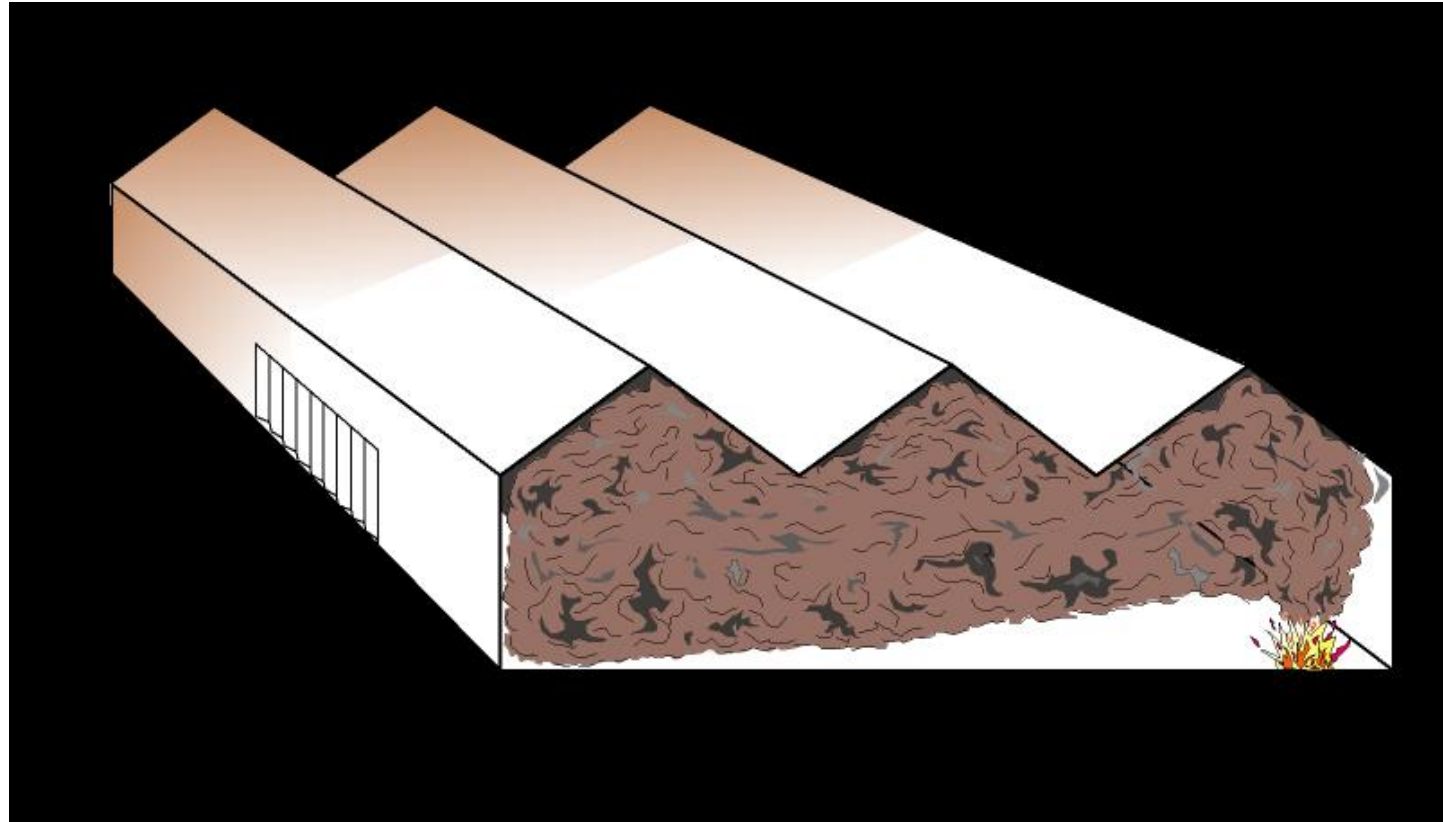


Smoke travels laterally beneath the roof and spreads throughout the building

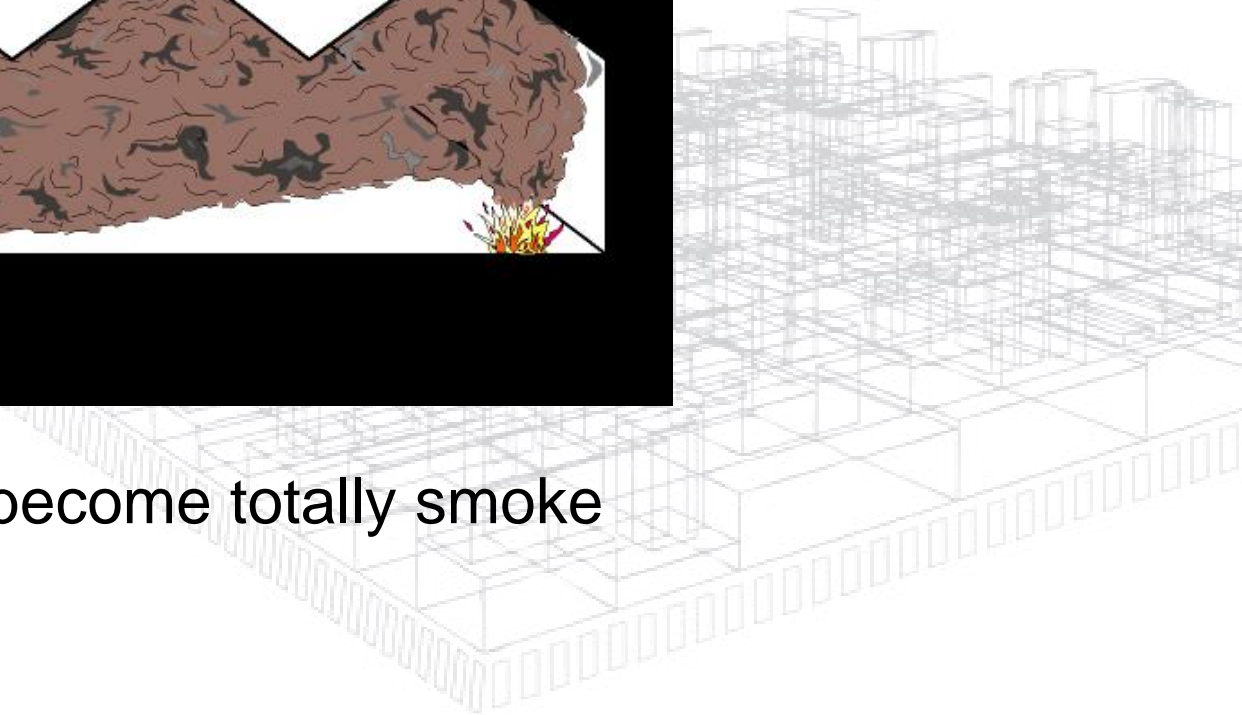




# Applications: Large Single Storey Buildings



Even large buildings can become totally smoke logged in minutes



# Applications: Large Single Storey Buildings



In a smoke logged building, way finding can be very difficult and temperatures will rise rapidly – leading to loss of structural stability and building collapse.

# Applications: Large Single Storey Buildings



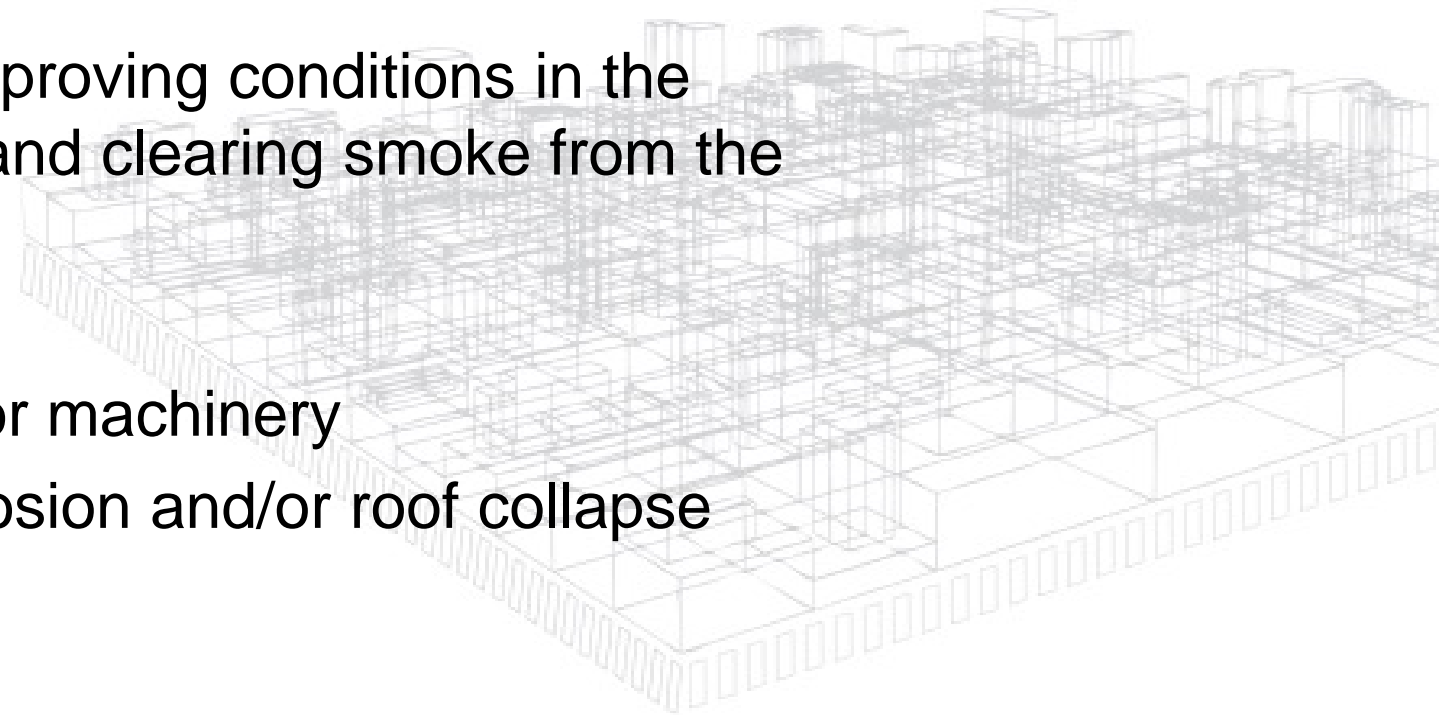
Evacuation is safer and fire fighting more effective when the routes are clear



# Applications: Large Single Storey Buildings

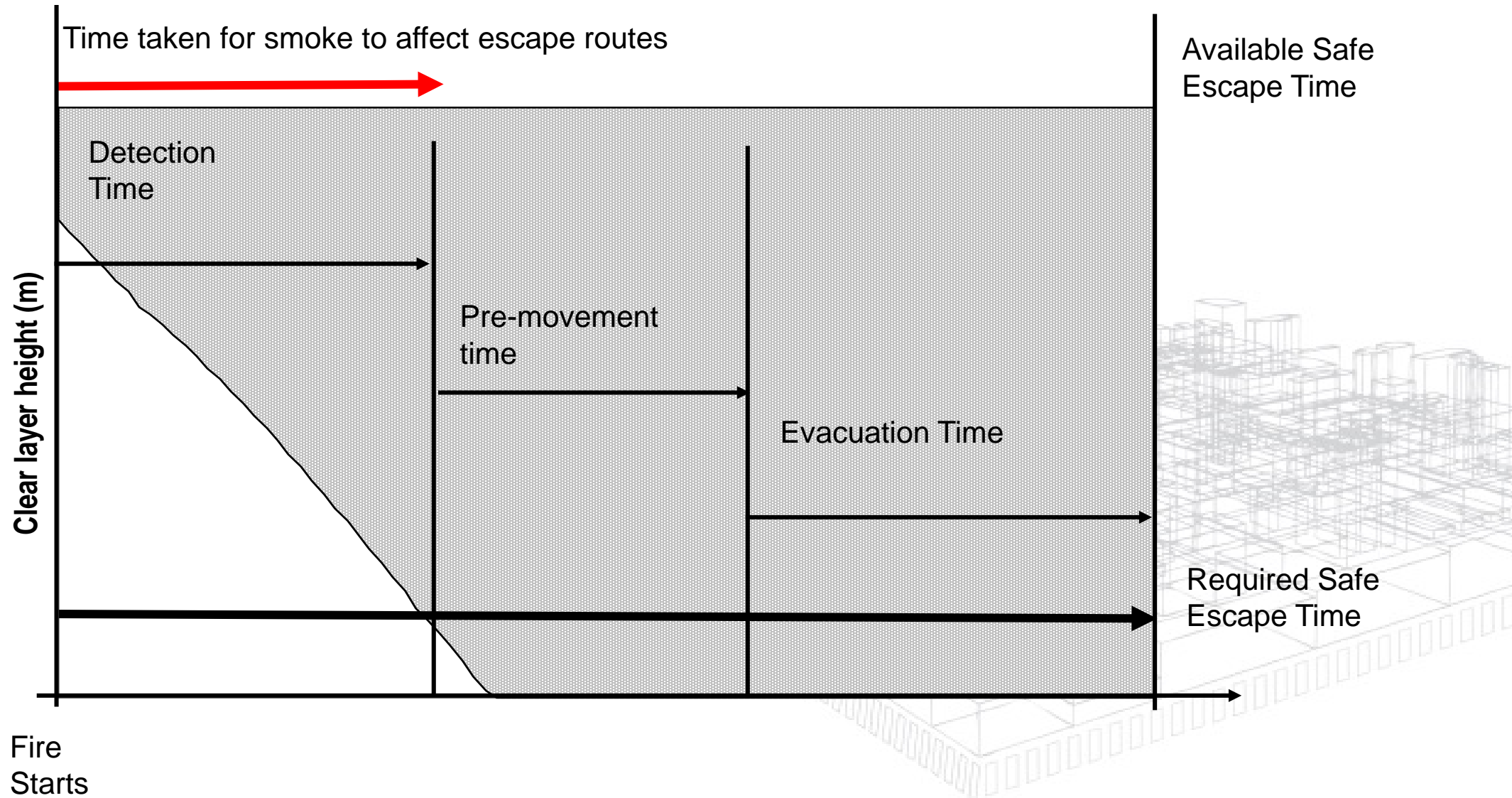
## Objectives of Smoke Control:

- Assist escape by extending available safe evacuation time
- Assist fire fighting by improving conditions in the building during the fire and clearing smoke from the building after.
- Protect valuable stock or machinery
- Reduce the risk of explosion and/or roof collapse

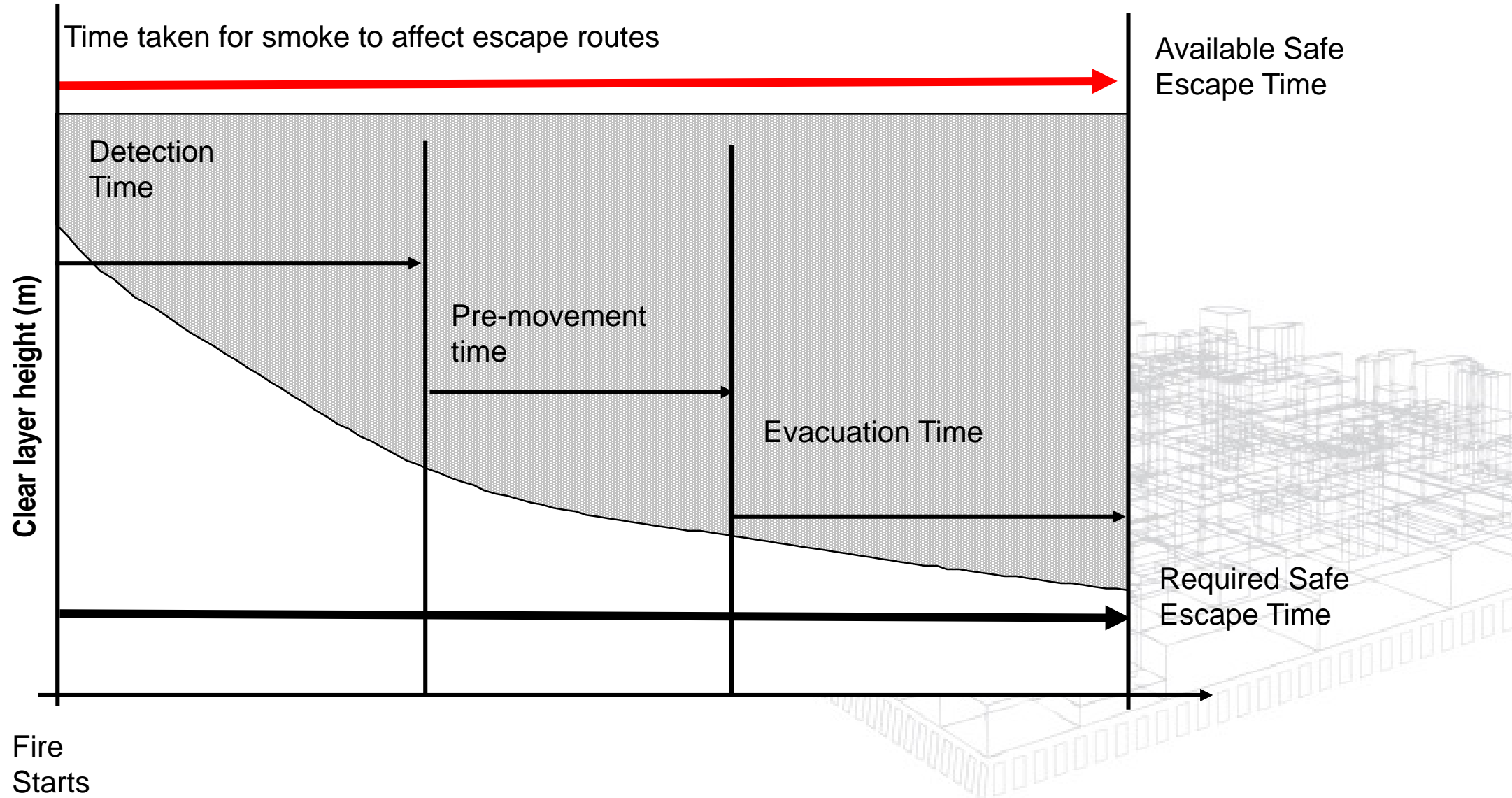




# Applications: Fire and Smoke without SHEV's.

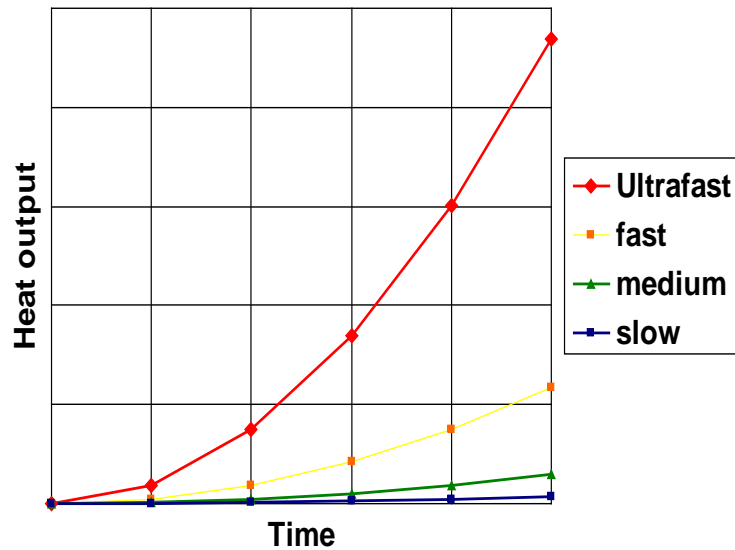


# Applications: Fire and Smoke with SHEV's.

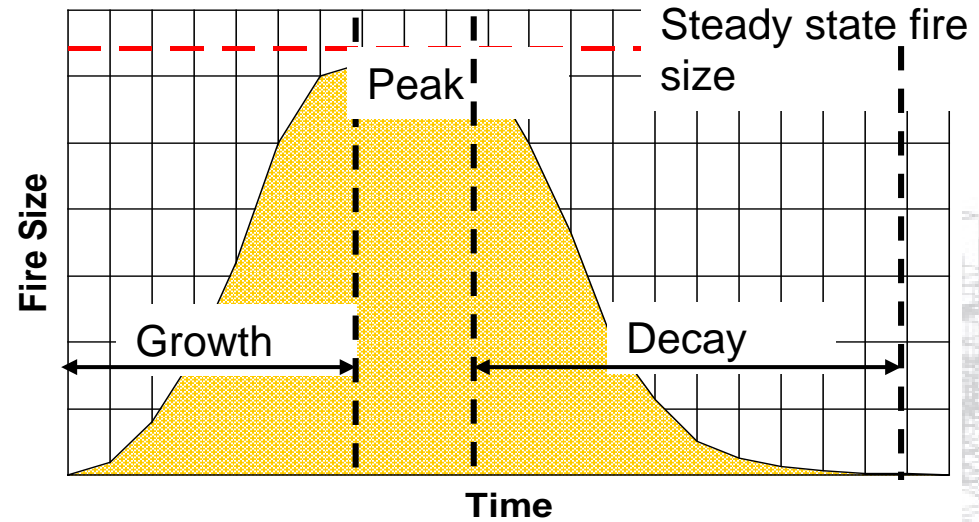


# Applications: Fire and Smoke

## Time dependent Fires



## Steady State Fires



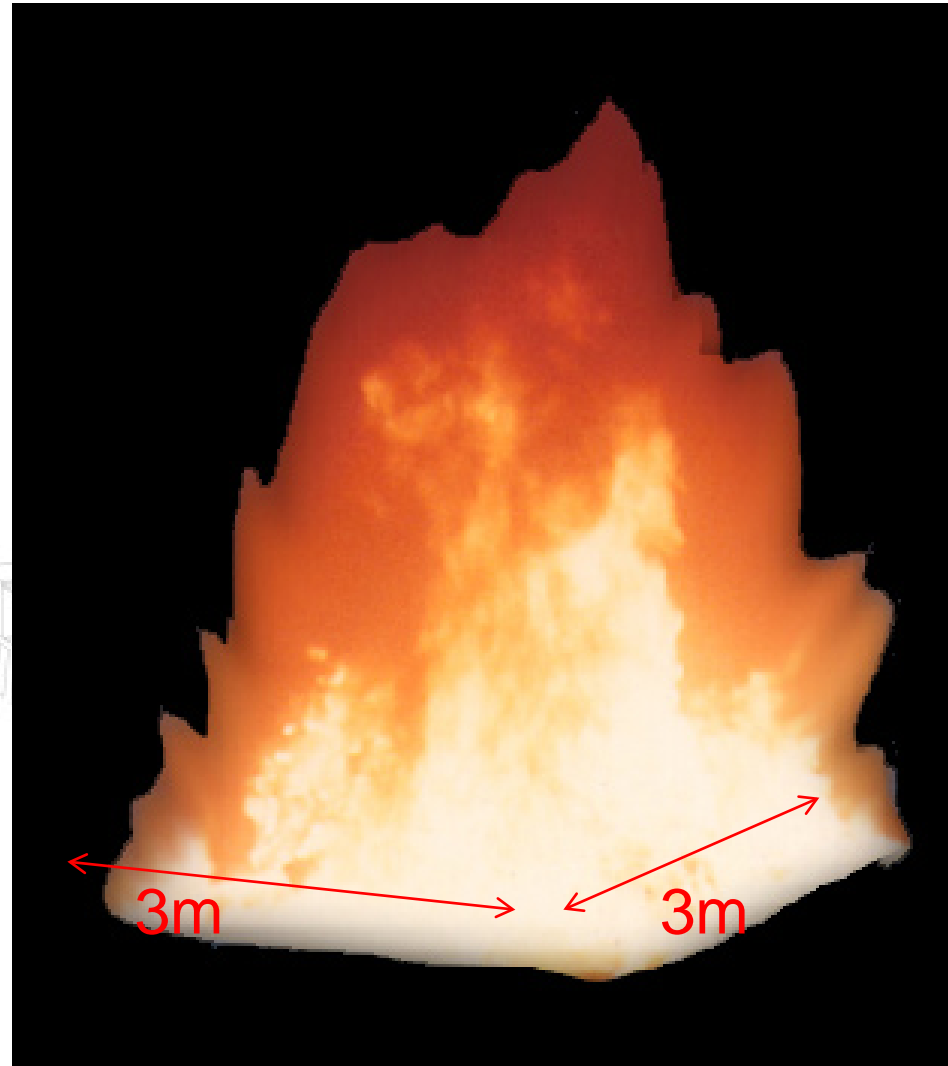
Steady State design ignores growth and decay of fire and takes into account the largest probable fire for a given risk

# Applications: Large Single Storey Buildings

## Steady State Fires

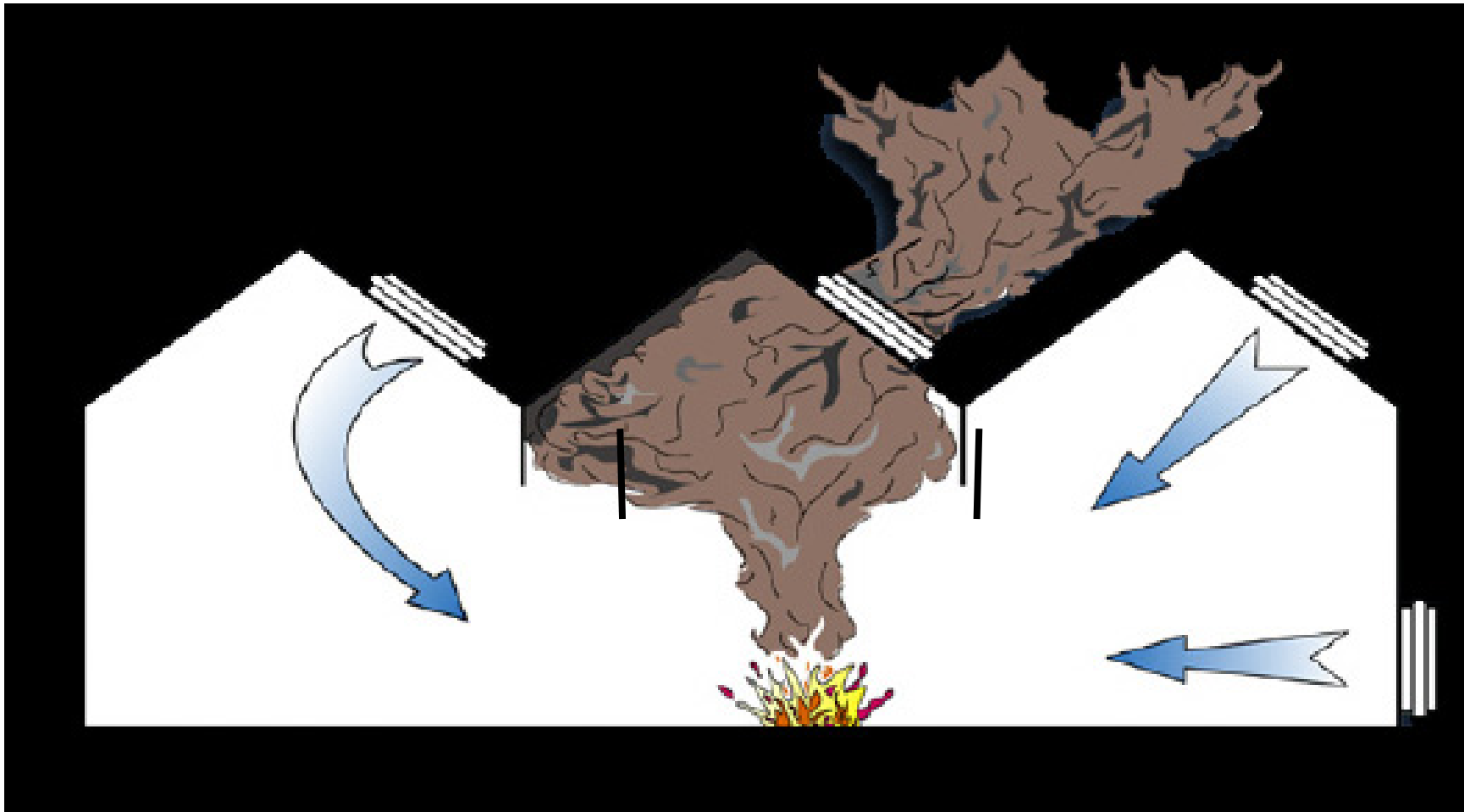
- 3 m x 3 m (minimum)
- 4,5 x 4,5 m
- 6 m x 6 m
- 9 m x 9 m (maximum)

Fire Engineer estimates the size of the fire surface according the type of industry.

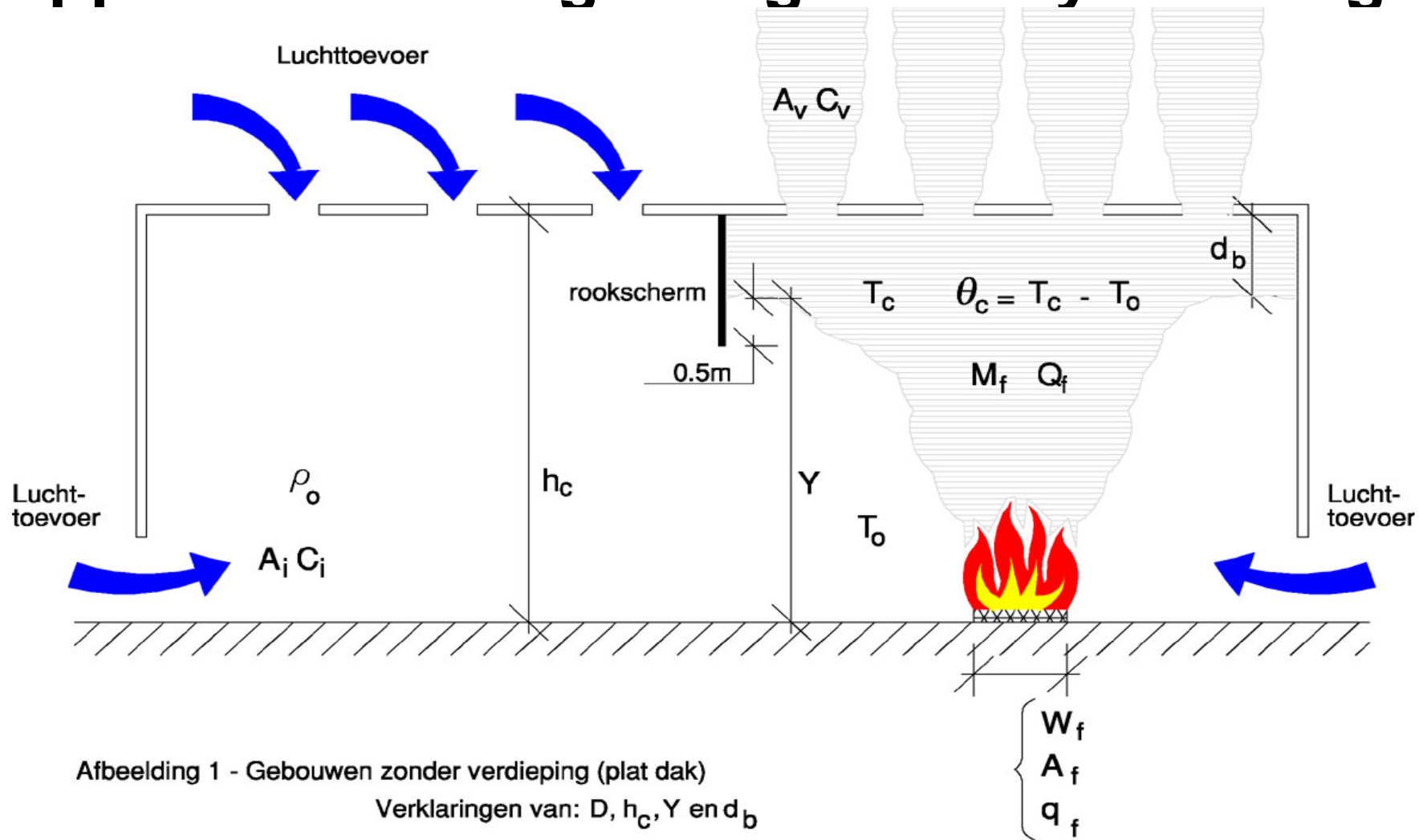


# Applications: Smoke Control

## Components of a Smoke Control System



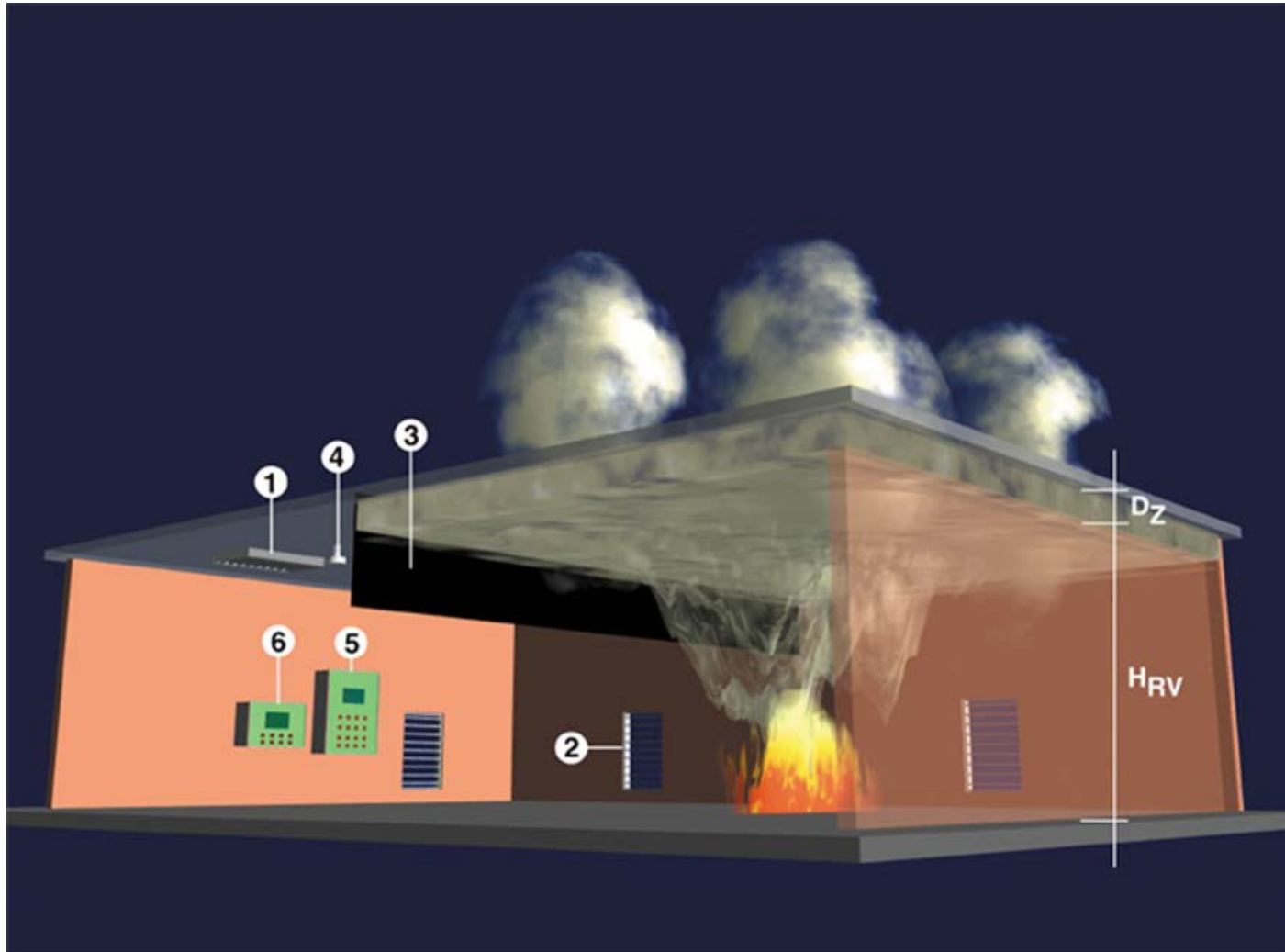
# Applications: Large Single Storey Buildings



Verklaring v/d symbolen volgens NBN S 21-208-1



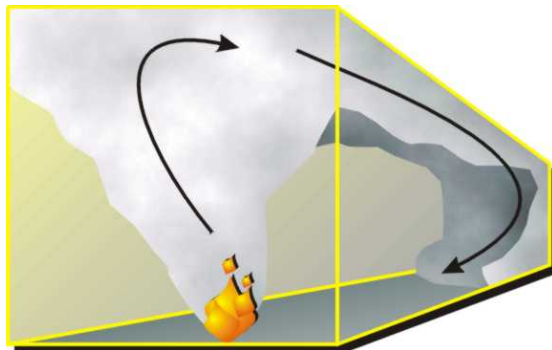
# Applications: Large Single Storey Buildings



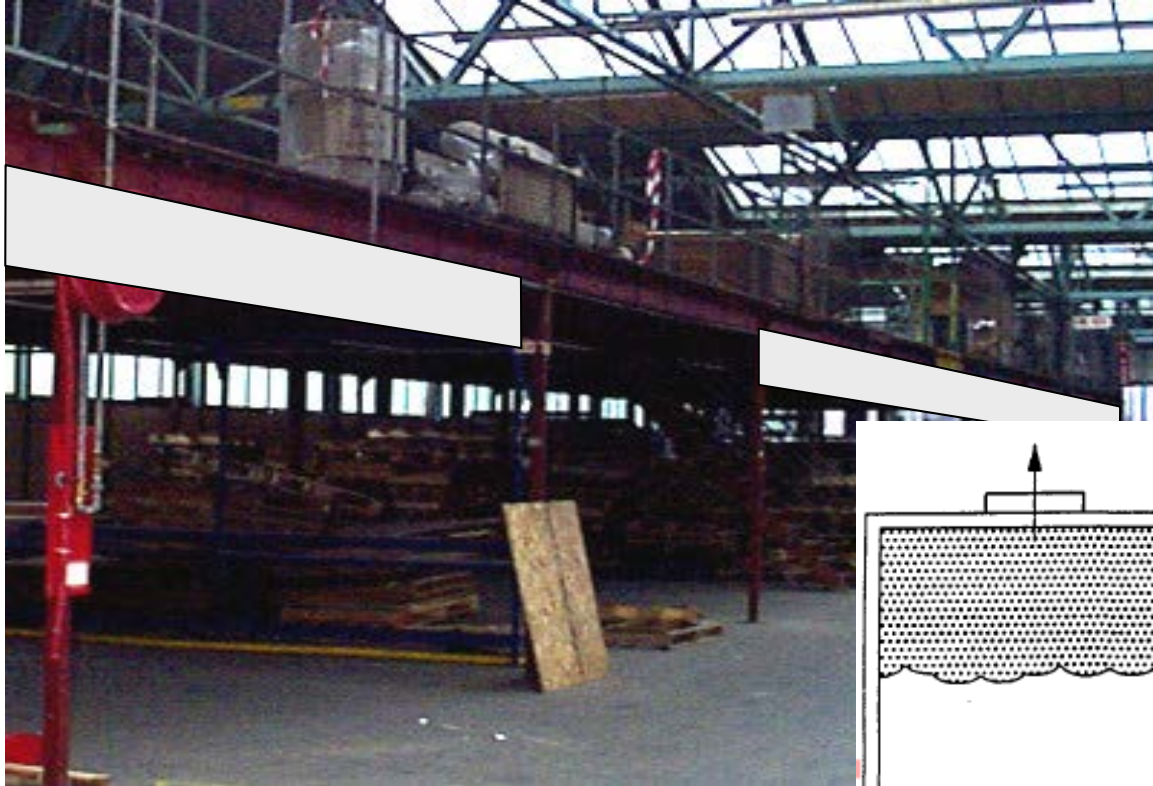
1. Smoke exhaust.
2. Air inlet.
3. Smoke screen.
4. Smoke detector.
5. Fire detection panel.
6. Control panel SHEV's.

# Applications: Large Single Storey Buildings

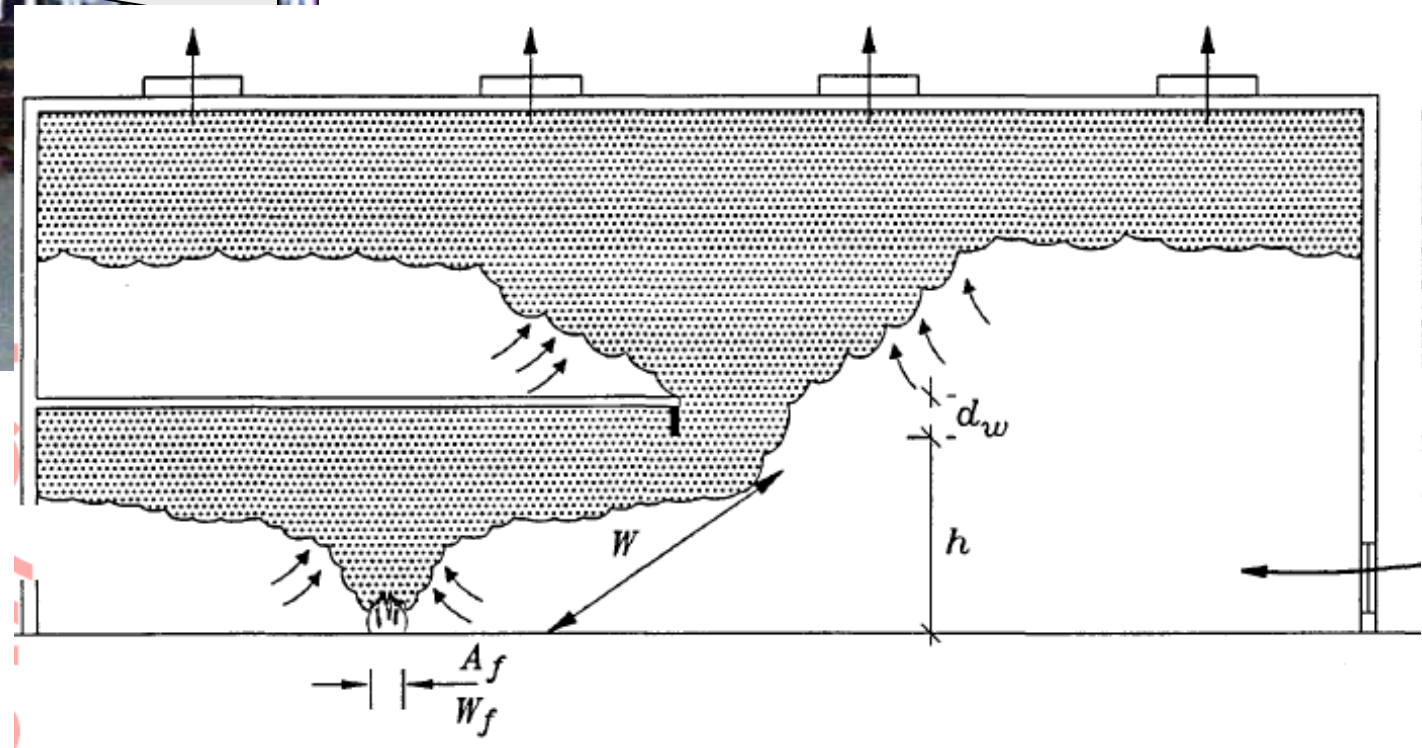
In buildings larger than 2.000 m<sup>2</sup> or longer than 60 m, the use of smoke screens is mandatory to avoid recirculation.



# Applications: Large Single Storey Buildings



Mezzanine Floors needs a separate approach to engineer.



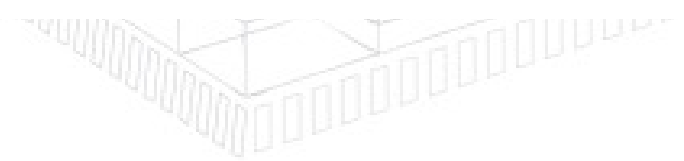


# Applications: Shopping Centres

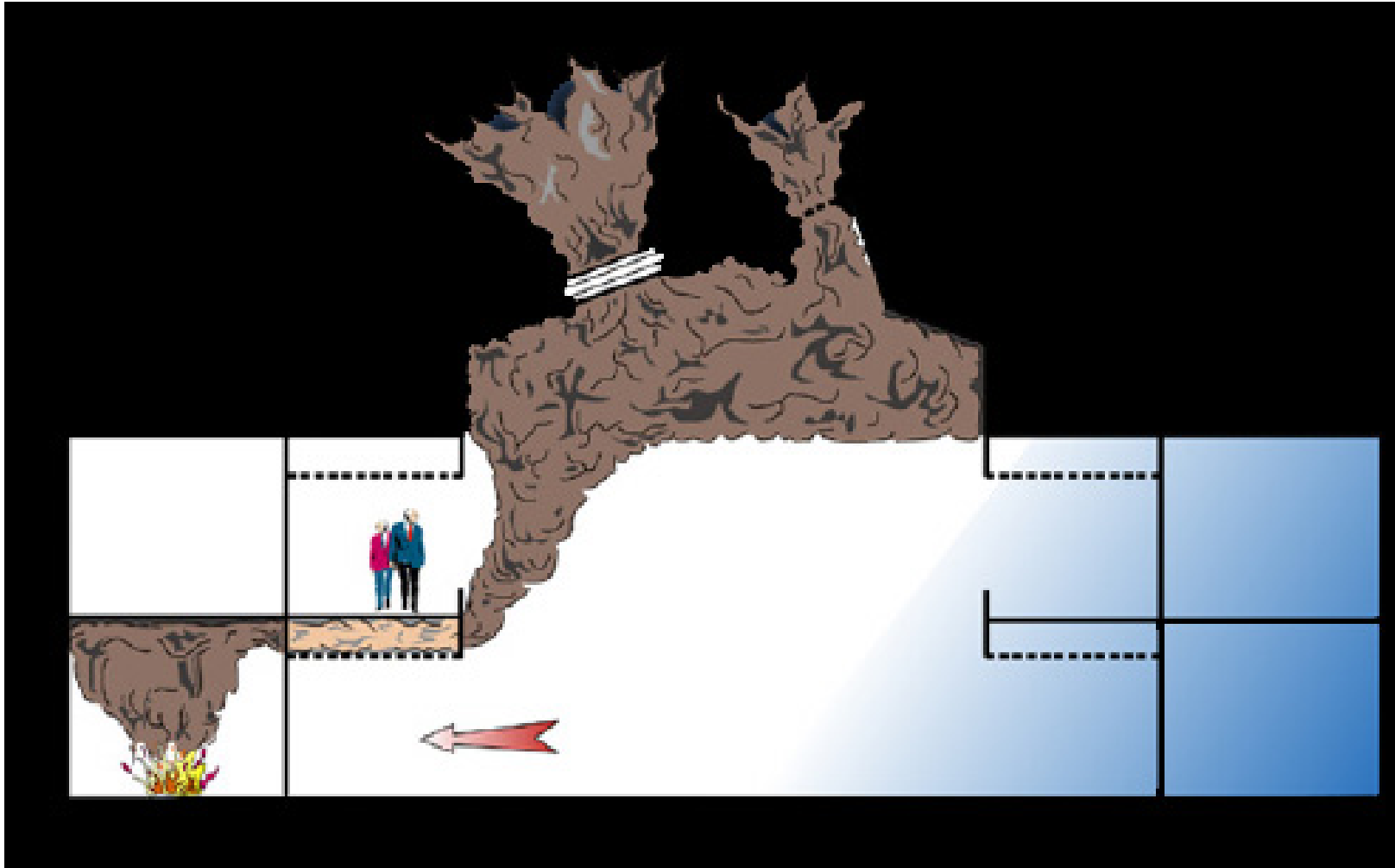
- Large uncompartmented buildings
- Full of people who are unfamiliar with the building layout.
- Varied cross-section community, e.g. elderly and disabled.
- Evacuation time can be considerable.

Smoke Control is therefore a requirement to assist in keeping escape routes safe for an extended time period.

Design guidance is given in BS 5588 Part 10: 1991, BS 9999, BS 7346-4 and BR 368 and for Belgium in the EN-12101-5



# Applications: Shopping Centres



Extract direct from shop

- Extract from under balcony
- Extract from mall roof space

Multiple levels further complicate the situation

# Applications: Large Shopping Centres



- Smoke flow only through one void
- Limit perimeter of spill edge
- Limit smoke reservoir length in mall
- Limit plume height for practicality / cost effectiveness
- Natural ventilators to be as high as possible
- Inlet availability

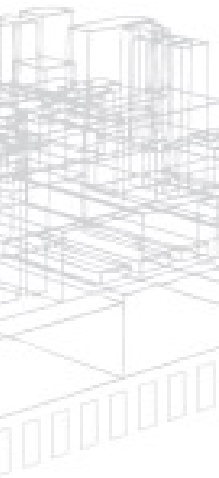


# Applications: Atria Buildings

## Atria

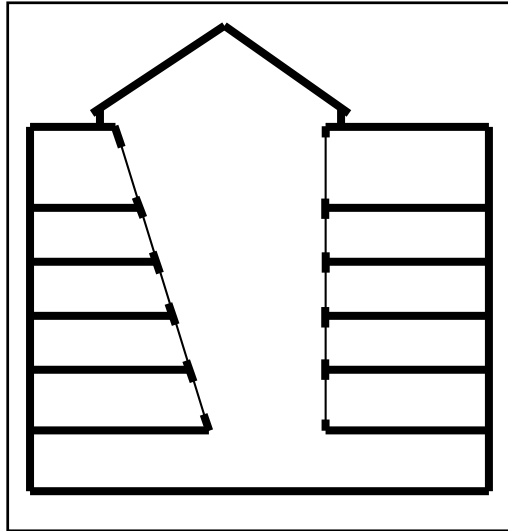
If the vertical compartmentation specified in ADB cannot be met, i.e. the building has an Atrium, then it should be designed in accordance with BS5588 Part 7:1997 or BS 9999, which, depending on the application, may require smoke clearance or smoke control.

Important factors are whether people are unfamiliar with the building (e.g. public buildings) and possibly asleep (e.g. hospitals or hotels).

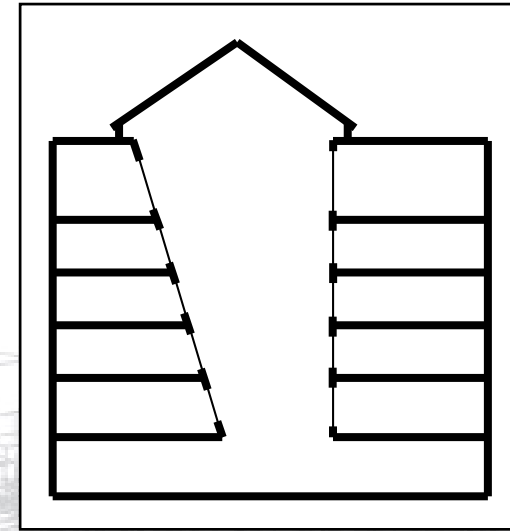


# Applications: Atria Buildings

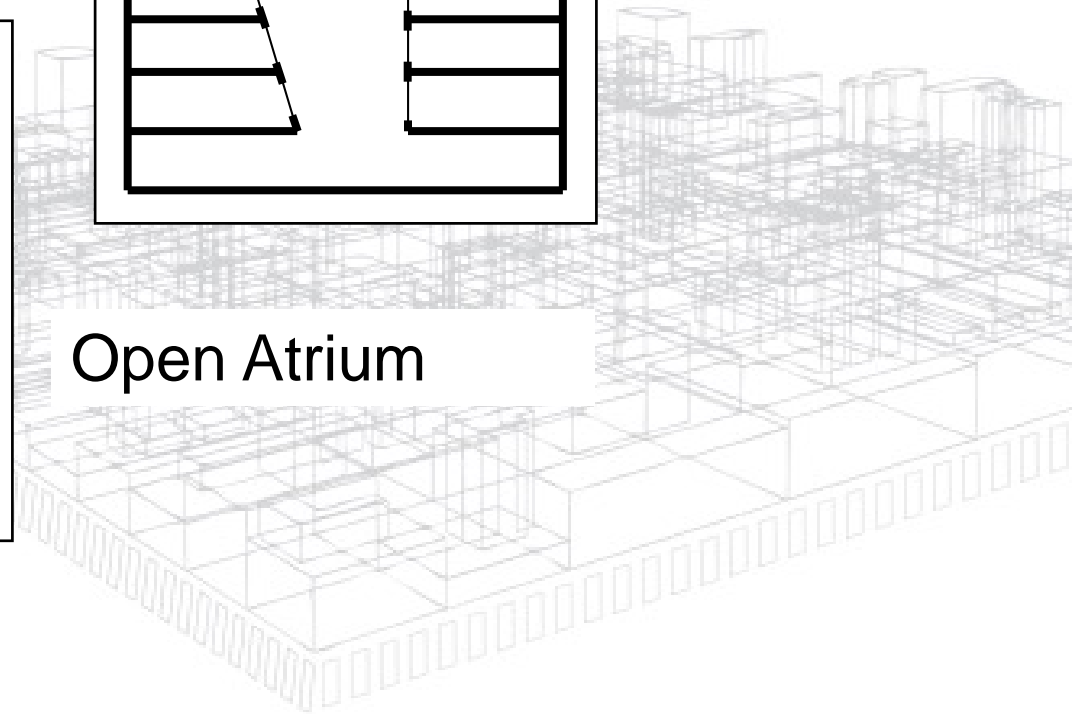
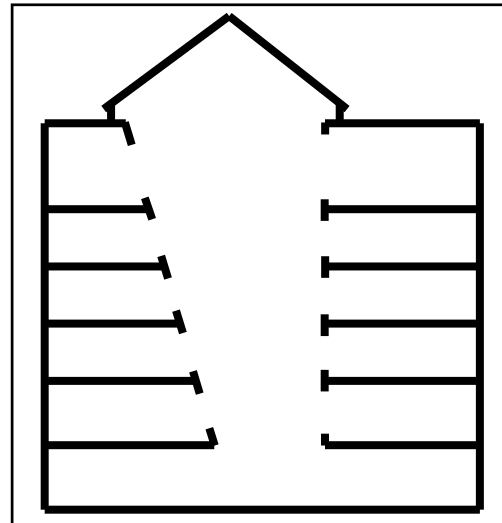
Sterile Tube



Closed Atrium



Open Atrium



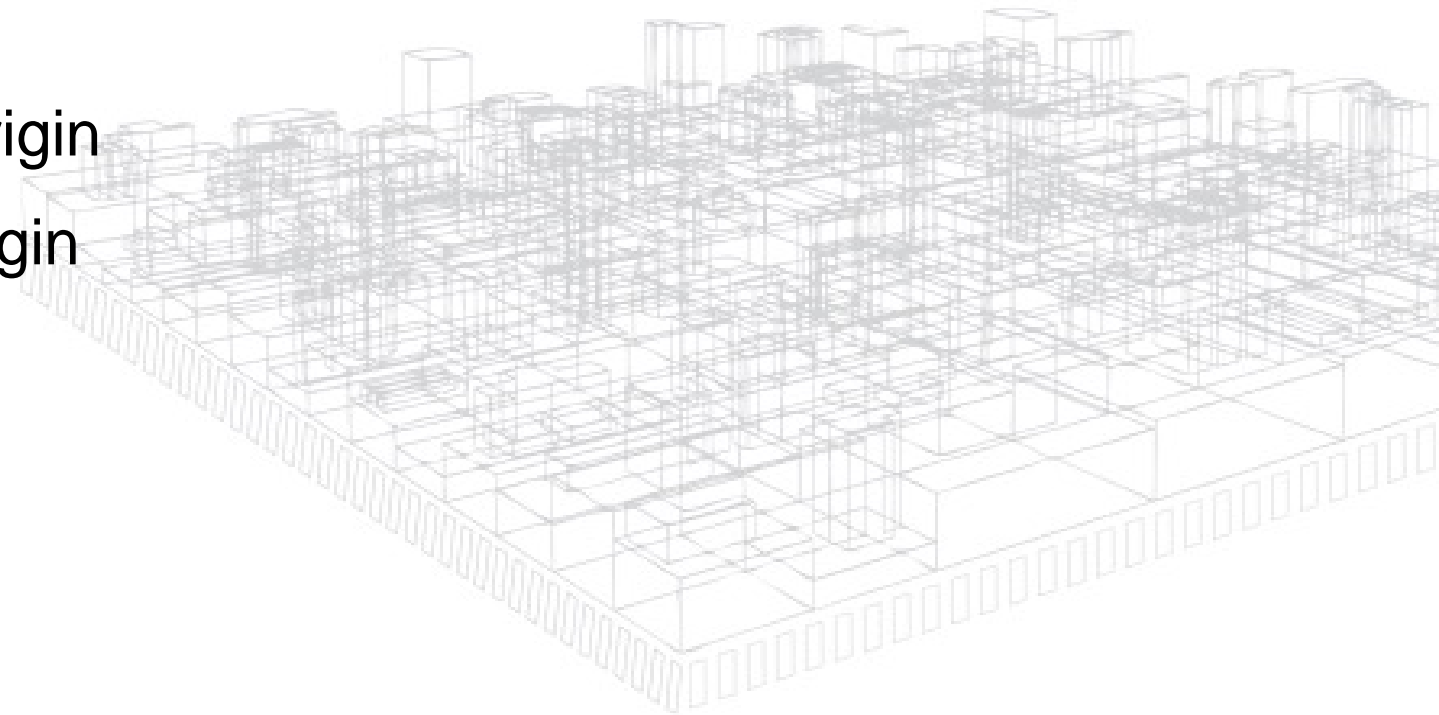
# Applications: Atria Buildings

## Possible Solutions

Depends on use of building, fire risk, occupancy type, type of atria, etc....

But usually one of the following:

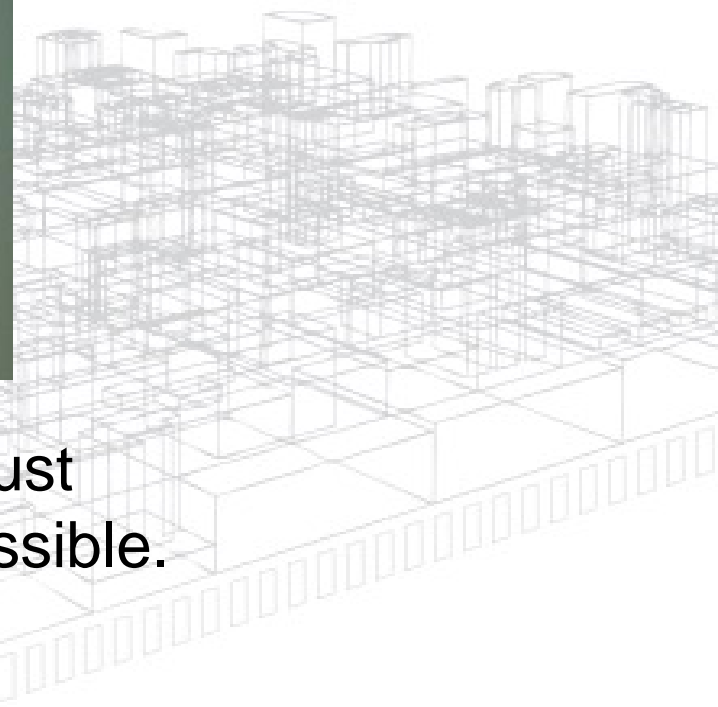
- Smoke clearance
- Extract from room of origin
- Extract from floor of origin
- Through flow
- Depressurisation



# Applications: Atria Buildings



As natural ventilation are buoyancy driven, exhaust ventilators should be located at the highest point possible.



# Natural or Mechanical Extraction

## Natural

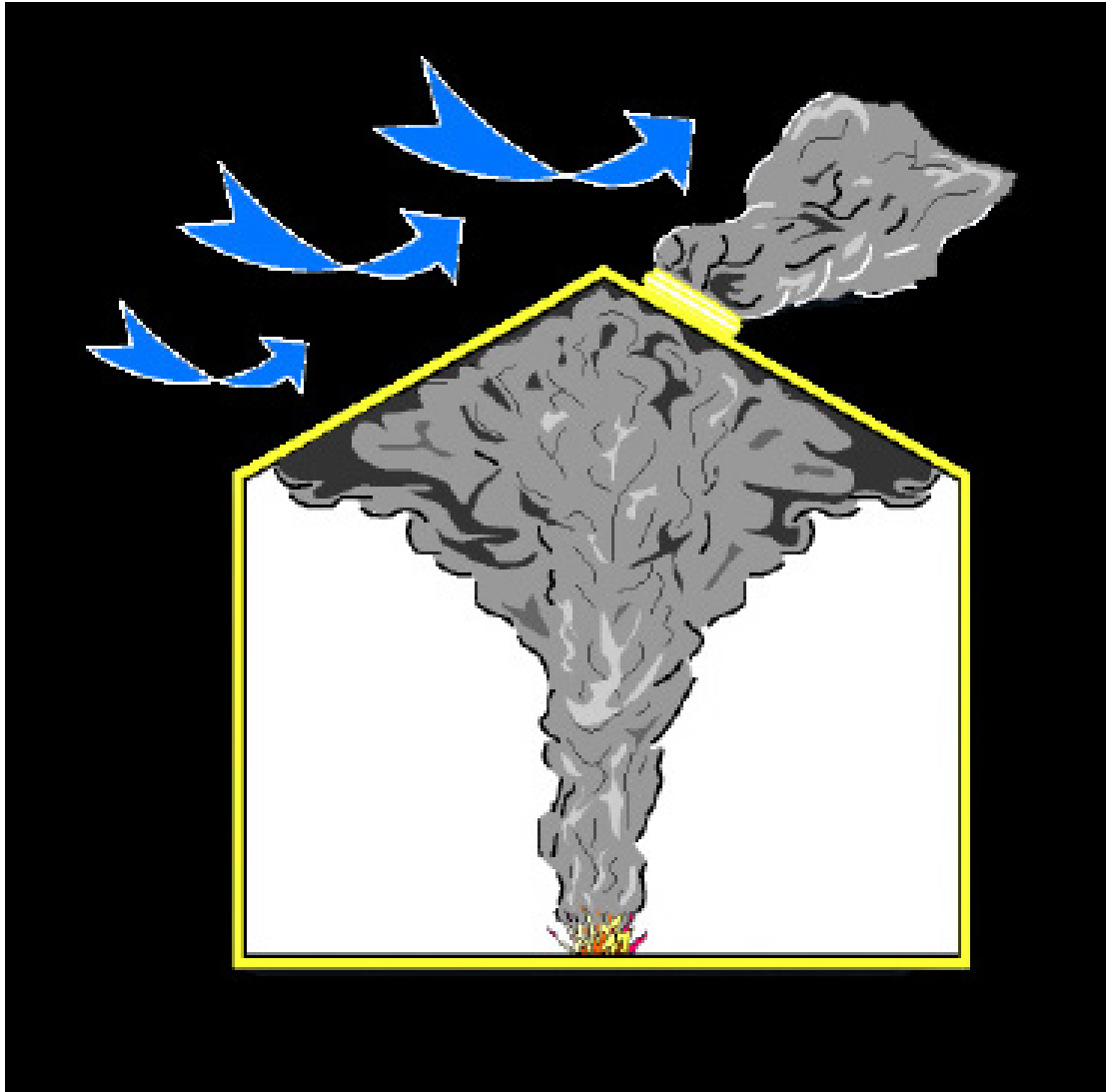
- Fail safe operation
- Self compensating
- Silent operation
- No time or temperature limits
- Lightweight
- Sensitive to wind effects

## Mechanical

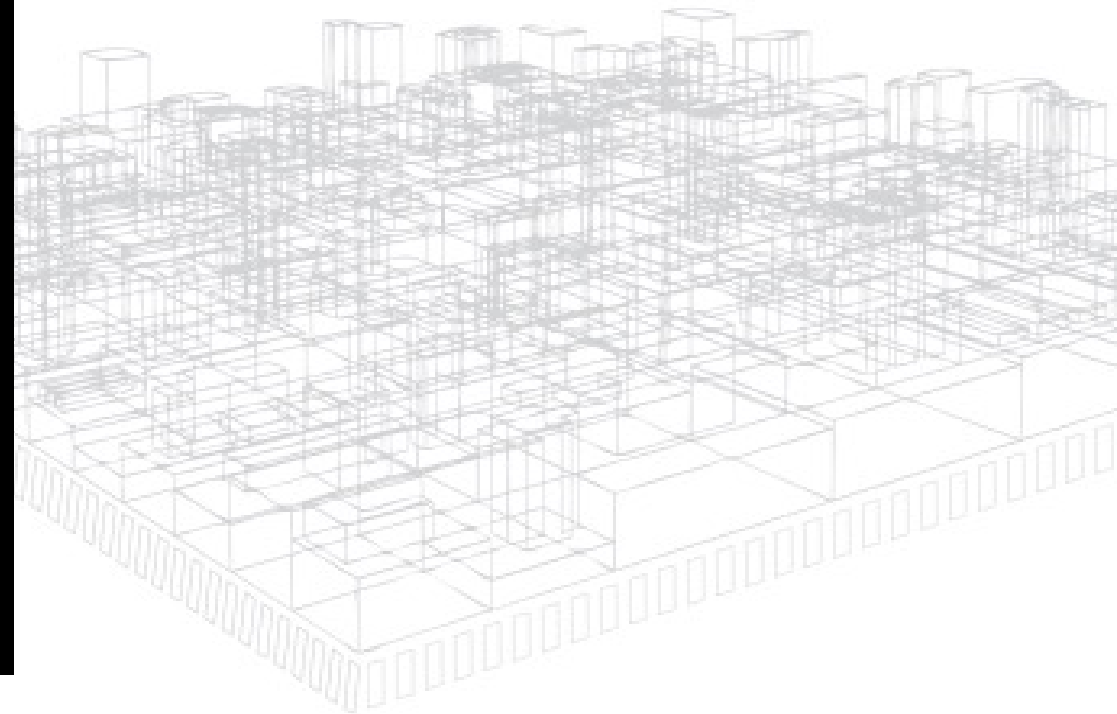
- Not wind pressure sensitive
- Suitable for ducting
- Fixed extract volume
- Noise and Weight
- Maintained electrical supply
- Dedicated air inlet
- Standby unit in case of fan failure



# Wind effects

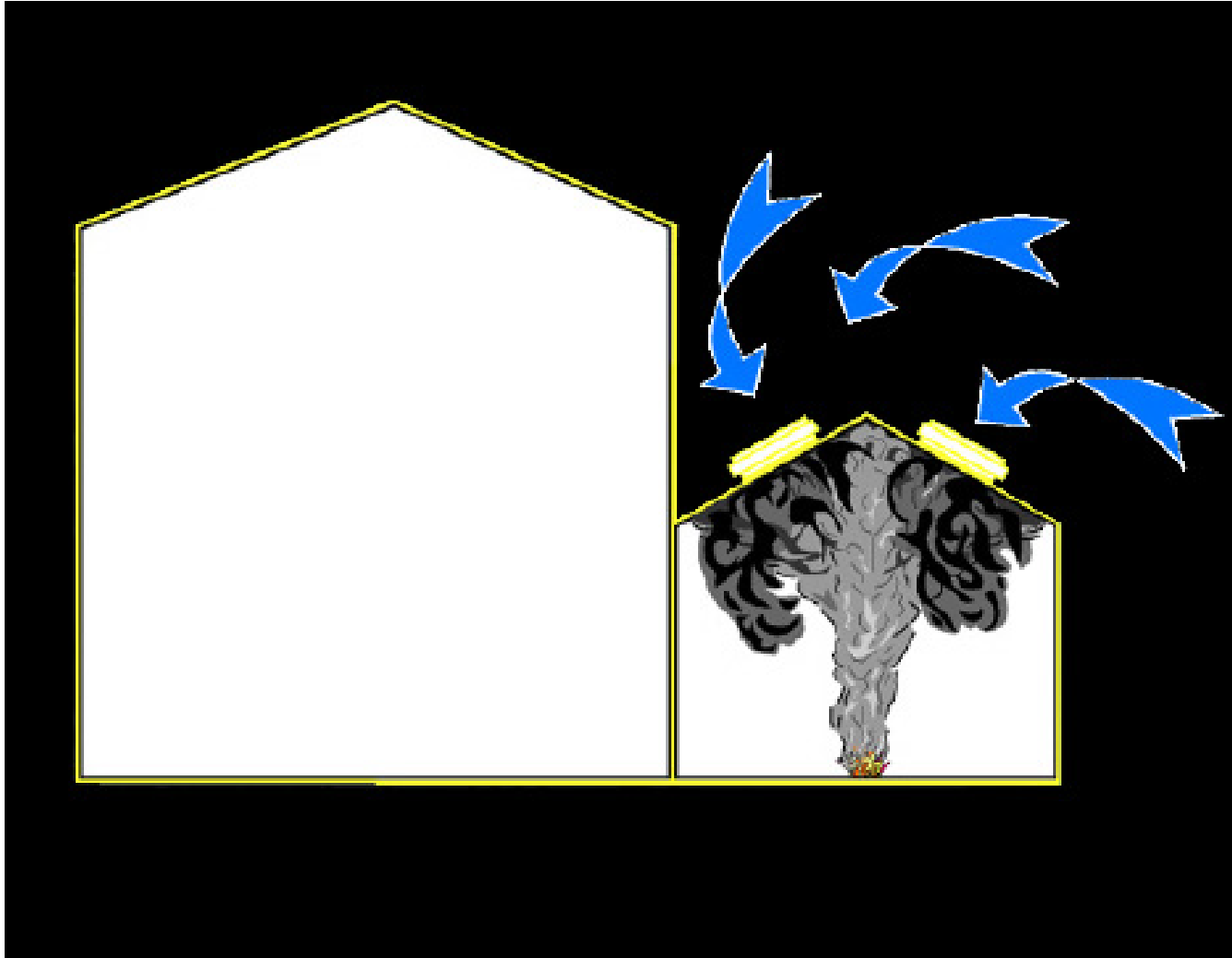


Positive wind pressures may be experienced on roof pitches steeper than 30 degrees...

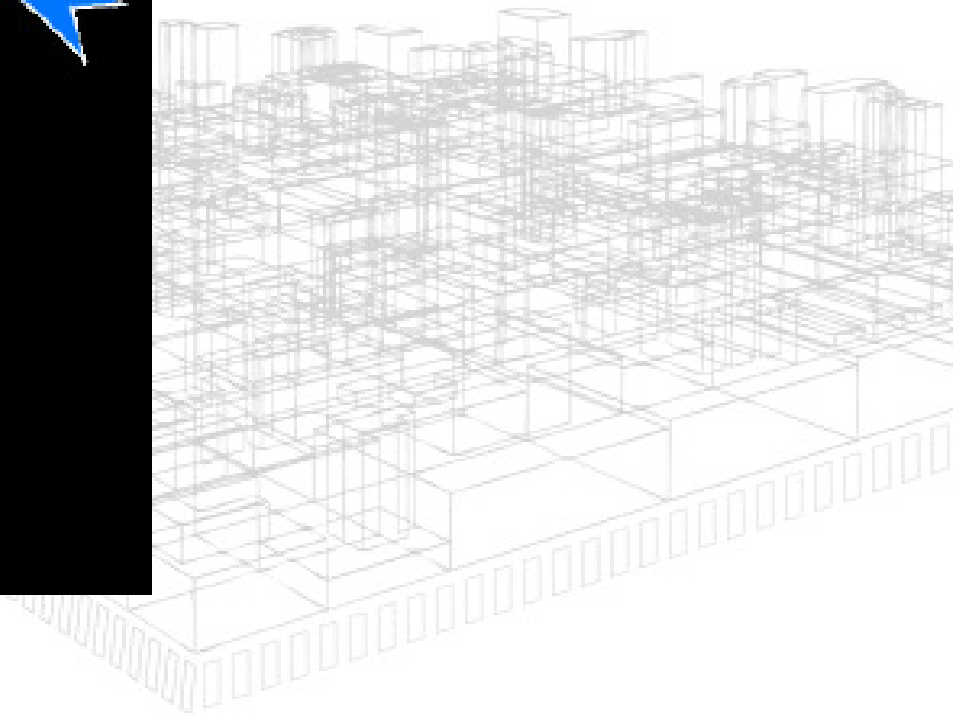




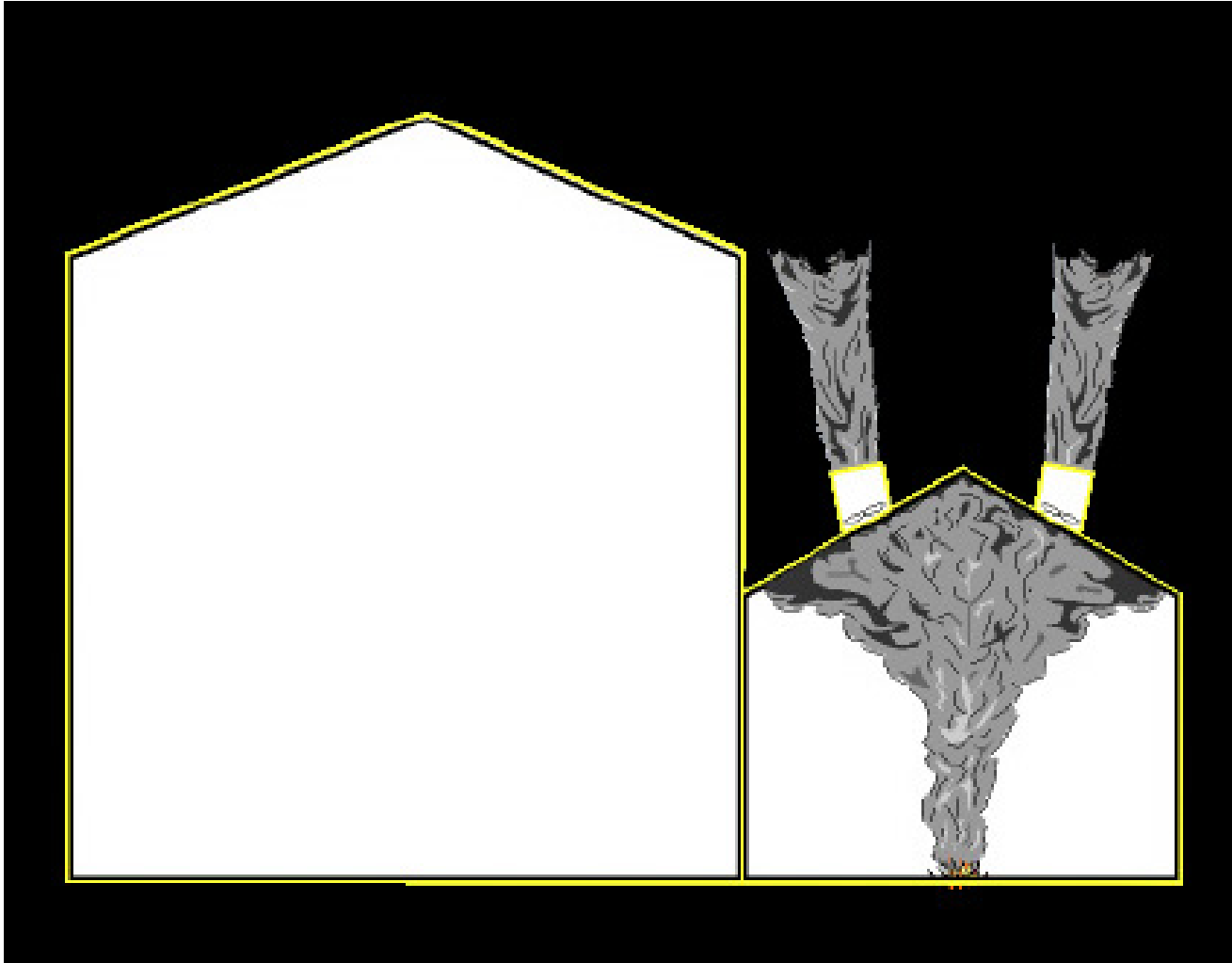
# Wind effects



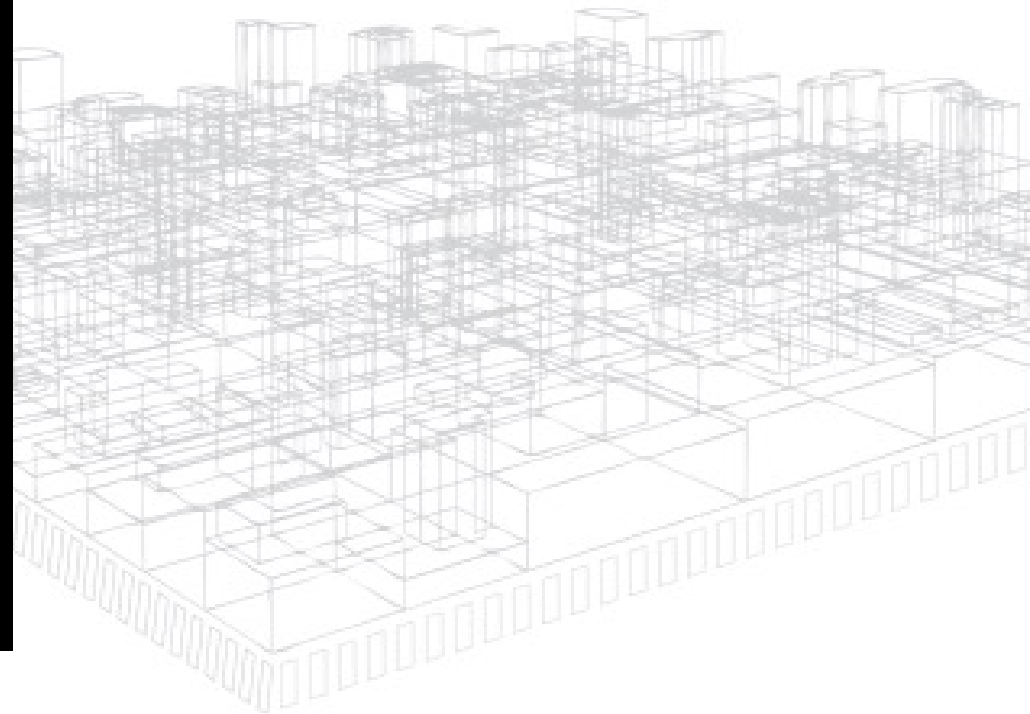
... and from higher adjacent structures



# Wind effects



Mechanical Ventilation may be the only alternative

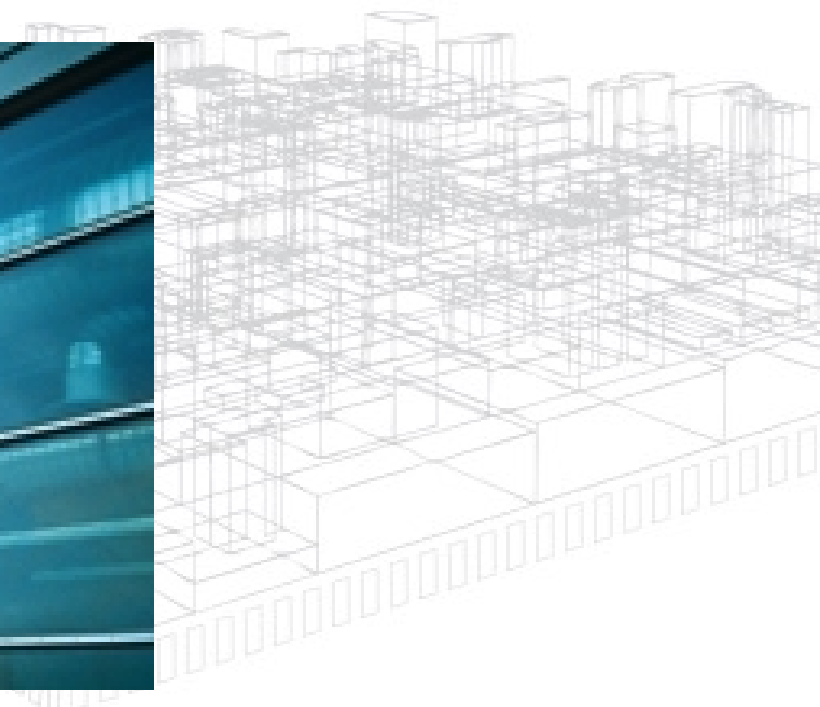


# Ventilator Types

Louvred Roof Vents



Glazed Wall Louvres



# Ventilator Types



Casement Roof Vents

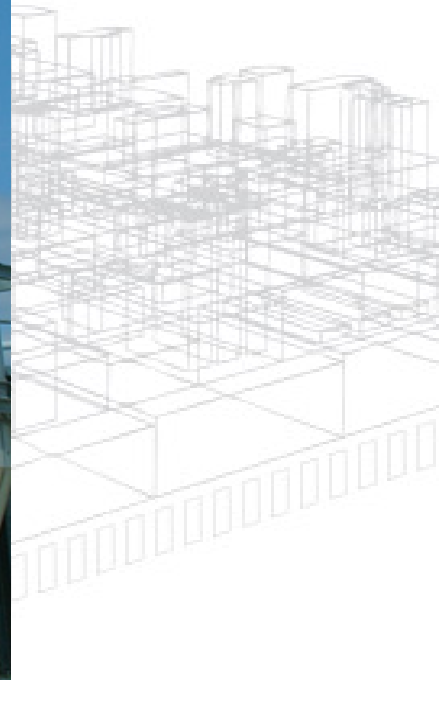
Double-Flap Roof Vents





# Ventilator Types

Mechanical (powered) vent



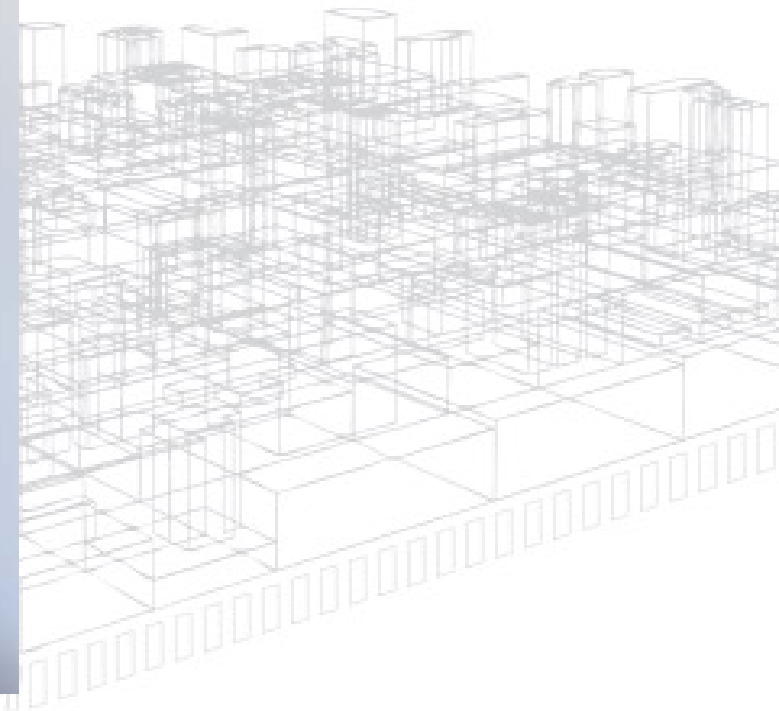


# Ventilator Types

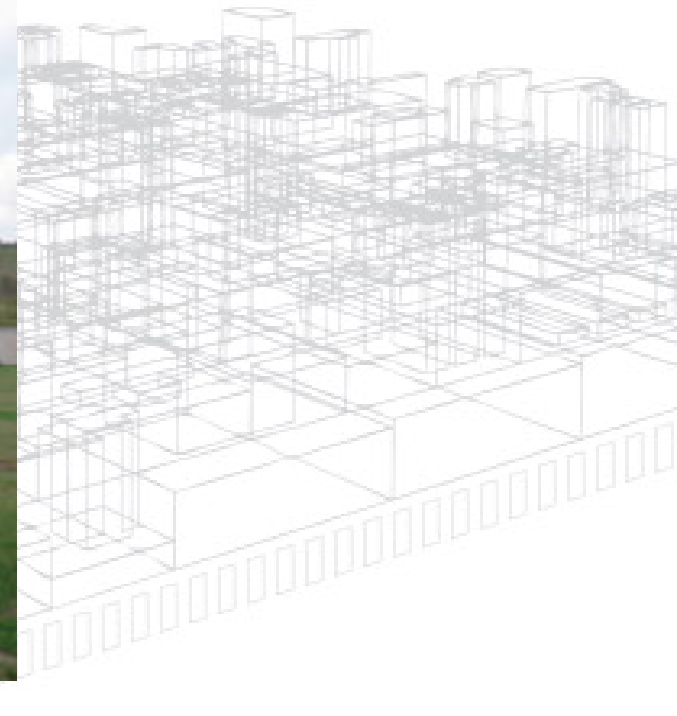
Mechanical (powered) vent



Tunnel ventilation



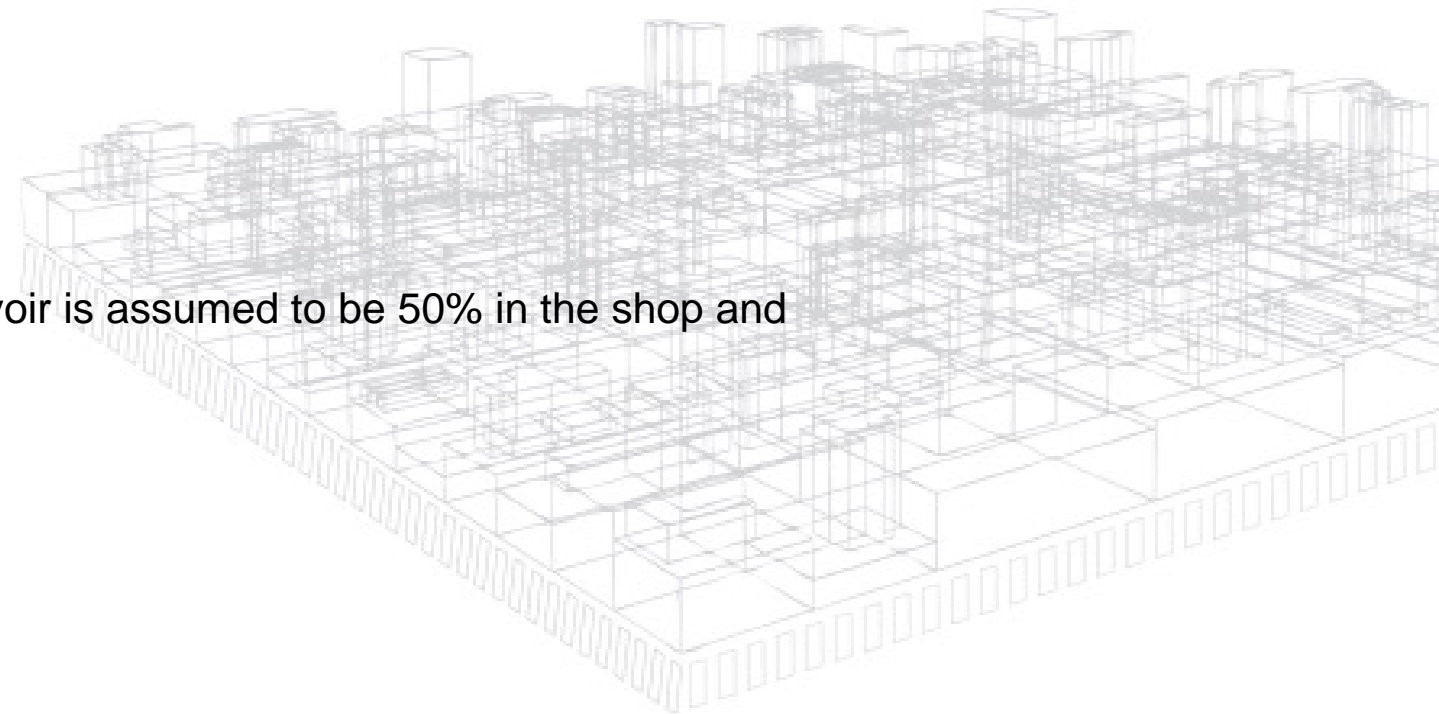
# Inlet or “Replacement” Air



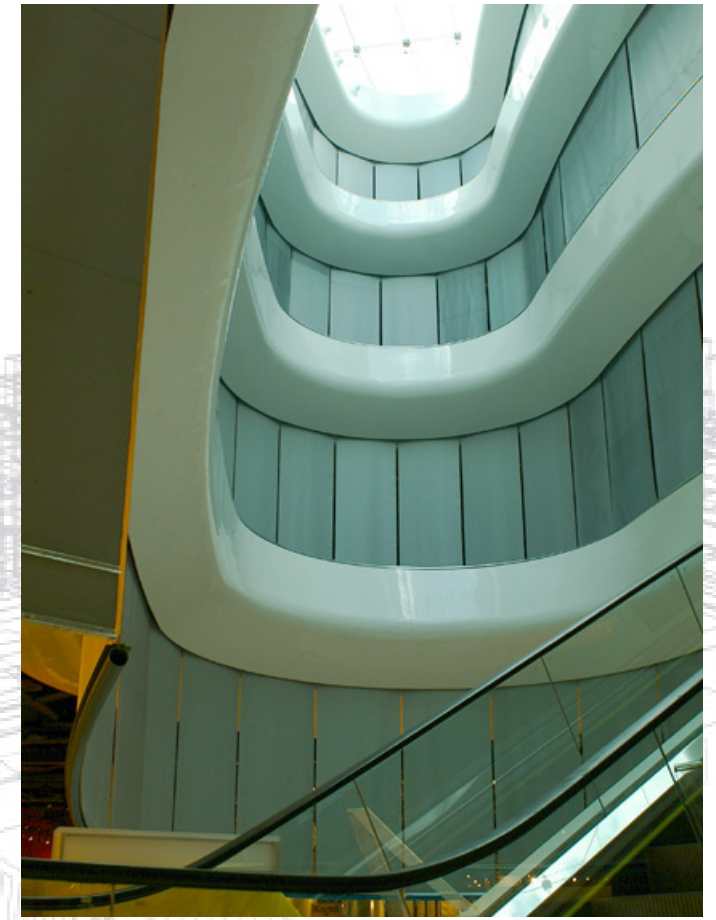
# Smoke Reservoirs

- Required to limit the spread of smoke
- Formed using fixed or automatic drop smoke barriers
- Arranged to limit the size of the smoke reservoir at high level to a maximum of:
  - 2000m<sup>2</sup> plan area, and
  - 60 m long in any direction

Note: In shopping centres the reservoir is assumed to be 50% in the shop and 50% in the mall



# Smoke Reservoirs



# Applications: Car Park Ventilation

Ventilation in car parks is provided for two purposes

- To prevent the build up of fume during the daily use of the car park in accordance with Approved Document F
- To provide smoke clearance ventilation in the event of a fire to assist the Fire Service in accordance with Approved Document B.

A single dual purpose system is normally provided to meet both requirements





# Applications: Car Park Ventilation



## Smoke Control Systems

Specifically designed to achieve the CONTROL of smoke movement. Usually requires additional extract over and above the basic clearance requirement.

**Min. 120.000 m<sup>3</sup>/h**

Can be designed to:

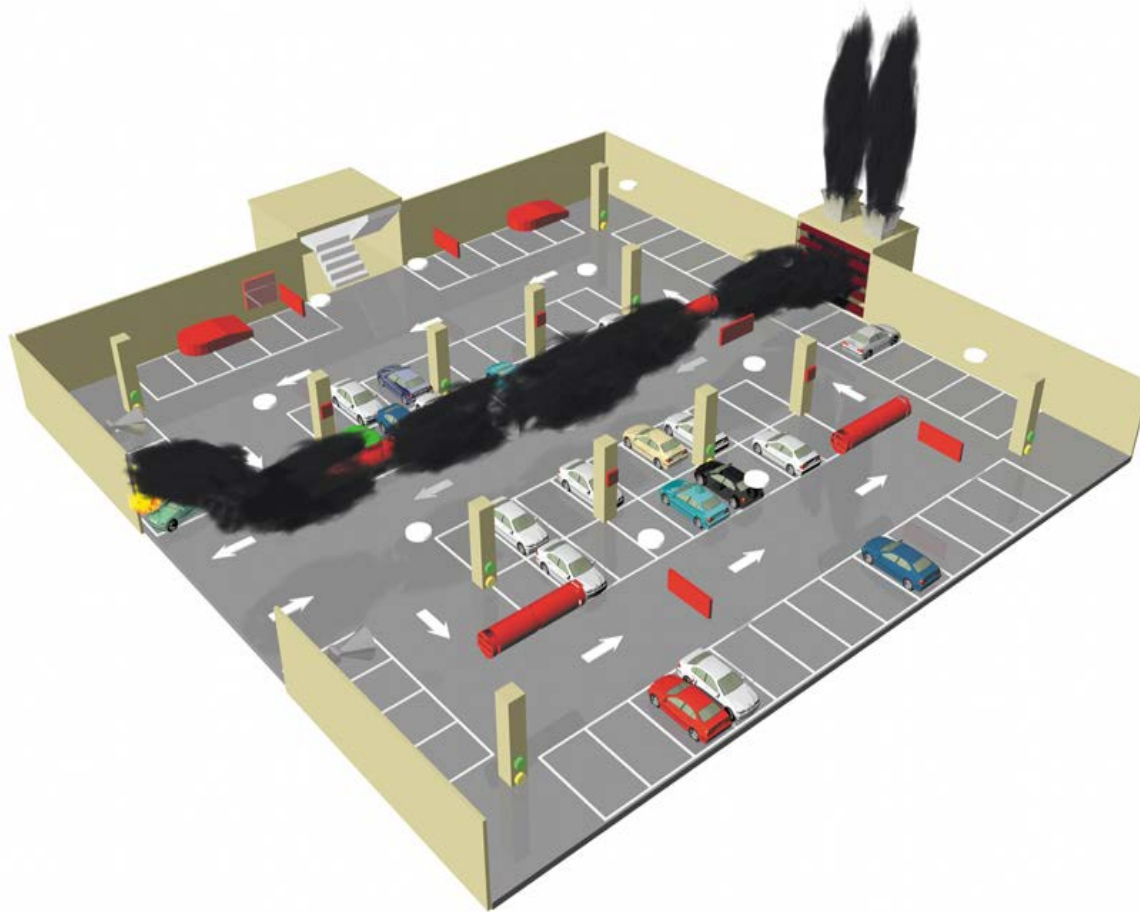
- Aid escape and therefore extend safe escape distances
- Assist fire fighting as an alternative to sprinklers. The fire brigade must be able to reach the fire within 15 m with the wind in their back.

In the UK and Belgium, sprinklers are generally not required in car parks, except in certain applications, such as shopping centres or larger projects in London and Scotland.

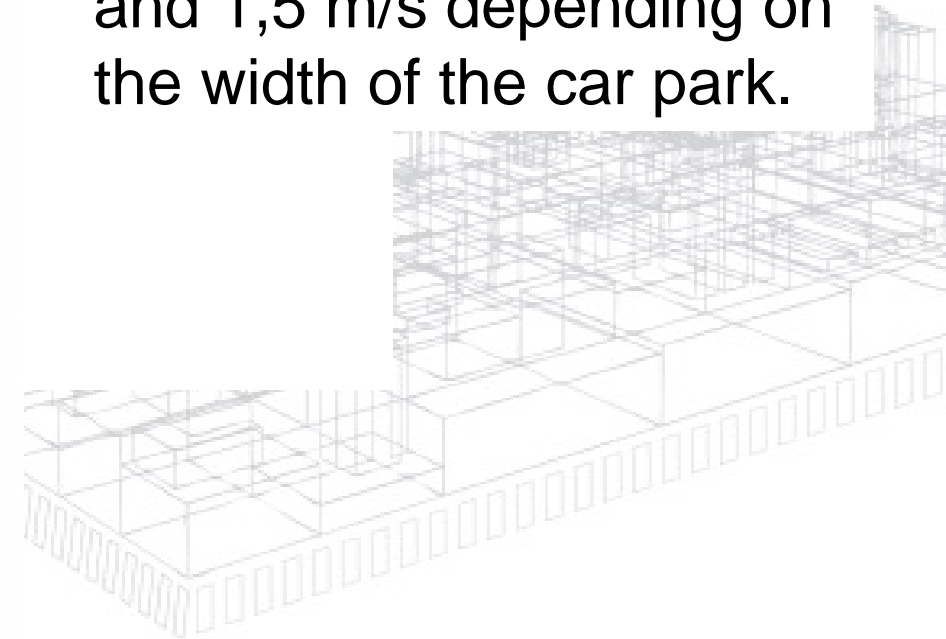


# Applications: Car Park Ventilation

## Smoke Control Systems



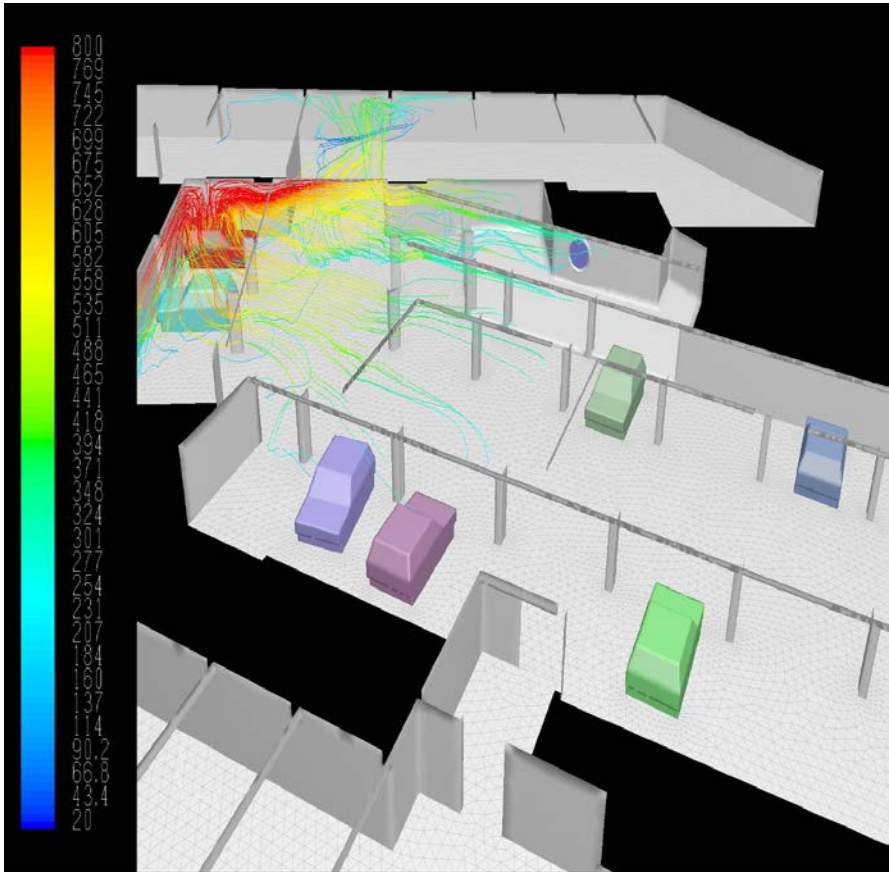
Velocity between 1,1 m/s and 1,5 m/s depending on the width of the car park.



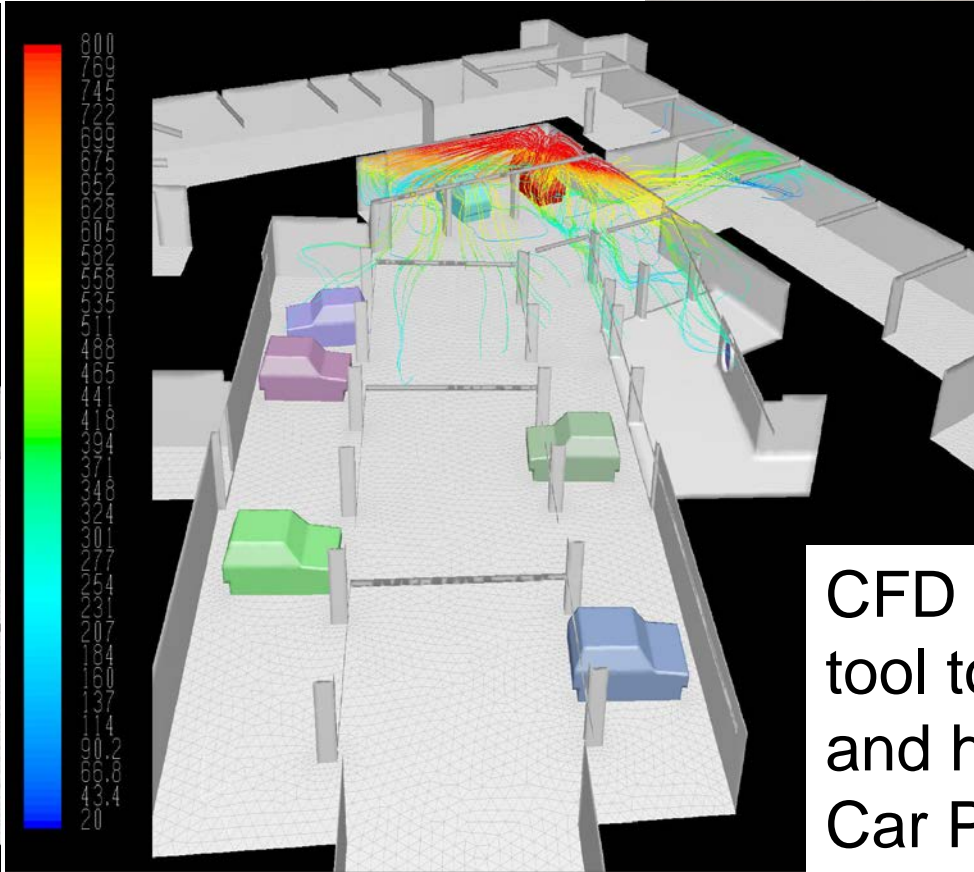
# Applications: Car Park Ventilation



## Smoke Control Systems

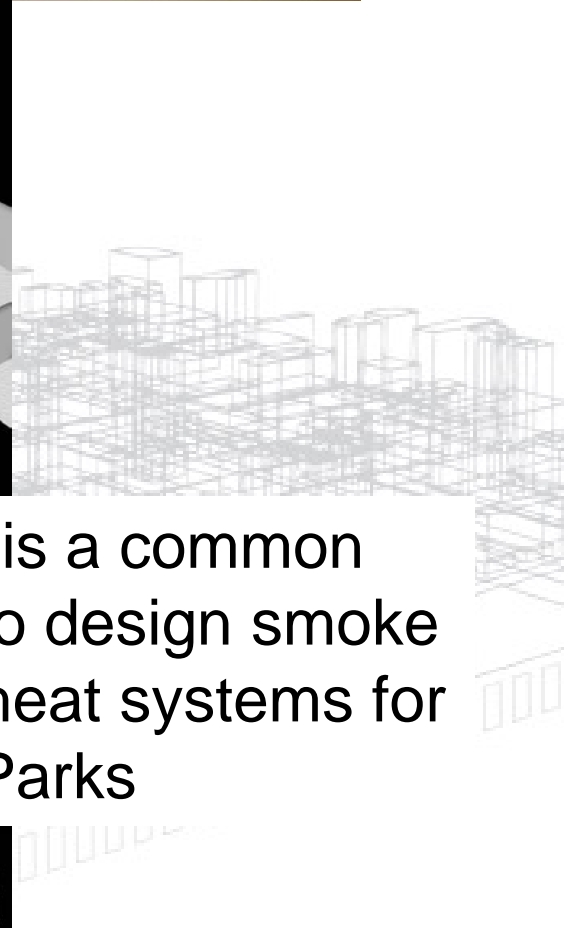


Path Lines Colored by Static Temperature (c) Sep 07, 2004  
FLUENT 6.1 (3d, segregated, spe2, ske)



Path Lines Colored by Static Temperature (c) Sep 07, 2004  
FLUENT 6.1 (3d, segregated, spe2, ske)

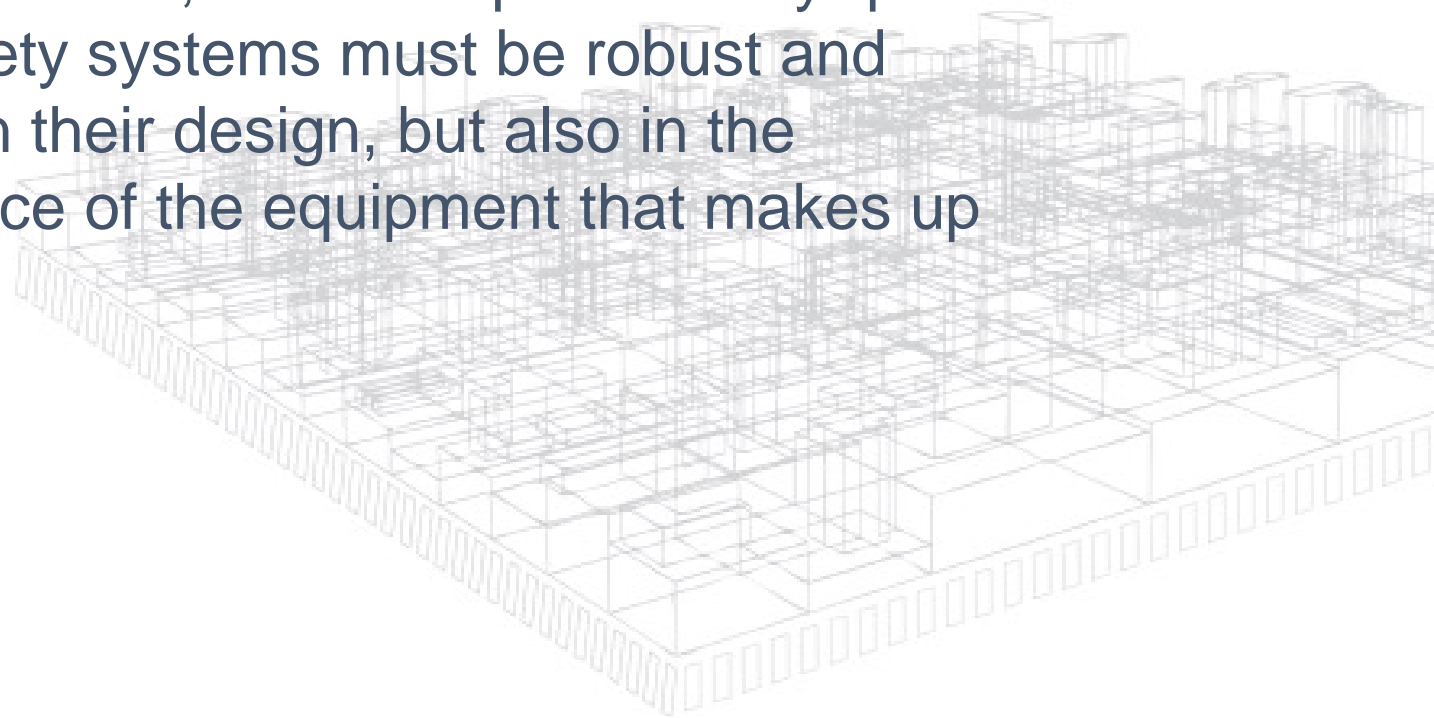
CFD is a common tool to design smoke and heat systems for Car Parks



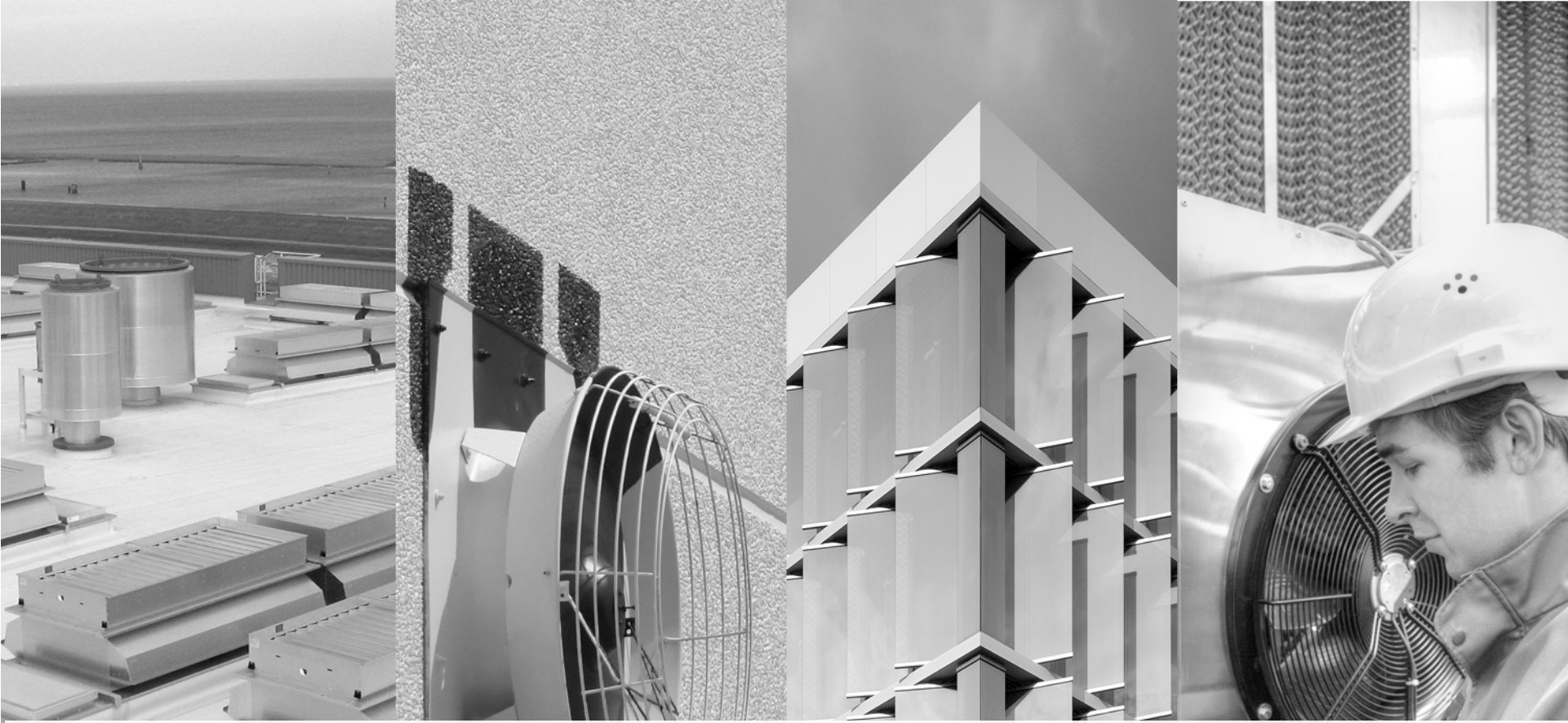
# Conclusions

The application of smoke clearance and smoke control are varied and with specialist knowledge can be used to compensate for other standard features in many ways.

As with many fire safety systems, the concept is usually quite straightforward but life safety systems must be robust and comprehensive, not only in their design, but also in the application and maintenance of the equipment that makes up the system.







Thank you.

Patrick Janssens

**COLT**

"People feel better in Colt conditions" | [www.coltgroup.com](http://www.coltgroup.com)