General Principles of Smoke Control

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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
Current UK & Belgian Business Markets for SHEV’s

- Smoke Control Static
  - SHEVS – Shopping Centres, Atria, Warehouses, Factories, etc

- Smoke Control Mechanical
  - Smoke Curtains - Shopping Centres, Atria, Warehouses, Factories, Car parks, …

  - 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

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.
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

Smoke is by far the biggest killer

Source: Fire Statistics, United Kingdom, 2011 - DCLG
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 – Smoke 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 m² plant destroyed

Loss of production of automatic gearboxes for 5 major car manufacturers
History and Development

Current Documents:


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.

- Time taken for smoke to affect escape routes
- Detection Time
- Pre-movement time
- Evacuation Time
- Available Safe Escape Time
- Required Safe Escape Time
- Fire Starts
- Clear layer height (m)
Applications: Fire and Smoke with SHEV’s.

Time taken for smoke to affect escape routes

Available Safe Escape Time

Detection Time

Pre-movement time

Evacuation Time

Clear layer height (m)

Fire Starts

Required Safe Escape Time
Applications: Fire and Smoke

Time dependent Fires

- Ultrafast
- Fast
- Medium
- Slow

Steady State Fires

- Growth
- Peak
- Decay

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 to the type of industry.
Applications: Smoke Control

Components of a Smoke Control System
Applications: Large Single Storey Buildings

Afbeelding 1 - Gebouwen zonder verdieping (plat dak)
Verklaringen van: $D$, $h_c$, $Y$ en $d_b$

Verklaring v/d symbolen volgens NBN S 21-208-1
Applications: Large Single Storey Buildings

1. Smoke exhaust.
2. Air inlet.
4. Smoke detector.
5. Fire detection panel.
6. Control panel SHEV’s.
Applications: Large Single Storey Buildings

In buildings larger than 2,000 m² 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:
  - 2000m² 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 m³/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

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

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