Smoke Control in Single Storey Buildings and Warehouses
INTRODUCTION

When a fire breaks out, the consequences can be devastating. A smoke control system will help to reduce the consequences by preventing roof collapse and providing smoke clearance.

Occupants are provided with a clear escape path, permitting them to exit the building far more quickly and safely, potentially allowing greater travel distances to be accepted.

Firefighters can enter the building and tackle the fire at source, saving considerable time and damage.

Cleaning up time can also be significantly reduced, allowing normal activities to resume as soon as possible.

One in four businesses do not recover from a large fire.

Between February 2002 to January 2003, over £126,858,023 of damage was caused by fires in UK industry and commerce from reported fires over £250,000. A frightening thought, made even worse by the fact that one in three fires are caused by arson.

Effective smoke control is a small, long term investment when considering all the possible consequences.

INSURANCE

Read the small print. Most insurance companies do not cover business interruption or the legal costs related to a fire claim.

In many cases, this is often equal to or more than the original claim itself.

“Smoke logging will seriously delay the time it takes to extinguish a fire”
“Estimated loss of warehouses last year due to fire & smoke damage was reported to be £11.6M” *

GUIDANCE AND REGULATIONS

Many regulations and codes have to be met and the safety and comfort of the building’s occupants must be the priority.

Reference can be made to the following:

SVA Guide
BR 368
BS 7346 Parts 1, 2, 3 & 4
BS EN 12101 Parts 1-10**
BS 7974
Fire Precautions Act
Local Government Acts
Building Regulations,
Approved Document B
Scottish Building Regulations,
Technical Standard D
BS 5588 Parts 1 - 11

* Source January issue (2004) FP & FEJ
** Some parts still awaiting publishing

These images are taken from live video footage of Colt-researched tests, that show the effects of fire and smoke within large industrial buildings and their interaction with sprinkler systems.
PURPOSES OF SMOKE CONTROL SYSTEMS

There are various purposes to which smoke control systems are applied:

1. It is required in buildings used by the public to facilitate escape and to provide smoke free escape routes.

2. In industrial situations, it reduces the likelihood of loss of production and stock.

3. If the smoke is kept at high level, firefighters will be able to see the fire and therefore extinguish it a lot more easily and effectively.

4. It can permit designers to design in greater travel distances to exits without the need for compartmentation.

Using the basic principles of ventilation and containment, a smoke control system will keep smoke above head height and prevent it spreading around the building.

“It has always been Rover policy to protect our people and facilities with smoke control systems - we think it’s a good policy”

Rover Group
“If production is halted for even just a few hours, it can cost us millions in lost revenue”

INDUSTRY

Colt have supplied many automobile manufacturers throughout the world. The very first UK smoke control ventilator was installed by Colt at the Vauxhall Motors plant in Luton in 1956.

The motor industry cannot afford to stop a production line for long, since this can result in millions of lost revenue even after just a few hours. Everything is done to ensure fires can be put out as early as possible with minimal clean up time.

Smoke control is a valued contributor to the overall fire safety system.

COMMERCE AND LEISURE

Many large commercial ‘superstores’ are protected with a smoke control system.

It is paramount in buildings that contain a large number of people that they can escape quickly and safely.

Allowance must be made for the elderly, disabled, and families with children.

Where ambient temperatures rise, the roof ventilators can provide natural ventilation, reducing the cooling loads on air conditioning plant. With the use of transparent louvres, ventilators can provide natural daylight entry to the building.
1. EARLY STAGES OF A FIRE

When a fire starts in a large building, a warehouse for example, it is not like a fire at home.

If a fire started at home you would close all the doors and windows and leave the room. Generally this would cause the fire to be suffocated and reduce rapid growth.

In a large industrial building, the amount of oxygen available and the amount of natural leakage will mean that this would not be effective. The fire cannot be sealed off.

In the early stages, smoke from the fire will quickly rise into the roof space.

2. SMOKE CHARACTERISTICS

The smoke can spread laterally at a velocity of up to 5m/s. An average person will walk at 1-2m/s and run at 7.5m/s.

Once the building roof space is full, the smoke will start to build down. The rate at which this occurs varies significantly with the nature of the combustibles and building geometry.

3. SMOKE LOGGED

In an unventilated situation, a building with a volume of 10,000m³ can become smoke logged in just a few minutes.

Although the smoke is made up mainly of entrained air, it can contain sufficient toxic substances and asphyxiates to disorientate and disable within seconds and kill within minutes.

This was proven at the Colt test facility in Ghent (with a volume of 13,000m³) where it was shown that the test building became completely smoke logged in under two minutes.
BASIC DESIGN PRINCIPLE

The basic principle of smoke control is therefore to limit the spread of smoke through the building and provide a means by which the smoke and heat can be extracted.

To achieve this requires three elements.

1. Openings or fans at high level to exhaust the smoke from the building.

2. Barriers to restrict the spread of smoke through the building.

3. Inlet ventilators to provide a replacement air supply to balance the smoke being extracted.

Fires do happen!
Snowflakes Factory, Ropley.

A fire involving a store measuring 20m x 40m plus two out-buildings and near-by equipment was destroyed by fire. Approximately 60 firefighters struggled for 2 days to bring the fire under control.
Design Considerations

DESIGN PARAMETERS

All the items listed below need to be taken into consideration when designing a smoke control system for single storey buildings.

Fire size

- Steady state, or
- Growing fires

Ceiling jet

Heat output of fire

Clear layer required

Smoke zones

The effects of sprinklers

Air inlets / replacement air

Depth of smoke layer

Ambient temperature

Plugholing

FIRE SIZE

The base dimensions of the largest fire which a smoke ventilation system should be expected to cope with. Calculations should be based on either steady state or growing fires.

Steady state

The scheme design is based on the anticipated largest fire size within the building and therefore the smoke control scheme will be capable of accommodating any fire up to that size.

Growing fires

The scheme design is based on a fire changing size over a period of time depending on the contents of the building.

CEILING JET

A horizontal flowing of hot gases driven in part by the kinetic energy of the rising fire plume. It typically has a depth of approximately one tenth of the building height.

HEAT OUTPUT

Total heat generated by the fire source. The convective element of this heat output drives the smoke flow.

CLEAR LAYER (y)

The minimum clear layer for industrial buildings should be 3 m.

The clear layer depth is very important as it permits the escape of personnel and the entry of firefighters.

SMOKE ZONES

Where the building is considered too large it must be divided into separate zones by use of smoke barriers.

Smoke zones should not exceed 2000 m² - 3000 m² in plan area.
CFD is used by Colt for building analysis. CFD can predict the temperature within a building (shown above), or the smoke behaviour patterns. Indeed, CFD is considered so important in the design of effective smoke control systems that Colt have their own CFD company, Colt Technology BV, based in Holland.

Fires do happen!

Sainsbury's, Chichester.

The fire started within the buffer store and travelled up over the fire-wall into the services section along the ceiling void. It didn’t take long to spread across the whole building making fire fighting from the inside, impossible.

A smoke control system is now installed within the buffer stores to release smoke and heat in the event of a fire.

EFFECTS OF SPRINKLERS

Sprinklers control the fire. They stop the fire from growing and spreading to other areas of the building, although it should be noted that sprinklers do not always extinguish the fire fully.

Colt would always recommend the combined use of sprinklers and smoke ventilators.

AIR INLET / REPLACEMENT AIR

Inlet or “make-up” air is important for the efficient operation of a smoke ventilation system to replace air entrained into the smoke plume.

Automatically opening ventilators, doors and windows can be used for inlet air. However it is important to consider the air velocities since if these are too high they can hinder escape.

DEPTH OF SMOKE LAYER, \( (d) \)

The smoke layer should not be designed to be less than one tenth of the floor-to-ceiling height.

AMBIENT TEMPERATURE

The ambient temperature for the UK is conventionally set at 15°C.

PLUGHOLING

If the smoke layer is too shallow for the size of the ventilator used, the ventilators efficiency may be reduced due to air being drawn through the middle of the ventilator instead of smoke.

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Sainsbury’s, Chichester.

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Smoke Reservoirs

SMOKE RESERVOIRS

Smoke containment is critical to the effectiveness of smoke ventilation systems.

If the lateral flow of the smoke is not prevented, the ventilators in the fire zone will be less effective in releasing the hot smoke which may cool and fall back to ground level, obscuring escape routes and endangering life.

Acting much as safety curtains do in theatres, smoke curtains are now an established part of smoke control installations.

BENEFITS

Increases the time available for occupants to escape the building.

Cost effective solution to zoning a building.

Assists the emergency services by containing or channelling the smoke into predetermined areas.

Limits travel and overcooling of smoke, reducing the risk of cold smoke dropping to low level and obscuring vision.

COLT SMOKEMASTER

Colt manufacture the Smokemaster range. Smokemaster comprises either fixed curtains, which are tailored to suit the particular building structure, or automatic drop curtains which are normally hidden and automatically lowered in an emergency.

SMOKEMASTER - FIXED CURTAIN

When head room is not a requirement, then a fixed smoke curtain is an ideal solution to zoning a large building.

A single fixed smoke curtain can be stitched together to provide one large continuous length, ideal for warehouses and large commercial units.
Smoke curtains are used to channel smoke away from particular areas. In this case, under a mezzanine floor.

For further information on the Colt Smokemaster, please see leaflet PD 50, Smoke & Fire Curtains.
# Extract Ventilation

## Introduction

Natural and mechanical ventilation each have their own advantages and disadvantages:

### Natural Smoke Ventilation

**Advantages**
- Fail safe operation
- Self regulating
- No time or temperature limits
- Lightweight

**Disadvantages**
- Sensitive to wind effects

### Mechanical Smoke Ventilation

**Advantages**
- Not wind pressure sensitive
- Suitable for ducting
- Fixed extract volume

**Disadvantages**
- Noise and weight
- Maintained electrical supply
- Dedicated air inlet supply

## Natural Smoke Ventilators

Natural smoke ventilators can offer the additional benefit of day-to-day ventilation. They are normally positioned on the roof for smoke and heat extract, and at low level for fresh air inlet, although roof mounted ventilators in zones not affected by smoke can also be used for air inlet.

A natural ventilator can be designed to operate in a fail safe manner, meaning that the ventilators always open when all control/power sources are removed.

For a natural ventilation system, if the fire grows larger than designed, the smoke will be hotter and therefore more buoyant making the ventilators more efficient.

## Mechanical Smoke Ventilators

Mechanical ventilation requires very reliable power supplies. Mechanical systems are designed to extract a fixed volume of smoke regardless of fire size, unlike natural smoke ventilators.

Consideration should be given to the weight of the fans, as this may lead to structural support issues. A mechanical extract system will require a dedicated air inlet system.

Noise can be a major issue, especially if voice alarm systems are used since the noise of the fans can reduce intelligibility.

### Associated Products:
- Colt mechanical extract unit
- Seefire
- Meteor
- Condor

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*Mechanical Extract Fans*
CONDOR NATURAL VENTILATOR
A sliding lid ventilator which has similar performance properties to the Colt Meteor. In addition, the Condor provides weathered ventilation even in the closed position. The Condor can be attenuated to provide sound insulation. Fixing is horizontal/inclined.

COLT MECHANICAL EXTRACT UNIT
A wide range of fan sizes and specifications are available from Colt. As with natural ventilators, mechanical extract units can be linked into the sophisticated Colt OPV 2000 control system.

SEEFIRE NATURAL VENTILATOR
The Colt Seefire is a louvred ventilator with a low profile. The louvres can be aluminium or translucent polycarbonate to allow daylight to enter the building. The Colt Seefire has a flexible size range with over 200 size variations. Fixing can be both vertical/inclined or horizontal.

METEOR NATURAL VENTILATOR
The Colt Meteor is a flap ventilator which can be manufactured with aluminium, translucent polycarbonate or glass flaps. Colt Meteors have large unobstructed openings producing high performance levels and high ‘U’ values. The Colt Meteor can be attenuated to provide sound insulation. Fixing is horizontal/inclined.

Fires do happen!
National Motorcycle Museum, Birmingham.

Over 500 vintage machines were destroyed by a carelessly discarded cigarette. Most motorcycles were said to be priceless and irreplaceable. The estimated damage is said to be around £8m.

The fire started outside the building within a rubbish collection area and spread quickly to the main building. Firefighters found it difficult and unsafe to enter the building to tackle the fire at source.

COLT MECHANICAL EXTRACT UNIT
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The Colt Seefire has a flexible size range with over 200 size variations.

Fixing can be both vertical/inclined or horizontal.

METEOR NATURAL VENTILATOR
The Colt Meteor is a flap ventilator which can be manufactured with aluminium, translucent polycarbonate or glass flaps. Colt Meteors have large unobstructed openings producing high performance levels and high ‘U’ values.

The Colt Meteor can be attenuated to provide sound insulation.

Fixing is horizontal/inclined.

CONDOR NATURAL VENTILATOR
A sliding lid ventilator which has similar performance properties to the Colt Meteor. In addition, the Condor provides weathered ventilation even in the closed position.

The Colt Condor can be attenuated to provide sound insulation.

Fixing is horizontal/inclined.
Inlet Ventilation

In order for a smoke ventilation system to work effectively and efficiently, a supply of inlet air is required.

An inlet air supply will basically create a ‘chimney effect’ within the building allowing a steady stream of air flow. Air and gases that are removed by the extract ventilators are replaced by the inlet ventilators. This is sometimes referred to as ‘make up air’.

Ventilators are an ideal solution in large single storey buildings when doors and windows are at a minimum.

NATURAL INLET VENTILATORS

Inlet air should be designed as low as possible within the building, generally at least 1.5 m below the designed smoke layer. If this is unachievable due to the height of the smoke layer, then smoke curtains should be considered.

There are two main solutions for providing inlet air:

Utilising adjacent non fire zones to provide inlet (roof level) and/or by automatically opening ventilators, windows and doors to provide inlet ventilation.

Inlet velocities must be below 5m/s as greater velocities can hinder escape.

Replacement air via roof mounted ventilators and ventilators installed at low level.

Replacement air installed at low level with mechanical extract at high level.

Seefire natural louvred ventilators installed at low level.
Fires do happen!
Sainsbury’s, Cheshire.
“We had to knock holes in the roof to allow the smoke and heat escape, it was the only way of making the building safe”
Quote from a senior firefighter speaking to Granada news.

“Fire-fighters must be able to quickly identify and safely tackle the fire at source”

Above, standard installation of Colt Seefire.
Left, installed flush to blend in with the aluminium cladding.
HIGH BAY STORAGE AREAS

The potential for fire growth within a high bay warehouse can be much greater than normal due to the rapid growth of the fire travelling up the vertical racking.

For any fire safety strategy to be effective it is essential that sprinklers are incorporated to control the fire.

A smoke control system will work in conjunction with the sprinklers to remove the smoke and hence limit damage and assist the fire service.

IN RACK SPRINKLERS & SMOKE VENTS

Most modern day high bay warehouses will contain an ‘in rack’ sprinkler system to control the fire growth.

In sprinklered warehouses, the smoke control system objectives must be clearly understood for a design to work effectively.

CONSIDERATIONS

Considerations for high raked storage buildings are:

The nature of the goods stored

The type of packaging used

The manner of storage

The surface area of any material that can support combustion

The type of sprinkler system installed

This vast warehouse is split into separate smoke zones using fixed Colt Smokemaster smoke curtains.
“It’s reassuring to know that we are protected by a Colt smoke control system”.

Edwards High Vacuum International
Inset, fire in racking after 20 seconds.

Main picture, after 90 seconds (before sprinkler detection). The room is completely darkened by the smoke as depicted from the rooflights.

A live fire test was constructed to find the effectiveness of a standard 5mm sprinkler system found in many warehouses and single story buildings such as DIY stores and industrial premises. Normally it should take no more than four sprinkler heads to 'activate' and control a fire.

In this scenario it took nine sprinkler heads to activate and it still wasn’t enough to control the spread of the fire. The Fire Service who were on hand, said that it was unlikely that the sprinklers would have controlled the fire and that there was a major threat of building loss.

Below
The clearing up process.
SPRINKLER SYSTEMS

Most sprinkler systems are not designed to extinguish fires, they are intended purely to control them.

Sprinklers cannot prevent the building from becoming smoke logged, nor extract the huge amount of heat generated from fires. Indeed, it has been shown that due to the drag down of the smoke in un-ventilated buildings, sprinklers can accelerate the rate of smoke logging in the building.

INTERACTION OF SPRINKLERS & VENTS

Unfortunately, there has been technical controversy for many years regarding the interaction of sprinklers and smoke ventilators.

The main arguments are that the removal of heat by the smoke vents could delay the operation of the sprinkler heads and that by maintaining the oxygen content of the building the fire could be allowed to burn more fiercely.

Now even some of the most sceptical about ventilation have agreed that its presence has virtually no impact upon the performance of standard sprinkler systems, a fact which has been demonstrated by research in the UK and USA.

Experiments have shown that venting did not significantly delay the operation of the first sprinklers, but did reduce the number of sprinklers operating unnecessarily away from the seat of the fire.

It is now accepted that when a fire breaks out, the operation of any fire fighting medium should not be delayed. The earlier the vents open, the greater is the chance of preventing the smoke from mixing into the layer of cool air near the floor.

THEIR FUNCTIONS

**Sprinklers**
- Will limit fire spread and control growth
- Will not reduce smoke damage
- Will reduce temperature increase within the building

**Ventilation**
- Will prevent smoke logging
- Will reduce building temperature
- Will assist escape
- Will aid firefighting

B&Q - SPRINKLER TESTS

In many situations traditional sprinkler systems have not kept pace with modern retail buildings and the way that they are stocked. B&Q’s own project team investigates a solution that maintained safety standards, was cost effective and supported the business development needs.

These photographs depict the effectiveness of sprinklers in a disused warehouse. It was discovered that the standard 5mm sprinkler system was inadequate.

This photograph shows racking starting to bend even after a small fire which was extinguished very quickly.

Subjected to extreme heat, racking will collapse, increasing the risk of spreading the fire and blocking escape paths.
The Colt OPV 2000 is an intelligent electronic control system, which uses the latest Echelon Neuron Chip for its communications network.

OPV 2000 revolutionises the control and operation of natural smoke ventilators and readily incorporates all other addressable equipment into the total smoke control system.

As life safety equipment, all OPV 2000 components meet the most stringent manufacturing and test procedures.
TOTAL CONTROL FLEXIBILITY

Each natural ventilator or addressable unit can be controlled individually and as part of the specified automatic control system.

The control software is configured to suit the automatic scheme requirements and should these change, it is a simple matter of reprogramming the OPV controller software to the latest configuration.
FIRE COMPARTMENTS

As well as fixed or controllable smoke curtains which are purely used to contain or channel smoke to specific areas, Colt also manufacture and supply fire compartmentation curtains.

GENERAL DESCRIPTION

Fire curtains stop the spread of fire to other areas within the building. They act like a solid fire wall but with the advantage that the Colt FirePath can be retracted to allow unobstructed movement around the building.

The curtains automatically descend upon receipt of a signal from the fire-alarm panel, and automatically retract when the signal has stopped.

Fire curtains are ideal for entrances which need to retain fire integrity in an emergency but will allow daily operation to continue.

FIRE CONTROL

The basic principle behind fire curtains is to seal off an area to contain the fire and prevent it from spreading to other areas.

An example of this could be an unsprinklered shop unit that needs to be separated from the mall during a fire condition.

Another example is access routes through compartment walls. The curtains must close to seal off the access route, keeping the integrity of the whole wall in a fire condition.

Colt fire curtains will contain a fire for up to 4 1/2 hours at up to 1000 °C and help maintain the fire integrity of a compartmentation wall.
The Colt FirePath is an automatic fire curtain, tested to BS476: Part 22.

Wire inserted woven glass fibre fabric is wound onto a steel tube, which incorporates a motor and an electronic control circuit.

The roller assembly, incorporating the fabric, is housed in a galvanised mild-steel head box which is normally bolted to the building.

The curtains automatically descend upon receipt of a signal from the fire-alarm panel, and automatically retract when the signal has stopped. During ascent the motors are controlled via a synchronised speed circuit to ensure all curtains are raised at similar rates. The curtains descend by gravity at all times, including total mains and battery back up failure.

Metal side guides with a fabric retaining system provide a seal between the curtain fabric and the building. Due to the positive or negative pressures created by the fire, it is imperative that this seal remains in place at all times.

The complete product has been tested in accordance with BS476: Part 22: 1987, clause 8 and achieved an integrity rating to BS 476: Part 20: 1987 of 270 minutes.

Colt FirePath fire curtains installed at Tate Gallery, London.

Colt FirePath fire curtains installed at Tesco’s in Glasgow. These are designed to separate the main shopping area from the storage area.

For further information on the Colt FirePath, please see leaflet PD 50, Smoke & Fire Curtains.
SOME RECENT UK PROJECTS

ASDA, 64 Stores throughout UK
Homebase - 8 Stores throughout UK
B&Q - 35 Stores throughout UK
Sainsbury’s - 53 Stores throughout UK
Co-op, 20 Stores throughout UK
Tesco, 42 Stores throughout UK
Allied Carpets, 7 Stores throughout UK
Pfizer, 8 Buildings throughout the UK
Ikea, 13 Stores throughout UK
Safeway, Over 48 Stores throughout UK
BOC, 13 Buildings throughout UK
BAe, Over 17 Buildings throughout UK
Vauxhall Motors, Ellesmere Port
Landrover T5 Building, Solihull
Toyota, Derby
BMW, Hams Hall
Hyundai, Dunfermline
Kellogg’s, Manchester
BAT, Southampton
Tibbett and Britten, Dublin
Lidl Distribution Warehouse, Livingston
Booker Warehouse, Dundee
Big W, Glasgow
Bookers, Reading
Honda, Swindon
Allsports, Manchester
ERF Trucks, Middleton
Argos Superstore, Manchester
JCB, Wrexham
Carlsberg Tetley, Wigan

REST OF THE WORLD

BAT, Nigeria
VW Autocity, Germany
Deutsche Bahn, Krefeld, Germany
Centre of Distribution, Slovak Republic
Singapore Expo, Singapore
Toyota Parts Centre, Belgium
BMW Manufacturing Centre, Bavaria
Volvo, Holland
Daimler Chrysler, Hanover, Germany
Daimler Chrysler, Fürth, Germany
Daimler Chrysler, Düsseldorf, Germany
Daimler Chrysler, Cologne, Germany
Toyota, France
Dinosaur Museum, China
Zamil Steel, Bahrain
Sony Warehouse, Argentina
Schiphol Airport Buildings, Holland
Ikea, Czech Republic
Opel, Rochnum, Germany
Opel, Rüsselsheim, Germany
Coca Cola, Kuwait
Philips, Holland
Quelle, Germany
Qatar General Petroleum Corp, Qatar
Aldi, Holland
Aldi, Mortfelden, Germany
Aldi, Langenfeld, Germany
Aldi, Wittlich, Germany

COLT SERVICE

Part of the Colt Group of companies, Colt Service offers a comprehensive range of maintenance packages incorporating the maintenance and repair of all building services equipment including non Colt products.

Colt Service provide a 24 hour, 365 day emergency cover as standard.

MAINTENANCE

Maintenance of a smoke control system is essential. Regular maintenance protects your investment and brings peace of mind that the system will operated effectively in an emergency.

British Standards, BS 7346, recommends that smoke control systems should be serviced at least once a year and tested weekly.

Colt is a member of construct-a-shed, the worlds first website devoted to warehouses and distribution centres.

www.constructashed.com