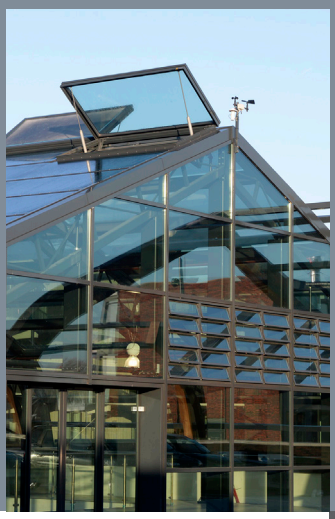
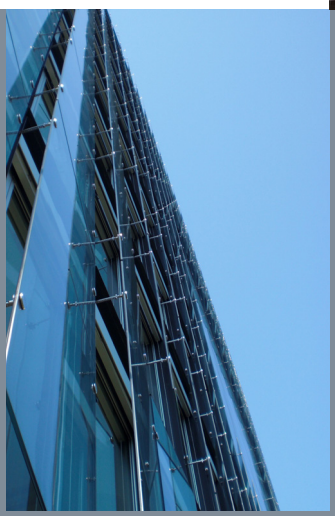


An Introduction to Smoke Management



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This guide is designed to provide architects, contractors, building owners and facilities managers with an overview of smoke control systems, including the different types of systems, where they can be applied, how they work and why they are critically important. It will also give information surrounding smoke control regulations, maintenance requirements and considerations when refurbishing or retrofitting a building.

What is smoke control?

Smoke control systems:

- Extract smoke
- Clear escape and rescue routes
- Aid firefighters in locating the fire
- Minimise casualties
- Limit building and contents damage

In a fire situation, you have one chance to get things right. Building owners and operators have a duty and responsibility to ensure the ongoing safety of the people who use their buildings, including implementing effective fire safety provisions designed to meet the specific building requirements.

Statistics from all around the world demonstrate that the greatest threat to life in a fire-related incident is not the fire itself, but the smoke generated by the burning building contents. This includes both the soot and aerosol particles visible in the air, and the invisible noxious gases such as carbon monoxide. In addition to posing a significant health risk, smoke can also obscure sight lines and irritate the eyes, impeding escape.

Forming a key and often mandatory part of the fire management plan, smoke control systems create smoke-free zones that enable occupiers to escape and firefighting teams to enter the property quickly and safely. With systems suitable for all types of buildings, these can be passively or mechanically assisted and are typically used to protect escape and rescue routes and common circulation areas.

Whilst occupant safety is the primary purpose of these systems, they also help to limit smoke and heat damage to the property and its contents. The combination of both life and asset protection can, in some cases, even help to lower insurance premiums and provide peace of mind that, should the worst happen, the building, and everything within it, is protected.

Considerations when specifying a smoke control system

Specifying a smoke control system is a complex task which requires an in-depth understanding of the systems available, the building it is to be installed on and the relevant building regulations and standards. It is important that it is considered as early on in the design process as possible by a qualified and experienced fire-engineering specialist to ensure that the solution selected is not only implemented correctly, but that it works as part of the holistic fire management plan.

When creating an optimised and reliable smoke control solution, there are five key aspects to consider:

1. Building specifics

Type

From high-rise offices to low-rise industrial facilities, to underground car parks, every building type will carry its own specific set of requirements and, in some regions, may even be subject to specific smoke control legislation.

Geometry

The height, surface and volume of the internal spaces to be protected must be clearly defined to ensure that the spread of smoke is accurately calculated and that the specified smoke control solution will perform as required. For example, in deep buildings with a high internal volume, such as a large warehouse with several floors

or mezzanines, it may be necessary to use a combination of natural and mechanical smoke control systems in different parts of the building to ensure that smoke is evacuated from the centre of the space. Or, in the case of a Smoke Pressurisation System on a high-rise building, additional sensors or fans may be required to navigate any areas with complex geometry.

Configuration

In addition to the volume, assessing the layout of the space is also key for working out both the flow of smoke and occupant evacuation routes. This includes establishing how the space will be divided, where the escape and rescue routes are located, their maximum permissible length, how they will be accessed, and where the smoke control system can be installed.

Airflow

Once the type, geometry and configuration of a building has been determined, computational fluid dynamics (CFD) software can be used to understand how air moves through a space and therefore how smoke may behave in a fire situation. This may also include looking at how the external building envelope will be constructed, especially for smoke pressurisation systems which rely on high levels of airtightness, and the potential effects of external wind conditions.

Location

The local climate and temperature can also have a significant influence over the specification smoke control systems. For example, the performance of natural ventilation can be adversely affected in places with high winds, therefore a mechanical solution may be more appropriate.

2. Risks during use

In addition to considering how it has been built, it is vital a thorough in-use risk assessment of the building is conducted to ensure the fire management solutions are fit for purpose. This should take into account:

Use

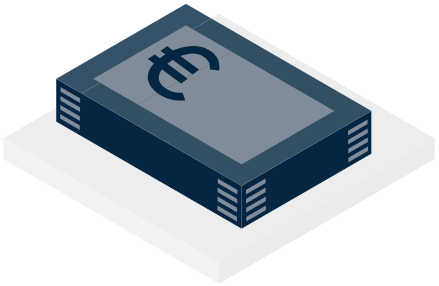
Whilst a building may be constructed to fulfil a generic brief, its exact use can have a significant impact on the fire risk and the potential fire and smoke load. For instance, an industrial building that manufactures, uses or stores flammable goods may require a much more stringent fire management solution to a typical plant. There may also be cases where the use impacts the configuration of, and airflow within, the internal space, such as logistics facilities with floor-to-ceiling storage racks.

Occupancy

It is not only important to consider how the building will be used, but who it will be used by. Buildings that have high occupancy, such as airports or shopping centres, or occupants who are less able to escape, such as in hospitals and prisons, may require more stringent smoke control measures. Additionally, buildings that have a "stay put" policy or phased evacuation procedures will require a different approach to a building that uses simultaneous evacuation.

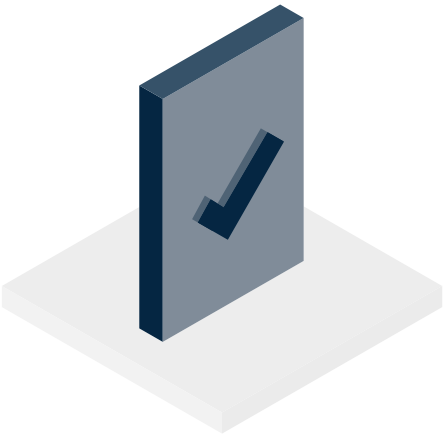
3. Regulations and standards

The specified system must be designed, tested, certified, and maintained in accordance with any local legislation and guidance set by the government and/or fire service. This includes standards that govern their use, as well as any component-specific certifications.



4. Financial constraints

Whilst fire safety is a fundamental consideration and should command an appropriate part of the project budget, it is important to get the balance right. Whilst under-specifying can lead to a smoke control system that is not fit for purpose, over-specification can result in unnecessary cost.



5. Testing, Commissioning and Maintenance

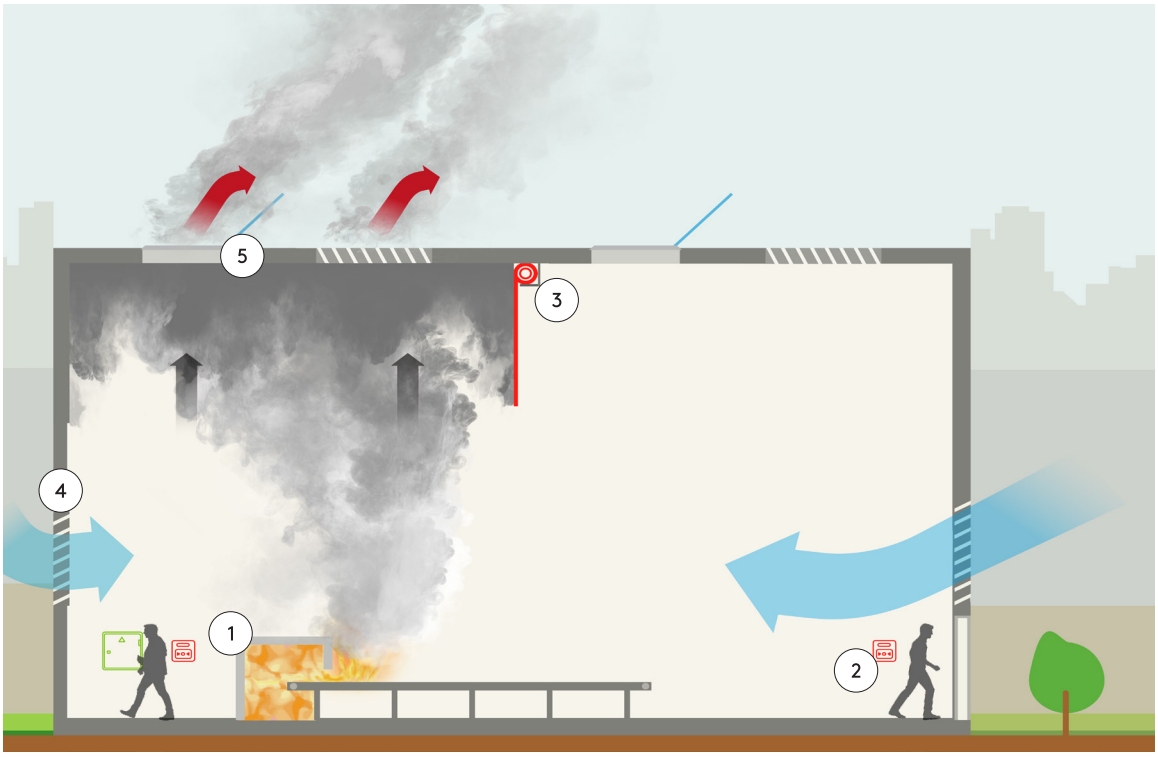
Once the system has been installed and the building work completed, all smoke control systems need to be accurately tested and commissioned by specialist technicians. They will also require regular maintenance throughout their lifespan, therefore it is important that the building owner or operator is provided with clear and detailed information about their ongoing responsibilities, and a service and maintenance plan should be immediately put in place.

Types of smoke control systems

There are two main categories of smoke control systems: natural and mechanical. As a general rule, the taller a building, the more the specification will move from natural to mechanical and pressurisation. However, there are no steadfast rules that define the limits of one system over another, and the physics of every project must be assessed individually to ascertain the most appropriate and effective solution.

Natural smoke and heat exhaust (SHEV)

Natural smoke control systems use the basic principles of thermal buoyancy to allow smoke and heat to rise out of the building through high level openings, whilst fresher and cooler air is drawn in at lower levels to create a smoke-free air layer, allowing occupants to escape and reducing the thermal stress on the structure. These can be employed as opening units within the roof or facade, typically alongside smoke curtains which limit the smoke spread, or as part of a natural smoke shaft solution.



1. A fire breaks out in an area of the building.

2. Once triggered, either by the fire and smoke detectors or manually at a call point, motorised actuators in the roof or wall ventilators open, allowing the smoke and heat to rise naturally out of the space below.

3. At the same time, smoke curtains are triggered to lower, compartmentalising the smoke and preventing it from spreading throughout the building.

4. Low-level side ventilation inlets are also activated to replace the smoke with fresh external air.

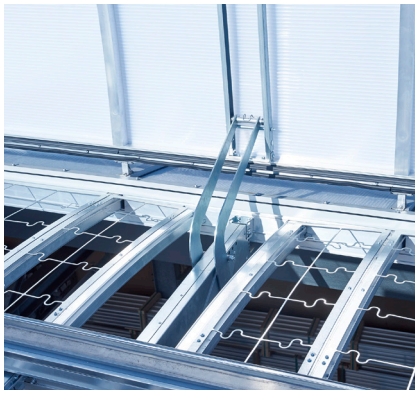
5. After the fire has been extinguished, the ventilators can be left open to help clear any remaining smoke.

What are the key components?

These systems typically comprise:

(a) An automatically opening ventilator (AOV), located on the roof, within the facade or, where an external wall or roof is not available, within a smoke shaft.





(b) Smoke curtains installed in a way that drives the smoke towards the ventilator.

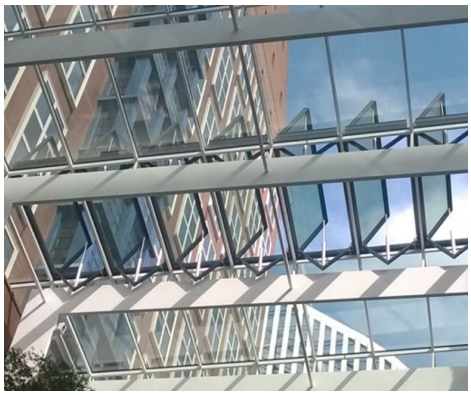


(c) A control system. Depending on the system configuration or project preference, these can be pneumatically, electrically or manually operated. It should include a secondary power supply, fire service override function and allow for easy system monitoring.

What benefits do these systems offer?

Design flexibility

There are several types of smoke and heat exhaust ventilators available that are suitable for a range of applications and building types, from modern offices and hospitals to industrial warehouses. These include simple mono- or double-flap rooftop ventilators, opening skylights and louvred vents to facade options such as motorised vertical glass louvres and ventilators.



Multifunction and sustainable benefits

Almost all natural smoke and heat exhaust ventilators can also be used to provide daily building ventilation, helping to maintain comfortable internal temperatures for occupants and limit the need for mechanical air-cooling systems, improving a building's energy efficiency. These should include integrated wind and rain controls to prevent water ingress or damage. Some systems can also offer the additional benefit of natural daylighting, further improving the comfort and health of occupiers and reducing artificial light demand and costs.

Cost efficiency

Natural smoke control systems are typically more cost-effective to specify, install and maintain due to their limited number of components.

What are their limitations?

Natural smoke control systems may not be suitable for:

- Buildings in locations subject to high winds, or where wind has a negative influence on the smoke ventilator.

- Buildings which require increased efficiency or where smoke must be extracted over a larger distance, such as across multiple floors in high rise buildings.

- Smoke shaft applications where space is limited, as natural smoke shafts are often much larger than mechanical.

- Buildings with limited options for outlet and inlet ventilators, such as buildings with one external facade.

- In situations where the smoke temperature will cool too quickly to rise out of the building, such as in high internal spaces or where sprinklers are installed.

Where are they commonly applied?

Low-rise buildings

Whilst they can be used in shaft applications, rooftop natural smoke control systems are more suited to single storey buildings and open plan areas. In addition to allowing smoke to rise up unimpeded, this allows designers to make the most of the potential for incorporating natural light and

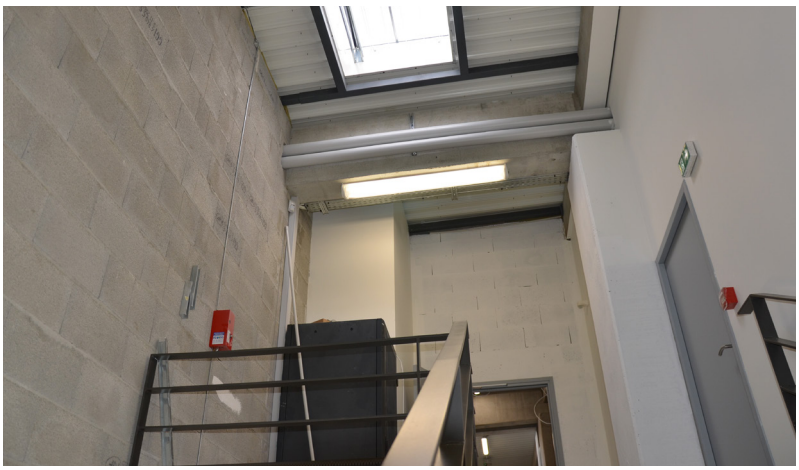
ventilation functionality. This makes them ideal for buildings where occupant health and wellbeing are a key focus, for example schools, sports buildings, retail units, and workplaces such as offices and industrial plants.

Atriums and Galleries

Atriums and galleries are often a common yet impressive architectural feature in many different building types, from hotels and offices to schools and hospitals. However, vertically spanning several storeys, these also present a particular fire spread risk. Natural smoke ventilation units designed into the facade and roof allow for smoke and heat to be effectively exhausted from the area, without having to compromise on the architectural finish or the feeling of space and light these spaces inspire.

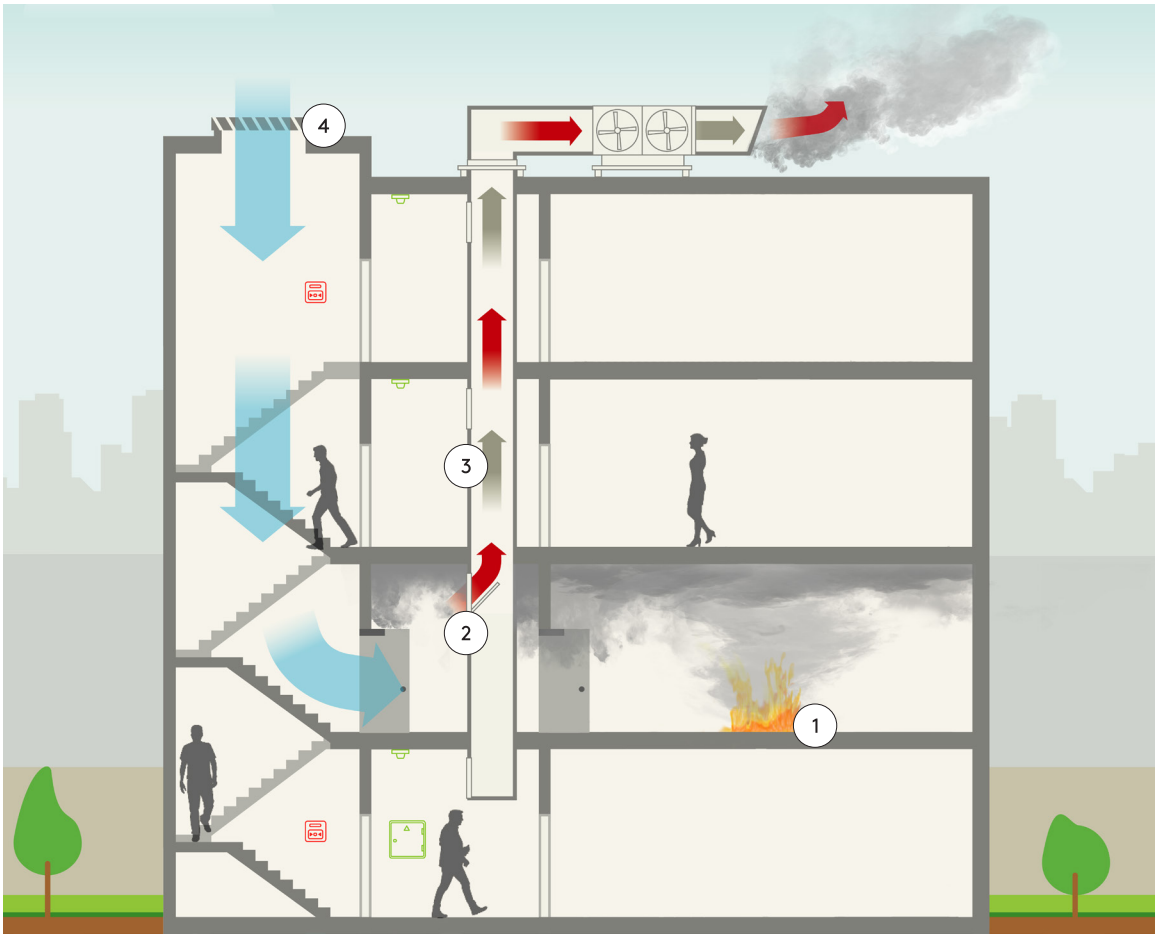
Staircases and elevator shafts

Natural smoke ventilators are often installed at the head of staircases and lift shafts, even on buildings protected with mechanical smoke shafts, to ensure the amount of smoke in that area is limited. They can also offer an additional escape and rescue route, which is particularly important for elevators in the case of a power cut.



Mechanical Ventilation

Mechanical smoke control systems use powered fans and smoke exhaust shafts to force smoke and heat up and out of the building, replacing it with fresher and cooler air from outside. This allows for efficient smoke control over multiple storeys and greater distances.



1. A fire breaks out in an area of the building.

2. When the smoke is detected, the fire damper within the smoke shaft on the level where the fire is located opens and the extraction fan at the top of the shaft is activated. This draws the smoke out of the room, up the shaft and out of the building.

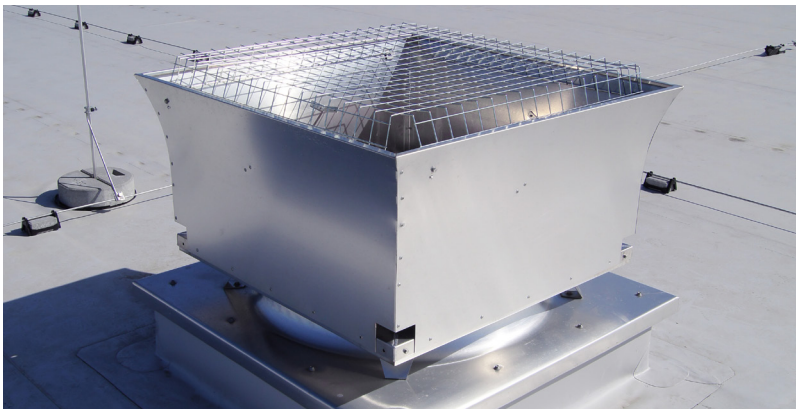
3 The other dampers located on the other floors are closed/remain closed to prevent the smoke from traveling to unaffected areas.

4 A vent located at the head of a staircase or another shaft is opened to draw in fresh replacement air.

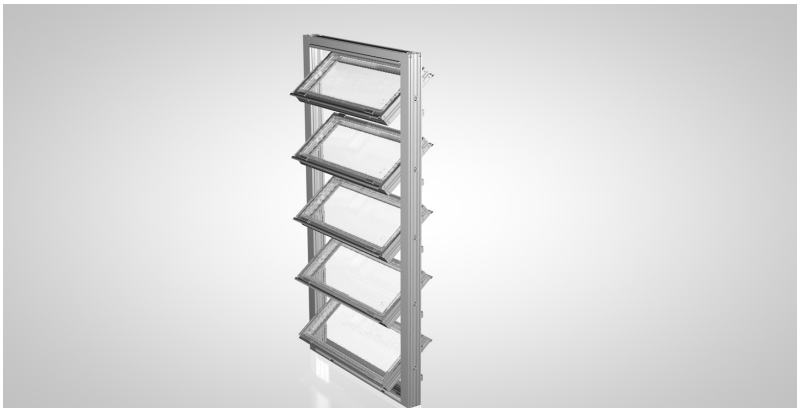
What are the key components?

These systems typically comprise:

a Powered extraction ventilators/fans usually located on the roof.



b A smoke extraction shaft which covers the common areas of the building, such as the corridors and lobbies.



(c) Smoke dampers within the shaft to control the flow of smoke from the lobbies or corridors

(d) An inlet for fresh air, typically supplied by another shaft system or from a natural ventilator in the stairwell

(e) Electrical control point. This should include a secondary power supply, fire service override function and allow for easy system monitoring.

What benefits do these systems offer?

High efficiency

The high-powered fans allow for greater volumes of smoke to be extracted much quicker than natural smoke exhaust. This measurable performance makes them ideal for applications where a certain level of efficiency must be achieved and can also help to reduce the size of the smoke shaft, reducing the impact on internal space.

Weather protection

Mechanical smoke control systems are unaffected by external weather or wind conditions, making them suitable for any climate.

Daily ventilation

Depending on their design, mechanical smoke control systems can also be used for daily ventilation purposes, helping to maintain comfortable internal temperatures or exhaust toxic fumes in applications such as car parks.

What are their limitations?

Mechanical smoke control systems may not be suitable for:

- High-rise buildings (over approximately 20 floors, depending on application)
- Projects with a limited budget as they are more expensive to specify, install and maintain than natural systems
- Buildings with limited accessible roof space
- Building projects subject to specific planning laws regarding the appearance of their roof space

Where are they commonly applied?

Buildings where natural smoke control is not viable

The higher efficiency and greater control offered by mechanical smoke control methods can overcome the limitations of natural systems, such as wind interference or speed of evacuation. This often makes them the system of choice for buildings with more stringent smoke control requirements. They may also be the only suitable solution where smoke travel distances are in excess of the building regulations or standards.

Mid-rise buildings

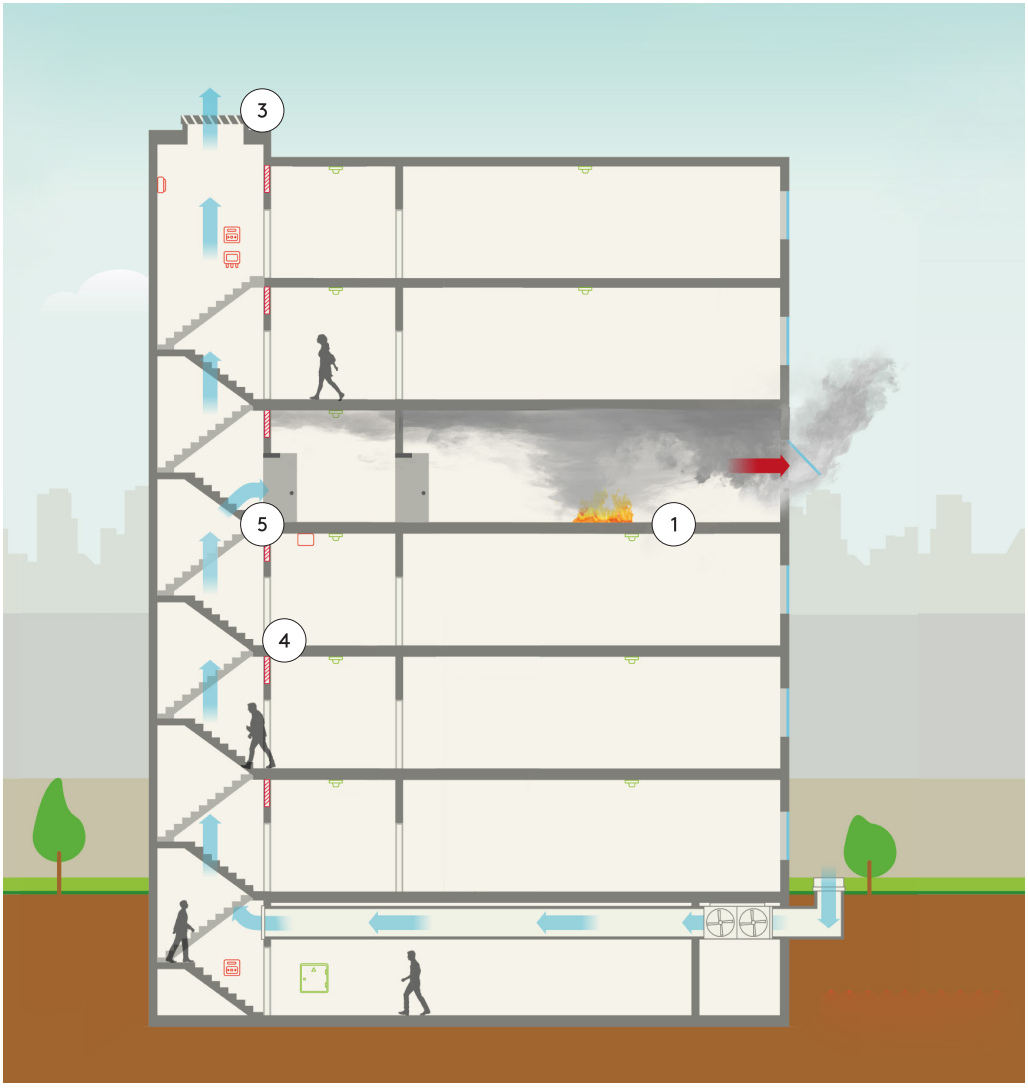
As mechanical smoke shaft systems allow for the evacuation of smoke over multiple storeys, they are often used in mid-rise buildings such as offices, hotels, residential apartment blocks and similar, to protect stairways, lobbies, corridors and floors.

Car parks

Car parks present a number of challenges when it comes to applying a smoke control system. Firstly, it must be designed to fulfil two key functions: in addition to clearing or controlling smoke in a fire incident, it must also allow for daily ventilation to prevent the build up of exhaust fumes from vehicles. Secondly, car parks are often enclosed or underground, and have multiple storeys, meaning that smoke must be evacuated over larger distances with limited external air coming in. This makes mechanical exhaust methods the ideal option for these structures.

Smoke pressure systems

Smoke pressure systems (SPS) are a specialised way of using mechanical smoke ventilation for more complex buildings, such as high-rise. These systems create controlled overpressure within the escape and rescue routes. As air will naturally always try to move from an area of higher pressure to an area of lower pressure, this stops smoke from travelling into the protected area, ensuring it remains clear and safe for those evacuating. Generally, these are based on the principle of active control to prevent their effectiveness being impacted by issues such as airflow, changes in the climate or open doors.



1. A fire breaks out in an area of the building and occupiers of the smoke-filled rooms escape to the staircase.

2. The SPS is activated either automatically by the fire and smoke detectors or manually from a call point. A signal is sent to the control centre to commence the flushing stage within a maximum of 60 seconds.

3. The SPS flushes out any smoke from the protected route using low level fans and automatically opening ventilators located at the head of the staircase.

4. During this period, the system's own acoustic and visual alarms are triggered, doors are closed and any ventilation systems that will impact the effectiveness of the system are deactivated

5. When the air has been replaced, the system activates the pressure control, increasing the internal air pressure to ensure the smoke cannot flow into the space, even if the door to the fire is opened. This is constantly compared to the external air pressure and adjusted if necessary.

6. During the pressurisation stage, the pressure is controlled to a level where emergency doors can still be opened and closed easily by hand. If they are opened, the system ensures that the flow of incoming fresh air is fast enough to keep the fumes out and reinstates the overpressure in just a few seconds.

7. Once the fire is extinguished, the system returns to monitoring status.

What are the key components?

These are sophisticated systems and their configurations will depend on the building they are installed on. However, they typically comprise:

(a) Alarm and detection systems, including visual and sound alarms and various sensors.

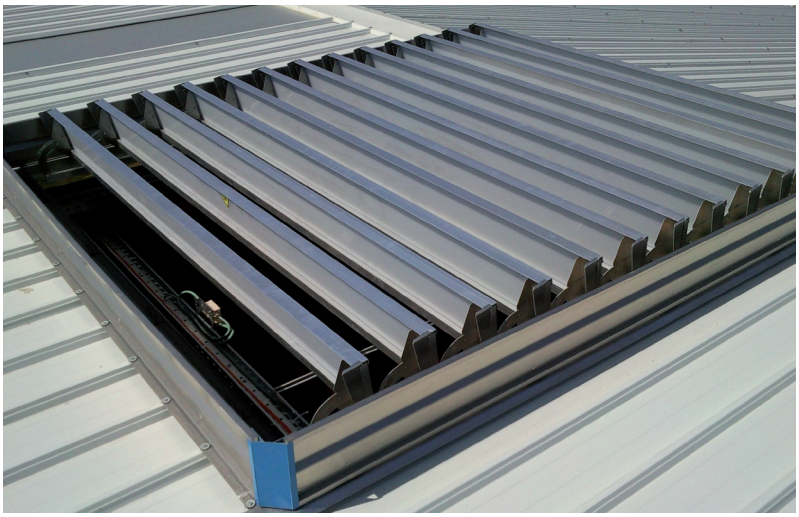
(b) A manual SPS call point.

(c) A powered air supply system, typically installed at ground level, to allow fresh air to enter the space and maintain the pressure differential.

(d) Pressure monitoring equipment to ensure the pressure is kept at the required level whilst in operation.

(e) A pressure relief system to avoid too much pressure building up when the doors are closed. This is usually a pressure relief damper in the ventilation system or a variable speed drive on the air supply fan.

(f) An opening rooflight or ventilator located at the top of the staircase to evacuate the smoke and heat which includes a wind/ rain sensor.



(g) An electrical control system located in a safe place such as the pressurised zone or a separate, fire resistant compartment. This should include a secondary power supply, fire service control and monitoring panel, and an override function.

What benefits do these systems offer?

Specialised application

SPS are a highly effective way of ensuring smoke-free escape routes for high rise and high risk buildings, overcoming many of the limitations of typical natural and mechanical smoke exhaust solutions.

What are their limitations?

Complex and costly

SPS are highly technical systems which need careful design, specification and ongoing maintenance. This makes them expensive and they are only suited to buildings with complex requirements, such as high-rise buildings with one escape route.

Where are they commonly applied?

High-rise buildings

SPS have been specifically designed for skyscrapers, for example office or apartment blocks, or buildings with complex geometry. Depending on the building type and use, they can be used to protect escape and rescue routes such as staircases, elevator shafts, corridors or lobbies, and fire service access routes and lifts.

Interaction with other **fire management systems**

Smoke control systems are not standalone solutions. They form a part of the wider fire management plan and their interactions with the other elements must be carefully planned and tested to ensure that the whole solution will perform as expected in a fire emergency, protecting lives and assets. For example, their activation by the fire and smoke detectors should also correspond with the systems that manage evacuation, such as the disabling of elevators, to ensure that people are directed towards safe, smoke-free escape routes.

Some examples of key elements that directly interact with the smoke system are:

Compartmentation

In buildings with extensive ceiling space, or where it is required by law, smoke curtains may be used as part of the smoke control system to compartmentalise the smoke. This limits damage and prevents the smoke from cooling too quickly and dropping below head-height, obscuring evacuation and rescue routes. These are typically employed as part of a natural smoke control system and are lowered from the ceiling when activated by the smoke and fire alarm system. It is important to note that these are different to fire curtains, whose primary purpose is to prevent the spread of flames.

HVAC

Heating, ventilation and air conditioning ductwork can provide a channel through which smoke and heat can spread throughout a building. In addition to being a fundamental element within a mechanical smoke shaft system, fire and smoke dampers can also be installed at key points within the HVAC ductwork. When a fire is detected and the fire management system is triggered, the ventilation systems are shut down and these dampers automatically close, blocking the duct and preventing the movement of smoke and flames.

Sprinklers

Sprinkler systems are primarily designed to contain and suppress the growth of a fire until its fuel runs out or it is extinguished by the fire service. However, even when sprinkler systems are in operation, it is still possible for large volumes of smoke and toxic gasses to be produced by the burning contents and spread quickly through the building. This means that, wherever possible, smoke evacuation must form a necessary part of the fire management plan.

The interaction between sprinkler and smoke control systems can be complex and it is vital that, where they are employed together, they are designed holistically using a fire-engineered approach to ensure one does not impact the performance of another.

Regulations and Compliance

Smoke control systems must be designed, tested and certified in accordance with any local legislation and guidance, as well as any overarching standards. Legislation varies from region to region, and there are even different stipulations for different building types. Navigating these legal requirements and best-practice can be a complex task, especially for designers, contractors and building owners working cross-regionally.

The governance of smoke control systems works on three levels:

1. Application

Seek support from experienced smoke control engineers to ensure the correct standards are being applied.

In Europe, the application of smoke control systems is governed at a regional level by building regulations, specific legislation for system and building types, and best practice guidance from industry bodies. It is vital that system engineers and specifiers thoroughly understand these stipulations to ensure that their smoke management schemes are not only compliant, but also that they have been designed and installed to the best of current standards.

For more information on the relevant standards in your region, please contact Kingspan Light + Air.

2. Products

EN12101 smoke and heat control systems provides the baseline standard for the products used within all types of smoke control systems in the EU. Member states and other countries may also apply their own legislation and guidance on top of this. Split into a series of parts, the standard specifies the requirements and provides testing methods for all three types of smoke control systems. Covering everything from the fans and opening ventilators to smoke curtains and dampers, it is important to check that all the elements specified have been CE marked to the appropriate part of the standard.

Currently, seven parts have been published as harmonised standards, although many of them are being reviewed and updated:

- EN 12101-1 Specification for smoke barriers
- EN 12101-2 Natural smoke and heat exhaust
- EN 12101-3 Specification for powered smoke and heat and control ventilators
- EN 12101-6 Specification for pressure differential systems. Kits.
- EN 12101-7 Smoke duct sections
- EN 12101-8 Smoke control dampers
- EN 12101-10 Power supplies
- EN 12101-9 Smoke and heat control systems has not yet been published as a harmonised standard.

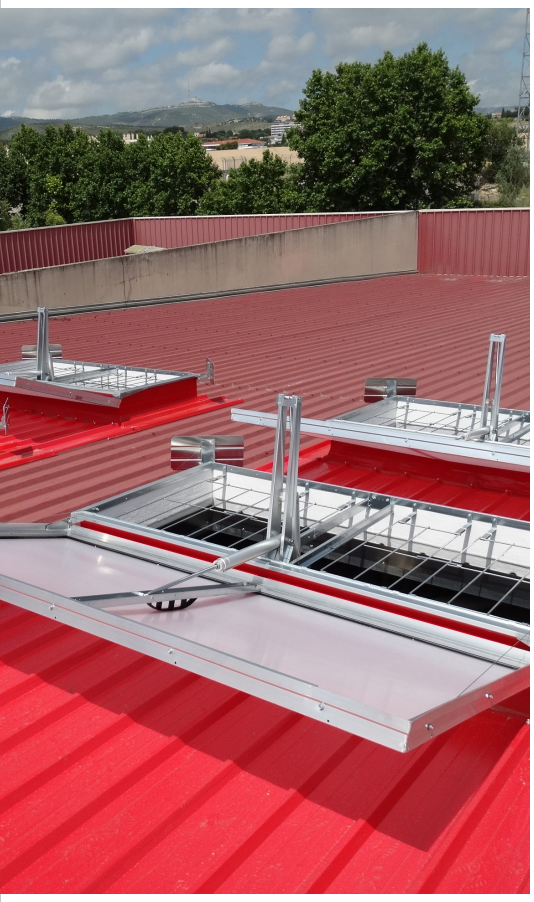
3. Maintenance

Regular and thorough testing and maintenance of a smoke control system is vital to safeguard its performance, even if it has not been activated. Consequently, many countries have specific legislation that demands these checks are carried out. For example, in a number of regions in Europe, smoke control systems must legally be kept in good working order and serviced once a year by skilled and competent people who understand the specific system installed.

Whilst other regions may not enforce such strict maintenance laws, the importance is such that responsible business owners and operators must still apply a strict, annual schedule to ensure the ongoing functionality of the systems in place and the safety of the building users.

Refurbishment and retrofit

When a building is upgraded, or its use defined in a new way, it is essential to reassess the fire risk and update the fire management plan. This is typically the responsibility of the building owner or facilities manager; however, it can also fall under the designer's or contractor's remit. This may include installing or commissioning a new smoke control system, ensuring regulatory compliance and occupant safety, irrespective of building age.



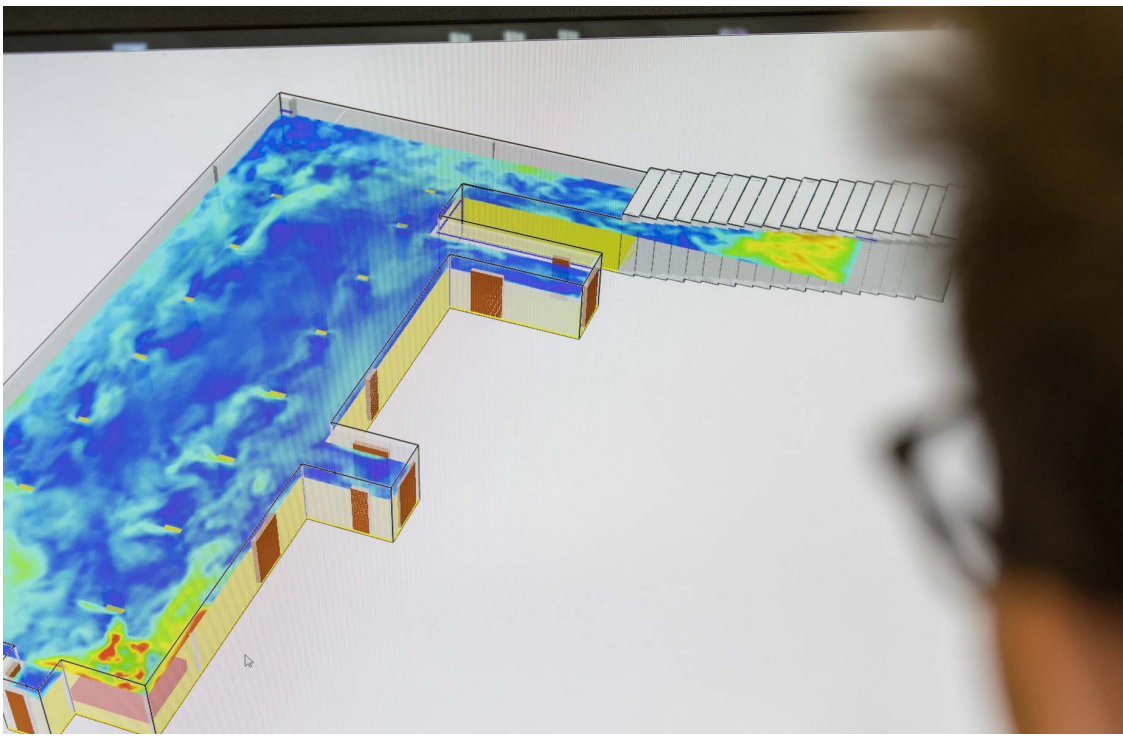
Refurbishment applications

Refurbishing an existing smoke control system may be necessary to ensure it remains fit for purpose throughout a building's lifetime, reacting to any changes in use or developments in smoke control regulation. This is particularly relevant to buildings built to allow for multiple functions, such as multi-unit commercial schemes or shell-only building developments. Having a regular, proactive maintenance schedule in place can help to streamline this process, and even reduce upfront costs, as different elements can be upgraded periodically when necessary.

Additionally, when a roof is refurbished to achieve higher levels of thermal performance, it is possible to install natural smoke exhaust ventilators that offer improved U-values, helping to create a more energy efficient and sustainable property.

Retrofit applications

On buildings where no smoke management solution has been installed, such as heritage properties, it will be necessary to design-in a new solution from scratch. Retrofit applications are complex, with system designers having to navigate the existing building geometry and technical limitations, balancing them with modern legislation and building standards. Therefore, it is vital that retrofit smoke control designs are only undertaken by qualified and experienced fire engineers to ensure that the best solution is selected, and it achieves compliance with the necessary regulations.



Service and maintenance

Handover

Whatever solution is implemented, the building must be handed over to the building owner and facilities manager with clear and comprehensive documentation, including:

- Technical details about the system components
- Details on where they are located
- Installation and commissioning certificates
- Instructions on how to operate the system for both the end user and the fire service
- A clear outline of the maintenance requirements and their responsibility to uphold them

Maintenance

Whether natural or mechanical, smoke control systems comprise several different components. The system's performance is not only reliant on the interactions between each of these elements, but also its interaction with other parts of the fire management plan, such as alarm systems or sprinklers. Failure of a single element can impact the effectiveness of the whole system, potentially resulting in a complete breakdown.

A proactive and frequent checking and testing schedule is therefore vital. It is recommended that this is done monthly, typically by site personnel, with a thorough service at least once a year to ensure it performs as anticipated as part of the fire safety strategy.

Smoke control systems should be tested yearly by a competent person and a service and maintenance contract should be put in place as soon as a system is installed.

It is the responsibility of the building owner or operator to ensure a suitable schedule is put in place, and that the main, yearly service is done by a skilled and competent person. As detailed in the regulation and compliance section, these checks are a legal requirement in many regions. However, beyond the legal repercussions, building owners have a duty of care to the people who use their building. Neglecting to maintain a system can lead to under performance which, if a fire breaks out, could have devastating consequences.

Operating a proactive maintenance plan also carries additional benefits. Regular servicing can extend the lifespan of the components, minimising the risk of system failure and the need for and cost of replacements. It offers the opportunity to upgrade the system in light of any advancements in the technologies used and helps to ensure that the system is always compliant with any legislative developments.

The specifics of how you maintain a system is dependent on a number of factors, from what type of system it is, to how frequently it is used. However, there are some basic actions building owners or operators can take to ensure their smoke control system will always perform as expected:

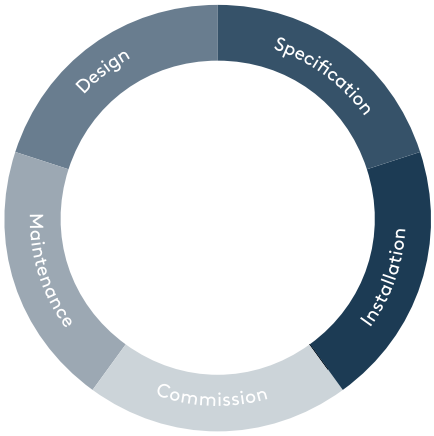
1. A service and maintenance contract should be taken out as soon as a system is installed. Competent maintenance providers will always look at the system holistically, checking every component, from the control panel to the ventilators, in the context of its role within the wider system and its dependency on other

elements. They will also thoroughly test the system for assurance, including checking that any back up power systems are active.

2 Smoke system checks should also form part of the building maintenance plan, including checking the status of any monitoring systems for fault alerts and visually assessing components for any obvious damage. Any issues should be immediately reported to the overall maintenance service provider.

How can Kingspan Light + Air **support your project?**

Drawing on knowledge and experience from across the globe, Kingspan Light + Air offers full project support—from initial fire engineering consultancy at the design stage, to supplying and commissioning products and bespoke solutions, through to providing ongoing service and maintenance throughout the system's lifetime—helping to ensure continuing compliance and reassurance that the system will perform as expected in the event of a fire.



01 Design

Our experienced and qualified fire engineers use the latest software and design methods to design a suitable smoke control system which is tailored to the project requirements and complies with local regulations.

02 Specification

Through constant innovation and testing, we offer some of the highest quality natural and mechanical smoke control solutions on the market. With a complete portfolio of products, we can provide impartial advice on which will be better suited to a specific project.

03 Installation

Our network of installers have the skills and qualifications to ensure each system is fitted correctly and to the highest standards, ensuring it will perform as expected.

04 Commission

Once the project is completed, our experienced and trusted commissioners can check the system has been installed to the correct standards and efficiently interfaces with the whole fire management system.

05 Maintenance

Our expert engineering teams can complete regular, mandatory checks to ensure continuing performance and compliance, in addition to providing advice on refurbishment opportunities.

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