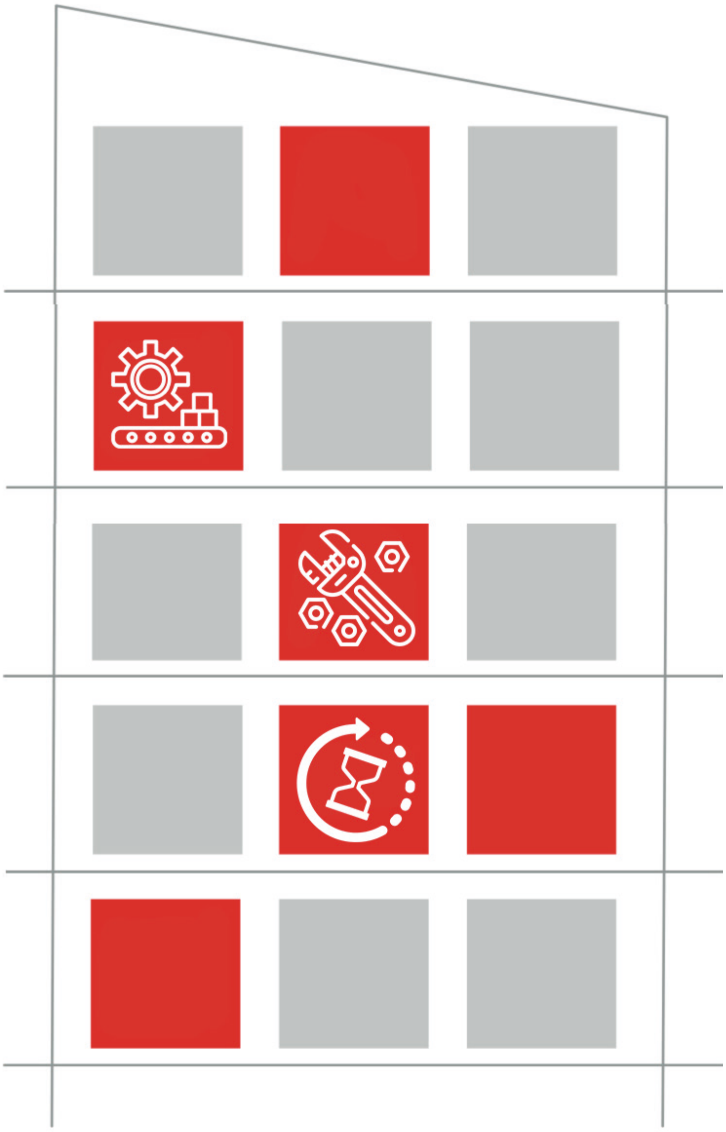
Guidance to Shafts for Smoke Control.

A USEFUL GUIDE TO PRACTICAL SMOKE SHAFT PRINCIPALS AND SPECIFICATIONS



About Group SCS

Industry experts with more than 25 years of experience

Group SCS is an expert provider of smoke control systems and BEMS, delivering solutions with safety at its core. Our work on thousands of complex UK construction projects and in-depth knowledge of the smoke control industry have paved the way to innovation and given us the expertise required to handle projects of any scope.

Group SCS offers a pre-designed suite of customisable solutions that can be applied to a wide range of buildings for the protection of escape routes. The current range includes:

- Smoke shafts
- Automatic opening vents
- Car park ventilation
- Fire and smoke damper control systems
- Fire curtains

What we offer

Smoke Control

Comprehensive packages with innovative open source controls that facilitate integration with our BEMS and fire alarm installations.

BEMS

Cost and energy-efficient systems that integrate various environmental controls such as heating, lighting, ventilation and security through one system.

Modular Solutions

A range of standardised modular smoke control systems that can be self-selected, specified and purchased through a variety of routes.

Window Technology

A wide range of innovative solutions for the automation of windows, roof & skylights for natural, smoke and environmental ventilation.

Training

Group SCS supports a network of trained Approved Installers, who have expert knowledge of our range and benefit from our ongoing support.

Support & Afercare

Our Support and aftercare division provides service and maintenance and ensures that buildings remain safe after handover.

Smoke Shafts

Overview

'Smoke shaft' is the common term for ventilation systems in the lobbies of tall buildings, used to maintain tenable conditions in the common escape routes in the event of a fire in the building. This document is a practical guide to the implementation of smoke shaft systems for regular multi-storey buildings up to 20 storeys in height. For mechanical ventilation, those with a single shaft extracting from a lobby with make up air being drawn from the stairwell.

NOTE

Complex bespoke designs, for example those using twin shafts with reversible fans, fall outside the scope of this guidance and the design of such would require the services of a suitably qualified fire engineer.

The origins of Smoke Shafts

Smoke shafts originated from research carried out by BRE and presented in a report in 2002 entitled 'Smoke Shafts Protecting Fire Fighting Shafts, Their Performance and Design'. This report specifically looked at fire-fighting shafts and proposed natural ventilation – with the output being commonly known as the 'BRE Shaft'.

The desire to reduce the space occupied by the ventilation system led to the development and common acceptance of mechanically ventilated shafts to provide both firefighting and means of escape protection.

In Common Usage

Such systems are now the most commonly employed smoke control measure for high-rise buildings, overtaking the other available approaches: automatic opening vents and pressurisation.

Applicable Standards

Documents and guidance

Guidance for natural smoke shafts is contained in *Volume 1 of Approved Document B* of the Building Regulations. Unlike the other methods mentioned previously, mechanical smoke shafts do not yet appear in the Building Regulations and are treated as a fire safety engineered approach. This means that although they are now very common, there is still an air of mystery surrounding what is in fact a very simple extract system.

As there is no single common standard applying to these products, they are typically approached using the appropriate parts of several related documents. In addition, the Smoke Control Association document *'Guidance on Smoke Control to Common Escape Routes in Apartment Buildings'*, amended in 2020, offers a comprehensive guide to smoke shaft applications for residential buildings.

This document applies the SCA guidance to the most common situations, offering a quick and reliable route to a robust solution.

Approved Document B (ADB)

Applied to the stairwell ventilators, lobby ventilators, system triggering method and ventilator free area measurement.

European Standard 12101

Applied to the stairwell ventilators, lobby ventilators, system triggering method and ventilator free area measurement.

PD 7974-6:2019

Used to identify acceptable conditions for the escape of occupants of buildings.

SCA Guide

The Smoke Control Association (SCA) document *Guidance on Smoke Control to Common Escape Routes in Apartment Buildings (Flats and Maisonettes) Revision 3: January 2020* offers a comprehensive guide to smoke shaft applications for residential buildings.

Design

The concept

Smoke shafts are essentially a simple ventilation system designed to extract any smoke leaking into a common lobby to protect the escape stairs. Typically a vertical builders' work duct rising through the building would be used to extract smoke from the lobbies and each lobby would have a damper connected to the builders work duct.

For natural shafts, the head of the shaft is terminated with an automatic opening ventilator. Mechanical shafts use extract fans, mounted on the roof and connected to the builders work duct with sheet metal ducting. An automatic opening ventilator would be mounted at the top of the stairwell and the complete system would be controlled by an addressable control system that provides automatic operation of the ventilation by interface with the fire alarm system or smoke detectors.

Firefighting

For buildings with a storey over 18m high, firefighting access would also need to be taken into account. This would usually mean that the system is designed to cope with the door to the fire room being open to the lobby, representing fire fighting conditions. In practise this simply means that a higher extract volume flow rate for mechanical systems. Typically the required conditions within the lobby would be based on the tenability criteria in PD7974 part 6.

The tenable criteria described in the guidance are:

- Visibility (5m for small enclosure and 10m for large enclosure - extended travel distance would require a 10m visibility)
- Temperature (smoke temperature is less than 120°C - some say 60°C in a moist environment)
- And a requirement by London Fire Brigade that the lobby/corridor returns to a smoke free environment within 2 minutes of the last occupant's escape through the stair before the onset of fire fighting. BS 7974 recommends design fire sizes for a range of applications.

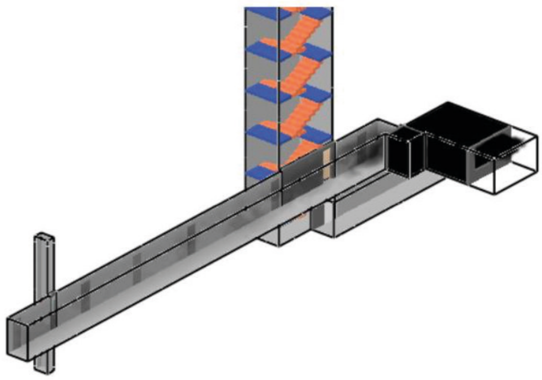
Natural systems for non-residential buildings, may require a larger shaft with larger ventilators.

Computational Fluid Dynamics

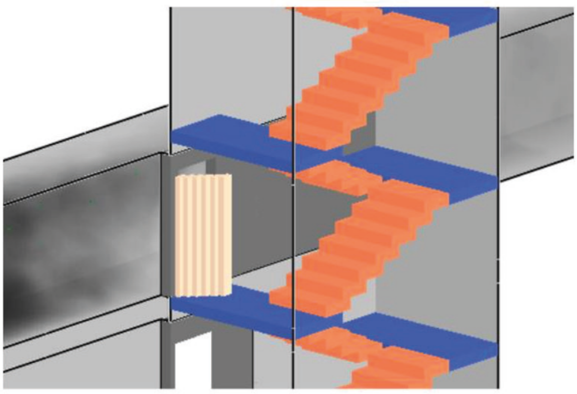
Selecting flow rate

Computational Fluid Dynamics (CFD) are often used to ascertain the volume flow rate required to maintain the design conditions within the lobby; this was essential in the early days of adoption of such systems as each situation was in effect a new scenario. However, after more than five years of common usage, there is a bank of data available to inform such selection for most buildings, particularly residential where one lobby is very similar to another.

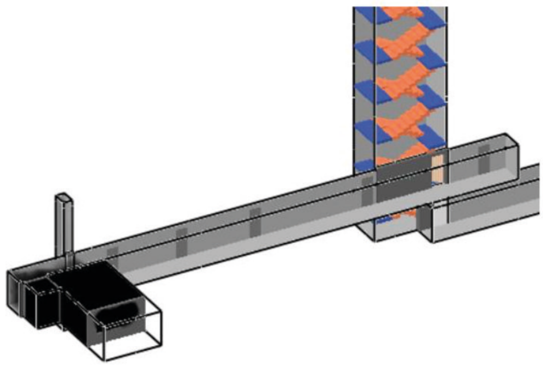
At Group SCS we have available data from dozens models and have aggregated this into a matrix to develop suggested extract rates for buildings within the parameters of this guide.


Time: 440.0

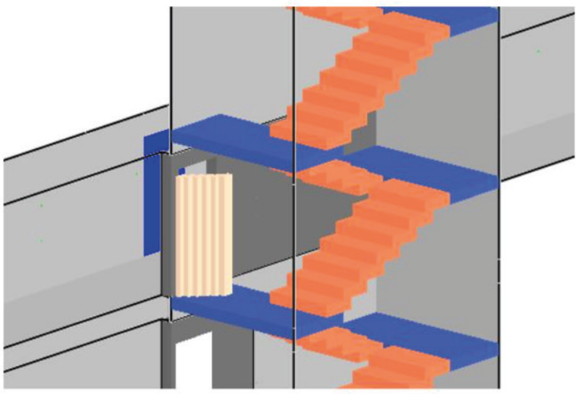
Straight - Fire 0


Time: 440.0

Straight - Fire 0


Time: 440.0

Straight - Fire 3


Time: 440.0

Straight - Fire 3

Replacement air

How it works

The automatic opening ventilator above the stairwell is used to provide replacement air for the smoke shaft. There is a risk of lobby de-pressurisation when using mechanical extract in confined spaces like residential buildings, which could make is difficult to open exit doors from the lobby. Common methods to overcome this are automatically opening/ reverse hanging the stair door or pressure sensing fan control.

Pressure sensing fan control monitors the pressure between the stair and lobby and controls the extract fan speed such that the maximum pressure difference remains within acceptable levels. Automatic opening of the stair/ lobby door uses a motorized actuator or door closer to open the stair door, usually a small distance, to ensure a flow of air into the lobby without allowing smoke to enter the stair.

It is possible to hang the stair/lobby door such that it opens into the lobby. When the extract system is operating the pressure difference is used to suck the door open allowing fresh air to enter the lobby. The pressure at which the door is pulled open is set by adjusting the door closer. This can be a simple and effective solution if it is acceptable for the exit doors to open against the escape travel direction.

To ensure effective smoke clearance, the extract shaft should be located as far away as practicable from the stairwell, which is the source of replacement air. This is particularly important in buildings with extended travel distance where the exhaust position would ideally be at least 5m away from the stairwell vent to prevent smoke being drawn into the building.

There is no risk of de-pressurisation with natural smoke shafts.

Environmental ventilation

Approaches to smoke shafts

Heat build up in corridors, particularly in residential buildings with energy centres providing heating, can be problematic and it is possible to use the smoke control system to dissipate some of this heat.

There are various approaches in use, from running the smoke fans at low speed and opening the smoke lobby dampers proportionately, to adding smaller environmental fans and dedicated dampers above the ceiling. Such approaches are obviously limited by the outside air temperature and are not guaranteed to reduce corridor temperature in all conditions. If this is likely to be a significant issue then a thermal model of the building should be undertaken and appropriate cooling measures implemented which would be outside the scope of this document.

A typical pragmatic approach to ventilation using the smoke control equipment would be to add a temperature control function to the control strategy such that ventilators are opened on excess temperature in a predetermined sequence to evacuate heat. For mechanical ventilation, the smoke fans would be inverter controlled and run at low speed to deliver a notional air change rate within the lobby, typically 4 air changes. Automatic rain sensing control would also be required to prevent the stairwell ventilator open in poor conditions.

All day to day ventilation functions must be overridden in an emergency condition.

System Components

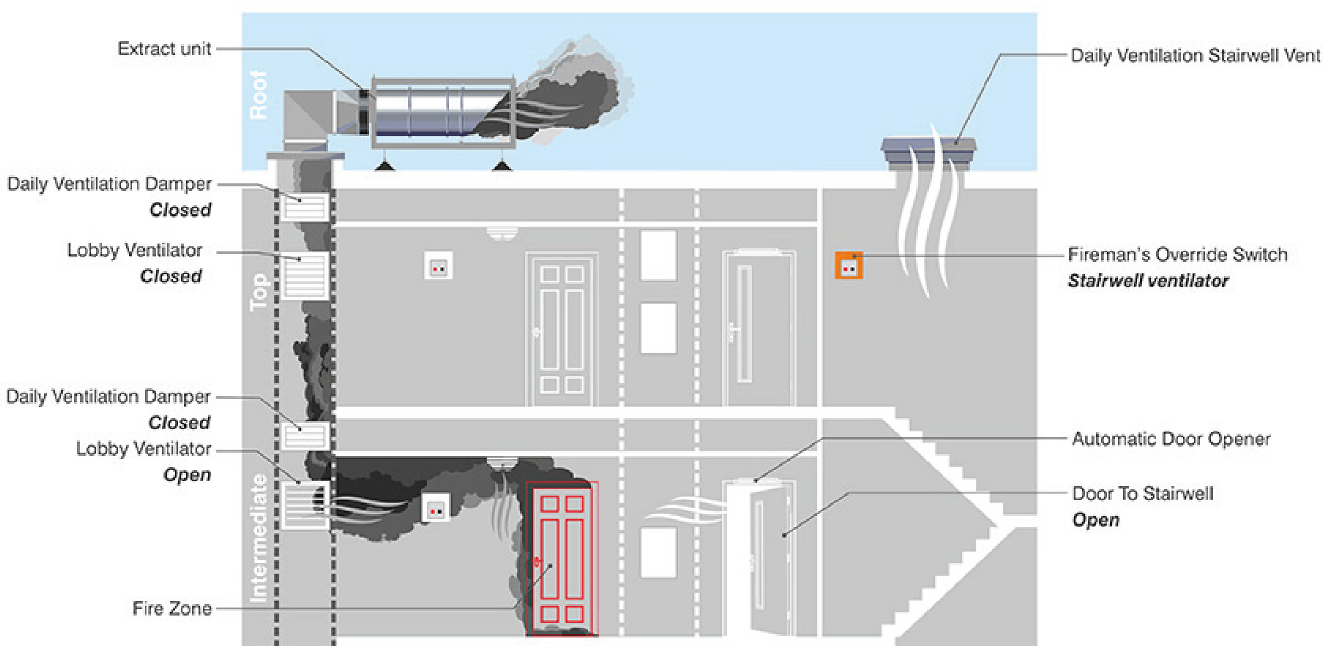
Builder's work shaft:

The extract shaft or duct shall meet the requirements for fire resistance for a period at least equal to the highest period of fire resistance through which the ductwork passes, when tested and classified in accordance with prEN 13501-3. In practice, this will usually mean a minimum of 1 hour fire resistance.

The internal surface should be smooth and the maximum air leakage should be 3.85m^3/hour at 50Pa pressure difference, as specified in the pressurisation standard EN12101 Part 6. A pressure test should be undertaken to prove the leakage prior to installation of the system.

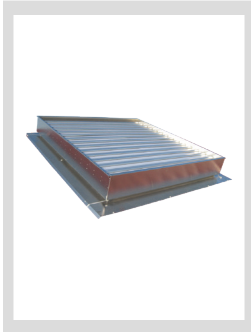
For mechanical shafts, the minimum free area is typically 0.6m^2 with an aspect ratio of 2:1 with the shaft rising vertically with minimal changes in direction or shape throughout its travel. The recommended size for ease of connection to roof extract equipment is 800mm x 800mm.

For natural shafts ADB specifies a minimum internal free area of 1.5m^2, with a minimum dimension in any direction of 0.85m. The recommended internal shaft dimensions for ease of roof vent sizing are 1.2m x 1.3m. Where there is a risk of falling into the shaft then floor grids may be required at intermediate levels and these should maintain a minimum free area of 1.0m^2. Shafts should extend a minimum of 2.5m above the ceiling of the highest floor, be at least 0.5m above and 2.0m distance from any roof structures. In non-residential buildings requiring fire fighting protection (those with a storey above 18m) the shaft free area required is 3.0m^2 (recommended dimensions 1.5m x 2.0m) and the construction should be 2hr fire resistant.



System Components

Stairwell ventilator



The ventilator above the stairwell will primarily be used as an air inlet for the smoke shaft and should have a minimum free area of 1.0m^2 when measured in accordance with diagram D7 of ADB. The ventilator should comply with EN12101-02.

Smoke exhaust plant

For mechanical shafts, extract fans should comply with EN12101-03 and a standby fan is required in case of fan failure. The selection of the appropriate temperature rating should be dictated by the results of any design calculations or CFD modelling however, based on previous project data, a rating of 300 deg C for 1 hour will be suitable for most residential situations.

Ventilators at the head of natural shafts should be to the same standard as stairwell ventilators, complying with EN12101-02. For residential buildings a free area of 1.0m^2 is required, while for fire fighting shafts the free area should be 2.0m^2.

Lobby ventilators

The Smoke Control Association guidance on Smoke Control to Common Escape Routes in Apartment Buildings states that smoke control dampers should be selected to reflect requirements of the smoke control system and accommodate the maximum performance requirements of the system, and where mounted in walls to allow access to shafts which will breach vertical compartmentalisation they shall be multi compartment smoke control dampers.

A damper that is used as a multi compartment smoke control damper should be CE marked to BS EN 12010-8.

Control system

The control system should comply with ISO 21927-9 where applicable, and sensitive equipment such as inverters and PLCs should be located out of the fire zone.

The control system may be designed specifically for the building, or be a modular standardised product that can be configured to the building. Most residential applications will suit the modular approach, with local zone control panels located throughout the building communicating with a central processor usually located at the fan position, and a HMI panel at a convenient location that is used for commissioning and testing.

Triggering of the system may be from dedicated smoke detectors purely for the operation of the smoke control system, or through interface with a building smoke detection system compliant with BS5839 part 1, L5 classification.

Manual control switches for fire fighter use should be located adjacent to the fire service access point and be clearly labelled that they are to be used to control the smoke ventilation system.

Power supplies and wiring

The system should have a secondary power supply in case of mains failure in accordance with EN12101-10. This may be from either an independent electricity utility supply or a generator back up supply. Electrical wiring should be of a suitable temperature rating for the application. All cabling for smoke ventilation system should be selected as per the SCA Guidance on the Specification of Products and Systems for Smoke Shafts published in December 2020.

Installation & Commissioning

Installation should be undertaken by a specialist contractor who understands the working relationship of each installed element of the shaft system.

Prior to handover, the commissioning process needs to be able to prove the effectiveness of the system in a variety of test operation scenarios, in accordance with the agreed 'cause and effect'.

Guidance exists to govern the quality of installation and the extent and scope of commissioning:

BS 7346-8:2013 Part 8 - Installation	**BS 7346-8:2013 Part 8** - Commissioning
"The nature and quality of the installation work needs to be such as to ensure the integrity of the smoke control system and minimise the duration and extent of any disablement of the system during maintenance or modifications. Penetration of construction (e.g. for the passage of cables, conduit, trunking or tray) ought to be made good to prevent the free passage of fire or smoke, regardless of whether the construction has a recognised degree of fire resistance."	"The process of commissioning involves thorough testing of the installed smoke control equipment, including interactions with other systems. The responsibility of the commissioning engineer is to verify that the system operates in the manner designed and that the installation workmanship is of an adequate standard. It is therefore necessary for the commissioning engineer to be provided with the agreed specification for the system."

Service & Maintenance

The Regulatory Reform (Fire Safety) Order 2005 (RRO) dictates that a building's "responsible person" (generally a building owner, manager or FM) has to ensure proper operational service and maintenance of smoke control systems.

Smoke shafts are life-critical aspects of a building's operation so their proper maintenance is vital. Many components come under the scheduled service recommendations of BS 9999, and the latest standard on smoke control (BS 7346-8:2013 Part 8) states that:

"Smoke control equipment should only be maintained by a competent person with specialist knowledge of smoke control systems, adequate access to spares and sufficient information regarding the system."

It is important to bear in mind the fact the smoke control systems are more than just a parts list. While one aspect may be apparently operational, it must also be suitably operational in relation to the rest of the system.

Software maintenance, too, is important, and the latest updates should always be installed to ensure maximum performance.

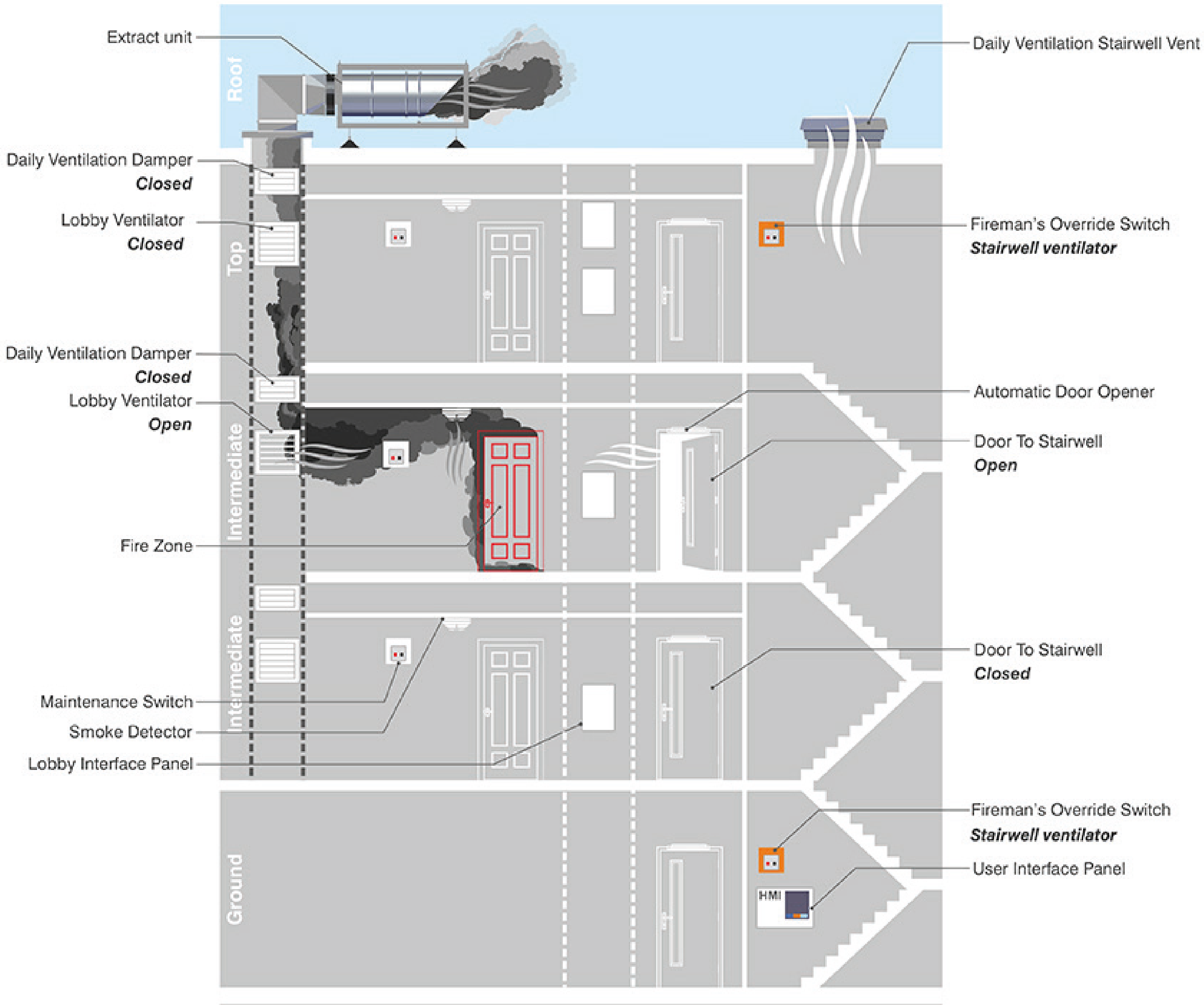
Examples

Mechanical shaft

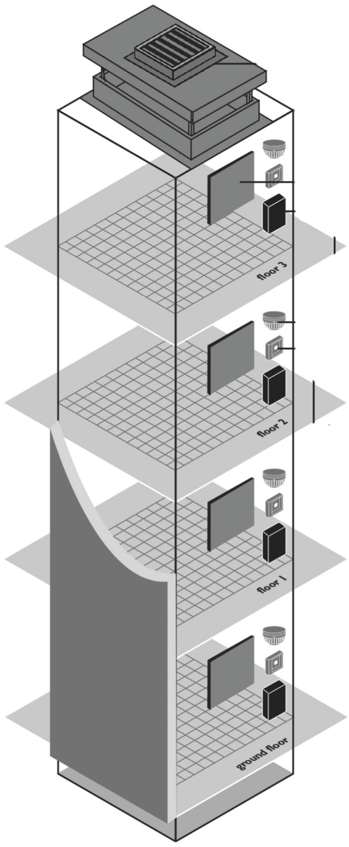
Mechanical shaft systems are particularly suitable for buildings where space constraints prevent the use of simpler solutions.

A provisional design can be achieved in minutes by selecting modular components:

- Builder's work shaft - Lobby vent
- Roof extract unit
- Control system



Natural shaft

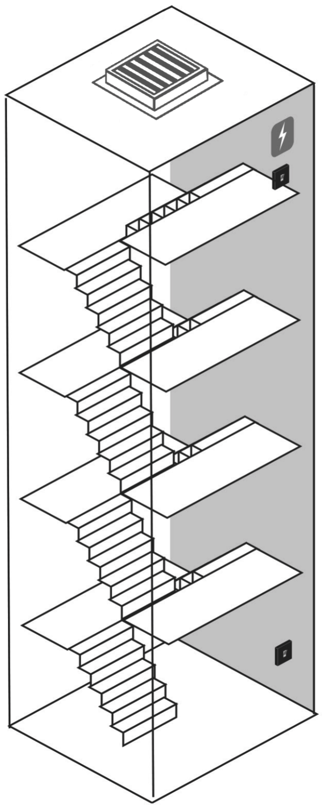


Natural shaft systems rely on the buoyancy of hot smoke and the inlet of fresh air to extract smoke in the case of a fire. With mechanical intervention, the shaft will generally require a larger footprint than the equivalent mechanical system.

A simple system will typically comprise:

- Builder's work shaft
- Lobby vent
- Roof vent
- Control system

Stairwell shaft



The ventilator at the head of the stairwell should be EN 12101-2 compliant. It should be manufactured from corrosion-resistant aluminium and be fully insulated, with a geometric free area of 1.0m2.

The control kit should comprise a local control panel with a battery-backed 24v DC supply and two remote control switches for positioning at the top and bottom of the staircase.

The control panel accepts a signal from lobby ventilators to automatically open with lobby ventilation.

References

- Smoke Shafts Protecting Fire Fighting Shafts, Their Performance and Design (BRE, 2002)
- Approved Document B – Volume 1 of the Building Regulations 2019
- PD 7974-6:2019. Application of fire safety engineering principles to the design of buildings. Human factors. Life safety strategies. Occupant evacuation, behaviour and condition (Sub-system 6)
- SCA Guidance on Smoke Control to Common Escape Routes in Apartment Buildings (Flats and Maisonettes) Revision 3: January 2020
- BS EN 12101-2:2017. Smoke and heat control systems. Specification for natural smoke and heat exhaust ventilators
- BS EN 12101-3:2015. Smoke and heat control systems. Specification for powered smoke and heat control ventilators (fans)
- BS EN 12101-10:2005. Smoke and heat control systems. Power supplies
- BS EN 13501-3:2005+A1:2009. Fire classification of construction products and building elements. Classification using data from fire resistance tests on products and elements used in building service installations: fire resisting ducts and fire dampers
- BS 5839-1:2017. Fire detection and fire alarm systems for buildings. Code of practice for design, installation, commissioning and maintenance of systems in non-domestic premises
- BS 7346-8:2013. Components for smoke control systems. Code of practice for planning, design, installation, commissioning and maintenance
- BS 9999:2017. Fire safety in the design, management and use of buildings. Code of practice.
- BS ISO 21927-9:2012. Smoke and heat control systems. Specification for control equipment
- The Regulatory Reform (Fire Safety) Order 2005 (RRO)

GROUPSCS.CO.UK
0300 303 4104
INFO@GROUPSCS.CO.UK

CARDIFF
Group SCS
Unit T2
Capital Business Park
Parkway
Cardiff CF3 2PZ

LONDON
Group SCS
3rd Floor
26 Finsbury Square
London EC2A 1DS

BOURNEMOUTH
Group SCS Manufacturing
Unit 70 Condor Close
Woolsbridge Industrial Park
Three Legged Cross
Wimborne BH21 6SU

PORTSMOUTH
Group SCS
58a Station Road
Hayling Island
Hampshire
PO11 0EL

SCS-BRO-02-V1_01-2021