Smoke Control Association

Guidance on Smoke Control to Common Escape Routes in Apartment Buildings (Flats and Maisonettes)

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Acknowledgements

Contributions to this revision are gratefully acknowledged from members of the Smoke Control Association. A list of members of the SCA can be viewed at:

https://www.smokecontrol.org.uk/members

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1 Foreword

From the National Fire Chiefs Council (NFCC); Mark Hardingham

The National Fire Chiefs Council (NFCC) support innovation in design of the built environment where it is striving to provide a safe environment for both residents and firefighters alike. Life safety for residents is obviously of vital importance, however in the past we have seen evidence of building design which considers occupant safety, but which fails to recognise the challenging conditions which firefighters might encounter in some buildings if those buildings are not designed with firefighting as a consideration from the outset.

We welcome industry bodies such as the Smoke Control Association for incorporating firefighting considerations within industry best practice guidance. We are hopeful that this will rightly put safe firefighting at the forefront of the design intent and will encourage early discussions with local Fire and Rescue Services.

NFCC are supportive of the factors which aid firefighting within this guide, and in particular:

- **Limiting the scope of this guidance to only include common corridor lengths of up to 30m**. Whilst 30m might seem like an arbitrary figure to some, firefighting from long corridors can present exceptionally onerous conditions for firefighters. Essentially, the corridor itself can become the fire compartment once the flat front door is either breached by the fire, opened by escaping residents or by firefighters. Critical factors include the amount of firefighting hose required to be laid out in a confined space; charging that hose with water prior to entering the corridor; the distance needed to rescue casualties from the fire; or in the worst cases of fire spread, for firefighters to retreat and self-rescue. Limiting the corridor length also limits the number of apartments which open on to the corridor and which may then require actions by firefighters during their firefighting and rescue operations. In our experience, corridor lengths over 30m may simply be too long for safe firefighting operations and we therefore advocate for this limit to be in place.

- **Extracting away from the stair.** The principle of only extracting heat and smoke away from the stair is critical for safe firefighting operations as this allows a relatively clean air path for firefighters to approach the flat affected by fire. This allows firefighters to conserve the limited air in their firefighting breathing apparatus and to reduce the potential for heat stress. This also supports better conditions for rescuing casualties or evacuating other flats if required.

- **Consideration of firefighting tenability**. The personal protective equipment which protects firefighters has limitations, and excess heat or radiation can put firefighters in significant danger of serious injury. NFCC believes that using appropriate referenced firefighter tenability, such as provided within this guide, allows for the right analysis to be undertaken. NFCC support the inclusion of firefighter tenability in this guidance and strongly advocate that it is considered in building design.

- **The simplification and consistency of firefighter system controls.** Designing systems to operate automatically, and ensuring the controls firefighters might need to use are consistent, greatly assists firefighting operations. NFCC have seen evidence of a wide variety of controls and some that are poorly labelled making it difficult for firefighters to use them safely and effectively during firefighting operations. The systems should be intuitive and allow firefighters to instantly recognise the controls including what and how they operate.

Whilst this guide primarily considers smoke control in residential corridors, we continue to support automatic suppression systems such as sprinklers in residential buildings. We encourage design teams and approval bodies to consider sprinklers alongside smoke control as these systems, used together, do provide a robust package of active measures to support the safety of occupants and firefighters.

From the chairman of the Smoke Control Association, David Mowatt

When this SCA guide was first produced in 2010, it quickly became the default reference document for many designers, installers and authorities having jurisdiction throughout the UK and even beyond.

Due to its popularity and the ever increasing complexity of building design and further design developments by our industry since 2012, it was decided that the document needed to be updated to ensure it remained current.

I am therefore very pleased to be able to introduce this updated guide from the Smoke Control Association.

The prevention of smoke spread through buildings is of critical importance, but little guidance is currently available in one publication. This document provides details and gives recommendations not previously covered in other standards or codes of practice and should make a significant contribution to improved understanding of smoke control systems.

Contained within the document are sections on the different types of system and their function, information on all the relevant legislation, standards and codes of practice. The SCA particularly recognises the importance of using certified products for smoke control applications, and is particularly pleased to see these topics addressed here.

Included in this revision are many new recommendations, updated product standards, a new section on Fire and Rescue Service Intervention and a limitation on the extension of travel distances to which all member organisations have agreed.

I would like to thank the working group for their hard work and dedication in producing this guide, and appreciate the contribution made by the many practitioners, Building Control Officers, Fire Engineers and Fire Officers who gave their valuable time.

The Smoke Control Association in conjunction with other experts from the fire industry promotes high standards of fire protection. The SCA is sure that this Guide will continue to be an essential reference work within the industry and shows a commitment from our members of using best practice in all that they do.

David Mowatt
Chairman of the Smoke Control Association

2 Introduction

This document covers information and requirements on the design, calculation methods, installation and testing of systems intended for smoke control within the common escape routes within apartment buildings.

The provision of such systems is recommended in order to achieve minimum standards in conditions for escape and firefighting. Alternative engineering judgement is acceptable.

2.1 Primary Objectives

The primary objective of the smoke ventilation system is to protect the staircase and protect the common circulation areas. The performance criteria and the design of the system vary depending on the layout of the common corridor or lobby.

Where the travel distances are no more than 7.5m in distance from the door to the staircase (or sterile lobby) to the most remote apartment entrance door, the primary objective of smoke control in residential buildings is to protect the staircase enclosure by ensuring that the stairway(s) remain free from smoke and heat in the event of a fire within a dwelling.

However, where corridors are extended, the primary objective of the smoke control system is to protect both the common corridor and the staircase enclosure. There are considered to be two forms of extended corridors:

I. Extended corridors – These typically have no more than 15m travel distance from the furthest apartment door to the staircase or sterile lobby. The primary objectives of the smoke control system are to protect the common corridor for means of escape and the staircase enclosure for means of escape and fire-fighting.

II. Significantly extended corridors – These typically have more than 15m travel distance from the furthest apartment door to the staircase door or sterile lobby. The primary objective of the smoke control system is to protect both the common corridor and the staircase enclosure for means of escape and Fire and Rescue Service operations. The increased length of the corridors can adversely affect fire-fighting operations and require additional consideration of design factors such as tenability limits, time lines and fire sizes.

    Note: regardless of the corridor design, it is recommended that the maximum travel distance should be limited to 30m from the furthest apartment door to the staircase door. Corridor lengths of greater than 30m are outside the scope of this guidance. See section 5.4.

This guidance document also covers the provision of systems where no communal lobbies or corridors are provided, such as small single stair buildings as detailed in Approved Document B or BS 9991. Here the primary objective is solely to protect the staircase enclosure, with an emphasis on Fire and Rescue Service access rather than means of escape.

2.2 Smoke Control Methods

The effect of the air movement forces, including buoyancy experienced by hot gases on the fire storey, thermal expansion of hot gases in the fire zone and even stack effect, can cause smoke to spread through leakage paths in vertical barriers between rooms, e.g. doors, walls, partitions, from the apartment of fire origin and into the corridor.

The ventilation methods most commonly used to limit the degree of smoke spread, or to control its effects, in the common areas of residential apartment buildings are:

a) Natural smoke control systems.
b) Mechanical smoke ventilation systems.
c) Pressure differential systems.

The design implications for each of the three system types are considered within this design guide.

2.3 Responsibilities

Through this document, the Smoke Control Association provides guidance on the design of smoke control systems in apartment buildings. While there is limited guidance in both Approved Document B and BS 9991 for either designers or authorities having jurisdiction, this document sets out the information and parameters that the designer should incorporate into the design when using calculations and/or CFD models.

Smoke control systems form one element of the overall fire engineering strategy for apartment buildings and should not be designed in isolation. It is the responsibility of the designer of the smoke control systems to ensure that any proposed systems complement the building specific fire safety strategy and provide a suitable level of fire safety, just as it is also the responsibility of the architect and fire engineer to ensure that building layout provided to the smoke control system designer is adequate for the purpose. Early consultation by the design team with a smoke control system designer is therefore recommended.

For the design and approval process to be successful it is strongly recommended that, except perhaps in the simplest cases, the system objectives, the scenarios to be calculated or modelled, the modelling criteria, the expected reporting and the success criteria are all agreed and documented prior to commencement of design.

Guidance in this document is based around compliance with Building Regulations. Designers should note that they should also consider the requirements of the Construction (Design and Management) Regulations, the Workplace (Health, Safety and Welfare) Regulations, the Regulatory Reform (Fire Safety) Order and any other relevant legislation. Consultation with the regulatory authorities may assist in achieving an appropriate design.

While this document predominantly references the principles of Approved Document B and BS 9991 and BS 7346-8, the majority of the principles are relevant where other design guidance is utilised (such as the Technical Standards in Scotland) although reference should be made to the authority having jurisdiction.

In designing a smoke control system where CFD is used for design and/or validation, reference to the SCA guide “SCA Guidance on CFD Analysis for Smoke Control Design in Buildings” is recommended.

3 Scope

The principles detailed within this document are specifically designed for apartment buildings containing flats or maisonettes. No specific limitations are set within this document on the age, disability, or familiarity of the occupants to each other or to the building provided that they are able to evacuate the building without considerable assistance. On this basis this document can be used for the design of smoke ventilation systems for the following examples of apartment buildings:

a) Owner occupied housing
b) Social housing, including assisted living and extra care accommodation.
c) Apartments provided for short term rental, including student apartments and apart-hotels, if designed and constructed to the same principles as apartment buildings.

This document is not considered suitable for use for prisons, hospitals, nursing homes or other building types where the occupants are not considered able to evacuate without substantial assistance. Notwithstanding this, system designers and authorities having jurisdiction may wish to consider the principles detailed in this document where insufficient other design guidance exists.

This design guide is intended for buildings operating a ‘stay put’ evacuation policy, it is not appropriate for buildings operating staged, phased or simultaneous evacuation.

Where such evacuation policies are considered, the system designer and authority having jurisdiction (AHJ) should carefully consider the impact of the evacuation on the design objectives, and any supporting justification put forward (including how any computer modelling used will account for the proposed evacuation regime and the potential need to maintain tenable conditions within the corridors throughout the whole of the means of escape phase).

This document specifies smoke control systems designed to control the spread of smoke from the apartment of fire origin into the common escape routes. It covers methods for calculating the parameters of the smoke control systems as part of the design procedure.

It gives test procedures for the systems used, as well as describing relevant and critical features of the installation and commissioning procedures needed to implement the calculated design in a building. It covers systems intended to protect means of escape from common escape routes such as stairwells, corridors and lobbies, as well as systems intended to protect Fire and Rescue Service access routes.

The systems incorporate smoke control components in accordance with the relevant British and European Standards. This document gives requirements and methods for the evaluation of conformity for smoke control systems as well as testing regimes.

Tall and very tall buildings (typically, in excess of 50m) should be considered using a qualitative design review process as described in section 0.7 of BS 9991. Of particular importance for consideration are the effects of stack and other environmental conditions which could compromise the performance of smoke control systems.

4 Terms and Definitions

4.1. Authority having jurisdiction (AHJ)

Organisation, office or individual responsible for enforcing the requirements of legislation or standards, or for approving equipment, materials, an installation, or a procedure.

4.2. Common escape route

Designated route from the front door of an apartment to a place of safety or relative safety

4.3. Compartment

Enclosed space, comprising one or more separate spaces, bounded by elements of construction having a specified fire resistance and intended to prevent the spread of fire (in either direction) for a given period of time

4.4. Computational Fluid Dynamics (CFD)

The use of computers to solve mathematical equations that simulate the flow of fluids, heat transfer and other associated phenomena. (Note: For the purposes of this paper, CFD modelling can be used to predict fire, smoke movement, heat, radiation, ventilation flow etc based on the input parameters provided)

4.5. Depressurisation

Smoke control using pressure differentials where the air pressure in the fire zone or adjacent spaces is reduced below that in the protected zone

4.6. Design fire

Largest fire with which the fire precautions in a building are expected to be effective

4.7. Fire engineering strategy

A strategy developed using application of scientific and engineering principles to the protection of people, property and/or the environment from fire

4.8. Fire resisting (resistance)

The ability of a component or construction of a building to satisfy for a stated period of time, some or all of the appropriate criteria specified in the relevant standard test.

4.9. Fire Separation

A compartment wall, compartment floor, cavity barrier or construction enclosing a protected escape route and/or a place of special fire hazard.

4.10. Manual control point

The term “manual control point” encompasses generic phrases such as fire fighter’s switch, call point, break glass etc. (refer to 8.2.5.2)

4.11. Mechanical (or powered) ventilation
Ventilation caused by the application of external energy to displace gases through a ventilator Note: fans are usually used

4.12. Natural ventilation
Ventilation caused by buoyancy forces resulting from differences in density between smoky and ambient air gases due to temperature difference

4.13. Pressurisation
Smoke control using pressure differentials, where the air pressure in the spaces being protected is raised above that in the fire zone

4.14. Primary power supply
Power supply that is used whenever it is available (Note: usually the normal mains supply to the building)

4.15. Secondary power supply
Power supply that automatically replaces the primary power supply in the event of its failure (Note: usually provided by batteries, generators or a separate mains supply)

4.16. smoke control
Measures to control the spread or movement of smoke and fire gases during a fire within a building

4.17. Steady state design
Design based on the largest fire with which a smoke control system is expected to cope
Note: there is no expectation that this fire size will be maintained for any significant period in practice)

4.18. Stay put strategy (*as per BS 9991*)
Strategy normally adopted in blocks of flats and maisonettes whereby, when a fire occurs in a flat or maisonette, the occupants of that dwelling evacuate, but occupants of all other dwellings can safely remain in their dwellings unless directed to leave by the Fire and Rescue Service, or if they are affected by heat or smoke, or feel unsafe to remain in their dwelling.

4.19. Tenable
Measure of the level of exposure to hazards from a fire that can be tolerated without violating safety goals

4.20. Time dependent design
Design based on a fire for which the heat release rate and/or other parameters change with time

4.21. Time line
A sequence of events and times representing actions that is sufficiently severe for it to serve as the basis of the design of a smoke control system

4.22. Zone model

A computer program using simplified calculations treating the space or spaces modelled as a series of homogenous zones and taking average characteristics for those zones

4.23. Smoke Shaft

An enclosed fire compartment vertically rising space in a building provided for venting smoke from a fire-fighting stair of one or more firefighting lobbies.

4.24. Aerodynamic free area

Geometric area multiplied by a coefficient of discharge. *[SOURCE BS EN 12101-2]*

4.25. Automatic activation

Initiation of operation without direct human intervention.

4.26. Geometric area

Area of opening through a ventilator measured in the plane defined by the surface of the construction works. No reduction is made for any obstructions such as grilles, control mechanisms and louvre blades. *[SOURCE BS EN 12101-2]*

NOTE: These definitions are taken from or based on definitions in relevant British or European Standards or other HEVAC guides wherever possible.

5 Objectives and Performance Criteria

5.1 General

All residential ventilation systems are intended to help protect means of escape (MOE) and assist fire-fighting operations (FF) in case of fire. It is the responsibility of the assessing engineer to determine which method of investigation should be used, with the limitations of the chosen method being understood/ declared.

Generally, for most smoke control systems applied in apartment buildings, the common spaces requiring smoke ventilation are the stairs and the lobbies and/or corridors opening onto the stairs. The level of protection will vary with the design of the stair core and corridors and the type of ventilation system provided.

Where the building design and the smoke ventilation system are in direct conformity to ADB to the Building Regulations or equivalent (outside England and Wales) and BS 9991, there is no requirement to consider objectives or performance criteria as the ventilation system is deemed to be suitable by virtue of its prescription to the relevant document. This section then does not apply.

In other cases it is necessary to consider the objectives and performance criteria for the system. Depending on the design of the common escape routes, this can either take the form of an assessment to ensure that the proposed design provides ‘equivalence’ to the prescriptive systems or a detailed engineering analysis.

Where travel distances are compliant with the relevant code of practice, a smoke control system can be designed to show equivalence to the solution following guidance, based on the same building layout and geometry.

Where travel distances are extended and/or corridor sub-divisions are removed in buildings with a ‘stay-put’ policy, proving ‘equivalency’ to code compliance is not appropriate. A detailed engineering analysis is required on a deterministic basis.

As with any alternative solution there are a number of methods which allow the investigation and demonstration of its performance. These range from hand calculations through to more sophisticated computer models such as zone models and CFD. Each method offers different benefits with associated limitations, ranging from fast calculations with limited spatial and temporal resolution to extensive spatial and temporal resolution with extended calculation time.

It is the responsibility of the assessing engineer to determine which method of investigation should be used. It is recommended, however, that the technique to be used be agreed with the relevant authorities having jurisdiction prior to an assessment being performed.

It is further recommended that, where an authority having jurisdiction (AHJ) is unfamiliar with the technique used or does not have the necessary technical knowledge to assess the technique, a peer review should be considered.

There is often confusion regarding fire fighting stairs in residential buildings. While specific reference should be made to the relevant design guide to which the building is constructed, in the case of buildings designed using BS 9991 or ADB, fire fighting stairs are recommended when the top storey (finished floor level) is more than 18m above Fire and Rescue Service access level. However, as long as the building layout conforms to ADB and the normal corridor/lobby ventilation is provided, there is no requirement for a dedicated fire fighting lobby as the ventilated corridor/lobby acts as the firefighting lobby in those cases. See clause 15.8 of ADB: 2019.

5.1.1 The basics of a smoke control system

The design of any residential smoke control system should follow the basic principles below:

- The system should activate automatically and not rely upon the interaction of firefighters to achieve initiation
- Where appropriate, there should be intuitive controls for firefighters to turn parts of the system off/on if conditions change during a fire incident;
- Dampers into shafts should at least have the same fire rating as the compartmentation they are passing through;
- Where required, inlet air for smoke extract can be sourced from a variety of sources, however if being sourced via the stair the only acceptable method is through the stair door. It is inappropriate to have a vent or damper between the corridor and stair for this purpose;
- For extended corridors the system should extract away from the stair to assist means of escape and in the protection of firefighters. For corridor lengths described

by ADB or BS 9991 the concept of extracting away from the stair should be implemented where possible.

- As the system is for life safety, if powered, the system should have a primary and secondary power supply, and if utilising hot smoke extract fans there should be a duty and standby;
- Extended corridors should be limited to 30m, otherwise they are outside the scope of this guidance;
- A system using shafts should open on the initial fire floor only and all other floors shall remain closed;
- Full height doors present particular challenges for smoke control systems and are best avoided. If full height doors are proposed as part of the system, the use of these will need to be assessed and justified by the project specific CFD analysis.

5.2 Objectives

5.2.1 Commentary

Fire statistics show that the majority of fire deaths in residential buildings are caused by smoke inhalation and not through direct exposure to the fire. In high rise buildings, the flow of heat and smoke from a fire creates even greater risks for the occupants and fire-fighters alike.

Most design guides identify the primary means of controlling the flow of smoke in residential buildings as the fire rated separation (i.e. the provision of protected escape routes and protected stairwells), with smoke control designed to supplement these provisions.

As stairs will be used by the majority of the occupants of the building, potentially for a longer duration than the common escape routes on the floor of fire origin, as well as being an access and egress route for the Fire and Rescue Service, it is considered of primary importance to protect the stair(s) irrespective of the design of the smoke ventilation system.

The ability of the system to prevent smoke from entering the staircase is affected by the proximity of the apartment door to the staircase. Although there is no control on this proximity in many design guides, including ADB and BS 9991, where possible, apartment doors should not be located in close proximity to doors to the staircase. Some smoke leakage into the staircase due to thermal expansion of hot gases in the fire zone (apartment of fire origin) may occur irrespective of the door location. This is because fire induced expansion of gases can result in a build-up of pressure, leading to a rapid flow of hot gases out of the compartment when the apartment door is opened, especially if the staircase door is already open. However, in most cases, the initial expansion forces dissipate quickly and the leakage of smoke into the stair due to this action is limited and may be acceptable to the designer and the authorities having jurisdiction where it does not adversely affect the tenability conditions within the stair.

Work by the BRE and others, as confirmed in ADB, has made it clear that it is not possible to keep common corridors and lobbies completely free of smoke (except possibly by pressurisation systems with protection extended past the entrance door to each dwelling). Any system should, however, be designed to promote tenable conditions for travel through the ventilated corridors/lobbies during the escape period. It should be noted that this may only be possible during periods when the apartment door is closed and the flow of smoke from the apartment into the corridor is substantially reduced by the passive fire protection provided by the door.

The designer should discuss any full height or larger flat entrance doors with the AHJ and the way in which these are modelled and tested should be agreed.

When undertaking CFD analysis, and whilst the principle objective is to protect the stair from the ingress of smoke (or maintain smoke free) it may be considered acceptable by the designer, for a very small amount of smoke to be shown to enter the stair enclosure temporarily if it is demonstrated that the smoke is subsequently quickly removed by the smoke ventilation system. However, this is considered to fall within the bounds of uncertainty when undertaking CFD simulation and it is not considered appropriate to apply tenability-based acceptance criteria to the stair enclosure, for example a visibility distance in smoke of 5, 10 or 30m. CFD analysis should demonstrate that the proposed smoke ventilation system protects the stair enclosure from smoke ingress during both the means of escape phase and when the stair door is held open during firefighting operations. This should be agreed with the AHJ before application.

5.2.2 Recommendations

The guidance provided describes single corridors with single direction travel but the recommendations also generally apply to building designs with multiple corridors or corridors with multiple direction of travel.

The design objective of any system should be to maintain smoke free conditions within the staircase such that it can be used for evacuation and Fire and Rescue Service access/egress at all times. Where the travel distance from the furthest apartment to the door to the staircase or the door to a sterile lobby does not exceed 7.5m, this is considered to be the only design objective. Therefore, where a mechanical ventilation system is provided to the common escape routes, it is not considered necessary to assess conditions within the corridor or the sterile lobby against specific performance objectives. The system provided should have at least equivalent performance to a compliant natural ventilation system and conditions should not be made worse. Where a compliant natural ventilation or pressurisation system is provided then generally no further consideration is required.

Where the building design follows BS9991 or, where the AHJ is willing to accept the proposal, and travel distances from the furthest apartment entrance door to the staircase door does not exceed 15m, and the building is provided with a sprinkler system meeting the enhanced design guidance in either BS9251 relating to its use as a compensatory measure, then irrespective of building height it is considered appropriate for the smoke ventilation system to meet the same performance criteria as a system provided for a building where the travel distance from the apartment of fire origin to the door to the staircase does not exceed 7.5m.

Note: Table 2 of BS 9991 states that sprinkler systems used to permit extended travel distances should be in accordance with BS 9251:2014 or BS EN 12845. Watermist systems are not applicable.

Where sprinklers are not provided and where the travel distances from the apartment to staircase or sterile lobby are over 7.5m but do not exceed 15m, the performance objectives of the system are to maintain the staircase relatively free of smoke and to ensure the designer's specified tenable limits for means of escape are met within the corridor. Additional performance objectives for protection of fire fighters are required where the building is of significant height and, therefore, under the relevant design guide (e.g. ADB) additional provisions for fire-fighting access, such as fire-fighting shafts, may be required.

Note: generally natural ventilation is not appropriate for corridors of this length, so the system provided should be mechanical.

Where the travel distances from the apartment to staircase or sterile lobby exceed 15m, the performance objectives of the system are to maintain the staircase free of smoke and to ensure the designer's specified tenable limits for means of escape and Fire Service operations are provided within the corridor. This may necessitate discussions with the Fire and Rescue Service and authority having jurisdiction (AHJ), prior to design or installation of the smoke control system, to ensure the system performance allows the operational requirements for fire fighters to be met, irrespective of building height.

Any ventilation design will form part of an overall fire safety strategy and should not be designed in isolation. The designer of a smoke ventilation system should demonstrate how the system meets the design principles of the fire safety strategy.

5.3 Performance Criteria

5.3.1 Introduction

Before setting any performance criteria it is necessary to set the design conditions under which these criteria should be met.

In its study of smoke ventilation where travel distances are in accordance with guidance, BRE focused its research on 'steady-state' conditions, examining a number of design fires and fixed door openings. This approach allows a straightforward comparison of different geometries and ventilation methods. It does not, however, capture the transient nature of an actual fire scenario, where the fire develops with time and doors open and close at various stages during the event. Nevertheless, an analysis of steady-state conditions can provide a convenient way to assess a smoke ventilation system, in particular with regard to the protection afforded to the stair enclosure and to after the arrival of the Fire and Rescue Service, where fixed door opening conditions may be relevant.

The alternative approach, employing a timeline of events and actions, is a more dynamic assessment and deals with a changing set of conditions but generally requires additional analysis and consideration of time dependent performance criteria, e.g. the time to return a corridor to conditions suitable for means of escape.

Performance criteria are generally based on tenability. The main criteria of interest could include visibility, gas temperature, thermal radiation and toxicity within the common corridors, lobbies and stair enclosures. Selection of appropriate performance (acceptance) criteria for assessing a fire engineered system design should be established at the start of the design process, typically at the qualitative design review.

Pressure differences between the corridor/lobby and adjacent stairs and accommodation should not cause door opening forces to exceed 100N. It is important also to consider the potential impact of the pressure difference between the dwelling and the corridor to ensure that smoke is not unduly pulled into the corridor when the dwelling door is in a closed position. The maximum acceptable level of depressurisation in the corridor relative to the apartment will depend on factors such as the doorset construction, including the performance of the smoke seals and size of gap under the door estimated by calculation or measured during commissioning.

Air flows from the stair enclosure into the corridor, in the situation where the door is open, might be adopted as a performance criterion, with a minimum design air speed set to prevent the flow of smoke into the stair.

It is recommended that performance criteria and accompanying fire scenarios be agreed with the authority having jurisdiction (AHJ) as part of the approval process, preferably in advance of detailed calculations or modelling. This will be relevant particularly where the performance is being assessed against specific tenability criteria rather than against an applicable guidance solution.

Typical performance criteria and accompanying fire scenarios are discussed below for both applicable guidance and extended travel distances, and encompass both steady-state and time-dependent design analyses. While these are offered as a suitable 'point of reference' for use in apartment buildings, they are not exhaustive and should not restrict the use of alternative criteria and scenarios that are considered more suitable for a specific project. It is the responsibility of the designer to determine which fire scenarios and performance criteria should be used.

5.3.2 Tenability criteria for means of escape

Where system performance is being assessed deterministically (and not compared to an ADB compliant one) it will generally be necessary to set acceptance limits for one or more performance criteria based on tenability. It is not appropriate to give definitive values here as they need to be established on a case by case basis as part of the overall fire strategy. However, published information is available (see, for example, BS 7974[1] and associated PD 7974 series *Application of fire safety engineering principles to the design of buildings*, BS 7899-2 *Guidance on methods for the quantification of hazards to life and health and estimation of time to incapacitation and death in fires*, the SFPE *Handbook of Fire Protection Engineering* and the ASHRAE *Handbook of Smoke Control Engineering* and CIBSE Guide E *Fire Engineering)*. Some recommendations that might be considered are provided below. The appropriate choice for an individual system should take into account the specific design details such as travel distances, occupancy characteristics etc.

Visibility distance and toxicity levels are important performance criteria in respect to means of escape and should be assessed. Both are functions of the smoke concentration, with visibility being approximately inversely proportional to the density of soot particulate. Care and engineering judgement is required as the calculated values will be strongly dependent on the choice of soot and toxic yields (generally an input parameter in a zone or CFD model) and also the ventilation conditions. Visibility distance is a widely used performance criterion for smoke control design, and in addition to allowing an estimate of how far a person could see provides a measure of the toxicity associated with the smoke. It is generally accepted that if visibility is acceptable then the toxicity condition is likely also to be acceptable, at least for the exposure times during the escape. It should be noted, however, that visibility distance is a working engineering parameter rather than a precise measure of how people will respond in a real emergency.

A commonly adopted conservative visibility distance limit is 10m (approx. $0.1m^{-1}$ optical density) as measured to a light reflective surface, representing an approximate value through which persons unfamiliar with a building would be prepared to travel (see, for example, ref: *T. Jin,* "*Studies on Human Behaviour and Tenability in Fire Smoke,*" *Proceedings, 5th International Symposium on Fire Safety Science, pp. 3–22, 1997*).

Exposure gas temperature and thermal radiation flux (irradiance) limits of 60°C and $2.5kW/m^2$, along with the above 10m visibility represents typical acceptance limits in respect to tenability for means of escape. Where these limits are exceeded, the travel time to the stair door should be assessed for suitability.

An alternative, and potentially more rigorous, approach is to determine whether or not the stair door is visible from the apartment entrances. This involves calculating the spatially averaged visibility distance along the line of sight from the apartment to the stair door, which could be seen on the proviso that the average visibility distance exceeds the travel distance. This approach is explored further, for example, in the ASHRAE *Handbook of Smoke Control Engineering*.

It is often difficult to maintain a minimum visibility distance when the apartment door to the corridor remains open; this is because the corridor fills with smoke generated by the apartment fire. BRE Report 213179 found that it was difficult under most fire scenarios to keep the corridor clear of smoke when the apartment door remained open (even partially). This highlights the importance of the reliability and the maintenance of the door closing device.

While the protection to the stair is of primary importance, where there are extended travel distances the rate of smoke clearance from the corridor is also likely to be an important requirement of the smoke control system. A time dependent analysis will be required to determine how long it takes to return the corridor to a specified visibility or other tenability criteria once the apartment door has closed. A maximum time of two minutes should be achieved.

5.3.3 Tenability criteria for fire fighting

It is acknowledged that it is extremely challenging to design smoke ventilation systems to maintain tenable conditions for occupant means of escape in common corridor and lobby areas once the door to the flat of fire origin has been opened. However for Fire and Rescue Service intervention, consideration should be given to what additional protection these smoke ventilation systems can offer fire fighters during fire fighting operations. This is of particular importance when dealing with common escape routes that do not accord with prescriptive guidance contained in the relevant guidance (for example, ADB or BS9991).

The basic principles of extracting away from the stair, and limiting the common corridor length to 30m (measured from the staircase door to the furthest flat entrance door) should be met before applying the firefighting tenability criteria. If those principles are not met it is likely that more stringent tenability should be applied, however that is outside the scope of this guidance.

Although fire fighters will be wearing suitable Personal Protective Equipment (PPE) when conducting search, rescue, and fire fighting activities within a building, this equipment does have limitations. Fire fighters themselves also have different, individual physiological capabilities which can further limit their ability to perform tasks, depending upon the fire scenario and conditions in which they are working.

Therefore, for common escape routes where smoke ventilation systems are being proposed to justify extended single direction travel distances of more than 7.5m in length (or more than 15m where appropriate suppression is provided in accordance with BS9991 guidance), specific assessment of the conditions within these spaces should be completed by the system designer to demonstrate that effective Fire and Rescue Service intervention can actually be achieved. This should also be considered where extended travel distances are proposed in corridors with two or more directions of escape/ fire fighter access.

Publicly available and recent research relating to fire fighter tenability is somewhat limited at present, however it is suggested that the criteria in Table 5.1 (as adopted by the Australasian Fire Authorities Council (AFAC)) could be applied by system designers when assessing this issue:

Table 5.1 Illustrative fire fighter tenability conditions

Tabel 5.1 Illustrative fire fighter tenability conditions

Exposure Condition	Maximum exposure time (minutes)	Maximum air temperature (°C)**	Maximum radiated heat flux (kW/m^2)	Remarks	Recommended distance from apartment door*
Routine	25	100	1	General fire-fighting	15-30m
Hazardous	10	120	3	Short exposure with thermal radiation	4-15m
Extreme	1	160	4-4.5	For example, snatch rescue scenario	2-4m
Critical	<1	>235	>10	Considered life threatening	0-2m

* This column and remarks are not part of the original research document and are the opinion of the SCA
** Measured at a height of 1500mm from FFL

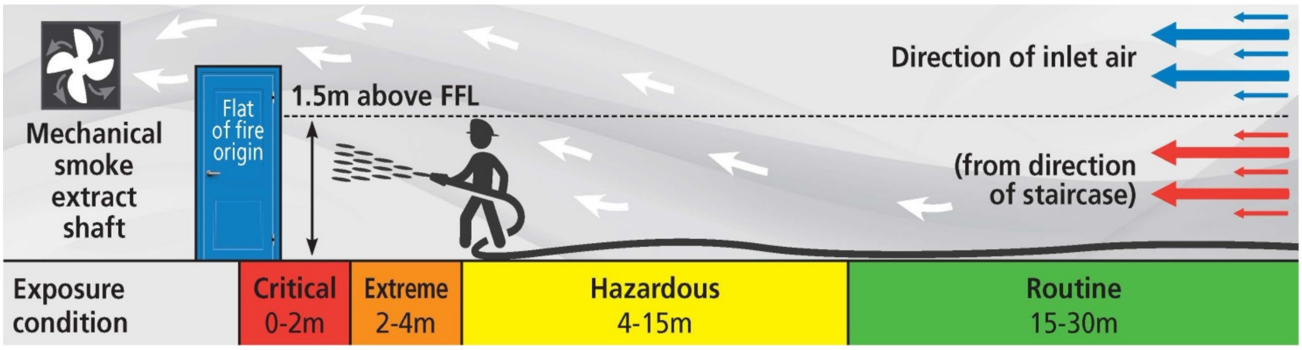


Figure 5.1 Fire fighter tenability conditions

5.3.4 Travel distance systems to applicable guidance

Where the travel distance in the corridor or lobby is to applicable guidance the primary issue is the protection afforded to the stair enclosure. As acknowledged in ADB, for example, performance criteria in the corridor are not explicitly demanded; adequate levels of safety are provided by the fire separation and limited travel distance.

Adopting a steady-state analysis allows a direct and potentially less time consuming design process. With the fire size, compartment ventilation provisions and door opening distances fixed, conditions (e.g. visibility, temperature) in the corridor and stair can be compared for different smoke ventilation schemes. In particular, conditions can be compared for the proposed smoke ventilation system against those generated by a solution in accordance with guidance, e.g. an alternative mechanical system against an applicable guidance one as described in ADB.

It is important when adopting this approach to use the same fire scenario boundary conditions for the proposed and designs following applicable guidance.

Table 5.2 shows one set of boundary conditions, derived from those used in the BRE project report 213179. These are for an un-sprinklered fire in a simplified representation of a dwelling, comprising a single room with floor dimensions 5m by 5m and height 2.2m, vented to the outside by a size of opening sufficiently large that replacement air is available to enable combustion within the room, but also small enough that most of the smoke is exhausted into the corridor (and not to the outside via the vent) when the door is open. Three stages of a fire scenario are indicated. Note that it is the flow of smoke passing through the dwelling entrance door and its associated temperature that determine the severity of the fire scenario in respect of the common areas rather than the fire size per se. Note also that heat losses to the compartment (room) boundaries account for a significant (majority) proportion of the heat generated by the fire.

Table 5.2 Illustrative steady-state design boundary conditions (buildings without sprinkler protection, with travel distances in accordance with guidance relevant, in particular, for comparative analysis)

Fire stage	**Fire size in dwelling (kW)**	**Dwelling and stair door opening widths (m)**	**Size of low-level vent to outside – single vent, not to be split**
Developed fire, relevant for later MOE.	1000	0.5	1.25m W x 1.25m H*
Immediately prior to flashover in fire compartment, relevant for Fire and Rescue Service intervention	2500	0.8	1.5m W x 1.5m H*
Flashover and post flashover fire	Fire strategy and fire size dependent upon room geometry and availability of combustion air – refer to the specific fire strategy and specialist engineering analysis		

* If during the modelling process it is found that the inlet areas proposed in this table lead to a ventilation controlled fire condition, it is recommended that the area of inlet is increased in 10% steps until a fuel bed condition is achieved for the fire sizes specified. The previous step and the final step should be presented in any report as evidence that an excessively large area has not been modelled for convenience.

Note: the designer should expect the heat release rate profile to have an oscillation amplitude average of up to 10% to indicate a steady-state fire that is not over or under ventilated.

If employing the steady-state design conditions in Table 5.2, you should impose the smoke flow as an explicit boundary condition at the location of the apartment door or use the proposed apartment geometry.

Where an actual apartment geometry is used for the model geometry, i.e. the modelling is project specific rather than generic, the inlet location should be placed in the same elevation and location as the actual windows in the project. There is no justification for proposing to model openings where solid walls will exist, for example.

The data in Table 5.2 generally describe conditions corresponding to an open plan apartment, but they are considered nonetheless to provide a useful 'design fire scenario' to allow a comparative analysis against a prescribed solution.

Note: the vent sizes are indicative only, and if used as part of a CFD model, may need to be modified depending on the code and modelling assumptions

The data may not be appropriate where the size of fire is controlled by the operation of sprinklers or water mist.

5.3.5 Extended travel distance systems

Where the common area travel distance in the corridor or lobby exceeds that of a code compliant layout, then a time-dependent analysis is likely to be necessary. This might include a set of separate steady-state analyses, each representing a stage in the fire scenario where conditions are quasi-steady, e.g. during fire fighting operations and where the door opening positions are fixed and the fire is burning at a (potentially full-developed) steady-state. However, the designer will need to undertake time-dependent calculations or simulations of part, or all, of the fire scenario timeline, e.g. to determine the time required to return the corridor to tenable conditions following a period of smoke exposure.

When a time-dependent approach is used, it is recommended that the fire scenario time line is first established and agreed with the authority having jurisdiction (AHJ). Table 5.3 presents a typical time line, and covers most of the events that might be considered in the design of the smoke control system. Other events, such as occupants escaping from other apartments, can be added as required.

The actual timings will depend on various factors such as the internal geometry of the apartment and the Fire and Rescue Service attendance time and will generally need to be agreed on a project by project basis.

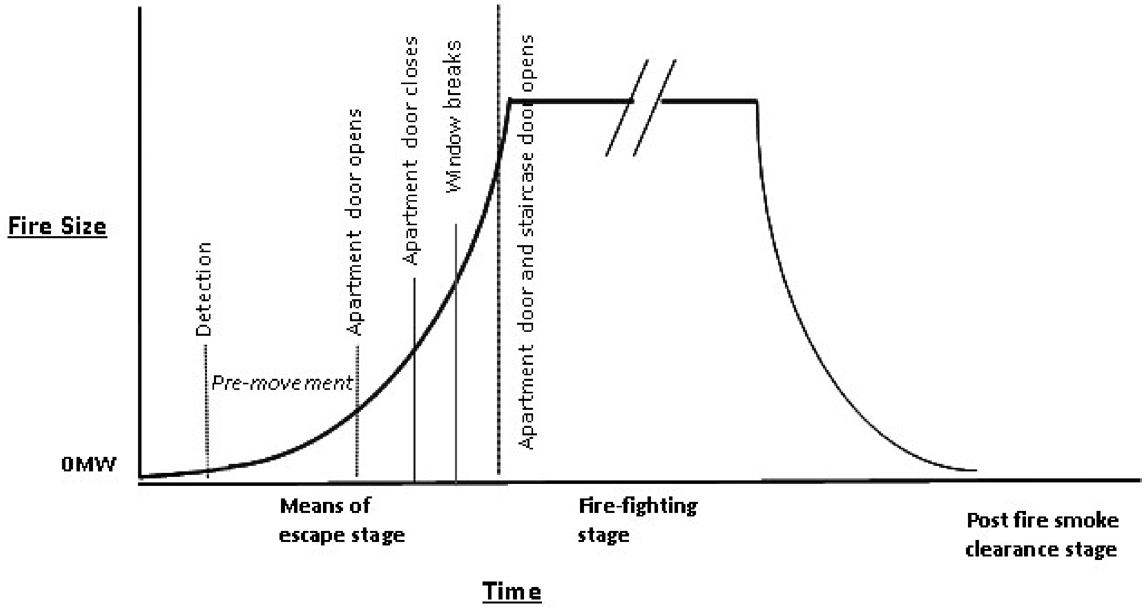
Table 5.3 Example of a typical time line for time-dependent design

Event	**Note**
Start of fire	Ignoring any smouldering period
Fire continues to burn at an increasing rate	A medium growth, t-squared fire (e.g. see PD 7974-1) is widely adopted
Fire detected in apartment	

Door to apartment opens (for occupant escape)	
Door to apartment closes	This should be 20s after the door opens
Door to stair opens (for occupant escape)	
Door to stair closes	This should be 20s after the door opens
Ventilation system reaches operational state	Smoke detection in the corridor will initiate the ventilation system. Full operation not likely to occur until after the first occupants have evacuated the corridor. The ramp up time of any system, fan or other components should follow the manufacturers' instructions
Ventilation system continues operating	Ventilation assists in protecting the stair, and depending on the performance criteria, to clear smoke from the corridor.
Fire continues to burn at an increasing rate to reach max heat release rate for design	Assuming sufficient ventilation is available in the apartment and there is no fire suppression (e.g. sprinklers). Additional ventilation by glazing failure is likely to be required.
Fire and Rescue Service access door(s) opens (e.g. at ground floor).	If this door is required to stay open to provide inlet air this may require an automatic actuator to be provided to the door. It should not be assumed that firefighters will open the door and secure it in the open position.
Door from stair to corridor/lobby opens (Fire and Rescue Service arrival) and remains open	The degree of door opening is case dependant
Door to fire apartment fully opens (fire fighting operations)	Ventilation protects the stair and reduces severity of conditions in the corridor.

Recommendations for suitable design fires can be found, for example, in PD 7974-1:2003 and the BRE Trust publication FB 29 (2011) *Design Fires for use in Fire Safety Engineering. The growth of the fire is likely to take a form similar to that shown in Figure 5.2.*

Figure 5.2 Typical time-dependent design fire (buildings without sprinkler protection)



It is likely that a medium growing t-squared fire (see PD 7974-1:2003) will be a suitable choice for a typical residential fire scenario. The size to which the fire grows will be strongly influenced by the availability of ventilation (air) to the apartment from the outside and whether suppression (sprinklers or water mist) is available.

If a medium growing t-squared fire is assumed, then after 5 minutes the heat release rate will be approximately 1MW. This size of fire might be considered as appropriate at the time the occupants of the fire apartment make their escape.

Unless the fire is controlled by a suppression system, subject to sufficient availability of fuel and air it will continue to grow. Typically, fully-developed, or post flashover, conditions will occur as the fire grows and once the upper smoke layer temperature has reached about 600°C. If a fire size is capped at a particular size on the basis of a suppression system, care is needed to ensure that the suppression system is designed using ‘use of sprinklers as a compensatory feature’ clauses (for example BS9251:2014 Section 4.4 and Table 2 footnotes)

In order to provide reasonably worse case (onerous) fire conditions up to the point of flashover, it is generally necessary to allow for just sufficient ventilation (from the outside at low level) to maintain most combustion within the apartment, i.e. to allow the fire to continue to burn and not become under-ventilated. This will generate the most onerous conditions with the maximum smoke and heat entering the corridor when the apartment door is opened and is representative of the methodology adopted in BRE project report 213179 which supported the current guidance on smoke ventilation in ADB. While a small opening (to the outside) will suffice in the early stages of the fire, a larger one will be required if the fire is allowed to grow. Timing and size of this opening needs to be justified.

If post-flashover, fully-developed fire conditions involving all or most of the combustible items in the room are to be included in the fire load, then it is likely that a significant amount of glazing will have failed and the fire has reached its ultimate ventilation controlled state.

For the purpose of justifying a smoke control system at Fire and Rescue Service access time it is generally reasonable to consider a fixed area fire size with sufficient ventilation to support complete combustion inside the room of fire origin and to generate conditions akin to those at flashover. Typically, in the absence of a suppression system, this will involve a fire generating of the order 2 to 6 MW depending on compartment size, and a ventilation (e.g. window) opening area in the range 1.5 to 3 m^2 (refer to table 5.2). The choice of the fire size and ventilation opening conditions needs to be considered carefully by the fire engineer and agreed with the authorities having jurisdiction. The need to complete a sensitivity analysis in relation to the fire size and extent of the glazing failure may, in some cases, be required.

It would generally be expected that the fire and the apartment is included within a CFD model for the later stages of the fire scenario (after the Fire and Rescue Service arrives and the stair and apartment doors are opened). This allows the full dynamic interaction between the apartment and the common areas to be included. However, at the initial stages of the fire scenario, where the rate of smoke clearance from the corridor is being examined, it might be more practical to impose the smoke, heat and soot source terms directly as a boundary condition at the apartment door. For explicit boundary conditions at the apartment door, please refer to the CFD guide.

Where water suppression is to be considered, it might be appropriate to assume that the fire grows until the suppression activates and then remains fixed at this size. Fully developed or flashover conditions would not subsequently be reached.

5.4 Fire and Rescue Service Intervention

5.4.1 – The ‘stay put’ strategy

The national guidance for the design and construction of apartment buildings, flats and maisonettes has historically encouraged the principles of compartmentation and ventilation to protect occupants and assist the fire-fighting operation, particularly where a ‘stay put’ policy is in place. Such design principles are based on a reliance that occupants not affected by fire or smoke are usually safer within their own flat and therefore can remain there during a fire elsewhere in the building. However the ‘stay put’ strategy also means that occupants that are affected at all by heat and smoke, or feel unsafe in any way, should take the opportunity to use the escape routes if it is safe to do so. The terminology ‘stay put’ does not mean that occupants should stay when they are in danger from a fire. Occupants not at immediate risk are free to evacuate at any stage.

Consideration should be given to the likelihood of uncontrolled occupant movements within common areas and both designers and the Fire and Rescue Service (FRS) should establish and align their strategies and areas of responsibility, taking such scenarios into account.

5.4.2 – General considerations

There are, however, some key aspects that should be considered when designing smoke control systems as compensation for extended travel distances:

- In the design and construction of extended length corridors beyond 7.5 metres served by a single stair, BS 9991 recommends that, in single stair buildings above 11m in height with accommodation on two (or more) sides of the common stair, the various wings of the building should be isolated by fire doors in order to prevent corridors from becoming contaminated by smoke. Where corridors are provided with smoke control systems as compensation for extended travel distances these cross corridor doors may be omitted, providing the designer is able to demonstrate that the ventilation provisions can provide acceptable tenability for occupants using escape routes to exit the building.

- Despite the absence of suitable research in this area, designers should be aware that single direction travel distances over 30m in length (measured from the staircase door to the furthest flat entrance door) in common escape routes are considered to present onerous conditions for fire fighters even if the flats are fitted with suppression systems. Therefore single direction corridor lengths over 30m are outside the scope of this guidance and it is recommended that they are not proposed.

- It is acknowledged that it is unlikely a mechanical smoke ventilation system can be designed to maintain tenable conditions in corridors for escaping occupants once fire fighting has begun or if the door to the flat of fire origin remains open for any other reason.

- It should be noted that where ‘stay put’ policies are incorporated into the building’s fire strategy, particularly where single direction travel exists, the authorities having jurisdiction may place a much greater emphasis on the need for sprinklers or fire suppression systems in flats and/or the provision of cross corridor suitably fire resisting doors to separate extended corridors into manageable sections.

- As outlined in section 6.4.1 of this document, smoke ventilation systems should extract smoke away from the stairs where single direction travel distances exceed 7.5m. This will help to ensure that the staircase is adequately protected from the products of combustion, as well as assist with fire fighter access (ideally fire fighters will be approaching the flat of fire origin with the flow of inlet air).

- The FRS have expressed their concerns in relation to the lengths of undivided corridor that fire fighters may have to navigate to carry out rescues or reach safety in situations where fire conditions deteriorate during intervention. Therefore the designer should consider that corridor sub-divisions may increase fire fighter safety.

- Where cross corridor doors are provided the ventilation strategy should take these into account when demonstrating performance capability.

- There needs to be an understanding and acceptance of responsibility between authorities having jurisdiction, smoke control system designers and the Fire and Rescue Service, that the risk to occupants should not be increased beyond that provided by a layout in accordance with guidance.

  Where a mechanical smoke system draws make-up air from the stairwell via an outward opening, self-closing door between the stairwell and corridor, consideration should be given to the long term durability and maintenance of the doors.

Where extended common escape route smoke ventilation solutions are proposed, it is recommended that designers discuss all relevant Fire and Rescue Service intervention aspects with the local Fire and Rescue Service.

5.4.3 – Controls for firefighter use.

Systems (with the exception of manual vents) should be automatic in their operation and not rely upon the interaction of firefighters to achieve their performance objectives during either means of escape or firefighting phases.

However controls or overrides are useful for firefighters to turn particular aspects of a system off or on if conditions change during firefighting.

These controls should be logical and intuitive to operate. Fire and rescue services have experience of controls which have been unclearly labelled which has meant they are unable to be used by attending fire crews. Firefighters will be reluctant to interact with systems whereby the outcome is unclear, particularly if that interaction has the potential to worsen conditions rather than improve them.

Fire fighter controls should follow the following basic principles:

- Controls should be labelled 'for firefighter use only';
- Manual control points should also be labelled according to their use – e.g. 'smoke vent stair', 'smoke vent corridor' or 'smoke vent lobby';
- Where controls have an operational mode this should be labelled as 'auto';
- Manual control points for the stair AOV should consist of one manual control point at ground or access floor, and be sited in the stair;
- Due to the possibility of keys being misplaced manual control points for firefighting use should not be key operated;
- There is benefit from having the above functionality replicated within a smoke control panel if required. Control panels should be simple and logical to operate in fire conditions without undue reliance on operational manuals;
- Manual control points for firefighter use should be coloured deep orange to RAL 2011;
- Any manual control points which are for maintenance only and not for firefighting use should be coloured white.

Variations to these recommendations might be considered as part of the consultation process with the AHJ.

Refer to section 8.2.5 for further information.

5.5 Documentation

Results should be presented in an appropriate form for each agreed criterion. Sufficient information should be provided to allow relevant parties to assess the analysis undertaken in relation to checking and meeting the required performance criteria.

The results of the analysis should be documented and may be provided in the form of a report, together with any necessary supporting animations from advanced modelling.

The documentation should include at least the following information:

- A description of the residential area and the proposed ventilation system
- The design criteria and performance objectives of the analysis
- The scenarios investigated and a full description of how these scenarios were arrived at provided.
- Details of the techniques used and related information
- The results of the analysis
- A statement as to whether the design criteria and objectives have been met
- Summary input/output data for the modelling used

For time dependent analyses, graphical results should be presented wherever possible to quantitatively show conditions plotted against a time line.

A sensitivity analysis should be carried out and presented such that it allows important outputs between different scenarios to be easily compared.

6 System types

6.1 Commentary

Smoke control can be achieved by natural, mechanical or a combination of mechanical and natural ventilation methods. Mechanical systems may be designed to allow extended travel distances subject to agreement from the authorities having jurisdiction.

Four different system types are considered:

- Natural ventilation
- Pressure differential
- Mechanical (powered) smoke ventilation
- Small single stair building

Small single stair buildings have been provided with their own system type since the functional requirements for the systems, whether natural, pressurisation or powered are slightly different to other residential building types.

Table 6.1. Smoke ventilation applications for residential buildings

Building Height (*H*)	Travel distance (*TD*)		Applied Solution		
	One Direction	More than one direction	Prescriptive Natural Ventilation	Prescriptive Mechanical Ventilation	Alternative Ventilation
H<11m	*TD* < 4.5m	*TD* < 30m	ADB Section 3.28e BS9991 Section 14.1.2	-	Mechanical Extract following a comparative or deterministic analysis
H<11m	*TD* < 7.5m (non-sprinklered) Or *TD*<15m (sprinklered)	*TD* < 30m	ADB Section 3.50 BS9991 Section 14.1.3	Pressure differential system in accordance to BS12101:6	Mechanical version of ADB/BS9991 following a comparative (to a shaft) or deterministic analysis
H>11m*	*TD* < 7.5m (non-sprinklered) Or *TD* < 15m (sprinklered)	*TD* < 30m (non-sprinklered) Or *TD* < 60m (sprinklered)	ADB Section 3.50 BS9991 Section 14.1.3	Pressure differential system in accordance to BS12101:6	Mechanical version of ADB/BS9991 following a comparative (to a shaft) or deterministic analysis
H>11m	*TD* > 7.5m – 30m (non-sprinklered) Or *TD* > 15m – 30m (sprinklered)		-	-	Mechanical following a deterministic analysis
Any height	*TD* > 30m	*TD* > 60m	-	-	Beyond the scope of this guide

***Only natural smoke shafts or mechanical systems (extract / pressure differential) should be used in buildings over 30m in height**

6.2 Natural Ventilation

6.2 Natural Ventilation

6.2.1 Introduction

ADB, while allowing both natural and mechanical ventilation to common corridors/lobbies, makes the presumption that natural ventilation is the norm and mechanical ventilation is an alternative.

Natural ventilation has many benefits including simplicity, reliability, low noise and low energy use. However, its performance relies on thermal buoyancy can be sensitive to wind effects and, for natural shaft systems, the loss of floor space is generally larger than alternative (mechanical) systems.

ADB provides recommendations for natural wall vents, natural vent shafts and vents at the head of the stair. The guidance in this section is intended to support and supplement the guidance in ADB.

6.2.2 General principles

Natural ventilation works by harnessing the natural forces of wind and thermal buoyancy to drive flow through the ventilator. For this application, the intended driving force is the buoyancy of hot smoke from the fire. Since buoyancy forces can be small compared to wind forces the performance in use can be significantly affected by wind.

For natural ventilation to operate effectively there needs to be both a source of inlet air and an exhaust opening. For a wall mounted vent, the vent generally provides both inlet at the bottom of the vent and exhaust at the top. Otherwise inlet air can be provided through the stair door when it is opened. To assist this, and to vent any smoke which enters the stair, a vent is needed at the head of the stair.

ADB recommends that the stair and the corridor/lobby adjoining the stair (i.e. the one the stair door opens onto) be ventilated.

6.2.3 Corridor/lobby vents

This section specifically applies to ventilators installed in the walls of corridors and lobbies that open directly to outside of the building.

For these items, ADB recommends:

A vent with a minimum free area of 1.5m^2 should be located on an external wall of each corridor/lobby to be ventilated. The 1.5m^2 is deemed geometric in nature and as defined in BS EN1201-2.
The vents should be located as high as practicable and such that the top edge is at least as high as the top of the door to the stair.
In single stair buildings the vents should be actuated by smoke detectors in the corridors/lobbies served. In multi-stair buildings the vents may be manually actuated. In either case the vent at the head of the stair needs to automatically open with the vents.

NOTE: In reality it is unlikely that escaping occupants will manually activate the corridor/lobby vents during the means of escape phase. It is beneficial to automate the activation of corridor/lobby vents as per the guidance for a single stair building. Additional considerations regarding manual corridor/lobby vents are described in 6.2.7.2.

However, the description above is open to interpretation and often leads to unprofessional and sometimes dangerous practices, such as site fitting actuators to windows that are not designed or tested to work together effectively, have no proper fall restraint, are not fixed to a suitable surface or are simply not compatible with the window to which they are fixed.

The following additional product information is recommended:

1 Smoke ventilators should be designed, tested and manufactured as a single entity to ensure compliance with EN12101-2. Refer to section 8.2.1.

2 ADB specifies minimum free area, which is not a method of measurement defined in EN12101-2 and can lead to a totally unrealistic claim of ventilation performance in some product categories.

To remove any ambiguity, it is suggested that the area used is taken as the aerodynamic free area, Aa. As this is a defined and tested characteristic under the EN, it must be declared on the CE mark label for the product, which should also make it simpler for the ventilator performance to be identified under inspection.

The ADB requirement should be considered to be fulfilled if the smoke ventilation product is CE marked to EN12101-2 and the Aa measurement for the of the ventilator is at least $0.9m^2$.

(Note: There is no direct correlation between ‘minimum free area’ and Aa. As a conservative estimate, Aa is likely to be no more than 60-70% of the geometric free area of the ventilator. The issue with the term minimum free area in ADB is that two products could have a very similar minimum free area under the ADB method, yet when tested under EN12101-2 could have very different Aa figures. The benefit of the Aa figure is that it is a measure of performance that is clearly defined and measured using a wind tunnel that is repeatable and unambiguous).

Building Geometry

In some instances, the building geometry can adversely affect the ventilator performance. This is particularly true of casement ventilators installed below an overhang or inset into the building construction to form a reveal. The net effect is to reduce the active area of the ventilator – see figures below:

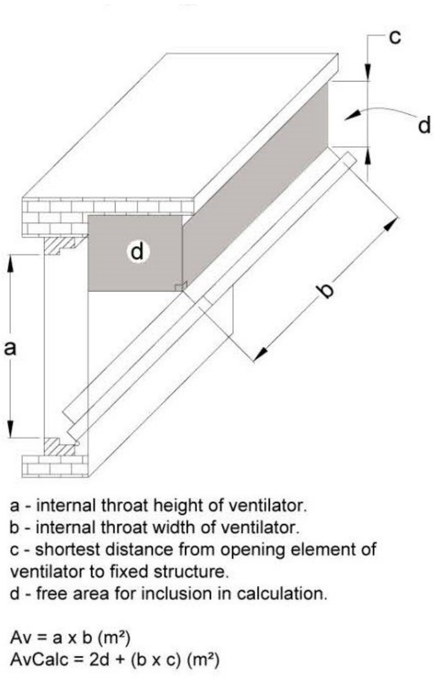


Fig a Typical bottom hung vent with overhang window reveal

(Note: If AvCalc from figure a. is greater than AvCalc from figure c. then use AvCalc from figure c. when comparing AvCalc to Av.)

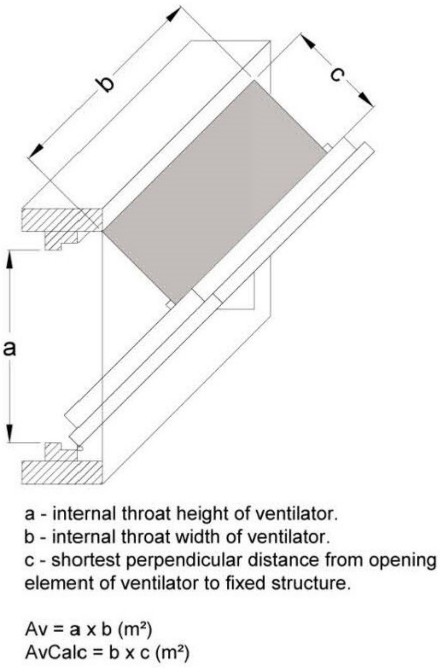


Fig b Typical bottom hung vent with

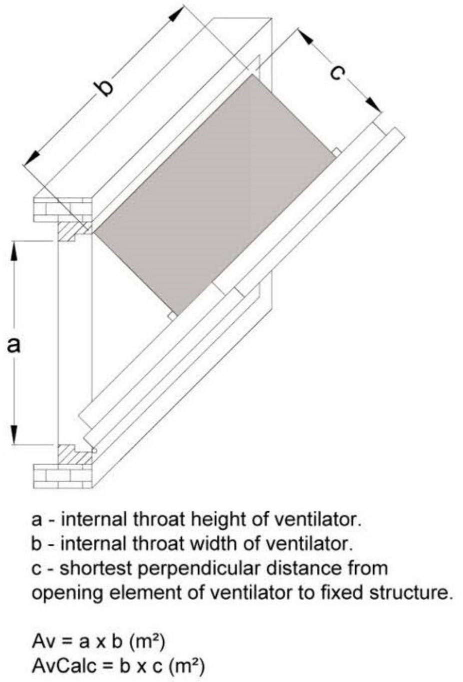


Fig c Typical bottom hung vent

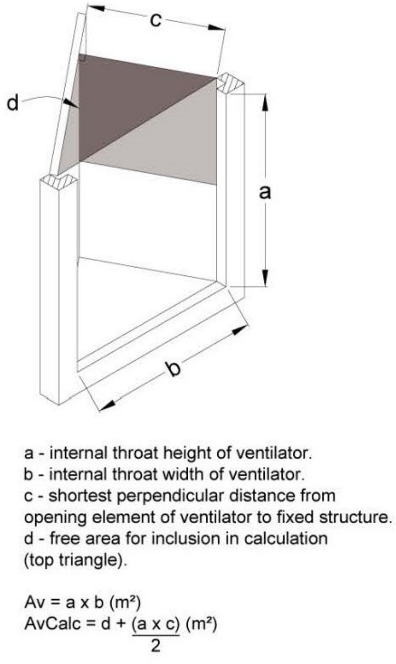


Fig d Typical side hung vent

In these instances, if the 'active area of ventilation' (AvCalc) is greater than the required aerodynamic free area, Aa then the requirement can be considered to be met.

6.2.4 Natural smoke shafts

The requirements for a natural smoke shaft are given in 3.51b of ADB: 2019 edition, volume 1 and reproduced below.

They should discharge into a vertical smoke shaft, closed at the base, that meets all of the following criteria.

i. The shaft should conform to the following conditions.

- Have a minimum cross-sectional area of 1.5m2 (minimum dimension 0.85m in any direction).
- Open at roof level, minimum 0.5m above any surrounding structures within 2m of it horizontally.
- Extend a minimum of 2.5m above the ceiling of the highest storey served by the shaft.

ii. The free area of all the following vents should be a minimum of 1m2 in the following places.

- From the corridor or lobby into the shaft.
- At the opening at the head of the shaft.
- At all internal locations within the shaft (e.g. safety grilles).

iii. The smoke shaft should be constructed from a class A1 material. The shaft should be vertical from base to head, with a maximum of 4m at a maximum inclined angle of 30 degrees. iv. If smoke is detected in the common corridor or lobby, both of the following should occur.

- Simultaneous opening of vents on the storey where the fire is located, at the top of the smoke shaft and to the stair.
- Vents from the corridors or lobbies on all other storeys should remain closed, even if smoke is subsequently detected on storeys other than where the fire is located.

The difference in this application is that the 'vent' as described in ADB has to serve two functions. Firstly, it must be capable of venting heat and smoke into the shaft from the fire level; secondly, 'vents' on other levels away from the fire must remain closed and maintain fire separation on the other levels to prevent fire and smoke spread to the non-fire affected levels. The only product designed, tested and certified to perform both these functions is a multi-compartment smoke control damper CE marked to EN 12101-8 refer to section 8.2.

NOTE: Fire dampers (or apparently modified fire dampers) that close and stay closed under motors, springs or fusible links, or have the fusible links removed are not acceptable,

Unfortunately, this standard does not currently define Aa as a characteristic for these products. Some manufacturers publish ζ figures (often known as k factors) and the geometric free area (Av) of the product. Aa can be approximated for a natural shaft system as follows:

$$Aa = Av \times \zeta^{-2} \ (m^2)$$

Note: designers should be aware that the relationship between the vent and the shaft may restrict the free area and should take this into account, where possible, when selecting, locating and sizing the vent.

Shaft construction should comply with 8.2.4.

6.2.5 Mechanical shaft ventilators

The same principles apply to mechanical shaft ventilators as 6.2.4. However, as fans used for mechanical shafts are able to overcome the resistance paths created by shafts much more effectively and can therefore be designed to suit the equipment more empirically.

The system resistance is now an important factor in the design of the system and ζ factors become critical. Dampers should be sized to suit the airflow required by system design without creating an excessive resistance pressure. Too high a pressure may cause excess leakage into the shaft from unknown or unpredicted locations resulting in a shortfall in airflow or may cause unexpected or excess noise, vibration or whistling from the system.

6.2.6 Head of stair vents

In accordance with ADB:

There should... be a vent, with a free area of at least 1.0m^2, from the top storey of the stairway to the outside. The 1.0m^2 is deemed geometric in nature and that is defined in BS EN12101-2.

With reference to the description in 6.2.3 above, it follows that this ventilator should also be certified to EN 12101-2 as it may be required to ventilate smoke from the stair itself. As the area is proportionately smaller than that of the corridor ventilator, an Aa of 0.7m^2 is considered a conservative estimate for the requirement.

The vent shall be operated automatically. See 6.2.6 and 8.2.1.2

The design of the stair vents should meet the guidance given in 6.2.3 above.

Note 1: Natural ventilators can be susceptible to positive wind pressures. To comply with EN12101-2, single flap roof mounted ventilators should be opened to a minimum of 140 degrees and double flap ventilators should be opened to a minimum of 90 degrees per leaf.

Note 2: Top hung ventilators should not be installed for natural smoke and heat exhaust ventilation.

6.2.7 Control

6.2.7.1 Minimum control requirements

The minimum control requirements for natural ventilation are set in ADB:

Design should be based on a single floor level being affected by the fire and therefore only the smoke vents on the floor of fire origin and any other design critical vents (such as the head of the smoke shafts and staircase) are required to open. System designers must avoid opening ventilators on multiple floor levels, to avoid smoke spread to otherwise unaffected parts of the building, and/or reduction of ventilation rate from the floor of fire origin.

For single stair buildings the controls should be fully automatic, operating from smoke detectors in the corridor/lobby at each storey. The vent on the fire affected floor only, the vent at the head of the smoke shaft and the vent at the head of the stair are required to open simultaneously. The vents on all other storeys should remain closed even if smoke is subsequently detected on floors other than the fire floor.

For multi-stair buildings smoke detectors are not required and the vents may be manually opened (where travel distances are in accordance with guidance). However, when any vent is opened the vent at the head of the stair is required to open simultaneously.
NOTE: In reality it is unlikely that escaping occupants will manually activate the corridor/lobby vents during the means of escape phase. It is beneficial to automate the activation of corridor/lobby vents as per the guidance for a single stair building. Additional considerations regarding manual corridor/lobby vents are described in 6.2.7.2

Consideration should be given, when positioning the manual activation switches, to ensure that these are not susceptible to vandalism or 'accidental' operation, leaving multiple vents open.

6.2.7.2 Additional considerations

It may be concluded from reading 6.2.7.1 that for multi-stair buildings simple manual windows can be used as vents to the corridors/lobbies. In this case, some additional issues need consideration:

Since the vent at the head of the stair has to open automatically when any vent is opened, each window will need a limit switch or other device to initiate this automatic opening;
Manual windows may be opened by occupants for general ventilation or other purposes. This would cause nuisance opening of the stair vent which, if not weathered, may allow significant water entry if left open in the rain;
Windows on upper storeys often have restricted opening to prevent falls, making it difficult to achieve the desired free area;
Windows opened manually can lead to smoke ingress on non-fire floors.

These problems can be overcome be installing automatic opening vents forming part of the overall smoke control system. Day to day ventilation can be achieved through local control such as a publicly accessible switch but on fire activation, any automatic opening vents on non-fire floors must close safely.

Where the operation of the smoke control component creates a risk of injury (for instance when a smoke vent closes automatically) this must be mitigated without compromising the emergency operation of the smoke control system.

e.g. consideration should be given to mitigating the risk of entrapment when vents close automatically, for example through the installation of movement sensors.

6.2.7.3 Additional Fire and Rescue Service controls

While ADB does not require a central fire-fighters panel, in complicated buildings, a central fire-fighter's panel may be desirable. Care should be taken to avoid adding over-complexity and risk of inappropriate operation.

The Fire and Rescue Service will usually require some manual control for Fire and Rescue Service use. Simplicity is recommended as fire-fighters will rarely have the time or knowledge to make proper use of complex controls.

Control should also be designed to ensure that the system responds to the first point of detection only and that subsequent detectors operating do not further activate the system.

Any controls provided for Fire and Rescue Service use should be clearly identified with permanent signage, indicating what function the controls have and that they are for ‘Fire fighter use only’.

Designers should also refer to the equipment guidance notes given in 8.2.5 below.

6.3 Pressure differential systems

6.3.1 Introduction

It is generally recognised that pressure differential systems (usually pressurisation as opposed to depressurisation in this context) can provide a high level of protection to stairs and lobbies.

The aim of a pressure differential system is to establish a pressure gradient (and thus an airflow pattern) with the protected escape stair at the highest pressure and the pressure progressively decreasing through lobbies and corridors.

With the correct level of pressure differential it is possible to be certain that smoke from a typical apartment fire will not enter the stair under normal conditions.

A decision as to whether such a system is appropriate to a particular project should be taken in context with the overall design strategy for means of escape, fire-fighting and property protection within the building.

6.3.2 General principles

Air will naturally try to move from an area of higher pressure to an area of lower pressure. By increasing the pressure in the protected areas (i.e. the escape routes) above that in the areas where the fire is likely to occur (in this case the apartments), it is possible to prevent smoke spread into these escape routes. This is usually achieved by pressurising the parts of the escape route to be protected.

In a building, the movement of smoke and air is restricted by the building fabric. If the building fabric were leak free, a pressure differential could be maintained once developed with no further action. However, since buildings leak, air needs to be continually blown in to maintain a pressure differential.

The amount of air that is required will be dictated by how much leakage is present. This is usually a function of the number of doors which will permit leakage around the perimeter, the area and type of wall construction and any other openings which could let air out from the protected space.

A difficulty is that when doors to the protected space are opened as people escape and the Fire and Rescue Service attend, the leakage area increases substantially, making it difficult to maintain a significant positive pressure. It is therefore necessary to design a system that is robust enough to provide sufficient protection even under conditions with some doors open while limiting the pressure differentials achieved with all doors closed. Too much pressure when all doors are closed will make doors opening into the pressurised space difficult to open and will impede escape into the protected area.

BS EN 12101-6 provides guidance on the performance to be achieved by a pressure differential system under both “doors closed” and “doors open” conditions and on which doors should be considered open. Under the 2005 edition of BS EN 12101-6, for a residential building, a system intended to protect means of escape is Class A and a system designed to assist fire-fighters is Class B.

Table 1: Classes of system

System class	**Examples of use**
A	For means of escape. Stay put.
B	For means of escape and fire-fighting.
C	For means of escape by simultaneous evacuation.
D	For means of escape. Sleeping risk.
E	For means of escape by phased evacuation.
F	Fire-fighting system and means of escape*.

* included for use in Austria and not normally specified in the UK

BS EN 12101-6 also provides a suitable calculation method to assess the air flow rates required through the system.

A pressure differential system requires three main components:

- a means of maintaining the pressure differential (usually a supply air system)
- a means of avoiding excess pressure differentials (usually a pressure relief damper or variable speed drive to the fan)
- a means of releasing air flowing through the open door to avoid eventual pressure equalisation (usually ventilators, automated windows or a natural ventilation shaft).

6.3.3 Areas to be pressurised

To provide the best level of protection, all of the common escape route from each apartment door to the final exit door would be pressurised. Unfortunately this is usually impractical due to the difficulties of providing and maintaining air release facilities from each apartment. It is therefore normal to provide air release from the common corridors/lobbies.

To protect means of escape (Class A), if there are no lifts, the stair only is usually pressurised. If there are lifts, then both the stair and either the lifts or lift lobbies may be pressurised in order to prevent smoke spread through the lifts.

To protect fire-fighters (Class B), the stair, lobbies and fire-fighting lift should be pressurised.

6.3.4 Supply air system

BS EN 12101-6 allows a single fan set to be used for each system, but recommends separate risers for supply to the stair and lift and lobbies/corridors (if pressurised). A standby fan is recommended if the building has only one stair.

Fans and ducts are not expected to operate at high temperature, so ambient rated fans and standard ducting to DW144 are adequate unless the duct crosses fire compartment boundaries, in which case relevant portions of the duct should be fire resisting. A supply grille is recommended at least every 3 storeys in the stair although, to keep grille sizes down, more are commonly used.

Inlet air should be taken from a point unlikely to be affected by smoke. When inlet is taken at roof level BS EN 12101-6 recommends dual inlets taken from 2 facades. Where this is impracticable, inlets separated by at least 5m and facing opposite directions are commonly accepted as sufficient. In either case in-duct smoke detection should be provided to shut down an inlet affected by smoke.

6.3.5 Pressure control

As noted earlier, there will be a difference between the air flow required to maintain pressurisation when all doors are closed and the air flow required to maintain the design velocity through an open door. The open door air flow is usually the greater.

A gravity operated pressure relief damper is usually mounted in the roof of the stair, sized to relieve the excess air flow at the design pressure. A sizing method is given in BS EN 12101-6 and manufacturer's data should always be consulted.

An alternative method is to use a variable speed drive to the fan, controlled from pressure sensing in the stair. Care needs to be taken in selection and commissioning to achieve the speed of response required by BS EN 12101-6 to avoid overpressures that can prevent doors from opening or slam violently, possibly resulting in injury, damage or preventing escape.

6.3.6 Accommodation air release (AAR)

Although often forgotten, this is an important part of the system. AAR is required on the accommodation side of every door leading from the pressurised areas into the unpressurised areas. In residential buildings this usually means the common lobbies or corridors.

Normal options are:
- automatic windows or vents
- natural shafts
- powered shafts
- HVAC system or other building leakage routes

Designers should carefully consider the positioning of AAR, if within an apartment, as this will be challenging for the responsible person to manage, monitor and maintain.

If AAR is to be provided by automatic windows or vents, these need to be located on two facades for each lobby/corridor. This is usually impractical so AAR is provided by shafts, with fire resisting dampers or vents at each level, with only the vent on the fire floor opening.

AAR shafts may be natural or powered. If a powered shaft is selected care should be taken to ensure that the combined effect of the pressurisation supply and the AAR does not cause excess pressure differentials to occur.

Extract fans used in powered AAR shafts should have an appropriate temperature rating for the application and standby fans should be provided.

Where an HVAC system or shaft passes through multiple compartments, it should have an appropriate level of fire resistance. Fire dampers may not be used in an AAR system.

6.3.7 Power supply and controls

A maintained power supply should be provided, with automatic changeover to the secondary power supply in case of interruption of the primary supply.

The main control panel should be located either within the pressurised space or in a separate one hour fire resisting compartment.

A Fire and Rescue Service control should be provided at the entrance to the stairs. It should provide, as a minimum, status of the power supply and each fan (run, trip) and an off/auto switch, protected against unauthorised use. The switch may also have a test position for ease of testing in use.

6.4 Mechanical (Powered) smoke ventilation

6.4.1 General principles

Mechanical smoke ventilation may be used as an alternative to natural ventilation systems. The recommendations of this section are based on the assumption that a shaft system will be used, but there is no reason why any floor level may not have its own dedicated mechanical system.

Benefits of mechanical systems include specified extraction rates, low wind sensitivity, known capability to overcome system resistances and reduced shaft cross sections.

Requirements of mechanical systems include a maintained power supply, fire resisting wiring, temperature classified equipment and a standby fan.

Suitable air inlet and exhaust is needed to prevent damage to the system and to ensure that excessive pressurisation or depressurisation of the ventilated area does not occur. This ensures that excess smoke is not drawn from the apartment of fire origin and that escape doors are neither rendered inoperable nor pulled open.

The design of the system should take into consideration that the source of inlet air should not compromise normal passive fire separation. Inlets which breach compartmentation between the stair and adjacent lobby/corridor are therefore inappropriate. Any inlets should be automatic in operation and should not be temperature controlled (see section 7.5). It may be considered acceptable in some instances to use the stair to supply inlet air via the stair door, which is pulled open into the corridor by the extract system. If the ventilation fails, the door will close under the closer and re-apply compartmentation subject to agreement with the AHJ.

Design should be based on a single floor level being affected by the fire and therefore only the smoke vents on the floor of fire origin and any other design critical vents (such as the head of the smoke shafts and staircase) are required to open. System designers must avoid opening ventilators on multiple floor levels, to avoid smoke spread to otherwise unaffected parts of the building, and/or reduction of extract rate from the floor of fire origin. See section 8.2.1.4 and 8.2.1.5.

Smoke shafts should be constructed of non-combustible material. The fire resistance of the shaft should be equivalent to the requirements of the elements of the structure through which it passes.

All vents to the lobbies/corridors should comply with EN 12101:8 (see paragraph 8.2.2 for further guidance). The fire rating of the vent should be equivalent to that of the smoke shaft or at least 60 minutes. This to ensure that the fire resistance of the smoke shaft is maintained when the vent on the floor of fire origin is in the open position.

Activation of the system is subject to discussion with the AHJ and other interested stakeholders, however the system is typically activated on detection of smoke in the common corridor / lobby. Upon activation of the system the smoke vent(s) on the fire floor, the vent(s) at the top of the smoke shaft(s) and the vent at the head of the stairway should open and any fans should run at the design speed. The vents on all other storeys should remain closed even if smoke is subsequently detected on floors other than the floors of fire origin.

Basic mechanical systems are commonly provided simply as an equivalent to the natural ventilation systems described in Approved Document B. It is possible to design systems providing a higher performance that may then be used to allow extended travel distances in corridors although care should be taken when considering removal of corridor subdivision doors. In this case the system objectives and performance should follow the guidance in section 5.

Note: As well as limiting the potential travel distance through smoke these doors may also limit the number of apartments needing evacuation by fire fighters and protect fire fighters. Removal of these doors may compromise fire fighter safety.

The location of extract and inlet points should be designed to protect the stair and to ensure that the layout minimises the potential for heat and smoke in the corridor/lobby to affect escaping occupants and fire fighters. It is important to ensure that the location of the inlet air source in relation to the point of smoke extract does not create dead spots in the protected zone.

Extracting smoke away from the stairs should be the default position where travel distances are in excess of 7.5m. This will normally result in the extract shaft(s) being positioned remote from the stair. The location of the extracts should be subject to early discussions with the AHJ.

When calculating the rate of extract and making fan selections, adequate allowance should be made for system leakage, including for example, leakage through ductwork, smoke shaft and all other closed dampers in the system. Calculation of the leakage rate should take account of the pressure to which the system is subjected. Some guidance on smoke shaft leakage rates is given in section 8 of this guide, but it is important that any published data is adjusted according to the system pressure.

The following are examples of typical design principles for mechanical systems:

6.4.2 Mechanical Extract, Natural Inlet

The system comprises mechanical extract shaft(s) serving one or more common spaces on all, or some, floor levels supplemented by the provision of natural air inlet provided by automatically opening vents or permanent vent to the outside (either directly or by way of a shaft, stairway or duct). Typically the mechanical extract is by a shaft although it can be via fans direct to the outside. Design of the system is dependent on the layout of the building and the recommended performance and design criteria as detailed in Section 5.

The mechanical extract should discharge directly to the outside. Where only a single mechanical extract is provided duty/standby fans should be provided as fan failure would result in failure of the system.

The area of natural air inlet openings should be sufficient to ensure not only that an excess pressure differential does not occur across a closed door but also that the pressure differential does not otherwise compromise means of escape by ‘pulling’ excessive amounts of smoke through door cracks or other leakage sources from the apartment of fire origin into the corridor.

Mechanical extract can be designed such that the system provides a steady extraction rate throughout all the stages of the fire (e.g. means of escape and fire-fighting), or ramp up and down automatically based on pressure variations due to door openings.

Figure 6.4.2a – Indicative layout showing a typical mechanical extract and natural inlet ventilation solution for a common access corridor using two shafts

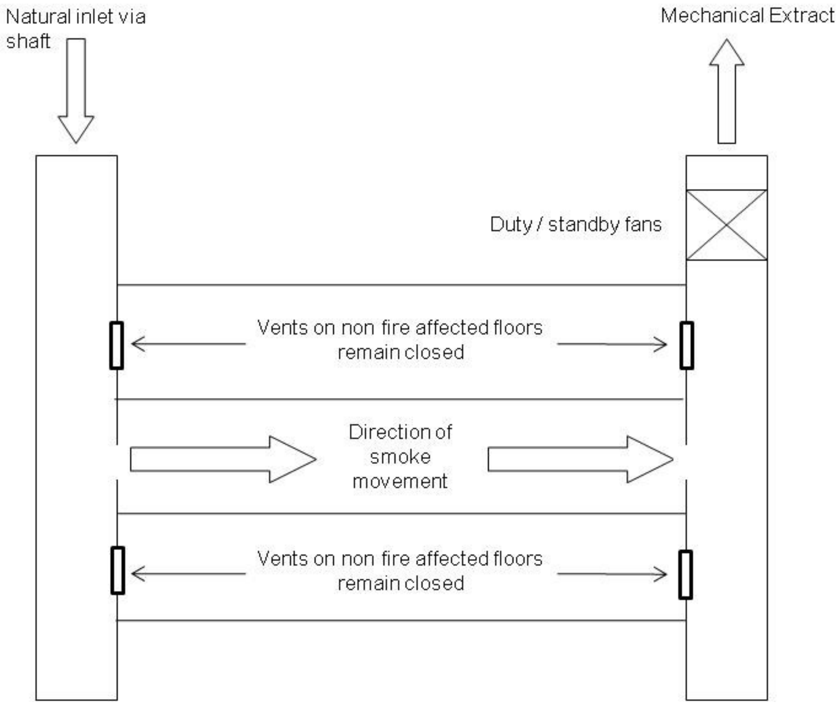
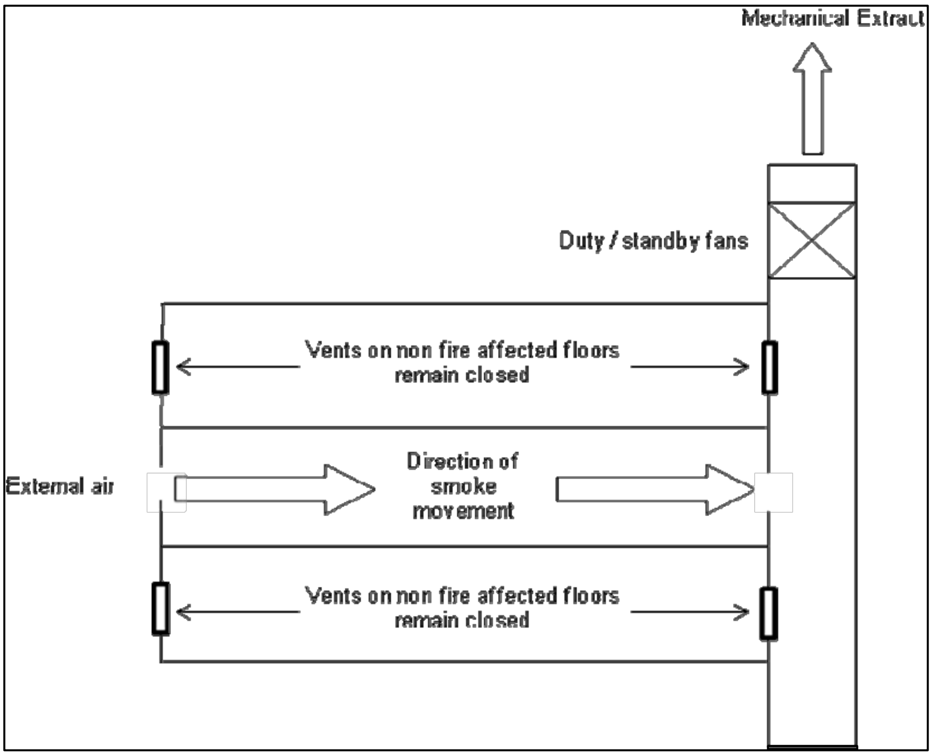


Figure 6.4.2b – Indicative layout showing a typical mechanical extract and natural inlet ventilation solution for a common access corridor using an inlet vent directly from the outside and an extract shaft



6.4.3 Mechanical Extract, Mechanical Inlet

Typical examples are:

a) Reversible fans which provide mechanical extract and mechanical air inlet. With this design, the system can be controlled by the fire detection system so that the fan closest to the initial point of detection can be selected as the smoke extract fan in means of escape mode with selected fans providing air inlet.

b) Systems with dedicated extract and inlet fans.

The system design is dependent on the exact requirements to match the building layout and other arrangements are possible.

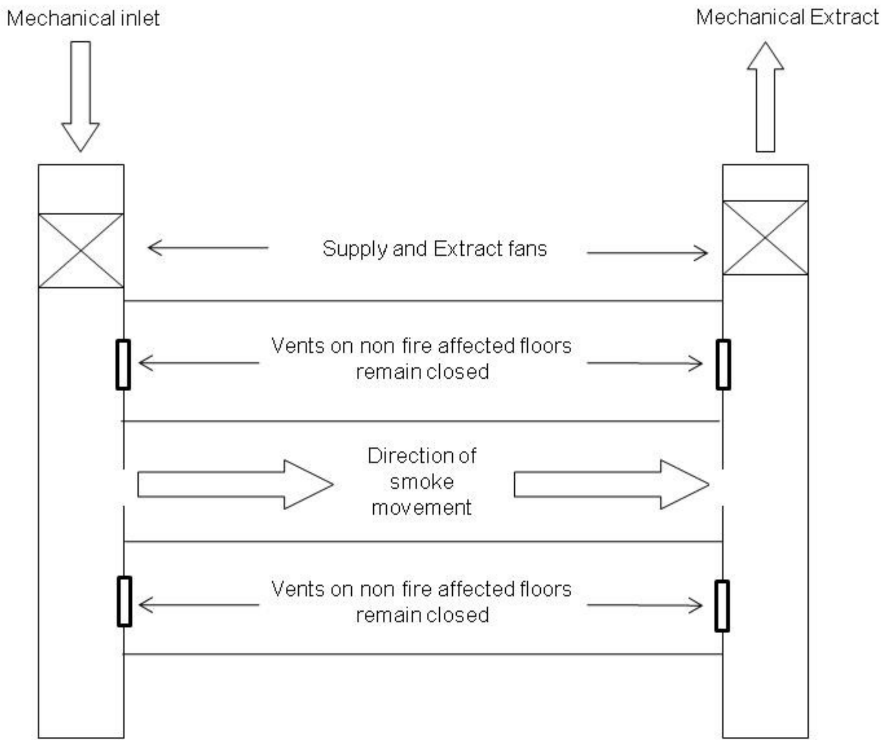
A mechanical extraction system provided with mechanical inlet requires careful balancing to ensure that the common access spaces are not overly pressurised or depressurised for all fire scenarios.

While the extract fan should be specified to operate at the appropriate temperature range, the inlet fans need not be temperature rated unless a reversible system is used.

This system can be designed to provide a steady extraction rate throughout all the stages of the fire. Alternatively the system can be provided with a variable rate of extraction, to reflect the different stages that occur during the fire and the requirements of the building. The decision regarding the ventilation rates, undertaken by the designer, should reflect the specific risks presented within the building.

Where an inverter forms a component of the fan extract system, the impact of failure of the inverter should be considered. Typically this will result in the system running at the highest extract rate unless a standby inverter is provided.

Figure 6.4.3 – Indicative layout showing mechanical inlet and mechanical extract ventilation for a common access corridor.



6.4.4 Mechanical Extract only

The system comprises mechanical extract shaft(s) serving one or more common spaces on all, or some, of the floor levels. The system uses a single mechanical extract shaft, with replacement air typically provided by natural leakage. Air replacement forms a key component of a mechanical extract only system and the designer should specify how this is to be achieved and how this is to be confirmed and tested onsite to ensure excessive pressure does not occur across a closed door or otherwise compromise means of escape by pulling smoke into the common escape routes from the adjoining space.

The design of the system is dependent on the layout of the building and the recommended performance and design criteria (as detailed in Section 5).

Where only a single mechanical extract is provided the fans should be duty/standby fans as fan failure would result in failure of the system.

Mechanical extract can be designed so that the system provides a steady extraction rate or alternatively the system can be provided with a variable rate of extraction, varied to reflect the different stages that occur during the fire. The decision regarding the ventilation rates, undertaken by the designer, should reflect the specific risks presented within the building.

Mechanical extract only systems using natural leakage for replacement air are not suitable where extended travel distances occur, unless specific consideration of the risks is undertaken by the designer and approval obtained from the authority having jurisdiction.

6.4.5 System performance overview

Mechanical System Type	Inlet smoke contamination risk	Excessive depressurisation risk	Automatic or FF interaction	Options for FF Interaction
Mechanical Extract, Natural Inlet (Window AOV)	Medium: *Possible where the inlet AOV(s) are located in close proximity to the fire flat*	High: *AOV sizing critical to the system as excessive depressurisation may occur when all doors in protected space are closed.*	Both: *Interaction is normally required as the AOV will present a significant leak in preventing smoke from spreading into the stairs from the ventilated space.*	• Variable rate of extract • Closing Inlet AOV.
Mechanical Extract, Natural Inlet (Inlet Shaft)	Low: *Inlet normally located on the roof remote from potential flat fire*	Medium: *Shaft sizing is critical to the system as excessive depressurisation may occur when all doors in protected space are closed.*	Both: *Interaction is normally required as the AOV will present a significant leak in preventing smoke from spreading into the stairs from the ventilated space.*	• Variable rate of extract • Closing Inlet Shaft Damper and / head of shaft AOV.
Mechanical Extract, Natural Inlet,	Low:	Low: *Depressurisation is regulated by the calibrated door closer.*	Automatic	• None as the system operates under

(Calibrated Stair Door)	*Inlet AOV(s) normally remote from the fire flat.*			a single rate of extract
Mechanical Extract, Mechanical Inlet	Low: *Inlet terminal(s) are remote from the flat fire*	Low: *Outlet and Inlet Airflows rates are balanced to safe depressurisation levels*	FF interaction: *Low depressurisation levels from balanced systems offer little benefit in preventing smoke spreading into the stairs during FF*	• Variable rate of extract • Shut down inlet fan. • Shut down inlet fan and close inlet damper. • Reverse Inlet to Extract.
Mechanical Extract Only	Low: *Inlet AOV(s) normally remote from the fire flat.*	High: *Extract rates influencing pressure levels in the ventilated space need to be modulated.*	FF Interaction: *Change the rate of extract to maximum to avoid interference from the pressure modulating mechanism.*	• Variable rate of extract
Ideally inlets should be at the bottom of the building. Inlet and Outlet terminal should be separated by 5m horizontally and 1m vertically as a minimum				

6.4.6 Manual control points (MCP) for mechanical systems (speed control)

For systems that are switchable between a ‘normal’ and ‘boost’ mode, (i.e. two-speed systems with different means of escape and fire-fighting extract rates), the MCP should be provided in a place of relative safety (usually the stair enclosure) at each floor level so that fire fighters can operate it locally, prior to entering the risk area on the relevant floor.

Variations to these recommendations might be considered as part of the consultation process with the AHJ.

Note: Due to the potential for keys to be misplaced or lost, it is generally advisable to avoid using key operated manual control points as fire fighting operations may be significantly impacted if the relevant keys are not available.

If the use of key operated manual control points cannot be avoided, then their use should be carefully considered and discussed with the local fire and rescue service. How relevant keys will be stored on site and made available to the fire service, whether the keys have been provided with robust fobs to prevent loss if dropped, and whether fobs will indicate where a key can be used and its function will all need to be clearly discussed and defined as part of this process.

6.5 Small Single Stair Buildings

6.5.1 General principles

In England and Wales a small single staircase building is considered to be one which meets the following criteria:

a. the top floor of the building is no more than 11m above ground level;
b. there are no more than 3 storeys above the ground level storey;
c. the stair does not connect to a covered car park;
d. the stair does not serve ancillary accommodation unless the ancillary accommodation is separated from the stair by a protected lobby, or protected corridor, which has not less than $0.4m^2$ permanent ventilation or is protected from the ingress of smoke by a mechanical smoke control system; and

e. a high level openable vent, for Fire and Rescue Service use, is provided at each floor level, with a minimum free area of $1m^2$. Alternatively, a single openable vent may be provided at the head of the stair which can be remotely operated from the Fire and Rescue Service access level.

Buildings which do not comply with the criteria, unless otherwise approved by the AHJ, should be designed in accordance with Sections 6.2 to 6.4 above (as appropriate). Designers of buildings using other codes of practice should discuss the applicability of the guidance given below with the AHJ.

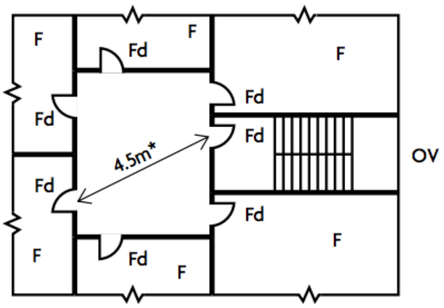
Those buildings which do comply with the small single staircase building criteria can be provided with natural or powered extract or pressurisation.

6.5.2 Natural ventilation

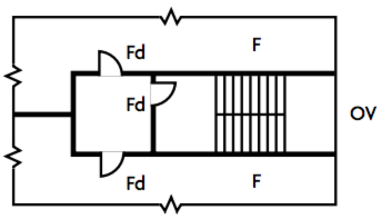
Smoke ventilation from the common areas should be designed in accordance with the guidance given in Diagram 3.9 of ADB: 2019.

The smoke ventilation should otherwise comply with the guidance given in Section 6.2 above (e.g. with regards to calculation of ventilation area, provisions of control points etc.)

See para 3.28



a. SMALL SINGLE STAIR BUILDING
*If smoke control is provided in the lobby, the travel distance can be increased to 7.5m maximum (see Diagram 3.7, example b).



b. SMALL SINGLE STAIR BUILDING WITH NO MORE THAN TWO FLATS PER STOREY
The door between stair and lobby should be free from security fastenings.

If the flats have protected entrance halls, the lobby between the common stair and flat entrance is not essential.

NOTES:

1. The arrangements shown also apply to the top storey.
2. If the travel distance across the lobby in diagram (a) exceeds 4.5m, Diagram 3.7 applies.
3. Where, in Diagram (b), the lobby between the common stair and the dwelling is omitted in small single stair buildings, an automatic opening vent with a free area of at least $1m^2$ is required at the top of the stair, which is operated automatically on detection of smoke at any storey in the stair.
4. For further guidance on the fire rating of the fire doorsets from the corridor to the flat and/or stairway refer to Appendix C, Table C1.

▬ Fire resisting construction
OV Openable vent at high level for fire service use ($1.0m^2$ minimum free area); see paragraph 3.28e
F Flat
Fd Fire doorset

6.5.3 Pressurisation

Pressurisation may be used as an alternative to natural ventilation as a means of protecting the staircase. The design of the system should be as per Section 6.3, for a means of escape (Class A) system if BS EN 12101 Part 6 is used as the basis of design.

It may not be acceptable to provide a pressurisation system where access is required into a resident's apartment in order to maintain any part of the equipment. External access is recommended; for example, if an air release path is required via a vent from an apartment, the actuator of the vent should be accessible from a location outside of the apartment.

The system designer should provide an access and maintenance statement in the O&M manual on how the equipment can be readily maintained and replaced in the event of failure.

6.5.4 Mechanical (powered) ventilation

Mechanical ventilation may be used as an alternative to natural ventilation as a means of protecting the staircase. The design will vary depending on the building layout.

6.5.4.1 With an unventilated common lobby

Where the apartments access the staircase by an unventilated common lobby, ventilation of the stair is required for fire-fighting (only). It is not needed for means of escape. It can therefore be actuated by a fire fighter's switch and is not required to operate automatically,

A fire fighter's manual control point should be provided at the designated Fire and Rescue Service access point in accordance with 8.2.5.2.

The system may pull smoke into the staircase if it is operated while the apartment/lobby door is open. Therefore a manual control point should be installed.

It is important that a replacement air source is provided, usually via a manually opening door to the outside of the building. The air inlet route is not usually permitted to be via an enclosed corridor which is accessed by apartments or other accommodation (residential or otherwise), unless this has been specifically addressed by the system designer, as a fire occurring in one of these apartments may affect the ability of the system to operate effectively (e.g. smoke may be pulled into the staircase rather than clean air).

The systems extract rate is considered to satisfy the functional requirements if it meets the higher of the following:

a) A minimum of 10 air changes is provided to the staircase, or
b) The minimum extract rate is not less than 2m^3/s.

Note: These values have not been scientifically proven but are based on good practice. The minimum flow rate ensures sufficient air flow into the staircase and is solely based on the committee's opinion. It is acceptable for a designer to alter these values subject to approval from the authority having jurisdiction.

Duty and standby fans should be provided.

6.5.4.2 With no common lobby (small single stair building)

Where no common lobby is provided for a small single stair building with the apartments directly access the stair, the system is required to be automatic and activated by smoke detection in line with the guidance given in ADB. The system is intended for use for both means of escape and Fire and Rescue Service access. A fire fighter's override should be provided in accordance with 8.2.5.3 with an open/auto/closed function.

It is likely that smoke will enter the staircase when the door to the apartment of fire origin is opened and this smoke may reduce the visibility distances in the staircase to below the recommended tenability limit.

To mitigate against smoke entering the stair the following criterion is applied: When the doors from the apartment to the stair are closed the maximum pressure difference in the staircase should be no more than -15Pa to -20Pa. For pressure differences greater than this there is considered to be a risk that excessive smoke may enter the staircase via door leakage paths.

Note: the recommended limit is based on the experience of the working group and limited research and is subject to further scientific assessment. It should be noted that at -25Pa, CIBSE Guide E identifies that doors opening into staircase may be pulled open.

To ensure the system operates correctly a suitably sized, automatic opening, replacement air inlet source should be provided at the base of the stair. Replacement air should ideally be provided naturally. If this is not possible a mechanical alternative is acceptable provided the stair is kept at a negative pressure. The air inlet route is not usually permitted to be via an enclosed corridor which is accessed by apartments or other accommodation (residential or otherwise), unless this has been specifically addressed by the system designer, as a fire occurring in one of these apartments may affect the ability of the system to operate effectively (e.g. smoke may be pulled into the staircase rather than replacement air).

The systems extract rate is considered to satisfy the functional requirements if it meets the higher of the following:

a) A minimum of 10 air changes per hour is provided to the staircase, or
b) The minimum extract rate is not less than $2m^3/s$.

Note: These values have not been scientifically proven but are based on good practice. The minimum flow rate ensures sufficient air flow into the staircase and is solely based on the committee's opinion. It is acceptable for a designer to alter these values subject to approval with the authority having jurisdiction.

All testing during commissioning should be undertaken with the doors closed.

Duty and standby fans should be provided.

7 Interaction with other Fire Protection Systems and other Building Systems

7.1 Introduction

The designer should consider all interactions between the smoke control system and other systems to ensure that the smoke control system meets its intended design performance when required to do so in an emergency.

Where smoke control systems interact with other systems:

a) Any interaction in a fire situation should not compromise the operation and effectiveness of the smoke control system and vice versa;

b) The smoke control system should work with other fire protection systems as defined by the fire strategy.

The designer may need to consider the specific performance of individual manufacturers' systems and equipment, and take this into account in the design of the smoke control system.

7.2 Heating, Ventilation and Air Conditioning (HVAC) systems

Unless specifically designed to aid the smoke control system, HVAC systems in common areas should be switched off upon detection of fire or manual operation of the smoke control system.

Where HVAC ducts may cause unacceptable spread of smoke or fire, they should be shut off by an appropriate smoke or fire damper upon detection of fire or manual operation of the smoke control system.

7.3 Automatic fire suppression

Provision of automatic fire suppression systems in individual apartments or common/ancillary areas does not remove or reduce the need for smoke control.

The effect of automatic fire suppression systems should only be taken into account when all areas that could affect the system are fitted with an appropriate automatic fire suppression installation. In this case a reduction in the design fire size may be justified but only if the automatic fire suppression system should be designed using criteria for 'compensatory feature' (for example BS9251 Section 4.4 and Table 2 footnotes).

7.4 Fire Separating Elements

The design of the smoke control system components should be such that there is no reduction in the level of fire separating elements provided.

Where fire dampers are to be used to enforce lines of fire separating elements in conjunction with a mechanical smoke ventilation system, intumescent type dampers should not be used as the cooling effect of the ventilation system is likely to prevent the temperature build up necessary for the dampers to function correctly. Motorised fire and smoke dampers, of a suitable rating, operated by a smoke detector in the smoke zone should be used. Fusible link dampers are not appropriate.

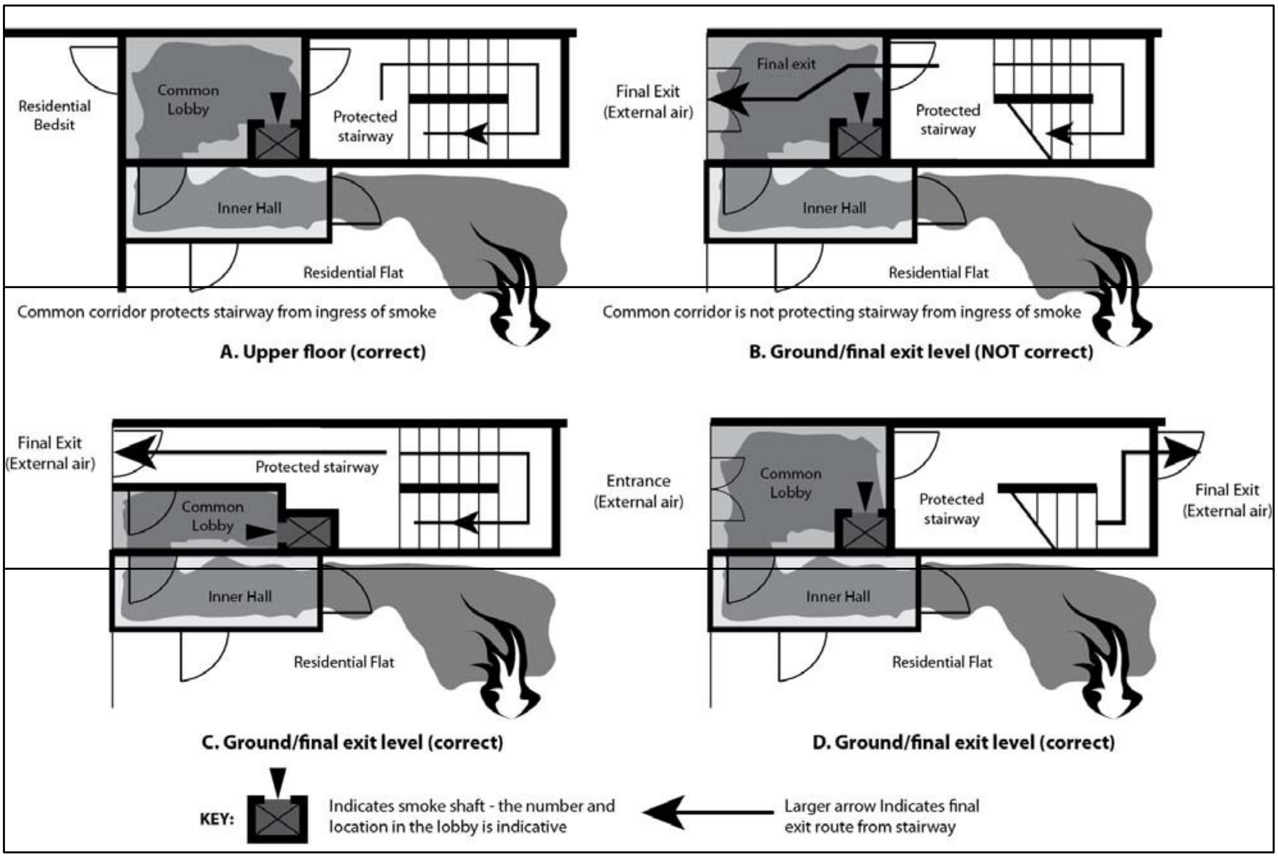
7.5 Ground floor / exit level final exit

A ventilated common lobby serving the stair and accommodation at the final exit level should not be regarded as suitable as part of the final exit route from the stair. It is important to ensure the protection to the stairway is maintained throughout the stairway and its final exit.

Diagram A in Figure 7.5 below shows a typical layout and lobby ventilation system on an upper floor. If this layout is repeated at the final exit level with the ventilated common lobby forming part of the final exit route from the stair, as indicated in Diagram B, escaping occupants may be forced to escape through a smoky lobby to the final exit door.

Diagrams C and D show alternative layouts which avoid escaping occupants being exposed to smoke and therefore provide the correct level of protection.

Figure 7.5 Location of lobby ventilators at Ground / exit level



7.6 Ventilation of lobbies to ancillary accommodation

The prescriptive codes recommend for means of escape that ancillary accommodation (e.g. car park or places of special fire hazard) is separated from the staircase by means of a natural ventilated lobby (e.g. where ADB recommends for a small single staircase building a 0.4 m^2 vent). This is normally achieved by a fire rated plenum or smoke shaft linking the lobby to the outside of the building allowing any smoke in the lobby to be ventilated.

This natural ventilation provision cannot always be easily achieved. An alternative approach may be to use one of the following mechanical ventilation systems:

1. Mechanical extraction from the lobby at a rate equivalent to the natural vent and a pressure not exceeding 20 Pa across the lobby doors. The fan discharge should be ducted to the outside.
2. Positive pressurisation of the lobby above the surrounding space.

In developing the above system, the replacement air should be taken from the sterile area ensuring smoke is not actively drawn into the lobby. This could be from the staircase or riser and where dedicated active openings are provided, they should be controlled by a local smoke detector.

Duty and standby fans should be provided to ensure the system operates in the event of component failure.

All testing during commissioning should be carried out with the doors closed.

8. Equipment and Installation

8.1 Introduction

A smoke control system must operate in the intended manner when called upon to do so in an emergency situation. To ensure the system operates correctly, it is essential that the processes of planning, design, installation, commissioning and maintenance are undertaken by competent parties and that clear responsibilities are established.

Typically a smoke control system is made up of a number of components, interconnected and controlled in a way which meets the performance requirements set out in the system design. The products will generally meet European or International product standards.

Typically, this will include roof and wall ventilators, supply or extract fans, dampers, ductwork, controls, power supplies and cabling. The design, testing and certification of these components will ensure that the system is robust, reliable and sufficiently resilient to withstand the test of performing in a real fire incident.

The Construction Products Regulation (CPR) came into force in July 2013 and introduced a mandatory requirement on manufacturers to only place products onto the European Union market which comply with relevant harmonised standard. EN12101 is the umbrella regulation which covers smoke and heat control systems. Several parts of EN12101 are harmonised under the CPR is therefore essential for any stakeholder to incorporate products which comply with this standard into the construction.

Compliance with the CPR is demonstrated by the manufacturer issuing a Declaration of Performance (DoP) for the product. As these products are designed to protect life, under the CPR's System of Attestation of Conformity, they must be tested to an Assessment & Verification of Constancy of Performance (AVCP) Level 1. This means that the manufacturer MUST appoint a Notified Body accredited to the relevant part of EN12101 to issue the manufacturer with a certificate of constancy of performance for the product which is necessary to allow the manufacturer to issue the DoP.

The certificate of constancy of performance will be based on:-

- Type Testing of the Product
- Initial Inspection of the Factory Production Control
- Continuous surveillance, assessment and evaluation of the Factory Production Control

The DoP will contain information about the essential characteristics of the product. These characteristics will indicate the suitability of the product for the required function. This section includes relevant tables of product essential characteristics, explaining the implications of the characteristics and allowing the designer to make an informed choice.

The installation of these products should be undertaken in accordance with the manufacturer's instructions and the SCA encourages the use of third party accreditation schemes (for example, the SCA actively encourages third party accreditation for Design, Installation, Commissioning and Maintenance of Smoke Control Systems).

Guidance on these processes can be found in BS 8519, BS9999 and BS9991 as well as BS 7346 Components for smoke control systems: Part 8 Code of practice for planning, design, installation, commissioning and maintenance. These documents serve to illustrate best practice, including minimum performance criteria and sample certification. Furthermore these documents set out the statutory responsibilities for smoke control systems.

A smoke control system should be installed and commissioned in accordance with a detailed engineering plan which should have considered as a minimum:

- Sub division of system into zones
- Component selection and compatibility
- System activation
- Location of components and equipment
- Electrical power supplies and cables
- Cause and effect summary
- System performance

The following sections provide useful notes on equipment selection. This information is intended to supplement the guidance given in BS 7346 Part 8, BS 9991 and BS 9999.

8.2 Equipment Guidance Notes

A summary of equipment and relevant test standards is included in Annex A and/or BS EN12101-8.

8.2.1 Automatic opening vents

All smoke control ventilators shall be CE marked to BS EN12101 part 2.

8.2.1.1 Automatic opening louvre, automatic opening casement window– used for external wall ventilation smoke ventilation

It is essential that stakeholders satisfy themselves that products carrying CE marks are supported by DoPs relevant to their proposed use. Refer to 8.2.1.4 for recommended classifications and thresholds.

8.2.1.2 Automatic opening casement window, automatic opening sloping roof window, automatic opening rooflight, automatic opening louvre – used for stairwell ventilation

These products may be used for both inlet and outlet according to the design of the system. Where the product is used for smoke outlet then, under the rules of the CPR, it must be CE marked to BS EN 12101 Part 2.

It is important that care is taken when selecting a suitable product and factors such as prevailing wind direction, proximity to other buildings, the angle of opening and the type of ventilator should all be taken into account as incorrect product selection can adversely affect the operation of the system leading to negative discharge. Where roof mounted hinged single flap ventilators are used for smoke extract a minimum opening angle of 140 degrees is recommended. Where an automatic opening vent is used solely for air inlet to the smoke control system, then it should also comply with BS EN 12101-2.

8.2.1.3 Automatic opening rooflight, automatic opening louvre – used for ventilation to top of smoke shaft

These products may be used for both inlet and outlet according to the design of the system. In either instance, a product CE marked to BS EN 12101 Part 2 is recommended.

It is important that care is taken when selecting a suitable product and factors such as prevailing wind direction, proximity to other buildings, the angle of opening and the type of ventilator should all be taken into account as incorrect product selection can adversely affect the operation of the system leading to negative discharge. Where roof mounted hinged single flap ventilators are used for natural smoke extract a minimum opening angle of 140 degrees is recommended.

Where an automatic opening rooflight or louvre is used above a smoke extract fan (or inlet fan on a push pull system) the activation of the unit must fail safe to the open position.

8.2.1.4 Classification

The essential characteristics of smoke control ventilators are detailed below. The performance characteristics recommended by the SCA show common applications, typically required by systems compliant with designs in accordance with Approved Document B. The designer should consider the application and select a classification accordingly.

Essential Characteristics of a Natural Smoke and Heat Ventilator tested to EN 12101 part 2 2017

SCA recommended performance characteristics by application

EN12101-2 Annex ZA

				Top of stair			Top of smoke shaft			Corridor		
Essential Characteristics	**Notes**	Unit	Relevant Clauses	Vertical	Combined roof pitch and vent pitch angle > 45° [Note 1]	Combined roof pitch and vent pitch < 45° [Note 1]	Vertical [Note 2]	Combined roof pitch and vent pitch angle > 45° [Note 1]	Combined roof pitch and vent pitch angle < 45° [Note 1]	Vertical	Combined roof pitch and vent pitch angle > 45° [Note 1]	Combined roof pitch and vent pitch angle < 45° [Note 1]
Nominal activation conditions/ sensitivity	Informative		4.1, 4.2	e.g. 24v	e.g. 24v	e.g. 24v	e.g. 24v	e.g. 24v	e.g. 24v	e.g. 24v	e.g. 24v	e.g. 24v
Response delay (response time)		s	7.1.2	<60s	<60s	<60s	<60s	<60s	<60s	<60s	<60s	<60s
Operational reliability emergency operation only	Reliability Re (number of operations)		7.1	Re 1000	Re 1000	Re 1000	Re 1000	Re 1000	Re 1000	Re 1000	Re 1000	Re 1000
Operational reliability emergency operation and comfort ventilation (dual purpose)	Reliability Re (number of operations)		7.1	Re 10000	Re 10000	Re 10000	Re 10000	Re 10000	Re 10000	Re 10000	Re 10000	Re 10000
Aerodynamic free area		m²	6	0.7*	0.7**	0.7**	0.9*	0.9**	0.9**	0.9*	0.9**	0.9**
*Coefficient of discharge Cvo (without side wind)												
** Coefficient of discharge Cvw (with side wind)												
Performance parameters under fire conditions [mechanical stability]	Classification in accordance with Annex B		7.5	B300	B300	B300	B300	B300	B300	B300	B300	B300
Ability to open under environmental conditions	Snow Load SL	Pa	7.2	SL 0	SL 0	SL 500	SL 0	SL 0	SL 500	SL 0	SL 0	SL 500
	Low ambient temperature T	°C	7.3	T 0	T 0	T 0	T 0	T 0	T 0	T 0	T 0	T 0
	Wind Load WL	Pa	7.4	WL 1500	WL 1500	WL 1500	WL 1500	WL 1500	WL 1500	WL 1500	WL 1500	WL 1500
Reaction to fire	Classification in accordance with EN13501-1		7.5.2.1	e.g. E								

Note 1	Consult manufacturer's data for instructions on the use and fitting of wind baffles
Note 2	Could be susceptible to adverse effects from wind. Refer to chapters 6 and 8.

8.2.2 Smoke control dampers

Smoke control dampers are used where there is a need to control the extract of smoke from within a building, for example between a lobby or corridor and a smoke extract shaft or duct, or ducting air directly to the outside of a building. The system designer must select the appropriate product in conjunction with building control and the fire brigade.

Smoke control dampers should be selected to reflect requirements of the smoke control system and accommodate the maximum performance requirements of the system (sizes, volumes and pressures)

For example, smoke control dampers mounting in walls to allow access to shafts which will breach vertical compartmentation shall be multi compartment smoke control dampers.

Smoke control dampers mounted in walls and shafts that proceed directly to the outside without breaching a compartment boundary can be single compartment smoke control dampers. It is uncommon for a single compartment damper to be used in a residential building, as a vent to EN 12101-2 may be more appropriate. If fire compartmentation is required, then a multi compartment damper is required.

For explanation:

(1) smoke control dampers have two safety positions and may be fully open (for extract) or fully closed (to maintain compartmentation) in a fire/smoke situation

(2) As a smoke control damper will open to allow the extract of smoke, the duct or shaft now becomes part of the fire compartment, so smoke control dampers along the route must be multi-compartment too, to prevent the fire and smoke leaving the duct or shaft to other areas/floors.

Products should be CE marked to BS EN 12101 Part 8.

ADB requires the use of smoke control dampers in association with smoke control

The smoke control damper selected should have an integrity value to suit the compartment barrier or ductwork into which it is to be installed

The use of fire doors with actuators is allowed under ADB but is not a solution recognised by the SCA, as products meeting the requirements of the EN12101 series is advocated.

Other ad hoc tested products or products meeting the requirements of EN 12101-2 are not allowed for allowing smoke to enter a vertical shaft and are not allowed under ADB.

Similarly, the use of fire dampers CE marked to EN 15650 with replaced actuators is not acceptable as the smoke control damper test requires the actuator to be cycled before the fire tests and to be part of the tested smoke control damper assembly – (NOTE: DW/144 Section 24 advises use of fire damper CE marked to EN 15650 then modified for use in smoke control. This is no longer acceptable as the CE mark is invalid for use as smoke control damper, which has its own CE marking requirements.)

8.2.2.1 Multi-compartment smoke control dampers

8.2.2.2 General

NOTE 1 Multi-compartment smoke control dampers have a classification as fire resisting and can be used to protect and cross compartment barriers. They are suitable for all applications and may be used in single compartment applications.

Smoke control dampers used should as a minimum be classified to BS EN 12101-8 as multi-compartment smoke control dampers.

Sufficiently large openings should be allowed at any wall to allow the smoke control dampers to be installed if they are to be within the boundary. Alternatively, they should be mounted in series with, or on the surface of, the multi-compartment smoke control duct.

If the system:

a) automatically starts on the receipt of a fire or smoke alarm; and

b) the smoke control dampers move immediately to their required position; and

c) there is no override required at any point,

then multi-compartment smoke control dampers classified to BS EN 12101-8 as suitable for automatic activation should be used. If an override is required for smoke clearance, but only after the event, this should be allowed, but it should be noted that any dampers that are closed might remain closed as they have not been proven to open again after exposure to elevated temperatures.

If the system allows inputs to change how the smoke is to be controlled during an event, then multi- compartment smoke control dampers classified to BS EN 12101-8 as suitable for manual intervention should be used.

8.2.2.2.1 Classification to EN13501-4

8.2.2.2.1.1 Multi compartment smoke control damper classification for smoke shaft extract or pressurization systems in apartment blocks

Example - **E {I} [TT] {S} [(V_e and/or H_o)] [1000] [AA] [(i↔o)] [C_{10000}] multi**

{X} are optional – see table

[Y] have options but are required – see table

Key

Segment		Description
Integrity E[TT]	E30 E60 E90 E120	Integrity for fire resistance and ability to maintain cross section for the period (minutes) shown. Maximum leakage at ambient and during the fire test 360 $m^3/h/m^2$ – largest and smallest sizes
Insulation {optional}	EI30 EI60 EI90 EI120	The unit has integrity (E) as above, but with an insulation rating demonstrated by testing to be 140° average / 180°C maximum on the non-fire side of the damper section for the period (minutes) shown.
Reduced leakage {optional}	E30S or EI30S E60S or EI60S E90S or EI90S E120S or EI120S	The unit has integrity (E) as above plus reduced leakage (S) or unit with integrity and insulation (EI) plus reduced leakage (S) section for the period (minutes) shown. Maximum leakage at ambient and during the fire test 200 $m^3/h/m^2$ – largest and smallest sizes
Vertical mounting	v_{ed} v_{ew} v_{edw}	Vertical in duct Vertical in wall Vertical in duct or wall
Horizontal mounting	h_{od} h_{ow} h_{odw}	Horizontal in duct Horizontal in floor Horizontal in duct or floor
Pressure	500 1000 1500	-500Pa ambient and -150Pa fire test -1000Pa ambient and -300Pa fire test -1500Pa ambient and -500Pa fire test
Activation	AA MA	Suitable for automatic activation – immediate in response to a fire or smoke alarm Suitable for delayed activation or manual override during an incident
Approach of fire	i↔o i→o i←o	From both sides From inside to outside (fire inside) From outside to inside (fire outside)
Cycles	C_{300} C_{10000} C_{MOD}	Tested for 300 operations Tested for 10000 operations Tested for 10000 operations plus 10000
Multi		Suitable for both multi and single compartment applications

8.2.2.2.1.2 Single compartment smoke control damper classification for smoke shaft extract or pressurization systems in apartment blocks

Example – **E_{600} [TT] {S} [(V_e and/or H_o)] [1000] [AA] [(i↔o)] [C_{10000}] single**

{X} are optional – see table

[Y] have options but are required – see table

Key

Segment		Description
Integrity E_{600}[TT] **Reduced leakage** {optional}	$E_{600}30$ $E_{600}60$ $E_{600}90$ $E_{600}120$ $E_{600}30S$ $E_{600}60S$ $E_{600}90S$ $E_{600}120S$	Integrity for elevated temperature (600°) and ability to maintain cross section for the period (minutes) shown. The unit has integrity (E) as above plus reduced leakage (S) for the period (minutes) shown.
Vertical mounting	v_{ed}	Vertical in duct
Horizontal mounting	h_{od}	Horizontal in duct
Pressure	500 1000 1500	-500Pa ambient and -150Pa fire test -1000Pa ambient and -300Pa fire test -1500Pa ambient and -500Pa fire test
Activation	AA MA	Suitable for automatic activation – immediate in response to a fire or smoke alarm Suitable for delayed activation or manual override during an incident
Approach of fire	i↔o	From both sides
C_{10000}	C_{300} C_{10000} C_{MOD}	Tested for 300 operations Tested for 10000 operations Tested for 10000 operations plus 10000
single		Suitable for single compartment applications only

8.2.3 Smoke control ducts

Any smoke control ducts should as a minimum be classified to BS EN 13501-4. Multi-compartment smoke control ducts shall be tested to EN1366-1 and then EN1366-8. Single compartment smoke control ducts shall be tested to EN1366-9. Depending on the application, construction and installation compliance with EN12101-7 may be applicable.

Further guidance on the application of the products is given in BS 7346 Part 8. Any ducts crossing a compartment boundary will need to be multi-compartment, which generally applies to all vertical shafts going through floors. Ducts not crossing compartment boundaries and leading directly to outside may be single compartment smoke control ducts.

NOTE 1: Commonly smoke control duct will be required for basement extraction as well as apartment floors and corridors.

The system designer must select the appropriate product in conjunction with building control and the fire brigade.

8.2.3.1 Classification to EN13501-4

8.2.3.1.1 Multi compartment smoke control duct classification for smoke shaft extract or pressurization systems in apartment blocks

Example **– E{I} [TT} {S} [(v_e and/or h_o)] [(i↔o)] [1000] multi**

{X} are optional – see table

[Y] have options but are required – see table

Key

Segment		Description
Integrity E[TT]	E30 E60 E90 E120	Integrity for fire resistance and ability to maintain cross section for the period (minutes) shown. Maximum leakage at ambient and during the fire test 360 $m^3/h/m^2$ – largest and smallest sizes
Insulation {optional}	EI30 EI60 EI90 EI120	The unit has integrity (E) as above, but with an insulation rating demonstrated by testing to be 140° average / 180°C maximum on the non-fire side of the damper section for the period (minutes) shown.
Reduced leakage {optional}	E30S or EI30S E60S or EI60S E90S or EI90S E120S or EI120S	The unit has integrity (E) as above plus reduced leakage (S) or unit with integrity and insulation (EI) plus reduced leakage (S) section for the period (minutes) shown. Maximum leakage at ambient and during the fire test 200 $m^3/h/m^2$ – largest and smallest sizes
Vertical mounting	v_e	Vertical
Horizontal mounting	h_o	Horizontal
Pressure	500 1000 1500	-500Pa ambient and -150Pa fire test -1000Pa ambient and -300Pa fire test -1500Pa ambient and -500Pa fire test
Approach of fire	i↔o	From inside to outside (fire inside) and from outside to inside (fire outside)
multi		Suitable for both multi and single compartment applications

8.2.3.1.2 Single compartment smoke control duct classification for smoke shaft extract or pressurization systems in apartment blocks

Example – **E_{600} [TT] {S} [(v_e and/or h_o)] [(i↔o)] [1000] single**

{X} are optional – see table

[Y] have options but are required – see table

Key

Segment		Description
Integrity E_{600}[TT]	E_{600}30 E_{600}60 E_{600}90 E_{600}120	Integrity for elevated temperature (600°) and ability to maintain cross section for the period (minutes) shown.
Reduced leakage {optional}	E_{600}30S E_{600}60S E_{600}90S E_{600}120S	The unit has integrity (E) as above plus reduced leakage (S) for the period (minutes) shown.
Vertical mounting	v_{ed}	Vertical in duct
Horizontal mounting	h_{od}	Horizontal in duct
Pressure	500 1000 1500	-500Pa ambient and -150Pa fire test -1000Pa ambient and -300Pa fire test -1500Pa ambient and -500Pa fire test
Approach of fire	i↔o	From both sides
single		Suitable for single compartment applications only

8.2.4 Builder’s work shaft used for smoke control

Builder’s work smoke shafts used for smoke control should follow the guidance given in Approved Document B, BS 9991 and BS 7346 Part 8.
The shaft should be constructed from non-combustible materials and be smooth internally. The size of the shaft should be in accordance with the design specification. The shaft and its ancillary components should maintain fire separation between corridors, lobbies and floors at all times. Suitable guarding should be provided where necessary to prevent injury when any ventilator is open to a shaft (e.g. floor grilles).

A builder’s work shaft should have a maximum leakage rate of 3.8 m^3 per hour per m^2 at 50 Pascals. This figure is derived from leakage data for walls in BS EN 12101-6 and is used to set a benchmark to limit air leakage from the shaft.

Whenever shaft systems are used, it is likely that the shaft will pass through a number of compartments, in which case it should be constructed to the same level of fire separation as the floors/walls through which it passes.

The smoke shaft should only contain equipment directly associated with the smoke ventilation system. No other building services should be contained within the smoke shaft.

8.2.5 Control equipment

All control equipment used for smoke control systems should comply with ISO 21927-9. A control system may be centralised, distributed, or a mixture of both.

Where both are used, care should be taken such that an activation of a distributed override device does not compromise the capability of the central control panel or vice versa.

The nature of the system should be that under quiescent conditions the control equipment should be in automatic mode. In this mode the control equipment should be protected against improper use.

Refer to section 5.4 for principles regarding firefighter interaction.

8.2.5.1 Control panel

Consideration should be given to the location of control panels and control equipment. Most control panels complying with ISO 21927-9 are only designed to operate at ambient temperatures. Therefore, they should be located such that the risk of exposure to high temperatures is minimised. It is acceptable to locate control panels which do not provide the primary system indication below the bottom of the lowest vent in the smoke shaft, if adequately protected.

In all instances, the fan control panel should be located in a separate fire compartment to that which it is designed to serve. Where fans are used for smoke extract, it is recommended that the control panel(s) ensure automatic changeover from duty to standby fan (and starting circuit) in the case of a duty fan failure. The controls should be located remote from the potential fire location.

Any fan starter circuit/panel, with or without inverters, needs to be as robust as possible to ensure that the fan will run for as long as practically possible in emergency mode.

Consideration should be given to access for maintenance purposes.

8.2.5.2 Manual control point

The term “manual control point” encompasses generic phrases such as firefighter’s switch, call point, break glass etc. and refers to a distributed activation device, located in or adjacent to the zone that it serves and designated to activate (or deactivate) the zone that it is located in.

There are several functions possible, for example:

- Simple activation (‘breakglass’) or frangible panel which is only capable of activating the zone/device
- Auto/open – switch that is capable of overriding the automatic function of the system and activating the zone/device, or returning it back to its automatic state
- Auto/open/closed– switch that is capable of overriding the automatic function of the system and activating/deactivating the zone/device, or returning it back to its automatic state

Manual control points should be clearly visible and located and/or labelled so their purpose and function is clear. This should include clear indication of what the manual control point is associated with (for example, stair vent or corridor vent). Manual control points should comply with ISO 21927-9 and be coloured deep orange to RAL 2011.

Where these are for FRS use only, they should be mounted at a height of 1.8-2.0m from floor level to discourage tampering.

Note: EN 60335-2-103:2003 sets out safety requirements for automatic gates, windows and doors. Where a potential hazard is evident (such as an automatically closing window or door) the close function of the manual control point should operate on a biased off principle and should be located in sight of the window or door.

8.2.5.3 Manual control points (MCP) for mechanical systems

For mechanical systems a fire fighters override switch providing open/closed/auto facility should be installed close to the designated Fire and Rescue Service access point. Variations to these recommendations might be considered as part of the consultation process with the AHJ.

8.2.5.4 Centralised control and indication equipment

There are no specific requirements for centralised control and indication facilities set out in any of the relevant design guides. However, in complex buildings, a centralised firefighter’s panel with indication showing the location (e.g. block and floor) of fire detection and the status (e.g. dampers or vents open / closed, duty fan running) of all systems may be beneficial and should be considered. Furthermore, it is common that there is no requirement for a fire alarm panel to be provided in residential buildings with a ‘stay-put’ evacuation strategy and the smoke control panel may be the only form of indication available to the Fire and Rescue Service.

The provision of centralised control and indication facilities may be particularly important where designs that do not follow applicable guidance, such as common corridors with extended travel distances, are proposed and the protection of the means of escape for occupants as well as access routes for the Fire and Rescue Service may rely upon the successful operation of performance-based smoke control systems.

In such cases, it is strongly recommended that the indication of system faults (e.g. failed dampers or fans) and the indication of the status of key system components when the system is operating are provided. Such indication is likely to assist with regular maintenance and fire safety management by providing indication of any system faults that may occur and this will also assist the Fire and Rescue Service in the event of an incident.

It is recommended that the monitoring of key system components be derived from direct feedback from the components (e.g. damper actuator end-switches or equivalent) and not simply from command status. This is particularly critical where a smoke control system is provided as a compensatory measure for non-applicable guidance designs as safe occupation of the building may be contingent upon the availability of the smoke control system. Indication of the status of key system components may be via the fire alarm panel if no smoke control system control and indication panel is provided.

All power and control cabling should comply with the relevant recommendations of BS 8519:2019. Control and indication panels should comply with ISO 21927-9 and be provided with a secondary power supply.

Where Graphic User Interface (GUI) panels (e.g. touch screen panels) are used, these panels should not be the only means for Fire and Rescue Service manual override of the system or for the control of critical functions. In particular, provision of a centralised control and indication panel should not replace manual control points for Fire and Rescue Service use.

Control/override panels should incorporate the following:

- A simple, user friendly interface, considering the needs of the Fire and Rescue Service
- The ability for the panel (whether GUI type or positive switched) to be used by firefighters wearing gloves
- Access level/security protection of the maintenance functions
- Protection from tampering when the panel is located in a public area, while continuing to allow override functionality for the Fire and Rescue Service when the system is operational
- Suitable reliability, resilience and robustness for the application.

Simplicity of control and indication equipment is recommended, as firefighters will rarely have the time during an incident or the specialised knowledge to make appropriate use of complex controls.

In addition to the above, it is important that clear and concise operational instructions for firefighters on the system operation and its controls are provided, especially where it is expected that firefighters may need to manually interact with the system. Such information should be appropriately sited in a suitably identified premises information box or folder, marked “For Fire and Rescue Service use only”.

The location of the centralised control equipment should be clearly indicated at all Fire and Rescue Service access points.

The AHJs should always be consulted regarding additional requirements for control and indication equipment where non-applicable guidance designs are proposed.

If the central fire-fighting control panel allows control of ventilators remotely, then care should be taken to ensure that occupants are not endangered by remotely closing vents. Refer to section 8.2.5.2.

8.2.5.6 Automatic smoke detection

Any smoke detection system used to operate the smoke control system should comply with either BS5839 part 1 at a minimum standard of L5 or ISO 21927-9. The detectors should comply with EN54. If the system is only compliant with ISO 21927-9, then the detection system should be used solely for the activation of the smoke control system and cannot be used as a fire alarm system.

8.2.6 Power supply equipment

BS EN 12101 Smoke and heat control systems: *Part 10 power supplies* is harmonised under the Construction Products Regulation. All power supplies for smoke control systems shall be CE marked to BS EN12101 part 10.

The power supply equipment should either have inherent resistance to or be protected from mechanical damage. Each connection to the power supply should be via an isolating protective device reserved solely for the smoke control system and independent of any other main or sub-main circuit. The power supply, isolating devices and related equipment should be clearly labelled as to their purpose and be secured against unauthorised operation.

8.2.6.1 Classification

The essential characteristics of power supplies for smoke control systems are detailed below. The performance characteristics recommended by the SCA illustrate those generally expected in common applications. The designer should consider the application and select a classification accordingly.

Essential Characteristics of Power Supplies for Smoke and Heat Control Systems tested to EN 12101 part 10 2005				
SCA recommended performance characteristics by application				
EN12101-10 Annex ZA				
			Power supply from secondary power source	Generator
Essential Characteristics	Unit	Relevant Clauses		
Operational reliability		6 and 7	Class 1	Class 1
Performance parameters under fire conditions		4.1 and 5.2.1	Class A	Class A
Response time	s	4.1, 5.2.1, 6.2.2 and 6.3.1	<5	<15

8.2.7 Inverters

Power supplies for life safety systems using an Inverter or Variable Frequency Drive (VFD) or Variable Speed Drive (VSD) to control the fan should be fitted with a DOL or Star-Delta bypass in event of fire, unless the fan has been tested with the VFD or de-rates have been applied as stipulated in EN12101-3.

If the life safety ventilation system is required to have multiple speeds in fire mode, in order to perform the required duty, each speed should be separately hard-wired and initiated from the individual fire alarm interface modules.

8.2.8 Fans

8.2.8.1 Smoke extract fans

All fans used for smoke extract shall be tested and certified to BS EN 12101-3 Smoke and heat control systems. Specification for powered smoke and heat control ventilators Designers of smoke control systems who wish to use variable speed operation should satisfy themselves that the combination of fan and inverter are compatible and will operate satisfactorily under the design conditions. In the event of a fire then the inverter should be bypassed as described above or one of the following two conditions should be met:

1) Fan and inverter have been tested to EN12101-3 together;
2) The fan is de-rated according with EN12101-3 and suitable filters fitted.

Care should be taken to ensure continuity of power supplies to all fans (see 8.3).

Designers should also clearly define what temperature rating of fan they are using, and provide a statement as to why this rating is appropriate for the project in question.

8.2.8.2 Supply fans

Supply fans used for air inlet to smoke ventilation and pressurisation systems are not expected to operate at high temperature, so ambient rated fans may be used (to ISO 5801: 2017, AMCA 210-16). BS EN 12101-6 allows a single fan set to be used for each pressurisation system in a multi-stair building but a standby fan is recommended if the building has only one stair. Care should be taken to ensure continuity of power supplies to all fans (see 8.3).

Where a reversible system is proposed both sets of fans should be CE marked to BS EN 12101-3

8.2.9 Pressure sensing devices

Pressure sensing devices are typically utilised in a system to protect against excessive pressure differentials across escape doors. The pressure sensing devices give outputs to the control system which will vary the speed drive to the pressurisation fan to prevent over pressure occurring. Care needs to be taken in selection and commissioning as the speed of response required by EN12101-6 is difficult to achieve.

The operational reliability of pressure sensing devices needs to be maintained to ensure the correct operation of the system therefore location of sensors and ongoing maintenance regimes need to be considered.

Failure modes of pressure sensors should ensure that, on sensor failure, high pressure differentials do not create excessive door forces.

8.3 Cabling and Electric Power Supply Installation

8.3.1 Cabling

To ensure correct operation of the smoke ventilation system, power and control cables must maintain their integrity during a fire incident. Cables should comply with BS 8519.

All apartment buildings over 11m high should have category 3 cables.

Where a smoke control system has a fire fighting interaction, whereby a fire fighter can change the status of the smoke control system, then the system is regarded as a category 3 system in accordance with BS 8519, and both power and control cables should have a 120 min fire survival time.

BS 8519 specifies separate test standards for power and control cables. Generally, it is considered that any cables providing power to the main control panel and fans should be considered a power cable, whilst cables to dampers and other devices should be considered control cables. BS 8519 specifies the test standard BS 8491 for power cables and BS EN 50200 for control cables.

There are circumstances where elements of cabling may not need to satisfy the categories identified in BS8519. In these instances, an engineering view should be applied. For example where the fan control panel and smoke ventilation fans are located on the open roof, the roof is fire resisting and the cables between the fan control panel and the fans do not run through a fire compartment, it may be acceptable to relax the cable specification set out in BS 8519 providing sufficient justification is evidenced.

8.3.2 Power Supplies

If a smoke control system fails to the operational position on loss of power, then only one power source is required, in all other cases a dual supply is required

If the primary power source fails, then the power supply should be automatically switched over to a secondary power source. Failure of or damage to one of the power sources should not cause the failure of the other power source or the failure of the supply of power to the system.

Each power supply should provide the power requirements of the worst case scenario at design duty under ambient conditions.

For electrical systems it is generally recommended that the primary power source is taken from the public utility supply. Secondary power can be supplied from an alternative utility supply from another substation, a generator, a UPS or batteries.

Guidance on the provision of power supplies for life safety systems within residential buildings is further provided within BS 9991.

8.3.3 Power Distribution

For mechanical systems the primary and secondary power cables should only come together in the fire resisting enclosure or fire resisting roof area housing the fan control panel by means of an automatic transfer switch (ATS) conforming to BS EN 60947-6. Where the availability of the safety and fire-fighting equipment is conditional to the occupation of the building, a bypass arrangement should be incorporated to enable the changeover device to be maintained without loss of service from the critical plant. The enclosures surrounding the ATS and the fan control panel should be provided with a minimum of 60 minutes fire resisting construction.

The electrical distribution system should conform to BS 7671 and the relevant parts of BS EN 60947, BS 7346 Part 8 and BS 8519.

9 Commissioning and Acceptance Testing

9.1 Introduction

Testing any form of ventilation system is a fundamental part of the process of setting to work and the proving of its performance against the design criteria.

As smoke control systems are primarily life safety systems and/or for assistance to the Fire and Rescue Service it is imperative that the smoke control system is tested by the installer and then offered for witness testing to the authority having jurisdiction (AHJ) to prove its compliance with the project specification and the approved design criteria.

BS7346 Part 8 sets out the recognised code of practice for commissioning and acceptance testing of a smoke control system including examples of certification. The following sections provide useful guidance intended to supplement that given in BS 7346 Part 8.

In addition extract rates for mechanical systems should be proven. Guidance to testing airflows can be found in the BSRIA Guide – Commissioning Air Systems.

Where smoke tests/ system demonstrations are being completed for AHJ to witness, it would be expected that the specialist contractor confirms the method statement for the test/ demonstration in advance, which would include agreed acceptance criteria.

9.2 Documentation

All smoke control systems should be handed over to the end user with a complete set of documentation. This should include at least:

- Design information detailing the performance criteria for the system and a description of the system
- A control philosophy or cause and effect diagram
- As installed drawings
- Relevant CE marking or type test certificates
- Installation and commissioning certificates
- Witness testing certificates or other evidence that the system was tested in front of the authority having jurisdiction (AHJ)
- Operation, maintenance and testing instructions
- Instructions for Fire and Rescue Service use

This information should meet the requirement of regulation 38 of the Building Regulations (England and Wales), requiring the person carrying out the work to provide sufficient information for persons to operate and maintain the building in reasonable safety. It will also assist the eventual owner/occupier/employer to meet their duties under the Regulatory Reform (Fire Safety) Order.

9.3 Test Procedures

9.3.1 Airflow measurement

There is no specific guidance for recording smoke extraction rates in mechanical smoke extraction systems.

Where it is difficult to undertake reliable pitot tube readings for mechanical smoke extraction systems due to the orientation of dampers, shafts and the fan location, the following guidance should be used.

BSRIA BG49/2013 clarifies that damper/grille flow rates can be considered as the average velocity multiplied by the grille face area with no correction for the free area of the grille. The readings should be taken as per the grid system recommended in Table 6 of the BSRIA document and the most favourable reading should be taken in each position making an allowance for the deflection of the grilles. In some circumstances depending on the grille finish, it may be necessary to record the readings 500mm away from the grille by means of a clear 4 sided box extension and the velocity multiplied by the box area.

It is recommended that the flow rates are recorded at the closest and most remote damper from the fan to ensure the required extraction rate through the damper/grille is achieved.

9.3.2 Stairwell ventilator

- Operate each stairwell ventilator via the activation of the designated manual or automatic device.
- Inspect the motor drive for correct operation and extension.
- Measure the size of the opening provided by the ventilator in accordance with diagram D7 of ADB 2019 and check the area for compliance with the specified area or confirm the product meets the declared aerodynamic free area.
- Check the operation of the manual control point(s) to ensure the system operates as requested.
- Check that a secondary power supply is available on loss of the primary power supply.
- Reset the system on completion of test.
- Provide a certificate of test
- Provide a certificate of compliance.

9.3.3 Wall mounted ventilator

- Operate each wall ventilator via the activation of the designated initiating manual or automatic device.
- Inspect the motor drive for correct operation and extension.
- Check the ventilators operate in accordance with the design cause and effect and inspect for correct operation and extension.
- Measure the size of the opening provided by the ventilator in accordance with diagram D7 of ADB 2019 and check the area for compliance with the specified area or confirm the product meets the declared aerodynamic free area.
- Check the operation of the manual control point(s) to ensure the system operates as requested.
- If present, check that a secondary power supply is available on loss of the primary power supply.
- Reset the system on completion of test.
- Provide a certificate of test
- Provide a certificate of compliance.

9.3.4 Natural ventilator shaft system

- Operate each shaft ventilator via the activation of the designated manual or automatic device.
- Inspect the motor drive for correct operation and extension.
- Check the ventilators into the smoke shaft operate in accordance with the design cause and effect and inspect for correct operation and extension. Only one shaft ventilator should open at any time, all ventilators on other floors should remain

closed. The test should confirm that this continues to be the case even if an automatic signal is received on floors other than the original floor.

- Measure the size of the opening provided by each of the ventilators in accordance with diagram D7 of ADB 2019 and check the area for compliance with the specified ventilator areas.
- Check the operation of the manual control point(s) to ensure the system operates as requested.
- Check the cross sectional area of the smoke shaft and that it complies with the specified design area.
- Where appropriate:

  − Check that the minimum dimension of 850mm (in any direction) for the shaft has been complied with.
  − Check the shaft opening at roof level is at least 0.5m above any surrounding structure within a horizontal distance of 2.0m
  − Check that the smoke shaft extends at a minimum of 2.5m above the ceiling of the highest storey served by the shaft.
  − Check that a secondary power supply is available on loss of the primary power supply.
  − Reset the system on completion of test.
  − Provide a certificate of test
  − Provide a certificate of compliance.

9.3.5 Mechanical shaft system

- Operate each shaft ventilator via the activation of the designated manual or automatic device.
- Check the automatic change over is operational for the standby fan.
- Check the automatic change over is operational for the secondary power supply.
- Check the ventilators in the smoke shaft and the fans operate in accordance with the design cause and effect and inspect for correct operation.
- Measure the flow rate into the shaft system at the ventilator furthest from the fan position.
- Only one shaft ventilator into one shaft should open at any time, all ventilators on other floors should remain closed. The test should confirm that this continues to be the case even if an automatic signal is received on floors other than the original floor.
- Check the maximum forces required to open escape doors whilst the system is operating in means of escape mode and record results. The recorded force must not exceed 100N.
- Check the operation of the manual control point(s) to ensure the system operates as requested. Where a manual control point for firefighting use is provided at each floor level to switch between fan speeds then the operation of this switch should also be checked that it results in the correct action.
- Carry out a cold smoke test if appropriate (generally only for systems used to allow extended travel distances).
- Reset the system on completion of test.
- Provide a certificate of test
- Provide a certificate of compliance with the design intent.

9.3.6 Pressure differential system (pressurisation and de-pressurisation)

BS EN 12101-6 provides a detailed set of test procedures which should be carried out, and recorded for this type of system and in addition to the test readings taken in accordance with the standard, the following inspections are also recommended:

- Operate each motorised damper by activation of the designated manual or automatic device.
- Check that the fan(s) operate at the same times as the opening of the dampers, measure its performance and check against the design value.
- Check the automatic change over is operational for the standby fan.
- Check the automatic change over is operational for the secondary power supply.
- Inspect the motor drive for correct operation and extension.
- Operate the ventilators and fans in accordance with the design cause and effect and inspect for correct operation and extension.
- Check the maximum forces required to open escape doors while the system is operating in means of escape mode and record results. The recorded force must not exceed 100N.
- Check the operation of the manual control point(s) to ensure the system operates as requested.
- Where applicable, the operation and function of the pressure sensors should also be checked.
- Reset the system on completion of test.
- Provide a certificate of test.
- Provide a certificate of compliance.

10. Maintenance

It is the responsible person's duty under the Regulatory Reform (Fire Safety) Order to ensure that any smoke control system provided in their building for life safety and/ or fire fighting purposes is adequately maintained in effective working order at all times. The premises fire risk assessment should fully account for the type of smoke control system installed, its operation, and what monitoring checks and maintenance regime it is subjected to.

Routine inspection and maintenance of the smoke control system should be carried out in accordance with BS 9999, Annex I.

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 (such as the manufacturers' operation and maintenance instructions as a minimum). The SCA strongly recommends the use of third party accreditation schemes (for example, the SCA supports the IFC Certification Ltd SDI 19 scheme for Installation and Maintenance of Smoke Control Systems).

Further guidance on the maintenance of smoke control systems is available in BS 7346-8.

11 References

11.1 EU Directives

Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products

Council Directive EMC 89/336/EEC on Electromagnetic Compatibility (as amended)

Council Directive LVD 2006/95/EC on Low Voltage Electrical Equipment (as amended)

11.2 Legislation

The Building Regulations 2010 No. 2214 as amended, The Stationery Office, London, 2010

The Construction Products Regulation 2013 No 1387

The Construction (Design and Management) Regulations 2015 No. 320, The Stationery Office, London, 2015

The Workplace (Health, Safety and Welfare) Regulations 1992 No. 3004, The Stationery Office, London, 1992

The Regulatory Reform (Fire Safety) Order 2005 No.1541, The Stationery Office, London, 2005

Approved Document B (Fire Safety) – Volume 1 – Dwellings
(2019 Edition), The Stationery Office, London, 2019

Approved Document L2A: Conservation of fuel and power (New Buildings other than dwellings) 2013 edition, The Stationery Office, London, 2013

2017 Technical Handbook, Domestic, The Scottish Government, Building Standards Division, 2017

DFP Technical Booklet E: 2012 – Fire Safety, Department of Finance and Personnel, Belfast, 2012

DFP Technical Booklet F2: 2012 – Conservation of fuel and power in buildings other than dwellings, Department of Finance and Personnel, Belfast, 2012

11.3 Standards

BS 476-20 *Fire tests on building materials and structures. Method for determination of the fire resistance of elements of construction (general principles)*

BS 476-22 *Fire tests on building materials and structures. Methods for determination of the fire resistance of non-load bearing elements of construction*

BS 476-24, ISO 6944 *Fire tests on building materials and structures. Method for determination of the fire resistance of ventilation ducts*

BS 5588-5 *Fire precautions in the design, construction and use of buildings. Access and facilities for fire-fighting* (withdrawn)

BS 5839-1 *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 *Codes of Practice for planning, design, installation, commissioning and maintenance*

BS 7899-2 *Code of practice for assessment of hazard to life and health from fire. Guidance on methods for the quantification of hazards to life and health and estimation of time to incapacitation and death in fires*

BS 7974 *Application of fire safety engineering principles to the design of buildings. Code of practice*

BS 8434-2+A2:2009 *Methods of test for assessment of the fire integrity of electric cables. Test for unprotected small cables for use in emergency circuits. BS EN 50200 with a 930° flame and with water spray*

BS 8491 *Method for assessment of fire integrity of large diameter power cables for use as components for smoke and heat control systems and certain other active fire safety systems*

BS 8519 *Selection and installation of fire-resistant power and control cable systems for life safety and fire-fighting applications. Code of practice*

BS 9991 *Fire safety in the design, management and use of buildings – Code of practice*

BS 9999 *Code of practice for fire safety in the design, management and use of buildings*

BS EN 54 (all parts) *Fire detection and fire alarm systems.*

BS EN 1363-1 *Fire resistance tests. General requirements*

BS EN 1364-2 *Fire resistance tests for non-load bearing elements. Ceilings*

BS EN 1366-1 *Fire resistance tests for service installations. Fire resistance tests for service installations. Ducts*

BS EN 1366-2 *Fire resistance tests for service installations. Fire dampers*

BS EN 1366-8 *Fire resistance tests for service installations. Smoke extraction ducts*

BS EN1366-10 *Fire resistance tests for service installations. Smoke control dampers*

BS EN 1634-1 *Fire resistance and smoke control tests for door, shutter and, openable window assemblies and elements of building hardware. Fire resistance tests for doors, shutters and openable windows*

BS EN 12101-2 *Smoke and heat control systems. Specification for natural smoke and heat exhaust ventilators*

BS EN 12101-3 *Smoke and heat control systems. Specification for powered smoke and heat exhaust ventilators*

BS EN 12101-6 *Smoke and heat control systems. Specification for pressure differential systems. Kits*

BS EN 12101-7 *Smoke and heat control systems. Smoke duct sections*

BS EN 12101-8 *Smoke and heat control systems. Smoke control dampers*

prEN 12101-9 *Smoke and heat control systems. Control equipment*

BS EN 12101-10 *Smoke and heat control systems. Power supplies*

BS EN 12589 *Ventilation for buildings. Air terminal units. Aerodynamic testing and rating of constant and variable rate terminal units*

BS EN 13501-4+A1:2009 *Fire classification of construction products and building elements. Classification using data from fire resistance tests on components of smoke control systems*

BS EN 60335-2-103 *Household and similar electrical appliances. Safety. Particular requirements for drives for gates, doors and windows*

BS EN 60730-2-6 *Automatic electrical controls for household and similar use. Particular requirements for automatic electrical pressure sensing controls including mechanical requirements*

BS EN 61000-6-3+A1:2011 *Electromagnetic compatibility (EMC). Generic standards. Emission standard for residential, commercial and light-industrial environments*

BS EN ISO 5801, BS 848-1 *Industrial fans. Performance testing using standardized airways*

BS ISO 21927-9 *Smoke and heat control systems. Specification for control equipment*

ANSI/AMCA Standard 210-16/ASHRAE Standard 51-16: *Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating*

11.4 Guidance and papers

BRE Project Report 79204, *Smoke Shafts protecting Fire-Fighting Shafts: their performance and design*, Building Research Establishment Ltd, Garston, 2002

BRE project report 213179, *Smoke Ventilation for Common Access Areas of Flats and Maisonettes (BD2410) – Final Factual Report*, Building Research Establishment Ltd, Garston, 2005

BSRIA Guide BG 49/2013, *Commissioning Air Systems*, BSRIA, Bracknell, 2013

CIBSE Guide E, *Fire Engineering*, 4th edition, CIBSE, London, 2019

LDSA paper, *Mechanical Smoke Venting of Residential Lobbies and Fire Fighting Shafts. LDSA Fire engineering performance criteria Paper,* London District Surveyor's Association, London, 2006

SFPE *Handbook of Fire Protection Engineering*. 5th edition, Society of Fire Protection Engineers

T. Jin, *Studies on Human Behaviour and Tenability in Fire Smoke,* Proceedings, 5th International Symposium on Fire Safety Science, pp. 3–22, 1997

Annex A: Equipment List

Ref	Product Group	Product	Location	Product Type	Application	Associated Standards	Regulatory Guidance	
Ventilators								
8.2.1		Automatic Opening Vent	External Wall	Automatic Opening Louvre	Outlet	EN12101-2, EN 60335-2-103	AD-B	AD-L
				Automatic Opening Casement Window	Outlet	EN12101-2, EN 60335-2-103	AD-B	AD-L
			Stairwell Vent	Automatic Opening Casement Window	Inlet/ Outlet	EN12101-2, EN 60335-2-103	AD-B	
				Automatic Opening Sloping Window	Inlet/ Outlet	EN12101-2, EN 60335-2-103	AD-B	
				Automatic Opening Rooflight	Inlet/ Outlet	EN12101-2, EN 60335-2-103	AD-B	
				Automatic Opening Louvre	Inlet/ Outlet	EN12101-2, EN 60335-2-103	AD-B	

			Head of shaft Smoke Vent	Automatic Opening Rooflight	Inlet/ Outlet	EN12101-2	AD-B	
				Automatic Opening Louvre	Inlet/ Outlet	EN12101-2	AD-B	

8.2.2		Smoke shaft damper	Lobby to shaft AOV	Automatic Opening Vent Smoke control damper	Inlet/Outlet	EN12101-8, EN1366-10, EN13501-4, EN 60335-2-103	AD-B	
8.2.3		Manual Opening Vent	External Wall	Louvre	Outlet		AD-B	AD-L
				Casement Window	Outlet		AD-B	AD-L
8.2.4			Stairwell Vent	Casement Window	Outlet		AD-B	
				Roof light	Outlet		AD-B	
				Louvre	Outlet		AD-B	
Fans								
8.2.5		Powered Extract Fan	Smoke Shaft	Smoke Ventilation Fan	Outlet	EN12101-3		

8.2.6		Powered Inlet Fan	Smoke Shaft	Fan	Inlet	ISO 5801: 2017 AMCA210-16		
Ductwork								
8.2.7		Barometric (Pressure Relief / Non Return) Damper				Special test to EN12589		
8.2.8		Pressure Volume Flow Rate (PDS)				EN60730-2-6, Special test on basics of EN12589		
8.2.9		Smoke Control Ductwork				EN12101-7, EN13501-4, BS 476-24, EN1366-8, EN1366-1	AD-B	
8.2.10		Builders Work Shaft				BS 476 *BS 7346-8*	AD-B	
Control Systems								
8.2.11		Control Panels Centralised				*prEN12101-9,ISO 21927-9*, EN12101-10, LVD 2006/95/EC, EMC 89/336/EEC		
		Control Panels Distributed						
		Control Panels - Motors						
8.2.12		Manual Control Point				*prEN12101-9, ISO 21927-9*, EN12101-10, LVD 2006/95/EC, EMC 89/336/EEC , EN60335-2-103		
8.2.13		Automatic Smoke Detection				*prEN12101-9, ISO 21927-9*, EN54, BS5839		

8.2.14		Indication Panel				LVD 2006/95/EC, EMC 89/336/EEC		
8.2.15		Power Supplies		Primary		EN12101-10, LVD 2006/95/EC, EMC 89/336/EEC		
				Secondary				
8.2.16		Cables				BS 8491, BS 5839 enhanced, BS8519		
8.2.17		Pressure Sensing Devices				EN61000-6-3		