

Fire precautions in the design, construction and use of buildings —

Part 4: Code of practice for smoke control using pressure differentials

ICS 13.220.20; 91.040.01

Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee FSH/14, Fire precautions in buildings, upon which the following bodies were represented:

- British Gas plc
- British Retail Consortium
- British Standards Society
- British Telecommunications plc
- Chartered Institution of Building Services Engineers
- Chief and Assistant Chief Fire Officers' Association
- Consumer Policy Committee of BSI
- Department for Education
- Department of Health
- Department of the Environment (Building Research Establishment)
- Department of the Environment (Property and Buildings Directorate)
- Department of the Environment for Northern Ireland
- District Surveyors' Association
- Electricity Association
- Fire Brigades Union
- Health and Safety Executive
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- Institute of Building Control
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- London Fire and Civil Defence Authority
- Loss Prevention Council
- National Association of Fire Officers
- National Council of Building Material Producers
- Royal Institute of British Architects
- Scottish Office (Building Directorate)
- Timber Research and Development Association

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

- Access Committee for England
- Association of Building Engineers
- Association of Consulting Engineers
- British Automatic Sprinkler Association
- British Council of Shopping Centres
- British Fire Protection Systems Association Ltd.
- British Fire Services' Association
- British Property Federation
- Building Services Research and Information Association
- Flat Glass Manufacturers' Association
- Hevac Association
- Institute of Fire Safety
- Institution of Fire Engineers
- Intumescent Fire Seals Association
- Nationwide Fire Services
- Steel Window Association
- Warrington Fire Research Centre

This British Standard, having been prepared under the direction of the Management Systems Sector Board, was published under the authority of the Standards Board and comes into effect on 15 March 1998

© BSI 8 December 2004

First published June 1978
Second edition March 1998

The following BSI references relate to the work on this British Standard:
Committee reference FSH/14
Draft for comment 92/39700 DC

ISBN 0 580 26246 4

Amendments issued since publication

Amd. No.	Date	Comments
10019 Corrigendum. No. 1	April 1998	Unit corrected
13868	4 December 2002	See national foreword
14989	8 December 2004	See national foreword

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Foreword

This code of practice was prepared under the direction of Technical Committee FSH/14. It supersedes BS 5588-4:1978, which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags **[A]** **[A]**. Tags indicating changes to text carry the number of the amendment. For example, text altered by Amendment No. 1 is indicated by **[A]** **[A]**.

The other parts which comprise BS 5588 are as follows:

- *Part 0: Guide to fire safety codes of practice for particular premises/applications;*
- *Part 1: Code of practice for residential buildings;*
- *Part 5: Code of practice for firefighting stairs and lifts;*
- *Part 6: Code of practice for places of assembly;*
- *Part 7: Code of practice for the incorporation of atria in buildings;*
- *Part 8: Code of practice for means of escape for disabled people;*
- *Part 9: Code of practice for ventilation and air conditioning ductwork;*
- *Part 10: Code of practice for shopping complexes;*
- *Part 11: Code of practice for shops, offices, industrial, storage and other similar buildings;*
- *Part 12: Managing fire safety.*

It has been assumed in the drafting of this code that the execution of its provisions will be entrusted to appropriately qualified and experienced people.

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 73 and a back cover.

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Introduction

The pressure differential systems referred to in this standard are primarily intended for life safety and firefighting purposes with the objective of maintaining tenable conditions in protected escape routes, refuges, firefighting shafts, lobbies, etc. The general principles presented in this standard may also be applied in situations where the primary aim is to prevent contamination by smoke, of goods or equipment in rooms adjacent to a fire-affected space.

Guidance is given on the design of systems intended either to maintain a positive pressure within protected spaces (pressurization) or to remove hot gases from the fire zone so as to maintain it at a lower pressure than the adjacent protected space (depressurization).

Pressure differential systems provide one means of improving the level of fire safety within a building. 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, firefighting and property protection within the building.

This standard presents the general principles to be adopted in the design of various types of pressure differential system. However, circumstances vary from building to building and it is not possible to cover every situation here, although it may be possible to design an effective system for other applications using the principles of this standard.

1 Scope

This part of BS 5588 gives guidance on the design, installation, testing and maintenance in new and existing buildings of systems intended to limit the spread of smoke by means of pressure differentials.

However, this standard does not cover smoke ventilation systems used in theatres and other places of assembly which protect the auditorium from a fire in the stage area by creating a pressure differential between the stage and the auditorium.

2 References

2.1 Normative references

This part of BS 5588 incorporates, by dated or undated reference, provisions from other publications. These normative references are made at the appropriate places in the text and the cited publications are listed on page 72. For dated references, only the edition cited applies; any subsequent amendments to, or revisions of the cited publication apply to this part of BS 5588 only when incorporated in the reference by amendment or revision. For undated references, the latest edition of the cited publication applies, together with any amendments.

2.2 Informative references

This part of BS 5588 refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on page 73, but reference should be made to the latest editions.

3 Definitions

For the purposes of this British Standard the following definitions apply.

3.1

accommodation area

area of a building where the main work function of the building is carried out

3.2

air release

means by which pressurizing air is able to escape from the accommodation area or other unpressurized space to external air

3.3

atrium

space within a building, not necessarily vertically aligned, passing through one or more structural floors

NOTE Enclosed lift wells, escalator wells, building services ducts and stairways are not classified as atria

3.4

basement

storey with a floor that is at some point more than 1.2 m below the highest level of ground adjacent to the outside walls

3.5

controlled fire load

fire load that is limited by means of management controls on the quantities of combustible material that are present on the atrium base or where the fire load is limited by an effective automatic suppression system

3.6

dedicated system

pressure differential system that does not share components with any other system

3.7

depressurization

smoke control using pressure differentials where the air pressure in adjacent spaces is reduced to below that in the protected space

3.8

depressurized space

part of a building from which air and smoke are extracted for the purposes of depressurization

3.9

depth (of a building)

distance to the surface of the lowest point of the floor of the lowest storey, measured at the centre of that face of the building where the measurement is greatest from the level of the footway or paving in front of that face, or if there is no such footway or paving, from the level of the ground

3.10

escape route

route forming part of the means of escape from any point in the building to a final exit

3.11

evacuation lift

lift that may be used for the evacuation of disabled people in an emergency

3.12

final exit

termination of an escape route from a building giving direct access to a street, passageway, walkway or other open space sited to ensure the rapid dispersal of persons from the vicinity of a building so that they are no longer in danger from fire and/or smoke

3.13

fire compartment

building or part of a building, comprising one or more rooms, spaces or storeys, constructed to prevent the spread of fire to or from another part of the same building, or to an adjoining building

3.14

fire detection zone

sub-division of the building such that the detection of a fire within it will be indicated by the fire alarm system separately from an indication of fire in any other sub-division

3.15

fire resistance

ability of a component or construction of a building to satisfy for a period of time some or all of the appropriate criteria specified in the relevant part of BS 476

3.16**fire zone**

room or compartment in which the fire is assumed to occur for the purposes of design of pressure differential systems

3.17**firefighting lift**

lift designated to have additional protection for firefighting use, directly controllable by the fire service when fighting a fire

3.18**firefighting lobby**

protected lobby providing access from a firefighting stair to the accommodation area and to any associated firefighting lift

3.19**firefighting shaft**

protected enclosure containing a firefighting stair, firefighting lobbies and, if provided, a firefighting lift together with its machine room

3.20**firefighting stair**

protected stairway communicating with the accommodation area only through a firefighting lobby

3.21**height**

for buildings, the distance to the surface from the highest point of the floor of the highest storey (excluding any such storey consisting exclusively of plant rooms), measured at the centre of that face of the building where the measurement is greatest to the level of the footway or paving in front of that face, or if there is no such footway or paving, to the level of the ground

3.22**HVAC**

heating, ventilation and/or air conditioning

3.23**inherent leakage paths**

gaps or cracks in the construction or around doors and windows etc. which provide a path for air to flow between the pressurized/depressurized space and the external air

3.24**lift well**

space in which the lift and the counterweight (if any) move. This space is materially enclosed by the bottom of the pit, the vertical walls and the ceiling

3.25**means of escape**

structural means whereby a safe route is provided for persons to travel from any point in a building to a place of safety

3.26**neutral pressure plane**

point in a building where the internal air pressure due to wind and stack effects is equal to the external ambient pressure

3.27**non-dedicated system**

pressure differential system that shares components with another system, such as an HVAC system

3.28**over-pressure relief**

provision for releasing excess pressurizing air from the pressurized space

3.29

phased evacuation

system of evacuation in which different parts of premises are evacuated in a controlled sequence. Those parts of the building expected to be at greatest risk are evacuated first

3.30

place of safety

place in which persons are in no danger from the consequences of a fire within the building

3.31

pressurization

smoke control using pressure differentials, where the air pressure in the spaces being protected is raised above that in the fire zone

3.32

pressure containment lobby

lobby provided at fire access level to reduce the loss of pressure from a stair due to a final exit door being constantly open

3.33

pressure differential system

system of fans, ducts and vents provided for the purpose of creating a pressure differential between the fire zone and the protected space

3.34

pressurized space

shaft, lobby, corridor or other compartment in which the air pressure is maintained at a higher value than that of the fire zone

3.35

protected corridor

circulation area consisting of a corridor enclosed with fire-resisting construction (other than any part that is an external wall of a building)

3.36

protected escape route

escape route having an adequate degree of fire protection

3.37

protected lobby

circulation area consisting of a lobby enclosed with fire-resisting construction (other than any part that is an external wall of a building)

3.38

protected space

fire-resisting shaft or compartment within a building which is protected against the ingress of smoke by a pressure differential system

3.39

protected stairway

stair discharging through a final exit to a place of safety (including any exit passageway between the foot of the stair and the final exit) that is adequately enclosed with fire-resisting construction

3.40

refuge

area that is both separated from a fire by fire-resisting construction and provided with a safe route to a storey exit, thus constituting a temporarily safe space for disabled persons to await assistance for their evacuation

3.41**simple lobby**

lobby that does not give direct access to lifts, shafts or ducts that could constitute a significant leakage path for smoke to spread to other storeys within the building. A simple lobby may be either unventilated or naturally ventilated

NOTE A lobby connected to a lift well or other shaft is still a simple lobby if all such shafts are pressurized.

3.42**single-pressure system**

pressure differential system in which the air supply to a pressurized space or extraction from a depressurized space is designed to operate only in an emergency

3.43**single-stage system**

pressure differential system designed to work only in an emergency

3.44**smoke control**

technique for influencing the production, movement or removal of smoke from a building in order to protect the means of escape, contents or structure, and/or to assist firefighting operations

3.45**smoke control zone**

sub-division of a building for smoke control purposes

3.46**smoke damper**

mechanical device that when closed prevents smoke passing through an aperture within a duct or structure. The device may be open or closed in its normal position and may be automatically or manually actuated

3.47**smoke shaft**

enclosed space in a building provided for venting smoke from a firefighting stair or one or more firefighting lobbies or other protected areas

3.48**stack effect**

pressure differential resulting from the differences in density of two interconnected columns of air at different temperatures, one inside the building at the internal ambient temperature, and the other outside the building at the external ambient temperature

3.49**storey exit**

final exit (see 3.12), or a doorway giving direct access to a protected stairway, protected lobby or external escape route

3.50**two-pressure system**

pressure differential system in which a continuous low level of operation is provided as part of the normal ventilation system, with provision for increasing the pressure differential in an emergency

3.51**two-stage system**

pressure differential system designed to provide a low level of ventilation normally and is brought into full operation in an emergency

3.52**vent**

window, roof-light, door, louvre, grille or other ventilating device either open or capable of being opened to permit the passage of air between a part of the building and the external air

3.53

zoned smoke control

system that combines depressurization of the fire zone and pressurization for all contiguous spaces requiring protection

4 Analysis of the problem

4.1 General

The purpose of a pressure differential system, whether used for the protection of means of escape, property or for firefighting operations, can have a significant influence on the system design and specification. It is therefore essential that the fire safety objectives are clearly established and agreed with the appropriate approval bodies at an early stage in the design process.

The need for smoke control and the type of system chosen should not be considered in isolation but as an integral part of the total package of fire safety measures for the building, e.g. means of escape, firefighting facilities, degree of compartmentation.

The acceptability of any system depends ultimately on whether the necessary pressure differential levels and airflow rates are achieved (see Clause 12 [A2](#) and BS 5588-12 [A2](#)).

NOTE 1 Guidance on the means of calculating the air supply rate for these levels and rates is given in Clause 14. However, provided that the appropriate functional objectives [see items a), b) and c) below] are met, the designer may choose to use other calculation procedures if these are appropriate to the specific case.

The main objectives addressed in this standard are as follows.

- a) *Occupant safety.* It is essential that tenable conditions are maintained in protected escape routes and refuges for as long as they are likely to be in use by the building occupants.
- b) *Firefighting.* To enable firefighting operations to proceed efficiently, firefighting shafts should be maintained essentially free of smoke so that access to the fire-affected storey can be achieved without the use of breathing apparatus. The pressure differential system should be designed so as to limit the spread of smoke from the lobby into the protected shaft under normal firefighting conditions.
- c) *Property protection.* The spread of smoke into sensitive areas such as those containing valuable equipment, data processing facilities and other items that are particularly sensitive to smoke damage should be limited.

NOTE 2 A pressure differential system may be used for property protection. The procedures for occupant safety detailed in this standard are generally appropriate to the protection of such sensitive items. However, it may be desirable first to investigate the sensitivity to smoke damage of the individual items of concern and to ensure that the system design provides an adequate pressure differential and sufficient dispersal of any stray smoke in order to maintain smoke concentrations within acceptable limits.

4.2 Smoke movement in the building

In the event of fire, the smoke produced follows a pattern of movement arising from the following main driving forces.

- a) *Buoyancy experienced by hot gases on the fire storey.* Within the fire zone smoke produced by the fire experiences a buoyancy force owing to its reduced density. In a building this can result in an upwards smoke movement between storeys if leakage paths exist to the storey above. In addition, this buoyancy can cause smoke to spread through leakage paths in vertical barriers between rooms, e.g. doors, walls, partitions. The pressure differential typically causes smoke and hot gases to leak out of gaps at the top of a door and cool air to be drawn in through gaps at the bottom.
- b) *Thermal expansion of hot gases in the fire zone.* Fire-induced expansion of gases can result in a build-up of pressure, accompanied by a flow of hot gases out of the compartment. However, in most cases the initial expansion forces may be ignored.
- c) *Stack effect throughout the building.* In winter the air in a building is generally warmer and less dense than the external air. The buoyancy of the warm air causes it to rise within vertical shafts in the building, and a pressure gradient is set up in the column such that cold air is drawn into the bottom of the shaft and warm air is forced out at the top. In summer, when the air inside the building can be cooler than that outside, the reverse condition may exist, i.e. air is forced out at the bottom of the stack and drawn in at the top. In either case, at some intermediate point a neutral plane is formed where the pressures of the external and the internal air are equal.

d) *Wind pressure forces.* When wind blows against the side of a building, it is slowed down, resulting in a build-up of pressure on the windward face. At the same time the wind is deflected and accelerated around the side walls and over the roof, creating an eddy on the leeward side of the building and a consequent reduction in pressure, i.e. suction in these areas. The greater the speed of the wind, the greater the suction. The main effect of these pressures is to produce a horizontal movement of air through the building from the windward to the leeward side. If the building is tightly constructed this effect will be slight. However, if the building is loosely constructed, i.e. with openable doors and windows, then the effect will be more pronounced. For example, in a fire, if a broken window exists on the windward side of the building, the wind can force the smoke through the building horizontally or in some circumstances vertically. It is difficult to predict accurately the wind pressures that will be exerted on buildings or the resultant internal airflows, and computer (see 9.1.5) or wind tunnel analysis may be necessary for a full understanding.

NOTE Guidance on wind loadings is given in CP 3:Chapter V:Part 2 or BS 6399-2.

e) *HVAC systems.* HVAC systems can supply air to the fire zone and aid combustion or transport smoke rapidly to areas not within the fire zone and should generally be shut down in the event of fire. However, such systems can often be modified to assist in restricting smoke spread or be used in conjunction with pressure differential system air supply and/or release systems.

4.3 Methods of smoke control

4.3.1 General

The effect of the air movement forces described in 4.2 is to create pressure differentials across the partitions, walls, floors and doors that can cause smoke to spread to areas removed from the fire source.

The techniques most commonly used to limit the degree of spread are listed below.

- a) Smoke containment using a system of physical barriers, e.g. walls and doors, etc., to inhibit the spread of smoky gases from the fire-affected space to other parts of the building.
- b) Smoke clearance, using any method of assisting the fire service in removing smoky gases from a building when smoke is no longer being produced, i.e. after extinction.
- c) Smoke dilution; deliberately mixing the smoky gases with sufficient clean air to reduce the hazard potential.
- d) Smoke (and heat) exhaust ventilation, using any method to achieve a stable vertical separation between the warm smoky gases forming a layer under the ceiling and those lower parts of the same space requiring protection from the effects of smoke for evacuation of occupants and firefighting operations. For example, the continuous exhaust of smoke using either natural or powered ventilators, and the introduction of clean replacement air into the fire-affected space.
- e) Pressurization. (See 3.31.)
- f) Depressurization. (See 3.7.)
- g) Zoned smoke control. (See 3.53.)

NOTE This standard provides guidance and information on smoke control using pressure differentials, i.e. only the techniques given in items e), f) and g).

4.3.2 Pressure differentials versus other forms of smoke control

A combination of containment and extraction/venting is usually used as smoke control in large undivided spaces, e.g. shopping malls, atria, warehouses etc. Smoke produced by the fire is allowed to flow under its own buoyancy toward smoke reservoirs above the occupied space. Powered extraction systems or natural vents assist in the containment process by removing smoke from the reservoir and thus maintain the base of the smoke layer at a safe height. However, the entrainment of air into the smoke plume can produce a large volume of hot smoky gases, even from a modest fire, and high extraction rates are generally required.

Smoke clearance systems are generally intended for clearing smoke in the aftermath of a fire and are therefore generally unsuitable for meeting the functional objectives listed in 4.1.

Smoke dilution systems work on the principle of supplying and exhausting large quantities of air from the fire zone. They do not control the movement of smoke, but instead rely on diluting the smoke to such a level that the vision and breathing of occupants in that space are not critically affected.

Smoke control using pressure differentials generally requires lower ventilation rates but is limited to the protection of enclosed spaces adjacent to the fire.

5 System classification

5.1 General

Smoke control using pressure differentials can be implemented in several different types of buildings, with differing requirements and design conditions.

For the purposes of this standard, the design conditions have been placed into five separate systems (classes A, B, C, D and E) and are detailed in Table 1.

Systems for atrium buildings are not covered within this standard, but the recommendations given in Annex A should be followed.

Table 1 — Classification of buildings for smoke control using pressure differentials

System class	Examples
A	Residential, sheltered housing and buildings designed for three door protection (see 5.2)
B	Protection of firefighting shafts (see 5.3)
C	Commercial premises (using simultaneous evacuation) (see 5.4)
D	Hotels, hostels and institutional-type buildings, excluding buildings designed to meet class A (see 5.5)
E	Phased evacuation (see 5.6)

NOTE 1 The system classes listed above are not exhaustive.

NOTE 2 Attention is drawn to the Building Regulations 1991 [1] regarding means of escape and firefighting, and to the recommendations in the relevant parts of BS 5588.

5.2 Class A system

The design conditions for blocks of flats and maisonettes are based on the assumption that dwellings (other than the dwelling of fire origin) are not evacuated unless directly threatened by fire.

NOTE 1 The class A system is not to be used if the flats form part of mixed use development.

The level of fire compartmentation in blocks of flats and maisonettes at design stage is such that is usually safe for the occupants to remain in their own dwellings during a fire. The prime objective of the class A system is to maintain the staircase(s) free from smoke when there is a fire in a dwelling. The system would offer equivalent or better arrangement for the protection of the staircase compared with natural smoke ventilation systems. Therefore a class A system does not provide a form of smoke control to the front entrance door of the flat/dwelling.

NOTE 2 Smoke seals should be provided to the flat front entrance doors.

NOTE 3 On projects where smoke control is required to the front entrance doors of the flats/dwellings, this situation is outside the scope of a class A system, and therefore should be referred to a fire engineering solution.

NOTE 4 It is imperative that the designer of the system consults with the appropriate authority to establish the correct design objective.

It is unlikely that more than one door onto the protected space (either between the stair and the lobby/corridor or the final exit door) will be open simultaneously.

NOTE 5 Where there is three door protection between the protected stairway enclosure and the compartmented accommodation area, the recommendation for open door airflow velocity as applicable to items a), b), c), d) and e) below does not apply.

The airflow through the doorway between the pressurized stair and the lobby or corridor should be not less than 0.75 m/s when:

- a) the door between the lobby/corridor and the pressurized stair is open on any one storey;
- b) the air release from the lobby/corridor on that storey is open;
- c) all doors between the pressurized stair and the lobbies/corridors are closed on all other storeys;
- d) all doors between the pressurized stair and the final exit are closed; or
- e) the final exit door is closed.

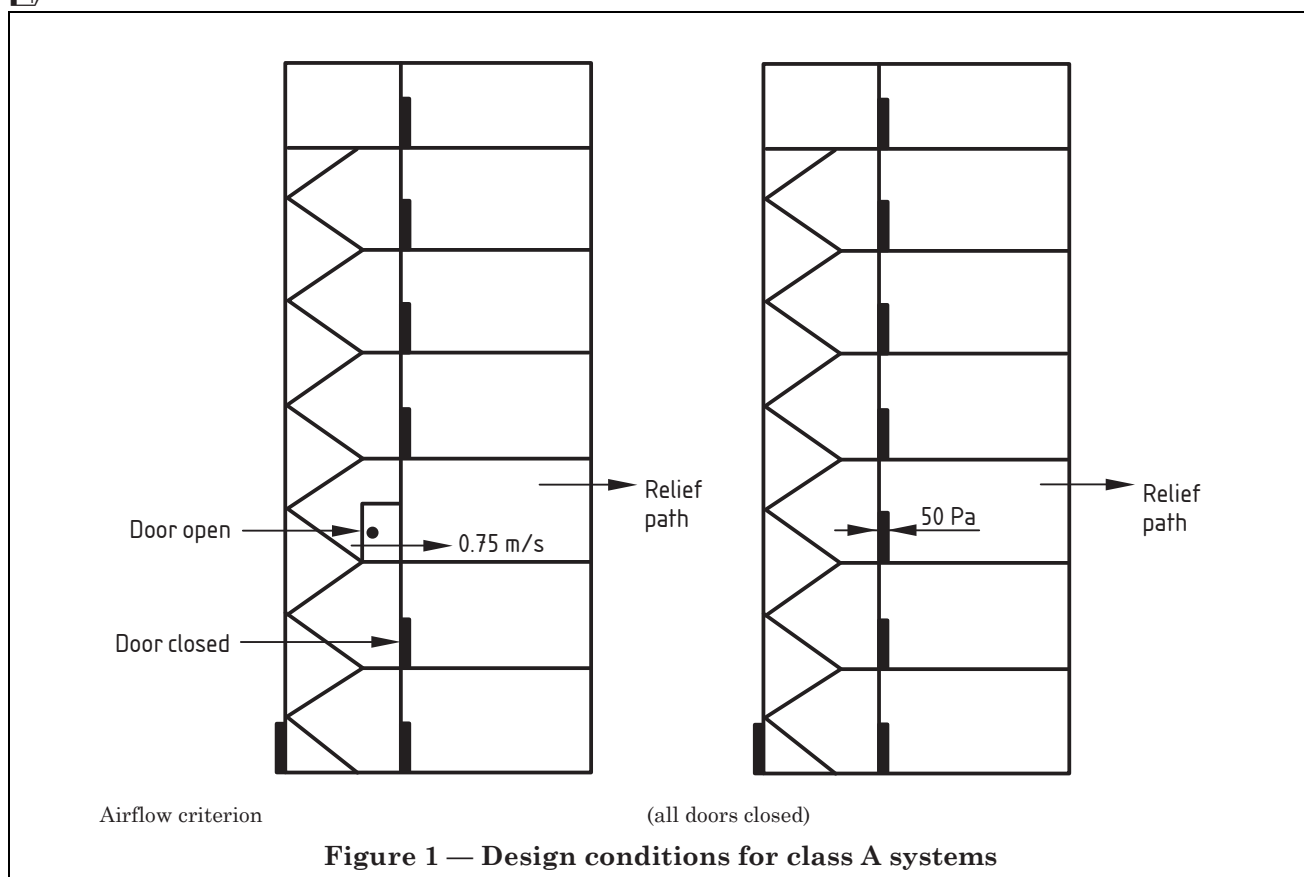
The pressure difference across a closed door between the pressurized stair and the lobby/corridor should be not less than 50 Pa $\pm$ 10 % when:

- 1) the air release from the lobby/corridor on that storey is open;
- 2) on all other storeys the doors between the pressurized stair and the lobby/corridor are closed;
- 3) all doors between the pressurized stair and the final exit are closed;
- 4) the final exit door is closed.

The above design conditions for class A systems are shown in Figure 1.

NOTE 6 Figure 1 can include lobbies.

A1



A1

5.3 Class B system

A pressure differential system can be used to minimize the potential for serious contamination of firefighting stairs by smoke during fire service operations.

BS 5588-5 provides guidance on the general design and construction of firefighting stairs and lifts.

NOTE 1 During firefighting operations it is necessary to open the door between the firefighting lobby and the accommodation area to deal with a fully developed fire.

It is common firefighting practice that the first crews arriving at an incident in a building with a firefighting shaft obtain information about the floor involved and set up a bridgehead/forward control.

Crews committed from forward control to attack the fire usually attempt to take hoselines uncharged to the protected lobby on the fire-affected storey and connect to the riser outlet. However, if the lobby area on the fire-affected storey is untenable, hoselines are connected to the riser on the floor below or, in the case of basements, the floor above the fire-affected storey.

Where hoselines are connected to the riser on a floor other than the fire-affected storey, the hoselines can prevent the closing of the doors between the lobby and stairs whilst firefighting operations are in progress. This can cause smoke to enter the protected area.

The velocity of hot smoke and gases from a fully developed fire can reach 5 m/s. Although firefighting operations, such as the use of a jet, can contribute significantly to the holding back of hot smoke and gases, it is impractical to provide sufficient through-flow of air in order to prevent ingress of smoke into the firefighting lobby.

It is, however, essential that the stair shaft is kept clear of serious smoke contamination. To limit the spread of smoke from the fire zone to the lobby and thence into the stair an air velocity of at least $2 \text{ m}\cdot\text{s}^{-1}$ through the open door between the firefighting lobby and the accommodation area should be provided.

To achieve the recommended flow of 2 m/s through the open stair door, sufficient leakage should be ensured from the accommodation area to the exterior of the building. In the later stages of fire development more than adequate leakage is generally provided by breakage of external glazing. However, it should not be assumed that windows will have failed before the arrival of the fire service, and it is therefore essential to ensure that sufficient leakage area is available, via the ventilation ductwork or specifically designed air release paths.

The system should be designed to keep the firefighting stair and firefighting lobby and, where provided, the firefighting lift well, clear of smoke. In the event of smoke entering the lobby, the pressure within the stair should not drive smoke into the lift well or vice-versa. This should be achieved by providing separate pressurization of the firefighting lift well, lobby and stair.

The fan/motor units for a firefighting lift well may be common with its associated stair, providing that:

- a) the air is provided through separate ductwork;
- b) the distribution of air to each duct is controlled so that sufficient air is provided to each space at all times.

The air supply should be sufficient to maintain the pressure differential given in Table 2 when all doors to the lift, stair and lobby, and the final exit doors are closed and the air release path from the accommodation area is open.

Table 2 — Minimum pressure differentials between specified areas for class B systems

A1

Specified area	Pressure differential to be maintained min
Across lift well and accommodation area with all doors closed ^b	50 Pa $\pm$ 10 % ^a
Across stairway and accommodation area with all doors closed ^b	50 Pa $\pm$ 10 % ^a
Across closed doors between each lobby and accommodation area with all doors closed ^{b c}	45 Pa $\pm$ 10 % ^a
^a The $\pm$ is not to be used in designing the system, it is only there for flexibility when testing the system. ^b Air release path from the accommodation on the storey (fire floor) where the pressure difference being measured is open. ^c 45 Pa is required to overcome wind pressure, fire pressure and stack effect components incorporating a safety margin. Providing 45 Pa is the outcome, there are no restrictions on how it is achieved.	

A1

The air supply should be sufficient to maintain an airflow of 2 m/s through the open door between the lobby and the accommodation area at the fire-affected storey with all of the following doors open between:

- 1) the stair and the lobby on the fire-affected storey;
- 2) the stair and the lobby on the adjacent storey;
- 3) the firefighting lift well and the lobby;
- 4) the stair and the external air at the fire service access level;
- 5) the air release path from the accommodation area, on the storey on which the airflow is being measured.

See Figure 2 for these design conditions.

NOTE 2 Where a class B system is used within a residential building, the air release path may be from the non-firefighting lobby corridor on the storey where the airflow is being measured.

NOTE 3 Where a door has two leaves, one leaf (or the leaf with the least openable area where unequal size doors are provided) may be assumed to be in the closed position for these calculations.

NOTE 4 If a pressure containment lobby is provided at fire service access level, for design purposes, the door indicated in item 4 above may be closed. $\langle A_1 \rangle$ The design of such pressure containment lobbies and their effect on pressure differential smoke control systems should be justified on a case by case basis. $\langle A_1 \rangle$

Any air supply system serving a firefighting shaft should be separate from any other ventilation or pressure differential system.

The maximum force required to open any door within the escape route should in no circumstances exceed 100 N, applied at the door handle.

NOTE 5 The corresponding maximum pressure differential across the door can be determined using the procedures in Annex B, as a function of the door configuration.

$\langle A_1 \rangle$

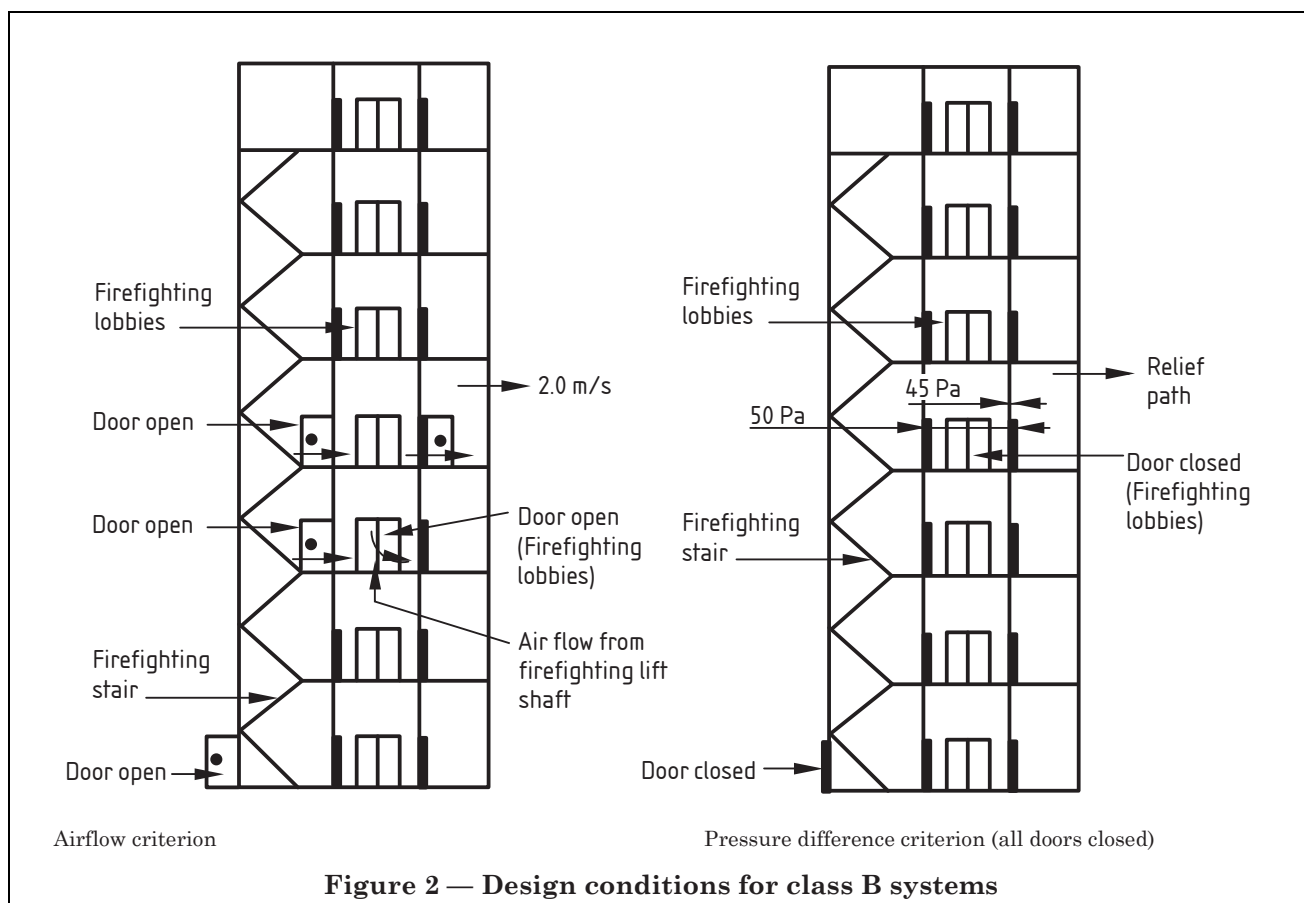


Figure 2 — Design conditions for class B systems

5.4 Class C system

This classification applies to systems other than classes A, B or D using simultaneous evacuation and with one of the following:

- a) $\langle A_1 \rangle$ with lobbies, no restrictions in height $\langle A_1 \rangle$;
- b) $\langle A_1 \rangle$ without lobbies, a single stair up to 11 m and $\langle A_1 \rangle$;
- c) $\langle A_1 \rangle$ without lobbies, more than one stair up to 18 m $\langle A_1 \rangle$.

In the event of a simultaneous evacuation it is assumed that the stairways will be occupied for the nominal period of the evacuation, and thereafter will be clear of evacuees. Consequently, the evacuation will occur during the incipient stages of fire development, and some smoke leakage onto the stairway can be tolerated. The airflow due to the pressurization system should clear the stairway of this smoke.

The occupants being evacuated are assumed to be alert and aware, and familiar with their surroundings, thus minimizing the time they remain in the building.

The airflow through the doorway between the pressurized space and the accommodation area should be not less than 0.75 m/s when:

- 1) the doors between the accommodation area and the pressurized stairway and any lobby on the fire floor are open;
- 2) the air release path from the accommodation area on the storey where the airflow being measured is open;
- 3) all other doors other than the fire floor doors are assumed to be closed.

The pressure difference across a closed door between the pressurized space and the accommodation area should be as given in Table 3.

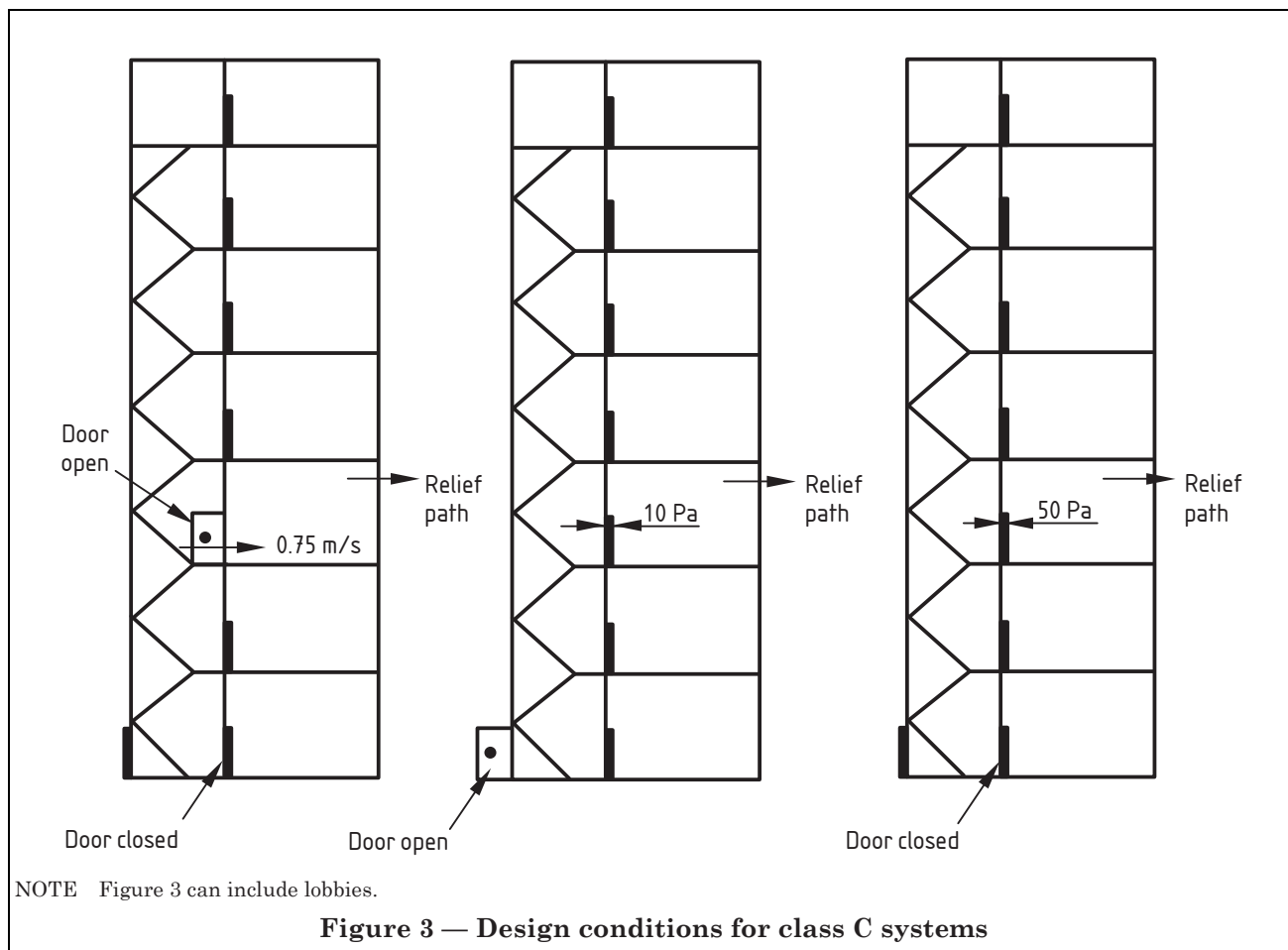
Table 3 — Minimum pressure differentials for class C systems

Position of other doors	Pressure differentials to be maintained min.
i) Doors between accommodation area and the pressurized space are closed on all storeys	50 Pa $\pm$ 10 %
ii) All doors between the pressurized stair and the final exit are closed	
iii) Air release path from the accommodation on the storey where the pressure difference being measured is open	
iv) Final exit door is closed	
v) Final exit door is open and other items i) to iii) above	10 Pa

The design conditions for class C systems are shown in Figure 3.

NOTE Figure 3 can include lobbies.

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5.5 Class D system

This classification applies to systems used in the following:

- hotels, hostels and institutional-type buildings, excluding buildings designed to meet class A system classification;
- any building where a discounted stairway has not been provided because a pressure differential system is installed;
- any buildings more than 18 m high where the pressure differential system has been adopted in lieu of the provision of lobbies (not including residential-type buildings or firefighting shafts).

Class D systems are appropriate in buildings where the occupants may be sleeping, e.g. hotels, hostels and institutional-type buildings. The time for the occupants to move into a protected area prior to reaching the final exit can be greater than that expected in an alert or able-bodied environment, and occupants may be unfamiliar with the building or need assistance to reach the final exit/protected space.

Class D systems are also appropriate when the presence of a pressure differential system has served to justify the absence of a discounted stairway and/or lobbies that would normally be required under the appropriate building regulations (England and Wales, Scotland, Northern Ireland) [1].

The airflow through the doorway between the pressurized space and the accommodation area on the fire floor should be not less than 0.75 m/s when:

- 1) the door between the accommodation area and the pressurized space on the fire storey is open;
- 2) all doors within the pressurized spaces on the fire floor to the final exit which cross the escape route from the accommodation area are open;
- 3) all doors between the pressurized stair and the final exit are open;
- 4) the final exit door is open;
- 5) the air release from the accommodation area on the fire floor is open;
- 6) the doors on the other floors are closed.

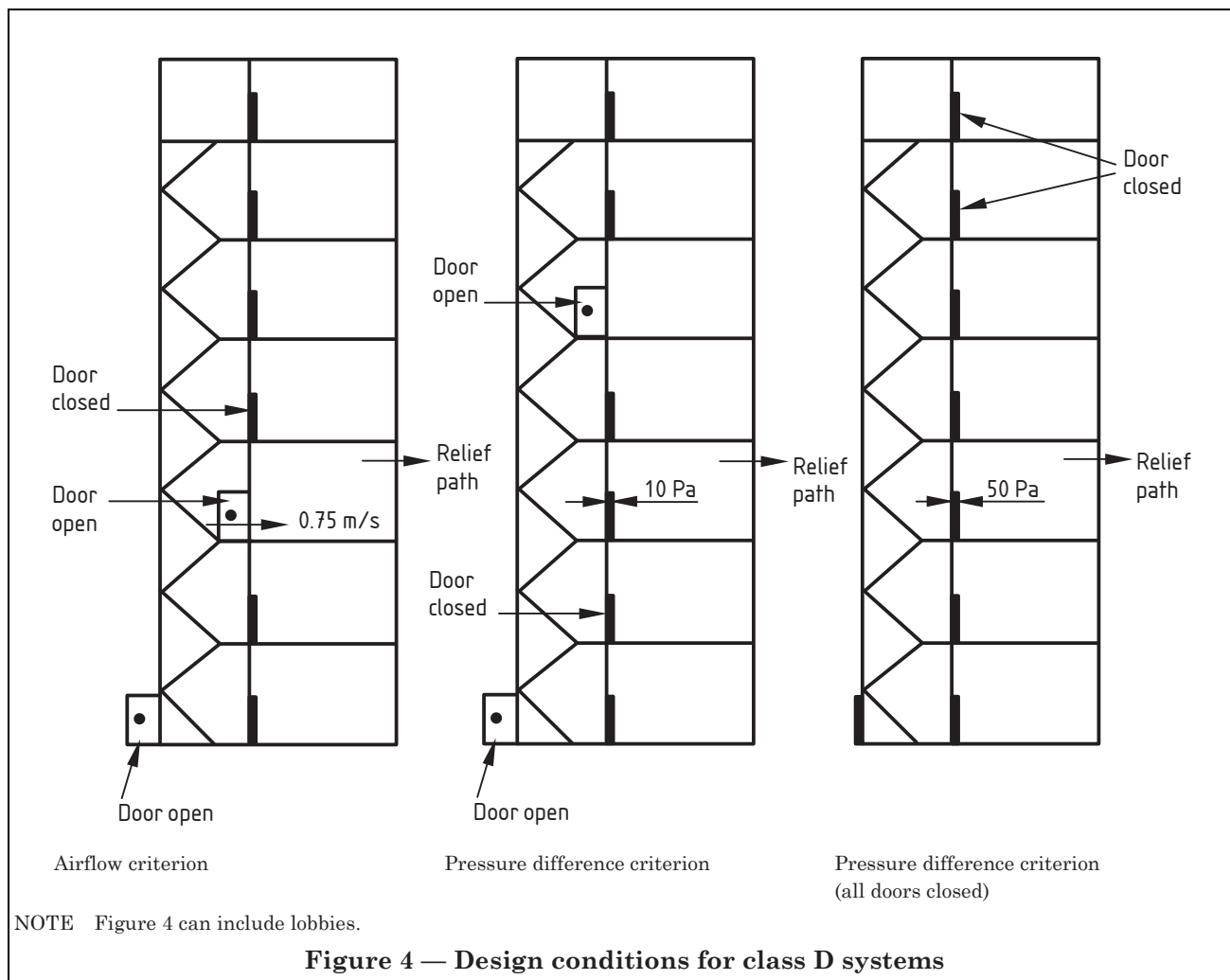
The pressure difference across the closed door between the pressurized space and the accommodation area on the fire storey should be as given in Table 4.

Table 4 — Minimum pressure differentials for class D systems

Position of other doors	Pressure differential to be maintained min.
Door between accommodation area and pressurized space on the fire storey is closed	10 Pa
All doors within pressurized space that cross the escape route from the accommodation area to the final exit door are open	
All doors between the pressurized stair and the final exit door are open	
The final exit door is open	
The air release path from the accommodation area on the storey where the pressure difference is being measured is open	
The doors between the accommodation area and the pressurized space are closed on all storeys	50 Pa $\pm$ 10 %
All doors between the pressurized stair and final exit door are closed	
The air release path from the accommodation area on the storey where the pressure difference being measured is open	
The final exit door is closed	

The design conditions for class D systems are shown in Figure 4.

NOTE Figure 4 can include lobbies.



5.6 Class E system

This classification covers systems used in buildings with phased evacuation, and where the expected total evacuation time exceeds 10 min. For design purposes, this represents the situation where the number of evacuation stages is greater than three, using two floors at a time.

It is assumed that the building would still be occupied for a considerable time during phased evacuation whilst the fire develops. The protected stairways should be maintained free of smoke to allow persons to escape in safety from floors other than the fire floor at a later stage in the fire development.

The airflow through the doorway between the pressurized space and the accommodation area on the fire floor should be not less than 0.75 m/s when:

- a) the doors between the accommodation area and the pressurized space on the storey above the fire floor are open;
- b) all doors within the pressurized spaces on those two storeys that cross the escape route from the accommodation area to the final exit are open;
- c) all doors between the pressurized stair and the final exit are open;
- d) the final exit door is open;
- e) the air release from the accommodation area on the fire floor is open.

The pressure difference across the closed door between the pressurized space and the accommodation area on the fire floor should be not less than as given in Table 5.

Table 5 — Minimum pressure differentials for class E systems

Position of other doors	Pressure differential to be maintained min.
The doors between the accommodation area and the pressurized space are open on two adjacent storeys	10 Pa
All doors within the pressurized space on those two storeys that cross the escape route from the accommodation area to the final exit are open	
All doors between the pressurized stair and the final exit are open	
The final exit door is open	
The air release path from the accommodation area on the storey where the pressure difference being measured is open	
The doors between the accommodation area and the pressurized stair on all storeys are closed	50 Pa $\pm$ 10 %
All doors between the pressurized stair and the final exit are closed	
The air release path from the accommodation area on the storey where the pressure difference being measured is open	
The final exit door is closed	

NOTE 1 See 9.2.2.2 regarding pressure gradient.

The design conditions for class E systems are shown in Figure 5.

NOTE 2 Figure 5 can include lobbies.

A1

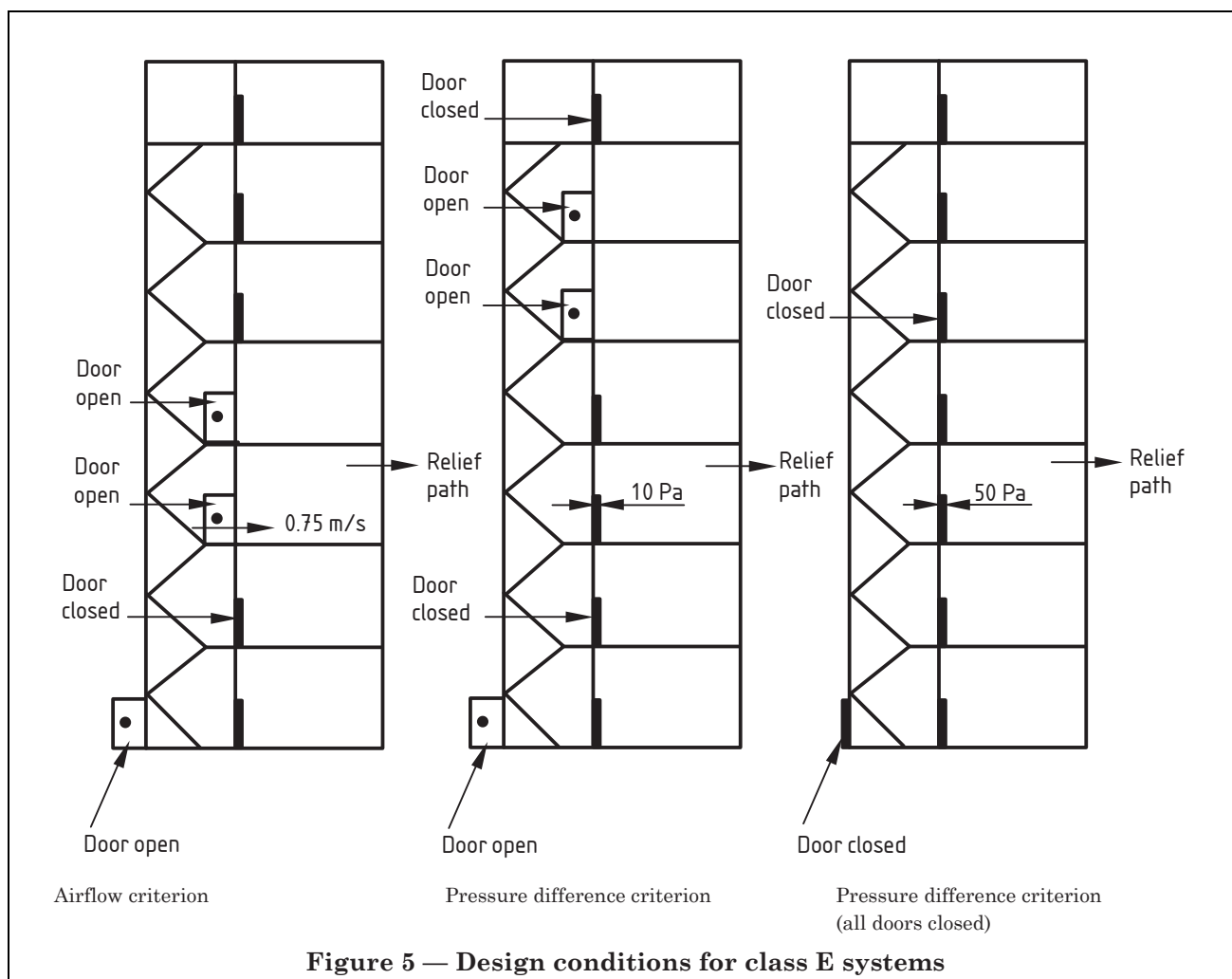


Figure 5 — Design conditions for class E systems

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6 Equipment

6.1 General

The equipment needed to create a pressure differential between the protected space and the accommodation area consists of:

- a) fans and drive mechanisms;
- b) air release provisions;
- c) actuation systems;
- d) over-pressure relief vents;
- e) electrical power supplies (primary and secondary);
- f) stand-by equipment;
- g) distribution ductwork system.

Where a ventilation system (HVAC) is used to form part of the pressure differential system, the components should conform to the recommendations of this clause.

To ensure that the system operates satisfactorily at all times in the event of an emergency there should be provision for an alternative power supply and stand-by plant.

Installations should conform to BS 5720.

6.2 Fans and drive mechanism

The fan duty is calculated by summation of the leakage from all the identifiable leakage paths in the pressurized zones. It is essential that the architect and builder agree with the installing engineer what is expected from the escape route construction, e.g. gap size under doors, leakage through joints in the construction and through the boundary of the pressurized space, so that the actual leakage closely matches that of the design. The calculated leakage should then be increased by a factor (see below) to allow for uncertainties in identified leakage paths.

A factor of 1.5 should be used where solid construction encloses the protected space. Where materials and construction techniques that may produce significant leakage are used, e.g. plasterboard walls and false ceilings, this factor of 1.5 may need to be increased, following consultation with the architect and builder.

Where there is doubt as to the air tightness of an existing building construction (particularly in the case of a building refurbishment), and where refurbishment is taking place, it may be advisable to assess the leakage areas using a calibrated portable fan prior to specifying the fan performance.

The ductwork should be sized according to the expected flow rate. The pressure loss in the ductwork and through any dampers and registers should be used together with the required pressure in the protected space to specify the fan performance.

When selecting a fan for the required duty, account should be taken of the temperature and time for which the system is required to work. (See Table 6 for air release and depressurization systems.)

The fan duty should be assessed for the following.

- a) *Volume flow rate.* The volume flow rate is the total air supply to or from all pressurizing or depressurizing spaces served by the particular fans plus an allowance for unidentified leakage paths and for probable ductwork leakage. The allowance for leakage to be added to the volume flow rate should be 15 % for sheet metal ductwork and 25 % for builders' ducts, unless an on-site test determines a lower level of leakage.
- b) *Total fan pressure.* This is the total resistance of the distribution system plus the emergency pressurization level.
- c) *Static fan pressure.* This is the fan total pressure minus the velocity head at the fan discharge.
- d) **A1** *Text deleted* **A1**

To control the pressure differential, over-pressure release vents may need to be fitted in the pressurized spaces. It is recommended that the pressure release vents are located at the top of each stair and should open directly to the external air.

Where pressure differential fans serve more than one pressurized space concurrently, it may be necessary to interpose high-pressure drop volume control dampers to ensure that when high leakage occurs from an area, e.g. when doors are open or construction failure occurs, some protection continues in the remaining areas.

6.3 Air release

It is essential that a low-resistance path to external air is provided in a pressurization/depressurization system. By providing such a path from the accommodation area, the desired pressure differential between the accommodation area and the protected space can be maintained, thus excluding smoke from the protected space.

The methods of air release are:

- a) external wall vents, which include automatically openable windows and trickle ventilators;
- b) vertical shaft air release, where vents in accommodation area spaces connect to a common vertical shaft which releases smoke at the top of the building;
- c) mechanical extraction, which consists of fans and ductwork, either dedicated to the removal of air/smoke from the spaces affected by fire or an HVAC system suitably equipped and controlled to fulfil this function. **A1** The fan should be suitable for continuous operation for the appropriate period of time and temperature specified in Table 6. **A1**

Where the actuation of the air release system is automatic it should be controlled in such a way that it only operates in the fire zones.

NOTE Arrangements for the control of a powered automatic air release system are given in Annex C.