

Fire precautions in the design and construction of buildings —

Part 4: Code of practice for smoke control in protected escape routes using pressurization

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Code drafting committee BLCP/24

Precautions against fire

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Foreword

This new code of practice was prepared under the direction of the Fire Standards Committee.

In addition to the existing BS 5588-1.1, BS 5588-2, BS 5588-3 and BS 5588-5, other parts will include new codes for the precautions to be taken in places of assembly, for means of escape for disabled people, for ventilation and air conditioning ducts, for enclosed shopping complexes and the revision of CP 3:Chapter IV-1, which will appear as BS 5588-1.2

This code offers a method for keeping protected escape routes clear of smoke by pressurizing these routes and so creating a pattern of airflow away from them. The objects of this code are to state general principles and to give both planning and technical data concerning pressurization of protected escape routes. Pressurization is one of several methods of smoke control in buildings in the event of fire and it is not suggested that it is the only effective method in all circumstances. It has however certain advantages inasmuch as it offers greater flexibility of layout than other methods and in some cases reduced costs stemming from this flexibility.

Designers will need to offer the system described in this code to the building control authority as an alternative to the natural ventilation that may be required by specific legislation. Protected escape routes may include corridors, lobbies, staircases and other communication spaces connecting to a final exit. Unprotected routes include spaces within rooms or open storeys and corridors where travel distances apply. The travel distances as specified in other codes or regulations should not be modified because smoke control is employed as described in this code.

Once inside a protected route, people in a building should be able to make their way to a final exit and safety in the open air. It is smoke and toxic gases, rather than flame, that will in the first instance inhibit this movement and the exclusion of smoke and gases from the protected routes is thus of great importance.

In normal fire-prevention design the intention always will be to confine the fire within a fire compartment and, although this may be effective in limiting the spread of fire, smoke will readily spread to adjacent spaces through the various leakage openings that occur in the compartment enclosure, such as cracks, openings around pipes, ducts, airflow grilles and doors. In good building practice the leakage at some of these points will be minimized but it is not generally possible to seal them completely.

There are two main factors that determine the movement of smoke arising from a fire in a building. These are:

- a) the mobility of smoke that results from its consisting of hot gases less dense than the surrounding air;
- b) the normal air movement (which may have nothing to do with the fire) that can carry smoke, sometimes slowly, sometimes quickly, to all parts of the building.

Air movement is itself controlled by:

- a) the stack effect (see **3.1.4**);
- b) the wind, all buildings having some air leaks and wind action contributing to air movement through the leaks;
- c) any mechanical air-handling system installed in the building.

Pressurization provides pressure differences that oppose and overcome those generated by the factors causing movement of smoke. In pressurization, air is injected into the protected escape routes, i.e. into staircases, lobbies or corridors, to raise their pressure slightly above the pressure in adjacent parts of the building. Consequently smoke or toxic gases will be unlikely to find their way into escape routes.

The use of a system to extract air from spaces that are pressurized is very strongly deprecated because it will render the maintenance of the required pressure in the escape routes extremely difficult.

It is necessary to determine not only where the fresh air supply for pressurization is to be introduced into a building but also where that fresh air will leak out and what paths it will take in the process. The aim will be to establish a pressure gradient (and thus an airflow pattern) with the protected escape routes at the highest pressure and the pressure progressively decreasing in areas remote from the escape routes. The design criteria given in detail in clause 5 deal with the various ways in which the escape of pressurized air can be arranged.

A pressurization system for smoke control should:

- a) give positive smoke control in the protected escape routes;
- b) be readily available when a fire starts;
- c) be reliable and capable of functioning for a period corresponding to the standard of fire resistance of the elements of structure in a building;
- d) be simple and economic.

Some of the advantages that can be expected from the use of pressurization are:

- a) staircases and lobbies need not be placed on external walls;
- b) smoke shafts may not be required as a means of alternative ventilation;
- c) it may be possible to omit some “smoke stop” doors from escape routes;
- d) the additional staircase considered necessary in calculating the number of staircases required in relation to the population density when other methods of smoke control are used may possibly be omitted;
- e) conservation of energy.

Diagrams that accompany the text in this code are intended only to clarify points made in the text. It should not be assumed that the arrangements shown are more satisfactory than others that may be devised.

Consultation with the building control authority at an early stage is recommended, to check not only that proposals for means of escape are satisfactory but also that other building regulations, concerned for example with ventilation of parts of the building for public health purposes, are satisfied.

This code does not contain all the necessary information for the satisfactory design of a pressurization scheme, which should be undertaken by a competent person.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their 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 38, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This code of practice gives guidance on the use of pressurization in buildings for the purpose of smoke control in protected escape routes.

The code is intended to apply to new buildings, though there is no reason why the principles should not be used when existing buildings are to be altered or adapted. It is intended initially for application to protected escape routes in flats and maisonettes, and in offices and shops.

The principles stated in the code may be used for other occupancies and purpose groups where the fundamental aim is to keep the protected escape route clear of products of combustion.

This code is not intended to apply to shopping malls and town centre redevelopments. Information on these will be found in HMSO publication "Fire Prevention Guide 1: Fire Precautions in Town Centre Redevelopments".

2 References

The titles of the publications referred to in this code are listed on the inside back cover.

3 Definitions

For the purposes of this code, the definitions given in BS 4422, together with the following, apply.

3.1

air duct

a passageway for the transmission of air

3.2

air escape or air venting

the movement of air out of a building through a low-resistance path provided by incidental or specially provided apertures, the air movement being caused by pressure differences developed in the building

3.3

air leakage

the movement of air, generally from a pressurized space through openings that have relatively small cross-sectional area

3.4

air supply

a mechanically driven current of air led by suitable ductwork or impelled by the direct action of a fan

3.5

buoyancy

an upward force exerted on a fluid when it is surrounded by a denser fluid

3.6

leakage area

the cross-sectional area of the air leakage path, measured normally to the direction of airflow and generally integrated into a total area for a particular building component (such as a door or a window)

3.7

lobby

a space in a building used to separate one part of the building from another part, usually separating a staircase from the general accommodation

3.8

plenum

a compartment or chamber or space to which one or more air ducts are connected and that forms part of an air distribution system

3.9

pressure differential

the difference in pressure between two adjacent spaces in a building

3.10**pressurized space**

a space in a building in which the air pressure is maintained at a higher value than that in the rest of the building by direct input of an air supply

3.11**pressurization**

a method of protecting escape routes against the ingress of smoke by maintaining the air within them at pressures higher than those in adjacent parts of the building

3.12**pressurization level**

the pressure difference between the pressurized space and the accommodation served by the pressurized escape route [expressed in pascals (Pa)]¹⁾

3.13**simple lobby**

a lobby that has no door opening out of it other than a door to a staircase and a door (or doors) leading to the accommodation

NOTE A lobby that has doors to toilets or doors to lifts is not a simple lobby.

3.14**stack effect**

the pressure differential caused by the air inside the building being at a temperature different from that of the air outside the building, which, when there are openings top and bottom, will promote natural airflow through the building, upwards when the building air is warmer than the outside air and downwards when it is cooler

4 The building**4.1 General**

4.1.1 General principle of pressurization. The spaces to be pressurized will be those that constitute the protected escape routes. These are the staircase(s), the lobbies and in some cases the corridors. One or more of these spaces will be pressurized and the general principle is that smoke control will only be satisfactory for those spaces that are pressurized, i.e. that have an input of pressurizing air (air supply). Thus the extent to which smoke encroachment is to be prevented will determine the spaces to be pressurized.

4.1.2 Single-stage or two-stage pressurization. The pressurization system can be designed to operate only in an emergency. This is called a single-stage system. Alternatively, a continuously operating low level of pressurization of the appropriate spaces can be incorporated as part of the normal ventilation with provision for an increased level of pressurization to be brought into operation in an emergency. This is called a two-stage system. (See 5.2.1.)

The two-stage system is generally regarded as preferable because some measure of protection is always operating and therefore any smoke spread in the early stages of fire will be prevented. However, either method will be acceptable subject to any special circumstances dealt with in this code.

4.1.3 Combustible material in protected escape routes. It is important that any staircase, lobby or corridor of a protected escape route should contain or be likely to contain, a minimum of combustible material in which a fire could occur.

4.2 Methods of pressurizing the spaces to be pressurized

4.2.1 Method 1. Pressurizing staircase(s) only. The protection given by this method is entirely confined to the vertical part of the escape route. It is only appropriate in buildings where no smoke control is needed for the horizontal part of the escape route on each floor of the building and, in general, it should be used only when a staircase is approached directly from the accommodation area or through a simple lobby. By definition (see 3.13) this lobby should not give access to lifts or other rooms (e.g. toilets) that could constitute an appreciable leakage path and allow the pressurizing air to bypass its required direction of flow.

¹⁾ 1 Pa = 1 N/m².

The simple lobby, which may be required to complete the fire-protecting enclosure of the staircase, will serve to reduce the effect of an open door to the pressurized staircase.

The simple lobby should be unventilated, in which case it will be automatically pressurized by the air flowing out of the staircase. Figure 1 shows examples of pressurized staircases leading into simple lobbies. The resulting pressurization of the lobbies is indicated, as also is the effect of an open lobby door.

During a fire emergency all protected staircases interconnected by lobbies, corridors or accommodation areas should be simultaneously pressurized.

4.2.2 Method 2. Pressurizing the staircase(s) and all or part of the horizontal route

4.2.2.1 General. In every building in which each floor has a horizontal component of the protected escape route (other than the simple lobby mentioned in 4.2.1) the pressurization should be carried into the lobby and possibly into the corridor beyond.

This arrangement carries the protection right up to the door leading into the accommodation area in which a fire might occur. Additionally, the effect of an open door on the pressurization levels is largely localized on the floor concerned.

During a fire emergency all protected staircases and associated lobbies/corridors forming part of the whole pressurization scheme should be simultaneously pressurized.

4.2.2.2 Pressurizing staircase and lobby. If a lobby separating the staircase from the accommodation is other than a simple lobby, this lobby should be pressurized independently of the staircase, i.e. it should have pressurizing air supplied from a duct (or source) that is separate from that supplying the staircase. The lobby pressure should be equal to or slightly below the pressure in the staircase (but not more than 5 Pa below). Figure 3 shows an example of independently pressurizing staircase and lift lobby and indicates the effect of an open door.

4.2.2.3 Pressurizing staircase, lobby and corridor. If the lobby opens into a corridor of substantial construction (i.e. 30 min fire resistance or more) that forms part of the protected escape route, the pressurization may with advantage be extended to include the corridor and so take the smoke control right up to the door of the accommodation unit, office or flat. To do this an independent air supply should be provided to the corridor and the pressure should be equal to or slightly below that in the associated lobby, but not more than 5 Pa below.

There are difficulties associated with this extension of the pressurization. If the corridor has many doors (or other leakage paths) the air supply needed will be large, each door should be self-closing and each unpressurized space opening onto the corridor should have adequate leakage to the outside air (as recommended in 5.5).

4.2.3 Method 3. Pressurizing lobbies and/or corridors only. In some buildings it may be found necessary, perhaps for constructional reasons (such as difficulty in arranging the required ductwork for independent pressurization) to allow the staircase to be pressurized by the air that leaks into it from the associated pressurized lobbies or corridors. If properly designed this can be a satisfactory method but in some cases it may be found that the total air supply needed for pressurizing the lobbies only may be greater than that needed if the staircase and lobbies are independently pressurized.

In this method the staircase should not be permanently ventilated except by any opening shown to be necessary by the calculation for the open-door condition dealt with in 5.3.2.8.

All pressurized lobbies and/or pressurized corridors on all floors in a building should be pressurized in an emergency.

4.2.4 "Pressurizing" the whole building (not recommended). Designs have been suggested for a scheme in which pressure differentials are not developed inside the building but air is introduced in such a way that the whole building is raised to a pressure in excess of that obtaining outside the building. In the event of fire, airflows are set up in opposition to the smoke flow by opening vents on the fire floor. This system has been suggested for buildings in which the internal divisions are so leaky that pressurizing particular spaces (such as staircases or lobbies) is not possible.

In the UK there is no experience with this method and it is suggested that, unless there are over-riding reasons for its adoption in a special case, it does not constitute a satisfactory method.

To design this type of system the details, including location, of the air leakage from the external wall are required. If this leakage is appreciable (as suggested by some of the information available), a wastefully high amount of pressurizing air is required.

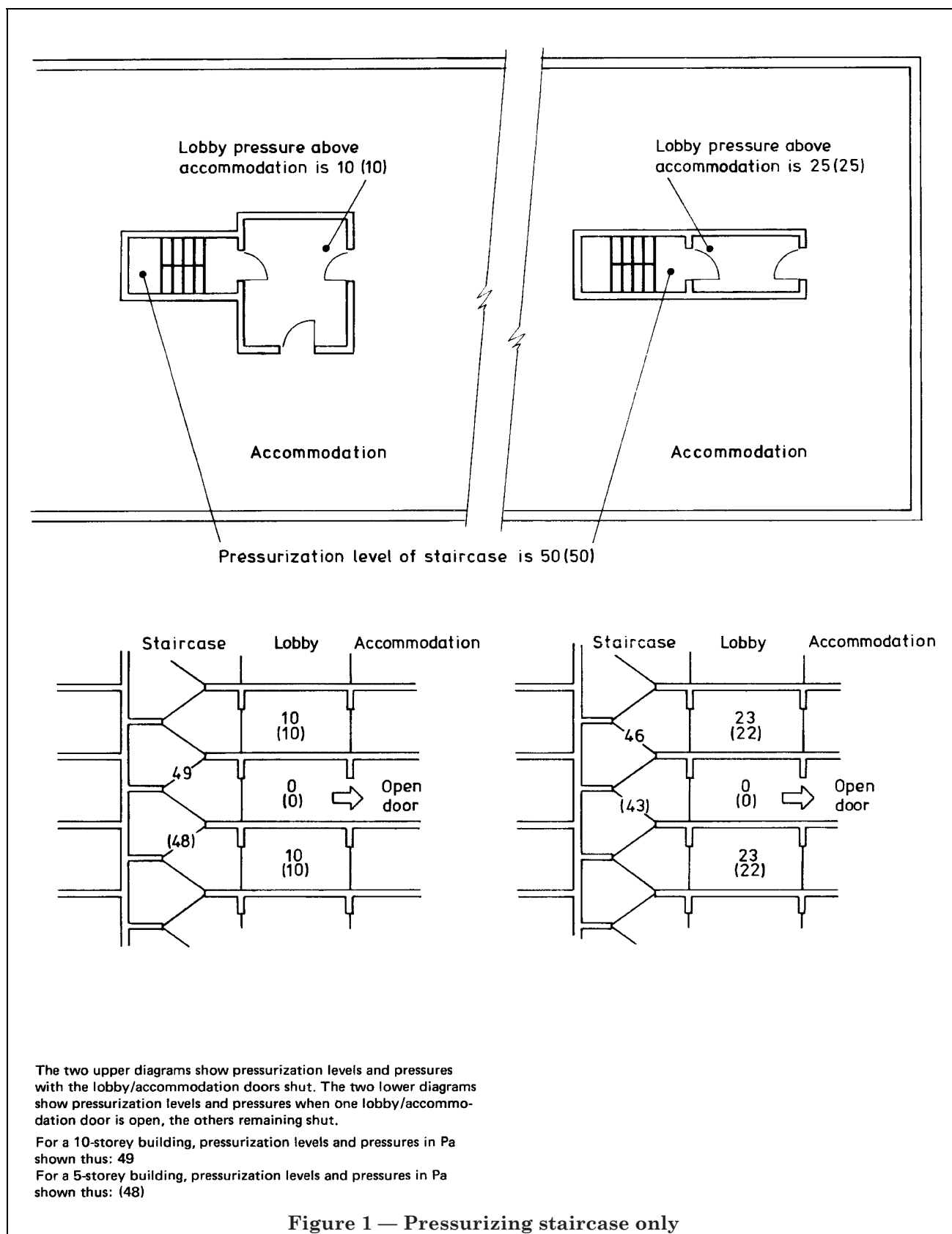
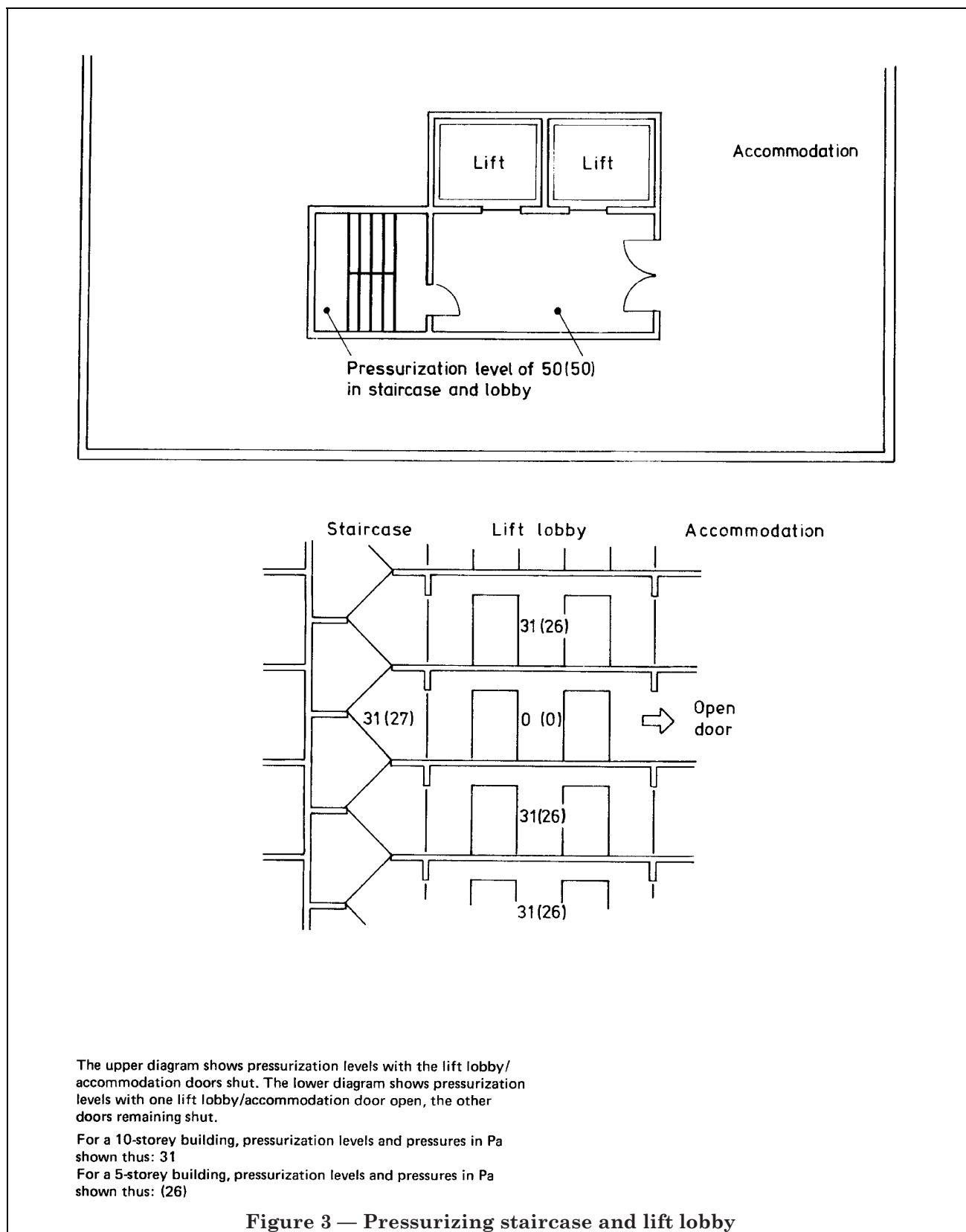


Figure 2 — Deleted



The effectiveness of a system pressurizing the whole building relies entirely on the opening of venting on the fire floor only. Venting elsewhere can cause smoke to spread to other parts of the building. In particular, an open door at the foot of a staircase can cause that staircase to become filled with smoke. Consequently, if this system is used additional “smoke stop” doors have to be installed. For these reasons the pressurization of the whole building is not recommended in this code of practice.

4.3 Interaction between several pressurized spaces

4.3.1 General. In a building, particularly a large building, there may be several pressurized spaces. These may be directly interconnected or they may be separated by a large unpressurized area. The presence of several pressurized spaces in a building does not generally create a problem.

4.3.2 Directly connected pressurized spaces. This condition will arise when the staircase and the lobby (and perhaps the corridors) are pressurized. This will apply to many buildings. In such a system the design aim should be to ensure airflow from the staircase, through the lobby, through the corridor (if appropriate) and into the accommodation space where a fire might occur.

There is no objection to all the connected pressurized spaces being maintained at the same pressure, which should be that given in Table 1 for the appropriate building height.

If there is a difference in pressure between adjacent pressurized spaces, this should be small and should not exceed 5 Pa. The pressurized space nearest to the accommodation should always be at the lower pressure.

This design condition will be disturbed if, for instance, a door on the staircase is opened on to an unpressurized space. This circumstance may be regarded as a shortlived temporary occurrence during which the staircase pressure will fall below that of the adjacent lobby, but the lobby pressurization will still maintain a sufficient airflow towards the possible fire area. A design check is outlined in clause 5 to ensure that this condition is satisfied.

4.3.3 Pressurized spaces that have no direct connection. This condition arises when a building has two or more pressurized escape-route systems opening out into the same unpressurized accommodation area.

There are no particular problems or restrictions associated with this arrangement because each escape-route system should have its own independent pressurizing plant and the unpressurized accommodation space should have adequate leakage arrangements to allow the pressurizing air from all the pressurized areas to escape to open air. Provided these conditions are satisfied there will be no possibility of any interaction between the several pressurized parts of the building.

4.4 Single-staircase or multiple-staircase buildings

4.4.1 The staircases. The factors associated with floor area that determine whether a building may have a single staircase or needs to have two or more staircases will not be affected by the proposal to use pressurization in the building, except that a pressurized staircase (with a lobby and/or corridor, as appropriate) may be considered safer than an escape route that is naturally ventilated.

4.4.2 Restrictions

4.4.2.1 Pressurized and unpressurized staircases in the same building. No restrictions will arise when all the staircases in a building are pressurized, but the use of pressurized and naturally ventilated staircases in the same building will introduce difficulties and should be avoided if possible. It should be considered only if the staircase is cross ventilated and separated from the pressurized staircase(s) by a large unpressurized undivided space from which the air can escape at points well away from the unpressurized staircase(s), in order to prevent the unpressurized staircase from becoming filled with smoke.

Under no circumstances should a pressurized staircase be connected by a corridor or lobby to an unpressurized staircase.

4.4.2.2 Pressurized and unpressurized spaces in the same escape route. Another possibility is a mixed system for the escape route, for instance a pressurized staircase with a naturally ventilated lobby between it and the accommodation. In this example the protection afforded by the pressurization will be completely confined to the staircase. The pressurization will do nothing to keep the naturally ventilated lobby clear of smoke; it will only provide a steady supply of fresh air to dilute any smoke entering the lobby. This arrangement is not recommended and the lobby in this position should be unventilated.

4.5 Relation between emergency pressurization and the normal air conditioning system. It has been explained that the purpose of a pressurization system is to establish an airflow condition in the building that will prevent the smoke from a fire moving towards or past the escape route doors. This is achieved by maintaining the escape routes at an excess pressure by providing them with a mechanically driven constant supply of fresh air, and, additionally, by providing for this air to leak out of the building at identified places in or near external walls that are as far as possible from the escape route doors.

It is therefore preferable that the airflow pattern established in the building by the normal air conditioning system should also be away from the escape route entrance, with the vitiated air being removed for exhaust or recirculation at points remote from the escape route entrances.

If the pressurization system is two-stage, i.e. has a constant running feature that maintains the escape routes always at a slight excess pressure, the general air conditioning system to fit in with this arrangement will probably adopt a satisfactory airflow pattern that is always away from the escape routes. When the pressurization system is single-stage, i.e. operates in an emergency only, the interaction between it and the normal air conditioning arrangement may not be so obvious but nevertheless it should be considered in the overall design concept.

An air conditioning system that uses the corridors or the false ceiling of a corridor as the exhaust plenum for the vitiated air should not be used in conjunction with a pressurization system unless special arrangements are made for closing off the whole exhaust system in case of fire.

In any case, an air conditioning system that could encourage smoke to enter the corridors is not favoured for fire safety reasons even if there is no pressurization in the building.

4.6 Integration of emergency system with normal air conditioning equipment. It is suggested that the normal air conditioning system and the pressurization system should be treated as an integral whole when design calculations are carried out. This will certainly be necessary when the pressurization is two-stage, i.e. a reduced level of pressurization will be operative at all normal times and so the air volumes and air movement used for it need to be considered in the wider context of the air movements in the normal ventilation system.

When the emergency pressurization is brought into action the following changes in the normal air conditioning system should be made.

- a) Any recirculation of air should be stopped and all exhaust air vented to atmosphere, e.g. by means of a suitable damper.
- b) Any air supply to the accommodation spaces should be stopped.
- c) The exhaust system may be continued, provided:
 - 1) the positions of the extraction grilles are compatible with the need to establish a general airflow that is not towards the protected escape route entry;
 - 2) the construction of the ductwork and fans is such that it will not be rendered inoperable by hot gases and smoke;
 - 3) there is no danger of smoke spreading to other floors by the path of the extraction system; to ensure this the extraction fan has to be kept running and therefore its position and electrical supply have to be protected.

The signal to initiate all these changes in the operation of the air conditioning system should come from the same source as that which operates the emergency pressurization.

The use of a smoke detector in the air conditioning ductwork should not be relied on for this purpose because of the dilution of the smoke that will occur when several floors are served by the same system. This could cause a delay in operating the necessary adjustment to the air conditioning system in case of fire.

5 The system

5.1 Basic design criteria for designing the system and its component parts

5.1.1 Basic design. The criterion is to establish in the building a pressure gradient pattern that will always ensure that smoke moves away from the escape route. To do this the escape route is maintained at an excess pressure and adequate air leakage has to be provided from the accommodation areas.

5.1.2 Pressure differentials. These are established by maintaining a continuous supply of fresh air, fed by mechanical means into the pressurized space.

5.1.3 Space being pressurized. This will unavoidably, in any building, have air leakage paths in its enclosing surfaces. These leakage paths will be the cracks round doors, cracks round windows, direct leakage through the building fabric, leakage through air conditioning ductwork, and so on. If a pressure difference is maintained between a pressurized space and its adjacent space(s) air will flow through these leakage paths.

5.1.4 Pressurization system. This is designed by first identifying the leakage paths (see 5.1.3), estimating their size and then calculating the airflow that will be needed to create and maintain the required pressure difference across these leakage paths. A constant air supply of this magnitude has then to be delivered to the space it is desired to pressurize.

5.1.5 General principle. The important principle to understand is that to maintain a space A at a higher pressure than space B, the spaces being connected by, say, a closed but leaky door, there must be a leakage path from B so that a flow from A to B can be maintained. If there were no leakage path from B, air fed into A would raise both A and B to the same excess pressure above the surroundings and smoke from a fire in B could not be prevented from spreading to A.

5.1.6 Components of a pressurization system. These are:

- a) a mechanically driven supply of fresh air ducted directly into each pressurized space (i.e. staircase, lobby or corridor);
- b) air leakage paths from each pressurized space;
- c) an air leakage path from the accommodation areas.

In order to design a pressurization system for a building all of these factors have to be determined or specified. Each will partly depend on the level of pressurization required, which is the first factor to be decided.

5.2 The pressure differentials

5.2.1 One-stage or two-stage systems. The relative merits of a one-stage or two-stage system have been discussed in 4.1.2 and the pressure levels relative to each are now specified.

In a *single-stage system* the pressurization is applied only when a fire situation occurs, and in a *two-stage system* a low level of pressurization is maintained at all times and is increased to the emergency level when a fire occurs.

The emergency level of pressurization will be the same whether a one-stage or two-stage system is used and will depend on the height and position of the building. The reduced level of pressurization for the two-stage system will also depend on the height and position of the building.

5.2.2 Pressurization levels to be used. The level of pressurization used for design purposes for any pressurized space in a building should not be less than the appropriate level for the building height given in Table 1 (or greater than 60 Pa²⁾) with all doors to the pressurized space or spaces closed, and also all doors to simple lobbies closed.

NOTE 1 Buildings used for the very young or old or for handicapped people may need special consideration to ensure that doors can be used in spite of the force created by the pressure differential.

NOTE 2 The force that can be exerted to open a door will be limited by the friction between the shoes and the floor and it may be necessary to avoid having a slippery floor surfaces near doors opening into pressurized spaces in buildings in which there are very young persons.

NOTE 3 The self-closing mechanisms on doors opening into pressurized spaces should be adjusted to require the minimum force compatible with the effective closing of the door in normal use. In buildings in which young children may be unaccompanied, consideration of the forces needed to open self-closing doors may be necessary. Doors opening out of a pressurized space should have a closer that can keep the door shut against the pressure.

²⁾ 1 Pa = 1N/m²; 25 Pa ≈ 0.1 in water gauge.