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BSI Standards Publication

Smoke and heat control systems

Part 13: Pressure differential systems (PDS) — Design and calculation methods, installation, acceptance testing, routine testing and maintenance

bsi.

National foreword

This British Standard is the UK implementation of EN 12101-13:2022. Together with BS EN 12101-6:2022, it supersedes BS EN 12101-6:2005, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee FSH/25, Smoke, heat control systems and components.

A list of organizations represented on this committee can be obtained on request to its committee manager.

The UK committee emphasizes that BS EN 12101-13:2022 deals with the design of systems to be used in specific applications described therein. Both BS EN 12101-6:2022 and BS EN 12101-13:2022 should be considered in their entirety and only for the types of applications described. No clauses, designs or values in whole or in part should be used in isolation or as justification for system designs that are outside the scope of these standards.

This standard is not intended for corridor/lobby extract or Mechanical Smoke Ventilation Systems (MSVS). These systems generally create a lower pressure in protected spaces, such as lobbies and corridors and are outside of the scope of this standard.

It is the opinion of the UK committee that BS EN 12101-6:2005 contained useful guidance for applications commonly used in the UK. National Annex NA identifies these applications along with explanations of how BS EN 12101-13:2022 can be used to achieve similar design intent. While National Annex NA is informative, the UK committee believes UK users would benefit from referring to the Annex.

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Smoke and heat control systems - Part 13: Pressure differential systems (PDS) - Design and calculation methods, installation, acceptance testing, routine testing and maintenance

Systèmes pour le contrôle des fumées et de la chaleur - Partie 13 : Systèmes à différentiel de pression (SDP) - Méthodes de conception et de calcul, installation, essais de réception, essais périodiques et maintenance

Rauch- und Wärmefreihaltung - Teil 13: Differenzdrucksysteme - Rauchschutz-Druckanlagen (RDA) - Planung, Bemessung, Einbau, Abnahmeprüfung, Funktions-Tests, Betrieb und Instandhaltung

This European Standard was approved by CEN on 14 February 2022.

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Contents

European foreword

This document (EN 12101-13:2022) has been prepared by Technical Committee CEN/TC 191 "Fixed fire-fighting systems", the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2022, and conflicting national standards shall be withdrawn at the latest by October 2022.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document together with EN 12101-6 supersedes EN 12101-6:2005 which will be withdrawn.

This document has the general title "Smoke and heat control systems" and consists of the following parts:

— Part 1: *Specification for smoke barriers;*

— Part 2: *Specification for natural smoke and heat exhaust ventilators;*

— Part 3: *Specification for powered smoke and heat exhaust ventilators;*

— Part 4: *Installed SHEVS systems for smoke and heat ventilation* (published as CEN/TR 12101-4)*;*

— Part 5: *Design and calculation for smoke and heat exhaust ventilation systems using a steady-state fire* (published as CEN/TR 12101-5)*;*

— Part 6: *Specification for pressure differential systems;*

— Part 7: *Smoke control duct sections;*

— Part 8: *Specification for smoke control dampers;*

— Part 10: *Power supplies;*

— Part 11: *Design, installation and commissioning requirements for enclosed car parks;*

— Part 12: *Design and calculation for smoke and heat exhaust ventilation systems using a time dependent fire;*

— Part 13: *Pressure differential systems (PDS) - Design and calculation methods, installation, acceptance testing, routine testing and maintenance.*

Any feedback and questions on this document should be directed to the users' national standards body. A complete listing of these bodies can be found on the CEN website.

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Introduction

This document covers information and requirements on the design and calculation methods, installation, acceptance testing, routine testing and maintenance of Pressure Differential Systems (PDS). PDSs are installed in buildings to prevent smoke in hazardous amounts from entering into protected spaces via leakage paths through physical barriers (e.g. cracks around closed doors) or open doors by using pressure differentials.

The requirements and test methods for kits used in PDS are published in EN 12101-6. For certain components as part of the kits, additional tests must be carried out in accordance with Part 6 prior to the kit test.

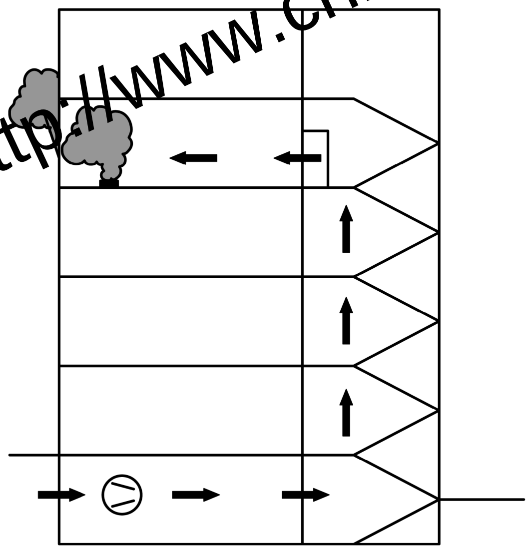


Figure 1 — Pressurization (General)

Pressure differential systems provide a means of maintaining tenable conditions in protected spaces, that are required to be kept free of smoke – e.g. escape routes, firefighting access routes, firefighting lift shafts, lobbies, staircases, and other spaces. It is necessary to determine where the fresh air supply for the PDS is to be introduced into a building as well as where that air and smoke will leave the building and what paths it will follow in the process, including during firefighting (e.g. with fire compartment door open) and in the event of likely events such as window failure.

By means of a PDS, a positive pressure difference is always achieved between the protected space and the unprotected space. This is achieved by pressurizing the protected space(s) (see Figure 1).

The aim therefore is to establish a pressure gradient from the protected space to the unprotected space while the doors are closed and an airflow from the protected space via the unprotected space to outside when specific doors are open.

The figures that accompany the text in this document are informative and are intended for clarification purposes only.

It is recommended that the designer should discuss the design and evacuation concept, including safety targets, with the authorities having jurisdiction, early in the building design process.

NOTE 1 From experience gained since EN 12101-6 was first published, this document now simply prescribes two systems only and these are specifically described in terms of the closed-door differential pressure and the open-door velocity only. Consequently the 10 Pa previously required in some scenarios is now withdrawn.

NOTE 2 It is recommended that an engineered solution for a PDS should adopt the functional requirements set out in this document where appropriate, inclusive of Table 1 as a minimum, in the absence of any national requirements.

1 Scope

This document gives calculation methods, guidance and requirements for the design, installation, acceptance testing, routine testing and maintenance for pressure differential systems (PDS).

PDSs are designed to hold back smoke at a leaky physical barrier in a building, such as a door (either open or closed) or other similarly restricted openings and to keep tenable conditions in escape and access routes depending on the application.

It covers systems intended to protect means of escape e.g. staircases, corridors, lobbies, as well as systems intended to provide a protected firefighting space (bridgehead) for the fire services.

It provides details on the critical features and relevant procedures for the installation.

It describes the commissioning procedures and acceptance testing criteria required to confirm that the calculated design is achieved in the building.

This document gives rules, requirements and procedures to design PDS for buildings up to 60 m.

For buildings taller than 60 m the same requirements are given (e.g. Table 1), but additional methods of calculation and verification are necessary. Requirements for such methods and verification are given in Annex D, but the methods fall outside the scope of this document [e.g. Additional mathematical analysis and/or Computational Fluid Dynamics (CFD)].

Routine testing and maintenance requirements are also defined in this document.

In the absence of national requirements and under expected ambient and outside conditions, the requirements in Table 1 are fulfilled by the PDS.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 12101-2, *Smoke and heat control systems - Part 2: Natural smoke and heat exhaust ventilators*

EN 12101-3, *Smoke and heat control systems - Part 3: Specification for powered smoke and heat control ventilators (Fans)*

EN 12101-6, *Smoke and heat control systems - Part 6: Specification for pressure differential systems - Kits*

EN 12101-7, *Smoke and heat control systems - Part 7: Smoke duct sections*

EN 12101-8, *Smoke and heat control systems - Part 8: Smoke control dampers*

EN 12101-10, *Smoke and heat control systems - Part 10: Power supplies*

EN 13501-4, *Fire classification of construction products and building elements - Part 4: Classification using data from fire resistance tests on components of smoke control systems*

ISO 21927-9, *Smoke and heat control systems - Part 9: Specification for control equipment*

EN 16763, *Services for fire safety systems and security systems*

EN 12259-1, F*ixed firefighting systems - Components for sprinkler and water spray systems - Part 1: Sprinklers*

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

EN 60770-1, *Transmitters for use in industrial-process control systems - Part 1: Methods for performance evaluation*

EN 60751, *Industrial platinum resistance thermometers and platinum temperature sensors*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 13943 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at https://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

3.1
accommodation
any part of the construction works which is not part of the protected escape route

3.2
air inlet
connection from the outside of the building to allow air entry

3.3
authorities
authorities having jurisdiction
AHJ
organizations, officers or individuals responsible for approving pressure differential systems, e.g. the local/national fire and building control authorities having jurisdiction, or other approved third parties

3.4
barometric relief damper
damper which opens at automatically without a controlled actuator at a specific pressure to allow pressure relief by providing flow of air to outside

3.5
control panel
multi-operational device to activate and/or control a PDS.

3.6
fire compartment
space (room or set of rooms) contained by boundaries with classified fire resistance

3.7
pressurized space
space (e.g. lift shaft, staircase, lobby, corridor, or other compartment) in which the air pressure is maintained at a higher level than that in the space where a fire is located

3.8
protected space
space where the design prevents smoke entry

3.9
smoke and heat exhaust ventilation system
SHEVS
system in which components are jointly selected to exhaust smoke and heat in order to establish a buoyant layer of warm gases above cooler, cleaner air

3.10
stack effect
movement of air into and out of buildings, resulting from air buoyancy

3.11
unpressurized space
space adjacent to or separate from the protected space where the pressure and airflow are not controlled by the PDS

4 Design objectives

4.1 General

The following design objectives are addressed in this document and can be selected to match the required application.

4.2 Protection of means of escape

It is essential that tenable conditions for life safety are maintained in protected spaces for as long as they are likely to be in use by the building occupants.

4.3 Protection of firefighting routes

To enable firefighting operations to proceed efficiently, protected firefighting access routes shall 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 shall be designed so as to limit the spread of smoke into the dedicated firefighting route under normal firefighting conditions, but not compromising means of escape or firefighting objectives which remain the top priority.

4.4 Property protection

The spread of smoke shall be prevented from entering sensitive spaces such as those containing valuable equipment, data processing and other items that are particularly sensitive to smoke damage.

NOTE The purpose of a pressure differential system, whether used for the protection of means of escape, firefighting operations or property protection, has 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 authorities having jurisdiction at an early stage in the design process.

4.5 Additional functions

If designed accordingly, the PDS may have a secondary function as a ventilation system, provided that it shall close the ventilation system down and switch to operation specifically as a PDS alone when a smoke alarm is received.

5 Requirements

5.1 General

For this document the PDS will only have to deal with one fire at any one time, following generally accepted practice. Designs and calculations will reflect this approach to fulfil the normative requirements of this document.

The PDS shall be designed in such a way, that the PDS can fulfil its function throughout the required operating time (e.g. 30, 60, 90 min) in accordance with national requirements.

If there is more than one PDS installed in a building, each PDS shall have its own control system. The failure of any one PDS control system shall not negatively affect any other PDS.

Therefore, in operation, pressure differential and airflow velocity criteria shall only be required to be met on the fire floor, but it shall be proven that the PDS can meet these requirements on all floors during acceptance testing, but not necessarily at the same time. It is not acceptable for the PDS to draw smoke into the protected space.

The PDS shall be triggered automatically by smoke detectors in accordance with EN 54 series. This may also be achieved by the PDS receiving smoke signals from a separate fire/smoke detection system. There shall be at least one single smoke detector on each floor installed on the unprotected side of the door to the protected space (e.g. in the corridor or lobby). The smoke detection system may be zoned to cover the whole building. Once the fire has been detected in a defined place by either smoke detection or a fire detection system, the PDS shall be activated. Any stray smoke, which may be detected in another place or in the protected space on another floor shall not change the operation of the PDS.

If there is a smoke detector or fire alarm activation within the protected space (e.g. staircase) before smoke has been detected on a specific floor, this shall not lead to activation of the PDS.

Any additional signals from smoke detectors or fire detection systems shall be ignored by the PDS.

NOTE 1 Early detection is given when smoke detectors are placed in spaces with fire load (e.g. accommodation), and not in the lobby or corridor, for example. However, if placing smoke detectors in accommodation or other areas, access for maintenance and testing shall be provided.

Each escape and rescue route, protected by PDS, shall be a stand-alone system (e.g. independent fan, ductwork, controls).

NOTE 2 PDSs for staircases and firefighters lift shafts, connected in one common lobby, are handled as one PDS, however consideration should be given to the use of separate fans for the staircase and for the firefighting lift shafts to give easier control and balancing of airflows.

Stack effect, convective airflow, airflow resistance, external wind etc. are amongst other influences which can adversely affect the function of a PDS and therefore shall be taken into account.

The following parameters are defined for the design and shall be met and confirmed by the acceptance test on site:

— Maximum door opening force (N);

— Minimum pressure differential (Pa);

— Minimum air flow velocity (m/s);

— Maximum response delay (s) – defined by initiation, operation and response times.

Table 1 — Design requirements of a PDS

Parameter	Class 1	Class 2
Door opening force	≤ 100 N	
Pressure differential	≥ 30 Pa	
Airflow velocity	≥ 1 m/s	≥ 2 m/s
Initiation time	≤ 60 s	
Operation time	≤ 120 s	
Response time	≤ 5 s	

NOTE Refer to Clause 8 when measuring the normative requirements given in Table 1.

5.2 Application of Class 1 and Class 2

5.2.1 Class 1

Class 1 will be required:

— in buildings with automatic water extinguishing systems using quick response sprinkler according to EN 12259-1 (with response time index (RTI)≤50) which operate in response to temperatures ≤ 72 °C; or

— in residential buildings up to 30 m or below the high-rise buildings limit (in accordance with national requirements); or

— in residential buildings, if there are at least two rooms without fire load between the protected space and the potential fire source and self-closing doors are present; or

— if accepted by authorities having jurisdiction.

5.2.2 Class 2

Class 2 will be required:

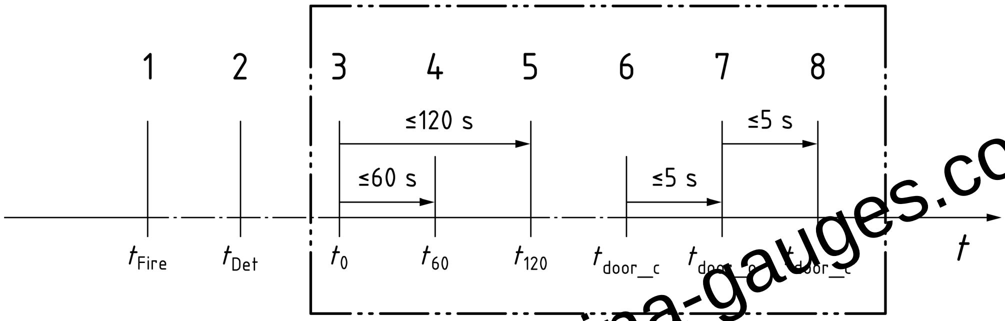
— where Class 1 is not applicable; or

— if required by authorities having jurisdiction.

5.3 Response delay – time period definitions

5.3.1 General

For the successful design and operation of the PDS, the initiation, operation and response times shall meet the requirements stated in Table 1, as further explained below and in Figure 2. The times for the start and detection of the fire are outside the scope of this document.



Key

1	t_{Fire}	start of a fire
2	t_{Det}	detection of the fire
3	t_0	activation of the Pressure Differential System (PDS)
4	t_{60}	initiation time
5	t_{120}	operation time
6	t_{Door_c}	time door closed
7	t_{Door_o}	time door open
8	t_{Door_c}	time door closed
t		time

NOTE The times within the scope of this document are shown in the key.

Figure 2 — PDS Response delay – time period definitions

5.3.2 The start of a fire (t_{Fire})

This is the point of the start of the fire (shown in Figure 2). It is outside the scope of this document and the results but is included to show the relationship to the other times specifically defined.

5.3.3 Detection of a fire (t_{Det})

This is the point of the detection of the fire (shown in Figure 2). It is outside the scope of this document and the results but is included to show the relationship to the other times specifically defined.

5.3.4 Activation of the PDS (t_0)

This is the point of the PDS activation and occurs as soon as the PDS receives an alarm signal from the detection system (Figure 2).

5.3.5 Initiation time (t_{60})

The initiation time is the time period which starts at the activation of the PDS (t_0) and ends after 60 s, by which time all the necessary components shall be in the correct operating position (e.g. damper, vents) - see Table 1 and Figure 2 - and the fan shall have started.

5.3.6 Operation time (t_{120})

The operation time is the time period which starts4 at the activation of the PDS (t_0) and ends after 120 s, by which time the PDS shall be in its fully operational status (see Table 1 and Figure 2).

5.3.7 Response times (t_{door_c}, t_{door_o})

The response time is the time period under which the PDS shall achieve the objective of either the pressure differential requirements (including maximum door opening force) or the air velocity requirements as the door is opened (5 s) and closed (5 s) (see Table 1 and Figure 2).

NOTE The requirement for the response time of 5 s in this document is with regard to site variances to allow a site tolerance on the test performed in EN 12101-6.

5.4 Door opening force

5.4.1 General

The PDS shall be designed so that the opening force at the door handle does not exceed 100 N. This requirement shall be met on all floors including the fire floor and for each door within the escape routes, when the PDS is in operation.

The characteristics of doors and their door closers (size, closing force and location of door handle) shall be taken into account when designing the PDS (see calculation information in Annex A).

All doors shall be kept closed while the PDS is in operation to maintain fire compartmentation except when manually or intentionally opened for escape or firefighting. All doors between pressurized and unpressurized spaces shall be fitted with automatic closing mechanisms including the final exit door (e.g. door closers with brake mechanism, to prevent accidents).

Door opening forces apply to all doors leading to protected spaces and to the outside as long as the PDS is in operation.

Door opening forces for doors along escape routes shall not exceed 100 N limit, if the PDS is in operation or not.

5.4.2 Doors (doors between pressurized and unpressurized spaces)

The opening force for these doors shall not exceed 100 N if the PDS is in operation or not.

All the requirements for the PDS in Table 1 shall be met on the fire floor despite the fact that, in some instances, the final exit door may not be completely closed.

NOTE 1 See also Annex A. Be aware that all combinations of door size and door closer cannot be acceptable as the 100 N value can be exceeded.

Where doors must open against pressure, the designer shall ensure that the door opening force does not exceed the requirements and that the door does not close with excessive force under the influence of the pressure (e.g. door closers with brake mechanism to prevent accidents).

If the door opening is aided by the pressurization (e.g. the final exit door), the designer shall ensure that either the door is kept closed, without causing excess door opening forces when the PDS is not in operation, or, if the door is not fully closed, the requirements of Table 1 are still met.

NOTE 2 As an option, door closers with dual functionality are available. If the PDS is not in operation, the door closer acts as a standard door closer. However, if the PDS is in operation, the door closer activates an additional, second door closer and increases the force used to close the door (e.g. the final exit door against the PDS).

5.5 Pressure differential systems

5.5.1 General

Pressure differential systems can be designed using overpressure (named pressurization).

The design of a PDS is influenced by the choice and definition of the protected and unprotected spaces together with the type and position of the air supply and air release routes.

The structure used in Clause 5 follows Figure 3.

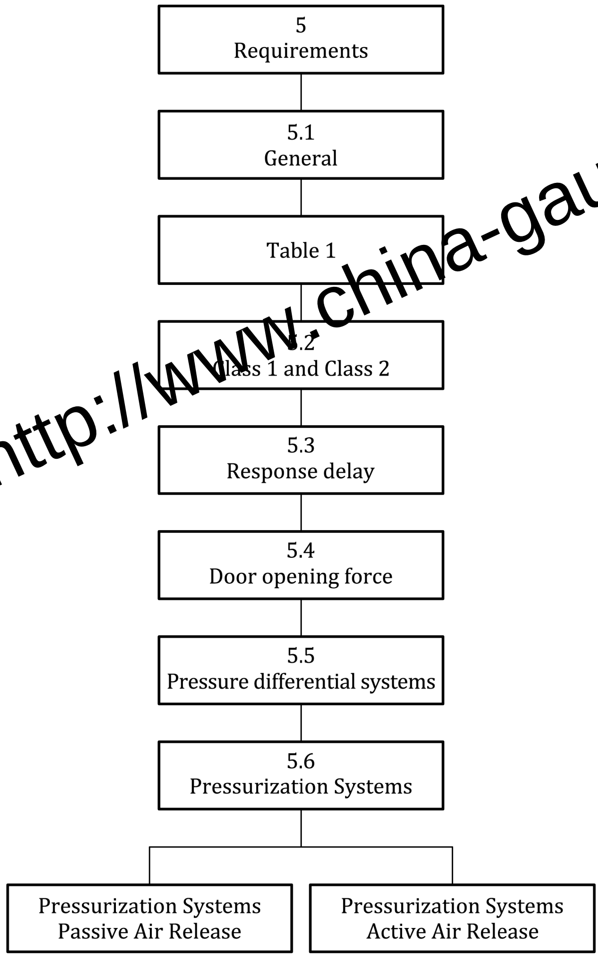


Figure 3 — Structure of the requirements depending on the system in use

5.5.2 PDS system types

5.5.2.1 General

Pressurization systems can be designed with passive (natural) or active (powered) air release;

NOTE See subclause 7.5 for component requirements.

5.5.2.2 Pressurization systems with passive air release

These systems have air supply fans which produce an overpressure within the protected space in reference to the unprotected space.

Air release is provided by means of controlled openings (e.g. natural vents to outside (in accordance with EN 12101-2), smoke control dampers (in accordance with EN 12101-8) to shafts).

Main feature of this system:

— controlled overpressure in the protected space (e.g. staircase).

5.5.2.3 Pressurization systems with active air release

These systems have air supply fans which produce an overpressure within the protected space in reference to the unprotected space.

Air release for these systems is provided by means of additional smoke control fans in accordance with EN 12101-3 (and EN 12101-6 when required), with associated ducts or shafts if appropriate to exhaust the hot air or smoke to the outside.

Main features of these systems:

— controlled overpressure in the protected space (e.g. staircase, lobby, lift shaft).

5.6 Pressurization systems

5.6.1 General

Requirements for the installation and equipment, including the function of the various essential components involved, are described in the following and in subclause 7.5.

Figure 4 shows a typical pressurization system with staircase and firefighters lift shaft protection and air release in the façade(s).

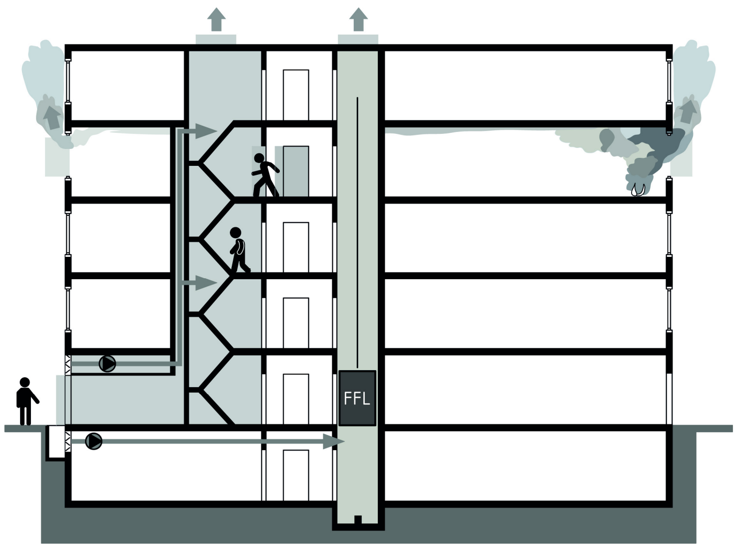


Figure 4 — Typical pressurization system

Examples of pressurization systems (floor plans) are described in subclause 5.6.3.

A firefighters' lift shaft, connected to the same lobby (see also Figure 6) as the staircase may have the same, or a separate air supply fan.

An example of a more complex pressurisation system is found in Annex E.

5.6.2 Connected lobbies and corridors

5.6.2.1 Connected lobbies

In most cases, the connected lobby is not protected in the same way as the protected staircase because, depending on the position of air release, there is only airflow if the relevant doors are all open at the same time (see e.g. Figure 7).

Examples of protected lobbies are shown in Figure 12 and Figure 13.

NOTE Additional pressurized spaces may have to be provided and this should be in accordance with project specific requirements and/or national requirements where they apply.

5.6.2.2 Connected corridors

Connected corridors are considered in the same way as above.

5.6.3 Design examples showing protected spaces and airflow directions for pressurization systems

5.6.3.1 General

The following floor plans represent examples of possible pressurization systems.

A key is given with each figure to indicate protected spaces, pre-conditions and other essential information. The protected areas are marked in grey.

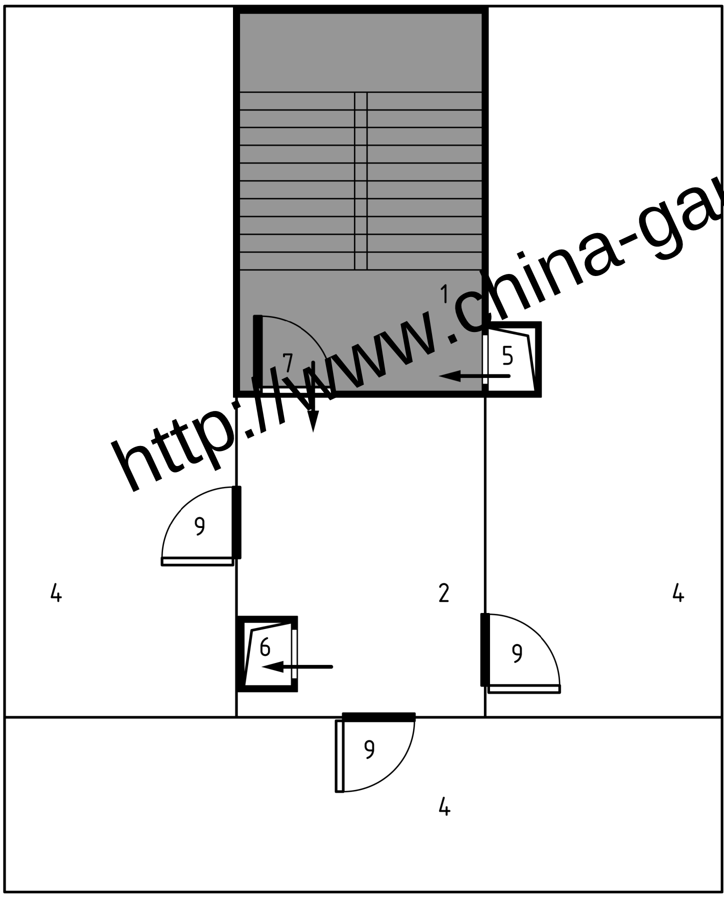
The air release path shall be designed in accordance with 5.6.7 and may be either by a shaft or by façade openings.

The direction of the airflow shall be in accordance with the arrows in the Figures 5, 6, 7, 8, 9, 10, 11, 12, and 13.

The air supply is shown as an individual supply to each protected space in some of the examples. However, this might be designed and solved in practice differently using qualified construction products (e.g. dampers) and in accordance with national requirements (see Figures 6, 8, 11, 12 and 13). In any variation the requirements of table 1 still have to be met.

NOTE The examples shown in this section are for pressurization only.

5.6.3.2 Example 1: Staircase protection (pressurization system)



Key

1	staircase	6	air release	←	airflow direction
2	lobby	7	door to staircase	(grey box)	protected space
3	—	8	—		
4	accommodation	9	door to accommodation		
5	air supply	10	—		

Figure 5 — Pressurization system for a staircase with air release in the lobby

Preconditions

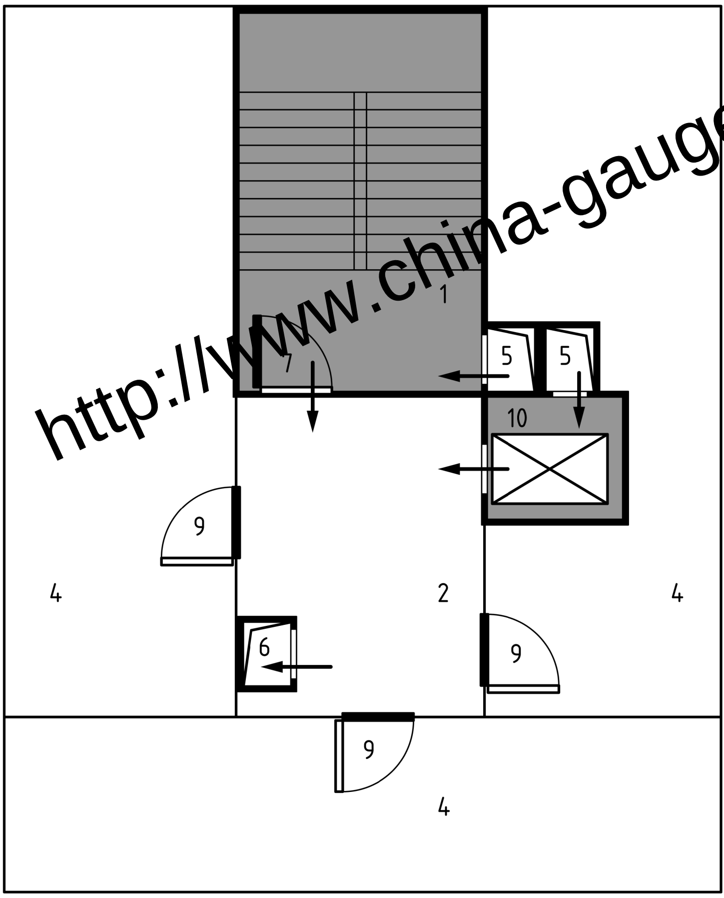
— PDS is activated and air release (6) is open on the fire floor only;

— between staircase (1) and lobby (2) an Air Transfer Damper (ATD) may be installed (in accordance with national requirements);

— door (7) shall be equipped with a door closer;

— in the absence of national requirements, door(s) (9) may be equipped with door closers.

5.6.3.3 Example 2: Staircase, firefighters lift, and/or other lift shaft(s), protection (pressurization system)



Key

1	staircase	6	air release	←	airflow direction
2	lobby	7	door to staircase	■	protected space
3	—	8	—		
4	accommodation	9	door to accommodation		
5	air supply	10	firefighters' lifts, or other lift shaft(s), that require protection		

Figure 6 — Pressurization system for staircase and firefighters lift shaft with air release in the lobby

Preconditions

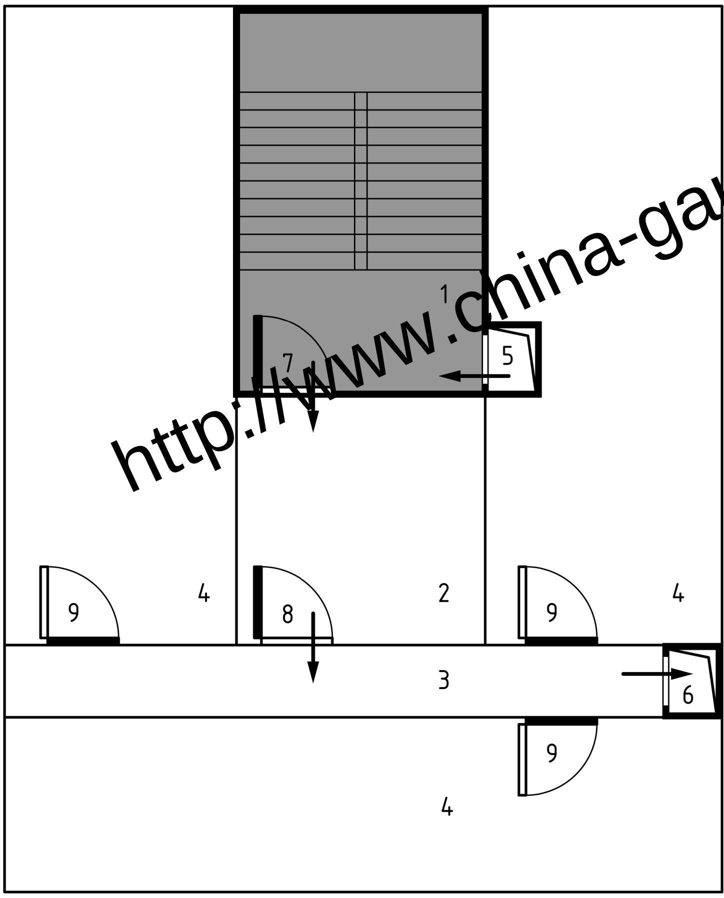
— PDS is activated and air release (6) is open on the fire floor only;

— between staircase (1) and lobby (2) an Air Transfer Damper (ATD) may be installed (in accordance with national requirements);

— door (7) shall be equipped with a door closer;

— in the absence of national requirements door(s) (9) may be equipped with door closers.

5.6.3.4 Example 3: Staircase protection (pressurization system)



Key

1	staircase	6	air release	←	airflow direction
2	lobby	7	door to staircase	▭	protected space
3	corridor	8	door to lobby		
4	accommodation	9	door to accommodation		
5	air supply	10	—		

Figure 7 — Pressurization system for staircase with air release in the corridor

Preconditions

— PDS is activated and air release (6) is open on the fire floor only;

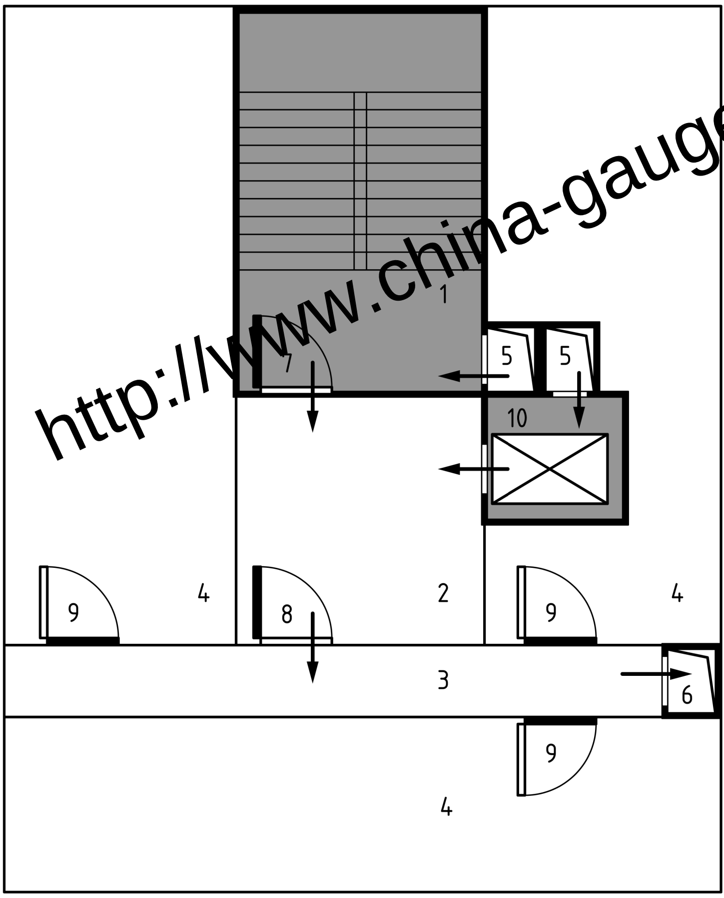
— between staircase (1) and lobby (2) and between lobby (2) and corridor (3) Air Transfer Damper (ATD)s may be installed (in accordance with national requirements) to allow pressurization of the lobby (2) and ventilation of the corridor (3);

— doors (7, 8) shall be equipped with door closers;

— in the absence of national requirements door(s) (9) may be equipped with door closers;

— if openings in the façade are used for air release, refer to the specific subclause in 5.6.7.

5.6.3.5 Example 4: Staircase, firefighters lift and/or other lift shaft(s), protection (pressurization system)



Key

1 staircase
2 lobby
3 corridor
4 accommodation
5 air supply
6 air release
7 door to staircase
8 door to lobby
9 door to accommodation
10 firefighters' lifts, or other lift shaft(s), that require protection

airflow direction
protected space

Figure 8 — Pressurization system for staircase and firefighters lift shaft with air release in the corridor

Preconditions

— PDS is activated and air release (6) is open on the fire floor only;

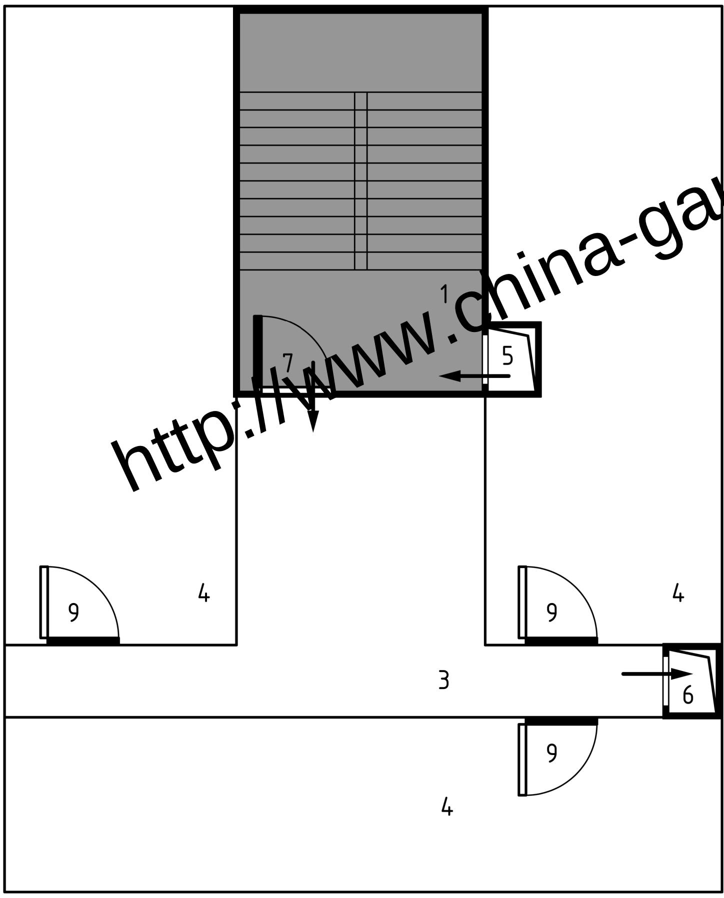
— between staircase (1) and lobby (2), between lift shaft (10) and lobby (2), and between lobby (2) and corridor (3) Air Transfer Damper (ATD)s may be installed (in accordance with national requirements) to allow pressurization of the lobby (2) and ventilation of the corridor (3);

— doors (7, 8) shall be equipped with door closers;

— in the absence of national requirements door(s) (9) may be equipped with door closers;

— if openings in the façade are used for air release, refer to the specific subclause 5.6.7.

5.6.3.6 Example 5: Staircase protection (pressurization system)



Key

1	staircase	6	air release	←	airflow direction
2	—	7	door to staircase	▭	protected space
3	corridor/lobby	8	—		
4	accommodation	9	door to accommodation		
5	air supply	10	—		

Figure 9 — Pressurization system for staircase and air release in the corridor/lobby

Preconditions

— PDS is activated and air release (6) is open on the fire floor only;

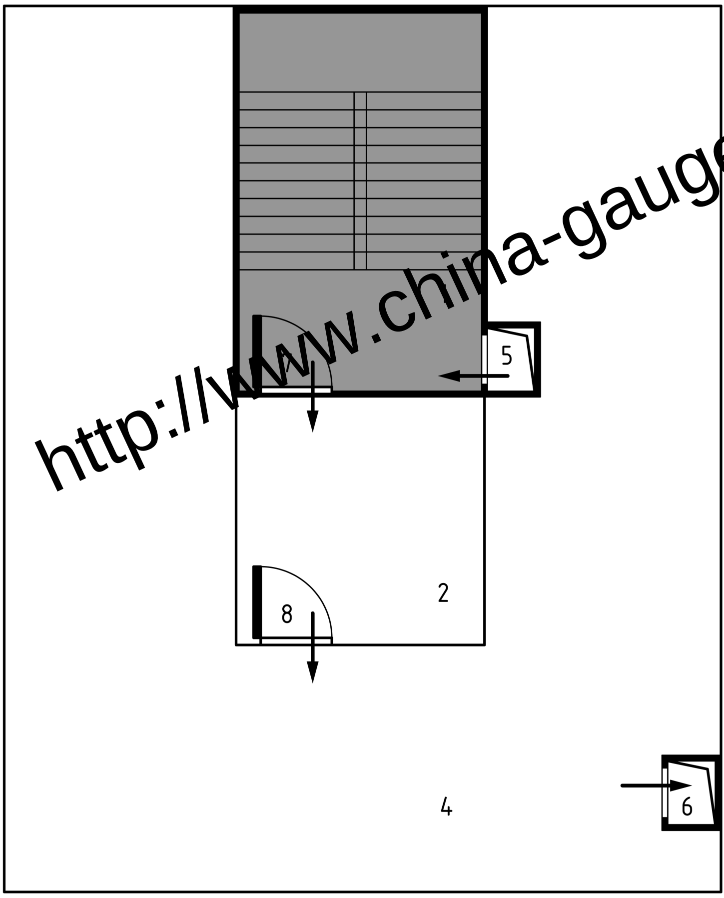
— between staircase (1) and corridor/lobby (3) an Air Transfer Damper (ATD) may be installed (in accordance with national requirements);

— door (7) shall be equipped with a door closer;

— in the absence of national requirements door(s) (9) may be equipped with door closers;

— if openings in the façade are used for air release, refer to the specific subclause 5.6.7.

5.6.3.7 Example 6: Staircase protection (pressurization system)



Key

1	staircase	6	air release	←	airflow direction
2	lobby	7	door to staircase	▭	protected space
3	—	8	door to lobby		
4	accommodation	9	—		
5	air supply	10	—		

Figure 10 — Pressurization system for staircase and air release in the accommodation

Preconditions

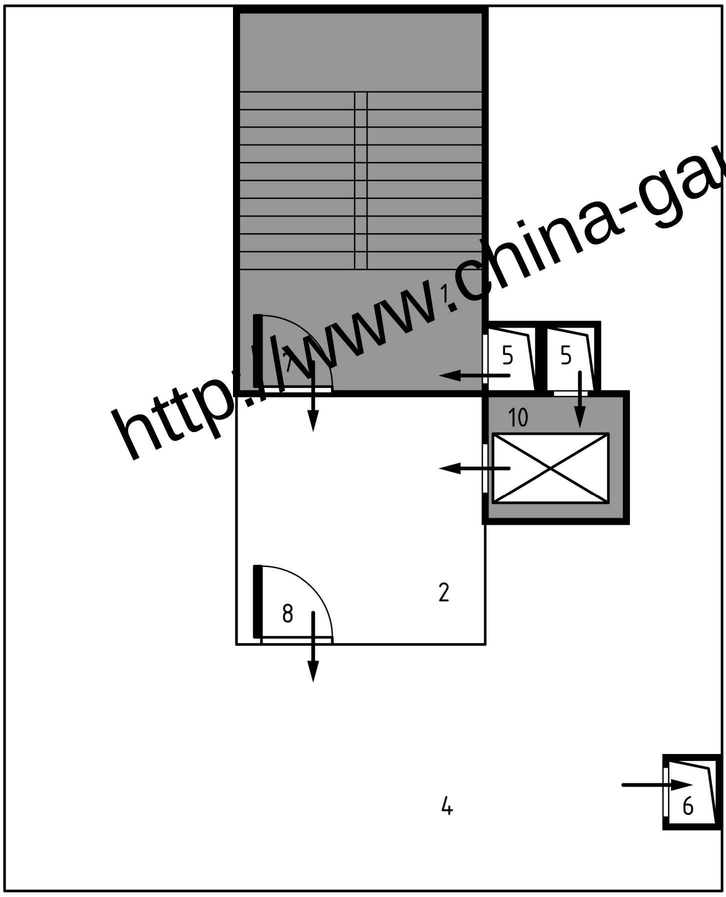
— PDS is activated and air release (6) is open on the fire floor only;

— between staircase (1) and lobby (2) and between lobby and accommodation (4) Air Transfer Damper (ATD)s may be installed (in accordance with national requirements);

— all doors (7, 8) shall be equipped with door closers;

— if openings in the f façade are used for air release, refer to the specific subclause 5.6.7.

5.6.3.8 Example 7: Staircase, firefighters lift and/or other lift shaft(s), protection (pressurization system)



Key

1	staircase	6	air release	←	airflow direction
2	lobby	7	door to staircase	▭	protected space
3	—	8	door to lobby		
4	accommodation	9	—		
5	air supply	10	firefighters’ lifts, or other lift shaft(s), that require protection		

Figure 11 — Pressurization system for staircase and firefighters lift shaft with air release in the accommodation

Preconditions

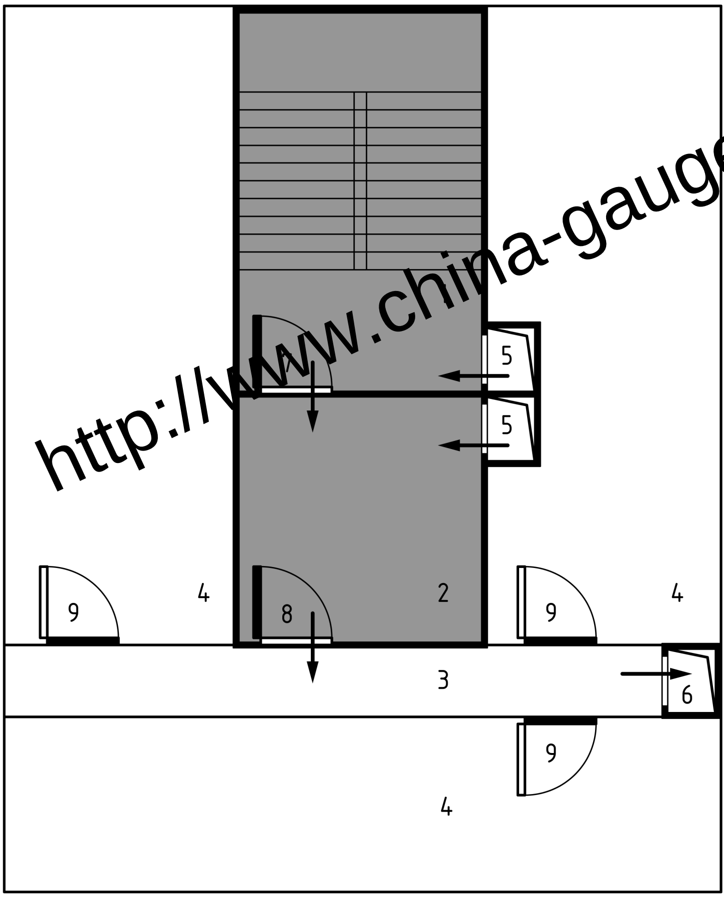
— PDS is activated and air release (6) is open on the fire floor only;

— between staircase (1) and lobby (2) Air Transfer Damper (ATD)s may be installed (in accordance with national requirements) to allow pressurization of the lobby (2);

— all doors (7, 8) shall be equipped with door closers;

— if openings in the façade are used for air release, refer to the specific subclause 5.6.7.

5.6.3.9 Example 8: Staircase and lobby protection (pressurization system)



Key

1	staircase	6	air release	←	airflow direction
2	lobby	7	door to staircase	■	protected space
3	corridor	8	door to lobby		
4	accommodation	9	door to accommodation		
5	air supply	10	—		

Figure 12 — Pressurization system for staircase and lobby with air release in the corridor

Preconditions

— PDS is activated and air release (6) is open on the fire floor only;

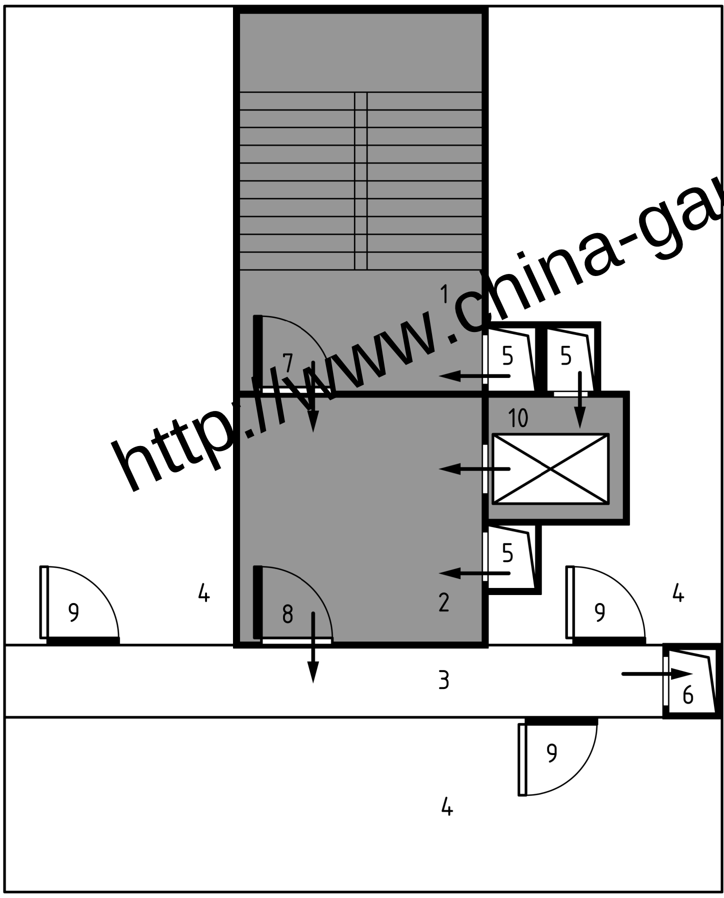
— between staircase (1) and lobby (2) and between lobby and corridor (3) Air Transfer Dampers (ATD, see 7.5 for more explanation) may be installed (in accordance with national requirements);

— doors (7, 8) shall be equipped with door closers;

— in the absence of national requirements door(s) (9) may be equipped with door closers;

— if openings in the façade are used for air release, refer to the specific subclause 5.6.7.

5.6.3.10 Example 9: Staircase, lobby and firefighters lift shaft protection (pressurization system)



Key

1	staircase	6	air release	←	airflow direction
2	lobby	7	door to staircase		protected space
3	corridor	8	door to lobby		
4	accommodation	9	door to accommodation		
5	air supply	10	Firefighters' lifts		

Figure 13 — Pressurization system for staircase, firefighters lift shaft and lobby with air release in the corridor

Preconditions

— PDS is activated and air release (6) is open on the fire floor only;

— between staircase (1) and lobby (2) and between lobby and corridor (3) Air Transfer Dampers (ATD)s may be installed (in accordance with national requirements);

— doors (7, 8) shall be equipped with door closers;

— in the absence of national requirements door(s) (9) may be equipped with door closers;

— if openings in the façade are used for air release, refer to the specific subclause 5.6.7.

NOTE Non-firefighters' lift shafts, connected to a protected lobby, do not have to be pressurized.

5.6.4 Pressure differential criteria

The design shall provide a pressure differential of at least 30 Pa between the protected and unprotected space (with the air release open) on the fire floor. This requirement shall be met when:

— all doors in the protected staircase including the final exit door are closed (exception, see chapter 5.4.2); and

— all doors to the pressurized lift shaft except one access door (generally the door to the lift on the evacuation exit floor) are closed (including the lift door on the fire floor); and

— the air release (active or passive) to the outside from the unprotected space is open and operating.

When the doors between the protected and unprotected spaces are open, the pressure differential criterion is replaced by the velocity criteria (see subclause 5.6.5).

The overpressure within the lift shaft of a firefighting lift shall not adversely affect the operation of the firefighting lift. If necessary, the lift shaft shall be equipped with an appropriate overpressure relief device (e.g. Barometric Relief Damper or Pressure Control Damper).

In the event of smoke entering a common unprotected lobby, the pressure differentials between staircase and lobby and between lift shaft and lobby shall not drive smoke into the staircase or into the lift shaft.

5.6.5 Airflow velocity criteria

The design shall provide minimum air velocities through open doors between the protected and unprotected spaces that comply with Table 1.

When more than one door leads from the protected to the unprotected space, it shall be demonstrated that the PDS will work with one door fully open and in the case of differing door sizes, this shall be the door with the largest area.

If a door, including the final exit door, has two leaves, it shall be demonstrated that the PDS will work with only the largest leaf fully open.

NOTE 1 During the escape period many people will obstruct the door opening, such that free cross section of one fully open door, or leaf, without any obstruction is sufficient for the design.

NOTE 2 Where more doors open from the protected to unprotected spaces on any one floor and/or there is more than one exit door that can be used, consideration must be made in the design to perhaps allow for more volume.

Doors with two leaves that need to close in a specific order shall be designed to do so.

Airflow velocity criteria only needs to be met on the fire floor. The respective release path to the outside shall be open.

As an option, if the designer can justify to the authorities having jurisdiction that the final exit door can be designed to be closed, e.g. if the fire brigade does not have to prop it in its open position during their intervention, this is acceptable. The door shall always be openable for people to escape and the firefighters to enter.

However, clear information about the door not being propped open during an incident shall be provided to the responsible person.

5.6.6 Requirements for air supply

5.6.6.1 General

Consideration shall be given to the position and design of the fans and ducts or shafts to ensure that they are not compromised by a fire from the unprotected space.

NOTE Wind and the specific shape of the building can have an influence on air intake positions and it can be necessary to consider this.

5.6.6.2 Air intake

Intake air shall be drawn directly from the outside in such a way that it is not contaminated by smoke from a fire within the building.

The air intake shall be located away from any potential fire hazards or smoke hazards (e.g. waste containers, basements smoke vents). Air intakes shall be located on ground level to avoid contamination by rising smoke.

NOTE It is advisable that no building openings are situated below the air intake point.

Each PDS shall have a separate outside air intake or be fitted via a ducted plenum system. The intake points of individual PDSs shall not interfere with each other. All connections to supply ductwork/plenums shall be equipped with multi-compartment smoke control dampers. The main air intake of the supply air duct/plenum shall be either permanently open or if controlled, each PDS can control the inlet specifically and individually.

The air intake should be located a minimum of 1 m vertically below and 5 m horizontally from any building openings (e.g. air outlets, windows, doors) or be in accordance with national requirements if these differ.

Glazing in these areas shall have fire resistance in accordance with national requirements or E30 in accordance with EN 13501-2 as a minimum.

As an option, where air intakes on ground level are not possible then they can be positioned at roof level or elsewhere in the façade. For this application there shall be at least two air intakes, spaced as far apart as possible and facing different directions in such a manner that they could not be directly downwind of the same source of smoke and/or as defined in national requirements. Each inlet shall be independently capable of providing the full air requirements of the PDS.

Wherever placed, each inlet shall be protected by an independently operated air supply control damper in accordance with 7.5.10 which shall close in response to an individual self-resetting smoke detector mounted in the ductwork just after the damper. If all relevant dampers are closed, the supply fan shall be switched off. Then, if one, or more, of the smoke detectors resets, to indicate a clean air supply, then the relevant damper will re-open and the fan will re-start automatically.

5.6.6.3 Air supply to firefighter lift and other lift shafts

The air supply shall not negatively affect the lift operation (e.g. creating oscillation of travelling cable/belt, opening and closing of the lift doors). This can be achieved by:

— limiting the air supply speed into the lift shaft to max 3 m/s; or

— positioning the air supply inlet on the top of the lift shaft; or

— positioning the air supply inlet positioned at the lowest possible position, but higher than the maximum possible water level in the lift shaft pit and taking the lowest car position into account; or

— a combination of the above.

The piston effect shall be ignored. All measurements for PDS shall be done with lifts inactive.

NOTE If there is a firefighters intercom system the sound pressure level in the firefighter lift shaft and in the staircase, created by PDS in any situation, should be lower than 80 dB (A) measured in the cabin. The sound pressure level is measured approximately half a meter from the microphone of the intercom system.

5.6.6.4 Air supply to staircases

The air supply to the staircase shall be distributed evenly over the height of the staircase using a vertical shaft to ensure that the pressure differential and velocity requirements are fulfilled.

NOTE 1 An air supply point at every third floor, as a minimum, provides the necessary performance. More supply points can make it easier to fulfil the performance requirements. If it can be shown in the design that fewer supply points deliver the required performance, then this will be acceptable.

It is recommended that the air supply points in the staircase should not be placed close to doors, so as not to compromise an even air distribution through the doors.

The air supply velocity from the staircase supply points shall be not more than 5 m/s.

Lower air supply velocities are recommended.

5.6.7 Requirements for air release

5.6.7.1 General

During operation of the PDS, pressurizing air will flow from the pressurized space into the unpressurized space. It is important that provision be made on the fire floor for the air that has flowed into the unpressurized spaces to escape from the building. The air release path may be passive, for example, from windows or active by fan control.

NOTE 1 The air being released will be a mixture of air and smoke, not clean air.

NOTE 2 For air release paths the means of control can be open-loop control or closed-loop control to suit the specific system/application.

It is advisable that all open windows that are not part of the air release path are closed when the PDS is operating. If the windows cannot be closed automatically, the leakage from these open windows and the additional wind impact shall be considered and covered by the PDS design.

Air release vents e.g. windows, are influenced by wind and thermal effects. This shall be taken into account at the design stage (see chapter 9 and Annex C and D).

Sufficiently sized air release path(s) shall be provided to ensure that the performance parameters specified in Table 1 are delivered.

The pressure loss in the passive air release path between a protected space and the outside shall not exceed the specified overpressure in the protected space.

The air release path shall be designed to achieve the required performance and it shall not be assumed that air release is provided by the breaking of glazing due to the fire or building leakages.

5.6.7.2 Passive air release by openings in the façade

In the case of a smoke incident, the air release vents on the fire floor shall be fully open and shall be closed on all other floors. Appropriate automatic control shall be provided to achieve this.

To provide nearly wind-independent air release the necessary opening area may be provided in at least two sides of the building and preferably on opposite façades.

The openings in each façade shall have the total required area unless it can be demonstrated that the air release is not adversely affected by wind pressure.

Building labels (e.g. LEED Leadership in Energy and Environmental Design) dictate that windows can be opened (manually or automatically) from the building users. The impact to the PDS can be significant (e.g. leakage, wind) and should be considered accordingly.

5.6.7.3 Passive air release by shafts and/or duct systems

There shall be a clear path out of the building for the air release. The general principle will be that vents and dampers shall open or stay open in the fire room and along the release path and shall close or stay closed to maintain compartmentation in all other zones.

Automatic control shall be provided to achieve the positioning of the smoke vents and dampers.

Depending on the design of the PDS some components may be required to operate, modulate and adjust their position whilst being subjected to fire conditions and shall be selected, tested and classified appropriately.

Full details of the specifications for ducts, dampers and vents are given in subclause 7.5.

5.6.7.4 Active air release by shafts and/or duct systems

There shall be a clear path out of the building for air release and the required air movement will be achieved using fans. The active air release shall be automatic in operation under the control of the PDS. The system design shall ensure that the active air release is balanced to release sufficient air flow to achieve the design requirements of the PDS.

It is advisable that all open windows that are not part of the air release path are closed when the PDS is operating. If the windows cannot be closed automatically, the leakage from these open windows and the additional wind impact shall we considered and covered by the PDS design.

The system may include components that will be required to operate, modulate and adjust their position whilst being subject to fire conditions and shall be selected, tested and classified accordingly.

Full details of the specification for ducts, dampers and vents are given in subclause 7.5

NOTE This design may need to take into account that the PDS shall go on operating and keeping smoke out of protected spaces even if the fire is fully evolved. In this instance, if the extract fans are drawing smoke and heat directly from the fire compartment, the gas temperatures may be greater than 600 °C and the components involved like e.g. the fans shall be selected accordingly.

5.6.8 Requirements for pressure control

To fulfil the requirements in Table 1 and to achieve the required response times when doors are opened and closed, devices to control pressure differentials and air volume rates shall be used.

Pressure control shall be realized by:

— Pressure relief devices (which discharge directly or via appropriate duct work from the pressurized space to the outside; or

— Controlling the air volume flow rates (e.g. control of fan speed, damper control, bypass solutions).

5.6.9 Protection device for the controlled opening

Any protection device shall operate in accordance with 5.3.5 and the pressure relief opening shall not be compromised with respect to all weather conditions (e.g. wind loading, snow loading) or loss of the cross-sectional area.

The use of a natural smoke ventilator in accordance with EN 12101-2 will fulfil these requirements.

5.6.10 Requirements for pressure relief, controlled openings and flushing

National requirements may request continuous flushing of the protected space.

NOTE Consideration can be given to the application of flushing in any PDS design.

Where flushing is to be included, the protected space shall be flushed with a minimum airflow in accordance with national requirements, or a minimum of 7 500 m^3/h.

This may be achieved by using a simple opening, or an opening with a device fitted (e.g. pressure relief damper, control damper) selected to be capable of allowing the required minimum discharge rate, combined with the selection of the fan to achieve this, whilst maintaining the required design parameters of the PDS.

If the PDS is required to protect other spaces (e.g. lift shaft), the above shall be provided accordingly for those spaces.

6 Interaction

6.1 General

The PDS will require a connection to the fire alarm system, smoke detector(s) or an alternative control unit to allow activation.

The PDS control unit may be required to activate or shut down other additional building systems to allow the correct operation of the PDS (e.g. shut down HVAC systems, close of doors).

If it is necessary, any cause and effect safety matrix for the PDS shall include all these additional control functions.

The pressure differential system, when triggered, may interact with any or all of the following systems:

— Fire detection system, alarms and Public Address and Voice Alarms (see 6.2.1);

— HVAC systems (see 6.2.2);

— Firefighting lifts and other lifts (see 6.2.3);

— Smoke and heat exhaust ventilation systems (SHEVS) (see 6.2.4);

— Spaces being pressurized or depressurized for other reasons than fire (see 6.2.5);

— Automatic water spreading system (e.g. Sprinkler system) (see 6.2.6);

— Window and sun shading systems (see 6.2.7); and

— Windows and other openings (see 6.2.8).

6.2 Requirements

6.2.1 Fire detection systems, alarms, public address and voice alarm systems

An interface is required for the fire detection system if this is the designed means of activation of the PDS.

Alarms, public address and voice alarm systems give information and action messages to occupants within the building in case of fire. The required levels of audibility are determined by national requirements valid in the place of use for the PDS. Generally, there is a requirement for alarms and messages from public address and voice alarm systems to be clearly audible above the sound of any operating pressure differential system. The PDS shall comply with relevant audibility requirements.

6.2.2 Heating, ventilation and air conditioning (HVAC) systems

The HVAC system shall in case of fire:

— be designed so that it does not adversely affect the pressure differential strategy; or

— be shut down to prevent the smoke penetrating other interconnected spaces; or

— comply with the relevant requirements and control functions of this document if used as part of the pressure differential system.

The HVAC system shall generally be controlled by a system independent to the PDS (see also 4.5).

6.2.3 Firefighting lifts, evacuation lifts and other lifts

Design issues are shown in 5.6.3. Any electrical inputs or outputs shall be part of the cause and effect safety matrix and shall meet national requirements.

6.2.4 Smoke and heat exhaust ventilation systems (SHEVS)

If any part of the building is equipped with a SHEVS, the designs of both systems (PDS and SHEVS) shall be demonstrated to not conflict. The design parameters of both systems shall be within their permitted ranges.

SHEVS can produce additional underpressure which may affect the PDS. The combination of the SHEVS' negative pressure and the differential pressure from the PDS may combine to increase the door opening force. Any combination shall not cause the door opening force to exceed 100 N at the door handle.

The smoke vents that are part of the SHEVS can be used as air release for the PDS if they are in compliance with the requirements for air release in this document (see subclause 7.5).

There may be a requirement for staircase ventilation as the PDS will not operate if smoke is detected in the protected space (e.g. staircase).

— There may be a separate SHEVS system associated with the staircase, which will function if smoke is detected in the staircase. The PDS will not function until this system is turned off/closed.

— Alternatively, if the PDS has a SHEVS function for the staircase this will operate automatically or more often from an override button used by the fire brigade. The PDS will not function until this SHEVS function is turned off/closed.

6.2.5 Spaces being pressurized for reasons other than fire

If buildings contain spaces such as computer suites, cleanrooms, or medical facilities that are e.g. pressurized for reasons other than fire, consideration shall be given to the conflicting pressures that may affect the differential pressures and required direction of airflow in the escape routes for smoke control purposes.

The combination of such pressures and the differential pressure from the PDS may also combine to increase the door opening force. Any combination shall not cause the door opening force to exceed 100 N at the door handle.

6.2.6 Automatic water spreading system

No negative influences between the automatic water spreading system (e.g. sprinkler system) and the PDS are expected but shall be considered.

NOTE Influences from PDS to a fog system shall be checked, depending on the position of the air release. If the air release is located in the lobby or corridor (normally not protected by a fog system), no negative interaction to a fog system is expected. If the air release is located in the accommodation, where a fog system is installed, negative interaction to a fog system is possible.

6.2.7 Window and sun shading systems

The windows and sun shading in the building may be controlled by a separate system. When a smoke signal is received the control of these windows shall be overridden by the PDS. All windows will close and the PDS will open the windows required for air supply/release. All shading systems will fully open. Care shall be taken to ensure that any sun shading devices do not obstruct the opening or air flow.

Where retractable shading may interfere with opening of the window or ventilator, the shading shall automatically retract upon receipt of a smoke signal, overriding any other control signal. Opening of the window or ventilator may need a delay to allow this to occur. Any such delay shall comply with the maximum operating time in Table 1 (see subclause 5.3 and Figure 2).

Where shading may affect the pressure drop of the air release system, either the shading shall automatically retract upon receipt of a smoke signal, overriding any other control signal, or the additional pressure drop caused by the shading device shall be determined and included in the system design calculations.

6.2.8 Windows and other openings

In the case of pressurization systems all windows and other openings in the protected space (e.g. staircase) used for ventilation shall be closed before the PDS can function correctly and it is advisable that these windows and openings are under the control of the PDS.

7 Equipment and components – specification and installation

7.1 General

A PDS is designed with a set of components e.g. air supply, pressure control, air release, control panel (see Figure 14 and Figure 15).

All the important components which are necessary to produce and control the required pressure differential are defined as a PDS kit. A kit can be designed using different components such as fans, dampers, controllers, sensors, frequency inverters.

The PDS shall be installed in accordance with the documented design.

All service providers shall demonstrate competencies and the knowledge and skills of their involved staff with regard to planning, design, installation, commissioning, verification, handover or maintenance of fire safety systems in accordance with EN 16763 regardless of whether these services are provided on site or remotely.

7.2 Software based fire control systems

If dedicated computerized control systems are used to control the various operating functions of a pressure differential system relying on specific software to carry out the modes of operation, as defined in the cause and effect safety matrix the following requirements shall apply:

— The PDS computerized control panel shall be in accordance with ISO 21927-9.

— To protect the information supplied to and from the PDS computerized control panel, consideration shall be given to the protection of signalling system wiring.

— Where other external control systems (e.g. Building management System (BMS), access control, fire alarm, shading systems) are integrated as part of the operational requirements of a PDS, then any changes to the external control system software shall be demonstrated to not negatively affect the operation of the PDS, or a full functional test (see Clause 8) of the PDS shall be carried out to confirm the continued functioning of the system.

— Wireless communication (e.g. WLAN) shall not be used to control the PDS, but monitoring for visualization/reporting only, is acceptable.

— All operational components of the PDS shall have fault reporting (short-cut, open wire).

— The software-based control systems need to be designed in such a way that faults of individual devices will not affect the rest of the controllers.

— Faults of control units and field devices shall be detected and signalled.

7.3 Automatic control of a PDS

The control panel shall provide the functionality as described in 5.1 and the rest of this document.

There shall be a cause and effect safety matrix showing the automatic control of the system. This cause and effect safety matrix shall also contain details of any manual control as detailed in 7.4 below.

In the absence of national regulations, the automatic control panel shall provide the following indications:

— Ready (green);

— Activated (red);

— Error (yellow – flashing);

— Fan running (white).

7.4 Manual control of a PDS

7.4.1 General

The PDS is generally controlled automatically. If national requirements of local authorities having jurisdiction require an additional manual control, this shall be in accordance with ISO 21927-9 (reliability, functional, environmental, etc), or in accordance with equivalent national requirements, and only used by authorized personnel.

The cause and effect safety matrix shall include the requirements of the manual control of the PDS.

7.4.2 Manual control of a PDS for firefighters

The manual control shall be located at the firefighters' main access, or close to the building entrance.

It is recommended that the location of the manual control should be agreed by the authority having jurisdiction and by the fire brigade.

The manual control shall be designed so that it can only be operated by authorized personnel (e.g. by key holders, using a coded lock, by switches being located behind a frangible panel, in a room only accessible by authorized personnel).

The manual control shall be a switch or switches, or a device such as a "touch-screen". The manual control shall provide three options. Each option shall be selectable such that the other options are then unselected.

The switching options are as follows:

— OFF;

— AUTOMATIC;

— ON.

The "OFF" position stops the fan from running. The yellow Error indication goes on.

The "AUTOMATIC" position is the system ready position. The system is awaiting an activation signal to run automatically (e.g. from a smoke detector, from a fire detection system) or a change from this manual control panel, which will turn off the PDS or allow the system to flush.

NOTE When the manual control panel is not in the "AUTOMATIC" position, the basic function of the PDS is lost and out of scope.

The position "ON" starts the PDS without controlling a specific air release and is intended to only flush the protected space to attempt smoke clearance:

— The supply fan is switched on;

— The pressure relief in the staircase is operational;

— The door opening force shall be in accordance with Table 1;

— If the PDS is designed to provide flushing of the staircase according to clause 5.6.10, the opening for flushing will be open.

The selected option shall be clearly indicated (e.g. rotary switch, lit buttons, screen button colour change).

In the absence of national regulations, the manual control panel shall also provide the following indications:

— Ready (green);

— Activated (red);

— Error (yellow – flashing);

— Fan running (white).

The use and status of the firefighter manual control shall be mirrored on the main control panel.

7.4.3 Manual control for means of escape (operated by the people escaping)

The manual control shall be located close to the building entrance.

It is recommended that the location of the manual control should be agreed by the authority having jurisdiction and by the fire brigade.

The manual control shall be designed so that it cannot be triggered by mistake and shall be located behind a frangible panel or similar.

The manual control starts the PDS without controlling a specific air release (as FLUSH mode above):

- The supply fan is switched on;
- The pressure relief in the staircase is operational;
- The door opening force shall be in accordance with Table 1.

Indication is not required.

This manual control for means of escape has the lowest priority and will be overridden by a smoke detection system signal (including the smoke detector in the air inlet) or from a firefighter's manual control which has a higher priority.

The use and status of the means of escape manual control shall be mirrored on the main control panel.

7.4.4 Manual control for testing and maintenance

Functionality shall be provided for testing and maintenance. This can be built in to the control system and controlled from the main panel by switches or touch screen. As an addition, or an alternative, this may consist of external switches mounted near system components.

The control system shall be designed in such a way that the operator has the option to manually activating/deactivating individual components to check their proper functionality (see Clause 11). Depending on the specific system and component, this will take the form of OFF/AUTO/ON or similar.

This manual control for testing and maintenance has the highest priority and will override all other functions, including smoke inputs and firefighter override – effectively the PDS is turned off and will not work automatically. Therefore, there shall be a system in place when this is being used to watch for smoke signals, so that, in the case of a smoke incident, the testing and maintenance manual control can be stopped/turned off and/or the building occupants evacuated as necessary without the PDS working.

There shall be a mirrored indication at the main panel that the system or part of the system is in testing and maintenance mode. At the same time the error indication shall be turned on at the firefighter manual control panel.

7.5 Description of components and their requirements

7.5.1 General

For a better understanding about the components and the structure of a PDS the following drawings are included. A PDS is a combination of a standardized kit and the design for the specific project. This gives a selection of components. Not all the components referenced may be necessary in any one PDS.

For each component a reference is made to a standard where this document is relevant to smoke control. If no standard is referenced, there is no standard relevant to smoke control available, but other design standards/requirements may apply. Each component of the PDS shall be uniquely identifiable and clearly indelibly labelled.

Openings for air release shall not be adversely affected by any obstructions inside or outside the façade (e.g. advertising signs in front of them).

Fire resistance classifications and temperature classifications shall be in accordance with national requirements.

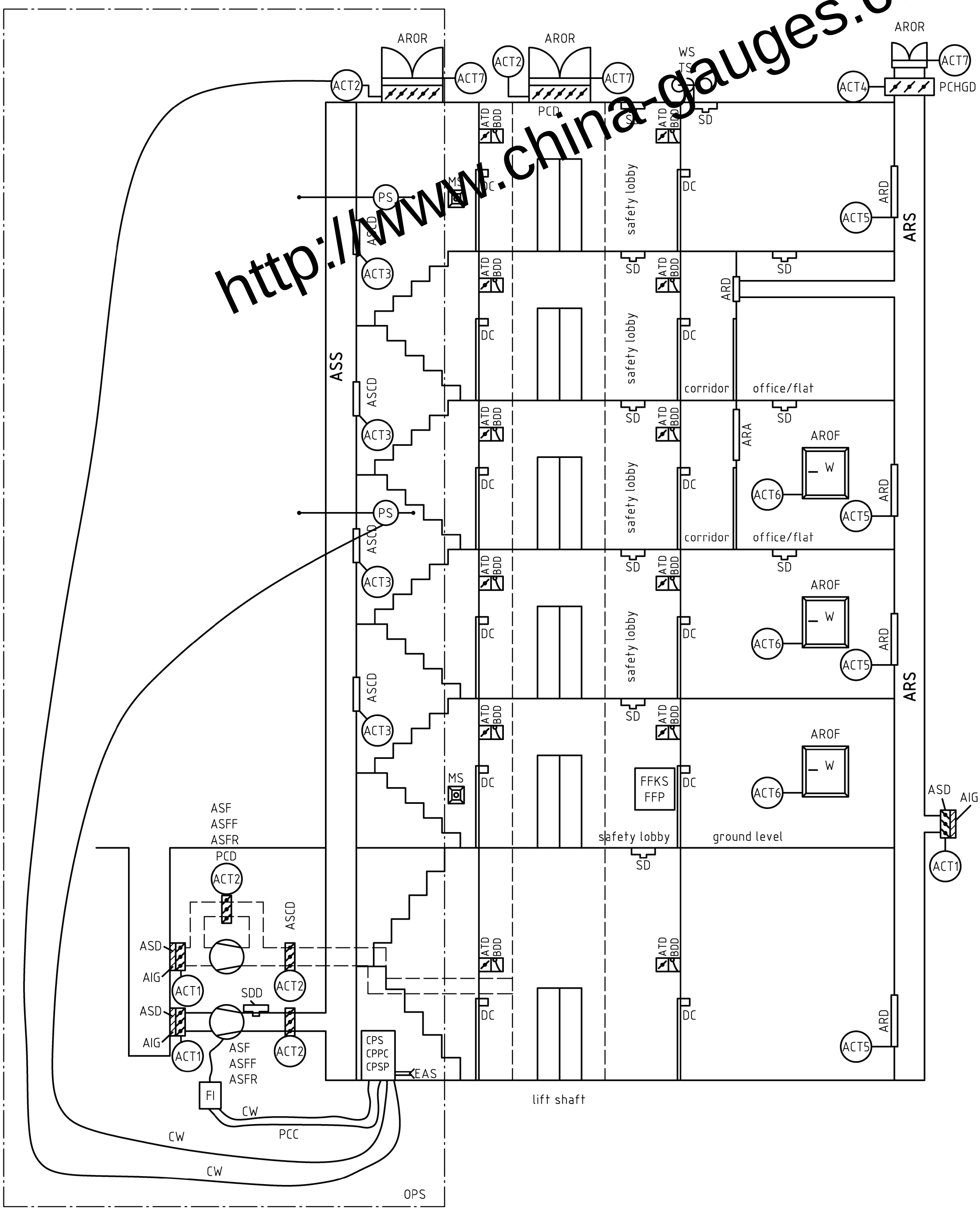


Figure 14 — Overview of possible components of a PDS with passive air release

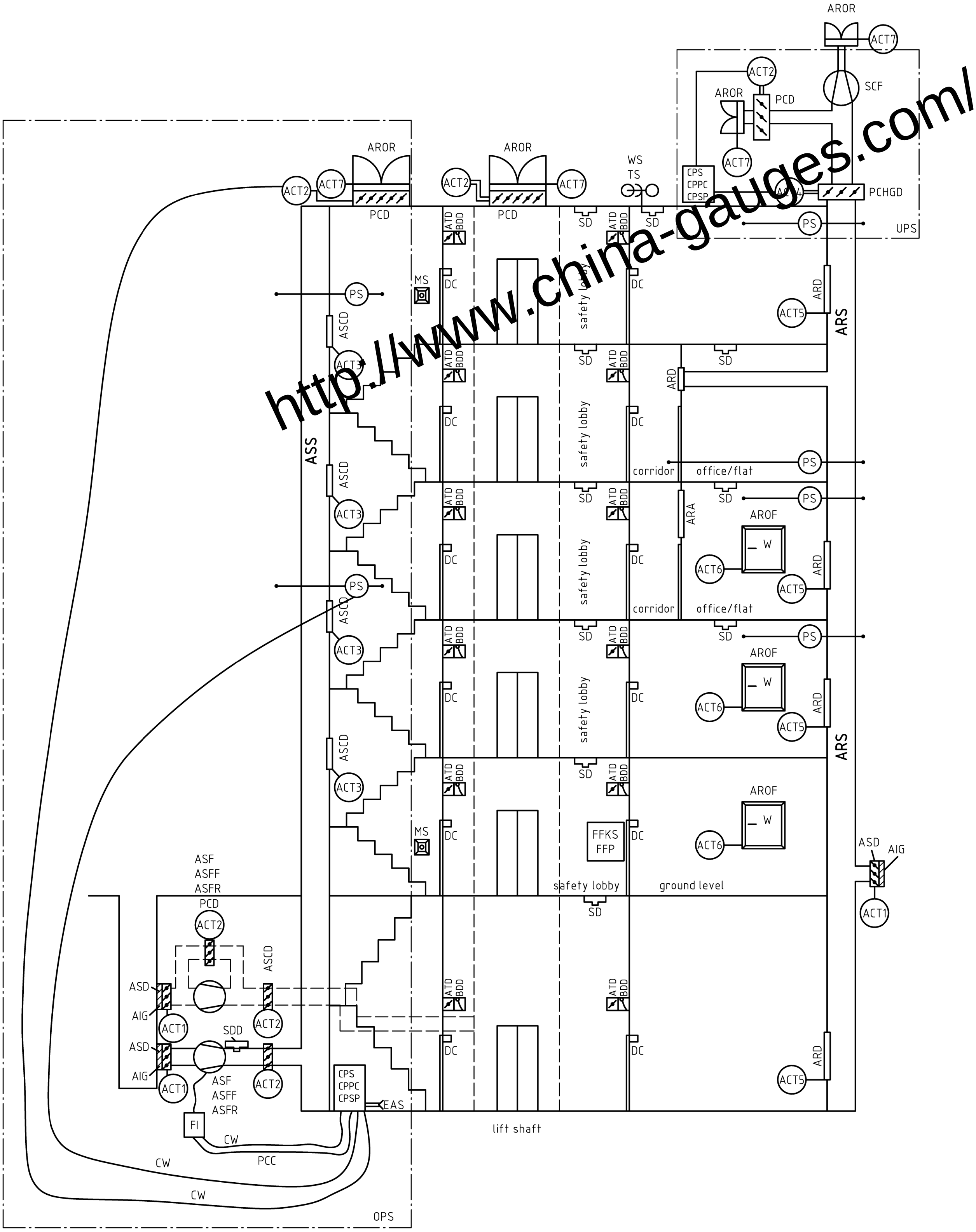


Figure 15 — Overview of possible components of a PDS with active air release

NOTE The abbreviations are explained in the following subclauses.

7.5.2 Air Intake Grille (AIG)

The air inlet grille comprises of a weather protection louvre and a bird/insect protection screen. In areas where temperatures are expected to get very low the air inlet grille shall have additional heating functionality or some other alternative, so as to keep the inlet clear of ice and snow.

The pressure drop through the air inlet grille shall be taken into account when selecting the fan.

The AIG shall be installed following the manufacturer's/supplier's instructions.

7.5.3 Air Release into the Accommodation damper (ARA)

The air release into the accommodation damper (ARA) associated with the compartment boundary shall conform to EN 12101-8, multi-compartment, tested from both sides and be classified in accordance with EN 13501-4 to suit the compartmentation (national requirements) that they maintain.

If the PDS operates automatically on receipt of a signal from a smoke detection system and the smoke control dampers move to their operational position in accordance with5.3.5, an AA classification shall be allowed. The PDS, once initiated, shall not cause the damper position to be changed. After the fire is extinguished a function may be allowed for smoke clearance, if dampers are still able to operate.

If the PDS needs a manual intervention to operate initially or allows the changing of damper position during operation (except for smoke clearance after the fire is extinguished) an MA classification shall be required.

If smoke control dampers, positioned outside the monitored space from the smoke detection system, have to move to their operational position in accordance with the specific time specification, then a classification MA is required.

NOTE Some classification examples for smoke control dampers used in multi-compartment applications are given below:

— E(I)xx (v_{edw}-h_{odw}) (i ⟷ o) S 1'000 $C_{10'000}$ HOT 400/30 MA multi;

— E(I)xx (v_{edw}-h_{odw}) (i ⟷ o) S 1'500 $C_{10'000}$ MA multi;

— E(I)xx (v_{edw}-h_{odw}) (i ⟷ o) S 500 $C_{1'000}$ MA multi.

Fire resistance (xx) and the insulation (I) classifications shall be in accordance with national requirements.

The ARA shall be installed, and penetration sealed following the manufacturer's/supplier's instructions.

7.5.4 Air Release Damper (ARD, Act 5)

The air release dampers (ARD) associated with the ARS smoke extraction shaft shall conform to EN 12101-8, tested from both sides and be classified in accordance with EN 13501-4 to suit the compartmentation that they maintain.

If the PDS operates automatically on receipt of a signal from a smoke detection system and the smoke control dampers move to their operational position in accordance with 5.3.5 an AA classification shall be allowed. The PDS, once initiated, shall not cause the damper position to be changed. After the fire is extinguished a function may be allowed for smoke clearance, if dampers are still able to operate.

If the PDS needs a manual intervention to operate initially or allows the changing of damper position during operation (except for smoke clearance after the fire is extinguished) an MA classification shall be required.

If smoke control dampers, positioned outside the monitored space from the smoke detection system, have to move to their operational position in accordance with the specific time specification, then a MA classification is required.

NOTE Some classification examples for smoke control dampers used in multi-compartment applications are given below:

— E(I)xx (v_{edw}-h_{odw}) (i ⟷ o) S 1’000 $C_{10’000}$ HOT 400/30 MA multi;

— E(I)xx (v_{edw}-h_{odw}) (i ⟷ o) S 1’500 $C_{10’000}$ MA multi;

— E(I)xx (v_{edw}-h_{odw}) (i ⟷ o) S 500 $C_{1’000}$ MA multi.

Fire resistance time (xx) and the insulation (I) classifications shall be in accordance with national requirements.

The ARD shall be installed and penetration sealed following the manufacturers’/supplier’s instructions.

7.5.5 Air release opening façade (AROF, Act 6)

The air release opening façade (AROF) shall be fitted with a window or damper operated by a suitable actuator. The safe opening function and operational reliability, with respect to the expected environmental conditions (e.g. temperature, snow load, wind load) shall be proven.

An NSHEV in accordance with EN 12101-2 fulfills the requirements and may be used.

The area with the air release opening shall be monitored by a smoke detector. As soon as it detects smoke, the actuator shall be triggered.

NOTE In special applications (e.g. historical buildings), the opening and its actuator can be designed for its specific use.

The AROF shall be installed following the manufacturer’s/supplier’s instructions.

7.5.6 Air release opening roof (AROR)

The air release opening roof (AROR) shall conform to EN 12101-2 or a smoke control damper in accordance with EN 12101-8 may be used provided it is protected from wind and snow loads (e.g. protected with a penthouse louvre).

The classification shall be in accordance with national requirements.

7.5.7 Air Release Shaft (ARS)

The air release shafts (ARS) shall conform to EN 1366-8, tested from inside to outside and from outside to inside and be classified in accordance with EN 13501-4 to suit the compartmentation through which they pass. Builders work shafts constructed from class A1 material are acceptable for ARS if they meet national requirements.

The shafts shall be constructed and penetration sealed in accordance with the manufacturer’s/supplier’s instructions.

7.5.8 Air Supply Control Damper [ASCD, Act 3 (if required)]

The air supply control damper (ASCD) shall be one of the following options:

a) a manual balancing damper or grille commissioned to a fixed position to control the supply air volume;

b) a motorized damper, having two positions (drive open and drive close);

c) a motorized damper having positions between 0 and 100 % (modulating); or

d) a multi-compartment smoke control damper (as ARD 7.5.5).

In all cases dampers shall reach their end positions within 60 s and be able to achieve 10’000 cycles. It is recommended that the maximum average velocity through the damper is limited to 3m/s to prevent excessive noise from the inlet air flow.

If the ductwork remains in one fire compartment (e.g. staircase) options a) to c) may be used (ambient) (e.g. the dampers supplying the air from ASS to staircase).

If the ductwork leaves the single compartment (e.g. staircase) and becomes multi-compartment ductwork, any associated components need to have fire resistance and option d) shall be used (fire resisting to maintain compartmentation).

Where the ductwork leaves the single compartment (e.g. staircase) and connects to or passes through other compartments, option d) shall be used (fire resisting to maintain compartmentation).

NOTE If there is a firefighters intercom system, the sound pressure level in the firefighter lift shaft and in the staircase, created by PDS in any situation, should be lower than 80 dB (A) measured in the cabin. The sound pressure level is measured approximately half a meter from the microphone of the intercom system.

The maximum average velocity across the ASCD is advised to be limited to 3 m/s to prevent excessive noise from the inlet air flow.

The PDS is intended to operate at ambient temperatures at this point, so this assembly does not need to be temperature rated.

The ASCD shall be installed following the manufacturer's/supplier’s instructions.

7.5.9 Air Supply Damper (ASD, ACT 1)

The air supply damper (ASD) shall be one of the following options:

a) a motorized damper, having two positions (drive open and drive close); or

b) a multi-compartment smoke control damper.

In all cases dampers shall reach their end positions within 60 s and be able to achieve 10 000 cycles.

If the ductwork remains in one fire compartment (e.g. staircase) option a) may be used (ambient).

Where the ductwork leaves the single compartment (e.g. staircase) and connects to or passes through other compartments, option b) shall be used (fire resisting to maintain compartmentation).

7.5.10 Air Supply Fan (ASF)

The air supply fan (ASF) shall conform to EN 12101-6 where relevant.

The ASF shall be located and/or protected in accordance with national requirements.

7.5.11 Air Supply Fan, Frequency controlled (ASFF)

The air supply fan, frequency controlled (ASFF) shall conform to EN 12101-6 where relevant.

The ASFF shall be located and/or protected in accordance with national requirements.

7.5.12 Air Supply Fan, Reversible Frequency controlled (ASFR)

The air supply fan, reversible frequency controlled (ASFR) is a fan that is frequency controlled with reversible air flow direction and shall conform to EN 12101-6 where relevant.

The ASFR shall be located and/or protected in accordance with national requirements.

7.5.13 Air Supply Shaft (ASS)

The air supply shaft (ASS) shall conform to the following:

— The ASS sited in the one fire compartment (e.g. staircase) may be standard non-fire resisting ductwork or builders work (ambient).

— Where the ASS leaves the single compartment, it shall conform to EN 12101-7 tested from inside to outside and from outside to inside and be classified in accordance with EN 13501-4 to suit the compartmentation through which they pass. Builders work shafts constructed from class A1 material are acceptable for ASS if they meet national requirements.

Any fire resisting shafts/ducts shall be constructed and penetration sealed in accordance with the manufacturer's/supplier's instructions.

7.5.14 Air transfer damper and backdraft damper (ATD, BDD)

The air transfer damper (ATD) assembly is used for producing a defined leakage between staircase and lobby or lobby and accommodation to create defined pressure differences and/or air exchange rates within the lobby.

The ATD shall comprise of a fire damper in accordance with EN 15650 and have the correct classification to meet national requirements where required.

Where necessary the ATD may be combined with an additional backdraft damper (BDD). The main parts of the BDD (e.g. housing, blade) shall be made of non-combustible building materials class A1 where requested by national requirements

The BDD within the ATD shall open at a certain pressure difference and automatically close again when the pressure difference falls below a certain value. The design shall specify the minimum pressure difference when the damper begins to open and the maximum pressure when the damper is closed.

7.5.15 Control Equipment (CP)

e.g.

Control Panel Pressure Controller (CPPC)

Control Panel Switch only (CPS)

Control Panel Switch and Positioner (CPSP)

All control equipment shall be in accordance with ISO 21927-9 (reliability, functional, environmental, etc.), or in accordance with equivalent national requirements.

All control options that are part of a kit (e.g. pressure sensor, pressure controller) shall be tested in accordance with EN 12101-6.

The CP shall be protected from the effects of fire, using a fire-resistant enclosure or by being placed in a different fire compartment room, and/or complying with national requirements.

7.5.16 Control Wire (CW)

The control wires (CW) shall be in accordance with national requirements.

7.5.17 Door Closer (DC)

The door closers (DC) shall be in accordance with EN 1154.

7.5.18 External Activation Signal (EAS)

The external control signals (ECS) is usually a potential free contact from the smoke detection system.

7.5.19 Firefighters Manual Control (FFMC)

The firefighters' manual control (FFMC) shall be in accordance with ISO 21927-9.

This is often at the main entrance or the entry to the staircase at the ground level of the building.

7.5.20 Frequency Inverter (FI)

The frequency inverter (FI) shall conform to EN 12101-6 where relevant.

7.5.21 Manual Switch (MS)

The manual switch (MS) used for manual control for means of escape, shall be in accordance with ISO 21927-9.

7.5.22 Power Circuit Cable (PCC)

The power circuit cable (PCC) shall be in accordance with national requirements.

7.5.23 Pressure Control Damper (PCD, ACT 2 if required)

The pressure control damper (PCD) (e.g. motorized Control Damper, Barometric Relief Damper) shall conform to EN 12101-6 where relevant – see also EN 12101-8 if fire resistance is required due to the damper position of installation.

7.5.24 Pressure Control Hot Gas Damper (PCHGD, ACT 4)

The pressure controller hot gas damper (PCHGD) shall conform to EN 12101-6 where relevant – see also EN 12101-8 if fire resistance is required due to the damper position of installation.

The PCD shall not be compromised with respect to all weather conditions, by installing a protection device. An air control damper protected from wind and snow loads (e.g. protected with a penthouse louvre), tested to achieve its end position within 60 s. and to achieve 10 000 cycles; or a device tested according to EN 12101-2 would fulfil the requirements.

7.5.25 Power Supply (POS)

The power supply (POS) shall conform to EN 12101-10 and EN 12101-6 where relevant.

NOTE In the absence of products in accordance with EN 12101-10, products in accordance with EN 50171 can be used also.

To ensure that the PDS operates satisfactorily in the event of an emergency, there shall be provision for a protected POS as well as stand-by equipment in accordance with national requirements.

Primary and secondary POS circuits shall be kept separate up to an automatic changeover device.

POS shall be protected against exposure to fire for a period of at least the fire resistance time of the enclosure of the protected space in accordance with the national requirements.

POS shall be separated from other circuits at the point of entry into the construction.

The electrical distribution system shall be organized such that the POS remains live when other supplies in the building are isolated in an emergency.

7.5.26 Pressure Sensor (PS); incl. tubing

The pressure sensor (PS) shall conform to EN 60770-1 and EN 12101-6 where relevant.

If tubing is passing through other fire compartment(s) it shall be temperature resistant (e.g. copper). It shall be designed to work for the same time that the PDS is required to operate.

The pressure sensor shall be protected from fire and be placed accordingly in the protected space.

7.5.27 Smoke Control Fan (SCF)

The smoke control fan (SCF) shall conform to EN 12101-3 and EN 12101-6 where relevant.

In the absence of national requirements, the following minimum temperature classes for ventilators (fans) shall be used:

— F300 for sprinklered applications; and

— F600 for non-sprinklered applications.

The SCF shall be located and/or protected in accordance with national requirements. In the absence of national requirements, the following recommendations shall be applied:

— In an enclosure or room: The SCF shall be placed in an enclosure or room with a fire resistance at least equal to the fire resistance of the protected space. It is recommended that it is placed in a plant room separate from other plant. The access doors to this enclosure or room shall have a fire resistance of at least EI30-C.

— At roof level: The SCF shall be installed with a fire resistance separation between the plant and the building below of a fire resistance at least equal to the fire resistance of the protected space.

— Outside the building: The SCF shall be installed with a fire resistance separation between the plant and the building next to it with a fire resistance at least equal to the fire resistance of the protected space. The fire resistant separation shall be provided for 5 m in both directions.

7.5.28 Smoke Detector (SD)

The smoke detector (SD) shall conform to the EN 54 series.

7.5.29 Smoke Detector Duct (SDD)

The smoke detector ducts (SDD) shall conform to EN 54-27.

7.5.30 Temperature Sensor (TS)

The temperature sensor (TS) shall conform to EN 60751.

7.5.31 Window (W)

The window (W) shall conform to the EN 12101-2.

7.5.32 Wind and Rain Sensor (WRS)

The function of the wind and rain sensor (WRS) used for HVAC applications shall be ignored when the PDS is activated.

7.5.33 Wind Sensor (WS)

The function of the wind sensor (WS) used for HVAC applications shall be ignored when the PDS is activated.

7.5.34 Wind and Temperature Sensor (WTS)

The function of the wind and temperature sensor (WTS) used for HVAC applications shall be ignored when the PDS is activated.

8 Testing and measuring

8.1 General

The PDS shall be commissioned by undertaking both functional and performance testing.

NOTE 1 Unless required by national requirements, there is no specific need to perform either cold or hot smoke tests.

The requirement for further confirmation and ongoing testing is to demonstrate that the installed PDS and all the components are fulfilling, and continue to fulfil, the requirements of the design (see Clause 11) and the normative requirements of this document.

NOTE 2 It would be preferable for the PDSs to monitor themselves and carry out regular functional tests on all operational components in accordance with the design and store this information automatically within the system.

8.2 Preconditions

8.2.1 Installed system (PDS)

To carry out testing, at least the following conditions shall be fulfilled (see also chapter 9 and Annex C):

a) The PDS is completely installed and commissioned.

b) The building is finished with all components/and building elements relevant to the PDS complete as follows:

- Firefighting stairs and lobbies are finished;
- Firefighting lift is finished;
- Air release openings are operational and tested;
- Backup power supply is operational and tested;
- Fire detection system is completely installed and has been approved;
- Fire control system is operational and tested; and
- Door opening forces by inactive PDS are controlled and documented.
- All final finishes that will affect leakage or air flow (such as carpets) are completed.

c) As-build documentation is available.

d) During acceptance testing, there are no obstructions due to work and operation.

e) If the PDS has a back-up power supply the reaction of the PDS, after change-over, shall be positively tested to confirm operation.

8.2.2 Climatic conditions during measurement

Before the measurement series is started, the climatic conditions shall be documented. At least the following measurements shall be carried out:

a) Outside temperature, wind speed, wind direction e.g. the nearest weather station.

b) A short description of weather conditions (e.g. sunny, windless, gusty wind from NW).

c) Three temperature measurements of each internal staircase.

d) Internal temperature in firefighting lift shaft.

8.2.3 Accuracy of test equipment

The calibration of test equipment for measuring pressure differentials, air flow velocities or door opening forces shall be such that the measured value is accurate in a range of values as follows:

a) Test equipment shall be suitable to measure the target values and give results within 5 % accuracy; e.g. pressure differentials 0 Pa to150 Pa; airflow velocities 0 $m.s^{-1}$ to 5 $m.s^{-1}$.

b) For dynamic response measurements, a manometer capable of recording differential pressure against time shall be used. It shall be capable of recording pressure at least every 0,2 s for differential pressures – ranging 0 Pa to 150 Pa.

c) Suitable test equipment for measuring opening forces on door handles shall be accurate to at least 5 %, referring values to be measured within a range up to 150 N.

All this measuring equipment shall be maintained calibrated in accordance with the instructions of the manufacturer/supplier.

8.3 Tests

Where tests are undertaken they shall meet the following requirements and a typical test report layout is shown in Annex H. The system shall be proven to meet the design, the parameters in Table 1 shall be confirmed as being met and that the other normative requirements of this document are fulfilled.

a) Completion test after commissioning

The installer shall perform completion tests in accordance with Table 2 (line a) and a report shall be provided. This test report is used as part of the handover to the operator/user. The commissioning test shall confirm that the PDS works in conjunction with all the other associated equipment and systems – see Clause 6.

The values in this test report shall be used as the reference values for any subsequent tests.

b) Acceptance test by the authorities having jurisdiction

Where required by national requirements, the interested parties and the authority having jurisdiction shall perform acceptance tests in accordance with Table 2 (line b) and a report shall be provided.

c) Routine testing by the operator

Appropriate protocol shall be drawn up for this verification and the operator shall perform tests in accordance with Table 2 (line c) and a report shall be provided. Where required by national requirements, the operator shall review some functions of the PDS.

d) Routine testing by a competent person

Where required by national requirements, or in accordance with the manufacturer's recommendations, but at least once a year, the complete PDS shall be tested by a specialist contracted by the operator. The specialist shall perform tests in accordance with Table 2 (line d) and a report shall be provided.

e) Repetitive tests by authorities having jurisdiction

Where required by national requirements, the PDS shall be regularly checked by an authority having jurisdiction. In addition to the testing, evidence of testing by a competent person (line d) may be required by the authorities having jurisdiction to complete this report. The authority having jurisdiction shall perform tests in accordance with Table 2 (line e) and a report shall be provided.

NOTE For many tests the installer/contractor should be on site to operate the PDS.

8.4 Minimum number of tests for a full system performance check; floor positions and other information

The minimum number of floors with tests to evaluate the normative required parameters in buildings or protected spaces are described in Table 2.

In buildings or protected spaces not higher than 60 m, tests for measuring pressure differentials and air velocities shall be carried out at least on the highest standard floors and on the lowest standard floors of the protected space.

Table 2 — Minimum number of Tests in buildings

Test Parameter Test Type	**Pressure differential test** (8.5.1)	**Air velocity test** (8.5.2)	**Static door opening force test** (8.5.3)	**Test of dynamic response time of the PDS** (8.5.4)	**Initiation time** (8.5.6)	**Operation time** (8.5.6)
a) Completion test, after commissioning	Min. 2 floors with a Max. of 3 floors between each test floor. And all floors with individual floor plans (e.g. air release path, doors)	Min. 2 floors with a Max. of 3 floors between each test floor. And all floors with individual floor plans (e.g. air release path, doors)	All floors	Min. 3 floors Approximately top, middle and bottom of the building	Min. 1 floor	Min. 1 floor
b) Acceptance test by the authorities having jurisdiction	In accordance with official authorities having jurisdiction	In accordance with official authorities having jurisdiction	In accordance with official authorities having jurisdiction	In accordance with official authorities having jurisdiction	In accordance with official authorities having jurisdiction	In accordance with official authorities having jurisdiction
c) Routine performance testing by the operator	In the absence of such national requirements (see Clause 8.1), the operator shall carry out this test at least once every six months.					
d) Routine testing by competent person see Clause 11 for details	Min. 2 floors with a Max. of 3 floors between each test floor. And all floors with individual floor plans (e.g. air release path, doors)	Min. 2 floors with a Max. of 3 floors between each test floor. And all floors with individual floor plans (e.g. air release path, doors)	All floors	Min. 2 floors	Min. 1 floor	Min. 1 floor

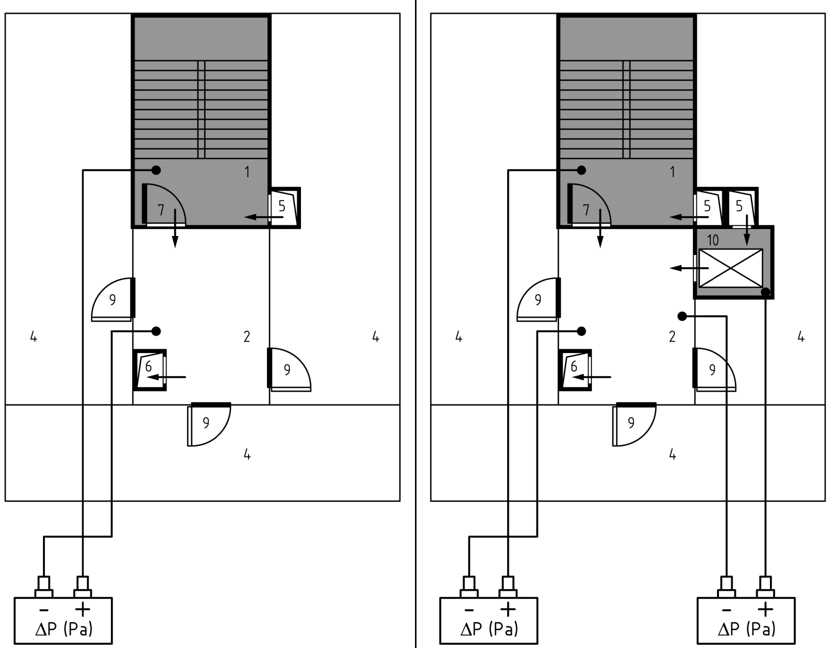
Test Parameter Test Type	**Pressure differential test** (8.5.1)	**Air velocity test** (8.5.2)	**Static door opening force test** (8.5.3)	**Test of dynamic response time of the PDS** (8.5.4)	**Initiation time** (8.5.6)	**Operation time** (8.5.6)
e) Repetitive tests by authorities having jurisdiction see Clause 11 for details	In accordance with official authorities having jurisdiction	In accordance with official authorities having jurisdiction	In accordance with official authorities having jurisdiction	In accordance with official authorities having jurisdiction	In accordance with official authorities having jurisdiction	In accordance with official authorities having jurisdiction

8.5 Test procedures

8.5.1 Pressure differential test

The pressure differential on the selected, activated floor, shall be measured between the protected space and the relevant space where the air release open is located, (see Figures 16 to 20).

The pressure differentials shall be recorded as the mean values of pressures in a time period of at least 60 s (see 8.2.3).



Pressure differential:

— final exit door is open or closed in accordance with the design concept, and

all other doors are closed

Air velocity:

— door 7 is open (1 or 2 m/s), in accordance with the concept

— doors 9 are closed

— final exit door is open or closed in accordance with the design concept

Door opening force:

— door 7 under test

— all other doors (9) are closed

Position lift cabin:

The lift cabin(s) position, as well as their door(s) position(s) are in accordance with the concept or in accordance with national requirements.

a) Example 1: see Figure 5 | **b) Example 2: see Figure 6**

Figure 16 — Measurement points for examples 1 and 2

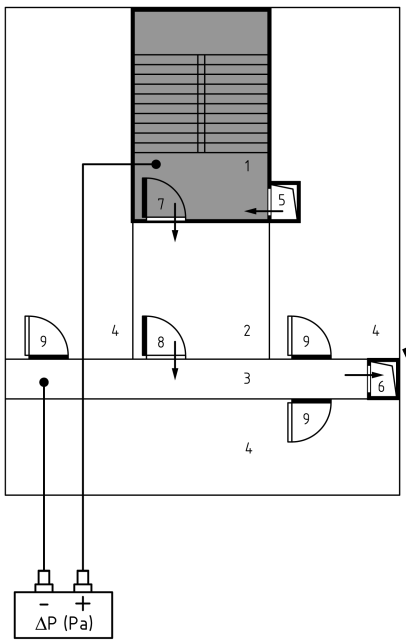
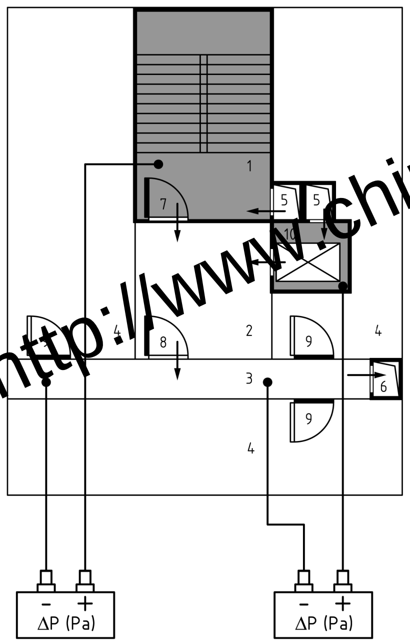
		**Pressure differential:** — final exit door is open or closed in accordance with the design concept, and all other doors are closed **Air velocity:** — through door 7 (1 or 2 m/s), in accordance with the concept — door 8 is open — all other doors (9) are closed — final exit door is open or closed in accordance with the design concept **Door opening force:** — door 7 (door 8 open) — door 8 (door 7 open) — all other doors are closed **Position lift cabin(s):** The lift cabin(s) position, as well as their door(s) position(s) are in accordance with the concept or in accordance with national requirements.
a) Example 3: see Figure 7	**b) Example 4: see Figure 8**	

Figure 17 — Measurement points for examples 3 and 4

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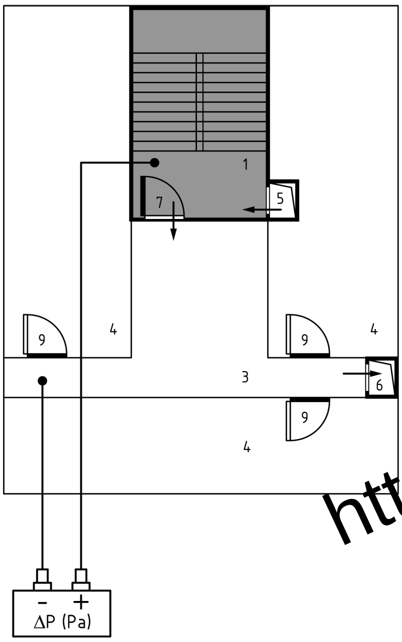
<td>
</td>
<td></td>
<td>Pressure differential:
— final exit door is open or closed in accordance with the design concept, and
all other doors are closed
Air velocity:
— through door 7 (1 or 2 m/s), in accordance with the concept
— all other doors (9) are closed
— final exit door is open or closed in accordance with the design concept
Door opening force:
— door 7
— all other doors are closed</td>
</tr>
<tr>
<td>Example 5: see Figure 9</td>
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</table>

Figure 18 — Measurement points for example 5

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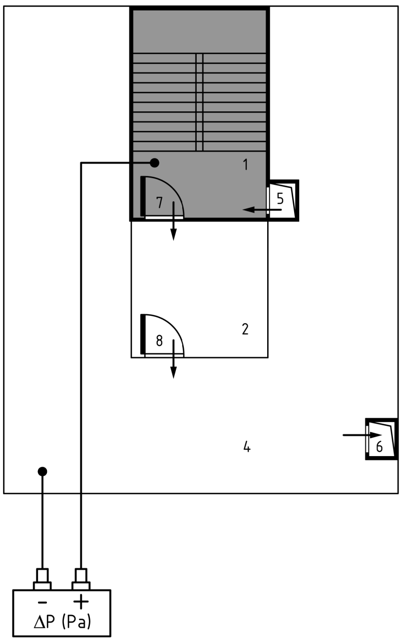
<td>
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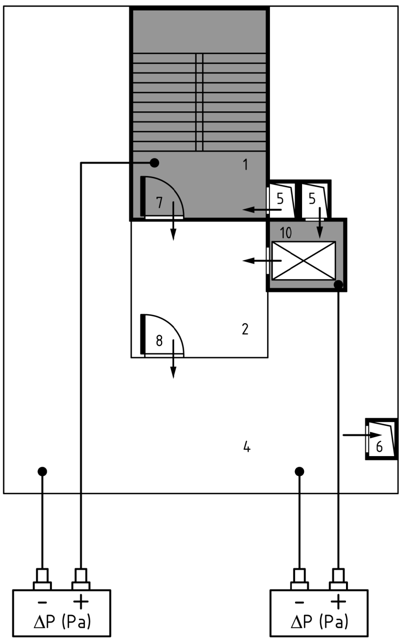
<td>
</td>
<td>Pressure differential:
— final exit door is open or closed in accordance with the design concept, and
all other doors are closed
Air velocity:
— through door 7 (1 or 2 m/s), in accordance with the concept
— door 8 is open
— final exit door is open or closed in accordance with the design concept
Door opening force:
— door 7 (door 8 open)
— door 8 (door 7 open)
— all other doors are closed
Position lift cabin:
The lift cabin(s) position, as well as their door(s) position(s) are in accordance with the concept or in accordance with national requirements.</td>
</tr>
<tr>
<td>a) Example 6: see Figure 10</td>
<td>b) Example 7: see Figure 11</td>
<td></td>
</tr>
</table>

Figure 19 — Measurement points for examples 6 and 7

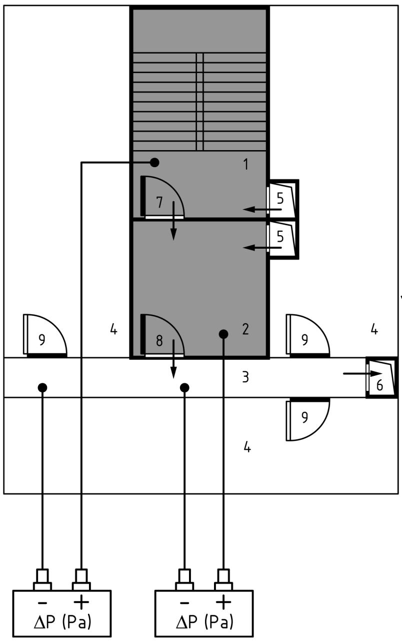
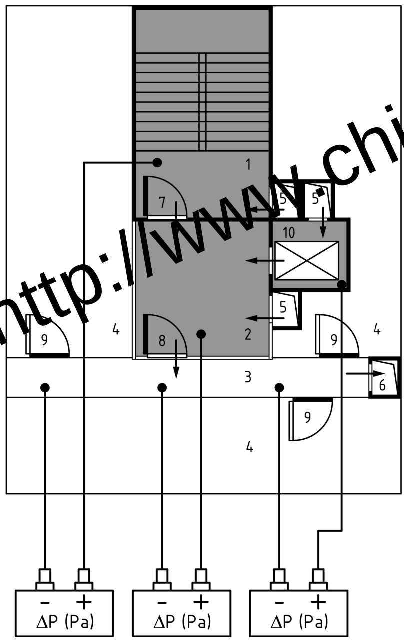
		**Pressure differential:** — final exit door is open or closed in accordance with the design concept, and all other doors are closed **Air velocity:** — through door 8 (1 or 2 m/s), in accordance with the concept — door 7 is open or / and closed — all other doors (9) are closed — final exit door is open or closed in accordance with the design concept **Door opening force:** — door 7 (door 8 open, and/or closed) — door 8 (door 7 open, and/or closed) — all other doors are closed **Position lift cabin:** The lift cabin(s) position, as well as their door(s) position(s) are in accordance with the concept or in accordance with national requirements.
a) Example 8: see Figure 12	b) Example 9: see Figure 13	

Figure 20 — Measurement points for examples 8 and 9

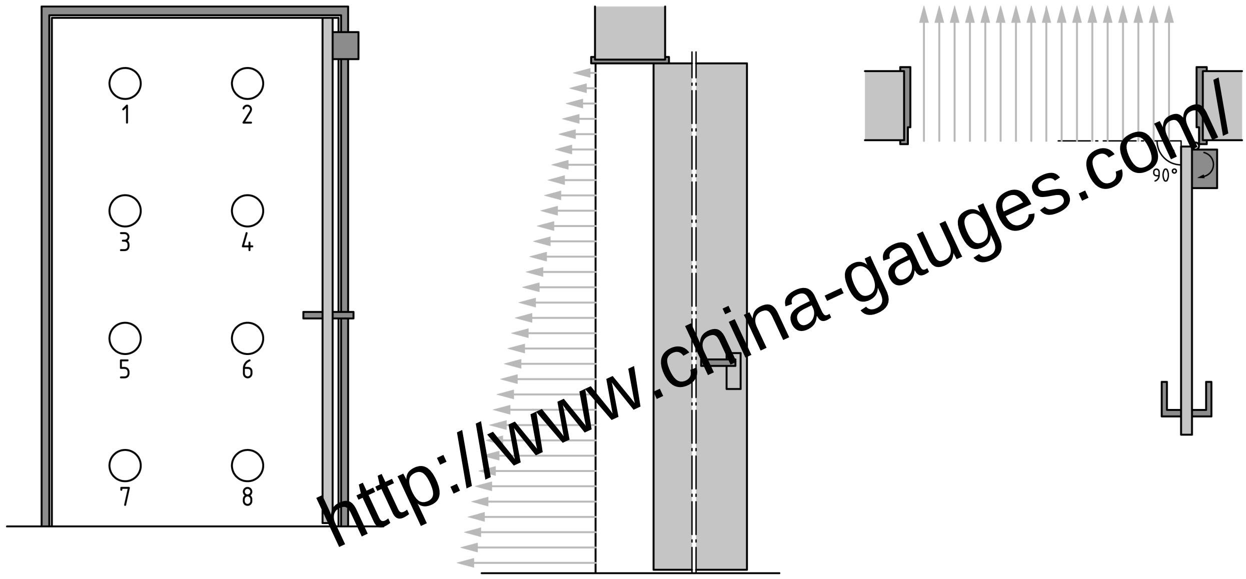
8.5.2 Air velocity test

This performance test shall measure the air velocity and the direction of flow (in accordance with the arrows in the Figure 16 to Figure 20) through an open door separating a protected space and an unprotected space.

The velocity shall comply with the requirements in Table 1.

The doorway shall be clear of obstructions.

Small obstructions, such as door closers, are allowed.



a) **b)** **c)**

Key

1 – 8 Measurements

Figure 21 — Measurement points for air velocity in a door opening; arrows are shown as examples

The velocity shall be determined as follows. Take a minimum of eight measurements, uniformly distributed over the doorway, within the plane of the door opening, where the measurement is taken. Each velocity measurement shall have a positive result in the desired direction of air flow in accordance with the arrows in Figures 16 to 20. Calculate the mean value of these measurements to determine the mean velocity through the door.

Large doors shall be divided into a minimum of five test points per m^2 (e.g. a 2 m^2 door will have 10 test points).

The final exit door shall be open or closed in accordance with the design concept.

The test procedure shall be performed twice. If the results deviate from each other more than 10 %, a third measurement shall be taken. If the result of this measurement still deviates more than 10 % from either of the two results of the previous measurements, the reason for these deviations shall be investigated and removed, before performing new measurements.

8.5.3 Static door opening force test

Measure the door opening force on all doors between the spaces where the air release is located and the protected space (in the direction of escape).

The door opening force on each of these doors shall comply with Table 1 (max. 100 N), as long as the PDS is active, except the 5 s response time (see Figure 2 and subclause 5.3).

The measurements shall be in accordance with the following procedure:

a) Activate the pressure differential system.

b) Fasten the end of the force-measuring device (e.g. a spring balance) to the door handle, on the side of the door in the direction of opening.

c) Release any latching mechanism, if necessary holding it open.

d) Push or pull, depending on the device in use, on the free end of the force measuring device, noting the highest value of force measured as the door opens.

e) The spot where the piston is pressed against the door shall be immediately above or below the door handle or if the door is equipped with a panic bar, immediately above or below the bar in a distance of approximately 0,1 m from the movable edge of the door.

f) The movement to open the door shall be performed uniformly and slowly to avoid additional forces due to impulse.

If there is more than one door present between the space with the air release and the protected space, (see Figures 5, 6, 7, 8, 9, 10, 11, 12, and 13 in subclause 5.6.3) any possible positions of those doors (open or closed) shall be respected.

The results of these measurements shall be in accordance with the performance requirements specified for the door opening force in accordance with Table 1 and subclause 5.4.

8.5.4 Test of dynamic response time of the PDS

The test for the PDS dynamic response time shall be carried out following the details in Table 2 for the required number of doors and floors. These will be the test doors.

All doors between the protected space subject to the test and the air release path shall be held in the fully open position. All other doors shall be closed.

A manometer capable of measuring differential pressure against time with accuracy as detailed in subclause 8.2.3 shall be used.

The test method shall be as follows:

a) Activate the pressure differential system.

b) Close the test door. Ensure all the other doors are in their correct position as described above – opened or closed.

c) Mount the manometer so that it can read the differential pressure between the protected space and the space where the air release is located (see Figure 16 to Figure 20).

d) Leave the pressure to stabilize for a minimum of 60 s.

e) Start recording the pressure differential versus time.

f) Record the pressure for a minimum of 30 s (Δp_c).

g) After this period of 30 s fully open the test door in 1 s to 2 s.

h) Keep the test door open for 10 s (stand away from the door opening, so as not to disturb the air flow through the door).

i) After the 10 s above, release the door leaf and let it close using the closing mechanism.

j) Stop the differential pressure measurement 60 s after the door has closed.

From the logged data determine the following:

a) Determine the average differential pressure across the door (Δp_{c1}) from the first 30 s of measured data using a simple average of the data recorded.

b) Calculate the maximum allowed differential pressure corresponding to 100 N of opening force ($\Delta p_{100\,N}$) – as per Annex A.

c) From the data determine the time at which the measured differential pressure exceeds $\Delta p_{100\,N}$ for the first time (t_1).

d) Determine the time after the door has closed that the measured differential pressure returns below ($\Delta p_{100\,N}$) – time (t_2). The time difference ($\Delta t = t_2 - t_1$) shall be less than 5 s.

e) Determine the average differential pressure across the door (Δp_{c2}) from the last 30 s of measured data using a simple average of the data recorded. (Δp_{c2}) shall be within ± 5 % of (Δp_{c1}).

8.5.5 Activation of the system test

8.5.5.1 General

All options for the cause and effect safety matrix shall be proven as described below.

8.5.5.2 Fire detection system

For testing, the PDS may be activated by the simulation of an input signal (potential-free contact) from the fire detection system on the PDS control.

All possible scenarios shall be simulated and the provided positions of the vent and damper actuators shall be checked.

The test of the fire detection system is not an integral part of the PDS. However, the fire detection system shall be tested and outputs [e.g. potential free contact(s)] confirmed to be working correctly before the PDS can be confirmed as working correctly.

NOTE The correct interaction of a fire detection system and downstream equipment (e.g. the PDS) can be performed with an integrated test. However, this test is not part of this document.

8.5.5.3 Smoke detectors as an integrated part of the PDS

If the PDS is activated by smoke detectors directly linked to the PDS, the system shall be tested by test gas at every single smoke detector.

8.5.5.4 Manual control of PDS for firefighters

To test manual control for firefighters, the following shall be performed:

a) Move the test switch to the ON position – confirm that the fans start and the pressure relief/control is activated.

b) Move the switch to the OFF position – confirm that the fans stop.

c) Return the switch to the AUTOMATIC position.

d) Test one alarm input (e.g. by smoke detector) – confirm that the system runs.

e) Move the switch to the OFF position – confirm that the fans stop.

f) Return the switch to AUTOMATIC – confirm that the system starts again [the alarm from d) shall remain active].

g) Clear the alarm input – confirm fans stop.

In each case above, confirm that the correct indication is given on the panel – see subclause 7.4.

8.5.5.5 Manual activation for means of escape (operated by escaping people)

For this test push the manual activation button and confirm that the fans start and the pressure relief is activated.

8.5.6 Initiation time and operation time

The PDS shall be proven to activate within the times stated in subclause 5.3.

9 Additional considerations for design and testing

9.1 General

It may be necessary, depending on various factors (e.g. building position, building height, prevailing weather conditions) to take other parameters into consideration. This will be for both the design and then the installed performance testing, where this may appear not to meet the design.

For instance, if the building is surrounded by buildings of similar height, then the wind effect could be negligible but shall be considered. Generally, the higher the building the more wind and temperature effects will have an influence.

The design shall record any assessments and calculations.

9.2 Parameters for consideration during design and performance testing

The following parameters shall be considered where they may be seen to have an influence:

a) Influence of wind effect:

- pressure in the protected space;
- natural air release;
- powered air supply or release (e.g. fan position);
- regional meteorological conditions.

b) Influence of temperature:

- passive pressure control;
- active pressure control;
- regional meteorological conditions;
- inside and outside temperatures (stack effects).

NOTE See Annex C for further information on wind and temperature effects.

10 Documentation

10.1 General

The following documents shall be provided to support the functionality, durability and reliability of a PDS.

They shall describe the final "as built/installed" PDS and shall be handed over to the customer/building owner. A full copy of the documents shall be stored on site.

NOTE The documents can be in paper format or digital format (in accordance with the contract).

10.2 Requirements by the authorities having jurisdiction

All documents representing the requirements for the PDS from authorities having jurisdiction shall be included in the documentation. These can include the:

a) decision by the authorities having jurisdiction, building permission, operation authorization;

b) fire protection concept, including evacuation concept, smoke exhaust concept;

c) additional requirements from the fire brigade.

10.3 Technical description of the PDS

The documentation shall contain at least the following information:

a) a description of the project/building including the size, use and fire specific infrastructure (fire strategy);

b) a description of the fire compartmentation confirming the locations, sizes, construction methods and uses;

c) differential pressure system information including: protection goals (e.g. means of escape, firefighting, time periods), protected spaces and protection in accordance with class 1 or class 2;

d) a description of physical PDS design: e.g. air inlet, air supply, transfer vent, air release, smoke exhaust, route of the air/smoke through the building, pressure control method, components (positioning and size);

e) design calculations and component selections (e.g. pressures, volume flows, duct, shaft and damper sizes, openings, total flow rate and flow rate at each expected location, dimensions, material, construction and mounting of air supply- and active air release ductwork);

f) a description and design plans of the energy supply and electrical installation; and

g) a comprehensive description of the control software together with documentation of all changes made to the system after installation.

10.4 "As built/installed" information

During the design and installation phases the drawings are unconfirmed. The documentation shall contain final "as built/installed" information only.

The following documentation shall be provided:

a) construction schema (overall view) with all components for the PDS including their references (e.g. components list);

b) ground plans (to scale) and intersection plans showing the layout, type of use, fire compartments, the protected spaces and fire specific infrastructure of the PDS (e.g. Air supply ductwork/shafts, air release ductwork/shafts, openings, transfer vents, smoke control dampers, fans, position of the manual devices, electrical cabinets and airflow/smoke flow directions);

c) “as installed” passive fire protection details for fire and smoke component installations with details on the fire stopping used with dimensions;

d) “as installed” ductwork details and competency details (e.g. hangers, as installed fire-stopping details, compensators, competency information);

e) “as installed” electrical details and competency information (e.g. in accordance with national requirements, fire resistance where appropriate, fire stopping, cable trays and cable tie details);

f) calculations; and

g) operation and maintenance requirements for the PDS.

10.5 Controls

The following documentation shall be provided:

a) specifications for the activation of the PDS (e.g. signal from the fire detection system, smoke detector, manual devices);

b) fire alarm zones;

c) fire control matrix (cause and effect);

d) description of function and control of the PDS;

e) electrical schematic of the PDS (circuit diagrams);

f) passwords; and

g) software.

10.6 Components list (inventory) and datasheets

All components shall be listed with their full references, manufacturer, relevant approvals and serial number (if applicable). Manufacturer's datasheets and installation and maintenance documentation shall be provided.

Where components are covered by the EN 12101 series, these shall have the relevant declarations of performance (DoP) supplied.

This applies to at least all the components referenced in subclause 7.5 where used, and any other components selected.

10.7 Completion certification

In addition to all the above information, the installer shall provide a simple signed certificate to indicate that all the above information has been provided and the system is compliant with this document and the design.

NOTE See Annex H for a typical example of the completion certificate.

11 Testing and Maintenance, design changes, faults, routine testing and operation

11.1 General

Unless defined differently by national requirements, the building owner shall have full responsibility for the pressure differential system (PDS).

Each building shall have a designated person, responsible for the PDS. In addition to any statutory duties placed by national requirements, this responsibility starts with ensuring that the PDS is functioning at all times, or that when it is not, providing an alternative solution, e.g. fire brigade attendance, permanent fire safety personnel, or all persons shall leave the building, until the PDS is working again.

PDS faults are a life safety issue, not a maintenance issue to be programmed and fixed later. If the PDS is not working, life safety is at risk and additional measures should be put in place.

NOTE Timely clearance and rectification of faults, routine testing, and general maintenance are all essential to the safe running of the PDS. This is the task of the responsible person.

The PDS and equipment shall be included in the building services maintenance schedule and shall include the following as a minimum:

— The responsible person shall ensure that the following information and systems shown in the whole of this Clause (Clause 11) are implemented.

— Where subcontract facilities management is used, they shall provide the responsible person with full details of how the information and systems (Clause 11) are implemented and controlled.

Much of this information should have been provided at handover, as per Clause 10, but the responsible person should ensure that it is comprehensive as below.

Unforeseeable out-of-service which are likely longer than 24 hours must be reported immediately to the building authorities having jurisdiction, indicating the expected duration of interruption. The necessary safety measures must be taken immediately and on their own responsibility. The proposed compensatory measures must ensure the equivalent protection goals during the shutting down period.

11.2 Records

PDS information shall be kept in a central place and all together (it may be necessary to update it as regularly as every day). The following information shall be kept:

a) Details of the responsible person;

b) The PDS installation and maintenance information;

c) System cause and effect (e.g. safety matrix);

d) Component list;

e) Component installation and maintenance information;

f) Drawings indicating all components and access, including cable runs;

g) Building design changes and PDS assessments;

h) Fault log(s);

i) Assessments of the effect of faults on building inhabitants/users (e.g. life safety);

j) Corrective actions and actions to prevent recurrence;

k) Routine testing and maintenance log – system;

l) Routine testing and maintenance log – components;

m) Inspector competency information;

n) Contractor competency information.

NOTE Keeping comprehensive records is essential to prove to authorities having jurisdiction that good practice is in place. It might also prove useful in the case of an incident.

11.3 Building design changes

If the building is proposed to undergo, or does undergo, any design changes or building work (e.g. layout of protected spaces or air release paths), the responsible person shall seek the input of the PDS supplier or similar design agency to provide a written assessment that the PDS will still achieve its design concept. This assessment will be kept with the records. This shall be done before any work is undertaken.

If the assessment is negative, steps shall be taken to provide a written assessment of how the building inhabitants/users are affected in the immediate term. The PDS shall be adjusted or re-designed, installed and tested in accordance with this document. If this is not feasible, other design considerations shall be taken into account.

11.4 Faults

In the absence of national requirements, the control panel shall be checked once per day to see if any faults have occurred.

If there is a fault showing, this shall be documented and reported immediately.

An assessment of the effect of the fault on the building inhabitants/users shall be made and recorded along with any required action taken to keep them safe.

Action shall be taken to clear the fault, determine any problems and, where necessary, put in place actions to prevent recurrence. A record shall be made of any corrective action. If a fault is seen to be repetitive, the supplier shall be consulted and a note made of this in the records.

The use of communication technology to allow remote indication of a fault or alarm should be considered at the design stage, so that information can be acted upon quickly to keep people safe.

As an option, consideration should be given to design the control system to allow it to maintain logs of all faults and the time between indication and clearance.

11.5 Routine testing

11.5.1 General

Details of the following shall be kept available:

a) the frequency of testing;

b) the details of who is able to test and maintain the PDS safely and competently for regular checks;

c) the details of who is able to do a full system check safely and competently;

d) the details of who is able to perform maintenance on the various components safely and competently; and

e) competency records for all of the above.

The responsible person shall also check that the people used for testing and maintenance are actually competent by checking certification.

Routine testing as an alternative, can also be performed using semi or fully automatic monitoring and control systems (see 11.5.2.5) but records as above shall be kept.

NOTE In practice, the provider of the system usually has the best knowledge of the system installed. However, third party contractors which are trained and certified by the system provider are qualified for the job too. The provider can offer training for the regular testing, so that operatives can show competency.

11.5.2 Testing frequency

11.5.2.1 General

In the absence of national requirements and supplier's recommendations, the test criteria outlined in 11.5.2.2, 11.5.2.3 and 11.5.2.4 shall apply.

11.5.2.2 Daily testing

a) Check for faults – make a record of any faults or no faults – see Clause 11.4;

b) Check that faults from the previous day have been cleared – check records.

11.5.2.3 Monthly testing

a) Do all the daily testing;

b) Operate (startup) the PDS monthly for at least 10 min – make a record of PDS performance;

c) Check for faults – make a record of any faults or no faults – see Clause 11.4;

d) Check the operation of the fans and at least 10 % of the smoke control dampers, vents, doors, air release paths (e.g. windows). This shall be a different 10 % of the components each month. All components shall be tested at least once per year – make a record of any findings;

e) Check the condition of the standby supplies [batteries, generators and fuel, Uninterruptible POS (UPS), etc.] – make a record of any findings.

11.5.2.4 Yearly testing

For the yearly test, the responsible person will ensure that a fully competent person (usually the supplier/manufacturer or specialist contractor) does the following:

a) Check and review the fault log(s), confirm corrective actions and actions taken to prevent recurrence.

b) Check the prior test information and records.

c) Make notes on the acceptability or make any recommendations on (a) and (b) above.

d) Fully run the PDS, checking each alarm input and confirming that all the specified components work in relation to the PDS cause and effect – make a record for each component.

NOTE Where smoke detection is provided by third party, the checking of alarm inputs should be done in cooperation with the smoke detection supplier.

e) Check for faults – make a record of any faults found or if no faults were found – see subclause 11.4.

f) While the PDS is running, undertake a performance test (refer to Clause 8).

The following shall be performed for the backup supply. Where no backup supply is required by national authorities the following g, h, i and j shall be ignored.

NOTE Where equipment is provided by third parties, the third parties should be present.

g) Simulate the failure of the normal supply and run the PDS on the backup supply for at least 60 min – make a record.

h) After at least 60 min, whilst still on the backup supply, simulate an alarm (cycle the alarm on an annual basis), confirm operation of the PDS and components, as monthly testing above – make a record.

i) Check for faults – make a record of any faults found or if no faults were found – see subclause 11.4.

j) Return the PDS to the normal supply.

To conclude the annual testing, the following shall be performed for all systems:

k) Re-confirm the condition of standby equipment (batteries, generators and fuel, UPS, etc.) – make a record of any findings.

l) Check for any changes in the building layout to make sure that the PDS is still providing the required life safety – make a record. If the layout has changed in any way, advise the responsible person that the PDS needs to be checked and re-designed without delay, making a record of this advice.

m) Provide a comprehensive report detailing all the work undertaken and the records of all the above.

11.5.2.5 Auto test and communication technology

Some systems come with an auto test facility. This is to be recommended, as it both exercises all the components regularly and will show faults as quickly as possible. Combined with the use of communication technology to allow remote indication of a fault or alarm information which can be acted upon quickly, this provides a comprehensive system to keep people safe.

It shall not replace the requirement for fault reporting and rectification or the consideration of the building inhabitants/users.

It shall not replace the physical requirement of the annual test requirements.

11.6 Maintenance

11.6.1 General

The following is recommended as a minimum, but any other national requirements shall be observed. It is advisable to combine the maintenance with the regular testing described in the previous Clause. Records of all maintenance shall be kept.

Faults are not maintenance issues, they are life safety issues, and should not be ignored or scheduled for later.

11.6.2 Maintenance frequency

Follow the specific maintenance regime for each component, following the manufacturer's requirements in the component list.

If maintenance issues are found during routine testing, these shall be rectified immediately following the manufacturer's requirements.

Make a record of each component's maintenance and final condition. Repair any faults. Make a record of any faults found or if no faults were found.

Used or damaged components, parts or materials shall only be replaced with new originals. Whole components may be replaced with alternative whole components using the advice of competent people such as a PDS supplier or components manufacturer.

NOTE It is advisable to do this alongside or whilst performing the annual test.

11.6.3 Duct and shaft cleaning

Ducts and shafts shall be cleaned in line with the specific standard or national requirements.

Annex A
(informative)

Calculation procedures

A.1 General

The purpose of a pressure differential system, whether used for the protection of means of escape, firefighting operations or property protection, 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 authorities having jurisdiction at an early stage in the design process.

The acceptability of any system ultimately depends upon whether the necessary pressure differential levels, the limitations of the stated door opening forces and the airflow rates all within the defined response times are achieved.

Guidance on the means of calculating the air supply rates to achieve these levels are given within this document. However, providing that the functional objectives of the systems (see Table 1) are met, then the designer may have to use other calculation procedures, as appropriate, in substantiation of their design.

The design of a smoke control system using pressure differentials involves balancing the airflows into and out of the building and analysing the pressure differentials between protected and unprotected spaces. It is important that all the relevant airflow paths are identified, and their effective flow areas evaluated. The typical leakage paths that may exist in a building are open doors, gaps around closed doors, lift doors, windows etc. Attention shall also be given to the inherent leakage due to construction cracks, etc. that will exist in walls, floors and partitions. Both the type of construction material and the quality of workmanship will significantly affect the total leakage area.

When calculating the air needed to create a pressure differential between the protected and unprotected spaces within a construction the procedure will generally vary dependent upon:

— the PDS concept (e.g. class of the PDS, pressure control method, air release method);

— the need for compensation for the negative influence of ambient conditions (e.g. stack effect, wind influence);

— the location and shape of the construction.

The air supply required for a pressure differential system is determined by the air leakage areas and the flowrates. The air supply requirements shall be compared for the following two situations and the higher flowrate selected:

— All doors closed (pressure criterion) with allowances, plus flushing (if required); and

— Relevant doors open depending on the class of the PDS (airflow criterion), plus flushing (if required).

In calculating the air supply, all leakage paths shall be identified and the leakages areas shall be used in the calculations.

A.2 Calculation procedure

The following steps listed below provide a logical method for calculating the air needed to ensure that the system runs correctly:

a) Firstly, identify any and all potential air leakage paths with the doors closed (system leakage). These will include all:

— cracks around the doors between the protected space and the unprotected space;

— cracks through the fabric of the building between the protected and unprotected spaces in the construction;

— the openings provided for the release of air from the unprotected spaces, or the openings provided for makeup air to the protected spaces;

— cracks through the fabric of the building between the unprotected spaces in the construction.

b) Then, using the areas determined and the required pressure, estimate the following:

— the leakage rate through closed doors - Q_{DC};

— the leakage rate through lift landing doors - Q_{LDC};

— the leakage rate through closed windows - Q_{WC};

— the leakage rate through walls - Q_{WALL};

— the leakage rate through floors - Q_{FLOOR};

— the supply leakage rate with the doors closed – Q_{SDC};

— the leakage rate via other air paths (known large openings) – Q_{DCOT};

— the leakage rate via the exit door in the doors closed condition, where the design concept does not require the exit door to be closed at all times – Q_{ED};

— the flushing volume (if required) - Q_{FLUSH};

— the total supply required with the doors closed – Q_{TDC} add an allowance for unknown leakages to Q_{SDC} and add the known leakages - Q_{DCOT} (large openings) - Q_{FLUSH} the flushing volume (if required), and Q_{ED} depending on the design concept.

c) With reference to the class of system (class 1 or class 2), identify which doors are going to be open and identify all the potential airflow paths, noting these may vary by floor/protected space.

d) Estimate the following:

— the air supply required with all the required doors open - Q_{DO};

— add flowrate through the exit door if the design concept requires it to be open at all times - Q_{EDO};

— add flowrate for flushing (if required) – Q_{FLUSH}; and

— the supply air volume with the doors open – Q_{TDO} — (sum of above).

e) Use the larger value of the estimated Q_{TDC} or Q_{TDO} above for the following – Q_{Sx}:

— Confirm the design of the air release requirements and paths (e.g. vents, shafts, ducts) – estimate pressure losses;

— Check any inlet paths for unexpected pressure drop and estimate where required;

— Use the selected supply volume, add an allowance for duct leakages to make the fan selection – Q_{DESIGN}.

f) Estimate the door opening forces.

A.3 Basic rules

A.3.1 Calculation of volume flowrates through openings ($Q_{OPENING}$)

When air flows through an opening, the flow can be expressed in terms of the area of the restriction and the pressure differential across the opening by the following equation:

$$Q_{OPENING} = C_v \times A_{OPENING} \times \sqrt{\frac{2}{\rho}} \left(\Delta P\right)^{\frac{1}{R}} \quad \left[\frac{\text{m}^3}{\text{s}}\right] \tag{A.1}$$

where

$Q_{OPENING}$	is the airflow through the relevant opening	(m³/s)
C_v	is the coefficient of discharge (0,6 – 0,9)	use 0,65 as typical (see NOTE 1)
$A_{OPENING}$	is the opening area	(m²)
ΔP	is the pressure difference across the opening	(Pa)
ρ	is the density of air	use 1,2 kg/m³ as typical
R	is the coefficient of flow (see NOTE 2)	

NOTE 1 Discharge coefficient may vary depending on different parameters e.g. shape of an opening, location of air inlets into the pressurized space. Normally it ranges from 0,60 to 0,95. In the absence of additional data, 0,65 should be used for the calculations of the PDS.

NOTE 2 For wide cracks such as those around doors and large openings, the value of R may be taken to be 2,0 but for narrow leakage paths formed by cracks around windows a more appropriate value of R is 1,6 (laminar v. turbulent flow).

$$Q_{OPENING} = 0{,}65 \times A_{OPENING} \times \sqrt{\frac{2}{1{,}2}} \left(\Delta P\right)^{\frac{1}{R}} \quad \left[\frac{\mathrm{m}^3}{\mathrm{s}}\right] \tag{A.2}$$

$$Q_{OPENING} = 0{,}83 \times A_{OPENING} \times \left(\Delta P\right)^{\frac{1}{R}} \quad \left[\frac{\mathrm{m}^3}{\mathrm{s}}\right] \tag{A.3}$$

A.3.2 Air velocities through geometric openings

The rate of air leakage is primarily a function of the effective area of the leakage path and the pressure differential across it (see NOTE below).

Table A.1 — Average airflow velocities through a one square metre opening

Pressure differential	Airflow velocity
[Pa]	[m/s]
60	6,43
50	5,87
40	5,25
30	4,55
20	3,71
10	2,62
5	1,86
1	0,83

NOTE The flow velocities and pressure differentials given in Table A.1 have been derived from Formula (A.3) assuming R = 2,0 and $A_{OPENING}$ is 1 m^2 and can be used as a means of quickly determining leakage rates and pressure differentials around door gaps and through large openings.

A.3.3 Leakage paths

A.3.3.1 General

Leakage paths may be seen to be either in series or parallel and when estimation in the sum of areas, the following calculations shall be considered.

A.3.3.2 Parallel leakage paths, A_{ep}

The effective leakage area is the sum of the leakage areas concerned.

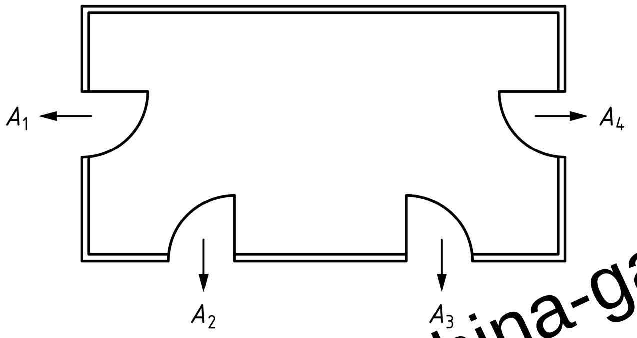


Figure A.1 — Example of leakage paths in parallel

$$A_{ep} = A_1 + A_2 + A_3 + \cdots + A_N \qquad \left[\mathrm{m}^2\right] \tag{A.4}$$

A.3.3.3 Series leakage paths, A_{es}

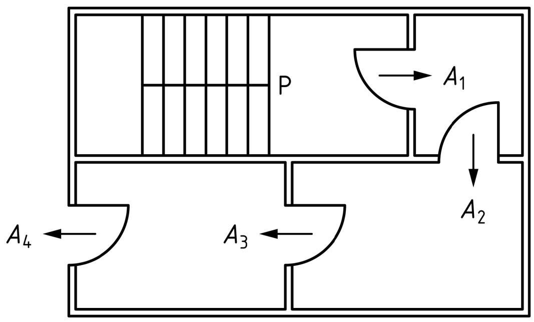


Figure A.2— Example of leakage paths in series

The effective leakage area of series paths is:

$$A_{es} = \left(\frac{1}{A_1^2} + \frac{1}{A_2^2} + \frac{1}{A_3^2} + \cdots + \frac{1}{A_N^2} \right)^{-\frac{1}{2}} \qquad \left[\mathrm{m}^2\right] \tag{A.5}$$

In the context of pressurization analysis there are frequently only two paths in series, in which case:

$$A_{es} = \frac{A_1 \times A_2}{\left(A_1^2 + A_2^2\right)^{\frac{1}{2}}} \qquad \left[\mathrm{m}^2\right] \tag{A.6}$$

A.4 Estimation of door closed volume supply rate

A.4.1 Estimation of leakage rate through closed doors

A.4.1.1 Air leakage data for closed doors

Table A.2 — Air leakage data from doors

Type of door	**Leakage area** [m²] **(See note 1)**	**Pressure differential** [Pa]	**Air leakage** [m³/s]
Single-leaf opening into a pressurized space	0,01	50	0,06
		40	0,05
		30	0,05
		20	0,04
		10	0,03
Single-leaf opening outwards from pressurized space	0,02	50	0,12
		40	0,10
		30	0,09
		20	0,07
		10	0,05
Double-leaf	0,03	50	0,18
		40	0,16
		30	0,14
		20	0,11
		10	0,08
Closed lift landing door (See note 2)	0,06	50	0,35
		40	0,31
		30	0,27
		20	0,22
		10	0,16
Closed lift landing doors high tightness (See note 2)	0,02	50	0,12
		40	0,10
		30	0,09
		20	0,07
		10	0,05
Open lift landing doors (See note 3)	0,35	50	2,05
		40	1,84
		30	1,59
		20	1,30
		10	0,92

NOTE 1 The leakage areas given in the table provided are for guidance only. Leakage areas are highly dependent on the quality of workmanship and actual values can vary from the range given.

The real leakage of the lift landing doors should be verified with the supplier of the lifts. Practical experience shows that in modern buildings realistic leakages of lift landing doors ranges from 0,02 to 0,06 m². For existing buildings, the leakage may be reduced by putting smoke curtains in front of lift doors, provided that the lifts are not used for evacuation or firefighting purposes.

NOTE 2 Status of the lift landing door will follow the design concept (open or closed).

A.4.1.2 Estimation of leakage through closed doors (Q_{DC})

The total air leakage rate through closed doors shall be estimated using the following equation derived from Formula (A.1):

$$Q_{DC} = 0,83 \times A_D \times (\Delta P)^{\frac{1}{2}} \quad \left[\frac{\mathrm{m}^3}{\mathrm{s}}\right] \tag{A.7}$$

where

Q_{DC}	is the leakage airflow through all the closed doors	(m³/s)	
A_D	is the total door closed leakage area	(m²)	basis Table A.2 - add up all the doors (series and parallel)
ΔP	is the pressure difference across the closed door	(Pa)	

A.4.1.3 Estimation of leakage through lift landing doors (Q_{LD})

The total air leakage rate through doors shall be estimated using the following equation derived from Formula (A.1):

$$Q_{LDC} = 0,83 \times A_{LD} \times (\Delta P)^{\frac{1}{2}} \quad \left[\frac{\mathrm{m}^3}{\mathrm{s}}\right] \tag{A.8}$$

where

Q_{LDC}	is the leakage airflow through all the lift landing doors	(m³/s)	
A_{LD}	is the total lift landing door leakage area	(m²)	basis Table A.2
ΔP	is the pressure difference across the door	(Pa)	

A_{LD} has to be determined for each specific project considering possible situations with closed lift landing doors, open lift landing doors, and including calculation with serial and/or parallel leakage.

A.4.2 Estimation of leakage rate via closed windows

A.4.2.1 Air leakage data for windows

Table A.3 — Air leakage data from windows

Type of window	Crack area per meter length [m²/m]	Pressure differential [Pa]	Air leakage, [m³/s/m]
Pivoted, no weather stripping	0,000 250	50	0,002 39
		40	0,002 08
		30	0,001 74
		20	0,001 35
		10	0,000 88
Pivoted, and weather stripped	0,000 036	50	0,000 34
		40	0,000 30
		30	0,000 25
		20	0,000 19
		10	0,000 13
Sliding	0,000 100	50	0,000 96
		40	0,000 83
		30	0,000 70
		20	0,000 54
		10	0,000 35

NOTE The leakage areas given in the table provided for guidance only. Leakage areas are highly dependent on the quality of workmanship and actual values can vary from the range given.

A.4.2.2 Estimation of leakage via closed windows (Q_{WC})

The total air leakage rate through closed windows shall be estimated using the following equation derived from Formula (A.1):

$$Q_{WC} = 0,83 \times A_W \times (\Delta P)^{\frac{1}{1,6}} \quad \left[\frac{m^3}{s}\right] \qquad (A.9)$$

where

Q_{WC}	leakage airflow through all the closed windows	m^3/s	
A_W	total closed window leakage area	m^2	basis Table A.3 - add up all the windows
ΔP	pressure difference across the closed window	Pa	

A.4.3 Estimation of leakage rates through walls

A.4.3.1 Air leakage data for walls

Table A.4 — Air leakage data for walls

Construction element	Wall tightness	Leakage area ratio [A_{LW}/A_{WALL}]
Exterior building walls (including construction cracks, cracks around windows and doors)	Tight	0,000 070
	Average	0,000 210
	Loose	0,000 420
	Very loose	0,001 300
Internal and stair walls (including construction cracks, but not cracks around windows and doors)	Tight	0,000 014
	Average	0,000 110
	Loose	0,000 350
Lift shaft walls (including construction cracks, but not cracks around windows and doors)	Tight	0,000 180
	Average	0,000 840
	Loose	0,001 800

NOTE The leakage areas given in the table provided for guidance only. Leakage areas are highly dependent on the quality of workmanship and actual values can vary from the range given.

A.4.3.2 Estimation of leakage through walls (Q_{WALL})

The total air leakage rate through closed windows shall be estimated using the following equation derived from Formula (A.1):

$$Q_{WALL} = 0,83 \times A_{LW} \times (\Delta P)^{\frac{1}{1,6}} \quad \left[\frac{m^3}{s}\right] \qquad (A.10)$$

where

Q_{WALL}	is the leakage airflow through all the walls and shafts	(m^3/s)	
A_{LW}	is the total wall/shaft leakage area	(m^2)	basis Table A.4 - add up all the wall / shaft areas (A_{WALL}) and use the ratio
ΔP	is the pressure difference across the closed window	(Pa)	

A.4.4 Estimation of leakage rate through floors

A.4.4.1 Air leakage data for floors

Table A.5 — Air leakage data for floors

Construction element	Floor tightness	Leakage area ratio [A_{LF}/A_{FLOOR}]
Floors (includes construction cracks and cracks around penetrations)	Average	0,000 052

NOTE The leakage areas given in the table provided for guidance only. Leakage areas are highly dependent on the quality of workmanship and actual values can vary from the range given.

A.4.4.2 Estimation of leakage through floors (Q_{FLOOR})

The total air leakage rate through closed windows shall be estimated using the following equation derived from Formula (A.1):

$$Q_{FLOOR} = 0{,}83 \times A_{LF} \times \left(\Delta P\right)^{\frac{1}{1{,}6}} \quad \left[\frac{\mathrm{m}^3}{\mathrm{s}}\right] \qquad \text{(A.11)}$$

where

Q_{FLOOR}	is the leakage airflow through all floors	(m^3/s)	
A_{LF}	is the total floor leakage area	(m^2)	basis Table A.5 - add up all floor areas (A_{FLOOR}) and use the ratio
ΔP	is the pressure difference across the closed window	(Pa)	

A.4.5 Estimation of total leakage rate with doors closed (Q_{SDC})

The air supply required is determined by summing the individual leakage rates via the routes from the protected space:

$$Q_{SDC} = Q_{DC} + Q_{WC} + Q_{WALL} + Q_{FLOOR} \quad \left[\frac{m^3}{s}\right] \qquad \text{(A.12)}$$

If an unprotected lift shaft is connected to the protected space, then the leakage through lift landing doors (Q_{LD}) from the protected space to the lift shaft, shall be added when calculating Q_{SDC} in Formula (A.12).

A.4.6 Estimation of other leakages (Q_{DCOT}), and final exit door leakage (Q_{ED})

If there are other known leakages/openings such as additional vents, dampers, openable windows, these shall be considered using the leakage data from manufacturer's information at the correct pressure or estimating using similar equations to those in the previous sections, using the correct pressure and noting the assumptions made.

This shall include the full area of the open final exit door where the design concept does not require the exit door to be closed at all times.

The total air leakage rate through these additional openings, A_{DCOT} and/or A_{ED} shall be estimated using the following equation derived from Formula (A.1):

$$Q_{DCOT} = 0,83 \times A_{DCOT} \times (\Delta P)^{\frac{1}{2}} \quad \left[\frac{m^3}{s}\right] \tag{A.13}$$

$$Q_{ED} = 0,83 \times A_{ED} \times (\Delta P)^{\frac{1}{2}} \quad \left[\frac{m^3}{s}\right] \tag{A.14}$$

The area of these additional openings, A_{DCOT} and/or A_{ED}, will be calculated using the Formula (A.1) shown in Clause A.3 or the information from Table A.1 and will be required later for the calculation of the staircase flow with the door open.

A.4.7 Estimate flushing volume (Q_{FLUSH})

For flushing, where used, which may be permanent large openings, then use the Formula (A.1) shown in Clause A.3 or the information from Table A.1. Flushing may or may not be required depending on the design concept.

A.4.8 Estimation of system supply rate with doors closed (Q_{TDC})

The system supply rate is estimated by adding an allowance of 50 % for unknown building envelope leakages and adding Q_{DCOT} ,Q_{FLUSH} and Q_{ED} (the last two only if required by the design concept).

$$Q_{TDC} = 1,50 \times Q_{SDC} + Q_{DCOT} + Q_{ED} + Q_{FLUSH} \quad \left[\frac{m^3}{s}\right] \tag{A.15}$$

NOTE The value of 50 % is based on experience, but can be varied upwards, if there are particular concerns that the building can differ from the conditions described in this section, i.e. much higher potential for leakage or be reduced for tight buildings.

A.5 Estimation of door open airflows

A.5.1 Estimation of protected space door open volume flowrate through the door between the protected and unprotected space (Q_{DO})

The requirements at the protected space door can be estimated using the following:

$$Q_{DO} = v \times A_{DOOR} \tag{A.16}$$

where

Q_{DO}	is the volumetric airflow through the open door from the protected space to the unprotected space	(m^3/s)
v	is the required airflow velocity from Table 1 (use 1 or 2)	(m/s)
A_{DOOR}	is the free area of the fully open door	(m^2)

A.5.2 Estimation of passive air release paths

A.5.2.1 General

Air release will either be by vents direct to the outside or through shafts, with possible mixing on differing floors due to building layout. The sizing of air release equipment is based on the net volume of pressurizing air flowing in to the unprotected space (excluding air leakage to atmosphere via lift shafts and toilets). The appropriate flowrate for these calculations is Q_{VA} from Formula (A.17).

If a protected lift shaft is present consideration shall be made with regard to the volume of air this requires in addition to Q_{DO} (e.g. add Q_{LD}/n where n is the number or doors). (See e.g. Figure 6.)

If the lobby is also protected by pressurisation the air volume required to be supplied into the lobby shall be added to Q_{DO} to determine the required extraction airflow rate in the air release Q_{VA}. (See e.g. Figure 12.)

Air release airflow will be then calculated using the following:

$$Q_{VA} = Q_{DO} + \frac{Q_{LD}}{n} + Q_{LOB} \left[\frac{m^3}{s} \right] \quad \text{(A.17)}$$

where

Q_{VA}	is the volumetric airflow to be released from unprotected space	(m^3/s)
Q_{DO}	is the volumetric airflow through the open door from the protected space to the unprotected space	(m^3/s)
Q_{LD}	~~V~~ is the volumetric airflow supplied in the protected lift shaft	(m^3/s)
n	is the number of lift shaft doors	
Q_{LOB}	~~V~~ is the volumetric airflow supplied in the lobby	(m^3/s)

A.5.2.2 Estimation of recommended minimum vent area requirements (A_{VA})

The requirements for any vents (vents to outside or dampers leading into shafts) needed from the unprotected space shall be estimated as follows:

$$A_{VA} = \frac{Q_{VA}}{v_{VENT}} \left[m^2 \right] \quad \text{(A.18)}$$

where

A_{VA}	is the vent area in m^2 (free area/aerodynamic free area)	(m^2)	
Q_{VA}	is the volumetric airflow through the open door from the protected space to the unprotected space	(m^3/s)	
v_{VENT}	Is the design velocity for air or smoke passing through vents and dampers	(m/s)	typically 2,5 m/s to 4 m/s

NOTE 1 Grilles and other items in serial with vents and dampers can have reduced free area/aerodynamic free area.

NOTE 2 Higher velocities can be used, but this will give higher pressures when using Formula (A.17) below.

A.5.2.3 Estimation of the recommended size of air release shafts (A_{VS})

The requirements for any shafts needed for air release from the unprotected space shall be estimated as follows:

$$A_{\mathrm{VS}} = \frac{Q_{\mathrm{VA}}}{v_{\mathrm{SHAFT}}}\left[m^2\right] \quad \text{(A.19)}$$

where

A_{VS}	is the shaft area in m²	(m²)	
Q_{VA}	is the volumetric airflow through the open door from the protected space to the unprotected space	(m³/s)	
v_{SHAFT}	is the design velocity for air for smoke control passing through ducts	m/s	typically 2 m/s to 3 m/s

NOTE 1 Consider the use of sensible aspect ratios, or more calculation should be considered.

NOTE 2 Higher velocities may be used, but this will give higher pressures when using Formula (A.17) below.

A.5.3 Estimation of the pressure in the unprotected space (P_{US})

The sum of the pressure drops in the release path and re-working Formula (A.1) provides the estimation of the pressure in the unprotected space using the following:

$$P_{US} = \left(\frac{Q_{VA}}{0{,}83 \times A_{VA}}\right)^2 + \left(\frac{Q_{VA}}{0{,}83 \times A_{VS}}\right)^2 + \left(\frac{Q_{VA}}{0{,}83 \times A_{VA-OUTLET}}\right)^2 \left[Pa\right] \quad \text{(A.20)}$$

where

$A_{VAOUTLET}$	is the area of any isolating vent/damper either in/ at the end of the ductwork calculated as Formula (A.18).

NOTE Shafts and outlet isolators will only be considered if they are part of the design.

Manufacturers' data for the determination of pressure drop for specific components (e.g. grilles or dampers) and ductwork pressure drop calculations can be used, but free or equivalent free area information is also required for further calculation (e.g. specific velocities). However, consideration should be given to the use of an adjustment factor in all cases.

The following fundamental calculation formulas for HVAC systems can also be used to calculate the pressure loss of the air release path, considering the sum of the individual pressure losses of components (e.g., grilles, dampers, straight ducts, bends, baffles, diffusors).

$$\Delta p_{US} = \frac{\rho}{2}\left(\frac{Q_{DO}}{A_i}\right)^2 \times \left(\lambda \bullet \frac{l}{d} + \sum \zeta_i\right) \quad [Pa] \tag{A.21}$$

where:

ζi	is the resistance coefficient of the individual component of the flow path	(dimensionless)
Ai	is the relevant area of the individual component of the flow path	(m^2)
ρ	is the density of the fluid	(kg/m^3)
λ	is the friction coefficient of the shaft / duct	(dimensionless)
l	is the length of the shaft / duct	(m)
d	is the hydraulic diameter of the duct	(m)

A.5.4 Estimation of the pressure in the staircase (P_{SC})

Addition of the above to the reworked Formula (A.1) at the door, the pressure in the staircase is estimated via the following:

$$P_{SC} = P_{US} + \left(\frac{Q_{VA}}{0{,}83 \times A_{DOOR}}\right)^2 [Pa] \tag{A.22}$$

A.5.5 Estimation of the pressure in the unprotected space (P_{US}) for active air release

Determination of P_{US} can be considered as 0 (Pa) when the fan is able to deliver the static pressure that is needed to overcome the pressure drop in the air release path.

NOTE Calculation of pressure drop in the active air release path can be done using Formula A.20 taking into account that air velocities considered for determination of A_{VA} and A_{VS}. The results may be found to be higher than the ones recommended for a passive air release.

A.5.6 Estimation of the exit door flowrate (Q_{EDO}), where required by the design concept

The flowrate through the exit door shall be estimated using the following equation derived from **Formula (A.1)**:

$$Q_{EDO} = 0{,}83 \times A_{ED} \times \left(\Delta P_{SC}\right)^{\frac{1}{2}} \quad \left[\frac{m^3}{s}\right] \tag{A.23}$$

where

A_{ED} is the exit door area (m^2).

A.5.7 Estimation of the flowrate with the door open (Q_{TDO})

The flowrate required with the door open is estimated from the staircase pressure and the other leakage areas, small gaps, large gaps and the outlet path as below:

$$Q_{TDO} = \left[0{,}83 \times \left\{A_W + A_{LW} + A_{LF}\right\} \times P_{SC}^{\frac{1}{1,6}}\right] + \left[0{,}83 \times \left\{A_D + A_{DCOT}\right\} \times P_{SC}^{\frac{1}{2}}\right] + Q_{DO} \left[\frac{m^3}{s}\right] \quad \text{(A.24)}$$

NOTE 1 If the design concept considers the final exit door to be open, Q_{EDO} is added.

NOTE 2 If national requirements require a minimum flushing, Q_{FLUSH} is considered and added when calculating the air flow rate.

A.6 Finalize design

A.6.1 Estimate design flowrate (Q_{DESIGN})

Determine whether Q_{TDC} (Formula (A.15)) or Q_{iTDO} (Formula (A.24) has the higher value. This higher value becomes Q_{Sx}.

Use Q_{Sx} to estimate Q_{DESIGN} by adding an allowance of 15 % for ductwork leakage.

$$Q_{DESIGN} = 1{,}15 \times Q_{Sx} \left[\frac{\mathrm{m}^3}{\mathrm{s}}\right] \quad \text{(A.25)}$$

where

Q_{Sx} is the higher value of Q_{TDC} and Q_{TDO}.

NOTE The value of 15 % is based on experience but can be varied upwards or downwards according to the ducting manufacturer's leakage information.

A.6.2 Determine fan supply path

A.6.2.1 General

Estimate the fan inlet pressure drop using accepted principles for duct, damper and grille resistances.

A.6.2.2 Estimation of mechanical extract requirements

The extract rate per floor when a free path exists through open doors to the pressurized space shall be not less than Q_{VA}. It is recommended that maximum air velocities in air release ductworks shall not exceed 10 m/s.

The above air release specifications are based upon an assumed pressure differential between the accommodation and the outside air of 10 Pa. It is possible, however, to increase the airflow rate or reduce the required vent area if the pressure differential between the accommodation and outside is increased. In such circumstances it is necessary to evaluate the air leakage rate. Where two or more pressurized stairs or lobbies open into the same unprotected space then the area of the relief vent per storey shall reflect the total air passing on to the floor from the pressurized spaces.

Where the unprotected space is partitioned into offices or similar units then the relief vents shall be provided between the door into the pressurized space and the start of the partitioning.

A.6.3 Estimation of the pressure drop across the staircase

The airflow resistance of the staircase can significantly influence the static pressure distribution inside the protected space. This pressure loss shall be taken into consideration. The calculation is based on empirical interpolation using a notional area A_{eff} based on experimental data.

The pressure loss of the staircase depends on the geometry of the staircase. This affects A_{eff} as it depends upon storey/floor height, the stair railing design and the dimensions of the eye (gap) between the stairs and whether the railing is closed or open. As each of these reduce, A_{eff} reduces and pressure drop increases.

The pressure drop per floor is again based on Formula (A.1):

$$\Delta P_{FLOOR} = \frac{\rho}{2} \times \left(\frac{Q_{VERT}}{A_{eff}} \right)^2 \quad (Pa) \qquad \text{(A.26)}$$

where

A_{FLLOR}	is the pressure drop per floor	(Pa)
Q_{VERT}	is the vertical volume flowrate up the staircase at the floor	(m^3/s)
p	is the density of the air	(kg/m^3)
A_{eff}	is the effective area (empirical - 1,8 to 3,8 for common staircase geometries)	(m^2)

Determine A_{eff} using Figures A.3 and A.4 using interpolation. The information is based on the following parameters with reference to Figure A.3 for common staircase geometries;

a) stair width (ws): 1,25 m – 1,50 m;

b) storey height (hs): 3,00 m – 4,00 m;

c) eye width (we): 0,15 m – 0,30 m;

d) filling design of the handrail (f): 0 % - 85 %.

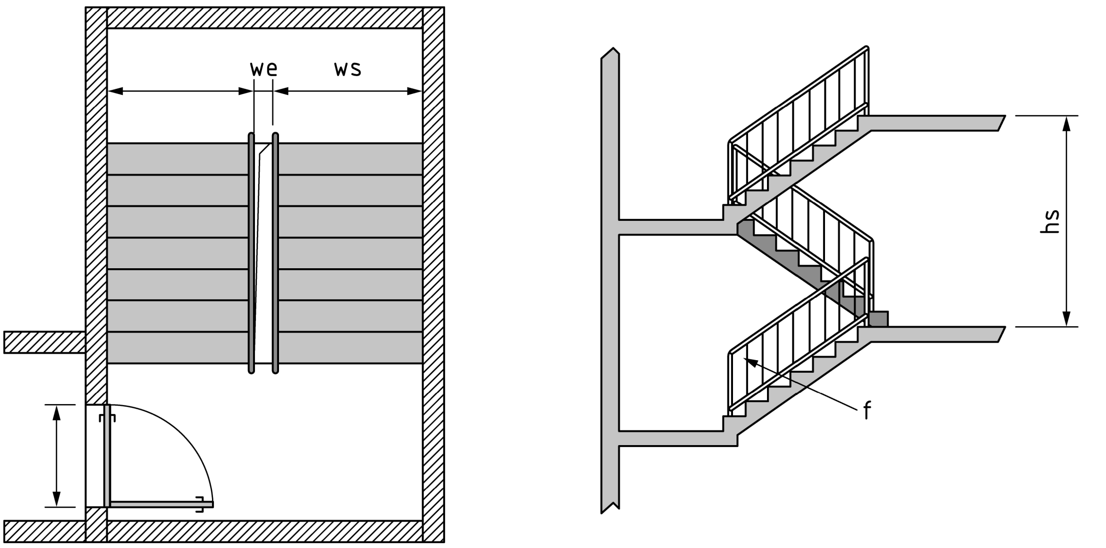
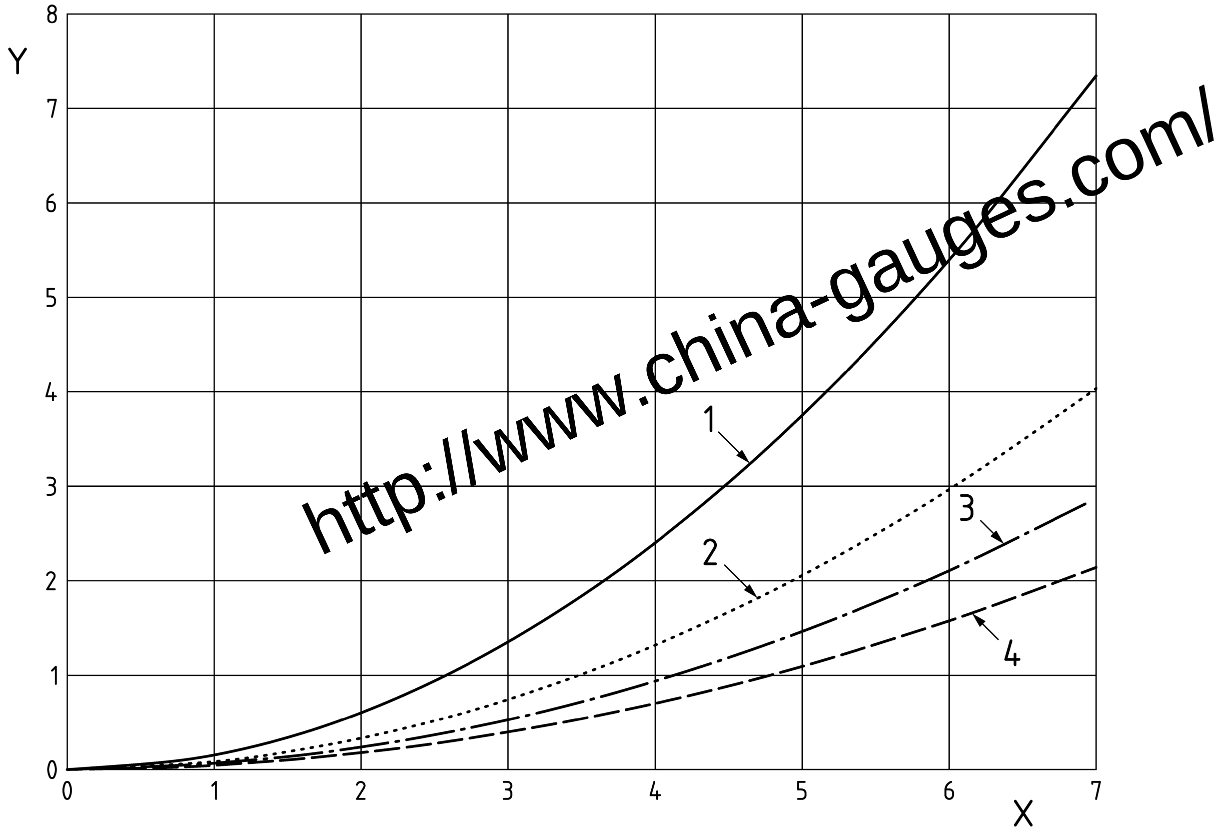


Figure A.3 — Staircase geometry

Pressure drop (Pa) per typical floor level vs. Air volume (m^3/s) with a variation of Aeff (m^2).



Key

X Q (m^3/s)

Y pressure loss / level (Pa)

1 A_{eff} = 2,0 m^2 storey height 3,5 m stair width 1,25 m eye width 0,15 m handrail 85 % open

2 A_{eff} = 2,7 m^2 storey height 3,5 m stair width 1,25 m eye width 0,3 m handrail 85 % open

3 A_{eff} = 3,2 m^2 storey height 3,5 m stair width 1,5 m eye width 0,3 m handrail 85 % open

4 A_{eff} = 3,7 m^2 storey height 3,5 m stair width 1,5 m eye width 0,3 m handrail 0 % open

Figure A.4 — Information to interpolate A_{eff}

A.6.4 Pressure distribution across the staircase

A.6.4.1 General

Select the floors where the air is to be supplied. As in the main body of the standard, this will normally be at a minimum of three entry levels/points. Depending on the calculation results it may be decided to have more entry points to make a more balanced system.

The overpressure in the upper area staircase is generated by the pressure loss of the pressure relief device at the top of the staircase, where used, following the design concept. In other areas it will be the release path, and this may vary per floor.

The pressure loss of each floor of the staircase is calculated from the respective vertical volume flow rate for the floor and is added to the pressure relief value.

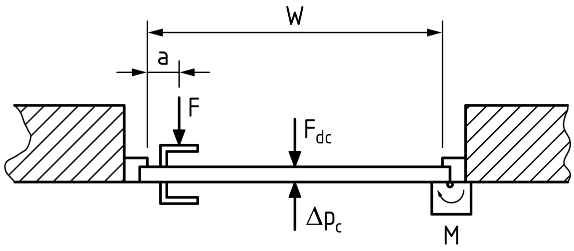
A.6.4.2 Estimation of door opening forces; Maximum pressure across doors

The pressure difference corresponding to a door opening force F = 100 N applied at the door handle, can be determined with the following equation:

$$\Delta P_{100N} = \frac{\left(100N - F_{dc}\right) \times 2 \times \left(W - a\right)}{W^2 \times H} \qquad \left[Pa\right] \tag{A.27}$$

where

F_{dc}	s the door closer force at handle without pressure difference	(N)
NOTE	F_{dc} = M / (W-a)	
M	is the opening torque of the door closer	(Nm)
W	Is the door width	(m)
H	is the door height	(m)
a	is the distance door handle	(m)
ΔP_{100N}	is the pressure difference corresponding to 100 N opening force	(Pa)



Key

a handle distance

F door opening force

F_{dc} door closer force

M opening torque of door closer

W door width

Δp_c pressure difference

Figure A.5 — Door opening force parameters

A.6.4.3 Door opening force limitations; Maximum pressure in the staircase.

Using the above Formula (A.27) results in the following table showing the maximum values of overpressure (Pa) across doors with different widths in order not to exceed the 100 N force to open the door.

As an example, the following parameters have been used to estimate Table A.6:

Opening force (F = 100 N), Height of the door (H = 2 m), Distance door handle (a = 0,1 m).

Table A.6 — Maximum values of overpressure (Pa) across doors with different widths and different door closer forces in order not to exceed the 100 N force to open the door

Door closer force –	**Door width**				
F_{DC} (N)	0,8 m	0,9 m	1,0 m	1,1 m	1,2 m
25	82 Pa	74 Pa	68 Pa	62 Pa	57 Pa
35	71 Pa	64 Pa	59 Pa	54 Pa	50 Pa
45	60 Pa	54 Pa	50 Pa	45 Pa	42 Pa
55	49 Pa	44 Pa	41 Pa	37 Pa	34 Pa
65	38 Pa	35 Pa	32 Pa	29 Pa	27 Pa

NOTE If F_{DC} is 65 N, without the PDS running, on 2,0 m high doors with width > 1,0 m, the minimum pressure differential value of 30 Pa (Table 1) will not be fulfilled – see highlighted cells in Table A.6.

If the 100 N requirement is exceeded the alternative technical solutions shall be found (e.g. reduce the door closer force, mechanical door openers/closers, split door leaves).

A.6.5 Estimate relief vent area (A_{PV})

In case of a design concept using a pressure relief vent as part of the pressure control system, it shall be designed for an airflow of $Q_{Sx} - Q_{SDC}$.

In absence of manufacturer's information, the following formula based on Formula A.1, can be used to estimate the relief vent area.

$$A_{PV} = \frac{(Q_{Sx}) - Q_{SDC}}{0{,}83 \times (P_{PV})^{\frac{1}{2}}} \left[m^2 \right] \qquad \text{(A.28)}$$

where

A_{PV}	is the free area required for the vent	(m^2)
P_{PV}	is the maximum pressure in the staircase	(Pa)

A.7 Other considerations

Example of calculations are shown in Annex B.

Annex B
(informative)

Design example and possible calculation procedures

B.1 General

The examples shown below is for a very simple application and is used to show the use of the equations given in Annex A, along with a simple flow of calculation procedure only.

The application to real buildings will need much more attention to detail and shall be undertaken by competent persons. There may be many more leakage paths or interactions with windows and other systems that shall be considered.

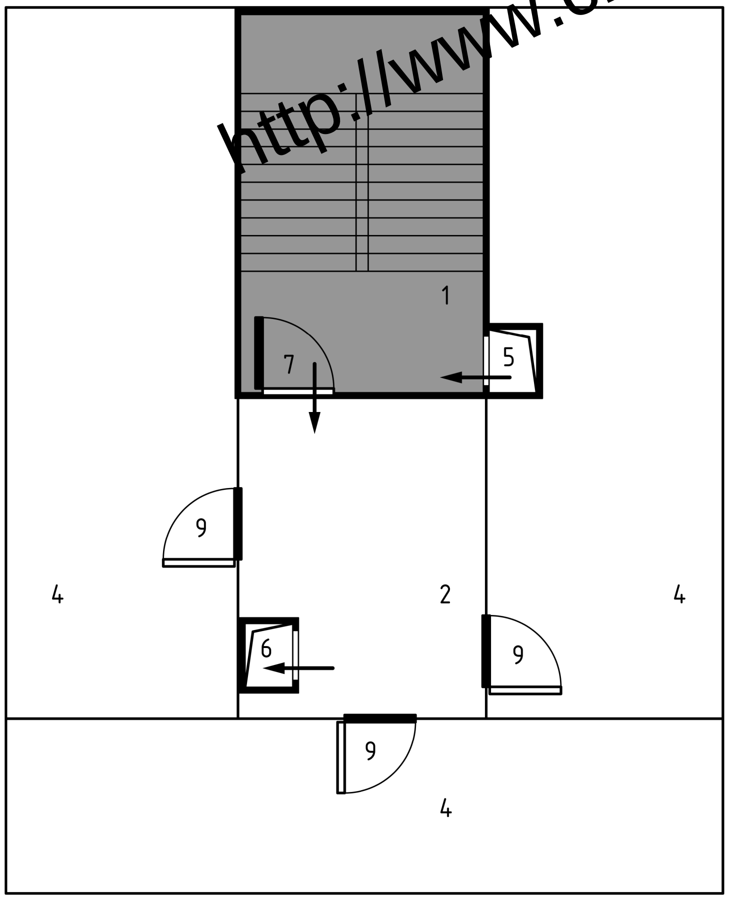
In some cases, the pressure profile calculations may need to be performed as an iteration until acceptable pressures with regard to door opening pressures can be confirmed.

B.2 Pressurization calculation

The pressurization calculation is presented in Table B.1.

Table B.1 — Pressurization calculation

Parameters and assumptions	
System	**Pressurization – staircase**
	10 storeys Class: 1 with design velocity 1m/s and design pressure of 30 Pa Staircase - 5 m x 2,65 m Building height: 30 m Storey height: 3,0 m Stair run width: 1,5 m Eye width: 0,3 m Design of handrail: 85 % Air supplies at levels 1, 4, 7, 10 Door to floor: 0,85 m (W) × 2 m (H) – area = 1,7 m^2 – door handle distance a = 0,1 m Exit door: area = 1,7 m^2 Door closer torque: 36 Nm Staircase doors open into the staircase from the lobbies. Final exit door opens outwards and considered open for volume checks. Closed “locked” windows on each floor in the staircase area 1m^2 each. See specific calculations for assumptions and simplifications.

Parameters and assumptions		
System	**Pressurization – staircase**	
	 	**Key** 1 Staircase 2 Lobby 3 – 4 Accommodation 5 Air supply 6 Air release 7 Door to staircase 8 – 9 Door to accommodation ← Airflow direction Protected spaces
	Reference calculation is as per 5.6.3.2: Pressurization system, example 1: Staircase protection generally in accordance with Figure 5.	

Closed door condition		
	Stair (considering final exit door closed)	Stair (considering final exit door open)
Closed door leakage areas - A_D Table A2 Consider equations A.4, A.5 and A.6	10 doors opening in – 10 × 0,01 m² 1 door opening out – 1 × 0,02 m² $A_D = 0{,}12\ m^2$	10 doors opening in – 10 × 0,01 m2 NOTE: Final exit door is open. Leakage through open final exit door is calculated later in this example $A_D = 0{,}10\ m^2$
Closed door leakage - Q_{DC} Equation A7	$Q_{DC} = 0{,}83 \times A_D \times \Delta P^{½}$ $Q_{DC} = 0{,}83 \times 0{,}12 \times 30^{½}$ $Q_{DC} = 0{,}546\ m^3/s = 1\ 964\ m^3/h$	$Q_{DC} = 0{,}83 \times A_D \times \Delta P^{½}$ $Q_{DC} = 0{,}83 \times 0{,}10 \times 30^{½}$ $Q_{DC} = 0{,}454\ m^3/s = 1\ 637\ m^3/h$
Window leakage area - A_W Table A3 (Pivoted, no weather stripping)	$A_W = 10 \times 0{,}000\ 250\ m^2/m \times 4\ m$ $A_W = 0{,}01\ m^2$	$A_W = 10 \times 0{,}000\ 250\ m^2/m \times 4\ m$ $A_W = 0{,}01\ m^2$
Window leakage – Q_{WC} Equation A.9	$Q_{WC} = 0{,}83 \times A_W \times \Delta P^{(1/1{,}6)}$ $Q_{WC} = 0{,}83 \times 0{,}01 \times 30^{(1/1{,}6)}$ $Q_{WC} = 0{,}069\ m^3/s = 250\ m^3/h$	$Q_{WC} = 0{,}83 \times A_W \times \Delta P^{(1/1{,}6)}$ $Q_{WC} = 0{,}83 \times 0{,}01 \times 30^{(1/1{,}6)}$ $Q_{WC} = 0{,}069\ m^3/s = 250\ m^3/h$
Wall leakage area - A_{LW} Table A4 (Internal and stair walls; average)	$A_{LW} = 0{,}000\ 110 \times ((2 \times 5\ m \times 30\ m) + (2 \times 2{,}65\ m \times 30\ m))$ $A_{LW} = 0{,}050\ m^2$	$A_{LW} = 0{,}000\ 110 \times ((2 \times 5\ m \times 30\ m) + (2 \times 2{,}65\ m \times 30\ m))$ $A_{LW} = 0{,}050\ m^2$
Wall leakage – Q_{WALL} Equation A.10	$Q_{WALL} = 0{,}83 \times A_{LW} \times \Delta P^{(1/1{,}6)}$ $Q_{WALL} = 0{,}83 \times 0{,}050 \times 30^{(1/1{,}6)}$ $Q_{WALL} = 0{,}348\ m^3/s = 1\ 252\ m^3/h$	$Q_{WALL} = 0{,}83 \times A_{LW} \times \Delta P^{(1/1{,}6)}$ $Q_{WALL} = 0{,}83 \times 0{,}050 \times 30^{(1/1{,}6)}$ $Q_{WALL} = 0{,}348\ m^3/s = 1\ 252\ m^3/h$

Floor leakage area - A_{LF} Table A5 (Floor; average tightness)	A_{LF} = 0,000 052 × 2 × 2,65 m × 5 m A_{LF} = 0,001 38 m²	A_{LF} = 0,000 052 × 2 × 2,65 m × 5 m A_{LF} = 0,001 38 m²
Floor leakage – Q_{FLOOR} Equation A.11	$Q_{FLOOR} = 0,83 \times A_{LW} \times \Delta P^{(1/1,6)}$ $Q_{FLOOR} = 0,83 \times 0,001\ 38 \times 30^{(1/1,6)}$ Q_{FLOOR} = 0,009 6 m³/s = 35 m³/h	$Q_{FLOOR} = 0,83 \times A_{LW} \times \Delta P^{(1/1,6)}$ $Q_{FLOOR} = 0,83 \times 0,001\ 38 \times 30^{(1/1,6)}$ Q_{FLOOR} = 0,009 6 m³/s = 35 m³/h
Total estimated leakage rates with doors closed - Q_{SDC} Equation A.12	$Q_{SDC} = Q_{DC} + Q_W + Q_{WALL} + Q_{FLOOR}$ Q_{SDC} = 0,546 + 0,069 + 0,348 + 0,009 6 Q_{SDC} = 0,972 m³/s = 3 501 m³/h	$Q_{SDC} = Q_{DC} + Q_W + Q_{WALL} + Q_{FLOOR}$ Q_{SDC} = 0,454 + 0,069 + 0,348 + 0,009 6 Q_{SDC} = 0,881 m³/s = 3 173 m³/h
Estimation of other leakages - Q_{DCOT}	No other leakage considered. $Q_{DCOT} = 0$	No other leakage considered. $Q_{DCOT} = 0$
Estimate flushing volume – Q_{FLUSH}	Flushing not required $Q_{FLUSH} = 0$	Flushing not required $Q_{FLUSH} = 0$

Estimation of exit door flowrate – Q_{ED} Equation A.14	Exit door is considered to be closed NOTE: The leakage for the final exit door has been considered at the beginning of this example when calculating the closed door leakage. $Q_{ED} = 0$	$Q_{ED} = 0{,}83 \text{ x } A_{ED} \text{ x } P_{SC}^{(1/2)}$ $Q_{ED} = 0{,}83 \text{ x } 1{,}7 \text{ x } 30^{(1/2)}$ $Q_{ED} = 7{,}73 \text{ m}^3/\text{s} = 27\ 828 \text{ m}^3/\text{h}$
Supply rates doors closed – QTDC Equation A.15	$Q_{TDC} = (Q_{SDC} \times 1{,}50) + Q_{DCOT} + Q_{FLUSH} + Q_{ED}$ $Q_{TDC} = (0{,}949 \times 1{,}5) + 0 + 0 + 0$ $Q_{TDC} = 1{,}459 \text{ m}^3/\text{s} = 5\ 251 \text{ m}^3/\text{h}$	$Q_{TDC} = (Q_{SDC} \times 1{,}50) + Q_{DCOT} ++ Q_{FLUSH}\ \ Q_{ED}$ $Q_{TDC} = (0,\ 0{,}881\ \times 1{,}5) + 0 + 0 + 7{,}73$ $Q_{TDC} = 9{,}051 \text{ m}^3/\text{s} = 32\ 582 \text{ m}^3/\text{h}$

Open door condition		
	Stair (considering final exit door closed)	Stair (considering final exit door open)
Open door volume flowrate - Q_{DO} Equation A.16	$Q_{DO} = v \times A_{DOOR}$ $Q_{DO} = 1 \times 1{,}7$ $Q_{DO} = 1{,}7\ m^3/s = 6\,120\ m^3/h$	$Q_{DO} = v \times A_{DOOR}$ $Q_{DO} = 1 \times 1{,}7$ $Q_{DO} = 1{,}7\ m^3/s = 6\,120\ m^3/h$
Extraction airflow rate in the air release - Q_{VA} Equation A.17	$Q_{VA} = Q_{DO}$ $Q_{VA} = 1{,}7\ m^3/s = 6\,120\ m^3/h$	$Q_{VA} = Q_{DO}$ $Q_{VA} = 1{,}7\ m^3/s = 6\,120\ m^3/h$
Vent area requirements - A_{VA} Equation A.18 Velocity of 2.5 m/s used	$A_{VA} = Q_{VA} / v_{VENT}$ $A_{VA} = 1{,}7 / 2{,}5$ $A_{VA} = 0{,}68\ m^2$	$A_{VA} = Q_{VA} / v_{VENT}$ $A_{VA} = 1{,}7 / 2{,}5$ $A_{VA} = 0{,}68\ m^2$
Shaft and entry area requirements - A_{VS} Equation A.19 Velocity of 2.0 m/s used	$A_{VS} = Q_{VA} / v_{SHAFT}$ $A_{VS} = 1{,}7 / 2$ $A_{VS} = 0{,}85\ m^2$	$A_{VS} = Q_{VA} / v_{SHAFT}$ $A_{VS} = 1{,}7 / 2$ $A_{VS} = 0{,}85\ m^2$
Outlet area requirements - $A_{VAOUTLET}$	None vent at outlet.	None vent at outlet.
Pressure in the unprotected space - P_{US} Equation A.20	$P_{US} = \{Q_{VA}/(0{,}83 \times A_{VA})\}^2 + \{Q_{VA}/(0{,}83 \times A_{VS})\}^2 + 0\}^2$ $P_{US} = \{1{,}7/(0{,}83 \times 0{,}68)\}^2 + \{1{,}7/(0{,}83 \times 0{,}85)\}^2 + 0\}^2$ $P_{US} = 9{,}08 + 5{,}8 + 0$ $P_{US} = 14{,}88\ Pa$	$P_{US} = \{Q_{VA}/(0{,}83 \times A_{VA})\}^2 + \{Q_{VA}/(0{,}83 \times A_{VS})\}^2 + 0)\}^2$ $P_{US} = \{1{,}7/(0{,}83 \times 0{,}68)\}^2 + \{1{,}7/(0{,}83 \times 0{,}85)\}^2 + 0\}^2$ $P_{US} = 9{,}08 + 5{,}8 + 0$ $P_{US} = 14{,}88\ Pa$
Pressure in the staircase – P_{SC} Equation A.21	$P_{SC} = P_{US} + \{Q_{DO}/(0{,}83 \times A_{DOOR})\}^2$ $P_{SC} = 14{,}88 + \{1{,}7/(0{,}83 \times 1{,}7)\}^2$ $P_{SC} = 14{,}88 + 1{,}45$ $P_{SC} = 16{,}3\ Pa$	$P_{SC} = P_{US} + \{Q_{DO}/(0{,}83 \times A_{DOOR})\}^2$ $P_{SC} = 14{,}88 + \{1{,}7/(0{,}83 \times 1{,}7)\}^2$ $P_{SC} = 14{,}88 + 1{,}45$ $P_{SC} = 16{,}3\ Pa$

Estimation of exit door flowrate – Q_{EDO} Equation A.22	No leakage through final exit door.	$Q_{EDO} = 0,83 \times A_{ED} \times P_{SC}^{(1/2)}$ $Q_{EDO} = 0,83 \times 1,7 \times 16,3^{(1/2)}$ $Q_{EDO} = 5,702$ m³/s = 20 527 m³/h
Estimate flushing volume – Q_{FLUSH}	Flushing not required	Flushing not required
Estimation of the flowrate with the door open – Q_{TDO} Equation A.23	$Q_{TDO} = [0,83 \times \{A_W + A_{LW} + A_{LF+}\} \times P_{SC}^{(1/1,6)}] + [0,83 \times \{(A_D + A_{DCOT}\} \times P_{SC}^{(1/2)}] + Q_{DO}$ $Q_{TDO} = [0,83 \times \{0,01 + 0,05 + 0,001\,38\} \times 16,3^{(1/1,6)}] + [0,83 \times \{0,12+0\} \times 16,3^{(1/2)}] + 1,7$ $Q_{TDO} = [0,83 \times 0,061 \times 5,72] + [0,83 \times 0,12 \times 4,04] + 1,7$ $Q_{TDO} = 0,292 + 0,402 + 1,7$ $Q_{TDO} = 2,394$ m³/s = 8 620 m³/h	$Q_{TDO} = [0,83 \times \{A_W + A_{LW} + A_{LF+}\} \times P_{SC}^{(1/1,6)}] + [0,83 \times \{(A_D + A_{DCOT}\} \times P_{SC}^{(1/2)}] + Q_{DO} + Q_{DEDO}$ $Q_{TDO} = [0,83 \times \{0,01 + 0,05 + 0,001\,38\} \times 16,3^{(1/1,6)}] + [0,83 \times \{0,1+0\} \times 16,3^{(1/2)}] + 1,7 + 5,71$ $Q_{TDO} = [0,83 \times 0,061 \times 5,72] + [0,83 \times 0,10 \times 4,04] + 1,7 + 5,71$ $Q_{TDO} = 0,292 + 0,335 + 1,7 + 5,702$ Q_{TDO} 8,029 m³/s = 28 905 m³/h
Compare Q_{TDC} and Q_{TDO} to determine Q_{Sx}	$Q_{TDC} = 1,459$ m³/s = 5 251 m³/h $Q_{TDO} = 2,394$ m³/s = 8 620 m³/h Therefore the last is the higher $Q_{Sx} = 2,394$ m³/s = 8 620 m³/h	$Q_{TDC} = 9,051$ m³/s = 32 582 m³/h $Q_{TDO} = 8,029$ m³/s = 28 905 m³/h Therefore the first is the higher $Q_{Sx} = 9,051$ m³/s = 32 582 m³/h
Finalize design		
	Stair (considering final exit door closed)	Stair (considering final exit door open)
Estimate the maximum design flowrate – Q_{DESIGN} Use allowance – 15% Equation A.24	$Q_{DESIGN} = Q_{SDx} \times 1\ 15$ $Q_{DESIGN} = 2,394 \times 1,15$ $Q_{DESIGN} = 2,754$ m³/s = 9 913 m³/h	$Q_{DESIGN} = Q_{SDx} \times 1,15$ $Q_{DESIGN} = 9,051 \times 1,15$ $Q_{DESIGN} = 10,408$ m³/s = 37 469 m³/h

Pressure distribution across the staircase:
In this example the overpressure in the upper area staircase is generated by the pressure loss of the pressure relief at the top of the staircase

Pressure drop and pressure distribution across the staircase	Using Storey height 3,0 m, Stair run width: 1,5 m, Eye width: 0,3 m and Handrail design: 85% open gives A_{eff} = 3,2 m² from Figure A.4, which is the closest to our parameters. Using the leakage by floor Q_{LF} the following profile may be generated.						Using Storey height 3,0 m, Stair run width: 1,5 m, Eye width: 0,3 m and Handrail design: 85% open gives A_{eff} = 3,2 m² from Figure A.4, which is the closest to our parameters. Using the leakage by floor Q_{LF} the following profile may be generated.					
Determine leakage by floor and use Equation A.25 and selected A_{eff} NOTE: The table shown is a simplification, and for more complex designs an iteration should be used to balance the pressure drops across the floors		**AIR SUPPLY FLOW**	**LEAKAGE FLOW PER LEVEL**	**VERTICAL VOLUME FLOW**	**PRESSURE LOSS PER LEVEL**	**PRESSURE DISTRIBUTION**		**AIR SUPPLY FLOW**	**LEAKAGE FLOW PER LEVEL**	**VERTICAL VOLUME FLOW**	**PRESSURE LOSS PER LEVEL**	**PRESSURE DISTRIBUTION**
				Q_{VERT}	ΔP_{FLOOR}					Q_{VERT}	ΔP_{FLOOR}	
	FLOOR	**[m³/s]**	**[m³/s]**	**[m³/s]**	**[Pa]**	[Pa]	**FLOOR**	**[m³/s]**	**[m³/s]**	**[m³/s]**	**[Pa]**	[Pa]
	10	0,598 6	0,088 15	1,422	0,12	30,00	10	2,262 6	0,088 15	8,193	3,93	30,00
	9	0	0,088 15	0,912	0,05	30,12	9	0	0,088 15	6,016	2,12	33,93
	8	0	0,088 15	1,000	0,06	30,17	8	0	0,088 15	6,102	2,18	36,05
	7	0,598 6	0,088 15	1,088	0,07	30,23	7	2,262 6	0,088 15	6,187	2,24	38,24
	6	0	0,088 15	0,577	0,02	30,30	6	0	0,088 15	4,010	0,94	40,48
	5	0	0,088 15	0,666	0,03	30,31	5	0	0,088 15	4,096	0,98	41,42
	4	0,598 6	0,088 15	0,754	0,03	30,34	4	2,262 6	0,088 15	4,182	1,02	42,40
	3	0	0,088 15	0,243	0,00	30,37	3	0	0,088 15	2,005	0,24	43,43
	2	0	0,088 15	0,331	0,01	30,38	2	0	0,088 15	2,091	0,26	43,66
	1	0,598 6	0,179 07	0,420	0,01	30,38	1	2,262 6	0,179 07	2,177	0,28	43,92
	TOTAL:	**2,394**	**0,972**				**TOTAL:**	**9,051**	**0,972***	* Q_{SDC} for final exit door closed condition has to be considered for calculation		
		Q_{Sx}	**Q_{SDC}**					**Q_{Sx}**	**Q_{SDC}**			

Estimate maximum pressure across doors - ΔP_{100N} Equation A.26	First F_{dc} is determined $F_{dc} = M / (W\text{-}a)$ $F_{dc} = 36 / (0{,}85\text{-}0{,}1)$ $F_{dc} = 48$ N $\Delta P_{100N} = (100N - F_{dc}) \times 2 \times (W - a) / (W^2 \times H)$ $\Delta P_{100N} = (100 - 48) \times 2 \times (0{,}85 - 0{,}1) / (0{,}85^2 \times 2)$ $\Delta P_{100N} = 54$ Pa From the pressure drop distribution above this shows that on all floors (1 to 10) the overpressure does not exceed the maximum overpressure corresponding to 100 N. So, the design is acceptable	First F_{dc} is determined $F_{dc} = M / (W\text{-}a)$ $F_{dc} = 36 / (0{,}85\text{-}0{,}1)$ $F_{dc} = 48$ N $\Delta P_{100N} = (100N - F_{dc}) \times 2 \times (W - a) / (W^2 \times H)$ $\Delta P_{100N} = (100 - 48) \times 2 \times (0{,}85 - 0{,}1) / (0{,}85^2 \times 2)$ $\Delta P_{100N} = 54$ Pa From the pressure drop distribution above this shows that on all floors (1 to 10) the overpressure does not exceed the maximum overpressure corresponding to 100 N. So, the design is acceptable
Estimate the pressure relief vent airflow - $(Q_{Sx} - Q_{SDC})$	$(Q_{Sx} - Q_{SDC}) = (2{,}394 - 0{,}972) = 1{,}422$ m³/s = 5 119 m³/h	$(Q_{Sx} - Q_{TDC}) = (9{,}051 - 0{,}972) = 8{,}078$ m³/s = 29 081 m³/h * Q_{SDC} for final exit door closed condition has to be considered for calculation
Estimate the pressure relief vent area - A_{PV} Equation A.27	$A_{PV} = (Q_{Sx} - Q_{SDC}) / 0{,}83 \times (P_{PV})^{1/2}$ $A_{PV} = (2{,}394 - 0{,}972) / 0{,}83 \times (30)^{1/2}$ $A_{PV} = 0{,}31$ m²	$A_{PV} = (Q_{Sx} - Q_{SDC}) / 0{,}83 \times (P_{PV})^{1/2}$ $A_{PV} = (9{,}051 - 0{,}972) / 0{,}83 \times (30)^{1/2}$ $A_{PV} = 1{,}78$ m² NOTE: Q_{SDC} for final exit door closed condition has to be considered for calculation

Annex C
(informative)

Further information on wind and temperature effects

C.1 General

Where the claim is made for the design to meet the requirements of Table 1, then the requirements of Table 1 shall also be met under the expected ambient and outside conditions – see also Clause 9.

C.2 Influence of wind effect

Wind produces a pressure field around the building envelope. This is affected by the building shape and the wind direction relative to the building and the air speed.

On the windward side of the building an overpressure (positive or high pressure) is produced. On the leeward side and on the sides of the building parallel to the wind an underpressure (negative or low pressure) is produced.

On the windward side of inclined roofs (>40 °C above horizontal) an overpressure is produced. On the leeward and on flat roofs an underpressure is normally produced.

The pressure at the building envelope varies proportionally with the square of the wind speed.

Openings in the building envelope, such as air release openings connect the spaces inside the building to the pressure found on the outside of the building. For example, an overpressure at the outside of the building, means that the space connected to the opening also has an overpressure.

Where pressure differentials are measured from a point in a space to a reference point outside of the building or at the building envelope, the pressure difference is influenced by both the pressure at the pressure point and by the reference point, which can increase or decrease the differential pressure considerably.

C.3 Pressure in the protected space

Where the pressure in the protected space is controlled by a barometric pressure control damper (BPCD) the damper is affected by both the pressure inside and outside of the damper. Therefore, the controlled opening will be moved by the pressure differential, not the inside static pressure.

Consequently, a wind effect producing low pressure at the outside of any open pressure control damper PCD (barometric or motorized) will decrease the pressure inside the protected space and a wind effect producing high pressure at the outside will increase the pressure inside the protected space.

The same effect occurs when the pressure of the protected space is controlled by a sensor measured pressure difference between protected space and wind affected area using a motorized damper or a fan with frequency inverter control.

C.4 Natural air release (Passive air release)

When an air release opening is located on the windward side of the building envelope the airflow velocity through the open door between the protected and the unprotected space will be reduced. The higher the wind speed is, the more the airflow velocity will reduce. When the door is closed the pressure difference between protected and unprotected space and the door opening force will be lower than would be found in a situation without wind.

When an air release opening is located on a low-pressure area (leeward or wind parallel side) of the building, envelope the airflow velocity through the open door between the protected and the unprotected space will be increased. The higher the wind speed is, the more the airflow velocity will increase. When the door is closed the pressure difference between protected and unprotected space and the door opening force will be higher than would be found in a situation without wind.

C.5 Powered air release (Active air release)

PDS with fixed volume powered air release are generally not affected by wind induced pressure effects. A PDS where the powered air release volume is controlled by sensor pressure differential measurement to a wind affected area, then it will be as described above.

C.6 Influence of temperature effect

Temperature differences between the inside and outside of a building create a difference in air density which produce a pressure difference over the building height and between inside and outside. This effect is called stack effect.

When the temperature outside is lower than inside (e.g. in colder months) the pressure inside at the top of the building is higher than outside and at the bottom of the building the pressure inside is lower than outside.

When the temperature outside is higher than inside (e.g. in warmer months) the pressure inside at the top of the building is lower than outside and at the bottom of the building the pressure inside is higher than outside. The stack effect is reversed.

The value of the total pressure difference under summer conditions is generally lower than in winter conditions because of the lower temperature difference.

The pressure difference of the stack effect is 0,43 Pa/K/ (10 m height). In a building with 30 m height a pressure difference of 26 Pa by stack effect is caused at a temperature difference of 20 K.

C.7 Pressure control

C.7.1 Passive pressure control

In a staircase with passive pressure control at the top, the stack effect in colder months can cause higher static pressure at the top of the building. This means that the pressure difference between inside and outside at the top of the building can be higher than the nominal operational differential pressure of the barometric pressure control damper (BPCD) and it will open, releasing the pressure. The stack effect will change and the pressure at the bottom of the building will increase its value.

When a natural air release at the bottom of the building is opened under these conditions the pressure difference produced by the PDS decreases by the value of the stack effect. In high buildings and under high temperature differences an airflow from the unprotected space to the protected space can occur.

A natural air release in a vertical shaft at the top of a building does not produce a high stack effect/ pressure difference between the unprotected and protected spaces, because the opening at the top of the shaft is at the same pressure as the staircase.

A barometric pressure control damper (BPCD) in the protected space at the same level as the fire compartment will control the pressure difference between the protected and unprotected space.

C.7.2 Active pressure control

Active pressure control can measure the pressure difference between the protected and unprotected space at the level of the fire compartment and use this to control the pressure inside the protected space.

Under the influence of the stack effect the pressure difference between the protected space and the ambient pressures at a different height levels may considerably vary the pressure difference at the height of the fire compartment. The design of the PDS needs to consider this effect to ensure that door opening forces remain lower than the permissible values.

C.8 Assessment of meteorological effect during performance test

C.8.1 General

Where performance tests show a large difference to the design, the influences of the wind effect and the stack effect at the time of testing shall be considered, as the specific meteorological conditions may be affecting the results.

C.8.2 Wind effect

Consider the principles shown in C.2 and Annex J to determine why the system is not performing correctly.

C.8.3 Stack effect

Consider the principles shown in C.3 and Annex J to determine why the system is not performing correctly.

Annex D
(informative)

Guidance for PDS design for buildings taller than 60 m

D.1 General

This annex provides general guidelines on the methodology and scope of calculations to be used to evaluate the design requirements for a PDS for buildings taller than 60 m. The details of the calculation software are, consequently, not specified in this document.

It is aimed at PDS designers (concept authors) who create PDS concept designs and submit them to the authorities having jurisdiction for approval.

This leaves open many possibilities of differences in the calculation and design results, depending on the quality of the software and input data used and the design methodology applied. Licensed software with complete technical documentation and numerical models with defined accuracy validated against real scale measurements should be used.

It is suggested that authorities having jurisdiction provide a technical document or procedure clearly stating their requirements in terms of acceptance criteria, results and levels of calculations to be provided for their analysis and acceptance. In the absence of such a technical document, this Annex D does not have the status of a technical specification and its use is left entirely to the responsibility of the users.

The pressure distributions and resulting airflows in all buildings are influenced by several factors which shall be taken into consideration for the concept design of a PDS (e.g. construction parameters, local climatic conditions).

The influence of ambient conditions may result in stack effects throughout the building and wind induced pressures at the building façades are proportional to building height. Therefore, for buildings taller than 60 m, it shall be demonstrated that for the specific PDS concept design and the relevant ambient conditions, the design requirements (see Table 1) are met.

Compliance with the design requirements shall be demonstrated using computational engineering methods considering the defined structural and climatic boundary conditions. This shall include information that on all storeys, the door opening force on all escape-route doors does not exceed 100 N.

The final responsibility for the concept, design, the selection of an appropriate calculation method, the appropriate input data and a correct implementation shall remain within the competence of the PDS designer.

D.2 Principles

The aim is to prove that all the requirements in the main body of this document are met.

It shall be proven that the performance criteria can be met under different climatic conditions for the specific location of the building. The pressure conditions in the protected spaces need to be calculated and visualized for at least three different thermal conditions. These are the summer, isothermal and winter cases. By means of verification methods, it shall be confirmed that the PDS concept is functional and that compliance with the performance criteria can be ensured.

For buildings between 60 m and 100 m, the climate data used in simulation needs to be in accordance with national requirements. In high-rise buildings taller than 100 m the climate data shall be agreed in advance with the authorities having jurisdiction before the concept design is started.

The PDS concept shall form the basis for the computational analysis.

The computational analysis shall be submitted in a report form.

The objective of the calculations is to demonstrate compliance with Table 1 with PDS running under differing ambient conditions.

D.3 Requirements

Calculations shall be carried out in accordance with the main body of this document (e.g. door leakage, window leakage, door open criteria).

Other calculations shall determine, as a minimum:

— the pressure differences between protected spaces and the relevant space where the air release is located; and

— the airflow direction and velocity at the relevant open doors depending on PDS class (see Table 1).

Calculations shall be carried out for at least three storeys with similar typical layouts located approximately at the top, the middle and at the bottom of the building. For any and all storeys with significantly different layouts, or with different air release details, additional calculations are required.

The requirement for wind influence modelling shall be evaluated individually by project taking into consideration:

— the location of the building and local wind directions and speeds;

— the PDS concept with particular reference to air release paths (e.g. natural air release); and

— the air tightness of the façade with consideration of design openings in the façade (e.g. openable windows).

For assessment, the pressure conditions throughout the whole building shall be provided graphically (e.g. diagrams, curves).

For PDS the direct effects of a fire (heat output, radiation, smoke, etc.) need not be considered in the simulation and calculations.

For PDS the temperatures and volume flow of air, removed through the air release shall be taken into account.

The proof of compliance of performance criteria using computational analysis shall be complete, comprehensive and be clearly and logically presented.

Where appropriate, authorities having jurisdiction may require wider scope of analysis and further calculations.

D.4 Selection of the engineering method

D.4.1 General

Engineering methods using computer simulations with multizone airflow models or CFD models shall be used.

Both tools can be used to model the functioning of the PDS, however, the appropriate engineering methods and tools shall be selected in agreement with all parties depending on the scope of analysis and complexity of the PDS before the design is started.

D.4.2 Multizone airflow models (zone-knot-models)

Multizone airflow models were developed to enable airflows and contaminant modelling inside the building. Using such tools, it is possible to calculate airflow rates and relative pressures between zones of the building for determining the variation in ventilation rates over time, for determining the distribution of ventilation air within a building and for estimating the impact of building envelope sealing on infiltration rates.

D.4.3 Computational Fluid Dynamics (CFD)

Computational Fluid Dynamics (CFD) is the use of applied mathematics, physics and computational software to visualize flows of the gas and liquids. It is generally based on the Navier-Stokes equations. These equations describe how the pressure, velocity, temperature, and density of the fluid are related.

D.5 Climatic input data

Inside air temperatures shall be defined in accordance with relevant national thermal comfort information. Outside air temperatures shall be defined in accordance with relevant national standards where recommended outside air temperatures are described.

In the lack of more precise guidelines, wind directions and speeds for the calculations shall be defined based on the local statistical meteorological data relevant for building location. Wind influence shall be modelled for dominant direction and speed representative for 95 % of the year taking into consideration wind speed variation with height. Data on wind directions and speeds can be found in weather reports or professional literature.

D.6 Information required for simulations

D.6.1 General

The basis of the simulation is the creation of a building model.

The model shall contain at least the following details:

— All rooms, installation shafts, partitions, elements of the interior design, devices and objects with significant dimensions and influence on the PDS;

— Columns, pillars, ceiling and wall beams, and all the above structural elements in protected and unprotected spaces, if they are determined to have an influence on the PDS;

— All doors, gates, windows and wall openings, transfer dampers (ATD, BDD) in rooms or areas that are connected with protected spaces and the PDS operation spaces; and

— All components relevant to the PDS (e.g. fans, ducts, dampers, silencers, grilles, pressure measuring points) where relevant to the design concept calculations.

By means of the simulation, the necessary volumes of distributed air, the selection of the supply and air release points with relevant flow characteristics, the pressure regulation method, the position of the pressure sensors and the set point specifications of the control system shall be verified.

Due to the complexity of computer simulations, it is important that such simulations are carried out by people who have relevant project experience in the field of fire safety, the design of PDS and factual knowledge in the field of fluid mechanics, heat transfer, dynamics of fires and other related areas.

The basic recommendations regarding the simulations shall be followed. Such basic recommendations include e.g. well-known books, publications and instructions, as well as articles and user manuals on the subject of engineering methods in fire protection, simulations or fire protection engineering procedures.

The results of the simulations shall be confirmed with the verification of the installed PDS.

D.6.2 Content requirements

The results of the simulation shall be presented in the form of a report. The simulation report shall contain the following minimum information:

— a building description and identification;

— the date and version of the submitted design documentation;

— the name and version number of the software used for the simulation;

— signatures of the simulation authors, the PDS designer and fire protection engineer;

— the date and version of the corresponding concept plans (description, plan number, revision date);

— a specification of the applied fundamentals;

— the determination of climatic and physical conditions;

— a detailed description of the building PDS model (including boundary and initial conditions);

— information about the statistics/data with regard to the resolution of the computational model, especially in the critical flow areas (e.g. size of the calculation grid, number of nodes, size of the largest and smallest computational cells, convergence criteria where relevant);

— assumptions in the selection of project values (e.g. open cross sections, leakages, wind pressure distributions);

— a declaration of accuracy of the simulations;

— diagrams or curves demonstrating the pressure conditions within the escape routes at each investigated floor in summer, isothermal and winter cases, as well as under wind load (where relevant) with design values and allowable tolerances indicated. The results shall be supplemented with an analysis;

— concise conclusions with clear information demonstrating that the design requirements are met and any additional remarks, if relevant;

— all input file(s) and files showing the results and the report shall be stored in electronic form.

D.6.3 Presentation of the results

The results are to be presented and interpreted in the form of clear diagrams and visualizations.

The report shall contain the full set of assumptions and constraints used, with an analysis of the impact that any changes would have on the results of the calculations. This is to allow the person reviewing the analysis to determine from the results which scenarios have been examined and whether all design criteria have been met.

The authors shall confirm the fulfilment of the requirements of Table 1 and point out any specific methods and technical solutions used in order to reach the conditions.

In order to eliminate possible errors in the simulation, the obtained results are to be analysed and compared with the results of simplified calculations (e.g. hand calculations) using simple empirical formulas, or real scale measurements, if available.

D.7 Project assessment by authorities having jurisdiction

The authority having jurisdiction will expect the PDS concepts, designs and reports to be presented for assessment at an early stage, prior to the start of construction.

Project assessments may be carried out by the authority having jurisdiction or by a competent external expert appointed by the authority having jurisdiction. The choice of the specialist lies in the competence of the authority having jurisdiction.

They will check the completeness, accountability, justifications, conclusions and verifications of the relevant PDS concepts and analysis.

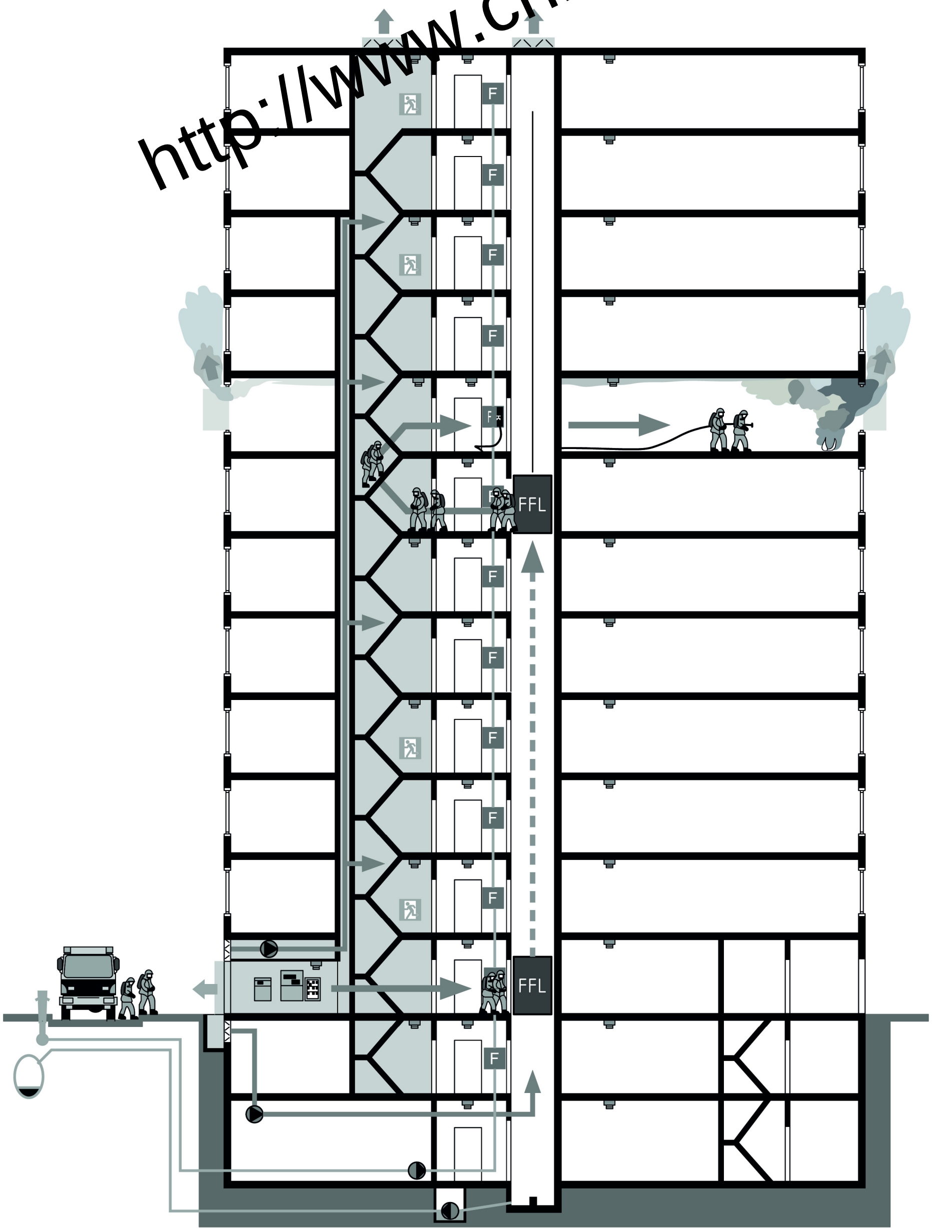
NOTE It is likely that only comprehensive and completed documentation will be examined by the authority having jurisdiction.

The results of the project assessment shall be communicated in writing to the PDS designer by the authority having jurisdiction.

Annex E
(informative)

Example of firefighters' intervention in building equipped with PDS

Following figure shows a section view of PDS and gives information about firefighters' intervention supported by the PDS and the firefighters lift.



Key

F Firefighting dry/wet riser

FFL Firefighters lift

NOTE The grey shaded areas represent the protected spaces

Figure E.1 — An example of a comprehensive PDS system

Annex F
(informative)

Documentation and responsibilities in the process

F.1 General

This annex defines the recommended content for PDS documentation required at different project phases. Table F.1 shows a summary of the most necessary tasks and which participants of the construction process should be involved at each particular project phase.

F.2 Concept studies

An example of a concept report is shown in Annex G, but shall contain at least the following:

- State the occupancy of the building;
- Define the protection objectives;
- Create a PDS concept, which is based on the fire safety concept and the evacuation concept;
  - The preliminary PDS concept needs to include:
    - defined protected spaces;
    - location of the building, showing the main wind directions and speeds;
    - location of the air supply;
    - location of the fans;
    - location of the control cabinet and sub-control devices;
    - location and requirements of the firefighters control switch;
    - type of air release (e.g. shaft, façade, powered);
    - location of air release (e.g. shaft, dampers, fans);
    - backup power supply;
    - principle diagram (illustration of the essential functional principle of the PDS);
    - floor plans with defined protected spaces.

Discuss and confirm the PDS targets and installation with the authority having jurisdiction.

F.3 Planning and Engineering

The PDS shall be further developed as follows:

— Create a PDS concept considering all the relevant PDS requirements.

— Create the PDS design based on the building architecture and the fire safety plans.

— Define the project organization and time schedules.

— Confirm the interactions. The PDS needs to be adapted to integrate with other fire protection measures. Interactions with other technical fire protection devices (such as mechanical smoke and heat extraction systems, firefighting lifts) shall be considered. Technical fire protection measures shall not adversely affect one another.

— Risk assessment – a risk assessment shall be undertaken following the requirements of Annex I.

— Have the designs and plans approved by authority having jurisdiction.

F.4 Execution stage

The installation and commissioning stage will include the following:

— A contractor will be appointed to install a PDS in accordance with the PDS design concept.

— The PDS installer/supplier shall commission the PDS installation and confirm that the design criteria are fulfilled.

It is recommended that a third party carry out or witness an acceptance test of the PDS and confirm that the building is acceptable for occupation.

F.5 Occupation phase

After handover and occupation, the following requirements shall be met:

— As-built documentation shall be accessible at the firefighter control panel.

— The building owner shall be responsible for maintenance and periodic testing of the PDS.

— The building owner or his delegate shall carry out integrated tests to confirm function and performance.

— All relevant changes to the PDS shall be reported to the authority having jurisdiction; any documentation shall be updated by the building owner or their delegate (see Clause 10).

— In accordance with national requirements, the authority having jurisdiction shall be given access and may periodically check the PDS.

Table F.1 — Participants of the construction process in the different project phases

Task list and responsibilities					
Actors and tasks	**Building owner/developer**	**Architect**	**Fire protection engineer/consultant**	**PDS engineer/consultant**	**Authorities having jurisdiction (AHJ)**
Define occupancy/ usage and protection objectives	Required	Required			
Preliminary PDS concept			Required	Optional	
Kick-off meeting	Required	Required	Required	Optional	Required
Define a project plan	Required	Required			
PDS concept		Required	Required	Required	
Approval by authority having jurisdiction			Required		Required
Control during building phase	Required	Required	Required	Required	Optional
Preliminary control of a PDS	Required	Required	Required	Required	
Acceptance test carried out or witnessed by the authority having jurisdiction	Required	Required	Required	Required	Required
Building accepted for occupation					Required
Maintenance and integral tests during operating phase	Required	Optional	Optional	Optional	Optional

Annex G
(informative)

(Example) PDS concept report

The following information shows the content that shall be included in a concept report.

Table G.1 — Example PDS concept report

Content requirements		Remarks	☑
1	**Title page**	Building description, address, zip code/city	☐
		Building-Number, Cadastral-Number	☐
		Client, Investment ownership	☐
2	**Summary**	Short summary about decisions that led to submitted PDS concept. As well as gained knowledge and the final measures	☐
3	**Declaration of liability**	Legal signature of all persons involved in the project and the investment ownership	☐
4	**Contents**	Content, list of figures and source reference	☐
5	**Basic data**	Responsible, involved persons and institutions	☐
		Date and version of the submitted documentation	☐
		Name of used plans (Name, Plan-Number, revision date)	☐
		Naming of used bases	☐
		Description of the situation concerning fire protection	☐
		Main climatic conditions	☐
		Description of the object with planned accommodation areas	☐
		Reference to fire protection concepts (author, concept name, date, version)	☐
		System boundary of the PDS concept	☐
		Influence of fire protection and smoke extraction measures (such as doors tightness, mechanical smoke extraction systems, elevators)	☐
6	**Scope of tasks**	Scope of tasks for a PDS concept	☐
7	**Protection objectives and definition of the system class**	Definition and explanation of the protection objectives (planning goal and performance criteria) for all PDS protected areas (during escape and intervention phase)	☐
		Determination of system classes	☐

Content requirements		Remarks	☑
8	**Description of PDS**	Description of the system type: active or passive control/ controlled with frequency inverter or e.g. using throttle valve	☐
		Type of air release (via facade or shaft): dimensions and positions	☐
		Floor plans, section drawings (to scale): defined overpressure zones, over-pressure relief, air release and requirements for doors (such as fire resistance, door closures, tightness) must be evident	☐
		Project plans (floor plans and section drawings) with marked system components (external air intake, installation shafts, ducts, dampers, control cabinets, sub-control devices, over-flow and air release openings, etc.)	☐
		Schematic diagram showing the entire PDS (including the most important system components) within the building	☐
		Principle diagram: Illustration of the essential functional principle	☐
9	**Dimensioning bases**	Location of the object/ main wind directions and wind speeds	☐
		Leakages / air supply points / volume flows / door sizes / door closers / maximum pressure differences / air release cross section	☐
		Comprehensible calculation documentation	☐
		Pressure distribution curve over the protected areas (if capacity analysis is required)	☐
10	**Requirements for system components and material**	Fans, ducts, dampers, actuators, over-pressure reliefs and insulation with fire resistance, etc.	☐
		Silencers, air supply points into the firefighting stair and firefighting lift shaft	☐
		Air release devices and actuators	☐
11	**Functions and description of regulation**	Display of the various operating phases	☐
		Fire control system, interfaces and system boundary	☐
12	**Control system for the PDS**	Description of the control system	☐
13	**Handling with disturbance**	Explanation how disturbances are represented and forwarded (intervention concept); Note: fault message must be transmitted via the fire alarm control centre to the same permanently occupied department as the fire detection and sprinkler systems	☐

Content requirements		Remarks	☑
14	**Fire control system**	Fire detection: The PDS is controlled in in any case via a fire detection system	☐
		Coarse depiction of fore control system (control matrix)	☐
15	**Location of control cabinets and remote control units**	Location needs to be defined at floor plans	☐
16	**Backup power supply**	Object-specific principle diagram of the backup power supply	☐
		NOTE Connection from power supply must be carried out as a ring (loop) or the power supply must be disconnected autonomously. The safety power supply must be carried with function maintenance	☐
17	**Requirements for parts, sections of the building**	Explanation of structural measures (e.g. by fresh air intake), air release at facade, door closing forces, door closers, free swing door closers, tightness if doors, etc.	☐
18	**Control stations for fire brigade**	Location and functions of control stations	☐
19	**Weak points and measures**	List of weak points and measures (e.g. failure / disturbance of pressure sensor)	☐

Annex H
(informative)

(Example) PDS test report

The following checklist shows an example of a PDS test report. The measurements should be recorded by the PDS supplier/installer.

Ideally, the completed document should be submitted to the authority having jurisdiction for a pre-assessment before the acceptance test takes place.

Test report PDS			Date:	
Object:	Name:		Building-Nr.	
	Street:		Nr.	
	City:		Post code:	
System designer:	Name:			
	Street:		Nr.:	
	City:		Post code:	
	Tel.			
System supplier:	Name:		Project:	
	Street:		Nr.:	
	City:		Post code:	
	Tel.			

Fire safety manager:	Name:			
	Street:		Nr.:	
	City:		Post code:	
	Tel.			

System class:		**Air release:**	facade	
			shaft in firefighting lobby	
			shaft in accommodation area	

PDS design:	Capacity analysis from		Version:	
	Approved by fire safety authority at			

Preconditions (all requirements must be answered with "YES")

1) PDS according to approved design		7) Fire detection system approved	
2) Building cover completed + tight		8) System manager is instructed	
3) Safety staircase + lobbies completed		9) As-build documentation is available	
4) Firefighting lift completed		10) No obstruction due to works or operations	
5) Air releases ready for operation + tested		11) Fire control system completed + integrally tested	
6) Safety power supply completed + tested		12) Electricity must be switched off in whole building	

Remarks and deviations (to approved design and conditions)

Measurement results

Climate conditions (indoor / outdoor)

Weather:		
Wind velocity roof:		m/s
Wind velocity terrain:		m/s
Wind direction:		
Outside air temperature:		°C
Inside air temperature - staircase:		°C
Relative humidity (outside):		%
Relative humidity (inside):		%

1. Measurement after 10 min PDS in operation

Inside air temp. - staircase:		°C
Inside air temp. - FF Lift:		°C
Relative humidity (inside):		%
Pressure differential - at the top		Pa
Pressure differential - middle		Pa
Pressure differential - at the bottom		Pa

Note: PDS is operated for at least 10 minutes and then switched off.

Then carry out measurements.

2. Further measurements

Max. flow rate staircase		m³/h	Max. flow rate FFL		m³/h
Sound pressure level staircase		dB(A)	Sound pressure level FFL		dB(A)
Response time 5 sec maintain		(yes/no)	Entry air velocity FFL		m/s

3. Measurement range over whole PDS

System status							PDS inactive		PDS active all doors closed				PDS active Outside and X-floor doors opened			
Air release (Facade/Shaft)							closed		opened				opened			
Area							STC		STC		STC	FFL	Air velocity		STC	FFL
Measurement	Door width		Door height		Door closers		Door opening force		Door opening force		Differential pressure				Differential pressure	Differential pressure
Floor / Unit	[m] 1)	[m] 2)	[m] 1)	[m] 2)	DC	FSDC	[N] 1)	[N] 2)	[N] 1)	[N] 2)	[Pa]	[Pa]	[m/s] 1)	[m/s] 2)	[Pa]	[Pa]
22. Floor																
21. Floor																
20. Floor																

	19. Floor																
	18. Floor																
	17. Floor																
	16. Floor																
	15. Floor																
	14. Floor																
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	7. Floor																
	6. Floor																
	5. Floor																
	4.Floor																
	3. Floor																
	2. Floor																
	1. Floor																
	0 Floor																
	01. Floor																

1) Door between staircase and lobby	2) Door between staircase and accommodation area	DC= Door closer	FSDC= Free swing door closer

NOTE: If there are several doors between firefighters-lobby and accommodation, measurements of the door opening force and air flow velocity need to be taken at the largest door

Remarks and pending matter

Confirmation measurement protocol

The responsible persons confirm that the information in this measurement protocol is correct and the PDS is ready for operation

System supplier:		System designer:	
Contact person:		Contact person:	
Phone:		Phone:	

Date, Signature

Date, Signature

Supplements:

1	Cadastral plan with marking of the protected areas, fire brigade access and location of PDS control panel
1	Evaluation of control behavior / control time (Diagram of differential pressure measurement with datalogger)
1	Protocol on the preliminary acceptance test

Annex I
(informative)

Risk assessment – List of potential disturbances

The following shows examples of the potential disturbances which could negatively affect the proper function of a PDS. As a part of the risk assessment process, a pragmatic evaluation of the designed PDS shall be made by PDS designer/supplier and documented in the PDS concept report. Potential issues with the main PDS-components shall also be taken into account and the PDS supplier shall recommend solutions which will ensure the proper safety level in the building.

Table I.1 — Surrounding Area

List of potential disturbances – surrounding area		**Explanation of the measures**
1	Smoke in the area of fresh air intake	
2	Fresh air intake doesn't operate - leaves, waste, snow or other foreign objects prevent suction	
3	Power failure – utility grid for the power supply	
4	Wind pressure on air release openings	
5	etc.	

Table I.2 — System

List of potential disturbances – System		**Explanation of the measures**
1	Failure/disturbance of control system or part of it	
2	Failure/disturbance of a fan	
3	Motor protection switch of a fan is activated	
4	Switch disconnector by fan is switched off (e.g. during service works)	
5	Failure/disturbance of the pressure monitoring (pressure sensor) in the staircase	
6	Failure/disturbance of the actuator, which operates the over-pressure relief in the staircase	
7	Failure/disturbance of the frequency inverter (control of volume flow)	
8	Failure/disturbance of the throttle damper (control of volume flow)	
9	Failure/disturbance of the air release openings (façade openings or smoke control damper	
10	Fire alarm system partially or completely out of service (e.g. reconstruction works on one or more stories) – providing a selective air release	

List of potential disturbances – System		**Explanation of the measures**
11	PDS is activated via manual call point station	
12	Reconstruction/adjustments in the object which leads to adaptation of the PDS (e.g. adjustment of space allocation)	
13	Shading devices in front of air release openings	
14	Air inlet in firefighting lift shaft affects the operational readiness of the firefighting lift	
15	Sound pressure level in the firefighting staircase disturb the audibility of evacuation system	
16	Sound pressure level at the intercom points of firefighting lift (firefighters access level, car and machinery space) disturb the audibility of the intercom	
17	Door opening forces are exceeded	
18	Door closing forces can lead to accidents (pinching, peeling off fingers)	
19	Doors in the firefighting staircase and lobbies are no longer ably to close completely after use	
20	Failure/disturbance of the control station	
21	Maintenance work on the PDS	
22	Software update of the control system	
23	Failure/disturbance of the backup power supply (e.g. response of the circuit breaker)	
24	Fire in the fire compartmentation, through which runs air supply ducts of the PDS	
25	Failure/disturbance of the smoke detection for fresh air intake (e.g. defect of duct smoke detector)	
26	Fire/smoke in the firefighting staircase	
27	Fire/smoke in the firefighting lift shaft	
28	etc.	

Annex J
(informative)

Practical suggestions for successful commissioning

Table J.1 — Commissioning: Issues, causes and solutions

Issue	Cause	Solution
Excessive/unexpected leakages	Poor construction of building fabric	Ensure that the appropriate design/construction teams are tasked with making the building fabric associated with the PDS as airtight as possible
Difficulty achieving the correct pressures/air volumes in several of the proposed locations	Too much airflow to one location and insufficient airflow to others	Install volume control dampers on all branches to allow correct air distribution.
Difficulty in achieving the correct pressures/air velocities in all proposed locations	Fan capacity is insufficient/air leakage is excessive	Make suitable allowance for unknown leakages and ductwork leakage at design phase Provide extra control and/or capacity
PDS performance is adversely affected by climatic conditions.	Stack effect or wind effects in the stair or lift shaft cause unexpected pressures or airflow	Ensure that the PDS design is able to compensate for stack and wind effects at the design stage. Provide extra control and/or capacity
Excessive air pressure experienced in the staircase using single speed pressurization fans	Pressure control damper is not big enough	Ensure that the pressure control damper is suitably sized at the design stage – it is easier to reduce the size of the unit than make it larger later Recalibrate or replace the pressure control damper

Annex K
(normative)

Labelling — Information and position

In the absence of a national requirement the following label shall be applied.

The label shall be red with black lettering and a white symbol in the centre, see below.

The label is to be positioned at the main firefighter entrance to the building.

Key

PDS Pressure differential system (use RDA, etc.); this shall be replaced by the French or German equivalent in the translation

Figure K.1 — System label for the building firefighter entrance

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National Annex NA
(informative)

Additional Information for UK Applications

NA.1 UK Specific Design Criteria

BS EN 12101-6:2005 was an adopted harmonised European Standard for Pressure Differential Systems (PDS) which defined Classes A to F to cover systems used throughout Europe.

The classes were applied to buildings as follows:

Table NA.1 — Classes of systems

Class	Purpose
A	For means of escape. Defend in place
B	For means of escape and firefighting
C	For means of escape by simultaneous evacuation
D	For means of escape. Sleeping risk
E	For means of escape by phased evacuation
F	Firefighting system and means of escape (using additional smoke purging for certain member states, not used in the UK)

The main differences between them, with the exception of Class B, was the number of doors considered to be open from the stair to other floors in addition to the door to the fire floor. Class B required a higher level of protection to the complete firefighting shaft. In this standard, these classes no longer exist.

This standard provides design principles that allow the designer to specify a PDS that will offer protection to spaces in the building, but it does not specify which spaces should be protected or differentiate between building types as in the table above. As a minimum, the UK committee believes the staircase should be considered a protected space. For applications other than firefighting, all the examples in Subclause 5.6.3 may be considered and the designer should justify their selection accordingly. Furthermore, this standard no longer specifies which doors should be considered to be open.

In the case of firefighting shafts, the UK committee believes PDS should be designed to protect the complete firefighting shaft, i.e. the firefighting stair, the firefighting lobby and the firefighting lift – refer to Subclause 5.6.3, Examples 7, 8, 9. It is the UK committee's opinion that:

- Example 7 may be used if the lobby is a simple lobby with just one accommodation door leading off and can be shown to be pressurized by air leakage from the stair and/or lift when the doors are closed.
- Example 8 can be used where there is no firefighting lift.
- In all other scenarios, Example 9 should be followed.

Where evacuation lifts are provided in conjunction with a PDS, it is expected that the PDS offers protection to the stair, the evacuation lift and the evacuation lift lobby – refer to Example 9.

When designing a PDS system:

1. The pressures specified in Table 1 (Section 5.1 BS EN 12101-13:2022) should be met when all doors to the staircase are closed.

2. The velocities through an open door to the fire floor, from the stair should be achieved with the following doors open:

Table NA.2 — Purpose Specific Design Criteria

Purpose	Open Doors
For means of escape. Stay put	• Stair door on fire floor • Lobby door on fire floor (if present) • Final exit door
For means of escape and fire-fighting	• Stair door on fire floor • Stair door on floor below • Lobby door on fire floor • Lift door on floor below • Final exit door
For means of escape by simultaneous evacuation	• Stair door on fire floor • Lobby door on fire floor (if present) • Final exit door
For means of escape. Sleeping risk (other than stay put)	• Stair door on fire floor • Lobby door on fire floor (if present) • Stair and lobby door on one floor other than the fire floor • Final exit door
For means of escape by phased evacuation	• Stair door on fire floor • Lobby door on fire floor (if present) • Stair door on two other floors • Final exit door

Table 1 (Section 5.1 BS EN 12101-13:2022) defines two classes of system performance and in Subclause 5.2.1 the standard refers to a high-rise building limit. In the absence of a defined limit, the UK committee advises this should be taken as the height of 18 m.

Table 1 specifies a maximum door opening force that may prove too much for some members of the community to be able to open. Designers should consider methods of ensuring that the escape doors can be used by all potential occupants. BS 8300-2:2018 contains useful guidance.

NA.2 UK committee advice on references to national requirements

NA.2.1 Subclause 5.6.10

There are currently no UK national requirements for flushing within pressurisation systems. Flushing systems may be used, for example, in a residential application with extended travel distances. In this instance the performance should meet the objectives of the Smoke Control Association: Guidance on Smoke Control to Common Escape Routes in Apartment Buildings.[1)]

Note The performance should be demonstrated by design. It is the opinion of the UK committee that the airflow stated in this standard may not be appropriate in all situations.

NA.2.2 Subclause 7.5.25

Power Supplies should meet the requirements of BS 8519:2020.

NA.2.3 Subclause 8.3 a), b)

Completion testing should be carried out in accordance with BS 7346-8:2013.

NA.2.4 Subclause 8.3 c), d)

Routine testing and maintenance is a requirement of the Regulatory Reform (Fire Safety) Order 2005 and should be carried out in accordance with the frequencies stated in BS 9999:2017 Annex I.

NA.2.5 Subclause 11.6.3

Ducts and shafts should be cleaned in accordance with BS EN 15780:2011.

1) See https://www.smokecontrol.org.uk/resources.

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