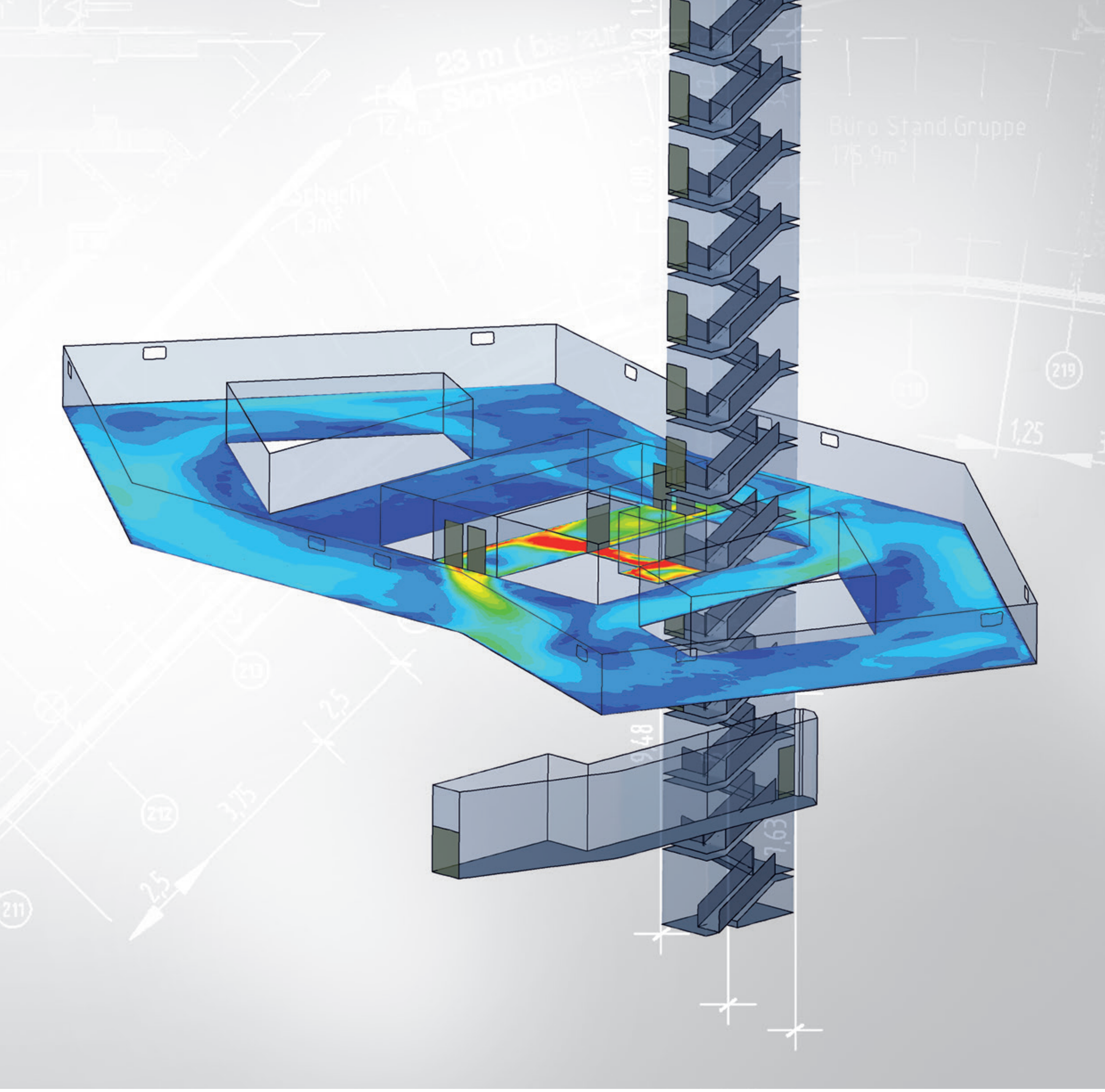

Information for Design

Differential Pressure Systems

strulik

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Photo: www.primetower.ch

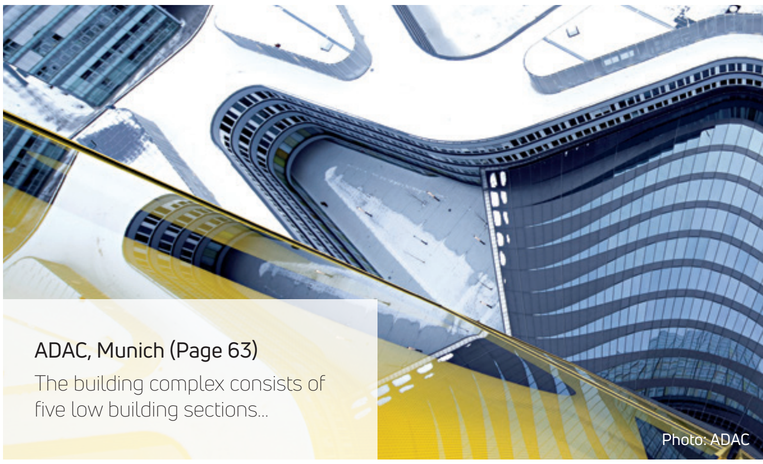

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Photo: ADAC

1 Introduction

1.1 Strulik – Your reliable partner

Strulik GmbH provides support for projects from conception to commissioning with the competence and responsibility of an experienced system integrator.

Keeping escape and rescue routes and especially indoor staircases free of smoke is an important prerequisite for the escape and rescue of people. Strulik systems meet the high standards involved, even under critical environmental conditions. This also applies to the consideration of different climate conditions in the summer and the winter and the physical effects associated with them.

Strulik considers a design and plans and calculates a selection of possible scenarios for the building on the basis of the structural conditions of the building and the variable framework conditions. These may be caused, for example, by changes in temperature or air pressure conditions which occur in the different seasons of the year. The basis for a qualified calculation of all the eventualities is given as a result of expert knowledge and practical experience in the implementation and operation of such systems. Regardless of the building type and use, the individual product components of our differential pressure systems can create a smoke-free safety zone in buildings, staircases, lobbies, corridors and firefighting lift shafts.

The basic types of differential pressure systems are:
- Regulated supply air systems
- Regulated exhaust air systems

And the combination:
- Regulated supply and exhaust air systems

In this brochure, we would like to introduce you to types of differential pressure systems, and also in combination with regulated supply and exhaust air systems.

1.2 Our products and services

Regardless of the property size, we are your partner for system solutions from consulting to implementation. Our focus lies in the clear, unambiguous compliance with standards in the technical realisation of individual projects.

In practice, a building's physical structure and additional critical environmental conditions often represent an enormous challenge for planning reliability and product selection.

The concentration on the best sector and system solutions is an important factor for excellent market and customer focus.

In addition, we also offer our clients specialised literature and training courses on both general and special engineering topics according to their needs. This covers current EU standards for our field and their application.

Our services range from comprehensive consulting to the successful realisation of a project:

Consulting – Planning – Commissioning – Service – Maintenance

"For us, sustainable
the basis for a pa

From practice for practice

Our decades of experience in structural engineering and detailed knowledge of the compliancy testing of building products guarantee that we can offer instrumental support in shaping your systems and minimising potential safety risks.

Strulik building products and systems not only deliver functions required by building law, but also in most cases go beyond those requirements.

1.3 The Strulik Philosophy

"When the company was founded in 1975, our goal was to become one of the best in our field".

Our successful mixture of tradition and innovation is put into practice by a team of over 100 employees in Germany who are active in the development and production of high-quality systems. Specialists with many years of experience and state-of-the-art technical know-how ensure customised solutions to meet the highest demands of our clients.

Competence, quality and exclusivity represent the philosophy of our company, including our branch offices and high-tech production sites within Europe. The production, planning and sales of building products and systems for safety engineering require a high level of responsibility and mutual trust.

All over the world, we have demonstrated in a wide array of projects that the trust our clients place in our company is justified. For us, a continuous ambition to make improvements is as natural as the patents for technical innovations. Our numerous impressive reference projects are the natural result of this ambition.

"Quality is an important statement
in our company philosophy and is
intimately connected with the name Strulik GmbH."

The qualification of all products relevant to building authorities has been certified by the German Institut für Bautechnik (DIBt), which has also approved the use of these products.

For Strulik, DIBt approvals demonstrate the suitability and implementability of our products within the application area of different regional building laws and their compliance with construction requirements.

For our domestic and international clients, the certification of our company according to the specifications and objectives of EN ISO 9001 – a procedure recognised worldwide as a standard for quality management systems – represents a verifiable, comparable proof of our competence and capability.

2 General principles

2.1 Terms/Abbreviations

2.1.1 Definition

There are many terms used in Europe for ventilation systems, in general supply air systems, used to protect escape routes.

When considered more closely, the systems to which these terms refer are actually identical. The main purpose of these systems is to prevent smoke from penetrating into protected areas. Systems which serve the general purpose of smoke suppression are suited to meet this important protection goal. Such systems presume that smoke will penetrate into protected areas. The goal of such systems, therefore, is to remove this smoke from the protected areas by creating an air change. These systems are referred to as clearance systems. However, this simple system concept is not approved for safety staircases.

Strulik GmbH employs the abbreviation DPS for differential pressure system. You will therefore find this designation multiple times within the following text. Because we offer and design these systems as system manufacturers, at Strulik you will receive differential pressure designs as a system.

2.1.2 Function of differential pressure systems (DPS)

The function of a DPS is to secure escape routes in buildings and keep them smoke-free. The differential pressure must be secured between the escape route (e.g. staircase) <u>and</u> the floor in which a fire has broken out with both closed and open doors to ensure that smoke <u>cannot</u> penetrate into the escape route.

The operator bears the responsibility for the safe operation of the escape route required by building law. He must consult the assistance of experts for planning and execution when building these routes.

2.1.3 Abbreviations

DIN	Deutsches Institut für Normung (German Insitute for Standardisation)
EN	Europäische Norm (European standard)
CEN	European Committee for Standardization
VDMA	Verband Deutscher Maschinen- und Anlagenbau (German Engineering Federation)
LBO	Landesbauordnung (State Building Code)
MBO	Musterbauordnung (Model Buidling Regulation)
MHHR	Muster-Hochhaus-Richtlinie (Model High-Rise Bldg. Regulation)
SBauVO	Sonderbauverordnung (Special Bldg. Regulation)
AS	Arrest System
SC	Staircase
SW	Stairway
DPS	Differential Pressure System
SPPS	Smoke Protection Pressure System
PVS	Pressure Ventilation System
SHV	Smoke and Heat Ventilation
FFL	Firefighting Lift
EPS	Emergency Power Supply
BMS	Building Management System
FDS	Fire Detection System
FACP	Fire Alarm Control Panel
DDC	Direct Digital Control
CFD	Computational Fluid Dynamics
WW	Stairwell width
SW	Stair width
SP	Smoke protection
TU	Technical University
MSES	Mechanical Smoke Extraction System

Example of a staircase within a building

penetrated smoke. In the case of staircases with air-locks to the necessary corridor, the experts follow this specification in fire protection certification.

If the air-lock is to be dispensed with, this is compensated for with the use of a DPS/SPPS.

The protection goal is generally considered to be only the minimum overpressure of 15 Pa and the maximum door-opening force of 100 N. The demonstration of flow in the opened door is not required.

2.1.4 Explanation of individual terms

Necessary staircase

This is the only structural escape route in this part of the building. Evacuation may only occur using this route and not from the outside. The fire-fighting measures of the fire brigade also include this route among others. High rise buildings regularly feature a safety staircase, though this requirement may also be placed on a lower building in the scope of a fire protection certification.

Necessary indoor staircase

The Model Building Regulation 2002 (MBO) states that the necessary staircase can be designed as an indoor staircase if its "use can remain unthreatened by the inflow of smoke for a sufficient amount of time." The doors to the necessary staircase are not equipped with door closers. "Necessary staircases must be able to be ventilated." Outdoor staircases require that this ventilation is secured through a window of at least 0.5 m^2 on door above ground. According to the MBO, necessary indoor staircases must have at least a 1 m^2 smoke and heat ventilation opening on the roof to remove

Lobby with doors according to building law

The lobby of a staircase is a component of the safety concept. The staircase, lobby and necessary corridor form a chain of graduated safety. Therefore, three doors are provided between the potential fire area and the staircase. The lobby can be used to generate a pressure change between the staircase and the corridor. Pressure equalisation openings between the staircase and the lobby and between the lobby and the corridor allow a controlled graduation of the pressure difference with closed doors. This pressure graduation (pressure cascade) reduces the pressure difference at a door and thus the door-opening force when the second door of the lobby is closed.

Pressure equalisation – air-lock

According to the MHHR, the lobby in a safety staircase is assigned to the negative pressure area of the staircase. The connection afforded by a pressure equalisation opening allows a pressure level in the lobby which can correspond to that in the staircase.

If a flow through the lobby is also required, an additional pressure equalisation opening between the air-lock and the corridor is necessary. No fire-protection-related requirements are generally made with respect to the opening between the staircase and the lobby. The opening between the air-lock and the corridor must be furnished with a shut-off device K90.

These openings are part of safety-engineering systems. They are not overflow openings. Smoke alarms may not be installed at these pressure equalisation openings. Backflow flaps may be built in at the opening between the air-lock and the corridor if they have been explicitly included in the maintenance plan of the DPS.

Firefighting lift

Pressure equalisation, lobby firefighting lift

Openings for equalising the pressure between the lobby of a firefighting lift and the corridor cannot be used to expand a pressure cascade (see item Pressure equalisation – air-lock), as there is generally no lobby available.

However, an air change can be allowed in the lobby through the opening between the lobby and the corridor. The lobby thus becomes a secure retreat room for people who cannot rescue themselves as well as for the fire brigade.

Classification of the protection goal according to DIN EN 12101-6 or MHHR or necessary staircase without air-lock

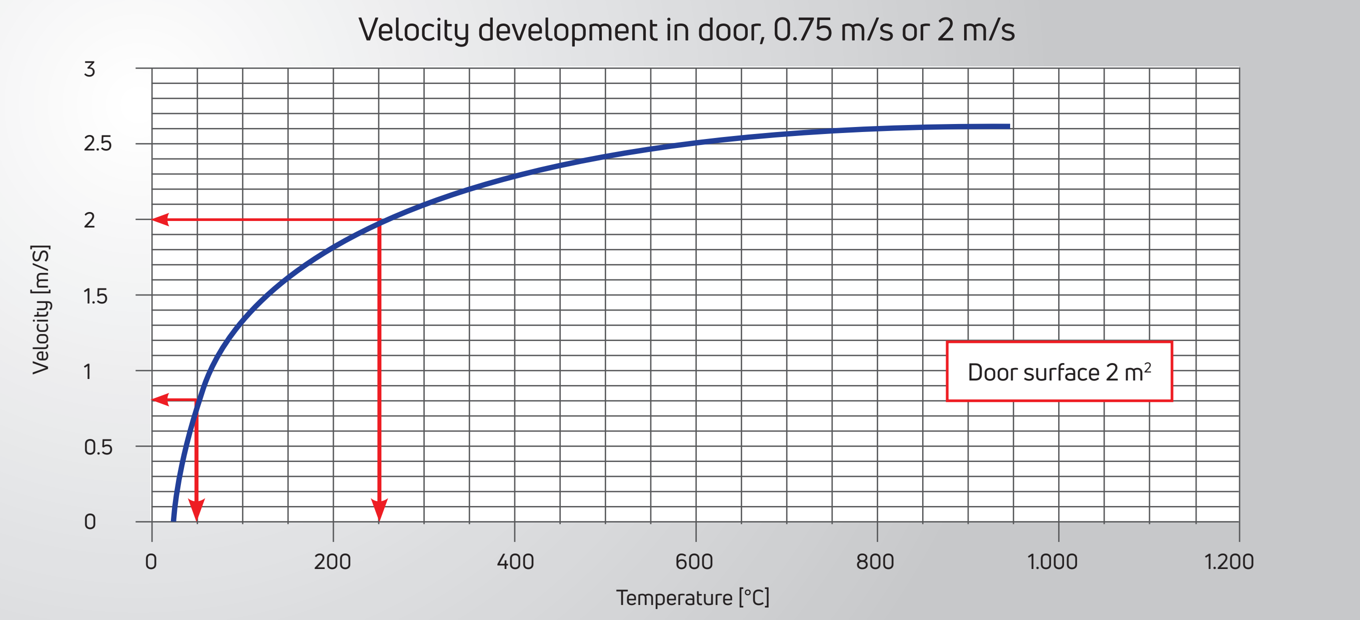
There are two approaches in Germany for defining the protection goals of a DPS. The building law of the German states is essentially based on the model guidelines and regulations of ARGEBAU. Important examples include the Model Building Regulation (MBO), the Model High-Rise Building Regulation (MHHR), and special building regulations (SBauVO).

The question of when the stairwell requires a DPS must be addressed with reference to building law when the fire protection certificate is prepared. The type and scope of the protection goals of a DPS can be defined on the basis of either DIN EN 12101-6 or the MHHR. DIN EN 12101-6 distinguishes six classes according to the building use and the use of the staircase. Each class describes the performance data of the protection goal requirement placed on the escape route in consideration of the building type.

MHHR 2008 defines the requirements placed on a staircase and a firefighting life in a high-rise building with the designation of a defined protection goal requirement. This MHHR definition can thereby be viewed as its "own class" in the sense of DIN EN 12101-6. Both possibilities lead to a safe system which must always meet at least one pressure criterion and one flow criterion.

The necessary staircase places a much smaller demand on the safety system. In terms of building law, an indoor necessary staircase is allowed if its use is not threatened by the inflow of smoke for a sufficient amount of time. Building law attempts to achieve this safety level by means of a smoke and heat ventilation opening with a size of at least 1 m^2.

The demand to achieve increased safety by means of a DPS can be met with simple means.



R. John: „Ventilation system for keeping free from smoke of staircases" (1979)

A goal-protection-based solution for equipping a staircase with a DPS has two approaches:

- SHV opening of 1 m² with pressure-controlling damper
- Air supply for the staircase to ensure approx. 20 to 25 Pa overpressure

The essential difference to solutions of the DIN EN 12101-6 is that they dispense with an automatically activating safety exhaust in the fire level. The protective function of the system can be increased at any time if relief units open openings in the facade. Depending on the door size, the flow velocity that can thus be reached through the open door of the staircase to the floor is over 1 m/s. The protection goals with respect to the flight routes must be defined in the scope of the fire protection concept by evaluating all safety-relevant aspects.

The specification for later planning may be limited to a few instructions.

The following are a few basic examples:

1. Safety staircase according to the High-Rise Building Regulation.
2. Pressure ventilation of the staircase is executed acc. to Class C of DIN EN 12101-6.
3. To compensate for the lack of lobbies, the necessary staircase is equipped with a pressure ventilations system. The minimum overpressure in the staircase is 15 Pa. The demonstration of flow in the opened door is not required.

Smoke temperature as criterion of air velocity

The air velocity range defined by DIN EN 12101-6 is between 0.75 and 2.0 m/s. The possible average temperature of the smoky air should be considered as a help for selecting the correct velocity. The higher the expectable temperature of the smoky air, the higher the velocity must be. The longer the fire goes on, the higher the expectable temperature of the smoky air.

If only self-rescue is to be secured, lower air velocities (0.75 m/s) are specified. In a high-rise staircase according to MHHR 2008, smoke with higher temperatures is held back with the high air velocity of 2.0 m/s. This is necessary to additionally ensure that the fire brigade can execute its fire-fighting measures.

Control time requirement: 3 seconds

Differential pressure system assemblies must be conceived in accordance with DIN EN 12101-6. "Assembly" refers here to the technically coordinated main components: supply air fan, pressure-discharge area and control device. The control time requirement (3 seconds) for the assembly is met if the installed operational system reaches 90% of the required target value within 3 seconds after its operating condition has been changed (pressure criterion – flow criterion).

"Pressure criterion" refers to the limitation of the door-opening force to a maximum of 100 N.

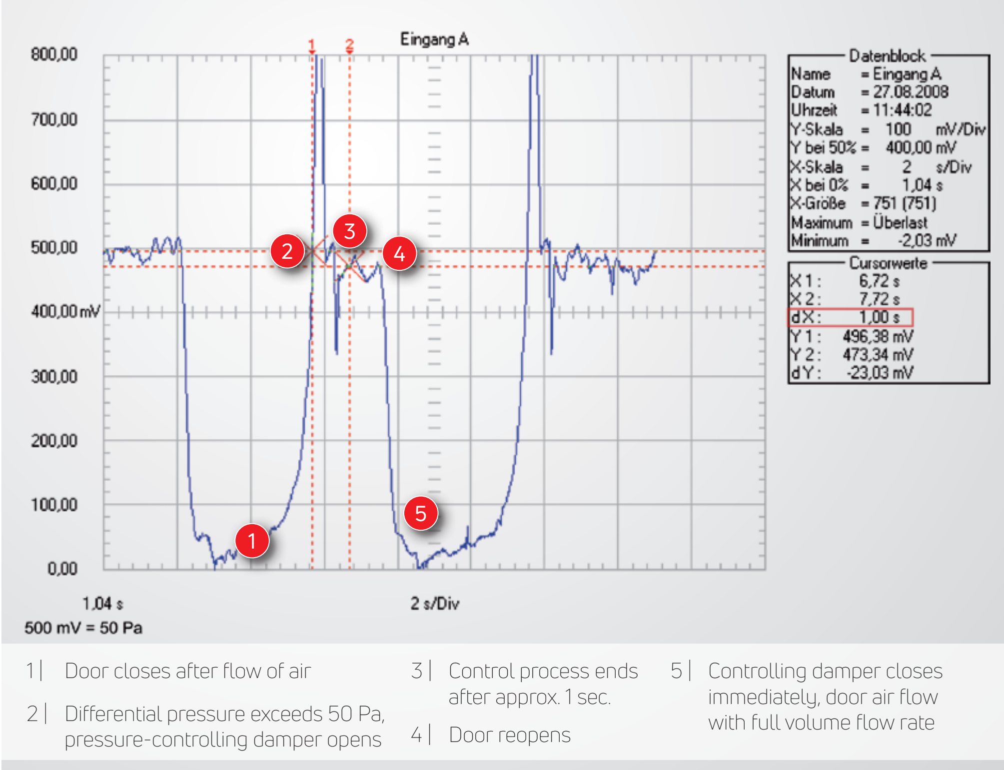
The pressure criterion describes the required flow velocity (0.75 m/s to 2.00 m/s) in the opened door from the safe zone to the fire level. This fast system reaction can be easily reached by means of an automatically regulating mechanical flap.

The diagram (right) shows the air pressure in the test room. At the start of the pressure recording, the door of the test room is closed, the fan is functional and the required supply air flow leaves from the test room through the pressure relief damper. The overpressure in the pressure room is set to approx. 50 Pa. After 2 seconds, the door to the test room is opened and the air conveyed by the fan flows disperses through the door. The pressure relief damper closes.

After 4 seconds, the door closer closes the door again. At 6 seconds, the overpressure in the test room quickly rises and exceeds the 50 Pa value. After approx. 0.5 seconds, the pressure relief damper is opened so far that the pressure in the test room sinks back to 50 Pa. After a total of 1 second, the target pressure value of 50 Pa has been reestablished in the test room. From the 8th second onwards, the door is reopened and the test begins again.

Arrest systems (AS) on doors in the required corridor

When measuring DPS/SPPS, one of the most important points is being aware of the leaks in alarm operation or calculating this leak in the scope of planning. It should be obvious that all self-closing doors are closed during alarm operation. This can only be achieved if the AS is centrally regulated.

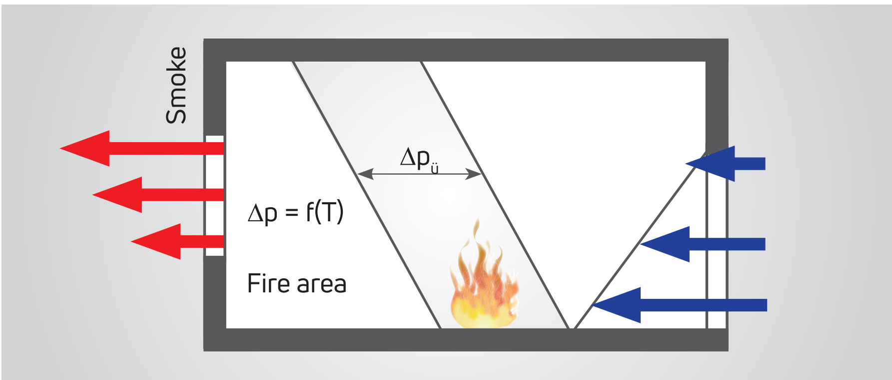


Pressure gradient in the test room with opened/closed door

Flow through door – Velocity criterion

To prevent the entry of smoke, it must be ensured in the fire level that, for every operating condition, there is an air flow from the pressure-ventilated protection room (SC, lobby FFL, escape tunnel) to the potentially smoky room outside of the protection room (corridor, use).

With closed doors, the air flow is only possible via door leaks. With opened doors, air flows through the entire free door section. The volume of flowing air is correspondingly high. The specified measureable protection goal is the achievable average air velocity (0.75 to 2.0 m/s) in the door section as a basis for measurement. In order to allow this air flow to be achieved automatically and permanently, the installation of a secured exhaust channel is required.



Smoke suppression from fire area

Door-opening force – Pressure criterion

The door-opening force must be limited to a maximum of 100 N when the pressure-ventilation system is operating. This value is the product of two force components. The first component must be generated with every door activation and is established by the door closer and the door itself.

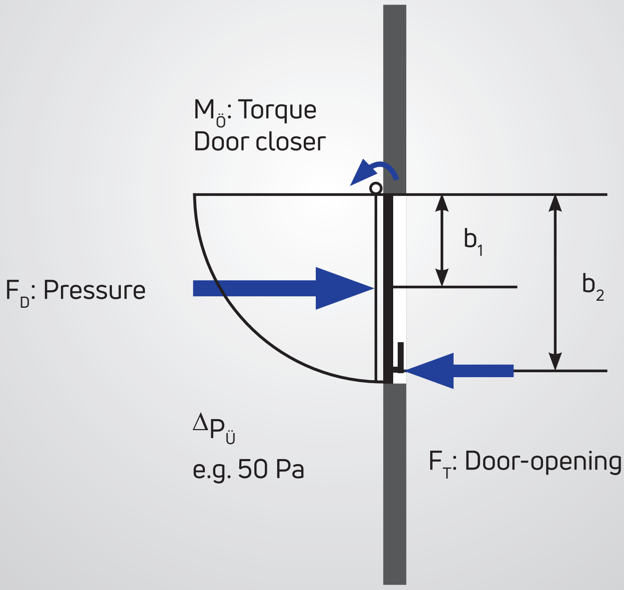
$$F_D = \Delta p \cdot A\,(H \cdot B)$$

Torque balance:

$$FT = \frac{F_D \cdot b_1 + M_Ö}{b_2}$$

Admissible door-opening force
100 N

$$\boxed{\Delta P_{max} = \frac{100\ N \cdot b_2 - M_Ö}{b_1 \cdot (H \cdot B)}}$$



Pressure difference at the closed door

Three aspects influence the magnitude of this force:

- the weight and size of the door leaf
- friction in the door pivot
- the design and quality of the door closer

According to DIN EN 1154, the size of the door closer required for the closing process can be selected. This standard also regulates the maximum torque for the opening process. Unfortunately, the boundary values of the standard are set so high that the use of such a door closer is no longer possible in conjunction with a DPS/SPPS. In our measurements, we use data from high-quality door closers available on the market. The selection of a door closer must be made in coordination with the system designer.

Pressure maintenance in the pressure area

After the DPS is alarmed, an overpressure is created in the protection area. This requires a source of supply air and a pressure discharge. The pressure-relief unit opens when the factory-set pressure of the opening is reached. The resulting overpressure in the protection area is directly proportional to the ratio of the opening surface and the volume flow to be discharged.

Automatic pressure-controlling damper/pressure-relief damper

The pressure-controlling damper or pressure-relief damper is a purely mechanical control device which has the following properties:

1. Minimises leaks → closed until the opening pressure is reached
2. Opens quickly when adjustable pressure difference is exceeded → < 1 second
3. Low loss of flow-through pressure in open state → reduces the required design size
4. Safely closes when the minimum pressure has been reached

For use in buildings, pressure-relief dampers are joined together with an electrically activated insulating damper and slatted hood or a front baffle plate to form a pressure relief unit.

Outside air intake, distance to other openings, dimensions

The air intake opening for outside air must be selected and set up so that smoke cannot be sucked in from a fire in the building. For this purpose, air intakes can only be at the bottom of the building. All windows and doors should be located above the air intake opening.

The lateral distance to other openings must be considered on a case-by-case basis. The requirements of building law with respect to openings in outer walls only considers the danger of fire transmission and are not helpful in this context.

If the intake of outside air is to be designed on the roof of the building, special measures must be taken.

The intakes must be provided redundantly at different locations so that one opening can intake smoke-free air at all times. Both intake openings must be equipped with smoke detectors and shut-off valves.

Safety exhaust (combination of supply air and exhaust air system)

One protection goal of MHHR 2008 and DIN EN 12101-6 is compliance with a defined air flow from the pressure area to the corridor/utility in the fire level.

In order to be able to meet this requirement in the fire level automatically, a secured exhaust channel (safety exhaust) must be opened in the fire level to the outside via SPPS/DPS control.

This opening must function properly irrespectively of weather conditions. Openings in the facade are permitted but must be made in at least two opposing sides of the building in order to use the openings of the empty side of the building in case of a wind flow on the side of the building. The required installation in the building and interfaces to other subsections make the implementation of this solution difficult. In addition, flexibility with respect to the expansion of the utilisation unit is highly limited.

A more simple solution is to use a vertical exhaust air shaft in the core area of the building. The shaft must be designed to have the quality of a smoke extraction channel in accordance with DIN EN 12101-7. Smoke extraction dampers are required for each floor in order to comply with building fire protection regulations. The smoke extraction dampers must be in line with DIN EN 12101-8. Depending on the number of floors, the use of an exhaust air unit may be appropriate.

What is an exhaust air unit?

An exhaust air unit consists of a smoke extraction fan and two pressure-controlling dampers. The unit is connected to the safety exhaust air shaft.

The exhaust air shaft along with the corridor in the fire level can be considered as its own "pressure area". It has a permanently running alarm-controlled exhaust air fan. This fan is intended to suck in the required air volume from the fire level when the door to the staircase is opened. If the door to the staircase is closed, the fan must remove the air from the atmosphere via a bypass valve. In order to execute this air channel switch quickly and securely, differential pressure dampers with sensitive adjustment are required. We refer to this functional unit composed of the fan and differential pressure dampers as an exhaust air unit.

Exhaust air shaft must be sealed with low leak

As a rule, vertical shafts must be employed for the safety exhaust in a building. The leak-tightness of such shafts must be ensured as based on the prevalent standard (DIN EN 12101-7).

Redundancy

With respect to differential pressure systems, the question of redundancy is not clearly regulated. The following information can be found in current regulations (as of 07/2012):

MHHR 2008, item 6.2.1:

"If only one indoor safety staircase is available, operational replacement devices must take over should the devices required for maintaining overpressure fail."

Explanation of MHHR 2008, item 6.2.1:

"The redundancy requirement concerns those components which are important for the effectiveness of the system, especially the fans and the control devices."

DIN EN 12101-6 only explicitly requires a replacement for the fans used to maintain the required pressure. Fans in exhaust air channels which ensure the air flow through doors are not designed to be redundant. The MHHR requirement with respect to the redundancy of control devices is basically to be affirmed, although there is no definition as to which part of the control system should be designed to be redundant.

The Strulik company has the following policy with respect to control systems:

- The programmable logic controller (PLC) mainly has a monitoring function in normal operation without alarm. Errors and faults in the system are detected and reported.
- After alarming, the PLC requires approx. 30 seconds to change the connected devices to alarm condition. When this time has expired, the PLC no longer has any safety-related tasks.

- If redundant fans have been provided, the functional monitoring and if applicable the switchover to the replacement device occur independently of the PLC. There is one contactor per fan. If there is a fault with the contactor, the system switches over to the second fan.

- No electric or electronic functions are employed to control the overpressure in the pressure area. The pressure-controlling damper functions without an external power supply.

As the pressure-relief unit functions passively, no redundancy is provided for in this case. On request, however, replacement devices may be used here too.

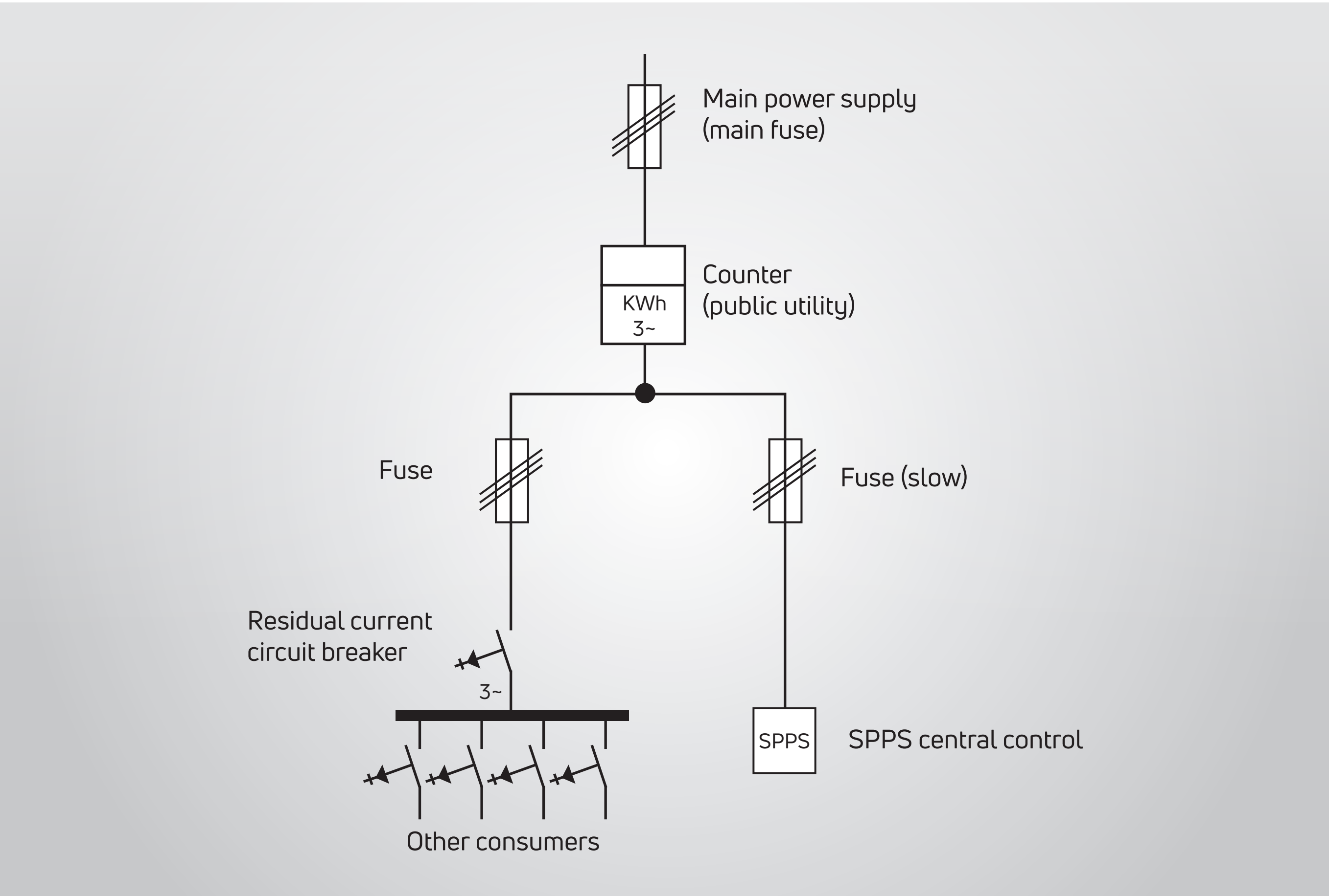
Voltage supply

The voltage supply of each safety system must be ensured for a sufficient amount of time (see DIN EN 12101-10). In a high-rise building, the use of a motor-driven emergency power system (EPS) is obligatory. In the case of smaller buildings which do not necessarily have to have an EPS, it must be ensured that the voltage supply remains functional when the fire brigade shuts down the house power grid. This function can be provided by employing a sprinkler pump switch system.
In this case, a separate connection line is set up for the safety systems at the entrance to the building after the electric meter. This outgoing line is independent of the main switch of the building.

Permanent monitoring of the system state

During normal operation, the DPS is a dormant system. Technological faults which may be caused by external factors must immediately be detected, reported, and then eliminated.

This requires a permanent, comprehensive monitoring of the system state. In accordance with the state-of-the-art, all signal lines for activation, lines to actuators and the switching position of the repair switch for cable break and short circuit must be monitored. Signal lines to the DDC/BMS must be monitored by the connected systems.



Sprinkler pump changeover

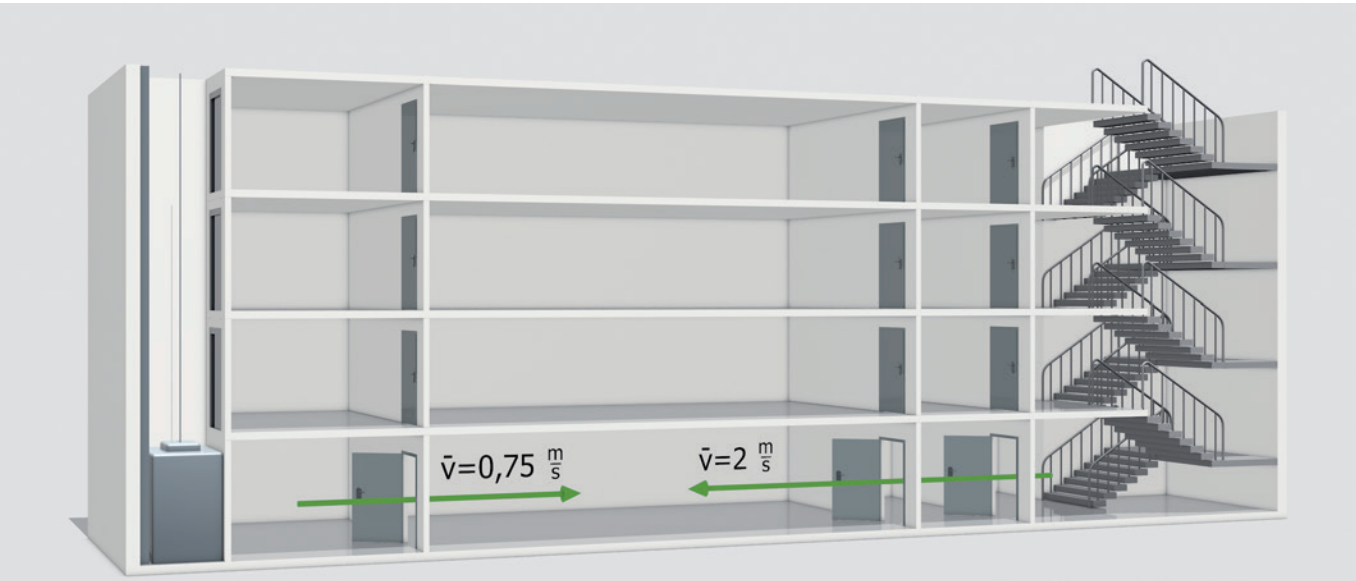
2.2 Protection goals/Application

The protection goal of smoke control by means of the target use of fresh air can be applied in different protection areas. The technology is conventionally used in the staircase of a high-rise building or in the shaft of a firefighting lift. The same system technology is used in horizontal escape routes and escape tunnels. Large showrooms and event buildings are examples of this.

Special protection areas can also be set up for persons who cannot leave the building and which are protected against smoke. These areas can be provided for persons who cannot escape by themselves. In addition, protection areas may provide assistance if the number of escaping persons is too large for the available escape routes. This concept is in place in the world's highest buildings.

Example of a server room

Not only can persons be protected in pressure-ventilated rooms, but also property, e.g. in server and storage rooms.



As opposed to natural or mechanical air holes which discharge the smoke from the room in consideration, the goal of differential pressure systems is to prevent the entry of smoke and thus to keep the escape or rescue route smoke-free. For this purpose, a controlled overpressure is created in the room to be protected. When access doors are closed, this safely prevents the entry of smoke via the door gap.

Immediately the door of the fire level is opened, a pressure equalisation between the protected room and the lobby is achieved in a very short time. In order to continue to prevent the entry of smoke while the door is open, an air flow through this door must be secured in the direction of the fire area. The minimum velocity for this flow depends on the temperature difference and thereby on the question of whether occupied space is connected directly to the staircase or whether intermediate rooms such as airlocks or corridors are present. The measurement velocities range according to DIN EN 12101-6 from 0.75 m/s to 2 m/s. A flow through the door is only possible if a downstream flow to the outside atmosphere which is independent of climatic conditions can occur from the bordering occupied space.

2.3 Our services

The following requirements are placed on system suppliers of differential pressure systems, the quality of the products and the execution of qualified installation and commissioning work:

2.3.1 Services

Measurement

Complete measurement of the system accounting for:

- Definition of protection goal
- Geometries of staircase, corridor, lift shaft
- Door dimensions and door closers
- Shaft cross-sections, etc.

Metrological inspection of the plant

In the scope of commissioning, a complete ventilation measurement is made, consisting of:

- Measurement of the door-opening forces with the DPS deactivated, if necessary there must be adjustment of door closer in conjunction with door manufacturer
- Measurement of door-opening forces with the DPS activated
- Measurement of air velocity through the door
- Measurement of the differential pressure between the pressure area and the occupied area/necessary corridor

Documentation

Project-specific documentation, consisting of:

- Functional description
- Maintenance contract
- Circuit diagram, EKS control system
- Data sheets of components
- Control diagram
- Commissioning reports, electrical
- Commissioning reports, ventilation
- Declaration of conformity
- Building inspection approvals

2.3.2 Warranty

Warranty for the DPS system

The manufacturer provides a system warranty for the reliable operation of the completely installed components and the operation of the entire differential pressure system.

2.3.3 Controlling system

Control velocity achieved in 3 seconds according to the standard requirements

This requirement describes the maximum time allowed to reach 90% of the necessary flow velocity (0.75 to 2 m/s) through the door from the staircase to the fire level after the doors is opened.

This time contains:

- The transmission of the signal "door opens" from the door to the controlling damper
- The closing time of the controlling damper
- The deceleration of the moving air mass in the staircase

Controlling system – high mechanical load capacity

The controlling damper consists entirely of stainless steel and aluminium. All pivot points have ball-bearing supports. The control system functions purely mechanically and is position-independent thanks to weight compensation. The available air pressure opens the controlling damper. The installed spring-lever system closes the controlling damper without auxiliary power. The controlling damper has been inspected for mechanical strength and tested with 10,000 loaded cycles.

Limitation of door-opening force to 100 N

The control system must be capable of opening the full outflow area immediately (< 3 seconds) and at any time.

Pressure-relief damper - climate-independent

The pressure-relief unit must function reliably independently of outside climate conditions. Snow and ice may not impede the opening of the damper. Wind from any direction may not influence the controlling function. The pressure-relief unit is protected from climactic influences by the use of a slatted hood or front baffle plate. An insulating damper protects it from cold draughts and condensation when idle.

Controlling damper factory setting

Each pressure-controlling damper is set at the factory to the projected response pressure. This presetting can be changed during commissioning.

Optional ventilation function

The pressure-relief unit may also be electrically opened for daily ventilation. There is no operation during alarm mode.

2.3.4 Control unit

Monitoring

There is monitoring of all cable connections for cable break and cable short circuit to detectors, control devices, utilities, alarm installations and actuators. Monitoring is continuous, even when the system is on stand-by.

Fault-tolerant control

After the FACP triggers the control unit, all functions of the triggered scenario are blocked. Even the failure of the control voltage does not interrupt the operation of the DPS.

Modular structure

The required functions of the control unit are subdivided among different modules. This increases the operational reliability of the overall system.

System status

The status of the DPS can be viewed directly on the control cabinet both in case of fire and in normal mode.

Cabling

Cable lists are prepared for on-site cabling. Cables laid on-site are inserted into the EKS, connected and tested in the scope of electrical commissioning.

2.3.5 Fan

Axial fan with characteristic curve stabiliser

The supply air fan is equipped with a characteristic curve stabiliser. The reliable operation of the fan is guaranteed over a broad application range without stall.

Design

Die-cast aluminium axial impeller with adjustable blades. Guide vanes for largely twist-free outflow.

2.3.6 Exhaust air unit

Exhaust air unit with suction-side control

The exhaust air unit contains a smoke-extraction fan with temperature class F300. The pressure is regulated as in the staircase with automatically controlling dampers on the suction side of the fan. Control properties as described above. The usable suction side negative pressure is 80 to 100 Pa.

2.3.7 RKI-V

Smoke-extraction damper – special model

Smoke-extraction damper for front-flush installation in shaft walls, maintenance access from front.

2.4 Calculation criteria

The calculation of differential pressure systems must have the objective of determining all the factors relevant for the reliable operation of the systems and to specify all operating parameters of the DPS.

2.4.1 Calculation methods

Manual calculation

We define "manual calculation" as comprising methods of calculation which can be executed manually on a piece of paper without commercial software. Generally, one relies on the assistance of a PC.
"Manual calculation" as we understand it covers both steady-state and transient flow and thermodynamic processes.

Different calculation methods are essentially possible:

- Estimation: rough calculation on the basis of experience
- Rough calculation: static calculations of all flow paths with precise figures on the basis of an air volume equilibration
- Precise calculation: The real structure is applied to a topological model. All flow paths are viewed mathematically in consideration of leaks. Taking account of the admissible overpressure (100 N at the door), the calculation is performed iteratively until the overpressures are maintained as a result of the selected volume flows. The results are checked by means of a mass balance of the incoming and outgoing mass flows. The calculation is capable of mapping isothermal or anisothermal and steady-state or transient processes.

Even if executing a dynamic calculation which accounts for convection is generally very involved, it is nevertheless referred to as a manual calculation method.

Simulation calculation according to the node-mesh method

This type of calculation is a simplified simulation calculation of complete building structures along average flow paths (flow lines). The extent of input data and calculation steps considerably exceeds that of manual calculation. The individual rooms of the building are interconnected by flow paths. A resistance is assigned to each flow path. In the scope of an iteration, the variable input data are modified until all partial calculations result in a coherent result.

Only steady-state calculations are used. The calculation results can generally be checked manually. The generation of models is time-consuming, while the calculations can be made relatively quickly using suitable software.

The simulation of a fire and of convection in a staircase is not possible.

One well-known program used for this method is COMIS.

CFD simulation as a field model

Currently, the most precise form of simulation is referred to as "Computational Fluid Dynamics" (CFD).

In this method, all the rooms of a building are viewed to scale. The rooms are analysed into small solids. The sizes of the solids are set to be larger or smaller depending on the expected detailing. The number of solids defined in the model determines the required computation time. Connections between the individual rooms are integrated into the model using their real geometries.

In the scope of a simulation, the energy exchanges between the solids and the building surfaces as well as between the bodies themselves are determined.

The basic structure of this software allows the computational simulation of complex processes, such as that of a fire or of convection in staircases. The exchange of heat with the structure is also taken into account.

This type of simulation naturally requires more time for generating a model and for computation. The costs for this method are significantly higher than for other simulations.

It is not possible to verify the results of a CFD simulation by means of manual calculation. Nevertheless, the results of the simulation must be tested for plausibility. The manual calculation methods described above can be used to do this. Field simulations should be made using a computer to complement and verify the manual calculations. CFD simulations are capable of inspecting the projected DPS in a building in consideration of a simulated fire progression. They account for convection influences in the summer and winter. Transient influences can also be taken into account.

2.4.2 Calculation of differential pressure systems

The following items must be considered when calculating differential pressure systems:

- Maximum pressure difference at the storey door of the staircase
- Required volume flow for achieving the flow velocity
- Leak volume of the closed doors along the staircase
- Total supply air volume for fan design
- Supply air shaft, supply air openings
- Exhaust air channel (e.g. exhaust air shaft, smoke extraction dampers)
- Selection of controlling damper in pressure-relief unit
- Through-flow pressure loss of the staircase

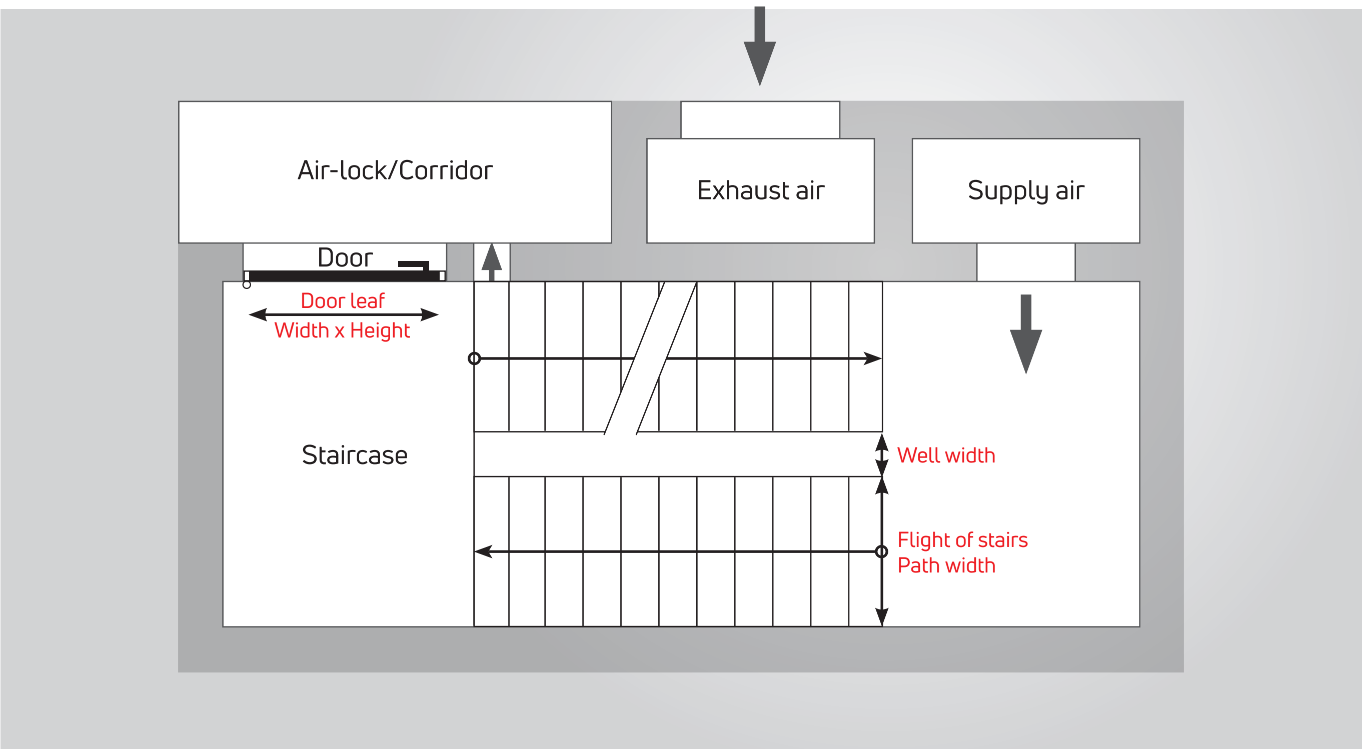
The following is an example calculation for a safety staircase based on the Model High-Rise Building Regulation 2008 (protection goal v = 2 m/s with maximum 100 N).

Technical data for the calculation:

- Door leaf, width x height: 1.2 m x 2.1 m
- Stairwell width: 0.25 m
- Width of flight of stairs: 1.30 m
- Staircase from ground floor to 14th floor: 15 levels
- Floor height: 3.30 m
- Quality of the storey doors: T30, RS
- Stair rail: filigree

The following information is also required:

- Exhaust air in the floor above the exhaust air shaft
- Pressure-equalisation openings from the staircase to the air-lock
- Outside air intake and fans in 1st basement floor
- Exit door on ground floor is closed



Maximum pressure difference at the storey door of the staircase

The calculation of the different forces which act upon the door leaf is brought together using a torque equilibration.

The force acting to close the door, which is determined by the size of the door leaf and the occurring pressure difference enter into the equilibration with the distance of half the door width.

The second closing force component is present as a specification of the opening torque of the door closer used. It is important to note here the difference between the closing torque and the opening moment of the door closer.

Depending on the door size and the application, the closing torque of the door closer is the expected usable value. The installed spring provides the force required for the closing process.

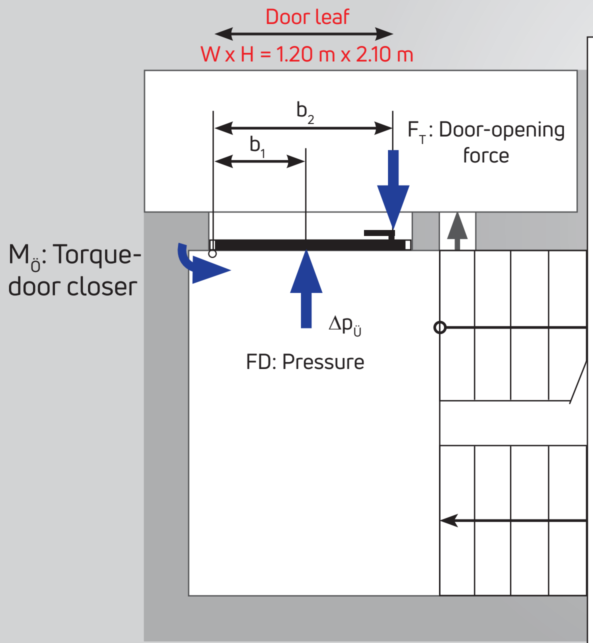
Mechanical friction losses cause a reduction of the usable closing torque when the door leaf moves. These losses are compensated by door-closer manufacturers by installing a stronger spring.

In stand-by mode with no movement of the door leaf, part of the friction is eliminated. However, the total amount of friction is increased by the amount of stiction.

It should be noted that the closing torque of the door closer is higher during the opening process than during the closing process.

The ratio of the two values is model-dependent. If no information is available about the door opener, we use the ratio: $\boldsymbol{M_{ö} = M_S \,/\, 0.7}$.

This assumption must be considered when selecting door closers.



Torque balance: $F_T = \dfrac{F_D \times b_1 + M_ö}{b_2}$

Admissible door-opening force = 100 N

$$\Delta p_{max} = \frac{100 \times b_2 - M_ö}{b_1 \times (H \times W)}$$

$M_S = M_ö \times 0.7$

$M_S = 37$ Nm (EN 1154)

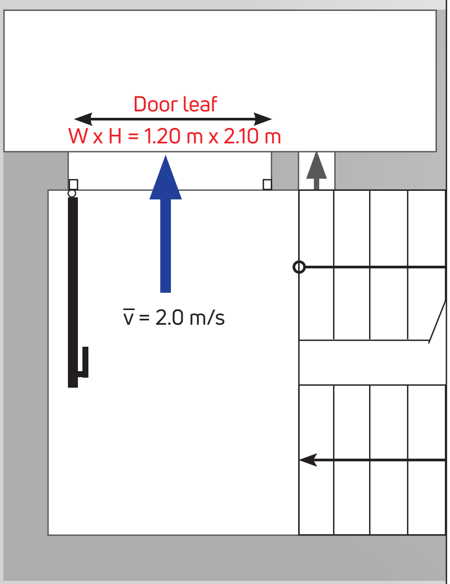
$M_ö = M_S \,/\, 0.7 = 53$

$$\Delta p_{max} = \frac{100 \times (1.20 - 0.065) - 53}{(1.20 \,/\, 2) \times (2.10 \times 1.20)}$$

$\boxed{\Delta p_{max} = 40 \text{ Pa}}$

Required volume for achieving the flow velocity

To calculate the air volume flow required for the door flow-through, it is correct to use the clear inside dimension of the frame. The dimensions of the door leaf are slightly larger. By using the dimensions of the door leaf, one obtains a small measure of certainty at this location.



Volume flow for door flow-through

$\dot{V} = B \times H \times \bar{v} \times 3{,}600$

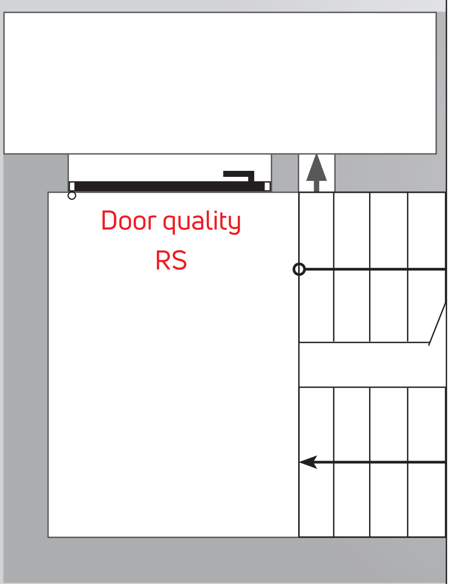
$\dot{V} = 1.20 \times 2.10 \times 2 \times 3{,}600$

$\dot{V} = 18{,}144\ m^3/h$

$\boxed{\dot{V}_{selected} = 18{,}200\ m^3/h}$

Leak volume flow of closed doors at staircase

In this context, one must introduce the distinction between different calculation methods. Values based on experience or permissible boundary values of certain products (e.g. leaks of one-leaf smoke protection doors: 20 m^3/h) can be used to make rough calculations.



Leak volume flow for all storeys

Storey doors RS, 20 m^3/h each:
$15 \times 20 = 300\ m^3/h$

Exit door, ground floor, cloased:
assumption: $V = 800\ m^3/h$

Pressure equal. opening: staircase → air-lock → corridor Assumption:
$V = 15 \times 200\ m^3/h$

$\boxed{\dot{V}_{Leak} = 4{,}100\ m^3/h}$

Figures adjusted for differential pressure (R-values [kg/m7]) must be used for a precise calculation based on DIN EN 12101-6. These values can be interconnected in parallel or in series like ohmic resistance in electrical engineering. R-values can be used to calculate complex and multiply intermeshed flow paths in a clear way.

The following table shows examples for certain doors.

	Door height	Door width	Frame circumf.		Floor connection		Leak surface	R-value Zeta =	R-value Zeta =
			3-sided	gap width	1-sided	undercut			
	[m]	[m]	[m]	[mm]	[m]	[mm]	[m²]	1.8	2.3
Door, single-leaf	2.0 2.2	1.0 1.2	5.0 5.6	5 5	1.0 1.2	10 15	0.03500 0.04600	882 510	1127 652
T30-door	2.0 2.2	1.0 1.2	5.0 5.6	1 1	1.0 1.2	10 10	0.01500 0.01760	4,800 3,487	6,133 4,455
Door, double-leaf	2.0 2.2	2.0 2.5	8.0 9.1	5 5	2.0 2.5	10 15	0.06000 0.08300	300 157	383 200
T30, double-leaf	2.0 2.2	2.0 2.5	8.0 9.1	1 1	2.0 2.5	10 10	0.02800 0.03410	1378 929	1760 1187

	Door height	Door width	No. of joints, vertical	Length	Gap width	Leak surface	R-value Zeta =	R-value Zeta =
Lift	[m]	[m]	[–]	[m]	[mm]	[m²]	1.8	2.3
Sliding door	2.0	1.0	5	12	5	0.06000	300	383
Revolving door	2.0	1.0	2	6	2	0.01200	7,500	9,583

A simple meshed system may look as follows. The volume flow can be determined at each point of the system by entering a pressure difference. The pressure difference can be calculated by specifying a volume flow.

Leak paths running in series or in parallel are defined as follows according to Kirchhoff's laws:

Principles

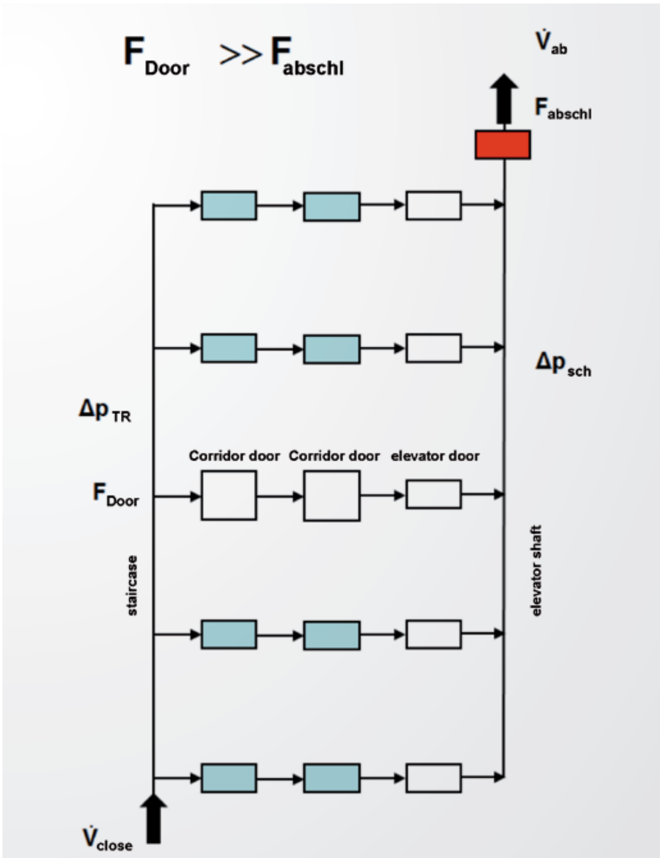
$$\Delta p_{t,i} = R_i \times \dot{V}_i^2$$

In which R is defined:

$$R_i = \zeta_i \times \frac{\rho}{2} \times \frac{1}{F_i^2}$$

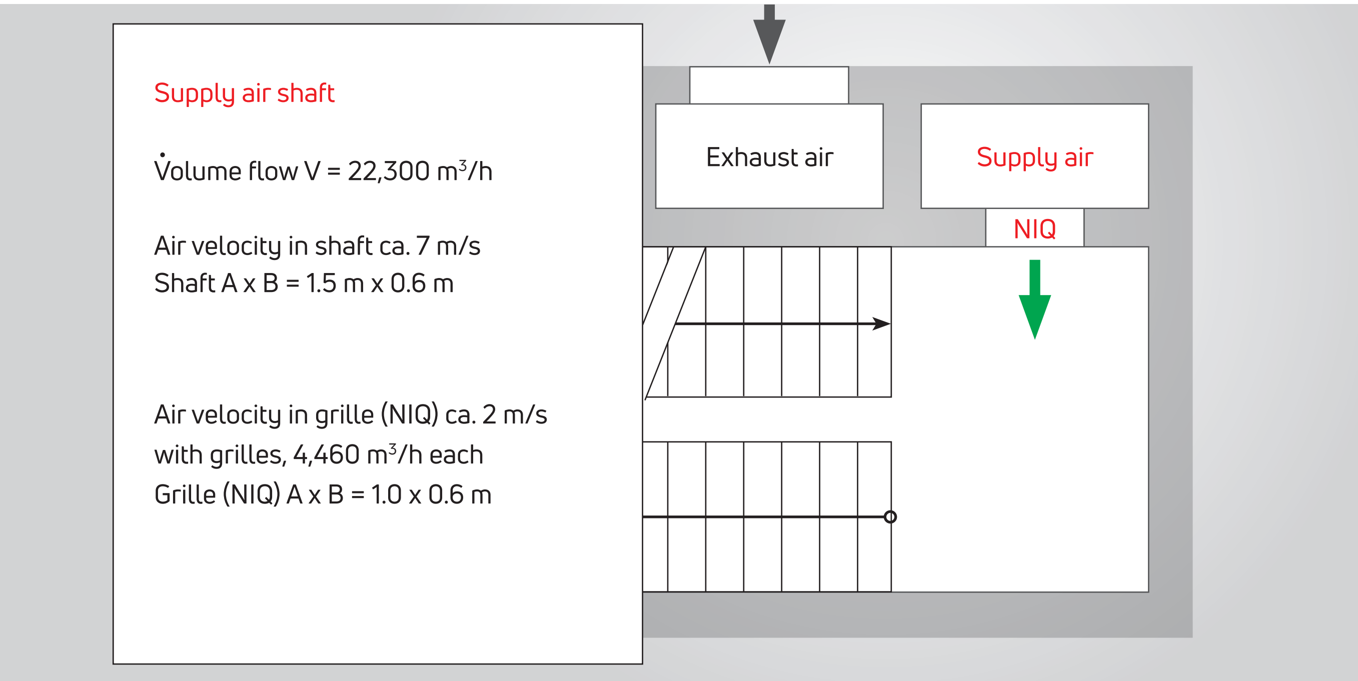
Total supply air amount for fan design

$$\dot{V}_{total} = \dot{V}_{door} + \dot{V}_{leak}$$



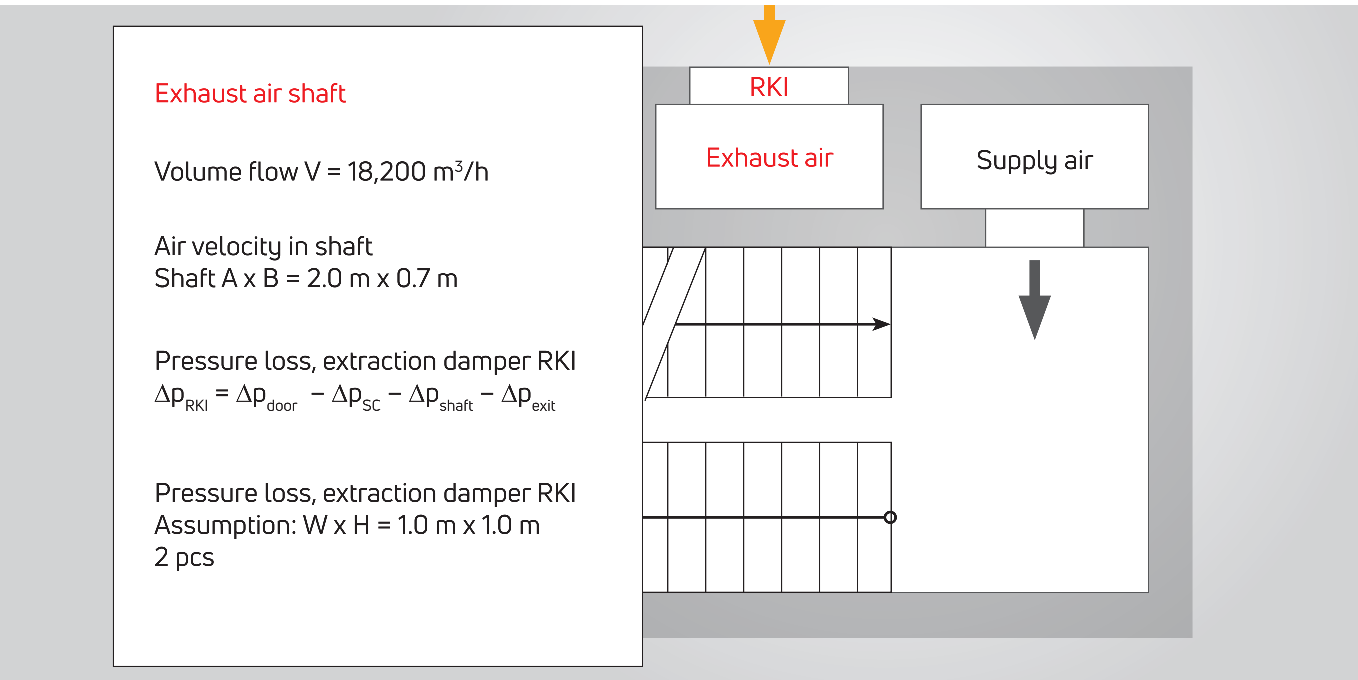
Supply air shaft, supply air openings

The dimensions of the supply air shaft and the supply air grille can be calculated using conventional methods of ventilation engineering. When determining the grille sizes, however, a low flow rate must be taken as a basis. We recommend a maximum of 2 m/s relative to the gross area of the grille. Simulation results for a high-rise building have shown that significantly higher flow velocities cause a significant increase in the flow-through pressure loss of the staircase.

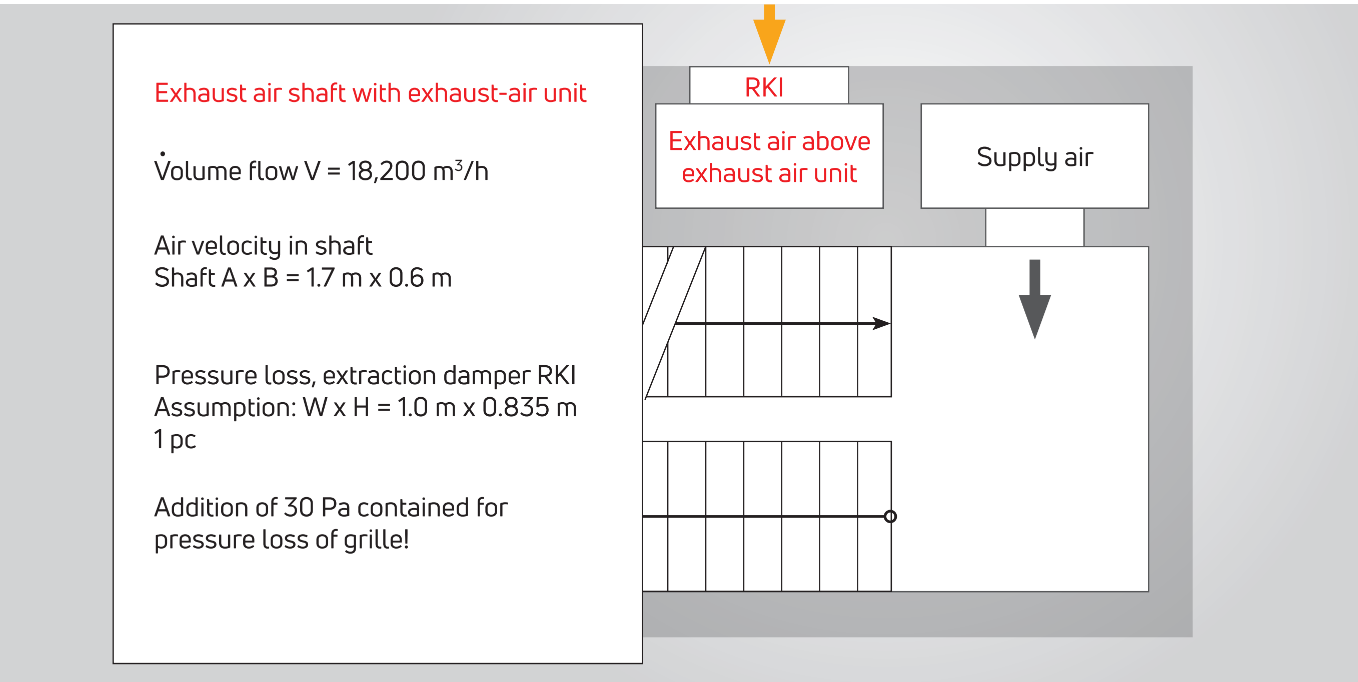


Exhaust air shaft, smoke extraction dampers

The exhaust air shaft should be dimensioned for a maximum flow velocity of 5 m/s. The pressure loss of the entire exhaust air path must be held low. Only the admissible overpressure at the doors (100 N) is available to transport air through the staircase via air-lock and corridor through the extraction damper into the exhaust air shaft and then via the roof into the atmosphere. In this example: a maximum of 40 Pa. Many calculation steps must be iterated to ensure an optimal system design.



When using an exhaust air unit at the exhaust air shaft, the pressure loss of the exhaust air path may be increased. In this example, the number of smoke extraction dampers and the shaft surface area can be reduced.



Selection of controlling damper in the pressure-relief unit

A pre-selection of the pressure-relief unit is made by considering the volume flow for the flow velocity in the door. It is recommendable to apply a pressure-relief damper for the first calculation run which is specified for the next-higher volume flow at 50 Pa pressure loss. Example: The pressure-relief damper model RK2 840 mm x 826 mm has a flow-through pressure loss of 50 Pa at a nominal air volume of 15,000 m^3/h. At maximum 40 Pa differential pressure at the door, the flow-through pressure loss must be lower. In the calculation example, the pressure-relieve damper has the dimensions 960 mm x 964 mm.

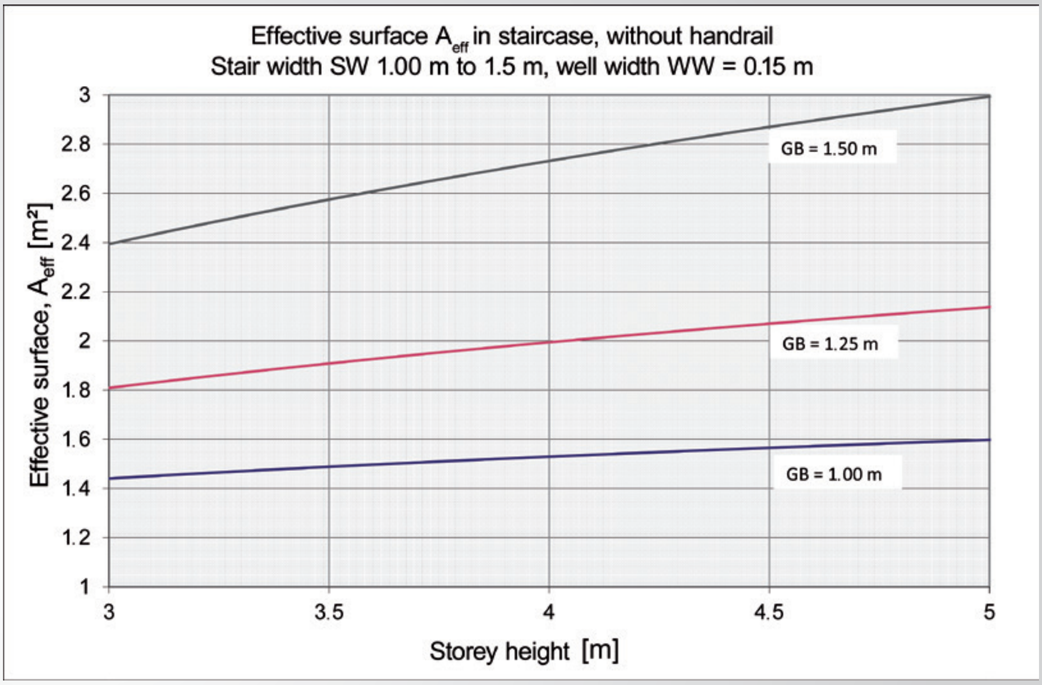
Through-flow pressure loss of the staircase

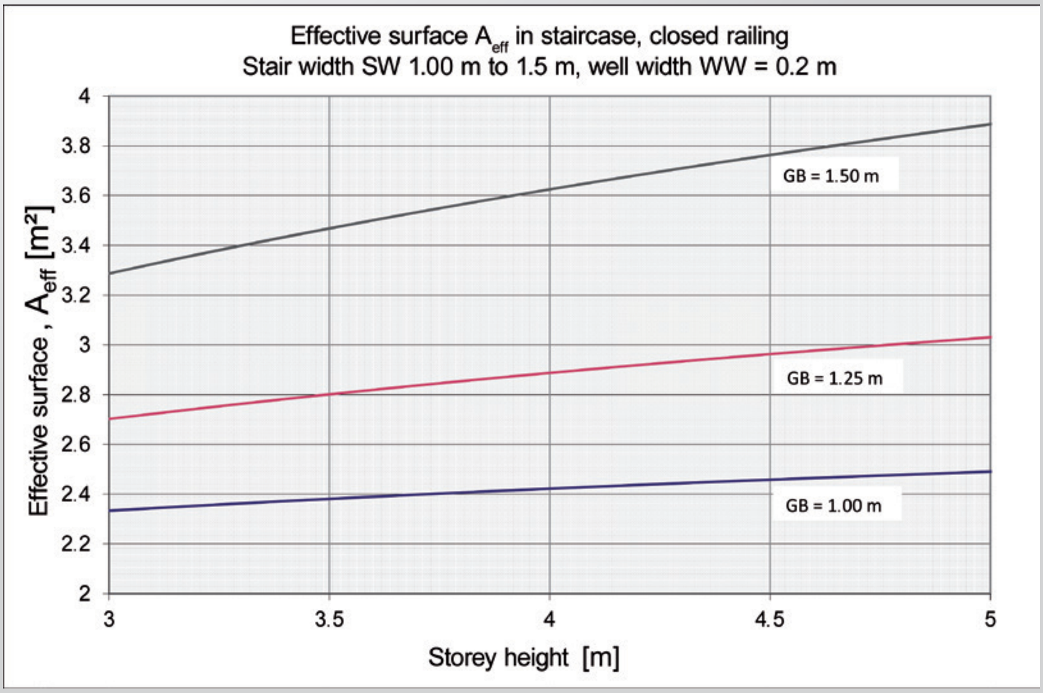
To calculate the DPS reliably, the flow-through pressure loss of the staircase must be known. As the measurement of pressure loss in a finished building will only rarely act as the basis of the calculation, the flow-through pressure loss must be calculable.

Studies from the Technische Universität in Munich from December 2002 act as a basis for this calculation. A report on the research project "Keeping free of smoke / smoke extraction of rooms and buildings - basis elaboration for the creation of building authorities' regulations - Vol. B" presents the results of measurements made on model staircases.

These results form the basis of formulae for calculating the pressure loss in staircases.

The calculation results based on this formula have been confirmed by simulations and proved in practice.


Effective surface A_{eff} in staircase, without handrail
Stair width SW 1.00 m to 1.5 m, well width WW = 0.15 m
Effective surface, A_{eff} [m²]
Storey height [m]
GB = 1.50 m
GB = 1.25 m
GB = 1.00 m
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
3
3.5
4
4.5
5


Effective surface A_{eff} in staircase, closed railing
Stair width SW 1.00 m to 1.5 m, well width WW = 0.2 m
Effective surface , A_{eff} [m²]
Storey height [m]
GB = 1.50 m
GB = 1.25 m
GB = 1.00 m
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
3
3.5
4
4.5
5

Result of isothermal calculation

You have been presented above with information about the calculation of differential pressure systems.

Two areas which should be noted in this respect are the flow-through pressure loss of the staircase and the pressure loss of the exhaust air path.

The bases for calculating the staircase flow-through must be further developed in future. The planning of a staircase offers too many possibilities which have not yet been realised by calculations. The calculation methods shown here are in part chosen conservatively.

The determination of the pressure losses of the exhaust air path is a simple engineering task. However, it requires meticulous work. Many situations cannot be mapped using the familiar resistance coefficients. The low available overpressure of the staircase can be viewed as an additional challenge. If the pressure loss calculation for a "normal" ventilation system exhibits an error of 30 Pa, this deviation will not presumably exert negative effects on the overall function. For a DPS, however, an error of this magnitude is highly dramatic. The protection goal of the DPS will not be achieved.

When considering pressure losses, the focus should primarily lie on each change to the flow cross-section, i.e. on each change in velocity. Changes in direction must be accounted for as a second factor.

In both cases, the flow velocity of the air is crucial, as its value is squarely introduced into the calculation.

It is essential to note the following with respect to pressure control in the pressure area:

Only one control system acts on a single pressure area.

The following will offer an account of the influence of convection. The calculation criteria for this have been developed from physical dependencies. [Albers, K.-J.; Rahn, B.: Stream Relations in a Safety Staircase – Influence of Thermic, TAB 34 (2003)]

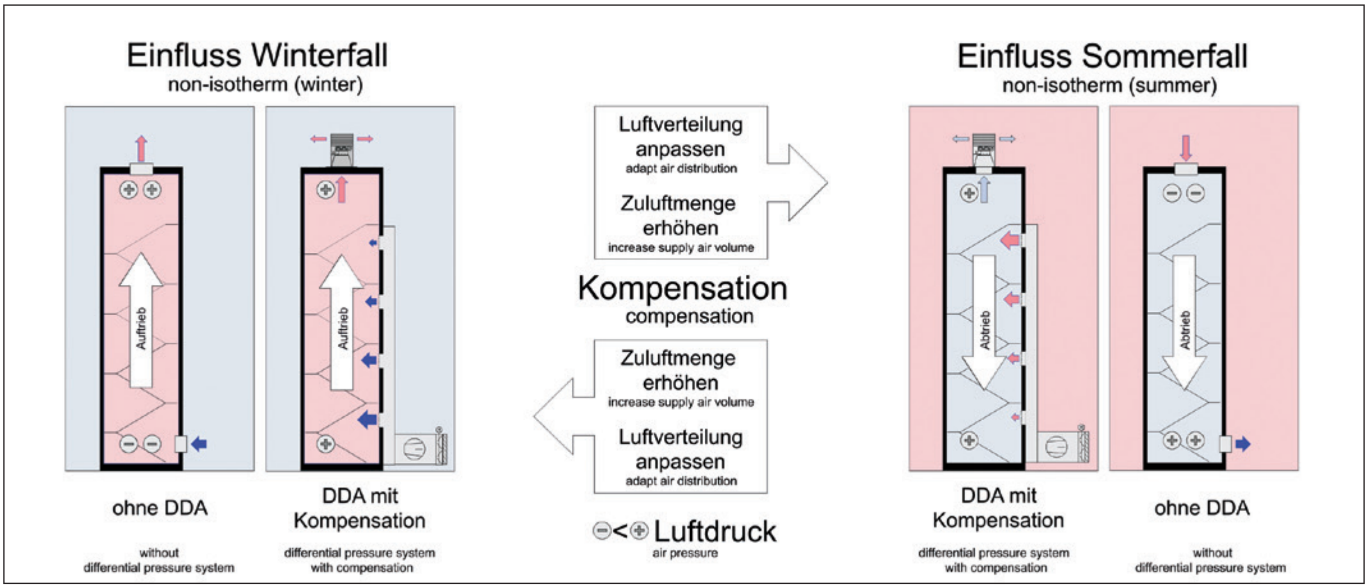
The metrological examination of designed systems and their comparison with the calculation results have up to now confirmed the calculation methods that have been worked out.

Despite all calculations, we recommend having the results of a system measurement verified by a CFD simulation prior to implementation. The simulation should represent the influence of climate (e.g. winter) and the transient consideration of the fire progression.

The adherence to the protective function of the DPS must be recognisable in the evaluation.

If the measurement has been conducted successfully, a system can be set up which can ensure a safe escape route for a certain time. After this time has expired, relief units must contribute to the further protection of the escape routes by means of effective firefighting measures.

2.5 Influence of summer/winter - Convection



Convection – Summer and winter in high-rise buildings

What is convection – lift (also negative) – thermal – stack effect?

Convection is an entirely normal everyday phenomenon. Gliders exploit thermal lift in order to fly without an engine.

The exhaust gases of a domestic boiler are drawn through the fireplace to the roof. The lift achieved here is even enough to provide the boiler with combustion air. The chimney at the open fireplace is only able to "suck" the smoke gas out of the fireplace by means of convection.

In high-rise buildings, the influence of convection is particularly evident in the winter. It pulls, for example, at the entrance door. The vertical shafts of the building, such as lift shafts and staircases, allow warm, lighter air in the building to ascend. While closed doors reduce this tendency, they cannot prevent it. The upward movement of the air is possible because the usual leakage in the building via non-airtight windows and doors, the smoke extraction of the lift shafts and the ventilation of the lift machine rooms allow the warm air of the room to contact with the cold outside air.

The warm ascending air creates an overpressure in the upper floors, leaving the building through the leaks. A negative pressure is generated in the lower part of the building which allows the continuation of air flow from the outside into the building.

This process is referred to as convection.

The engine of convection is the temperature difference or the density difference between the inside and outside air.

In the winter, the air in the building is warmer and lighter than outside. In the summer, it is colder in the building than outside, and all the processes are reversed. As the influence of convection increases with an increasing temperature difference, its effects are much greater in the winter than in the summer.

The magnitude of the pressure difference which can be created by the convection on the surface of the building or the boundary to the staircase depends on the conveyed air volume flow and the resistance of the leak areas.

Calculable convection

The technically and mathematically simplest case of convection is lift in a chimney. When allowing the assumption that the rising gases in the chimney do not change in temperature, the pressure difference created by the lift can be calculated using the chimney equation $\Delta p = \Delta \rho \times g \times h$. This simple formula is not the basis for calculating convection in a staircase.

Applicable values can only be achieved if the mass flow is considered and the pressure losses upon entering and exiting the staircase and with vertical flow are calculated. The calculation is based on the assumption of a constant heat output distribution over the height of the staircase. A dynamic calculation must also account for the change of the air temperature in the staircase. The cold inflowing air is heated at warm surfaces in the staircase. This addition of heat causes a prolonged convection.

It cannot be expected that the convection is not longer active a number of minutes after the differential pressure system is started. The stored heat in the concrete walls represents an enormous heating effect, continuing to heat the cold external air for hours.

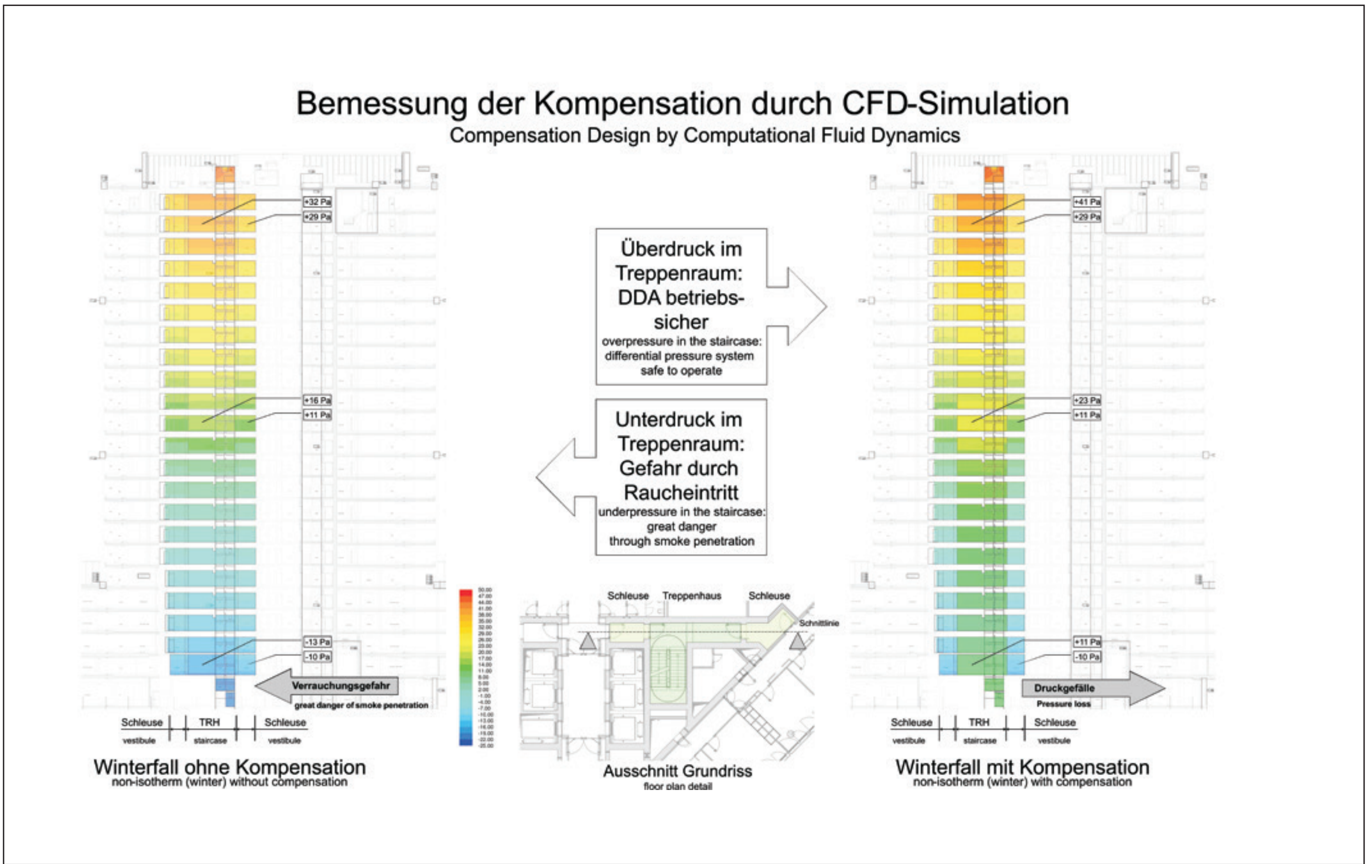
Measures for compensating the influence of convection in staircases

Convection in a staircase can be seen as a fan. One could imagine the staircase of the lower floors as the "suction chamber" and the uppermost floor as the "expulsion chamber". The "convection fan" sucks in air in the "suction chamber" and conducts this air upwards through the staircase to the "expulsion chamber". The conveyed air volume must flow through an opening in the outer wall to the "suction chamber" and requires a negative pressure in the "suction chamber" to do this. To compensate this harmful negative pressure, more air must be blown into the "suction chamber" than the "convection fan" can transport upwards. This is achieved by means of the real supply-air fan of the differential pressure system. An overpressure is created in the "suction chamber" by means of this excess air.

So much for the "simple" basics.

The problem now is that all the relevant boundary conditions must also be considered and the interactions in the system must be determined mathematically. The goal of the calculations is to obtain a pressure ventilation system which functions reliably at all outer temperatures that can be considered. The technical possibilities for realising this objective are very limited.

In order to achieve the main winter goal of increasing the flow-through pressure loss in the staircase, a larger air volume flow must flow from the bottom to the top through the staircase in comparison to an isothermal design. Depending on the design, this can be achieved by means of a modified distribution of supply air in the staircase and/or by increasing the supply-air output of the fan.



Assuming correct measurement, a positive pressure difference is reached in every floor at a suitable height between the staircase and the units.

With an increased convection, e.g. with buildings over 100 m, further measure may be required.

Although special measures for buildings below the high-rise limit are rarely required, this must be verified by the results of the measurement.

Measures for compensating the influence of convection in lift shafts

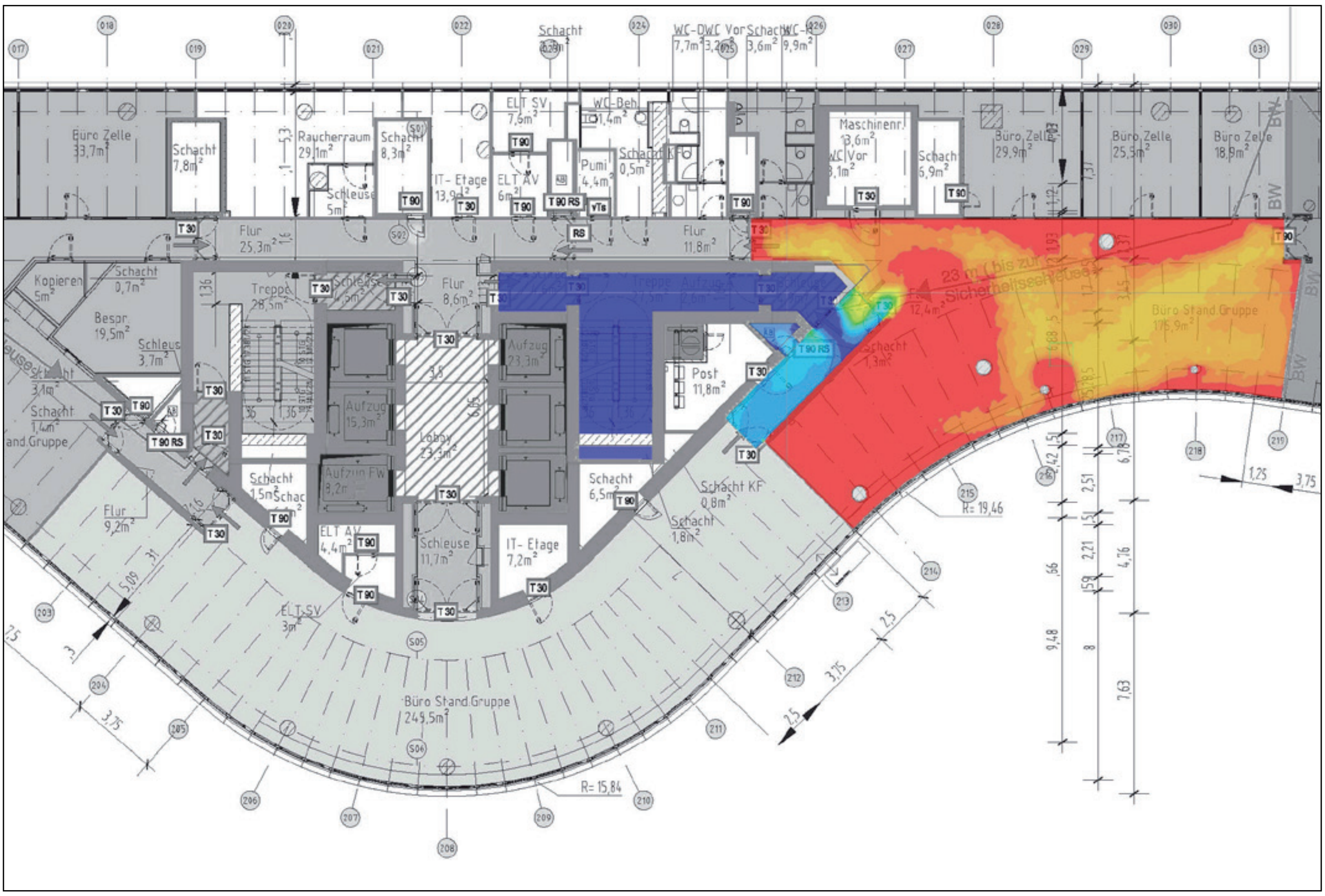
The basic features of convection in lift shafts correspond to the descriptions for staircases.

The essential important difference, however, is the considerably lower flow-through pressure loss of the vertical shaft. The compensation measures applied to a staircase cannot be applied in a lift shaft.

In the case of a lift shaft, the overpressure in the shaft must be increased by means of a targeted increase in the pressure loss at the pressure-relief opening on the roof. The increase in pressure is intended to achieve a sufficiently high pressure drop in the fire level from the lift shaft via the lobby to the required corridor. The height of the pressure to be achieved is based on the pressure loss of the exhaust-air path and the supply-air damper from the shaft to the lobby.

This method <u>cannot</u> adjust the pressure difference on all floors. The setting can only be adjusted for the fire level. The result is an increased pressure difference in the floors above the fire level. However, this limitation can be tolerated to some extent, as the firefighting lift can be used for more than escape purposes in the event of a fire.

An increase in the volume flow as an equivalent measure is theoretically possible.



CFD simulation – Smoke propagaion

2.6 Responsibility and liability

Functional test and maintenance

The maintenance of the system must be executed in regular intervals following initial commissioning. The required tasks comprise a simple quarterly functional test and the comprehensive annual system inspection.

The proper execution and documentation of all tests is a condition for receiving the system warranty.

The annual inspection must be executed by specially trained personnel from Stulik GmbH.

The quarterly functional test may be executed by qualified personnel of the operator or the installer. The qualified personnel must have received instruction in the system and its functions from an employee of Strulik GmbH. This instruction must be verified in an instruction log.

Warranty

The warranty for the overall function of the system is only granted if all maintenance specifications are complied with after commissioning has been performed by Strulik GmbH. The maintenance tasks must be executed as a condition for the granting of a warranty for the overall function of the plant on the part of Strulik GmbH.

Characteristics of a Strulik differential pressure system:

General:

- 30-year system warranty in compliance with maintenance conditions
- DPS guaranteed to pass acceptance tests
- No planning risk for clients
- Complete measurement/calculation from one source
- 100% conformity with regulations
- DPS designed according to the current state of the art
- German brand products used
- Supplied as a complete system solution with system warranty

Technological:

- Control time for pressure control ≤ 3 seconds acc. to DIN EN 12101-6
- Cable monitoring acc. to pr EN 12101-9
- Complete EKS control system
- Supply-air fan with characteristic curve stabiliser
- Exhaust-air unit with suction-side control, up to 80 Pa neg. pressure, suction-side
- Smoke protection pressure device DV-RK1 with 100% backflow air volume
- Complete project-specific software tested three times

3 Standards and directives

3.1 Building law/Conditions

Planning control law of German states

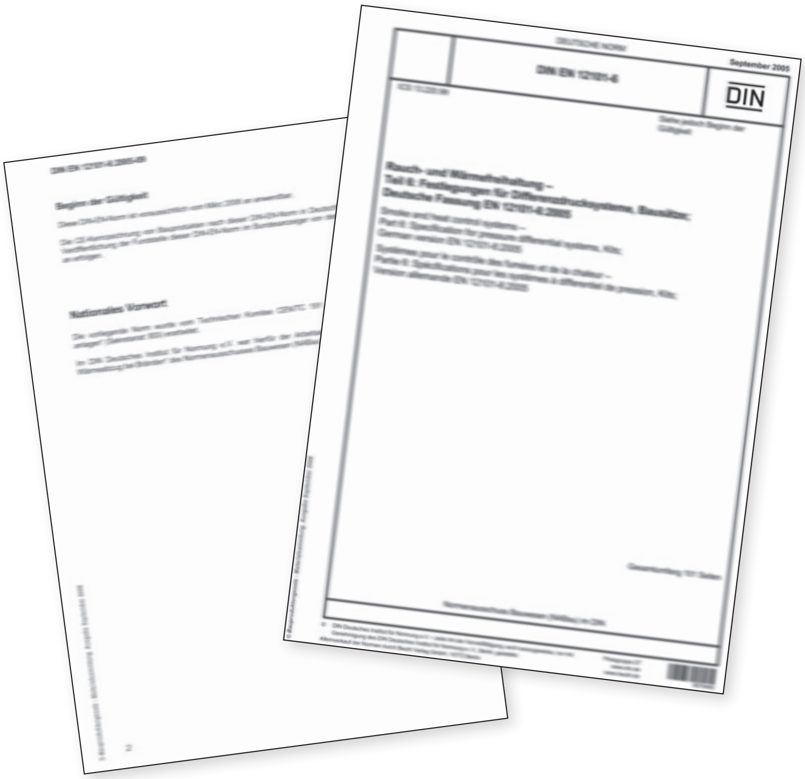
Planning control law is in the jurisdiction of the German federal states. This means that the individual states are responsible for issuing building codes. Corresponding to the organisation of the Federal Republic of Germany, there are 16 building codes in 16 federal states, in part with varying contents. They only have legal force in the respective federal state.

Building law is federal state law

In addition, expanded requirements may be placed on differential pressure systems due to the special type and use of structural systems. Also, the building control authority can in special cases require the use and operation of additional fire-protection installations and alarm systems.

Orders for issuing building permits are sent to the responsible building authorities along with the respective building plans, the associated structural data and an exact operational description on which the later utilisation, number of occupants or employees etc. are based.

The standards, regulation and directives listed here must be complied with when planning and setting up differential pressure systems and for creating a fire-protection concept. In addition to the requirements from building control authorities, the recognised engineering rules for planning, setting up and operating these systems as well as local conditions must be adhered to.



Reference sources for standards

The following will list some of the applicable standards, directives and regulations. These must be complied with in their currently valid form when planning, installing and operating a differential pressure system.

DIN standards, DIN-EN standards without VDE

Beuth Verlag GmbH
Burggrafenstraße 6
10787 Berlin · www.beuth.de

VDE standards, DIN-VDE standards

VDE-Verlag · Bismarckstraße 33
10625 Berlin · www.vde.de
www.vde-verlag.de

3.2 Documentation

All executed maintenance work, check measurements and visual inspections must be documented and stored in a log.

For this, a logbook is kept in practice.

A logbook serves to document both the condition of the system and all the events occurring over the entire period of its operation.

The operator and/or installer of the system must enter all the events in this logbook which are conspicuous in the scope of everyday operation and which may impair the proper function of the system.

This also applies to all activations/deactivations and work executed during servicing, such as the elimination of faults, check measurements and other actions which serve to ensure functional reliability.

The logbook must be stored in the immediate proximity of the system and must be freely accessible to all persons concerned. A logbook is kept over the entire duration of the functional readiness of a system, after which it is stored for an additional five years.

4 The system and its components

4.1 Fans

The supply air fan ensures a sufficient amount of supply air for the staircase or escape area to be protected. The required amount of air depends on the protection goal of the system and the leaks determined. The intake of smoke-free, clean air must be guaranteed.
Each intake of air is assigned to a multileaf damper with spring return motor. In case of redundant fans, additional airtight dampers must be present on each fan.

A repair switch with auxiliary contacts for monitoring must be mounted on each fan.

Supply air fan with housing for indoor installation

Type	DV1
Installation sizes	400 to 800
Power range	0,75 to 15 kW
Accessories, standard	Repair switch, 1 x mesh guard, rubber vibration damper
Accessories, optional	Flexible connectors, internal suspension, multileaf damper
Short text	Axial fan with characteristic curve stabiliser, in housing, impeller with adjustable blade and adjustable guide wheel
Colour	RAL 9006 or as requested

Supply air fan without housing for utility rooms

Type	DV2
Installation sizes	400 to 1,120
Power range	0,75 to 45 kW
Accessories, standard	Repair switch, air-intake nozzle, extension shaft, shaft feet
Accessories, optional	Flexible connectors, counterflanges, mesh guard, diffuser, spring vibration damper, vertical brackets
Short text	Axial fan with characteristic curve stabiliser, impeller with adjustable blade and adjustable guide wheel
Colour	RAL 7030

Supply air fan with sandwich housing for outdoor installation

Type	DV1-WSG
Installation sizes	400 to 1,120
Power range	0,75 to 45 kW
Accessories, standard	Repair switch, 1 x insulating connector, roof frame
Accessories, optional	Insulating damper, air-intake hood, 2 x insulating connectors
Short text	Axial fan with characteristic curve stabiliser, in housing made from sandwich panels, impeller with adjustable blade and adjustable guide wheel
Colour	RAL 9002 or as requested

Supply air fan with integrated pressure-relief unit for indoor installation

Type	DV-RK1
Installation sizes	450 to 800
Power range	0,75 to 11 kW, 5,000–35,000 m^3/h
Accessories, standard	Repair switch, 1 x mesh guard, rubber vibration damper
Accessories, optional	Flexible connectors, internal suspension, multileaf damper
Short text	Supply-air device with automatic pressure-discharge damper in housing, axial fan with characteristic curve stabiliser, impeller with adjustable blade and adjustable guide wheel
Colour	RAL 9006 or as requested

4.2 Supply air grille

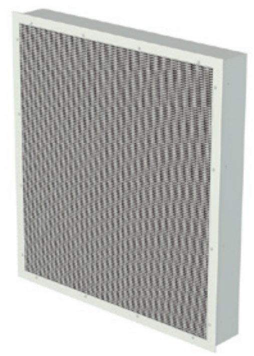
Grilles with the designated dimensions must be provided to allow the entry of supply air in the staircase. The measurements of the grilles must be dimensioned to approx. 2 m/s flow velocity with a distributed configuration on a supply air shaft. The selection of perforation is made based on the pressure loss of the grill, which determines the distribution of supply air in the staircase.

The grilles can also be used as individual grilles for supply air without the shaft.

In order to compensate for convection in the winter or summer, it may be necessary to install adjustable grilles. The design is as described above. In addition, the grille is equipped with an electrically adjustable multileaf damper and a modulated actuator.

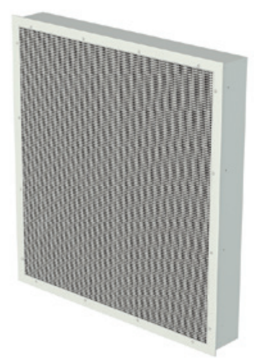
When used on an exhaust-air shaft in front of a smoke-extraction damper, the available pressure difference at the grille must be noted in particular.

Supply air grille with electric regulating damper



Type	ZE-NIQ-JZL65
Installation sizes	280 x 380 – 1,080 x 1,180
Power range	850–15,000 m^3/h at 50 Pa
Accessories, standard	Actuator SLM-SLC
Accessories, optional	–
Short text	Air outlet face made of perforated sheet with regulating damper and installation frame
Colour	RAL 9010 or as requested

Supply air grille



Type	NIQ
Installation sizes	300 x 300 – 1,200 x 1,200
Power range	850–15,000 m^3/h at 50 Pa
Accessories, standard	2 layers perforated sheet for pressure loss adjustment
Accessories, optional	Black PU sight protection mat between the perforated sheets
Short text	Air outlet face made of perforated sheet with installation frame
Colour	RAL 9010 or as requested

4.3 Pressure-relief unit

The pressure-relief unit is installed directly along the pressure area and is intended to discharge extraneous air from the pressure room when the door is closed.

The unit consists of an automatically regulating pressure-relief damper, a multileaf damper made of insulating material and a hood blowing out on four sides. The entire pressure-relief unit ensures pressure discharge independently of wind direction.

In order to prevent cold draughts and condensation, the pressure-relief damper must be connected „normally open" with a downstream multileaf damper made of insulating material with a spring return motor.

The automatic pressure-relief damper integrated in the pressure-relief unit is factory-set to the desired response pressure using a spring system.

In order to ensure the pressure discharge, the following should be noted:
The maximum total pressure loss calculated during the design of the system including the pressure-relief unit may not be exceeded at the required pressure-relief volume flow.

The dimensions of the pressure-relief unit, the selection of on-site mesh guards etc. as well as installation conditions must be coordinated with the manufacturer.

The spring return motors used are supplied with current using 2-wire technology (SLC). The supply air fan may only be put into operation when the multileaf damper in the pressure-relief unit is completely opened. Otherwise, the discharge of pressure cannot be guaranteed, and impermissibly high pressure levels may be reached in the pressure area.

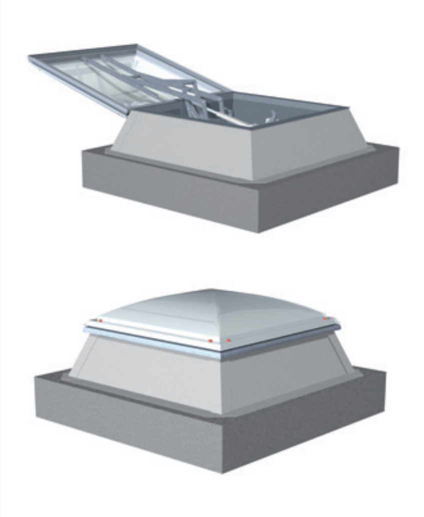
Setup of the pressure-relief damper:
The pressure difference for opening the pressure-relief damper is specified via the factory-set pretensioning length of the spring system in such a way that the pressure-relief damper reacts spontaneously to the opening or closing doors of the pressure area as a result of the associated change in pressure.

The factory-set spring tension may only be changed by qualified personnel from Strulik GmbH. The minimum overpressure in the staircase prior to relieving pressure corresponds with closed doors to the flow-through pressure loss of the entire pressure-relief unit with an open pressure-relief damper.

Pressure-relief unit for roof installation with slatted hood

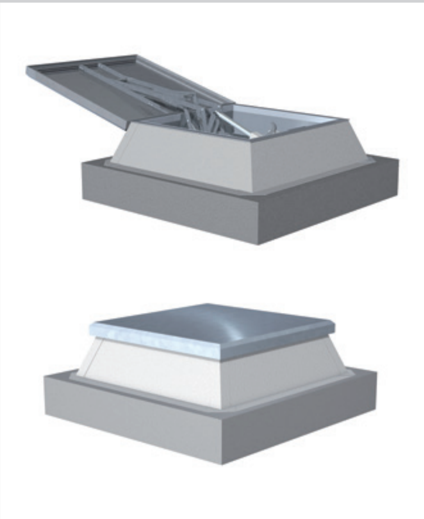
Type	DE-RK2-JZI-DS-AH
Installation sizes	420 x 550, 670 x 688, 840 x 826, 960 x 964, 930 x 1,102, 930 x 1,240, 1,000 x 1,240, 1,125 x 1,240
Power range	5,000–30,000 m³/h at 50 Pa
Accessories, standard	Insulating damper with spring return motor
Accessories, optional	Emergency SHV function, ventilation function, modulated spring adjustment
Short text	Pressure-relief unit for roof assembly with frame and slotted hood, incl. insulating damper with spring return motor
Colour	RAL 7001 or as requested

Pressure-relief unit for roof installation with dome light



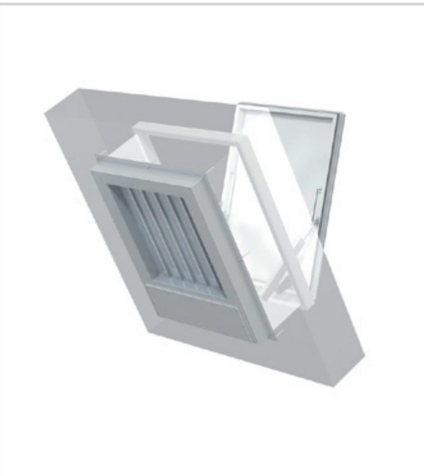
Type	DE-RK2-LK1
Installation sizes	420 x 550, 670 x 688, 840 x 826, 960 x 964, 930 x 1,102, 930 x 1,240, 1,000 x 1,240, 1,125 x 1,240
Power range	5,000–30,000 m³/h at 50 Pa
Accessories, standard	Roof frame 300 mm
Accessories, optional	Roof frame 400 mm, 500 mm, emergency SHV function, ventilation function, modulated spring adjustment
Short text	Pressure-relief unit for roof installation with frame 300 mm and dome light, single-wing, 165° opening angle, motor 24 VDC
Colour	Inside RAL 9006 or as requested, aluminium frame

Pressure-relief unit for roof installation with opaque skylight



Type	DE-RK2-DK1
Installation sizes	420 x 550, 670 x 688, 840 x 826, 960 x 964, 930 x 1,102, 930 x 1,240, 1,000 x 1,240, 1,125 x 1,240
Power range	5,000–30,000 m³/h at 50 Pa
Accessories, standard	Roof frame 300 mm
Accessories, optional	Roof frame 400 mm, 500 mm, emergency SHV function, ventilation function, modulated spring adjustment
Short text	Pressure-relief unit for roof installation with frame 300 mm and insulated opaque skylight, single-wing, 165° opening angle, motor 24 VDC
Colour	Inside RAL 9006 or as requested, aluminium frame

Pressure-relief unit for pitched roof



Type	DE-RK2-AF
Installation sizes	420 x 550, 670 x 688, 840 x 826, 960 x 964, 930 x 1,102, 930 x 1,240, 1,000 x 1,240, 1,125 x 1,240
Power range	5,000–30,000 m³/h at 50 Pa
Accessories, standard	Covering frame for profiled covering materials
Accessories, optional	Additional covering frames, emergency SHV function, ventilation function, modulated spring adjustment
Short text	Pressure-relief unit for roof pitch 20–60° with smoke extraction window, motor 24 VDC
Colour	Inside RAL 9006 or as requested, aluminium frame

Pressure-relief unit for wall installation without protection grille

Type	DE-RK2-JZI
Installation sizes	420 x 550, 670 x 688, 840 x 826, 960 x 964, 930 x 1,102, 930 x 1,240, 1,000 x 1,240, 1,125 x 1,240
Power range	5,000–30,000 m³/h at 50 Pa
Accessories, standard	Insulating damper with spring return motor
Accessories, optional	Emergency SHV function, ventilation function, modulated spring adjustment
Short text	Pressure-relief unit for wall installation, insulating damper with spring return motor, without protection grille
Colour	Inspection cover RAL 9006 or as requested, aluminium frame

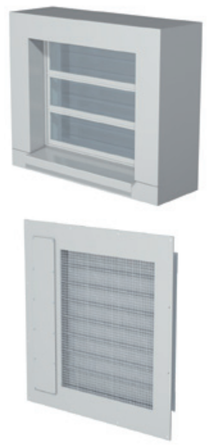
Pressure-relief unit for wall installation with front baffle plate

Type	DE-RK2-JZI-PBV
Installation sizes	420 x 550, 670 x 688, 840 x 826, 960 x 964, 930 x 1,102, 930 x 1,240, 1,000 x 1,240, 1,125 x 1,240
Power range	5,000–30,000 m³/h at 50 Pa
Accessories, standard	Insulating damper with spring return motor
Accessories, optional	Emergency SHV function, ventilation function, modulated spring adjustment
Short text	Pressure-relief unit for wall installation, insulating damper with spring return motor, front baffle plate
Colour	**Outside**: stainless steel or RAL as requested **Inside**: inspection cover stainless steel or RAL as requested

Pressure-relief unit for non-recessed wall installation with front baffle plate

Type	DE-RK2-JZI-VS-PBV
Installation sizes	420 x 550, 670 x 688, 840 x 826, 960 x 964, 930 x 1,102, 930 x 1,240, 1,000 x 1,240, 1,125 x 1,240
Power range	5,000–30,000 m³/h bei 50 Pa
Accessories, standard	Insulating damper with spring return motor
Accessories, optional	Emergency SHV function, ventilation function, modulated spring adjustment
Short text	Pressure-relief unit for wall installation, insulating damper with spring return motor in insulated shaft housing with front baffle plate
Colour	Stainless steel or RAL as requested

Pressure-relief unit for wall installation with slotted glass window



Type	DE-RK2-LF
Installation sizes	420 x 550, 670 x 688, 840 x 826, 960 x 964, 930 x 1,102, 930 x 1,240, 1,000 x 1,240, 1,125 x 1,240
Power range	5,000–30,000 m³/h at 50 Pa
Accessories, standard	–
Accessories, optional	Emergency SHV function, ventilation function, modulated spring adjustment
Short text	Pressure-relief unit for wall installation with slotted glass window, without wind shield
Colour	RAL 9006 or as requested, aluminium frame

Pressure-relief damper with installation frame and grille

Type	RK2-MG
Installation sizes	420 x 550, 670 x 688, 840 x 826, 960 x 964, 930 x 1,102, 930 x 1,240, 1,000 x 1,240, 1,125 x 1,240
Power range	5,000–30,000 m³/h at 50 Pa
Accessories, standard	Installation frame with inspection hole
Accessories, optional	Installation frame without inspection hold, emergency SHV function, ventilation function, modulated spring adjustment
Short text	Automatic controlling damper with multiple-slot design, damper system on same side via opening/closing rod connection, bearing of damper shafts in ball bearings, closing torques adjustable via tension spring systems
Colour	RAL 9006 or as requested, aluminium frame

4.4 Safety exhaust air shaft

The safety exhaust air guarantees an air velocity in the door section of the door of the secured area of 2 m/s or 0.75 m/s. The safety exhaust air is guaranteed via openings in the façade or a smoke extraction shaft with or without fan support.

The smoke extraction shaft is equipped with smoke extraction dampers for each storey. In case of a fire, smoke extraction dampers open on the fire level. The exhaust air shaft must continue straight and without offset until over the roof.

Front baffle plate for wall mounting

Type	PBV
Installation sizes	775, 1,045, 1,225, 1,315, 1,405 (height of hood)
Power range	5,000–30,000 m³/h
Accessories, standard	–
Accessories, optional	–
Short text	Front baffle plate for wall mounting, blowing out on 4 sides, with enclosing frame and rain shield
Colour	stainless steel or RAL as requested

Opaque skylight with roof frame

Type	DK1
Installation sizes	1.200 x 1,200, 1,500 x 1,500
Power range	–
Accessories, standard	Frame, height 300 mm
Accessories, optional	Frame, height 400 mm, 500 mm
Short text	Opaque skylight with insulating frame and lid, opening angle 165°, motor 24 VDC
Colour	Natural aluminium

Ventilation unit with insulating damper and slotted hood

Type	LE-JZI-DS-AH
Installation sizes	900, 1,200, 1,500
Power range	2,700, 6,900, 13,000 m³/h at 10 Pa
Accessories, standard	Insulating damper with spring return
Accessories, optional	–
Short text	Ventilation unit for roof mounting with base and slotted hood, incl. insulating damper with spring return motor
Colour	RAL 7001 or as requested

4.5 Exhaust air unit

In order to support the flow of air from the building behind the door for the safety area to be protected (staircase or escape route), an exhaust air fan with suction-side pressure control is installed at the end of the exhaust air shaft. The essential components of the exhaust air unit are the smoke-extraction fan up to 300 °C and two spring-loaded pressure-controlling dampers similar to the pressure-relief damper in the pressure area (staircase or tunnel).

The pressure-controlling dampers react to the opening or closing of doors to the pressure area. In order to prevent cold draughts and condensation, a multileaf damper made of insulating material with a spring return motor is mounted „normally open" in front of each outside air damper and the fan.

The pressure difference for opening the pressure-controlling damper is specified via the factory-set pretensioning length of the spring system. The factory-set spring tension may only be changed by qualified personnel from Strulik GmbH. A repair switch with auxiliary contacts is mounted to the fan for monitoring.

The inspection hole in the base is to the right of the duct connection.

The following must be noted to guarantee the reliable functioning of the exhaust air unit:

- The exhaust air must be sucked in in the necessary corridor behind the door to the staircase. The exhaust air may not be removed from the fire area.
- The exhaust air shaft should be created without delay and with a maximum 5 m/s flow velocity. Leaks in the shaft should be avoided. All connections are via smoke extraction dampers in the storeys.
- The doors of the pressure area (e.g. staircase) to the corridor must be provided with continuous flow openings. Dimensioning is executed on the basis of the minimum volume flow of the exhaust air unit (see data sheet).
- The negative pressure required at the shaft head is factory-set exactly. The pressure loss in the exhaust air duct must be determined by a duct network calculation.

Exhaust air unit with fan, integrated pressure-controlling dampers and slotted hood

Type	AE-EV-RK3-JZI-DS-AH
Installation sizes	560 to 800
Power range	3 to 15 kW
Accessories, standard	Repair switch
Accessories, optional	Modulated spring adjustment
Short text	Exhaust air unit with automatic pressure-relief dampers, axial fan 300 °C/120 min., impeller with adjustable blade and adjustable guide wheel, insulated housing with 2 insulating multileaf dampers, SLC technology
Colour	RAL 7001 or as requested

4.6 Control unit (EKS)

The EKS control unit controls and monitors the functions and processes of the differential pressure system. The EKS control unit is a closed functional unit. The condition of the system is continuously monitored (even when idle).

When a fault occurs, the message „collective fault" is displayed as follows:

1 x as display LED on control cabinet
1 x as potential-free contact to message to on-site BMS or constantly occupied position

All contacts provided by the EKS control unit are designed as changeover contacts, with an alarm or fault being the de-energised state.

Intelligent climate-independent control system

Activation

The differential pressure system is started up via activation by the FACP or by means of directly connected smoke detectors or push-button alarms. If a fire alarm is triggered, it is stored in the EKS. The multileaf dampers are opened and the fan goes into operation with a time delay of 30/60 seconds. The activation of the EKS can only be cancelled by resetting the EKS control unit.

Reset

In order to enable the system after an alarm and to deactivate the fan, the reset button located on the outside of the control cabinet must be pressed until the button light appears.

The system has only returned to an operational state and can be triggered again when the light of the reset button goes off again. During the reset process, the connected SLC components are initialised and execute a test run.

Ventilation mode

Ventilation mode (optional) is activating by switching a key-operated switch. This opens multileaf damper JZI and controlling damper RK2 by means of the actuator in the pressure-relief unit. In case of controlling dampers with a split design, part of the damper surface is opened.

Activating differential pressure mode overrides ventilation mode.

Manual mode

The control cabinet contains the manual mode section, consisting of the switches "Manual/Automatic", "Fan OFF/ON" (once for each fan), "Exhaust air unit OFF/ON" (if available) and "Scenario OFF/ON" (once for each scenario). If the system is in manual mode, the LED "Manual mode active" lights up outside on the control cabinet door and the activated manual switches.

This state is activated at the signal contact of the BMS. Activating the switch "Scenario XX ON" activates the pressure ventilation. The multileaf dampers open and the fan is switched on with a delay of approx. 60 seconds.

If the "Automatic/Manual mode" switch is reset to Automatic, the system automatically returns to its previous state. If the system was in stand-by mode, the multileaf dampers close and the fan switches off.

If the system was in an activated state, the scenario becomes active. Then the multileaf dampers open and the fan(s) switch(es) on.
This is not the case if the reset button was activated during manual mode, as this resets the scenario of automatic mode even if in manual mode.

Manual mode, fire brigade indicator panel (FBIP)

In order to allow manual action on the part of the fire brigade, each DPS has a manual switch in the FBIP with the positions, Off, Auto and On. As a rule, the switch is set to Auto. This contact is not connected with the EKS control unit.

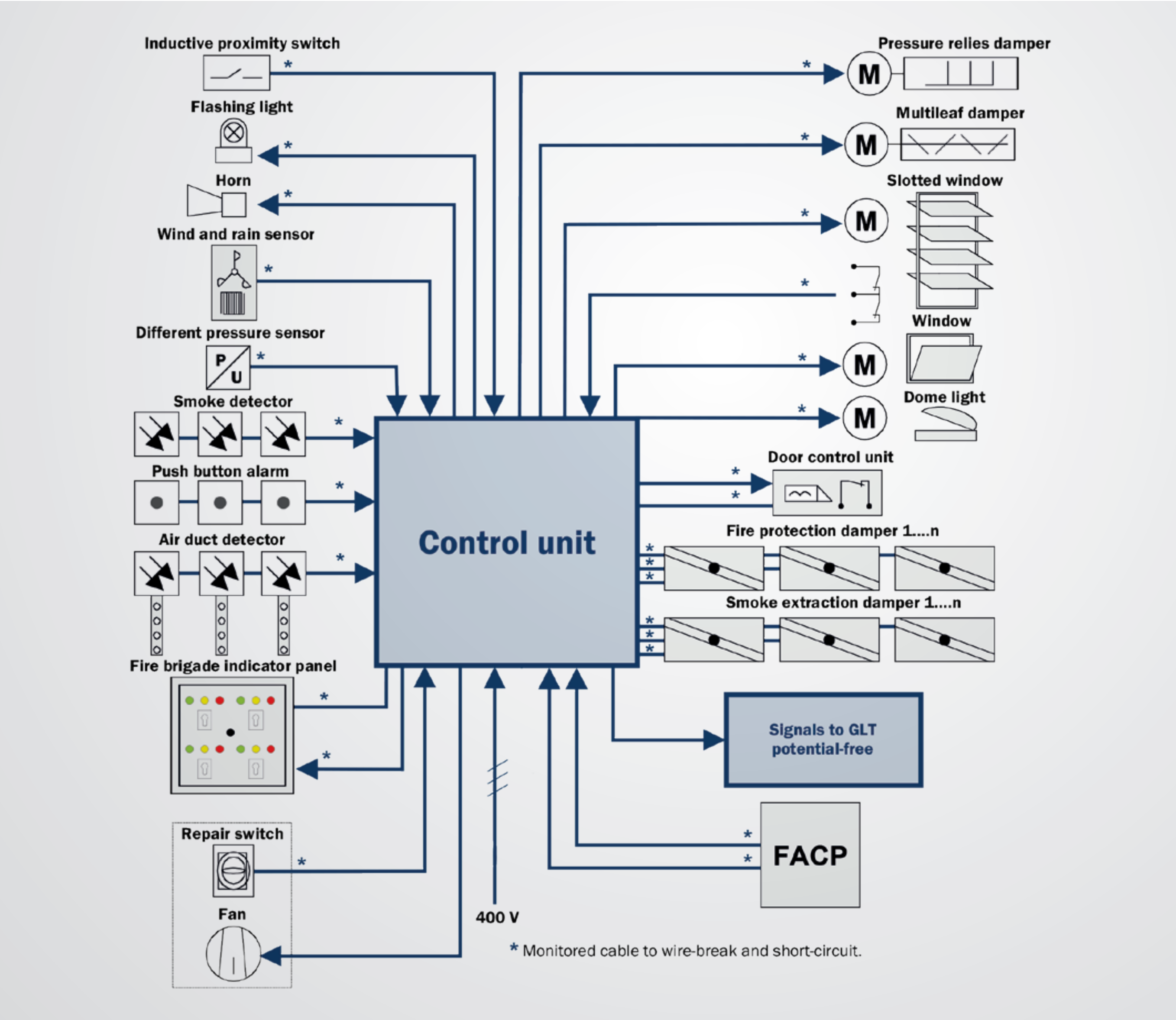
The contacts Off and On are connected with monitored EKS inputs and are continuously monitored for cable break and short circuits. A switch command is only made by the EKS if the corresponding cable is fault-free. A manual action using the FBIP is visually displayed on the EKS and shown as a message.

The messages Operational, Collective fault and Alarm are activated on the FBIP by LEDs.

Fire brigade indicator panel FBIP

System behaviour in case of faults

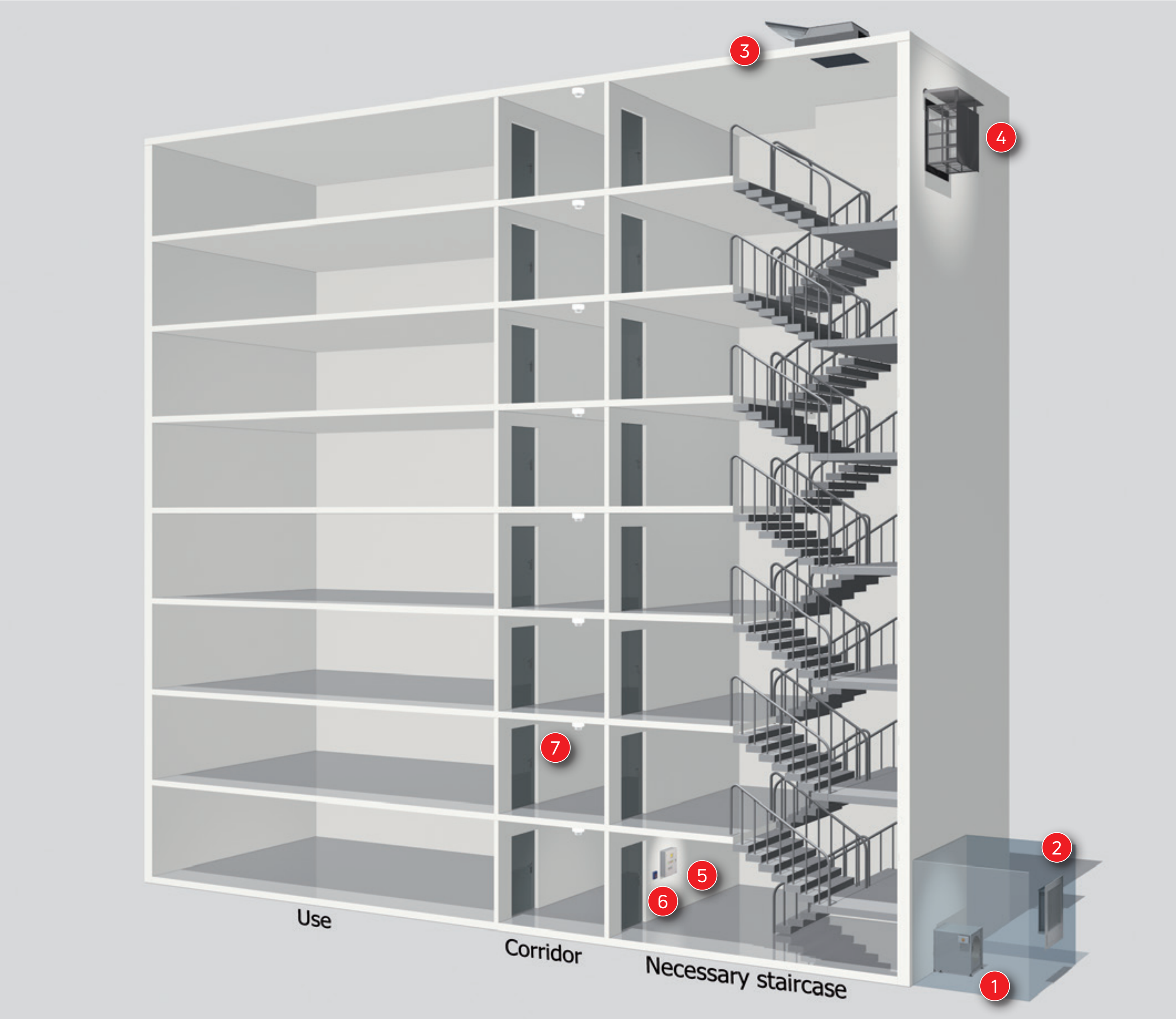
Faults are immediately communicated via contacts. If a fault is reported, the cause of the fault must be eliminated immediately. Recurring fault messages which are suggestive of a defect on a damper or actuator must be eliminated immediately by Strulik GmbH.



Due to the modular structure of the EKS control unit, the system can be expanded to meet the individual requirements of the building. Should an additional component or expansion require the expansion of the system at a later time, this can be achieved without great difficulty.

5 Design examples

5.1 Necessary staircase without air-lock and without flow detection



Necessary staircase without air-lock and without flow detection

Components (example)	
1.	Supply air fan (DV1, DV1-WSG, DV-RK1, DV2)
2.	Protection grille with multileaf damper (WG-JZL)
3.	Pressure-relief unit via roof (DE-RK2-LK1, DE-RK2-JZI-DS-AH)
4.	Alternative pressure-relief unit in outer wall (DE-RK2-JZI-PBV, DE-RK2-JZI-VS-PBV)
5.	Control unit (EKS-L, EKS-D)
6.	Push-button alarm (DKM)
7.	Smoke detector (ST-P-DA-STB) or via FACP

Example calculation

There are no controlled requirements placed on pressure ventilation systems in necessary staircases for compensating for not having an air-lock.

In consideration of the low protection offered by the SHV opening required by building law of at least 1 m^2 at the head of the staircase, we would like to recommend the following protection goals for the differential pressure system.

Protection goals

- Pressure maintenance and limitation of door-opening force to 100 N
- Air change in staircase with at least 15,000 m^3/h exhaust air through the pressure-relief opening at the head of the staircase
- A minimum pressure in the staircase of approx. 20 Pa with closed doors
- Flow through the door to the fire level (approx. 1 m/s) if a sufficiently large exhaust air opening (approx. 1 m^2) is manually created in the fire level, e.g. by the relief units

Basic building data

Floors	Basement, ground floor, 1st to 5th floor
Floor height	2.80 m
Stairway	Flight of stairs = 1.20 m, well width = 0.25 m
Door size	Width = 1.0 m, height = 2.0 m
Door quality	T30 or RS

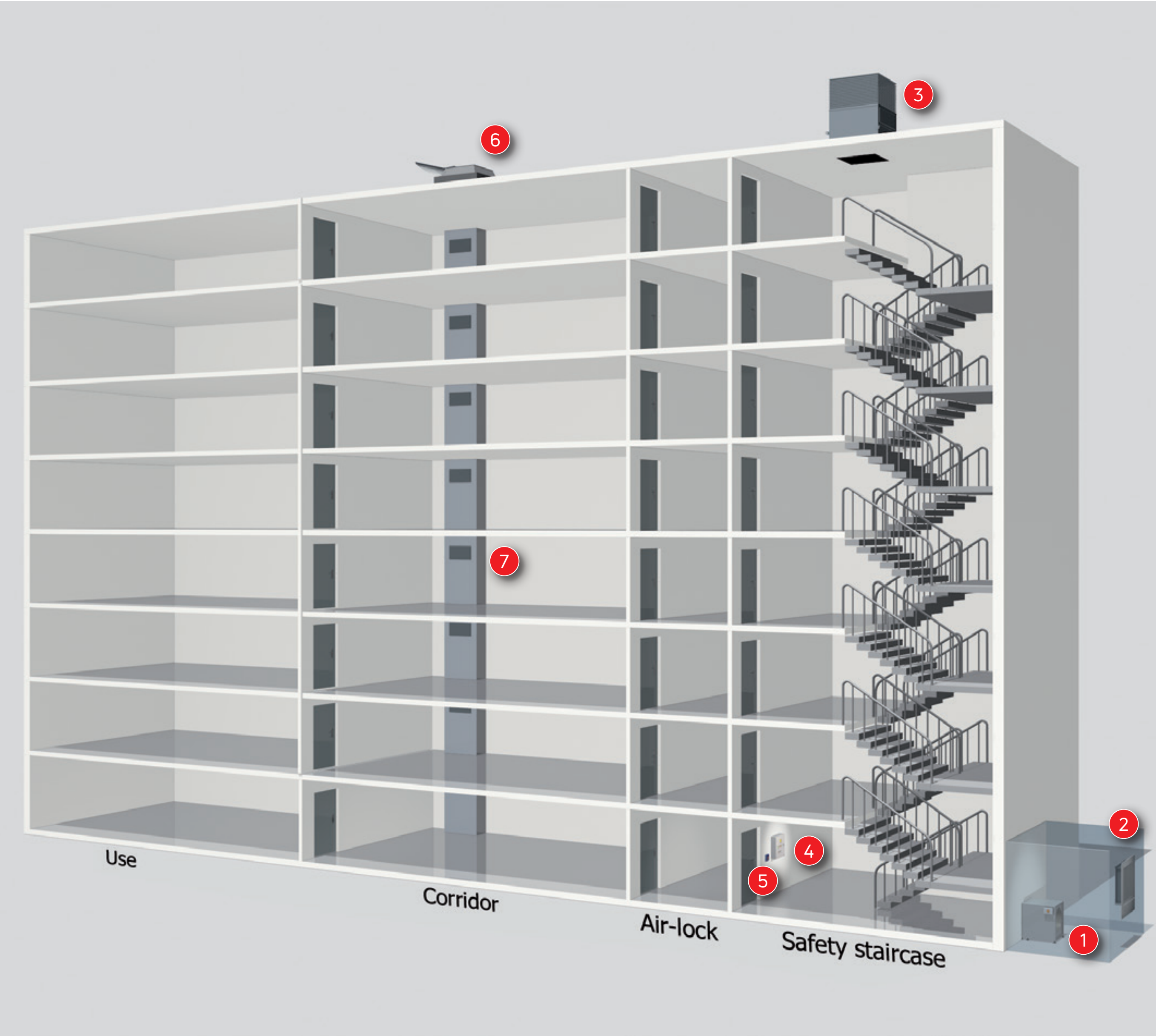
Basic DPS dat

Maximum overpressure in staircase	64 Pa
Supply air fan	Volume flow 18,000 m^3/h, DV1(2)-710/5.5 kW One blow-in point in basement or ground floor, approx. 1 m^2, NIQ 1,000 mm x 1,000 mm
Pressure-relief unit	Volume flow approx. 15,000 m^3/h, DE-RK2-LK1 930 mm x 1,102 mm
Control system	EKS-L for one alarm area

Basic calculation data

The basis for calculation is the air volume flow of approx. 15,000 m^3/h at the pressure-relief unit. Accounting for the determined leak yields a supply air volume flow of approx. 18,000 m^3/h. The flow-through pressure loss of the staircase in this example amounts to approx. 2.5 Pa per storey.

5.2 Safety staircase with air-lock, dynamic calculation, isothermal, steady-state, 7 storeys



Safety staircase with air-lock, dynamic calculation, isothermal, steady-state, 7 storeys

Components (example)	
1.	Supply air fan (DV1, DV1-WSG, DV-RK1, DV2)
2.	Protection grille with multileaf damper (WG-JZL)
3.	Pressure-relief unit (DE-RK2-JZI-DS-AH, DE-RK2-JZI-PBV)
4.	Control unit (EKS-D), alarm via FACP
5.	Push-button alarm (DKM)
6.	Opaque skylight (DK1)
7.	Smoke extraction damper (RKIV-90)

Example calculation based on DIN EN 12101-6, Class C

Staircases in buildings with average height can also be designed as safety staircases. In terms of systems engineering, they are then equated with safety staircases in a high-rise building.
The protection goals must be defined in the fire protection certificate and may be based on the specifications of the high-rise building regulation or DIN EN 12101-6. Two principal protection goals must be defined: the maximum door-opening force of 100 N and the flow velocity in the opened door of 0.75 m/s to 2 m/s. At a building height of below 22 m, it is possible to assume that the fire brigade, in principle, has the possibility to execute firefighting measures from outside by using the turntable ladder.

The primary task of the DPS may be viewed as securing escape routes prior to the arrival of the fire brigade.
In consideration of these conditions, System Class C of DIN EN 12101-6 can be consulted to describe the requirements.

Protection goals

- Pressure maintenance and limitation of door-opening force to 100 N
- A minimum pressure in the staircase of 10 Pa with closed doors in the storeys and opened exit door
- Flow through door to fire storey with 0.75 m/s via secured exhaust air opening in the fire level

Basic building data

Floors	Basement, ground floor, 1st to 5th floor	Door quality	T30 or RS
Floor height	2.80 m	Exhaust air shaft	0.4 m^2
Stairway	Flight of stairs = 1.20 m, well width = 0.25 m		
Exit door	Width = 1.0 m, height = 2.0 m		
Door size	Width = 1.0 m, height = 2.0 m		

Basic DPS data

Maximum overpressure (Door size) in staircase	64 Pa
Supply air fan	Volume flow 18,000 m^3/h, DV1(2)-710/5.5 kW One blow-in point in basement or ground floor, approx. 1 m^2, NIQ 1,000 mm x 1,000 mm
Pressure discharge	Volume flow approx. 15,000 m^3/h, DE-RK2-JZI-DS-AH 960 mm x 964 mm/412 mm
Smoke extraction damper	Smoke extraction damper on exhaust air shaft for each storey RKI 1,000 mm x 505 mm
Control system	EKS-D for 7 alarm areas

Basic calculation data

The supply air volume flow required for two operating states must be determined separately. With an open exit door, the air volume flowing out through the open door creates a pressure loss of at least 10 Pa. The additional leak in the staircase must be determined at a minimum 10 Pa overpressure in the staircase.

- Air flow through open exit door: 15,500 m^3/h
- Leak in staircase at 10 Pa overpressure: 2,500 m^3/h
- Total supply air: 18,000 m^3/h

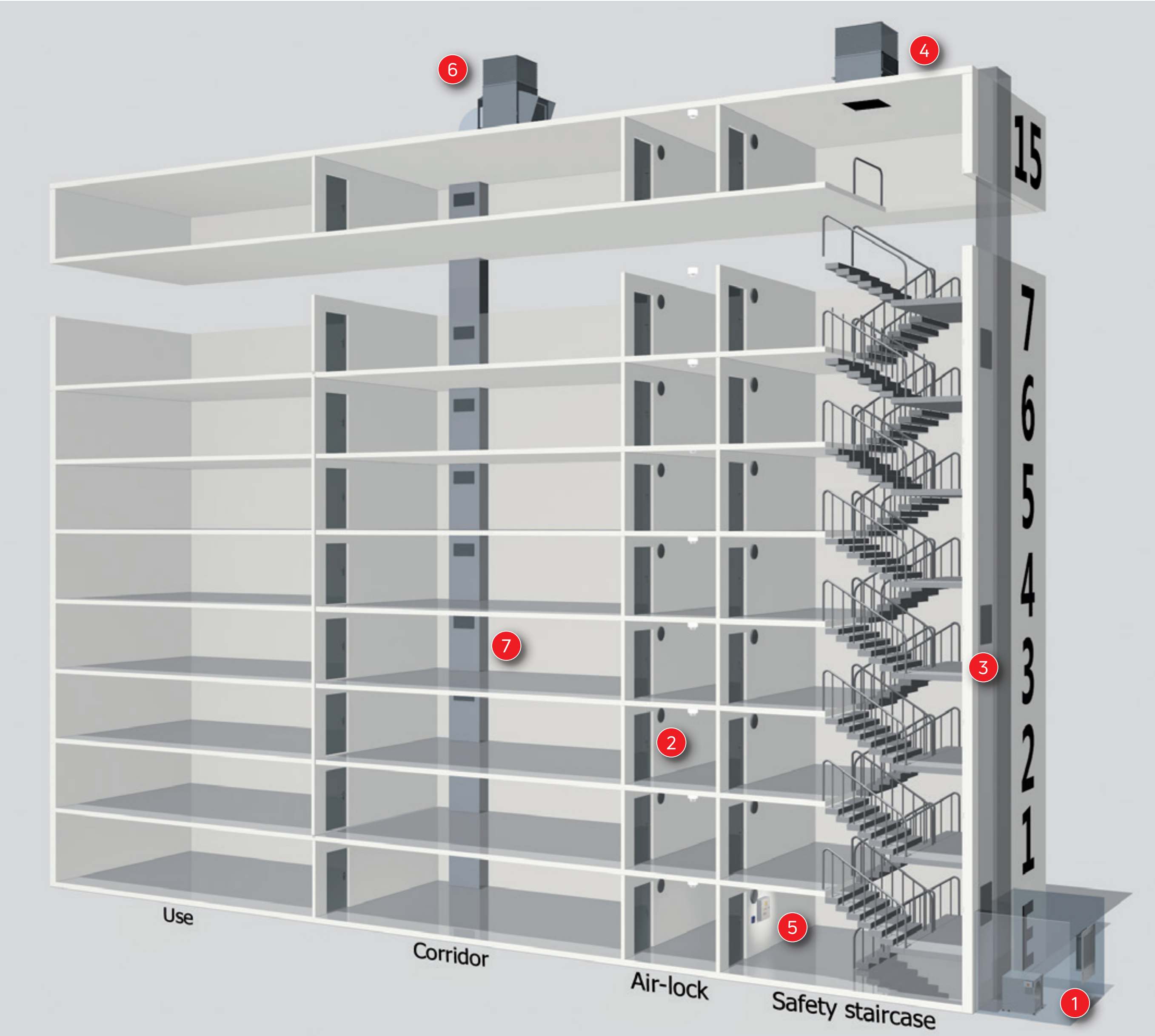
In order to ensure the flow criterion in the door of the fire level through the exhaust-air shaft via the roof, the following data are obtained:

- **Flow through door:** minimum 5,400 m^3/h at 0.75 m/s
- **Pressure loss over exhaust air path:** 35 Pa
- **Leak in staircase at 35 Pa overpressure:** 4.400 m^3/h
- **Total supply air:** 9.800 m^3/h

The supply air fan is designed for the higher requirement (V = 18,000 m^3/h) created with an open door to the fire storey: DV1(2)-710/5.5 kW.

The pressure-relief unit has a two-stage design for a volume flow of 18,000 m^3/h or 8,200 m^3/h: DE-RK2-JZI-DS-AH 960 mm x 964 mm/412 mm.

5.3 Safety staircase with air-lock, dynamic calculation, anisothermal, transient, 15 storeys



Safety staircase with air-lock, dynamic calculation, anisothermal, transient, 15 storeys

Components (example)	
1.	Supply air fan (DV1, DV1-WSG, DV2) with protection grille (WG-JZL)
2.	Pressure equalisation opening (BEK-K90 + 2x ÜSG)
3.	Supply air grille (NIQ-R6)
4.	Pressure-relief unit (DE-RK2-JZI-DS-AH, DE-RK2-JZI-PBV)
5.	Control unit (EKS-D) with push-button alarm (DKM)
6.	Exhaust air unit (AE-EV-RK3-JZI-DS-AH)
7.	Smoke extraction damper (RKIV-90)

Example calculation based on MHHR

Staircases in high-rise buildings are typically designed as safety staircases with differential pressure systems. The protection goals can be derived from the high-rise building regulation or DIN EN 12101-6.

If the Model High-Rise Building Regulation from 2008 is applied, the following protection goals are defined:

Protection goals

- Pressure maintenance and limitation of door-opening force to 100 N
- Flow through door to fire storey with 2 m/s via secured exhaust air opening in the fire level
- Closed exit door

Basic building data

Floors	Ground floor, 1st to 14th floor
Floor height	2.80 m
Stairway	Flight of stairs = 1.20 m, well width = 0.25 m
Door size	Width = 1.0 m, height = 2.0 m
Door quality	T30 or RS
Exhaust-air shaft	1.2 m²

Basic meteorological data

Outside temperature, winter	–10 °C	Inside temperature, winter	+20 °C
Outside temperature, summer	+32 °C	Inside temperature, summer	+22 °C

Basic DPS data

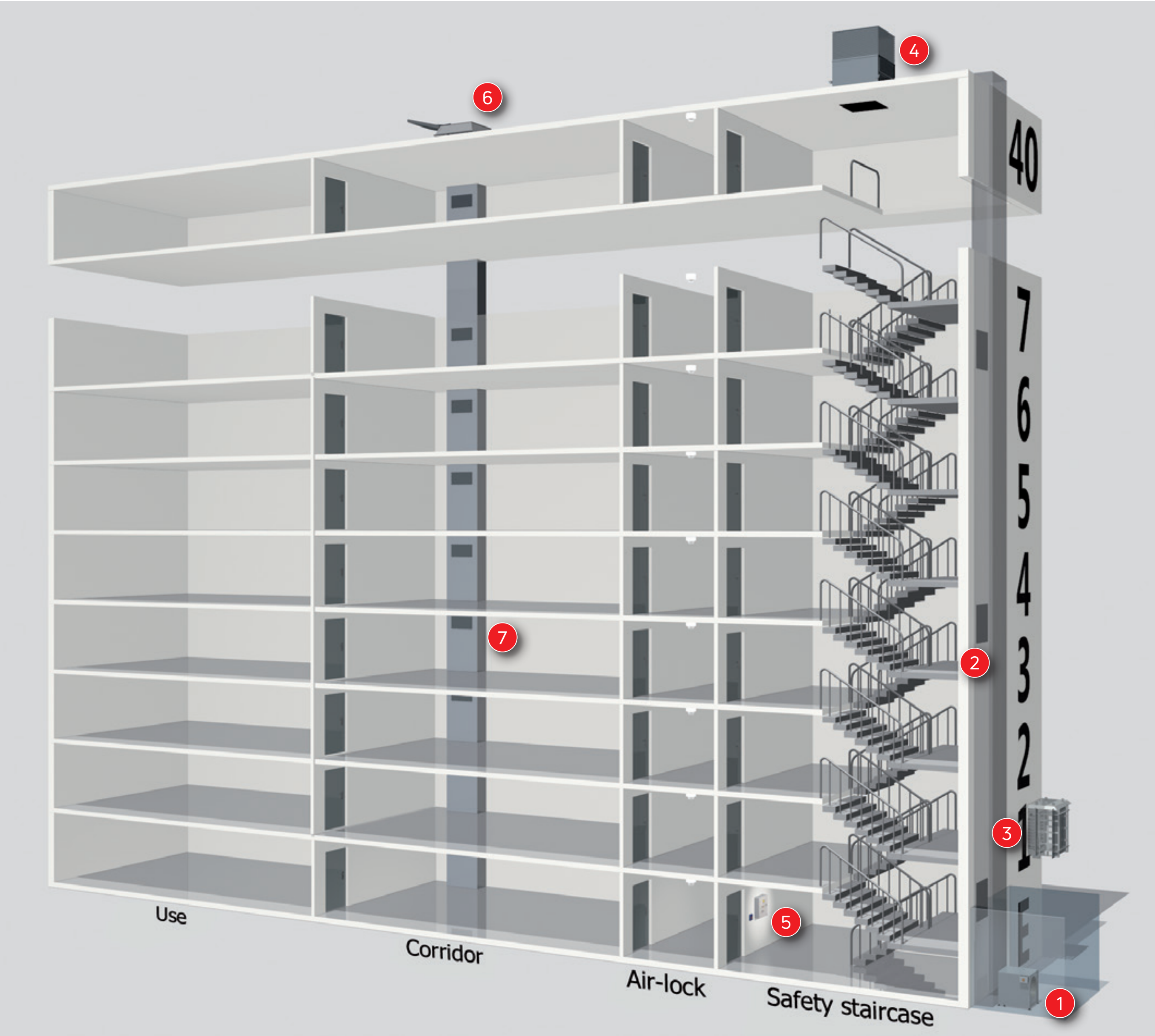
Maximum overpressure (Door size) in staircase	41 Pa
Supply air fan	Volume flow 22,000 m³/h, DV1(2)-710/7.5 kW 5 blow-in points, every 3 floors, approx. 0.63 m², NIQ 700 mm x 900 mm
Pressure-relief unit	Volume flow approx. 20,000 m³/h, DE-RK2-JZI-DS-AH 1,000 mm x 1,240 mm
	Pressure-equalisation openings, SC → air-lock, air-lock → corridor, BEK-K90 200
	Smoke extraction damper on exhaust air shaft for each storey RKI 1,000 mm x 835 mm
	Inspection grill in front of smoke extraction damper NIQ 1,300 mm x 900 mm
	Exhaust air unit on exhaust air shaft for min. 18,000 m³/h, AE-EV-RK3-JZI-DS-AH 710/5.5
	Flush connection (outside air) on exhaust air shaft in basement/ground floor approx. 0.05 m²
Control system	EKS-D for 15 alarm areas

Basic calculation data

The mathematical demonstration of system operability must be provided separately for three climate conditions (isothermal, summer, winter). In order to ensure the flow criterion in the door of the fire level through the exhaust air shaft via the roof, the following data are obtained:

- **Flow through door:** minimum 18,000 m³/h at 2.0 m/s
- **Pressure loss over exhaust air path:** 80 Pa
- **Leak in staircase at 15 Pa overpressure:** 3,500 m³/h
- **Total supply air:** 22,000 m³/h

5.4 Safety staircase with air-lock, dynamic calculation, anisothermal, transient, 40 storeys



Safety staircase with air-lock, dynamic calculation, anisothermal, transient, 40 storeys

Components (example)	
1.	Supply air fan (DV1, DV1-WSG, DV2) with protection grille (WG-JZL)
2.	Supply air unit with volume regulation (ZE-NIQ-JZL65)
3.	Pressure-relief unit, ground floor (DE-RK2-JZI-PBV, DE-RK2-JZI-VS-PBV)
4.	Pressure-relief unit, roof (DE-RK2-JZI-DS-AH)
5.	Control unit (EKS-D) with push-button alarm (DKM)
6.	Opaque skylight (DK1)
7.	Smoke extraction damper (RKIV-90)

Example calculation based on DIN EN 12101-6, Class D

Staircases in high-rise buildings are designed as safety staircases with differential pressure systems. The protection goals can be derived from the high-rise building regulation or DIN EN 12101-6. Assuming that two safety staircases are available, the differential pressure system can be planned according to Class D of DIN EN 12101-6. The following protection goals are defined based on Class D.

Protection goals

- Pressure maintenance and limitation of door-opening force to 100 N
- Flow through door to fire storey with 0.75 m/s via secured exhaust air opening in the fire level (flow criterion)
- Pressure maintenance and flow criterion with open exit door
- Exit door closed or open

Basic building data

Floors	Ground floor, 1st to 39th floor
Floor height	2.80 m
Stairway	Flight of stairs = 1.20 m, well width = 0.25 m
Door size	Width = 1.25 m, height = 2.0 m
Door quality	T30 or RS
Exhaust air shaft	0.8 m^2

Basic meteorological data

Outside temperature, winter	–10 °C	Inside temperature, winter	+20 °C
Outside temperature, summer	+32 °C	Inside temperature, summer	+22 °C

Basic DPS data

Maximum overpressure in staircase	41 Pa
Supply air fan	Volume flow 50,000 m^3/h, DV2-1000/30 kW 3 blow-in points, GF, 1st floor, 4th floor, approx. 1.27 m^2, ZE-NIQ-JZL65 1,080 mm x 1,180 mm
	from 8th floor every 3 floors, approx. 0.25 m^2, ZE-NIQ-JZL65 580 mm x 780 mm
Pressure-relief unit, GF	Volume flow approx. 22,000 m^3/h, DE-RK2-JZI-PBV 1,000 mm x 1,240 mm
Pressure-relief unit, roof	Volume flow 13,000 m^3/h, DE-RK2-JZI-DS-AH 960 mm x 964 mm
	Pressure-equalisation openings, SC → air-lock, air-lock → corridor, BEK-K90 200
	Smoke extraction damper on exhaust air shaft for each storey RKI 1,000 mm x 1,000 mm
	Inspection grill in front of smoke extraction damper NIQ 1,300 mm x 1,100 mm
	Flush connection (outside air) on exhaust air shaft in basement/ground floor approx. 0.5 m^2
Control system	EKS-D for 40 alarm areas

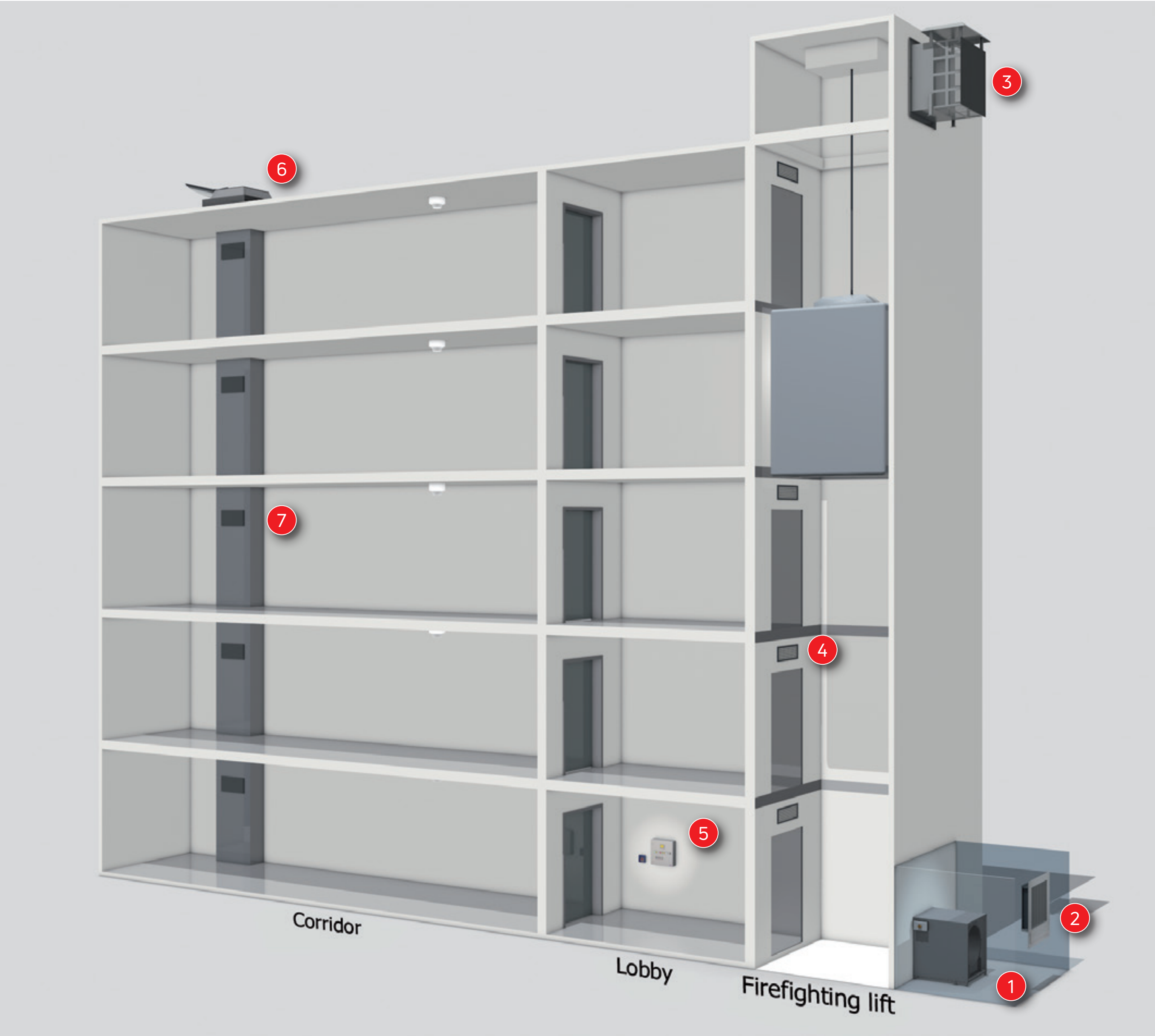
Basic calculation data

The mathematical demonstration of system operability must be provided separately for three climate conditions (isothermal, summer, winter). The requirement from Class D – flow criterion also with open exit door – entails additional calculation. The protection goals mentioned above (pressure criterion and flow criterion) must both be calculated and ensured for all climate conditions with open and closed exit door.

In order to ensure the flow criterion in the door of the fire level through the exhaust air shaft via the roof, the following data are obtained:

- **Flow through door:** minimum 6,800 m^3/h at 0.75 m/s
- **Pressure loss over exhaust air path:** 30 Pa
- **Leak in staircase at 30 Pa overpressure:** 15,500 m^3/h
- **Total supply air:** 50,000 m^3/h

5.5 Firefighting lift with lobby, dynamic calculation, isothermal, steady-state



Firefighting lift with lobby, dynamic calculation, isothermal, steady-state

Components (example)	
1.	Supply air fan (DV1, DV1-WSG, DV2)
2.	Protection grille with multileaf damper (WG-JZL)
3.	Pressure-relief unit (DE-RK2-JZI-PBV, DE-RK2-LK1)
4.	Supply air damper, lobby (RKIV-90, JZ180)
5.	Control unit (EKS-D) with push-button alarm (DKM)
6.	Opaque skylight (DK1)
7.	Smoke extraction damper (RKIV-90)

Example calculation based on MHHR

Firefighting lifts must be kept smoke-free in the event of a fire in the building. This applies to the lift shaft and the lobbies in all the floors. The protection goals must be defined in the fire protection certificate and can be based on the specifications of the high-rise building regulation. Two principal protection goals must be defined.

Protection goals:
- Pressure maintenance and limitation of door-opening force to 100 N
- Flow through door to fire storey with 0.75 m/s via secured exhaust air opening in the fire level

Basic building data

Floors	GF, 1st to 7th floor
Floor height	2.80 m
Lift shaft	Base area 2.0 m x 3.0 m
Door size	Width = 1.0 m, height = 2.0 m
Door quality	T30 or RS
Exhaust-air shaft	0.4 m^2

Basic DPS data

Maximum overpressure in lift shaft	64 Pa
Supply air fan	Volume flow 13,000 m^3/h, DV1(2)-630/3.0 kW One blow-in point in basement or GF, approx. 1 m^2, NIQ 1,000 mm x 1,000 mm
	from 8th floor every 3 floors, approx. 0.25 m^2, ZE-NIQ-JZL65 580 mm x 780 mm
Pressure-relief unit	Volume flow approx. 8,100 m^3/h, DE-RK2-JZI-VS-PBV 670 mm x 6,880 mm extraction
	damper on lift shaft in lobby per storey RKI 1,000 mm x 505 mm extraction damper
	on exhaust air shaft for each storey RKI 1,000 mm x 505 mm
Control system	EKS-D for 8 alarm areas

Basic calculation data

The required supply air volume flow must be determined in consideration of the leaks in the floors, the target volume flow through the open door of the lobby and the required ventilation of the lift machine room.

The following special aspect must be accounted for when calculating a FFL:

The lift shaft is generally used as a supply air duct for the lobby. A flow velocity of 0.75 m/s through the door of the lobby to the floor must be demonstrated. The air volume of 5,400 m^3/h required here must flow through a smoke extraction damper (SED) from the lift shaft to the lobby. The flow-through pressure loss of this SED with protection grille must be accounted for in the calculation. The sum of the pressure losses in the exhaust-air path and the flow-through pressure loss of the SED may not be higher than the maximum admissible pressure difference at the closed lobby door. The maximum admissible overpressure in the shaft is achieved when the door of the lobby is open. Leakage of the lift shaft and lobbies must be determined at 58 Pa overpressure in the lift shaft.

- **Flow through door:** minimum 5,400 m^3/h at 0.75 m/s
- **Pressure loss via SED at FFL shaft:** 28 Pa
- **Pressure loss over exhaust air path:** 30 Pa
- **Leak in staircase at 58 Pa:** 4,000 m^3/h
- **Exhaust air through lift machine room:** 3,000 m^3/h
- **Total supply air:** 12,400 m^3/h

The supply air fan is designed for the higher requirement (V = 13,000 m^3/h) created with an open door to the fire storey: DV1(2)-630/3.0 kW.

The pressure-relief unit is designed for a volume flow of 8,100 m^3/h: DE-RK2-JZI-VS-PBV 670 mm x 688 mm.

Appendix

A Maintenance and commissioning

B References

C DPS request form

A Maintenance and commissioning

Measurements in the scope of commissioning and expert inspection

In the scope of commissioning and later final expert inspection, the functionality of the DPS must be inspected together with all the other functions within the building. The building must be in its final condition (fully ready for occupancy) at this time.

Final inspection by an expert

The protection goals to be tested and special boundary conditions for commissioning/final inspection must be derived from the fire protection concept and the functional description of the system.

During final inspection, the DPS is activated directly by means of the detectors used to detect real fire hazards. As a rule, these are the smoke detectors of the FDS. After the system is activated, the air-flow measurements are executed.

During commissioning, different functions are tested separately so that the inspection of the connections to the FACP and the DPS of the building is already complete at the time of the air-flow measurements. This allows the DPS to be manually operated during the air-flow measurements.

The boundary conditions for the individual measurements are specified in the scope of the definition of the protection goals for the DPS. It must be ensured during each measurement that these boundary conditions are established.

Possible boundary conditions for the measurements

The following boundary conditions may influence the air-flow measurements and must be checked or set correctly.

a. All the doors along the pressure area are closed. These include the doors of the lobbies on staircases and fire-fighting lift lobbies. Depending on the class as defined by DIN EN 12101-6, individual doors in the staircase can be open for certain measurements.
b. The staircase exit door used for evacuation must be opened or closed according to the specifications in the fire protection concept or the functional description. The classes defined by DIN EN 12101-6 make exact specification for different measurements.
c. Natural and mechanical smoke extraction systems must be activated/deactivated as befits each fire scenario.
d. Ventilation systems must be activated/deactivated as befits the particular fire incident matrix.
e. The positions of the fire protection dampers in the ventilation systems must correspond to the specifications of the fire incident matrix.

The boundary conditions must be considered to ensure that the determined measurement values can be reproduced under the specified conditions. These boundary conditions must already be accounted for in the scope of the measurement.

Door-opening force (without DPS) of all doors along pressure area

The opening force of the doors is measured prior to commissioning the differential pressure system. In this process, the setting of the door closers is inspected. Doors which jam, thereby exhibiting an increased door-opening force, are detected and documented.

Measuring the door-opening force

The door-opening force will amount to between 20 N and 60 N depending on the door size. The door-opening force is measured in the vicinity of the door handle or lock plate.

The door-opening force must be measured with a suitable measuring device. As a rule, devices used have an integrated tension or compression spring. This measurement process not only measures the forces of the door closer and the friction created by hinges and seals, but also the force which must be applied to overcome the inertia of the door leaf. The inertia is the larger the heavier the door leaf is and the faster the door leaf is opened during the measurement. Opening the door too quickly during the measurement results in increase door-opening forces.

Therefore, a slow, uniform movement of the door leaf should be made during the measuring process.

Door-opening force (with DPS) of all doors along pressure area

When the DPS has been put in a proper alarm state, the door-opening force is measured in the activated fire storey. The information on use mentioned above also applies here.

The measured door-opening force may not as a rule exceed 100 N. Deviating specifications from the fire-protection concept should be noted.

Air velocity in the door on the fire level

In case the door of the staircase/lobby to the normal corridor is open, it must be demonstrated that the required flow velocity is reached in the fire storey. The dampers in the exhaust-air path of the fire level must open automatically. Other doors and windows in the fire level should be closed in order to obtain reproducible values.

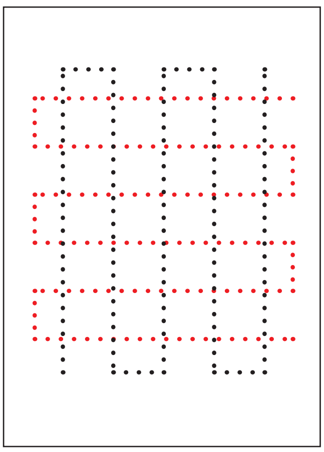
The measurement of the air velocity in the door section is generally made using a vane probe (60-100 mm). Different averaging methods are applied during the measuring process.

Two methods are used frequently:

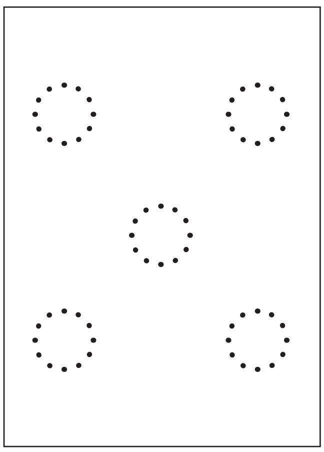
1. Loop measurement
2. Point measurement

In **loop measurement,** the entire door surface is covered uniformly on horizontal and vertical tracks. The measuring device used automatically generates a single average value from the recorded measurement values.

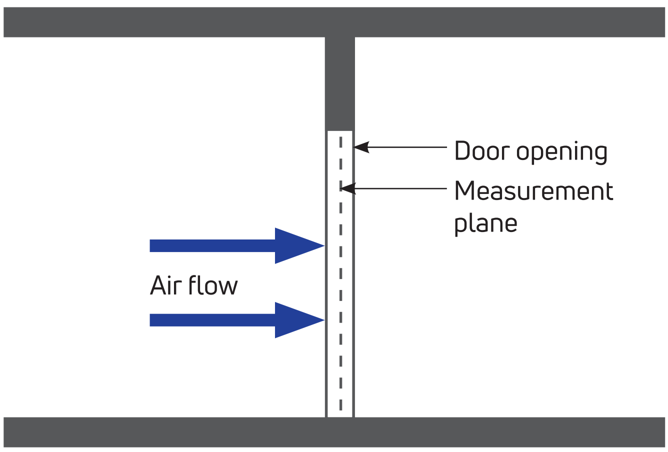
In **point measurement**, individual measurements are made uniformly at individual point on the door surface.



Loop measurement



Point measurement



Measurement plane

Each measurement generates the temporal average value for this point. All individual measurements are documented and then calculated together to form a common average value.

It should be noted with respect to both methods that turbulences arise at the edge area of the door in particular which influence the measurement results. For this reason, it should be ensured during the measurement that a small edge area of the door (top and sides) is not included in the averaging.

In addition, it should be noted that measuring devices with small, light vanes react more sensitively to these interferences. Vanes with 100 mm diameter react somewhat more inertly and are also affected less strongly by short-term fluctuations in the door flow-through.

However, it should be noted at the start of measurement that the vane must first be set in rotation by the air flow. When a constant flow velocity is shown, the measurement and the averaging can be executed.

Control velocity: 3 seconds

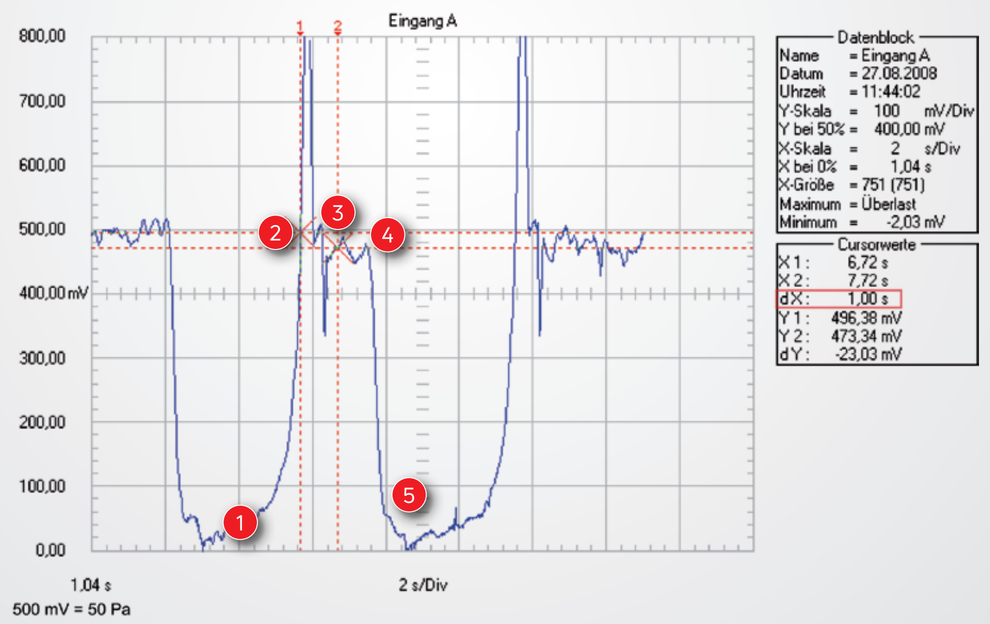
In order to test the requirement from DIN EN 12101-6, the control velocity of the fully installed differential pressure system must also be tested.

The required control velocity of 3 seconds applies on the one hand to the build-up of the flow velocity after the door to the fire level is opened with an activated safety exhaust-air unit.

As this measurement is an averaging process applied to the entire door section which requires at least 20 seconds to complete, only one measuring point can be used to test the control velocity. This measuring point can be in the middle of the door surface.

To execute the measurement, a fast-reacting measurement system, e.g. a small vane with a diameter of 20 mm, must be used. The vane is positioned at the measuring point with the door closed. Three seconds after the rapid opening of the door, the current flow velocity is read. A total of 90% of the target value must be reached.

The control velocity also applies to the door-closing process. In this case, the test is more simple. After the door has been fully opened and the velocity criterion has been reached, the door is allowed to shut by itself. Using a suitable measurement device, the pressure difference at the door is then measured 3 seconds after the door closes. This value must also reach 90% of the target value.



1 | Door closes after flow of air

2 | Differential pressure exceeds 50 Pa, pressure-controlling damper opens

3 | Control process ends after approx. 1 sec.

4 | Door reopens

5 | Controlling damper closes immediately, door air flow with full volume flow rate Volumenstrom

Pressure gradient in the test room with opened/closed door

B References


Photo: ADAC

We show you optimal system solutions even when our products are barely visible.

Modern buildings and historical edifices place their own demands on fire protection.

Regardless of the size of the property, an economical and effective implementation is required, one which can be integrated in the most inconspicuous way possible into the aesthetics of a building.

The following will provide an excerpt of references related to differential pressure systems and mechanical smoke extraction:

Properties in Germany	System	Building type	Protection area	Location
OASE Uniklinikum	DPS	Library	SC	Düsseldorf
DB-Zentrale FFM	DPS	Office building	FFL	Frankfurt
SIGN Hafenoffice	DPS	Office building	FFL	Düsseldorf
Bürogebäude Goebenstraße	DPS	Office building	SC	Cologne
Stadtsparkasse	DPS	Office building	SC	Erding
Villa Konrad-Adenauer-Ufer 101	SSPS	Office building	SC	Cologne
Ärztehaus	DPS	Office building	SC	Solingen
Hauptverwaltung ADAC	DPS	Office building	SC + FFL	Munich
OCCIDENS	DPS	Office building	SC + FFL	Frankfurt
Scheer Tower	DPS	Office building	SC + FFL	Saarbrücken
MaxCologne	DPS	Office building	SC + FFL	Cologne
Geschäftshaus Sevens	DPS	Commercial building	SC	Düsseldorf
Deka Herriot's	DPS	Commercial building	SC	Frankfurt
Geschäftshaus Partnachplatz	DPS	Commercial building	SC	Munich
Rewe-Markt	MSES	Commercial building	Sales	Hamburg
Hotel Aquasphere am Kurpark	DPS	Hotel	SC	Winterberg
Zugspitzbahn Zugspitze	DPS	Cogwheel Train	SC	Zugspitze

Properties in Germany	System	Building type	Protection area	Location
Kraftwerk 5, Irsching	DPS	Power station	SC	Irsching
Sächsisches KKH, Station B4	MSES	Hospital	Corridors	Rodewisch
Marienhausklinik	DPS	Hospital	SC	Bitburg
Klinikum Chemnitz gGmbH	DDA	Hospital	SC	Chemnitz
Dorothea Christiane Erxleben	DPS	Hospital	SC + corridor	Wernigerode
Zeche Zollverein, Halle 7	DPS	Museum	SC	Essen
Gemeindediakonie Mannheim, Margarete-Blarer-Haus	DPS	Nursing home	SC	Mannheim
Propapier PM2 GmbH	MSES	Production	Hall	Eisenhütten-stadt
ANNAX Anzeigesysteme GmbH	MSES	Production	Hall	Brunnthal
Pretema GmbH	SSPS	Production	Warehouse	Niefern
Gotthold-Epharaim-Lessing-Schule	DPS	School	SC	Pirna
Grundschule Jungingen	DPS	School	SC	Jungingen
Ditschhardt-Tunnel	DPS	Tunnel	Escape tunnel	Altenahr
B-10-Tunnelgruppe	DPS	Tunnel	Escape tunnel	Annweiler
Brenner, Zulauf Nord	DPS	Tunnel	Escape tunnel	Brenner
Lärmschutztunnel	DPS	Tunnel	Escape tunnel	Dußlingen
Josef-Deimer-Tunnel	DPS	Tunnel	Escape tunnel	Landshut
Tunnel U15, Zuffenhausen	DPS	Tunnel	SC	Zuffenhausen
Aula-Gebäude Universität	DPS	University	SC + FFL	Leipzig
Kulturhaus	MSES	Event building	Stage	Aue
Saalbau-Stadthalle Bergen	MSES	Event building	Event room	Frankfurt
Hochhaus Werderstraße	DPS	Residential building	SC	Heilbronn
Adalbert-Stifter-Weg	DPS	Residential building	SC	Chemnitz
Saporobogen	DPS	Residential building	SC	Munich
Karlstraße 6	DPS	Residential building	SC	Düsseldorf
Isar-Hochhaus	DPS	Residential building	SC + FFL	Munich
Betreutes Wohnen	DPS	Residential house	SC	Frankenthal

Properties in Switzerland	System	Building type	Protection area	Location
Prime Tower	DPS	Office building	SC + FFL	Zurich
Roche Bau 97	DPS	Chemical	SC + FFL	Basel
Novartis Ando Building	DPS	Administration building	SC	Basel

Properties in Poland	System	Building type	Protection area	Location
Biblioteka	DPS	Library	SC	Kielce
pozan Airport	DPS	Airport	SC	Ławica
Czerwona Góra Hospital	DPS	Hospital	SC	Czerwona Góra
Fast Tram	DPS	Tunnel	SC	Krakow

Properties in Austria	System	Building type	Protection area	Location
OeKB Strauchgasse	DPS	Bank	SC	Vienna
Geschäftshaus Raxstraße	DPS	Commerical building	SC	Vienna
Mode-Großhandels-Center MGC	DPS	Commerical building	SC + FFL	Vienna
Hotel Simmering	DPS	Hotel	SC	Vienna
GDK Kombinationskraftwerk	DPS	Power station	SC	Mellach
Time Travel Vienna	DPS	Museum	SC	Vienna
Steiererfrucht Fluchttunnel	DPS	Tunnel	Tunnel	St. Ruprecht an der Raab
Wohnhaus Grillparzerstraße	DPS	Residential building	SC	Vienna
Wohnhaus Gymnasiumstraße	DPS	Residential building	SC	Vienna
Palais Lichtenstein BB Palais	DPS	Residential building	SC	Vienna
Studentenwohnheim	DPS	Residential home	SC	Innsbruck
Krankenhaus Feldkirch	DPS	Hospital	SC	Feldkirch/Vlbg.
Uniqua Versicherung	DPS	Office building	Lift	Innsbruck
Arbeiterkammer	DPS	Office building	SC	Feldkirch/Vlbg.
Raiffeisenbank	DPS	Administration building	SC	Graz
König Abdulla Zentrum	DPS	Palais Sturany	SC + FFL	Vienna
Hanuschkrankenhaus	DPS	Hospital	SC + FFL	Vienna
Altenheim Turnergasse	DPS	Nursing home	SC + FFL	Vienna
Altenheim Seefeld	DPS	Nursing home	SC	Seefeld

Our technology is in these buildings

Prime Tower, Zurich

Prime Tower, Zurich

With approx. 3,500 occupants and a height of 126 m, the high-rise building contains three safety staircases and one firefighting lift. All safety staircases are equipped with differential pressure systems (DPS) in accordance with DIN EN 12101-6, System Class C. The DPSs of the staircases additionally feature a climate compensation unit.

This allows the system to be operated securely both in the winter and the summer. The exhaust air is discharged from the building in all storeys via smoke extraction windows located all around the facade. The smoke extraction windows are controlled via separate floor distributors.

Installed 2010/2011

Cable car station, Zugspitze

The 360° panorama on the peak of the Zugspitze is overwhelming. In favourable weather conditions, one can see a distance of 250 kilometres covering over 400 mountaintops in Germany, Austria, Switzerland and Italy. Enjoy Germany's highest mountain with all the senses: breathtaking views, alpine hikes up close to the rock and the eternal ice of Germany's largest glacier with an average of 4,000 tourists per day.


Cable car station, Zugspitze

Eibsee Cable Car Station

This cable car station contains a necessary staircase over a total of eight storeys and has a differential pressure system to secure its escapeand rescue route. Pressure is distributed in the staircase by means of a controlled supply-air fan with an integrated, automated controlling damper and a ventilation opening at the head of the staircase. The differential pressure system is controlled by means of its own control system, with cables continuously monitored for cable break and short circuits. Outside air is supplied by means of a snow-secure suspension shaft.

Installed 2011/2012

Highlight Business Towers, Munich

One Munich highlight is the "Highlight Business Towers". Both towers were planned by the architects Murphy and Jahn from Chicago. With the two 126 and 113 metre-high high-rise towers with 33 and 28 floors, the structure is an architecturally state-of-the-art business centre – a "highlight of glass and steel". Its four-storey forum contains a hotel with approx. 160 guest rooms. The premises offer over 700 parking spots on three basement levels. The Towers are among the highest buildings in Munich.
They previously possessed staircase ventilation units which were not acceptance-compliant. These have since been replaced with a Strulik differential pressure system suited to the buildings structural conditions. The supply of weight-loaded and pneumatically controlled dampers was replaced by automatic controlling dampers and fans. The differential pressure system was designed entirely to suit the building and to be acceptance-compliant.
Installed 2008

Highlight Business Towers, Munich

ADAC Main Building, Munich

ADAC, Munich

The building complex consists of five low building parts (height approx. 20 m) each with one or two safety staircases and a high-rise building (height approx. 90 m) with two safety staircases and a firefighting lift. All safety staircases are equipped with differential pressure systems (DPS) in accordance with DIN EN 12101-6, System Class C. The DPSs in the high-rise building additionally feature a climate compensation unit.
This allows the system to be operated securely both in the winter and the summer. The discharge of exhaust air is secured in all parts of the building by means of exhaust-air shafts, in the high-rise building by means of an exhaust-air unit.
Installed 2011

maxCologne, Cologne

maxCologne, Cologne

maxCologne has made its mark in cologne's architectural landscape: The building complex consists of two structural components: the Rhine floors and the high-riser. The high-riser and the Rhine floors have been completely renovated. The result was a 45,000 m2 rentable area for offices and restaurants fitting the standard of a new building.

The Rhine floors contain one safety staircase and one firefighting lift. The air-lock of the staircase partially leads to the lobby of the firefighting lift, at which additional passenger lifts are connected.

The pressure ventilation system of the staircase consists of two redundant supply-air fans, a vertical exhaust-air shaft with exhaust-air unit lead beyond the roof and various special solutions for securing the exhaust-air discharge in the lower floors. In these floors, the flow of exhaust-air is conducted to the underground car park. Two separate shafts with smoke extraction dampers have been installed in order to guarantee that no air-conducting connection exists between the escape route and the car park level on fire in the event of a fire in the underground car park.

maxCologne, Cologne

In addition to the shaft of the firefighting lift, the shaft of the passenger lift is also connected to the DPS. A list with defined operating conditions has been prepared for expert measurements.

The high-riser contains two safety staircases and one firefighting lift. Three self-sufficient DPSs have been installed for pressure ventilation. Exhaust air is discharged via vertical shafts with smoke extraction dampers in the floors with one exhaust-air unit each on the roof. Due to the height of the building, all DPSs are equipped with climate-compensating features. Settings are made on individual components of the DPSs depending on the outside temperature and the position of the fire level. The settings mainly have to do with the distribution of supply air in the staircase and the response behaviour of the exhaust-air unit. The maximum control velocity of the DPSs of 3 seconds is not affected by these measures.

All systems were planned and designed according to the requirements of MHHR 2008.

Installed 2012/2013

University Auditorium, Leipzig

The university auditorium in the Paulinum forms the intellectual and spiritual centre of the University of Leipzig. Architecturally suggestive of the demolished university church, the building will serve different purposes of university life, such as ceremonies, concerts and conventions, but also provide a space for non-university events. The architectural design was provided by „Erick van Egeraat associated architects" from Rotterdam. The auditorium has over 550 seats and 120 additional gallery seats as well as an oratory with a total of 130 seats. The upper floor accommodates the rooms for the Faculty of Mathematics and Computer Science. The basement level contains 1,170 bicycle parking spots. The building component „New Augusteum" closes off the inner-city campus in a structural interplay with the Paulinum in the direction of the Augustusplatz.


University Auditorium, Leipzig

DPS according to Model High-Rise Building Regulation

The supply-air system for the staircase and the firefighting lift could be designed in the standard way. Unusual and novel, however, is the solution for the secured exhaust air in the floors. Due to limited space, only a small exhaust-air duct leading to the roof could be provided for the staircase. The pressure loss of this duct with all the direction changes and installed components amounts to over 1,200 Pa (!). Two redundant smoke extraction fans designed in tandem are installed on the roof. The automatic pressure-controlling dampers tried and tested by Strulik have been integrated in each floor - in a bypass route between the staircase and the corridor – in combination with a smoke extraction damper. This concept was immediately operational with no additional adjustments to the building and fulfilled all expectations. The exhaust-air system of the firefighting lift is equipped with similar technology. In the scope of the planning phase, the concept was developed using computer simulations by the Dresden-based company INNIUS GTD in cooperation with Strulik.

Installed 2010/2011


Novartis Ando Building, Basel

Novartis Ando Building, Basel

A campus for knowledge and research has been created in St. Johann, Basel. For this structure, the Japanese architect used a triangular tract of land to the north of the campus near the French border. He wishes his architecture to express „both functional beauty and smoothness", thereby presenting a dignified image of the new, future-oriented Novartis. Novartis Pharma AG based in Basel is the patron of this architectural intention, which is to represent beauty and softness with a clear structure. The glassy facade, which represents a diamond, is not supporting, and is fixed at the roofs of the building floors. One exception is the eastern tip of the building, which forms a 20 degree angle. By leaving out the storey roofs, a light-flooded atrium arose over parts of three storeys.

The differential pressure systems for two staircases as well as for the firefighting lift are equipped according to DIN EN 12101-6, System Class C. The system is triggered by the fire detection system. In addition, there is a manual switch in the fire brigade control panel, with the exhaust air discharged via a lift shaft. Pressure discharge at the staircases was implemented in the form of a design created especially for this building.

Installed 2008

C Inquiry form - Differential pressure systems

1 Project data

Contact: ◯ Planner ◯ Contracting company ◯ Operator

Company:

Name:

Service:

Telephone/Fax:

Strulik representative:

Service expected of the Strulik company:

Consulting/planning support: Date:

Indicative quotation: Date:

Preparation of technical specifications: Date:

Submission of bid: Date:

Project: ◯ New building ◯ Renovation

Location:

Height above sea level [m]:

Designation:

Building owner:

Utilisation type:

Building permit:

Fire protection certificate:

Fire brigade requirements:

Fire protection certificate available: yes, from

Other comments:

2nd escape route available?

No. of storeys proper:

Height of highest common area above ground level:

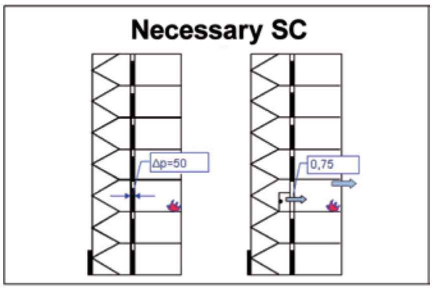
Differential pressure system: ◯ Safety staircase ◯ Necessary staircase

Other:

2 Definition of protection goal

2.1 Requirement according to building code or MHHR

◯ Necessary SC:

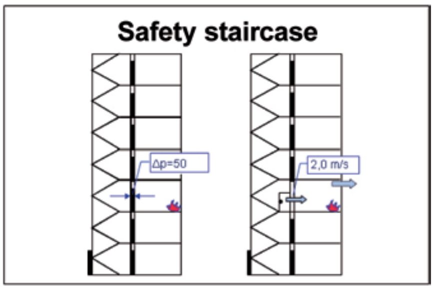


Air velocity in the door to fire storey:	0.75 m/s (1)
Exit door of pressure area with velocity criterion:	closed
Number of additionally open doors with velocity criterion:	0

(1) with manually opened exhaust air channel only

Necessary staircases must not according to MBO be endangered by the entry of smoke for a sufficient period of time. DPS can be used to compensate for missing air-locks.

◯ Safety staircase:

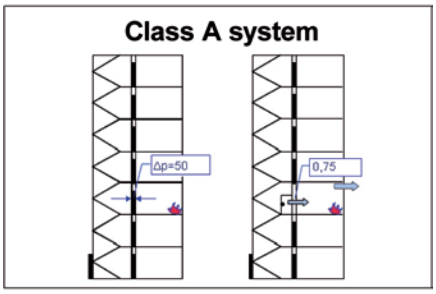


Air velocity in the door to fire storey:	2.0 m/s
Exit door of pressure area with velocity criterion:	closed
Number of additionally open doors with velocity criterion:	0

According to MBO, fire and smoke may not be able to penetrate into a safety staircase. A second rescue route is not available. The staircase is the action route of the fire brigade.

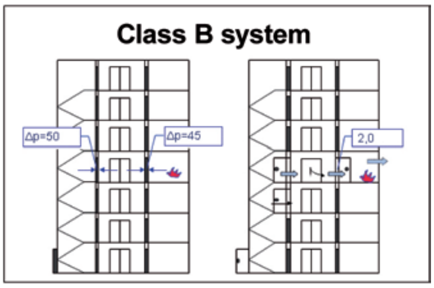
2.2 System selection acc. to DIN EN 12101-6

◯ Class A system



Air velocity in the door to fire storey:	0.75 m/s
Exit door of pressure area with velocity criterion:	closed
Number of additionally open doors with velocity criterion:	0

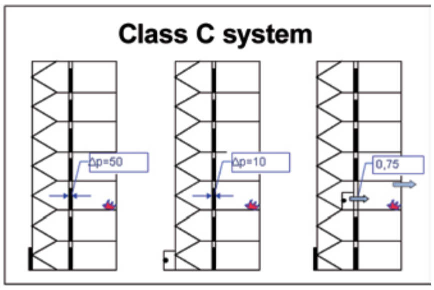
◯ Class B system:



Air velocity in the door to fire storey:	2.0 m/s
Exit door of pressure area with velocity criterion:	open
Number of additionally open doors with velocity criterion:	1

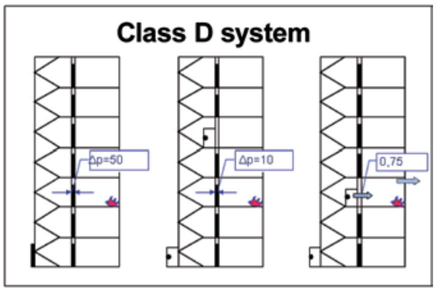
◯ Class C system:

Air velocity in the door to fire storey:	0.75 m/s
Exit door of pressure area with velocity criterion:	closed
Number of additionally open doors with velocity criterion:	0
Exit door of pressure room with 2nd pressure criterion:	open
Number of additionally open doors with 2nd pressure criterion:	0



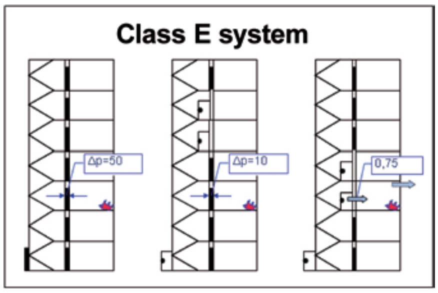
◯ Class D system:

Air velocity in the door to fire storey:	0.75 m/s
Exit door of pressure area with velocity criterion:	open
Number of additionally open doors with velocity criterion:	1
Exit door of pressure room with 2nd pressure criterion:	open
Number of additionally open doors with 2nd pressure criterion:	1



◯ Class E system:

Air velocity in the door to fire storey:	0.75 m/s
Exit door of pressure area with velocity criterion:	open
Number of additionally open doors with velocity criterion:	1
Exit door of pressure room with 2nd pressure criterion:	open
Number of additionally open doors with 2nd pressure criterion:	2



3 Property specifications and technology

3.1 Activation of system

◯ Automatic activation, without manual activation

◯ Automatic activation, with manual activation

◯ Fire-detection system in building available or in planning

◯ Without fire-detection system, smoke detection by EKS control

For smoke detection by EKS:

◯ Alarm areas per storey, quantity: ____________________

◯ Alarm/signal horns, quantity: ____________________

◯ Flashing alarm/signal lights, quantity: ____________________

◯ Push-button alarms, quantity: ____________________

Installation location, EKS control unit: ____________________

e.g. fan room, independent F90 room, technical control centre in upper floor (F90 cabinet)

3.2 Installation and configuration of supply-air fan

- ◯ Installation within protection area
- ◯ Outside protection area in separate installation room
- ◯ Outside building

3.3 Air inflow

- ◯ Free air-intake
- ◯ Suction-side channel, pressure loss: ____________________

3.4 Exhaust air from utilisation to door flow-through

- ◯ Via roof
- ◯ Facade
- ◯ Natural
- ◯ Mechanical
- ◯ Vertical shaft with smoke extraction dampers
- ◯ Slotted windows, at least 2 per alarm area per storey
- ◯ Other solution: ____________________

3.5 Pressure-relief at pressure area

- ◯ Via roof
- ◯ Facade
- ◯ With ventilation function
- ◯ Other solution: ____________________

3.6 Special notes for further processing

____

____

4 Structures

4.1 Staircases with differential pressure systems

No. of staircases: ◯ underground ◯ underground linked to underground car park

Storey height:

No. of storeys:

Width of flight of stairs:

Stairwell width:

Upstream air-lock/corridor:

Handrail design: ◯ filigree ◯ closed ◯ none ◯ Stairwell as concrete slab

4.2 Doors with protection goal at pressure area

Doors: ◯ T0 ◯ T30 ◯ T30 RS

No. of doors with simultaneous flow-through:

Dimensions of rough opening W x H:

Dimensions of door leaf W x H:

Double-leaf doors: ◯ 1 door leaf open ◯ 2 door leaves open

4.3 Air-lock flow-through

Air flow through air-locks: yes:

Pressure-relief openings: yes:

4.4 Exit door from pressure area to outside (escape route)

No. of consecutive doors:

Dimensions of rough opening W x H:

Dimensions of door leaf W x H:

4.5 Special notes for further processing

4.6 Leaks

4.6.1 Doors at pressure area

Doors: ◯ T0 ◯ T30 ◯ T30 RS

No. of doors:

Single-leaf door which opens into the pressure area:

Single-leaf door which opens from out of the pressure area:

Double-leaf door:

Smoke protection door, single-leaf:

Smoke protection door, double-leaf:

4.6.2 Windows at pressure area

Dimensions of casement W x H:

Quantity:

4.7 Other leaks

If the leak is not referred to in DIN EN 12101-6, determine the recognisable gap width and length if possible.

4.8 Special notes for further processing

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