

Smoke and Heat Ventilation Systems

RWAupdate



Planning aids

Natural smoke ventilation through facades and roofs

ZVEI:

Specialist group
for electrically driven
smoke ventilation
and natural ventilation





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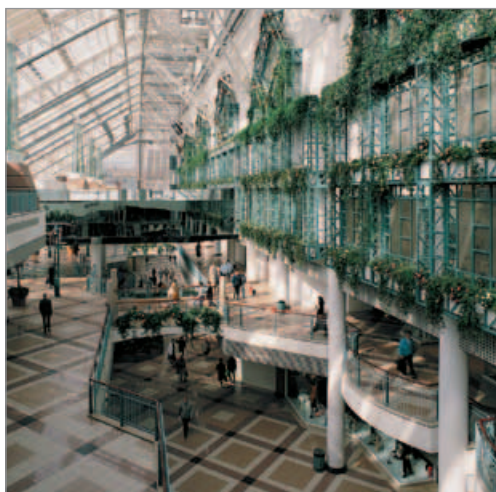
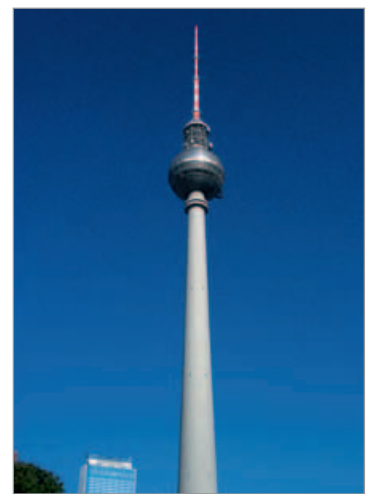
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Natural smoke ventilation through facades and roofs



Natural smoke
ventilation through
facades and roofs



Natural smoke
ventilation through
facades and roofs

The right solution for every building

The combustion products such as smoke, heat and hot conflagration gases generated during a fire rise upwards in rooms and form a layer of smoke and conflagration gases below the ceiling. This layer of smoke gas increases in density the longer the fire continues and fills the space within just a short period of time. With the help of a natural smoke ventilation system it is possible, using the principle of thermal lift, to get this layer transported directly out into the open air while it is still in the development phase. Replacement inlet air enables the mass flow to be compensated and also improves the thermal lift effect (chimney effect).

Different types of smoke and heat ventilation openings are possible depending on the type of building and architecture. For buildings with flat roofs the smoke and heat ventilation openings can take the form of dome lights, rows of windows or glass pyramids. Buildings with pitched roofs or shed roofs can be provided with bottom hung ventilators. Smoke and heat ventilation openings are most frequently installed in the exterior walls and have a wide variety of sash types. In order to achieve optimum natural smoke ventilation, consideration must be given to the size, type and arrangement of the opening elements.

What is important is that the smoke gases can escape from the building to the open air with as little hindrance as possible. The outflow must not be hindered either by the window sashes themselves or any other features of the building – such as projecting walls, stairwells, ventilation ducts, etc.

Excellent examples for well-designed smoke and heat ventilation systems in major buildings of the last few decades include the Commerzbank high-rise building in Frankfurt am Main and the Alexanderplatz radio tower in Berlin.



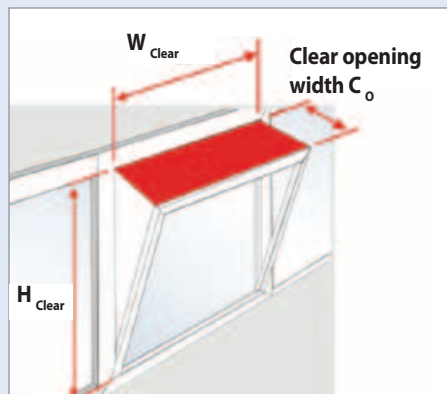
Natural smoke ventilation through facades and roofs



Aerodynamic and geometric opening area

In dependency on the basis for the planning work, a distinction is made between the aerodynamic and the geometric opening area. It is important to establish at the outset in the planning phase which method is to be used for determining the smoke and heat ventilation areas for further design work. Requirements in respect of smoke removal systems (e.g. in stairwells) generally require a geometric opening. The requirement for an aerodynamic opening area, on the other hand, presupposes the use of a smoke ventilation system and hence a natural smoke and heat exhaust ventilator.

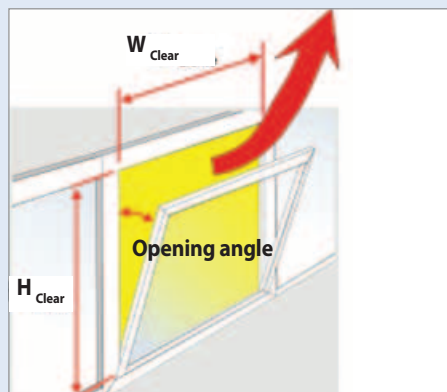
The German standard building regulations and associated state building regulations generally require a geometric ventilation area for the removal of smoke from stairwells, elevator shafts and basements in buildings. This value can be determined in advance on the basis of the following diagram. The available geometric opening area is determined by taking direct measurements on the available smoke and heat ventilation opening.



$$A \text{ (geometric area)} = C_o \cdot W_{\text{Clear}}$$

Where the opening angle is greater than 60°, the calculated value “A” should be used for the maximum clear opening area of the window. The maximum area can only be smaller than or equal to the clear area: $W_{\text{Clear}} \cdot H_{\text{Clear}}$

For the smoke vents which are required especially for special types of building or for fire protection strategies it is necessary for the aerodynamic opening area to be calculated. This requires the experimental determination of a flow rate coefficient, as stipulated in EN 12101 Part 2, which allows the aerodynamic opening area to be calculated as follows:



$$A_a \text{ (aerodynamic area)} = W_{\text{Clear}} \cdot H_{\text{Clear}} \cdot C_{v0}$$

C_{v0} = Experimentally proven flow rate coefficient in dependency on the opening angle and window geometry.

Fixtures installed in the opening on the wall which is a statutory requirement under building regulations will have an influence on the flow rate and this change must be accounted for by a coefficient.



Supporting regulations:

- EMC and low voltage directive for the electric drive unit used.
- Machinery directives and German trade association guidelines BGR232.
See also the ZVEI publication “RWAupdate 3” for power-operated windows.
- Standard cable system directive (Musterleitungsanlagenrichtlinie [MLAR]) for the maintenance of electric cable function.

**DIN 18232 Part 2**

“This standard applies to the design and installation of natural smoke ventilation systems for rooms with vertical smoke ventilation through the roof by thermal lift as described in DIN 18232-1 for single-storey buildings and the top storey of multi-storey buildings. In addition this standard provides informative notes for the design and installation of natural smoke ventilation systems for rooms with smoke ventilation through the exterior walls. This standard contains tables and calculation methods for designing low-smoke layers to comply with the requirements for various safety targets. This standard contains notes and definitions that must be complied with when using these design rules and for the installation of natural smoke ventilation systems.”

Note:

The regulations in building regulations relating to smoke ventilation systems, for example in the form of smoke ventilation openings of a specific size in staircases or at a specific distance from fire walls, are not affected by this. Special verifications are required for deviations from this standard.“ (Original text of DIN 18232 Part 2)

The range of applications within DIN 18232 Part 2, now enables the planning and design of smoke ventilation systems through vertical surfaces in buildings to a standard. This method, which has been acknowledged for decades and used successfully in many thousands of projects in that time, is reflected in the standard.



Natural smoke
ventilation through
facades and roofs



Terminology definitions

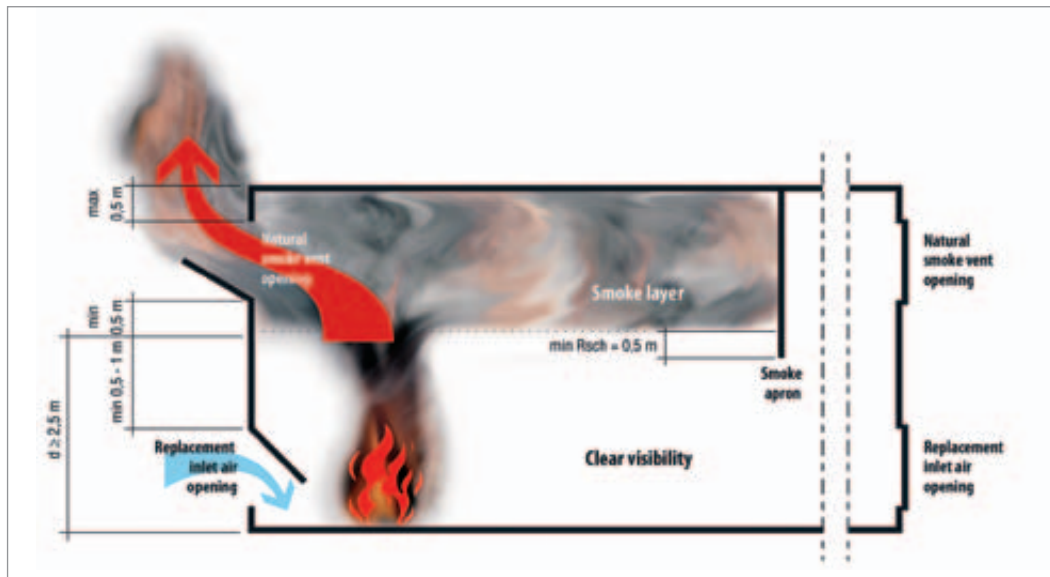
Smoke section area A_R

The building is split into sections. These are split into smoke section areas A_R where possible and necessary. As a rule the maximum A_R is 1600 m². Larger smoke section areas are possible, but in this case the aerodynamic smoke ventilation area A_w must be increased in size by 10% of the 1600 m² of the A_R area for every additional 100 m² of area. The resulting smoke section areas are separated from each other by smoke aprons. The appropriate rules governing the use of smoke aprons are also set out in DIN 18232 Part 2.

$$A_R \leq 1600 \text{ m}^2$$

$A_R > 1600 \text{ m}^2 \Rightarrow$ Division with smoke aprons

1600 m² < A_R < 2500 m² is possible if, for every additional 100 m² of A_R , A_w is increased by 10% of A_w 1600



Low-smoke layer d

The low-smoke layer should be at least $d = 2.5 \text{ m}$.

Fire development time

To define the required smoke ventilation area A_w in DIN 18232 Part 2, a fire development time is defined, which applies exclusively for the needs of this standard. This is made up of two times – first of all the time from the fire creation to the fire alarm and then the time from the fire alarm to the actual fire fighting. The appropriate details are provided in section 5.6 of the standard, and on the basis of these details is possible to calculate the fire development time required for a specific project.

Fire spreading rate

In addition to the fire development time a fire spreading rate is also defined. This contains an assessment of the expected fire on the basis of the substances stored in the area, the presence of a sprinkler system.





Design groups

In order to determine the design group required for the A_w value, the following conditions which have been determined to date can be used from Table 2 “Design groups”.

Table 2: Design groups

Expected fire development time	Design group for a fire spreading rate		
	Particularly low	Medium ^a	Particularly high
≤ 5 Minutes	1	2	3
≤ 10 Minutes	2	3	4
≤ 15 Minutes	3	4	5
≤ 20 Minutes ^a	4	5	5 ^b
> 20 Minutes	5	5 ^b	5 ^b

a) Average values without special verification; if these average values are used they require design group 5.
b) In these cases the safety aims of this standard cannot be achieved solely by the natural smoke ventilation system. Other measures are required to achieve the safety aims.

Smoke ventilation area A_w

The smoke ventilation area per smoke section is found using the design group, room height and the height of the low-smoke layer from the corresponding Table 3 from DIN 18232 Part 2: This full smoke ventilation area is then split into an appropriate number of façade openings (natural smoke ventilators) using the corresponding regulations provided by the standard. The facade openings formed in this way should be installed with a maximum distance from the top of the facade opening to the ceiling of 0.50 m in at least two facing exterior walls in a smoke section. The facade openings should be completely inside the smoke layer; the bottom of the discharge opening should be at least 0.5 m above the limit of the calculated low-smoke layer (as shown in Table 3, DIN 18232 Part 2).

Air supply area A_{zu}

The air supply areas must be fully contained in the low-smoke layer. The top of the air supply opening must be at least 1 m away from the smoke layer limit. This distance may be reduced to 0.5 m around doors or windows with a maximum width of 1.25 m. In any event it must be ensured that the incoming air does not stream straight into the layer of smoke gas and that this impulse does not cause any eddying of the smoke gas. The air supply must be fed into the building close to the floor and as far away as possible from the smoke gas layer.

Air supply areas are calculated as follows:

Air supply area $A_{zu} = 1.5 A_w$ of the largest A_R

The opening angles set out in Table 3 of the standard (page 10) are subject to a maximum tolerance of $\pm 5^\circ$. This means that the air supply area for each air inlet is calculated as follows:

$$A_{zu} = a \cdot b \cdot c_z$$



**Table 3: Correction factors c_z for different types of openings in air supply openings**

Opening type	Opening angle	Correction factor c_z
Door or gate openings, machine grilles		0.7
Opening louvers	90°	0.65
Turn or tilt leaf	90°	0.65
Turn or tilt leaf	≥ 60°	0.5
Turn or tilt leaf	≥ 45°	0.4
Turn or tilt leaf	≥ 30°	0.3
The standard regards a turning leaf as identical to a tilting leaf.		

The following are regarded as air supply openings:

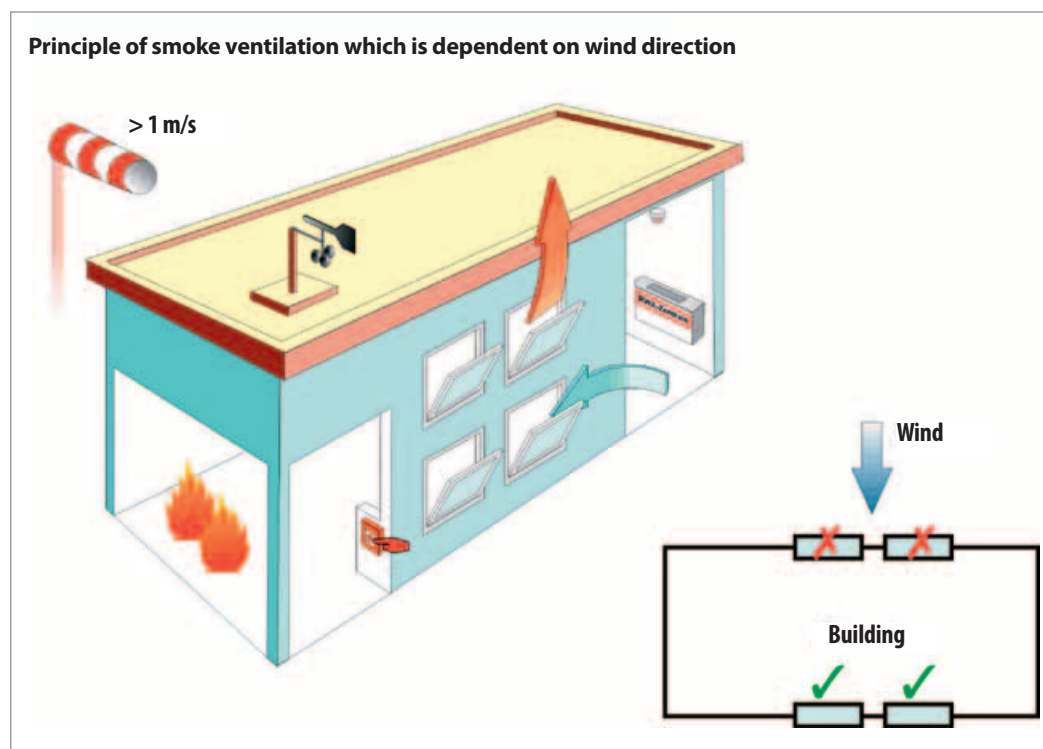
Independent air supply devices, gates, doors or windows if they are labeled on the inside and outside as air supply openings for natural smoke ventilation systems using signs that comply with DIN 4066 and can be opened from the outside without being destroyed (for example no breaking of window panes or demolishing of wall or gate areas). This does not apply if the plant fire service can create the appropriate air supply openings. It must be possible for the supply areas to be opened immediately (e.g. automatically by the smoke and heat ventilation system controller, by the plant fire service, by operational or organizational precautions) after the natural smoke ventilation system has been operated.





Actuation in windy conditions

The spread and ventilation of smoke gases depends to a large extent on the air flow in the room, especially when the fire is initially developing. The room air flow, in turn, is among other things influenced by the exterior wind pressure distribution on the natural smoke ventilation and air supply areas. This means that the influence of the wind must be taken into consideration for smoke ventilation through facades. In the studies and calculations used as the basis for the standard, a reference speed of smooth air flow of 3.7 m/s was used. This value corresponds to the annual mean value of the wind speed in many parts of Germany measured at a height of 10 m. The studies show that the opening of the natural smoke ventilation and air supply areas in the side walls, which is dependent on the wind direction, is unavoidable. The smoke ventilation area found in this way should be installed in at least two facing exterior walls in a smoke section.



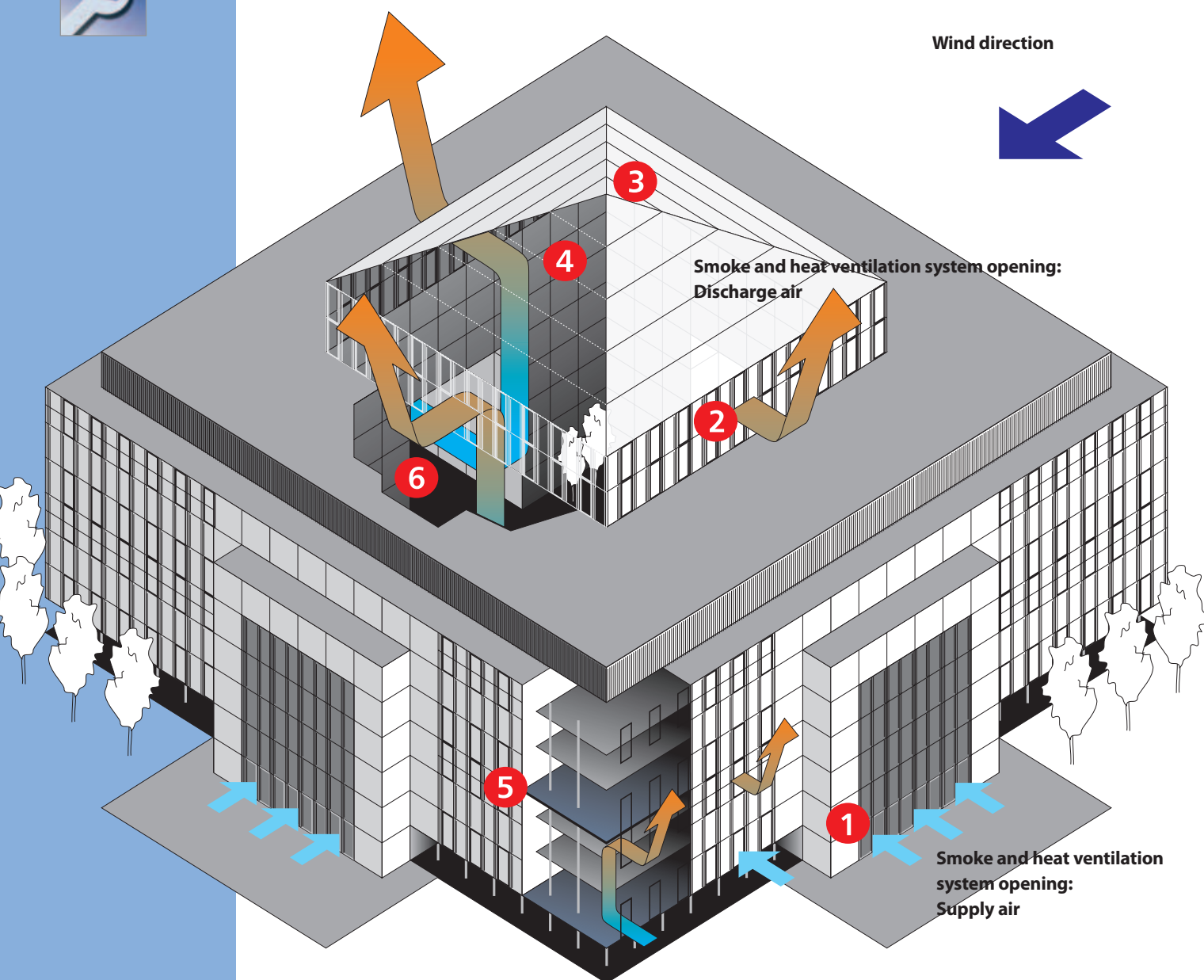
Summary

Effective smoke ventilation requires that a difference in pressure between the smoke section and its surrounding area be achieved. A fire generates a fire-related aerostatic difference in pressure, which provides the basis for natural smoke ventilation. The influences of wind along the building can interfere with this natural difference in pressure, so it is essential that these influences be given close consideration for any buildings in exposed locations.





Implementation using innovative system components



System benefits

- The main benefit is the combination of the smoke and heat ventilation functions in the event of a fire as well as every day natural ventilation.
- The ZVEI smoke and heat ventilation system manufacturer or ZVEI installer acts as an integrator for both functions and offers a low cost complete solution.
- The exchange of data with other systems using the building control system and bus systems allows the full use of data and enables complex system solutions to be produced.
- The electric smoke and heat ventilation system has a self-monitoring and diagnostic system and reports and faults automatically.
- If the building is extended or undergoes a change of use, the electric smoke and heat ventilation system can be adjusted flexibly.



Innovative technology

Electric motor driven systems for smoke and heat ventilation systems offer the perfect solution, particularly for smoke ventilation through building façades operating windows, vents and louvres in exterior walls. The following is a description of the most common system components.



Electrical manual control device

The electric manual control device provides for manual operation of the smoke and heat vent system. It also indicates the operating condition of the system.



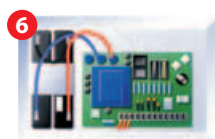
Electro-mechanical drive units

Infinite, precise opening of smoke and heat ventilation and normal ventilation flaps. A function test of the drive units is possible at any time without any material loss. The construction and design allow flexible adjustment to all window and frame profiles and flexible installation methods with all profile systems. A response relating to the status of the opening (open/closed or the precise position of individual drive units or drive unit groups) is possible, for example for evaluation or actuation by the building control system.



Automatic alarms and sensors

The actuation of smoke and heat ventilation openings may depend on the wind direction so that in the event of a fire the side of the building that is sheltered from the wind is used to ventilate the smoke. Smoke sensors, temperature sensors or differential thermal sensors are designed to detect a fire quickly and to trip the smoke ventilation system automatically. There is a range of sensors and alarms for safety functions or for providing convenient natural ventilation. Wind and rain sensors, temperature sensors and controllers are used to control ventilation systems and monitor the weather automatically. Sensors from other systems can also be used by the building control system for controlling smoke and heat ventilation and natural ventilation systems.



Electrical control

The control has two independent power supplies (mains and battery), which maintain operation in every situation. The functional reliability of the cables and switching devices is monitored. In the event of a fire the system is switched quickly using the characteristic smoke value by automatic fire sensors or by means of actuation using an external fire alarm system. There is also a large number of deluxe ventilation functions available, such as automatic, time-limited ventilation or lifting limits in ventilation mode to provide for practical every day ventilation.

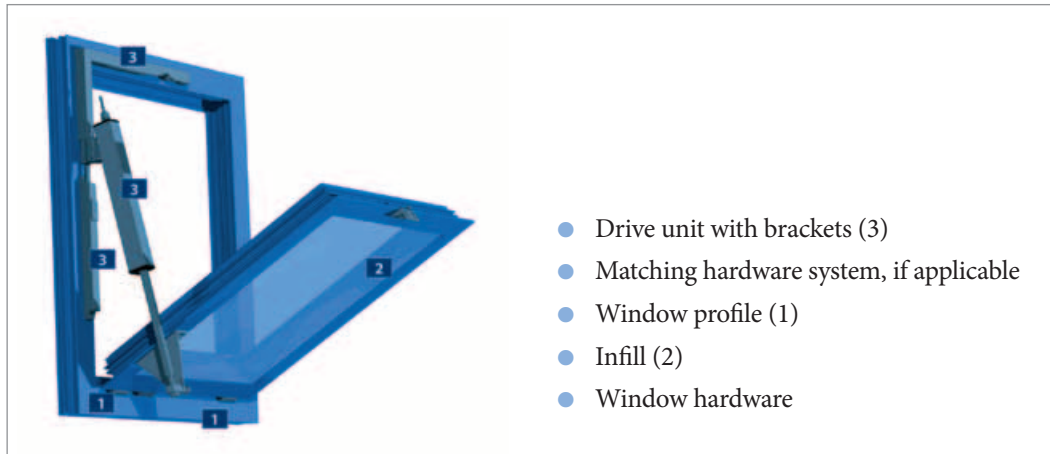


Natural smoke ventilation through façades and roofs



Natural smoke and heat ventilation ventilators

Natural smoke and heat ventilation ventilators are designed to ventilate smoke and hot gases from buildings in the event of fire. According to EN 12101 Part 2, these building products comprise the following components:



Smoke ventilation versus smoke removal

The term smoke ventilation refers to the process of evacuating hot smoke and gases from a building in the event of a fire. A stable, low-smoke layer is created close to the floor, which makes it possible to use escape and rescue routes in safety. It is a mandatory requirement in Germany that a natural smoke and heat ventilation device in accordance with EN 12101 – Part 2 must be installed wherever natural “smoke ventilation” is required under building regulations.

The purpose of smoke removal is cold smoke ventilation, which is for removing any smoke remaining in the building after a fire. The device used here is a building product without any safety relevance and which is listed in Building Rules List C.

Natural smoke ventilation opening devices

All conventional window types can be controlled using opening devices that have been time-tested in use for many years. The following electric motor systems dominate this field:

- Direct openers with rack, spindle or chain drive units
- Scissor drive systems

Depending on the size and weight of the leaf and its installation position, additional mechanical interlocks are used in combination with these systems so that the leafs can be adequately secured against driving rain and wind loads.

Supporting regulations

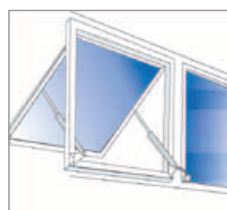
- For power-operated windows, see German trade association guidelines BGR 232 and the ZVEI publication “RWAupdate 3”
- Maintenance of electric cable function, see specimen cable system directive (MLAR), which has now come into force in all states in Germany.



Natural smoke ventilation opening types



1 Top hung opening outwards at bottom
With linear drive unit



2 Top hung opening outwards at bottom
Tandem with linear drive units



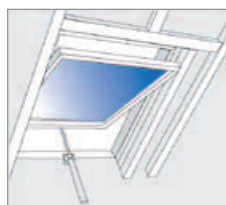
3 Roof window opening outwards at bottom
Tandem with linear drive units



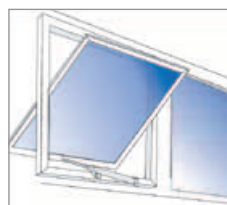
4 Top hung opening outwards at bottom
With chain drive unit



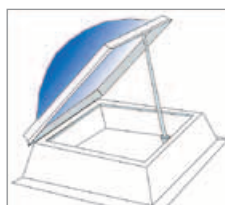
5 Top hung opening inwards at bottom
With chain drive unit



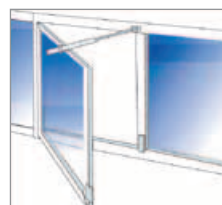
6 Flat window on pitched roof opening outwards
at bottom. With linear drive unit



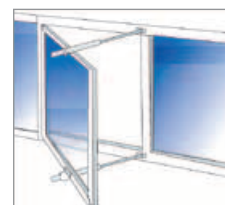
7 Horizontal center pivot opening outwards at
bottom. With linear drive unit



8 Dome light with linear drive unit



9 Side hung opening inwards
With linear drive unit and stop magnet



10 Side hung opening inwards
Tandem with linear drive units



11 Side hung opening inwards
With chain drive unit



12 Bottom hung opening outwards at top
With linear drive unit



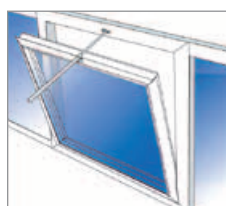
13 Bottom hung opening outwards at top
With chain drive unit



14 Bottom hung opening outwards at top
Tandem with linear drive units



15 Bottom hung opening outwards at top
Tandem with linear drive units



16 Bottom hung opening inwards at top
With linear drive units



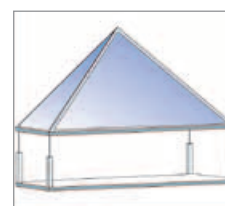
17 Bottom hung opening inwards at top
With chain drive unit



18 Bottom hung opening inwards at top
Tandem with linear drive unit



19 Bottom hung opening inwards at top
Tandem with linear drive units + auxiliary lock



20 Glass pyramid with 4 synchronized drive units
(support structure provided by owner)



21 Louver windows with louver drive unit



22 Parallel vent windows with 4 chain drive units

Summary:

In relation to the saving of lives and material, smoke and heat ventilation systems are an indispensable necessity. The installation of a smoke and heat ventilation system is the only way of averting the dangers of smoke and conflagration gases. It is not without good reason that the requirement for smoke and heat ventilation systems is stipulated in all the building regulations in the Federal Republic of Germany. Finally it should also not be forgotten that every electric motor driven system for smoke and heat ventilation offers the added advantage of daily ventilation. The member firms of the ZVEI specialist group for safety systems and their specialist installers will be pleased to help you whenever needed with the design and installation of smoke and heat ventilation systems specifically tailored to your building scheme. A list of manufacturers is available from the ZVEI. You will find your specialist ZVEI firm at: www.ZVEI.org/sicherheitssysteme or www.ZVEI-errichter.de



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More publications are available
from your specialist ZVEI firm or
direct from the ZVEI.



All publications are also available in German.

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