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Smoke and heat control systems

Part 11: Horizontal flow powered ventilation systems for enclosed car parks

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

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

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Rauch- und Wärmefreihaltung - Teil 11: Rauchfreihaltung von Parkhäusern

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European foreword

This document (CEN/TS 12101-11:2022) has been prepared by Technical Committee CEN/TC 191 “Fixed firefighting systems”, the secretariat of which is held by BSI.

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Introduction

0.1 General

The requirements in this document are provided for powered smoke and heat control systems installed in car parks with or without sprinkler protection.

Modern cars are generally larger than their predecessors and contain a larger quantity of flammable materials, in particular plastics, which results in an increase of heat and smoke output from burning cars. Consequently, the design fires recommended in this document are larger and have a greater heat and smoke output than those in some previous guidance.

0.2 Purposes of smoke control systems

Smoke control systems can be generally designed for one or more of three purposes in the event of a fire:

— to protect means of escape from the car park;

— to provide an access sufficiently free of smoke for fire-fighters to a point close to the seat of the fire;

— to assist fire-fighters to clear smoke from a car park.

The system requirements will differ depending upon the purpose. Not all types of ventilation systems are suitable for all purposes.

This document only covers smoke control systems which are intended to provide an access sufficiently free of smoke for fire-fighters.

0.3 Smoke control systems to provide an access sufficiently free of smoke for fire-fighters

This document deals only with horizontal flow powered ventilation systems.

The following systems are not covered by this document however, they are briefly discussed here:

— Horizontal natural ventilation - These systems may be suitable for open car parks, where at each level, ventilation openings are located on at least two opposite façades. The size of the ventilation openings will need to meet the relevant national regulations.

  — SHEVS – These systems are covered by the recommendations of CEN/TR 12101-5 for steady-state design fires or prCEN/TR 12101-12 (under development) for time-dependent design fires. Hot smoky gases from a fire rise up to the ceiling, where it spread to form a smoke layer above the denser cold air beneath. SHEVS, which may be natural or powered, are designed and sized to maintain conditions beneath the smoke layer that allow evacuation and/or firefighting operations. Such a system requires a sufficient height from the ceiling to the floor.

  — Smoke dilution systems – These systems are based on powered ventilation with air change rates which are significantly lower than these required for mechanical SHEVS. Smoke dilution systems are meant to reduce smoke concentration and temperature, and increase visibility, during the fire. In addition, it can assist firefighters to clear the smoke after the fire. They are not suitable to create smoke free areas during fire.

0.4 Effects of sprinklers

The main effects of sprinklers is to prevent fire spread to adjacent cars. This is reflected in the design fire sizes recommended for car parks with and without sprinklers. A further effect of sprinklers is to reduce the average temperature of the smoke.

Sprinklers are considered to have no negative effect on smoke ventilation systems in car parks.

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Measures to avoid possible negative effects of smoke ventilation systems on sprinklers efficiency are taken into account in this document.

0.5 Horizontal flow powered ventilation systems

When the hot gases from the fire reach the ceiling due to buoyancy, it create a relatively rapid gas flow spreading in every horizontal direction, in a shallow layer beneath the ceiling surface, which is called ceiling jet.

The aim of horizontal flow powered smoke ventilation is to oppose the ceiling jet generated by the fire, so that the upstream smoke propagation is limited.

This document is intended to describe the conditions to be fulfilled by a horizontal flow powered smoke ventilation system to provide an access path sufficiently clear of smoke to allow fire-fighters to reach a point close to the fire for fire-fighting operations. The smoke ventilation system should rely on a smoke detection installation able to activate immediately the evacuation alarm of the car park in order that the evacuation is completed prior to the full activation of the smoke ventilation system, to avoid conditions which would be worse for escape.

NOTE 1 Activation of SHEVS at a lower velocity could be possible during evacuation.

The smoke detection installation should also be able to locate the origin of the fire, i.e. the first activated smoke detector, in order to:

— start the right activation sequence of the smoke ventilation system;

NOTE 2 In large or complex car parks, it is likely that the smoke ventilation system will need to be automatically configured to move the smoke in one of several directions, depending on the location of the fire (multiple extraction points, multiple air inlets and/or multiple access points for fire-fighters).

— inform the fire-fighters on the location of the fire to organize fire-fighting operations.

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1 Scope

This document gives minimum design, installation and commissioning requirements for powered smoke and heat control systems for enclosed car parks using horizontal flow powered ventilation, with or without sprinkler protection, on one or more levels, for cars and light commercial vehicles (max 3,5 t), to reach the design objectives outlined in this document .

This document is applicable for car parks with vehicles powered by petrol, diesel, electricity, CNG or LPG.

NOTE 1 For the purpose of this document for smoke ventilation systems, it is assumed that cars powered by electricity, CNG (compressed natural gas) or LPG (liquefied petroleum gas) will have similar HRR to vehicles powered by petrol or diesel.

NOTE 2 Cars powered by hydrogen are not covered by this document.

This document only covers traditional car parks that are with cars parked alongside each other, with common car access lanes. It does not cover other forms of car parking systems, such as stacking systems.

This document does not cover requirements for day-to-day ventilation.

Any other risks than fire from cars are not covered by this document.

2 Normative references

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

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

EN 12101-1, *Smoke and heat control systems - Part 1: Specification for smoke barriers*

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

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

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

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

EN 12259 (all parts), *Fixed firefighting systems - Components for sprinkler and water spray systems*

EN 12845, *Fixed firefighting systems - Automatic sprinkler systems - Design, installation and maintenance*

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

EN ISO 13350, *Fans - Performance testing of jet fans (ISO 13350)*

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3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

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

3.1 Terms

3.1.1
enclosed car park
covered parking areas for vehicles which are completely enclosed by walls or façades, with limited openings as defined by national authorities

3.1.2
access path sufficiently clear of smoke
path kept sufficiently free of smoke to allow the safe intervention of the rescue services from a smoke free entrance towards the fire

3.1.3
Computational Fluid Dynamics Model
CFD model
computer simulation model where the fundamental equations of momentum, energy and mass transfer are solved using numerical methods

3.1.4
activation sequence
sequence involving change of state (starting, stopping, opening, closing,…) of a well-defined set of equipment

Note 1 to entry: This sequence generally depends on the location of the fire and involves several types of equipment specific to fire safety or not.

3.1.5
activation zone
part of a car park defined by all the detectors initiating the same activation sequence

3.1.6
detection zone
all or part of an activation zone which is individually identified on the synoptic device

3.1.7
design fire
hypothetical fire having geometrical, thermal and smoke production characteristics which are sufficiently severe as a basis for the design of the smoke and heat control system

3.1.8
exhaust ventilation system
combination of exhaust ventilators, ducts, power supplies, and controls used to remove smoky gases from a car park

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3.1.9
extraction point
location of an intake opening to an exhaust ventilator, or to a duct which leads to an exhaust ventilator, where smoke is removed from a car park

3.1.10
fire compartment
enclosed space, comprising one or more separate spaces, limited by elements having a specified fire-resistance, intended to prevent the spread of fire out of the enclosed space for a given period of time

3.1.11
independent power source
electric power source which is independent of the source used in normal operation

3.1.12
lock-up garage
space within a car park, enclosed by solid walls, intended for one or two cars

3.1.13
replacement air
outside air entering a car park to replace smoky gases being removed by the smoke and heat control system

3.1.14
safety position
position (open or closed) into which specific projects may require certain devices (smoke control dampers, curtains, doors, etc.) to move, depending upon the fire location within the building

3.1.15
Smoke and Heat Exhaust Ventilation System
SHEVS
system in which components are jointly selected to exhaust smoke and heat in order to establish a buoyant layer of warm gases above cooler, cleaner air

3.2 Symbols

3.2.1 Latin upper case letters

Af	fire area
D	horizontal distance
F	opening force applied to a door handle
F_{dc}	door closer force at handle
H	door height
M	closing torque
M_s	particle smoke production
Q	volume flow rate of a jet fan
Q_c	convective heat release rate
Q_d	design air flow rate
Q_{in}	inlet flow rate

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Q_{min}	minimum flow rate
Q_{ref}	reference flow rate
Q_t	total heat release rate
S	zone area
T_{in}	ambient air temperature
W	door width
W_{CP}	width of the car park
W_{in}	opening width of air inlet
W_{ref}	reference width

3.2.2 Latin lower case letters

a	distance to handle
d	distance, diameter
h	height of car park
h_{in}	opening free height of air inlet
h_{ref}	reference height
l	thrust of a jet fan
q_c''	convective heat release rate
t	time
t_e	time delay before activating high air flow velocity
v	exhaust velocity of a jet fan
v_a	velocity downstream from a fire
v_{crit}	outlet velocity
v_{in}	velocity at air inlet
v_o	velocity upstream from a fire
v_o	start velocity of air stream
v_{ref}	reference velocity
v_x	air stream velocity at a distance x from a jet fan
w	width of a car park
x	throw length
y	horizontal spread of air stream from a jet fan

3.2.3 Greek upper case letters

Δ_{100N}	pressure difference needed to correspond to a maximum opening force F = 100N applied at the door handle

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3.2.4 Greek lower case letters

α	angle of spread for an air stream
χ_c	convective coefficient
ρ	air density
ρ_{in}	ambient air density

4 Design fires

4.1 Design principle

The smoke and heat control system is designed for a single fire at a time which is located at any point of an enclosed car park (parking space, access lane or ramp).

4.2 Heat release rate

The design value of the maximum total heat release rate Q_t, the convective coefficient χ_c and the maximum convective heat release rate Q_c are defined in Table 1.

Table 1 — Design values of the maximum total heat release rate Q_t

	Q_t [a]	Cooling effect of sprinklers on smoke	χ_c	Q_c
No sprinklers	10 MW [b]	-	0,65	6,5 MW
Sprinklers in conformity with EN 12259 (all parts) and EN 12845 (or equivalent standard)	4 MW [c]	0,5 [d]	0,65	1,3 MW

[a] The total heat release rate Q_t of the fire includes all the heat emitted by it including that radiated towards the walls. It is independent of the car park design. The heat release rate values given above are taken from fire tests measured on cars representative of late 1990s models.

[b] As there is a risk of fire propagation between cars when no sprinklers are present, the maximum total HRR Q_t = 10 MW corresponds to 3 burning cars during the most intense phase of the development of the fire (considering a time shift of the maximum HRR of each car).

[c] When there is a sprinklers installation, it is considered that only one single car is burning which corresponds to a maximum total HRR Q_t = 4 MW.

[d] When sprinklers are present, the cooling effect of the water from sprinklers on the smoke is taken into account by reducing the total HRR by 50 %.

For CFD calculations, the design fires evolution over time, its geometry and other additional information to be considered are given in Annex C.

5 Normative requirements

5.1 Design objectives

5.1.1 The objective of the horizontal flow powered smoke ventilation is to oppose the spreading of smoke in a chosen direction, so that the system keeps at least one access route sufficiently clear of smoke for fire-fighters from the exterior or from a protected access route (e.g. stairwell) to a distance of 15 m from the front of the fire (Figure 1).

NOTE The limit of 15 m is necessary to reach the fire with the jet from the hose nozzle.

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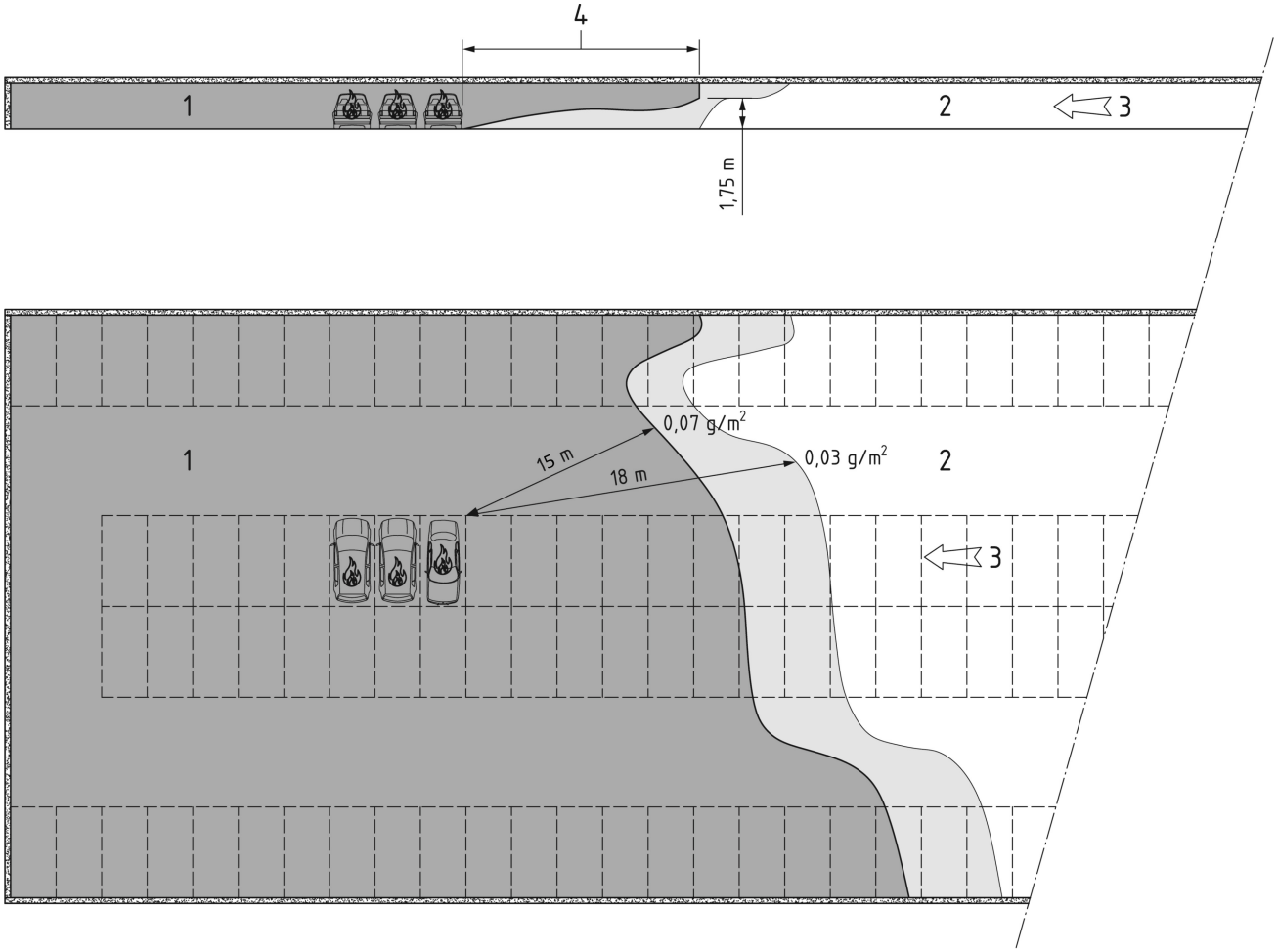
Criteria should be verified when the conditions within the car park have reached a steady-state regime.



Key

1 area filled with smoke
2 area free of smoke
3 direction of ventilation
4 15 m area filled with smoke

Figure 1 — Access path sufficiently clear of smoke (car park with sprinklers)

5.1.2 The propagation of smoke downstream from the fire to the most distant extraction point activated by the corresponding activation sequence shall not exceed 200 m.

5.1.3 In case of design based on CFD calculation, an access route for fire fighters is considered as sufficiently clear of smoke (Figure 1) if the following conditions are met up to a height of at least 1,75 m from the floor and on a width not less than 5 m, or on the total width between walls if it is less than 5 m, 5 min after the time at which the fire has reached its maximum HRR according to Figure C.2:

— The calculated smoke concentration does not exceed 0,03 g/m³ from the access to a distance of 18 m from the front of the fire.

— The calculated smoke concentration does not exceed 0,07 g/m³ at a distance of 15 m from the front of the fire.

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5.1.4 The velocity of air within air openings which are used for escape should not exceed 5 m/s.

NOTE An air velocity above 5 m/s makes it too difficult to evacuate the occupants.

5.1.5 The force needed to open escape doors shall not exceed 100 Newton (see also 8.2 and D.5), to allow the occupants to evacuate the car park safely.

5.1.6 When jet fans are used, the mass flow rate extracted by the powered smoke and heat exhaust ventilators (i.e. the main extract fans) should exceed the total mass flow rate of air and smoke induced by the jet fans system.

This is intended to avoid recirculation of smoke causing the fire-fighter access to become smoke logged and to avoid overpressure in the car park and shall be verified when Annex C is applied. Jet fans systems designed according to Annex B fulfill this condition.

5.1.7 When jet fans are used, the location and direction of thrust of jet fans should be coordinated with the location of any stairwell, lobby and/or corridor doors to avoid exposing the doors to dynamic pressure effects which might cause smoke to pass through the doors.

5.2 Design solutions

To meet the design objectives, one of the following three methods can be adopted:

— Simplified design without jet fans according to Annex A.

— Simplified design with jet fans according to Annex B.

— A design verified by CFD calculations according to Annex C.

5.3 Activation sequence

5.3.1 An addressable automatic smoke detection system shall be installed to activate the system.

— Activation sequences define the changes of state of the system's devices depending on the location of the first activated smoke detector.

— Activation zones are part of a car park where all the detectors initiate the same activation sequence.

5.3.2 The activation sequence of the smoke control installation starts when the smoke detection is confirmed. This confirmation corresponds to t = 0.

NOTE A smoke detection is confirmed when either a second smoke detector or a push-button or a sprinklers flow-switch is activated.

5.3.3 The evacuation alarm in the car park must have been switched on not later than t = 0.

NOTE The evacuation alarm is switched on as soon as the detection is confirmed unless otherwise specified by the authority having jurisdiction.

5.3.4 When day to day ventilation is present in the car park, it shall be automatically switched off at t = 0.

5.3.5 An horizontal flow powered ventilation system generating a high airflow velocity may have a negative effect on stratification of the smoke layer, and create unsafe conditions for occupants trying to escape. Therefore, a time delay t_e before activating high airflow velocity shall be defined to allow the occupants to evacuate the car park safely.

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5.3.6 The time delay t_e = 3 min unless otherwise specified by the authority having jurisdiction. When sprinklers are present in the car park, the time delay t_e shall be extended until a sprinklers water flow alarm switch or a smoke detector at another level (than the first activated smoke detector) is activated, whichever occurs first.

The response time of the sprinklers system should be short enough to allow the activation sequence of the smoke evacuation.

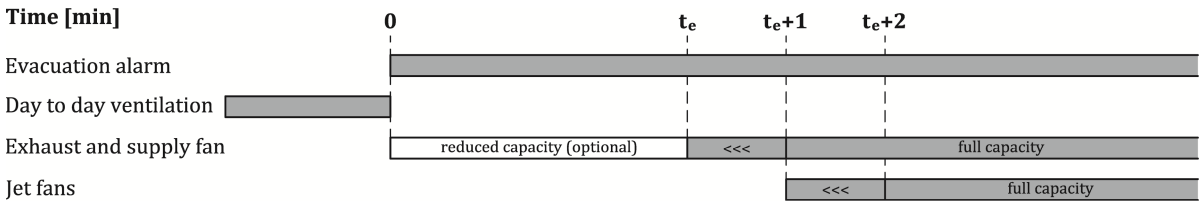

Figure 2 — Activation sequence of smoke ventilation

5.3.7 The following activation sequence shall apply automatically (Figure 2):

— At t = 0, smoke control devices that do not create air movements, such as smoke curtains, dampers, etc., shall be activated.

— Between t = 0 and t = t_e, the system may start at a reduced capacity which doesn't create a horizontal air velocity of more than 0,5 m/s through the cross section area.

NOTE The limitation of the velocity is intended to avoid de-stratification.

— At t = t_e, all smoke control fans (exhaust and supply, if present) shall be switched on and reach their full capacity at least at t = t_e + 1 min.

— At t = t_e + 1 min, the jet fans (if used) shall automatically be activated. In addition, a manual activation device shall allow the Fire Brigade to switch on the jet fans immediately.

The switch should also provide the facility to turn the jet fans off.

— At t = t_e + 2 min, the whole smoke and heat control system shall be fully operational.

5.4 Wind effect

5.4.1 When the smoke and heat control system involves natural air openings located on more than one façade the wind effect shall be taken into account in the design.

5.4.2 In the other cases, it is considered that the wind effect on the smoke and heat control system can be neglected and may not be taken into account.

6 Installation and components

6.1 Fans

6.1.1 All smoke and heat exhaust fans and jet fans shall comply with EN 12101-3. The same shall apply to supply fans which may be exposed to direct radiation from a car in fire.

6.1.2 All jet fans shall be tested according EN ISO 13350.

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6.1.3 All smoke and heat exhaust fans and the jet fans shall be at least class F300 without sprinklers and F200 with sprinklers according to EN 12101-3. The same shall apply to supply fans which may be exposed to direct radiation from a car in fire.

NOTE One jet fan in the immediate surroundings of the fire could fail due to direct radiation from the car in fire. However, in such a case the thrust from that jet fan does not contribute significantly to the flow pattern upstream the car in fire.

6.2 Controls

6.2.1 Operation of the smoke and heat control systems

6.2.1.1 The control equipment for automatic activation (see 6.3 and 12.4) are an integral part of the smoke and heat control system. They contain automatic control equipment, individual controls for the various devices (electric fan, damper, jet fan, smoke screens, etc.), signals required for the smoke and heat control systems.

6.2.1.2 A synoptic and manual control device shall be provided for the car park smoke and heat control system, in order to provide the Fire Services with all the information and control devices needed for their intervention in the car park.

6.2.1.3 The synoptic and manual control device and its access way from the exterior shall be outside the car park compartment, unless otherwise specified by the authority having jurisdiction. Its location shall be defined in the design. Its functions are defined in 7.2.2 below.

6.2.1.4 The synoptic and manual control device may be juxtaposed, or integrated in other fire control devices, or be a repeater panel.

6.2.2 Functions of the synoptic and manual control device

6.2.2.1 Synoptic device

6.2.2.1.1 The synoptic and manual control device shall include following elements:

a) A view of each level of the car park showing:

— the extraction points (symbol: fan with outgoing arrow);

— the limits between each activation zone (dotted lines);

— the powered air inlets (symbol: fan with incoming arrow);

— the natural air inlets (symbol: incoming arrow).

NOTE At each level, the air inlet(s) correspond to the location when supply air enters this level. For underground levels, the outlet of the ramps serving as an air transfer are considered as natural air inlets at those levels.

b) Indicator lights for:

— each activation zone (green; stand-by = off; operating = flashing);

— each extraction point (orange; stand-by = off; operating = where air/smoke flows through extraction point = on);

— each air inlet (blue; stand-by = off; operating = when fresh air is flowing through air inlet = on).

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