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PROPERTY INSURANCE COMMITTEE
Prevention Specifications

Natural Smoke and Heat Exhaust Systems (NSHES) Planning and Installation

CEA 4020: February 1999 (en)

(EFSAC endorsed)

CONTENS

1 Foreword

These specifications prepared by

- the Comité Européen des Assurances (CEA) in the framework of the traditional loss prevention work by the European Insurers and in line with the EC Commission's group exemption regulation (Regulation No.3932/92 dated 21 December 1992)

are aimed at providing the conditions for a Europe-wide uniform high level of personal and property protection.

The CEA association members have agreed to adopt these specifications and to withdraw from their own specifications any rule which is inconsistent.

2 Scope

These specifications lay down recommendations for the design and installation of Natural Smoke and Heat Exhaust Systems. They apply to Natural Smoke and Heat Exhaust Systems installed in the roofs of commercial or industrial occupancy, single-storey buildings and to those installed in the roofs of multi-storey buildings in which the ceiling and the roof form a single unit.

The use of Natural Smoke and Heat Exhaust Systems is not recommended in buildings protected by automatic extinguishing systems (total flooding systems) using gaseous extinguishing agents or high expansion foam, since roof openings would make it impossible to ensure adequate build-up and maintenance of an effective concentration of the extinguishing agent.

3 Function of Natural Smoke and Heat Exhaust Systems

When a fire occurs in an enclosed space, thermal convection currents carry smoke and hot gases upwards from the affected area to the roof or ceiling, where they spread. Without venting, smoke and hot combustion gases will eventually fill the entire enclosed space.

If, however, properly dimensioned and positioned air outlet and inlet openings are provided, and if the roof area is compartmented into roof sections by means of smoke and heat curtains, the layer of smoke and hot combustion gases produced by a fire can be kept within specified limits.

The operating principle of Natural Smoke and Heat Exhaust Systems is illustrated in figures 1a and 1b.

Hence, in the event of fire, Natural Smoke and Heat Exhaust Systems make it possible or easier:

- to maintain emergency exit routes in large enclosed spaces against smoke build-up;
- for fire brigades or fire-fighting teams to take prompt and effective action to extinguish the fire;
- to protect the building structure and its installations and contents, e.g. by retarding flashover;
- to reduce subsequent damage caused by combustion gases and thermal decomposition products.

The amount of hot gases to be vented is determined by:

- the fire hazard classification of the occupancy and the type and stacking height of stored materials;
- the anticipated fire development time;
- the height of the ceiling;
- the target height of the smoke-free layer.

For the system to be effective, the Natural Smoke and Heat Exhaust Ventilators located in the roof section affected by the fire must open promptly and there must be adequate intake of fresh air. The use of Natural Smoke and Heat Exhaust Systems in conjunction with action by works or public fire brigades can substantially contribute to loss limitation.

Fire detectors which can simultaneously give a prompt alarm and initiate Natural Smoke and Heat Exhaust Ventilators are particularly effective.

4 Definitions

Coefficient of discharge: ratio of actual flow to theoretical flow rate of a Natural Smoke and Heat Exhaust Ventilator

Design category: Rating required for the determination of the percentage α; the design category is determined on the basis of the calculated hazard and the expected fire development time

Detection time: time that elapses between the outbreak of a fire and its detection by persons or automatic detection systems; it forms part of the fire development time

Effective aerodynamic area A_w [m²]: Geometric free area A_g [m²], multiplied by the coefficient of discharge; the effective aerodynamic area is determined empirically and must be specified seperately for each size and type of equipment

Fire detection systems: Systems which respond to smoke, radiation or heat

Fire development time t [min]: time period used for design purposes to represent the time that elapses between the outbreak of a fire and the moment at which the measures taken to extinguish the fire become effective

Geometric free area A_g [m²] of a Natural Smoke and Heat Exhaust Ventilator: smallest geometric area measured in the plane of the roof

Initiation device (control device): device which receives commands from fire detection devices and transmits them to the release mechanism

Intervention time: time that elapses between the moment the fire is reported to the alarm receiving centre which can alert the Fire Brigade forces and the moment when the fire is brought under control; it forms part of the fire development time and represents total time needed for: alarm notification, fire brigade turn-out and travel, and control time

Multiple-device release: common automatic or manual release of more than one Natural Smoke and Heat Exhaust Ventilator in a single roof section

Natural Smoke and Heat Exhaust System (NSHES): installations which, in the event of fire, ensure that smoke and heat are discharged through Natural Smoke and Heat Exhaust Ventilators in the roof

Natural Smoke and Heat Exhaust Ventilator (NSHEV): device which, in the event of fire, automatically creates an opening in the roof through which combustion gases, heat and smoke can be vented naturally by thermal convection currents

Percentage α [%]: a design parameter indicating the percentage of the reference surface area of the building to be considered as the effective aerodynamic area

Release mechanism: Mechanism which causes the Natural Smoke and Heat Exhaust Ventilator to open

Roof height h [m]: Distance between the upper edge of the floor and the mean height of the highest and lowest points of the ceiling or roof structure

Roof section area A_R [m²]: Area underneath the roof, bounded by smoke and heat curtains or structural components such as solid web trusses

Roof sub-section: Part of a roof section bounded by solid-web load-bearing or other downward-projecting structures with a minimum height equal to 25 % of the height of the smoke layer and an area of at least 100 m²

Smoke and heat curtain: component which prevents smoke and hot combustion gases in a roof section from escaping laterally; it projects from the underside of a roof down to a specified height above the floor

Smoke layer a [m]: ceiling height h minus target smoke-free layer height d

Smoke-free layer d [m]: vertical distance between the floor and the target smoke layer

5 Dimensioning of Natural Smoke and Heat Exhaust Systems

5.1 Dimensioning criteria

The dimensions of a smoke and heat venting system should be such that smoke and combustion gases can be discharged to the atmosphere in sufficient quantities to ensure that an adequate smoke-free layer is maintained inside the building. The required minimum effective aerodynamic area of a smoke and heat venting system should be determined in accordance with the dimensioning rules given below. Other ventilation installations may be included in the calculations if, in the event of fire, they act as a smoke and heat venting system as defined by these specifications, and if the volume of air that is vented through them is certified.

5.2 Dimensioning rules for determining the required effective aerodynamic area A_{wA}

5.2.1 Design parameters

Under these dimensioning rules, the value of the required effective aerodynamic area A_{wA} is determined by :

- Type of occupancy, hazard in accordance with Table 1;
- Ceiling height *h* [m];
- Height of smoke-free layer *d* [m];
- Fire development time *t* [min];
- Area of building *A* [m²] or roof section area A_R [m²].

5.2.2 Fire development time *t*

Fire development time t is the sum of detection time and intervention time. It should be set at no less than **5 minutes**.

Detection time is taken to be .... 5 minutes

on condition that, in the event of fire, the alarm is given to a permanently manned alarm receiving centre by either:

- a fire detection system using heat detectors in accordance with EN 54 Part 5 or
- the opening of one or more Natural Smoke and Heat Exhaust Ventilators or
- a sprinkler system.

If none of these conditions are met, detection time should be set at .... 10 minutes

for dimensioning purposes.

If an automatic fire detection system using detectors complying with EN 54 Part 7 has been designed and installed in accordance with the "CEA Specifications for Automatic Fire Detection Systems", detection time may be disregarded.

Intervention time shall be determined as follows:

- For buildings equipped with sprinkler systems .... 0 minutes
- In cases where there is
  - a works fire brigade... 5 minutes
  - a company fire-fighting force on call 24 hrs a day .... 10 minutes
  - a company fire-fighting force which is not on stand-by 24 hrs a day .... 20 minutes
- In cases where there is a public fire brigade:
  - Professional, on standby 24 hrs a day.. 10 minutes
  - Professional or volunteer, on call .... 20 minutes
  - Other .... no less than 20 minutes

Note: The times have been taken from the "European model for the assessment of industrial and commercial risks" (CEA). Fire brigades may be assessed in accordance with the rules that apply in each individual member country.

5.3 Calculation of required effective aerodynamic area

The appropriate design category can be derived from Table 2, on the basis of the hazard class given by Table 1 for each type of occupancy and of the expected fire development time as per paragraph 5.2.2. In borderline cases, assignment should be to the higher group.

5.3.1 Influence of building size

For buildings of area greater than 1600 m², the effective aerodynamic area of Natural Smoke and Heat Exhaust System A_w is calculated as the product of the total area of the building multiplied by the percentage α in accordance with Table 3.

For buildings of area greater than 800 m² and smaller than 1600 m², the required effective aerodynamic area of a Natural Smoke and Heat Exhaust System is calculated as the product of an area of 1600 m² multiplied by the percentage α in accordance with Table 3.

For buildings of area smaller than 800 m² the required effective aerodynamic area is the product of twice the area of the building multiplied by the percentage α in accordance with Table 3.

For buildings of area smaller than 400 m² the required effective aerodynamic area is the product of 800 m² multiplied by the percentage α in accordance with Table 3.

		A	>	1.600 m^2	=>	A_{WA}	$\geq$	α A
1.600 m^2	$\geq$	A	$\geq$	800 m^2	=>	A_{WA}	$\geq$	α 1.600 m^2
800 m^2	$\geq$	A	$\geq$	400 m^2	=>	A_{WA}	$\geq$	α 2 A
400 m^2	>	A			=>	A_{WA}	$\geq$	α 800 m^2

5.4 Classification of occupancies and types of business operations

In practice an occupancy will always be associated with a basic fire load and hence a given hazard. On this basis three hazard categories can be broadly defined, see table 1.

Table 1: Determination of the hazard

Occupancy		Hazard		
		Intermediate	High	Extra-high
Manufacturing		■		
Dangerous manufacturing			■	
Trading centre		■		
Storages	stacking hight			
moderately combustible materials	< 2.5 m	■		
	≤ 5.0 m		■	
	≤ 7.5 m (*)			■
highly combustible materials	< 3.0 m		■	
	≤ 5.0 m (*)			■

Note:

(*) When the stacking height is greater or the fire development time is longer, the anticipated loss limitation is uncertain.

Table 2: Determination of design categories (DC)

Anticipated fire developement time *t* (**) [min]	Design category		
	Hazard		
	intermediate	high	extra-high
≤ 5	1	2	3
≤ 10	2	4	5
≤ 15	3	6	7
≤ 20	5	(*)	(*)
≤ 25	7	(*)	(*)

Notes:

(*) For "high" and "extra-high" hazards, fire developement times > 15 minutes are not acceptable since beyond this point, the loss-limiting effect is open to question

(**) cf. paragraph 5.2.2

Table 3: Required effective aerodynamic area A_W in % of relevant floor area in accordance with 5.3.1								
Ceiling height *h*	Thickness of smoke layer *a*	Percentage α [%]						
		Design category						
	[m]	1	2	3	4	5	6	7
$h \leq 6$ m	3.00	0.2	0.2	0.3	0.5	0.6	0.7	0.8
	2.50	0.2	0.3	0.5	0.7	0.8	1.0	1.2
	2.00	0.4	0.5	0.7	0.9	1.1	1.4	1.6
	1.50	0.5	0.6	0.9	1.3	1.6	1.9	2.2
	1.00	0.7	0.9	1.3	1.8	2.3	2.8	3.1
6 m < $h \leq 8$ m	4.00	0.3	0.3	0.5	0.7	0.8	1.0	1.1
	3.50	0.3	0.4	0.6	0.8	1.0	1.3	1.4
	3.00	0.4	0.5	0.8	1.1	1.3	1.6	1.8
	2.50	0.5	0.8	0.9	1.3	1.6	2.0	2.3
	2.00	0.7	1.0	1.2	1.7	2.1	2.6	2.9
8 m < $h \leq 10$ m	5.00	0.3	0.4	0.6	0.8	1.0	1.2	1.4
	4.50	0.35	0.5	0.7	1.0	1.2	1.5	1.7
	4.00	0.4	0.6	0.9	1.2	1.5	1.8	2.1
	3.50	0.5	0.7	1.0	1.5	1.8	2.2	2.5
	3.00	0.7	0.9	1.3	1.8	2.2	2,7	3.0
	2.50	0.85	1.1	1.5	2.1	2.6	3.2	3.6
	2.00	1.0	1.5	2.3	2.6	3.2	4.0	4.5

6 Positioning and size of Natural Smoke and Heat Exhaust Ventilators

6.1 Positioning on the roof surface

Natural Smoke and Heat Exhaust Ventilators should be spaced as evenly as possible over the roof section. Particular care should be taken to ensure that in the event of fire, the devices do not increase the risk of the fire spreading to other buildings or to other parts of the same building.

Because of the danger of flashover, the following minimum distances should be kept :

- from fire-break walls ....7.00 m
- from compartment walls ....5.00 m
- from external walls ....2.50 m

For buildings with different roof heights, special measures may be required to prevent flashover.

Natural Smoke and Heat Exhaust Ventilators shall be separated from each other by distances which are at least equal to the sum of the greatest lengths or of the diameters of both devices, For roofs with a slope of ≤ 12°, the distance between devices should be no more than 20 m, and the distance between the device and the edge of the roof no more than 10 m. On roofs with a slope of more than 12°, the maximum distance to the edge may be 20 m.

These distances should be measured from the outside edge of the roof opening.

For roofs with a slope of > 15°, proof that the device is not sensitive to side wind when installed must be supplied by a recognized body.

For roof slopes of ≥ 12°, the Natural Smoke and Heat Exhaust Ventilator should be positioned with its geometric centre above the calculated roof height.

When Natural Smoke and Heat Exhaust Ventilators are positioned close to the edges of flat roofs, it should be borne in mind that wind suction loads at these positions can be greater than elsewhere. The distance between the openings and structures or walls projecting above the roof surface should be sufficient to ensure that the functioning of the devices is not impaired by wind effects.

6.2 Number of Natural Smoke and Heat Exhaust Ventilators

To ensure that smoke and combustion gases can be quickly discharged to the atmosphere, a large number of small Natural Smoke and Heat Exhaust Ventilators is preferable to a small number of large ones. When Natural Smoke and Heat Exhaust Ventilators are installed in roofs with a slope of < 12° or in shed roofs, at least one device should be provided for each 200 m² of floor area. In roofs with a slope between 12° and 30°, at least one Natural Smoke and Heat Exhaust Ventilator should be installed for each 400 m² of floor area.

If roof sections are divided into smaller compartments (roof sub-sections) by structural elements, at least one Natural Smoke and Heat Exhaust Ventilator should be installed for each roof sub-section.

Examples of such installations are given in figures 2a and 2b.

6.3 Size of Natural Smoke and Heat Exhaust Ventilators

The size of each ventilator is determined by the target thickness of the smoke layer. The length of the longer side (or the diameter) of the geometric free area should be no greater than the thickness of the smoke layer.

6.4 Positioning in the case of special occupancies

Above areas where materials are stored which produce large volumes of smoke in a fire, or above areas with a high fire load, an appropriate number of additional natural smoke and heat exhaust ventilators should be provided. These areas should be partitioned off by means of smoke and heat curtains. Natural smoke and heat exhaust ventilators in these areas should have their own autonomous release mechanism.

7 Release of Natural Smoke and Heat Exhaust Systems

7.1 Functional performance of the release mechanism

Release mechanisms, including their wiring, should be designed and installed in such a way as to ensure that they function properly in the event of fire and that natural smoke and heat exhaust ventilators open fully within 60 seconds.

Multiple device release mechanisms should not be able to open natural smoke and heat exhaust ventilators located in more than one roof section.

7.2 Manual release

It should always be possible, as a matter of principle, to release natural smoke and heat exhaust ventilators manually. Release by means of manual controls located at a secure station should be possible in the event of fire and the controls should be secured against inadvertent activation. It must be possible to recognize whether or not the manual control has been activated, and to which roof section it belongs.

7.3 Automatic release

Natural smoke and heat exhaust ventilators should be equipped with a heat- sensitive release mechanism. Where persons or smoke-sensitive materials are to be protected, it is recommended that an additional release mechanism using smoke detectors be installed.

Where there is an automatic multiple device release system using smoke detectors, at least one smoke detector should be provided for each 400 m² of floor space.

7.4 Response temperature for thermal devices

The static response temperature of heat-sensitive single-device release mechanisms should not, under normal circumstances, exceed 74°C, assuming that the ambient temperature does not exceed 60°C. If the ambient temperature is higher, it may be necessary to raise the response temperature accordingly.

7.5 Buildings equipped with extinguishing systems

When Natural Smoke and Heat Exhaust Systems are installed in premises equipped with sprinkler systems or foam, water spray, or dry powder extinguishing systems, any special provisions given in the extinguishing system installation rules concerning the type of release mechanism and the timing of the release of Natural Smoke and Heat Exhaust Systems should be complied with.

Note: No agreement has as yet been reached by European experts with regard to mutual interference between automatic extinguishing systems and heat and smoke venting systems. It is therefore recommended that the choice of a smoke and heat venting system activation mechanism (manual/automatic) be made on a case by case basis in accordance with each individual set of circumstances.

8 Roof section area A_R

8.1 Size of roof section areas

Buildings should be sub-divided into roof sections that are as equal as possible in size. The area of each roof section should not exceed 1600 m² and its length should not exceed 60 m. In special cases (oil baths, hazardous machinery, small warehouses for highly combustible materials etc.) it may be advantageous for roof sections to be smaller.

Roof section boundaries may be formed, amongst other things, by the structural design of the roof (shed roof, solid web trusses) or by smoke and heat curtains.

Examples are given in figure 2b.

8.2 Smoke and heat curtains

Installed smoke and heat curtains should comply with fire resistance class RE 30 in accordance with ISO 834. Heat transmission through smoke curtains is disregarded.

Only non-combustible materials complying with ISO 1182 may be used for smoke and heat curtains. Examples of appropriate materials are: wire reinforced glass, sheet steel or structural panels made of mineral materials, such as ceramic structural panels, precast concrete structural panels, reinforced fibre cement panels, mineral fibre panels, gypsum plasterboard, fibreglass panels or glass cloth.

Note: CEN TC 191 SC 1 WG 1 is working on a draft on smoke curtains: requirements, test procedures, installation and maintenance.

The overall height of smoke and heat curtains must be equal to or greater than the height of the smoke layer. It is highly recommended that the smoke curtain height be even greater where occupancy permits.

Note: The height of the smoke-free layer depends on personnel safety requirements and on the need to ensure that smoke-sensitive equipment and readily combustible packaging do not extend into the layer of hot smoke. It should be borne in mind that operating requirements (eg. craneways) may place constraints on the dimensions of smoke and heat curtains which will make it necessary to increase the height of the smoke-free layer.

9 Air inlet for Natural Smoke and Heat Exhaust Systems

Care should be taken to ensure an adequate supply of air as soon as possible after the outbreak of fire. Control equipment of components which automatically open air inlets in the event of fire must be in good working order.

The geometric free area of air inlets should be at least twice that of the smoke and heat venting system of the roof section with the largest effective aerodynamic free area.

The inlets should be located as close to the floor as possible and should never be placed at a height of more than half the height of the roof. Air may flow in from inlets located within other roof sections, if there is no danger that the fire will spread and if the overall height of smoke and heat curtains is at least one half the height of the roof.

In order to avoid turbulence due to the effects of air inflow, air inlets should be distributed throughout the building.

In order to ensure that smoke is discharged as specified, air should be able to flow in as soon as the smoke and heat venting system is automatically released. Automatic opening of air inlets should therefore be provided, if possible. Manual control of air inlets may be appropriate when staff assigned to and trained in firefighting are on duty 24 hours a day.

10 General requirements for Natural Smoke and Heat Exhaust Ventilators

Natural Smoke and Heat Exhaust Ventilators should be designed and installed in such a way as to ensure that their proper functioning is not impaired by side wind. Proof that the installed devices are in good working order and proof of the effective aerodynamic free area of Natural Smoke and Heat Exhaust Ventilators must be provided in a test certificate.

11 Installation of Natural Smoke and Heat Exhaust Systems

11.1 Protecting combustible roof sealing and insulating materials

Combustible parts of the roof structure should be protected around the opening.

Ignition due to the effects of flame on the roof surface can be prevented by, for example:

- the use of non-combustible sealing materials such as fibre element panels or sheet steel, or
- providing a protective cover of a 5 cm deep layer of gravel (16/32 mm), concrete slabs or other non-combustible materials over combustible roofing materials. Its width around the opening should be at least 1 m.

Ignition due to heat conduction through the soffit can be prevented by, for example:

- the use of non-combustible insulating materials over a width of at least 0.5 m around the opening;
- the use of timber frames with edging made of non-combustible material;
- the use of screens at least 20 mm thick, and made of non-combustible panels.

Examples of installations are given in figure 3.

11.2 Obstructions

The geometric free area A_g may not be reduced by ceiling linings, pipes, joists or other such elements.

11.3 Height of projection above roof surfaces

When a natural smoke and heat exhaust ventilator is installed in a roof with a slope of < 15°, the venting surface must project above the surrounding roof surface by at least 250 mm; in roofs with slopes of > 15° (cf. paragraph 6.1), the minimum projection height given in the test certificate or report must be complied with.

11.4 False ceilings

Where there is a fire load in the false ceiling area, at least one additional opening (one natural smoke and heat exhaust ventilator for every 400 m² of area, with a geometric cross section of at least 1 m².) unless the suspended ceiling is open-worked, with at least 50% of its surface being open, and is separated from the roof by a distance of at least 0,5 m.

False ceiling areas without a fire load require no additional openings.

Examples of false ceiling areas are given in figure 3.

12 Maintaining operating readiness of Natural Smoke and Heat Exhaust Systems

12.1 Technical documentation, Acceptance

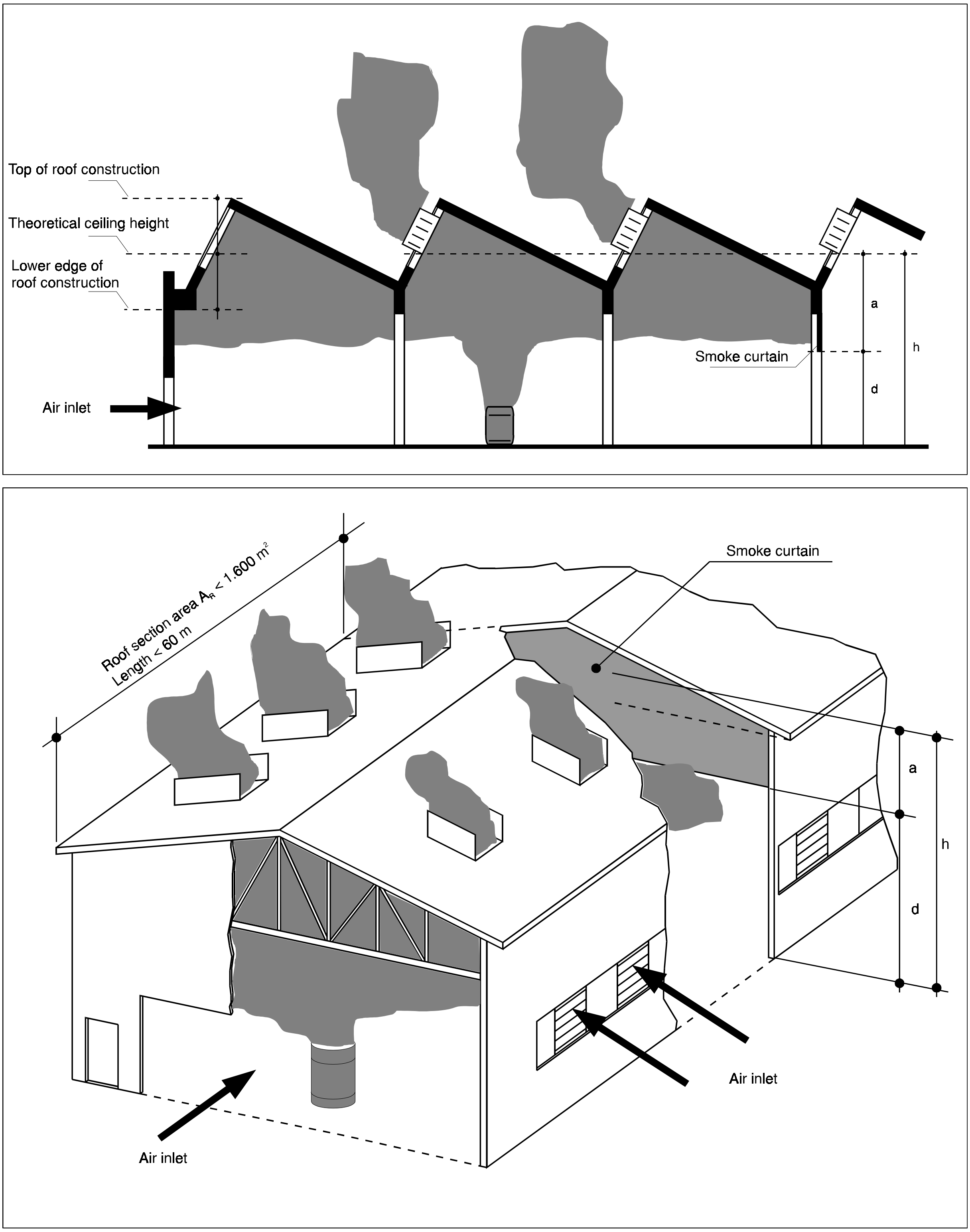
The installer must demonstrate, when the system is delivered, that it is in proper working order. The installer must provide the operator with the following documentation:

- operating instructions and user manual with a drawing of the functional components of the smoke and heat venting system and their system designations;
- testing and maintenance instructions with a list of spare parts needed for maintenance;
- drawings showing the positions, dimensions and release and initiation mechanisms of Natural Smoke and Heat Exhaust Ventilators.

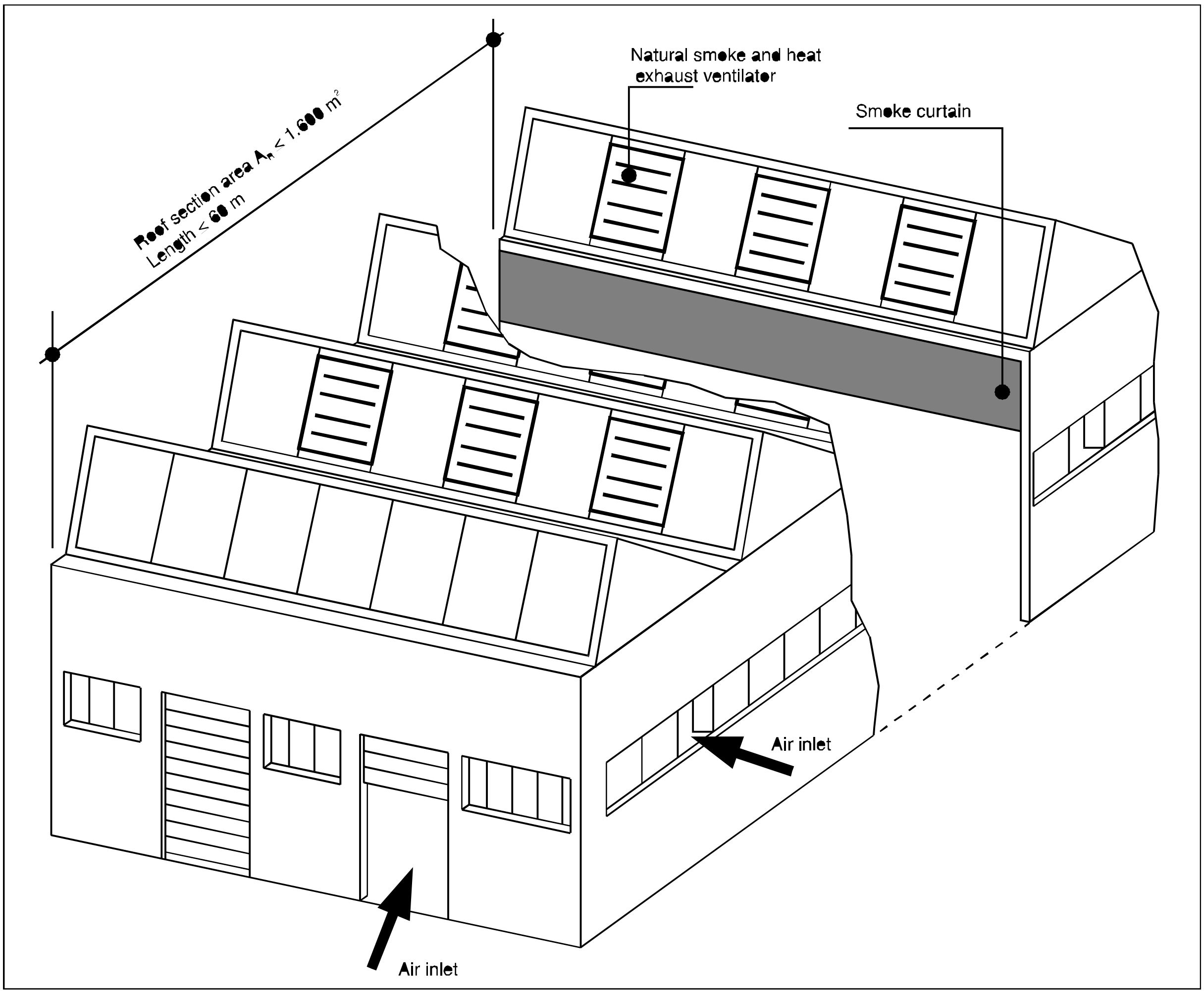
12.2 Maintenance

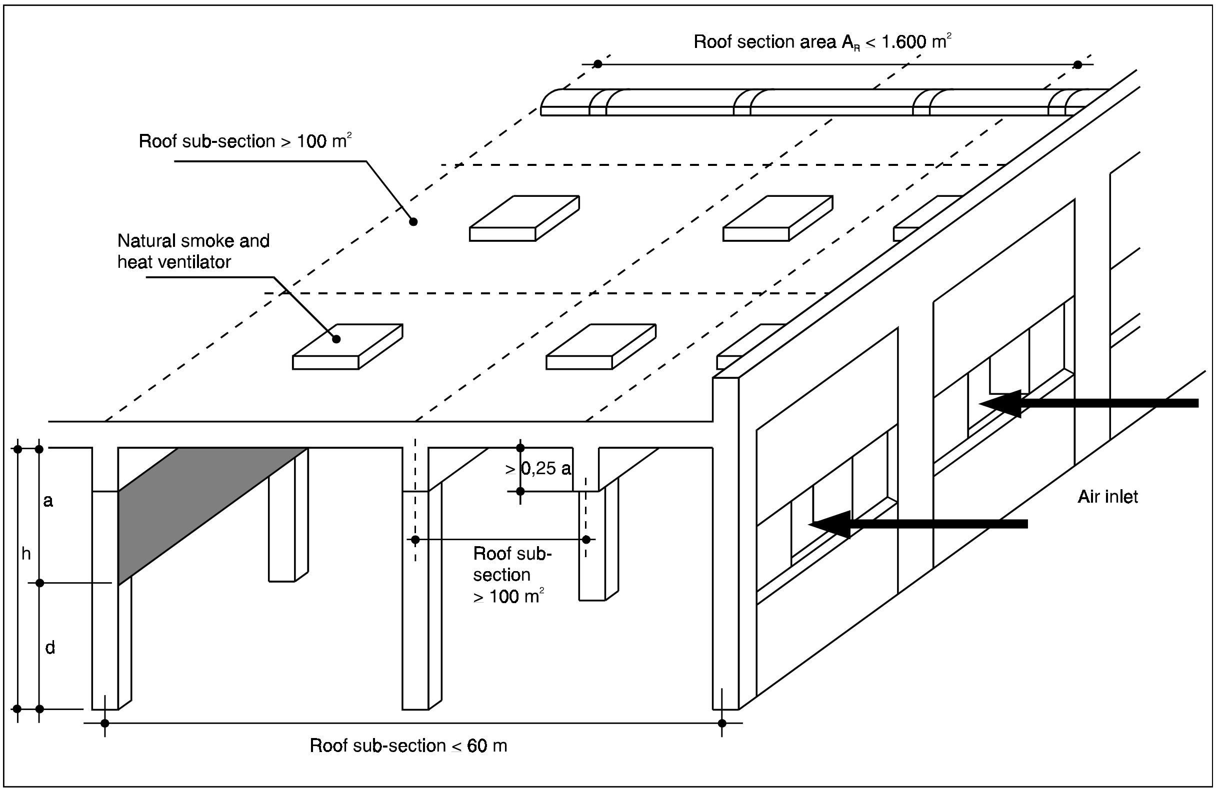
At regular intervals of no more than one year, a qualified technician should inspect the Natural Smoke and Heat Exhaust System, smoke curtains, any structural components which open air inlets, as well as power lines and ancillary equipment, in accordance with the installer's instructions, to ensure that these are in good working order and operational. He should perform maintenance and any repair work needed. Inspection results should be noted in an operator's log.

13 Diagrams



Figures 1a, b: Operating principle of Natural Smoke and Heat Exhaust Systems





Figures 2a, b: Installation examples

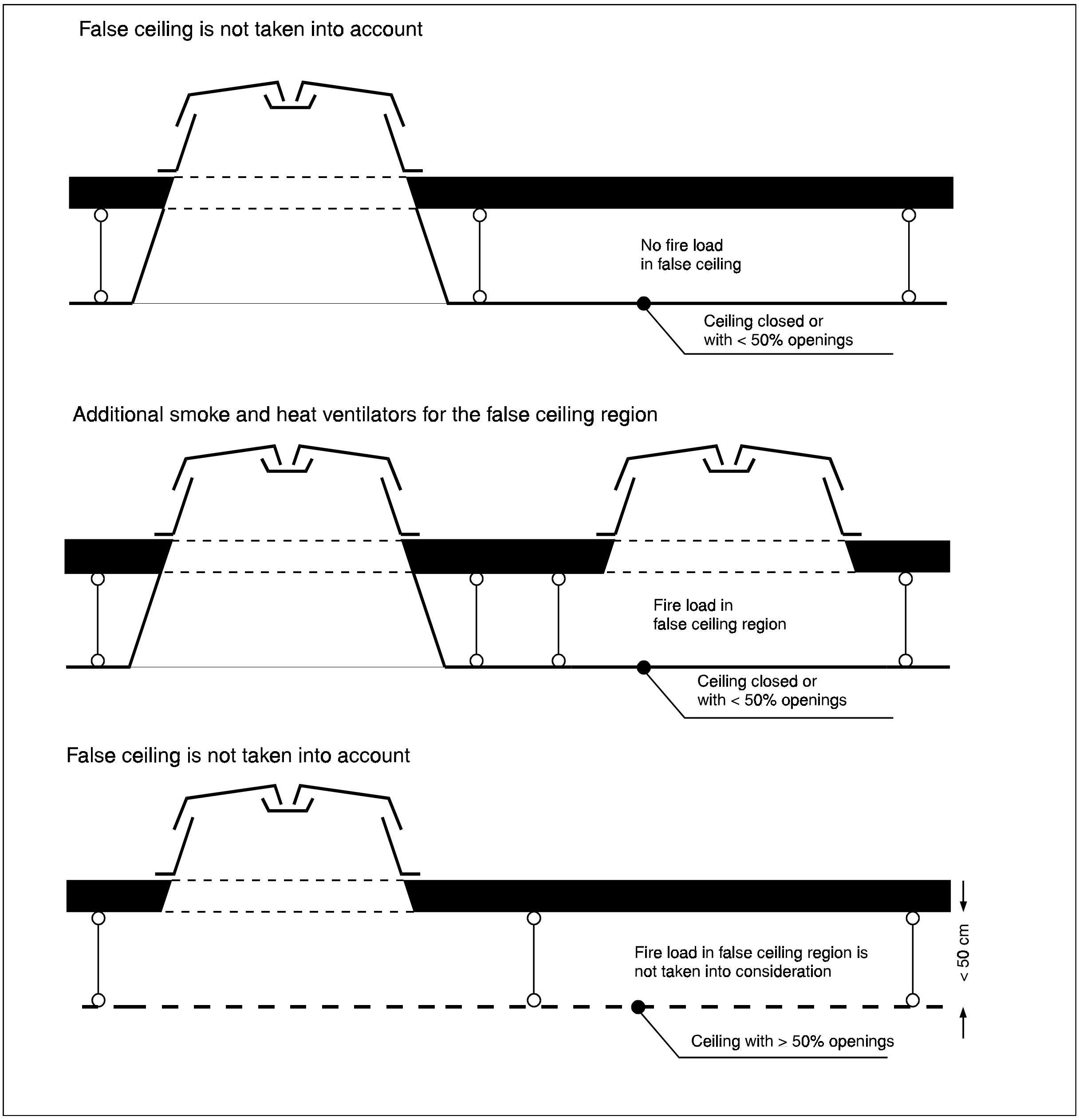


Figure 3: NSHES and false ceilings