INTERNATIONAL STANDARD

ISO 21927-4

First edition
2019-04

Smoke and heat control systems —

Part 4: Natural smoke and heat exhaust ventilators — Design, requirements and installation

Systèmes pour le contrôle des fumées et de la chaleur —

Partie 4: Exutoires de fumées et de chaleur naturels — Dimensionnement, exigences et mise en place

Reference number
ISO 21927-4:2019(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 21, *Equipment for fire protection and fire fighting*, Subcommittee SC 11, *Smoke and heat control systems and components*.

A list of all parts in the ISO 21927 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Smoke and heat control systems (SHCS) create and maintain smoke free areas in a construction works by controlling smoke flow and thus improve the conditions for the safe escape and/or rescue of people and animals and the protection of property and permit the fire to be fought while still in its early stages. The use of smoke and heat exhaust ventilation systems (SHEVS) to create smoke free areas beneath a buoyant smoke layer has become widespread. Their value in assisting in the evacuation of people from construction works, reducing fire damage and financial loss by preventing smoke logging, facilitating firefighting, reducing roof temperatures and retarding the lateral spread of fire is firmly established. For these benefits to be obtained, it is essential that smoke and heat exhaust ventilators operate fully and reliably whenever called upon to do so during their installed life. A heat and smoke exhaust ventilation system is a scheme of safety equipment intended to perform a positive role in a fire emergency.

Components for any smoke and heat control system are installed as part of a properly designed system.

Smoke and heat control systems help to:

— keep escape and access routes free from smoke;

— facilitate firefighting operations;

— delay and/or prevent flashover and thus full development of a fire;

— protect equipment and furnishings;

— reduce thermal effects on structural components during a fire;

— reduce damage due to thermal decomposition products and hot gases.

Pressure differential systems are used either to positively pressurize spaces separated from the fire or to depressurize the space containing the fire in order to limit or prevent the flow of smoke and heat into adjacent spaces. A typical use would be to pressurize an escape stair well in order to protect vertical means of escape.

Depending on the design of the system, natural or powered smoke and heat ventilators can be used in a smoke and heat control system.

Control equipment is needed in order to control all components in a SHCS, such as:

— natural ventilators;

— powered ventilators;

— smoke barriers;

— smoke dampers;

— air inlets;

— duct sections;

— dampers.

SHCS control equipment can also provide control for day-to-day ventilation and signals to other fire safety equipment under fire conditions.

SHCS control equipment can be for extra-low voltage or low voltage electrical systems or pneumatic systems or any combination thereof.

Power output devices for control equipment are dealt with in ISO 21927-10.

Smoke and heat control systems —

Part 4:
Natural smoke and heat exhaust ventilators — Design, requirements and installation

1 Scope

This document applies to the design and installation of natural smoke and heat exhaust ventilators (NSHEVs) for spaces from which smoke is extracted vertically by thermal buoyancy via the roof in the case of single-storey buildings and via the uppermost storey in the case of multi-storey buildings. It also applies to spaces in which NSHEVs are installed in external walls.

This document includes tables and calculation methods for the design of clear layers in order to comply with the requirements of various protection objectives.

This document includes information and provisions to be taken into account when applying the design rules set out herein and when installing NSHEVs.

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.

ISO 13943, *Fire safety — Vocabulary*

ISO 21927-1, *Smoke and heat control systems — Part 1: Specification for smoke barriers*

ISO 21927-2, *Smoke and heat control systems — Part 2: Specification for natural smoke and heat exhaust ventilators*

3 Terms and definitions

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

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

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

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

3.1
aerodynamic free area
measure of smoke and heat exhaust area of the ventilator

Note 1 to entry: It is the geometric area multiplied by the coefficient of discharge.

3.2
automatic activation
initiation of operation without direct human intervention

3.3
coefficient of discharge
aerodynamic efficiency
c_V
ratio of actual flow rate, measured under specified conditions, to the theoretical flow rate through the ventilator

Note 1 to entry: The coefficient takes into account any obstructions in the ventilator, such as controls, louvres and vanes, and the effect of external side winds.

3.4
exhaust ventilator
device for the movement of gases out of the construction works

3.5
initiation device
device that activates the operating mechanism of the component, e.g. of a damper or a ventilator, on receipt of information from a fire detection system or thermal device

3.6
smoke and heat exhaust ventilation system
SHEVS
group of components jointly selected to exhaust smoke and heat in order to establish a buoyant layer of warm gases above cooler and cleaner air

3.7
natural smoke and heat exhaust ventilator
NSHEV
product specially designed to move smoke and hot gases out of a construction works naturally under conditions of fire

4 Symbols and abbreviated terms

Symbol	Definition	Unit
A_a	area of smoke exhaust opening	m^2
A_{fa}	fire area	m^2
A_{in}	area of air inlet	m^2
A_R	area of smoke reservoir	m^2
c_z	factor for determining the area of the air inlet	—
d	height of clear layer	m
h	height of space to be protected	m
H_{sb}	height of smoke barrier	m
z	height of smoke layer ($h - d$)	m

5 Design principles

5.1 General

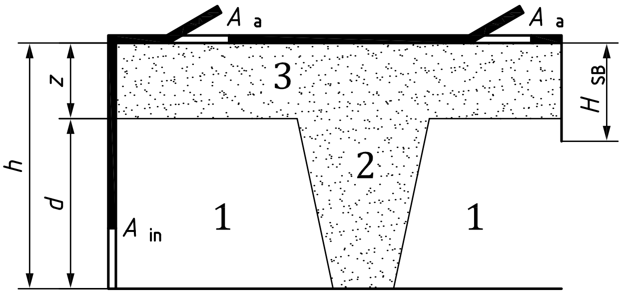
The design of natural smoke and heat exhaust ventilation systems (see Figure 1) depends, inter alia, on:

— the rate of energy release;

— the theoretical fire area of a building or the resulting design group;

— the target height of the clear layer; and

— the height of the relevant space.



Key

A_a	area of smoke exhaust opening, in m^2	z	height of smoke layer (h – d), in m
A_{in}	area of air inlet, in m^2	1	clear layer
d	height of clear layer, in m	2	plume
h	height of space to be protected, in m	3	smoke layer
H_{SB}	height of smoke barrier, in m		

Figure 1 — Diagram of a natural smoke and heat exhaust ventilation system in a smoke reservoir

The values to be used to determine the parameters above are auxiliary design values and only apply to designs in accordance with this document.

5.2 Height of space

The height, h, of the space to be protected shall be the clear height in the case of horizontal roofs/floors and the mean clear height in the case of pitched roofs or sloping floors. In both cases. it shall be measured from the floor to the lower surface of the roof/floor. Floors with smoke outlets are not regarded as floors in this context.

In the case of sawtooth roofs, the height of the space to be used for design purposes is the mean height of the NSHEV above the floor.

5.3 Target height of the clear layer, height of smoke barrier

The clear layer is defined as the distance between the surface of the floor assumed for design purposes and the lower surface of the smoke layer.

Clear layers enable, inter alia:

— the occupants of a building to escape to safety;

— the emergency services to rescue people, animals and property;

— fires to be fought effectively; and

— damage due to fire gases and products of thermal decomposition to be reduced.

The target height of the clear area, d, shall be not less than 2,50 m.

Design should be based on higher values of d if required by the purpose for which the space is to be used (e.g. spaces containing objects sensitive to smoke or flammable warehouse stock). The distance between the objects to be protected and the smoke layer should be not less than 0,5 m.

For clear layers with a height $d \leq 4$ m, the height of the smoke barrier shall protrude at least 0,5 m into the clear layer. For clear layers with a height $d > 4$ m the smoke barrier shall at least equal to the height of the smoke layer, z, but not less than 1,0 m in all cases.

5.4 Area of smoke reservoir

To enable NSHEVs to be designed according to this document, spaces shall either have a maximum area of 1 600 m^2 or be divided into smoke reservoirs with a maximum area, A_R, of 1 600 m^2 by means of smoke barriers. The maximum distance between smoke barriers or between wall and smoke barrier shall not exceed 60 m. Any further subdivisions (e.g. closed joists) within the smoke reservoir shall not affect the design.

NOTE Smoke reservoirs are created by placing separating elements around the perimeter of a space or, at the minimum, by placing continuous smoke barriers around the open inner sides of a space. A "space" is defined as an area enclosed by separating elements on all sides.

5.5 Air inlets

An adequate number of air inlets, with an area, A_{in}, is always required in the lower part of external walls to act as air replacement openings near floor level.

The required area of the air inlets shall be based on the area of the largest smoke reservoir. This area shall be taken into account when designing the external walls of a space. The air inlets should be located on at least two sides of the building and should be evenly distributed.

The following are considered as air inlets:

— separate supply air devices;

— doors or windows provided they are labelled as "air inlets for NSHEVs" on the inside and outside and can be opened from outside without being destroyed in the process (e.g. it shall not be necessary to smash window panes or break down walls or doors). This does not apply in cases in which a works fire service is able to create the necessary air inlets.

It shall be possible to open the air inlets immediately (e.g. automatically, by the works fire service or as a result of operational or organizational measures) after the NSHEVs have been activated.

The effective area of the air inlets shall be not less than 1,5 times the aerodynamic free areas of all NSHEV openings in the largest smoke reservoir in a space, as specified in Table 3.

The effective area of the following types of air inlet shall be obtained by correcting the area of the structural opening by a factor, c_z, as specified in Table 1.

Table 1 — Correction factors, c_z, for different types of opening serving as air inlets

Type of opening	Opening angle	Correction factor c_z
Door openings, wire mesh		0,7
Openable shutters	90°	0,65
Side-hung or bottom-hung windows	90°	0,65
	≥60°	0,5
	≥45°	0,4
	≥30°	0,3

A tolerance of ±5° is permitted for the opening angles specified in Table 1.

The factor c_z used to assess the effective area of an air inlet, as obtained from the area of the wall opening and the opening angle, should not be confused with the c_v value. The latter is used to obtain the aerodynamic free area of smoke exhaust openings, A_a, from the geometrical inlet area, A_g, of smoke and heat exhaust ventilators.

The distance between the upper edge of the air inlet and the bottom of the layer of smoke gases shall be not less than 1 m. The distance may be reduced to 0,50 m in the vicinity of doors or windows with a width not greater than 1,25 m.

In the case of air inlets resulting in an upward air flow (e.g. those with protective gratings facing upwards) the distance between the upper edge of the air inlet and the bottom of the layer of smoke gases should be not less than 1,5 m.

5.6 Duration of fire growth

The duration of fire growth to be assumed for the purposes of this document (see Table 2) is the time that elapses between the outbreak of a fire and the start of firefighting measures.

The time that elapses between the outbreak of a fire and the alarm being raised shall be taken as 10 min.

This period of time does not apply where fire alarm systems incorporating automatic fire detectors activated by smoke have been installed. The fire alarm shall be transmitted to a fire station or other station that can provide assistance and is manned around the clock.

It does not apply either to spaces that are continuously manned, ensuring that any fire is detected immediately and the fire service notified accordingly.

It shall be taken as 5 min where NSHEVs are fitted with automatic fire detectors activated by smoke. In such cases, it is sufficient to install one smoke detector per every 200 m^2 of the smoke reservoir. A distance of 10 m between beams is sufficient for linear smoke detectors.

A mean time of 10 min shall be assumed for the time that elapses between the fire alarm being raised and the start of firefighting measures. In favourable circumstances, such as where there are on-site firefighters who can reach the scene of a fire in less than 5 min, it may be reduced to 5 min. The mean time shall be increased to 15 min if the circumstances are unfavourable and to 20 min if the circumstances are exceptionally unfavourable.

The times referred to in this clause are auxiliary design values and are only to be used when calculating the fire growth rate needed for the purposes of this standard.

5.7 Theoretical fire area, design groups

The theoretical fire area is obtained from the fire propagation rate and the assumed duration of fire growth. The design group is based on the theoretical fire area (see Table 2).

Table 2 — Design groups

Assumed duration of fire growth (see 5.6) min	**Design group for specific fire propagation rates**		
	<0,15 m/min particularly low	<0,25 m/min average[a]	<0,45 m/min particularly high
≤5	1	2	3
≤10	2	3	4
≤15	3	4	5
≤20[a]	4	**5**[a]	5[b]
>20	5	5[b]	5[b]

[a] Average values without specific verification; design group 5 (in bold) is obtained if the average values are used.

[b] In such cases, the protection objectives set out in this standard cannot be achieved solely by means of NSHEVs and other measures are required in order to achieve them.

The highest fire propagation rate shall always apply if the individual smoke reservoirs within a space are used in different ways so that very different fire propagation rates can be expected.

