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**Smoke and heat control systems —**

Part 2:

**Specifications for natural smoke and  
heat exhaust ventilators**

*Systèmes de contrôle de fumée et de chaleur —*

*Partie 2: Spécifications pour les dispositifs d'évacuation naturelle des  
fumées et de la chaleur*

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## 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](http://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](http://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](http://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*.

This second edition cancels and replaces the first edition (ISO 21927-2:2006), which has been technically revised. It also incorporates the Amendment ISO 21927-2:2006/Amd1:2010.

The main changes compared to the previous edition are as follows:

- the test apparatus has been amended;
- the whole document has been revised.

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](http://www.iso.org/members.html).

## Introduction

In a fire situation, smoke and heat exhaust ventilation systems create and maintain a smoke free layer above the floor by removing smoke. They also serve simultaneously to exhaust hot gases released by a fire in the developing stages. The use of such systems to create smoke-free areas beneath a buoyant layer has become widespread. Their value in assisting in the evacuation of people from buildings and other construction works, reducing fire damage and financial loss by preventing smoke damage, facilitating access for firefighting by improving visibility, reducing roof temperatures and retarding the lateral spread of fire is firmly established. For these benefits to be obtained, it is essential that natural smoke and heat exhaust ventilators (referred to in this document as NSHEV) operate fully and reliably whenever called upon to do so during their installed life. A smoke and heat exhaust ventilation system (referred to in this document as a SHEVS) is a system of safety equipment intended to perform a positive role in a fire emergency.

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# Smoke and heat control systems —

## Part 2: Specifications for natural smoke and heat exhaust ventilators

### 1 Scope

This document applies to natural smoke and heat exhaust ventilators (NSHEV) operating as part of smoke and heat exhaust systems (SHEVS), placed on the market. This document specifies requirements and gives test methods for natural smoke and heat exhaust ventilators which are intended to be installed in smoke and heat control systems in buildings.

### 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 11925-2, *Reaction to fire tests — Ignitability of products subjected to direct impingement of flame — Part 2: Single-flame source test*

ISO 21927-9, *Smoke and heat control systems — Part 9: Specification for control equipment*

ISO 21927-10, *Smoke and heat control systems — Part 10: Specification for power output devices*

IEC 60584-1, *Thermocouples — Part 1: EMF specifications and tolerances*

EN 54-5, *Fire detection and fire alarm systems — Part 5: Heat detectors — Point detectors*

EN 54-7, *Fire detection and fire alarm systems — Part 7: Smoke detectors — Point detectors using scattered light, transmitted light or ionization*

EN 13501-1, *Fire classification of construction products and building elements — Part 1: Classification using test data from reaction to fire tests*

EN 13823, *Reaction to fire tests for building products — Building products excluding floorings exposed to the thermal attack by a single burning item*

### 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:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

**3.1  
aerodynamic free area**

$A_a$   
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  
ambient**

relating to the properties of the surroundings

**3.3  
automatic initiation**

activation of operation without direct human intervention

**3.4  
aspect ratio**

ratio of length to width

**3.5  
comfort ventilation position**

position of a NSHEV defined by the manufacturer for the purpose of comfort ventilation

**3.6  
coefficient of discharge**

$c_v$   
ratio of actual flow rate, measured under specified conditions, to the theoretical flow rate through the NSHEV, as defined in [Annex B](#)

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

**3.7  
dual purpose NSHEV**

NSHEV which has provision to allow its use for comfort (i.e. day to day) ventilation

**3.8  
fire open position**

configuration of the NSHEV specified by its designer to be achieved and sustained while venting smoke and heat

**3.9  
gas container**

vessel containing gas in a compressed form, the energy of which, when the gas is released from the vessel, will open the NSHEV

**3.10  
geometric area**

$A_v$   
area of the opening through a NSHEV, measured in the plane defined by the surface of the construction works, where it contacts the structure of the NSHEV

Note 1 to entry: No reduction is made for controls, louvres or other obstructions.

Note 2 to entry: Specific configurations are given in Figures B.1 and B.4.

**3.11  
initiation device**

device which activates the operating mechanism of the NSHEV on receipt of information from a fire detection system or thermal device

**3.12****opening mechanism**

mechanical device which operates the NSHEV to the fire open position

**3.13****projection area**

cross-sectional area of the movable part (e.g. flap, window) of the NSHEV:

- a) above the plane of the roof, at a right angle to the side wind flow;
- b) on the wall at a right angle to the side of the wall

**3.14****range**

NSHEV of various sizes having the same method of construction and the same type of opening mechanism

**3.15****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

Note 1 to entry: In the context of this document, smoke and hot gas movement means any motion of smoke and hot gas within and out of a construction work under the influence of thermal buoyancy, e.g. exhausting and extracting smoke and hot gas, directing and guiding smoke and hot gas.

Note 2 to entry: A typical NSHEV consists of a fixed frame or upstand and of one or more flaps to be opened in case of fire by an opening mechanism initiated by a smoke or heat sensitive initiation device.

**3.16****thermal device**

temperature-sensitive device which responds to initiate a subsequent action

**3.17****throat area**

smallest cross-sectional area of the flow path through the NSHEV

Note 1 to entry: See [Figure G.6](#).

**3.18****ventilator**

device for enabling the movement of gases into or out of the construction works

**3.19****wind deflector**

any part of the NSHEV guiding the wind over the open NSHEV

**3.20****wind-sensitive control system**

control system designed to control two or more banks of NSHEV on separate elevations so that only the NSHEV not subject to positive wind pressures opens in case of fire

**3.21****wall**

external building surface with an inclination of more than 60° relative to the horizontal

**3.22****roof**

external building surface with an inclination of 60° or less relative to the horizontal shed roofs, and which continuous roof-lights, independent of the inclination angle

## 4 Symbols and abbreviated terms

For the purposes of this document, mathematical and physical quantities are represented by symbols, and expressed in units as follows.

Symbol	Definition	Unit
$A_a$	aerodynamic free area, expressed in square metres	$m^2$
$A_{ex}$	area of the exit plane of NSHEV, expressed in square metres	$m^2$
$A_n$	nozzle exit area (for open jet facilities); test section entrance area (for closed test section facilities), expressed in square metres	$m^2$
$A_{pr}$	projection area of the NSHEV for the side wind flow, expressed in square metres	$m^2$
$A_{sc}$	horizontal cross section area of the settling chamber, expressed in square metres	$m^2$
$A_{throat}$	smallest geometric cross section area through which the air flows	$m^2$
$A_v$	geometric area of the NSHEV, expressed in square metres	$m^2$
$B$	width of the open hole of the settling chamber, expressed in metres	m
$b$	width of the geometric opening of a NSHEV, expressed in metres	m
$B_n$	width of nozzle exit area in open jet facilities, width of the test section in closed test section facilities, expressed in metres	m
$B_v$	maximum width of the NSHEV in the fire open position, expressed in metres above the upper surface of the settling chamber	m
$C_v$	coefficient of discharge, dimensionless	—
$C_{v0}$	coefficient of discharge without side wind influence, dimensionless	—
$C_{vw}$	coefficient of discharge with side wind influence, dimensionless	—
$d_h$	hydraulic diameter of the settling chamber [ $d_h = (4 \cdot A_{sc}) / P$ ], expressed in metres	m
$d_{h,g}$	hydraulic diameter of the geometric NSHEV area, expressed in metres	m
$H_n$	height of nozzle exit area in open jet facilities, height of the test section in closed test section facilities, expressed in metres	m
$H_v$	maximum height of the NSHEV in the fire open position above the upper surface of the settling chamber, expressed in metres	m
$h_p$	profile height of a wall-mounted NSHEV, expressed in metres	m
$h_{us}$	height of the NSHEV upstand, expressed in metres	m
$h_{uwd}$	height of the upper edge of wind deflectors above the roof surface, expressed in metres	m
$L$	length of the open hole of the settling chamber, expressed in metres	m
$l$	length of the geometric opening of a NSHEV, expressed in metres	m
$I_{u, h_{us}}$	turbulence intensity in flow direction at height $h_{us}$	—
$m$	ratio of geometric areas ( $= A_{ex} / A_v$ ), dimensionless	—
$\dot{m}_{ing}$	mass flow rate entering the settling chamber, expressed in kilograms per second	kg/s
NSHEV	natural smoke and heat exhaust ventilator	—
$P$	perimeter length of the cross section of the settling chamber, expressed in metres	m
$p_{amb}$	ambient pressure, expressed in Pascals	Pa
$p_d$	wind stagnation pressure, expressed in Pascals	Pa
$p_{int}$	internal static pressure, expressed in Pascals	Pa
$p_{int, v0}$	internal static pressure without side wind, expressed in Pascals	Pa
$p_{int, vw}$	internal static pressure with side wind, expressed in Pascals	Pa

Symbol	Definition	Unit
$T$	temperature, expressed in degrees C	°C
$U_v$	length of the boundary of the geometric area of a NSHEV, expressed in metres	m
$V_\infty$	side wind velocity, expressed in metres per second	m/s
$V_l$	local air speed, expressed in metres per second	m/s
$V_{m,sc}$	mean velocity of the settling chamber, expressed in metres per second	m/s
$V_n$	mean nozzle velocity, expressed in metres per second	m/s
$V_{sc}$	local velocities in plane above settling chamber, see Figure B.6, expressed in metres per second	m/s
$\alpha$	opening angle of the NSHEV, expressed in degrees and referenced to the closed flap position	—
$\beta$	angle of attack, expressed in degrees	—
$\beta_{crit}$	incidence angle at which the smallest value of $C_{vw}$ obtained with side wind, occurs, expressed in degrees	—
$\delta$	relative wall thickness ( $= h_{US} / d_h$ ), dimensionless	—
$\delta_p$	relative profile thickness ( $= h_p / d_h$ ) of a wall-mounted NSHEV, dimensionless	—
$\mu$	contraction coefficient ( $= A_a / A_{ex}$ ), dimensionless	—
$\theta$	angle of installation of NSHEV on a roof or in a wall, expressed in degrees	—
$\Delta p$	pressure difference, expressed in Pascals	Pa
$\Delta p_{v0}$	reference pressure difference between the static pressure in the settling chamber and the ambient pressure without side wind, expressed in Pascals	Pa
$\Delta p_{vw}$	reference pressure difference between the static pressure in the settling chamber and the ambient pressure with side wind, expressed in Pascals	Pa
$\Delta p_{int}$	pressure difference between the static pressure in the settling chamber and the ambient pressure, expressed in Pascals	Pa
$\Delta T$	temperature difference, expressed in Kelvins	K
$\rho_{air}$	density of air, expressed in kilograms per cubic metre	kg/m <sup>3</sup>

## 5 Requirements

### 5.1 Nominal activation conditions/sensitivity

#### 5.1.1 Initiation device

##### 5.1.1.1 General

To ensure the natural smoke and heat exhaust ventilator (NSHEV) opens in the event of a fire, it shall be fitted with one or more of the following automatic initiation devices:

- a) a thermal initiation device;
- b) an initiation device activated by an electrical signal from a remote source, e.g. a smoke and heat detector system, the interruption of electrical power supply;
- c) a pneumatic initiation device, e.g. a pneumatic signal or a loss of compressed air;
- d) an initiation device able to respond to other types of release signals.

In addition, remote initiation can take place by means of a manually operated initiation device.

- e) A pneumatic non fail safe NSHEV, which does not open automatically on loss of power, shall have at least a thermal device and one power source in accordance with ISO 21927-10, which is mounted

directly in the NSHEV, unless the required control panel monitors the lines to the NSHEV and indicates a failure.

In some specific design cases where it is suitable to initiate the NSHEV manually only, the NSHEV may be installed without an automatic initiation device.

#### 5.1.1.2 Automatic initiation or release device

Any automatic initiation or release device shall be within the NSHEV and shall be exposed to the hot gas entering the closed NSHEV.

There are two exceptions to this requirement, where an automatic thermal initiation or release device shall not be fitted to the NSHEV.

- a) If the NSHEV is to be installed as a wall-mounted NSHEV. Adverse wind conditions may cause a NSHEV which has been opened by the automatic initiation device to inlet and not remove heat and smoke.
- b) In specific design cases where it is suitable that the NSHEV shall only be manually initiated. The response behaviour of thermal automatic initiation devices shall be in accordance with ISO 21927-9. Smoke detectors shall comply with the requirements of EN 54-7 and heat detectors with EN 54-5.

### 5.1.2 Opening mechanism

#### 5.1.2.1 General

The NSHEV shall be provided with an opening mechanism with energy within the NSHEV, e.g. gas containers, spring systems, electrical power supply, and/or with an external energy source. For the external links, the manufacturer of the NSHEV shall specify the operating requirements for the initiation device and the opening mechanism, e.g. voltage, energy.

#### 5.1.2.2 Integral gas containers

Any gas container forming an integral part of the NSHEV shall be equipped with a pressure release device to prevent an explosion if the container overheats. The energy supply shall comply with ISO 21927-10.

#### 5.1.3 Inputs and outputs

If the NSHEV is intended to operate with an external energy source, it shall be equipped with inputs and/or outputs to allow connection of the NSHEV to the control panel and power supplies in accordance with ISO 21927-10.

## 5.2 Response delay (response time)

### 5.2.1 Reliability

The NSHEV shall when tested in accordance with [Annex C](#) open, i.e. reach its fire open position, within 60 s after actuation.

### 5.2.2 Opening under (snow/wind) load

Roof mounted NSHEV shall open, reach its fire open position not more than 60 s after actuation and remain in position without an external energy supply (until reset), when tested under the snow load appropriate to its classification and under the specified side wind in accordance with [Annex D](#).

After testing the NSHEV in accordance with [Annex F](#) it shall open into the fire open position within 60 s after actuation.

### 5.2.3 Low ambient temperature

When tested in accordance with [Annex E](#) the NSHEV shall open into to the fire open position within 60 s after actuation.

### 5.2.4 Opening under heat

The NSHEV shall when tested in accordance with [Annex G](#) open, i.e. reach its fire open position within 60 s under exposure to heat and to remain in the fire open position with not more than 10 % reduction of the throat area.

## 5.3 Operational reliability

The NSHEV shall when tested in accordance with [Annex C](#) open, i.e. reach its fire open position, within 60 s after actuation without damage and remain in its fire open position without an external energy supply (until reset).

## 5.4 Effectiveness of smoke/hot gas extraction (aerodynamic free area)

The aerodynamic free area,  $A_a$ , of the NSHEV shall be determined in accordance with [Annex B](#).

Roof mounted NSHEV shall be tested without and with side wind. Wall-mounted NSHEV may be tested without side wind only.

In order to prevent air from flowing through the NSHEV into the fire room the aerodynamic free area,  $A_a$ , shall be larger than 0 m<sup>2</sup>.

Wind deflectors subjected to atmospheric wind when the NSHEV is in the closed position and forming an integral part of the NSHEV to ensure the determined aerodynamic free area,  $A_a$ , shall be tested in accordance with [5.6.4](#).

Devices having influence on the aerodynamic performance are integral parts of the NSHEV and shall be installed in accordance with the manufacturer's instructions and shall be tested in accordance with [Annex B](#), whether they are fixed to the NSHEV itself or to the surrounding construction.

When using the simple assessment procedure to determine the aerodynamic free area, see [B.1](#). The side length shall not exceed 2,5 m and the aspect ratio of the geometric area shall not exceed 5:1.

Large area NSHEV may lead to plug holing, i.e. exhaust flows where smoke from the smoke layer and room air are mixed and removed and therefore the removal of smoke is decreased.

## 5.5 Performance parameters under fire conditions

### 5.5.1 Resistance to heat

The NSHEV shall open within 60 s under exposure to heat and remain in the fire open position without an external energy supply with not more than 10 % reduction of the throat area when tested in accordance with [Annex G](#).

If the NSHEV shall be installed in a building, it shall have a minimum class B<sub>30030</sub>.

For NSHEV larger than the largest NSHEV tested in accordance with [Annex G](#), an assessment of the heat exposure effect shall be made by the testing station to ensure that the performance is not negatively affected.

NOTE At present, maximum dimensions of the test apparatus for the heat exposure test are in the range of 4 m.

### 5.5.2 Mechanical stability

The reduction of the throat area shall not be more than 10 % reduction when tested in accordance with [Annex G](#).

No part or component of the NSHEV shall fall from the NSHEV during the first 6 min of the test.

Devices having influence on the aerodynamic performance are integral parts of the NSHEV and shall be installed in accordance with the manufacturer's instructions and shall be tested in accordance with [Annex G](#) whether they are fixed to the NSHEV itself or to the surrounding construction.

### 5.5.3 Reaction to fire

The reaction to fire shall be classified in accordance with [A.5](#) and tested in accordance with [Annex H](#).

## 5.6 Performance under environmental conditions

### 5.6.1 Opening under load

To simulate the side wind influence, the roof-mounted NSHEV shall be subjected, in the most unfavourable wind direction, to a side wind of 10 m/s velocity when tested in accordance with [Annex D](#).

Roof mounted NSHEV shall open, reach its fire open position within not more than 60 s after actuation and remain in position without an external energy supply (until reset), when tested under the snow load appropriate to its classification and under the specified side wind in accordance with [Annex D](#).

For NSHEV fitted with wind deflectors, the deflectors shall not be fitted in such a way to encourage snow or ice to collect to the detriment of the operation of the NSHEV.

### 5.6.2 Low ambient temperature

When tested in accordance with [Annex E](#), the NSHEV shall open into to the fire open position within 60 s after actuation. No such test is necessary for NSHEV classified T(05), see [A.6](#).

Tests shall be conducted with simulated snow load with the classification in accordance with [A.6](#).

### 5.6.3 Stability under wind load

The NSHEV shall not open at the opening side(s) more than 50 mm (measured at the location of the actuator) under the wind load appropriate to its classification, see [A.6](#). It shall also not suffer permanent deformation when tested in accordance with [Annex F](#) and, following this test, shall open into the fire open position within 60 s after actuation.

### 5.6.4 Resistance to wind-induced vibration

If wind deflectors form an integral part of the NSHEV, their natural frequency of vibration shall be higher than 10 Hz with a logarithmic decrement of damping greater than 0,1 when tested in accordance with [E.5.2](#).

### 5.6.5 Resistance to heat

The NSHEV shall open within 60 s under exposure to heat and remain in the fire open position with not more than 10 % reduction of the throat area when tested in accordance with [Annex G](#).

If the NSHEV shall be installed in a building it shall have a minimum class B<sub>30</sub>030.

## 5.7 Durability

### 5.7.1 Response delay (response time)

The durability of NSHEV considering response delay is fulfilled if the fire open position is reached within 60 s after being tested at least 49 times in accordance with [Annex C](#).

### 5.7.2 Operational reliability

The durability of NSHEV considering operational reliability is fulfilled if the fire open position is reached after being tested at least 49 times in accordance with [Annex C](#).

### 5.7.3 Performance parameters under fire conditions

The NSHEV is regarded to be durable if, after the test in accordance with [Annex C](#), the throat area is not reduced by more than 10 % and all parts relevant for the aerodynamic performance of the NSHEV, e.g. filling, wind deflectors and flaps and all structural parts, remain in place.

## 6 Testing, assessment and sampling methods

Test of NSHEV shall be carried out in accordance with [Annexes B, C, D, E, F, G](#) and [H](#).

For each test, a test report shall be prepared.

The methods for testing, assessing and sampling for the essential requirements of [Clause 5](#) are:

- For the “nominal activation condition/sensitivity”, the presence of the initiation device according to [5.1.1](#), the “opening mechanism” according to [5.1.2](#) and “inputs and outputs” according to [5.1.3](#) shall be checked as present.
- The “response delay (response time)” shall be less than  $\leq 60$  s. It shall be tested for reliability according to [Annex C](#), for opening under (snow/wind) load according to [Annex D](#) and [E](#), for low ambient temperature according to [Annex E](#) and for opening under heat according to [Annex G](#) and assessed in accordance with [Annex A](#). The sampling methods are given in [Annexes C, D, E, F](#), and [G](#).
- The operational reliability shall be tested in accordance with [Annex C](#) and assessed in accordance with [Annex A](#). The sampling method is given in [Annex C](#).

**Table 1**

Reliability classes	Number of openings into the fire open position
Re 50	50
Re 500	500
Re 1000	1 000
Re A	A

- The effectiveness of smoke/heat gas extraction — aerodynamic free area shall be tested and assessed in accordance with [Annex B](#). The aerodynamic free area,  $A_a$ , shall be larger than 0 m<sup>2</sup>. The sampling method is given in [Annex B](#).
- The performance parameters under fire conditions, resistance to heat and mechanical stability shall be tested and assessed in accordance with [Annex G](#) with A as:

B<sub>300</sub>30,

B<sub>600</sub>30,

B<sub>A</sub>30.

and reaction to fire in accordance with [Annex H](#) with A as:

class

The sampling methods are given in [Annexes G](#) and [H](#).

- The performance under environmental conditions shall be tested and assessed for the performance under load in accordance with [Annex D](#) with A as:

**Table 2**

Snow load	Load Pa
SL 500	500
SL 1000	1 000
SL 1500	1 500
SL A	A

for the stability under wind load in accordance with [Annex F](#) with A as:

**Table 3**

Wind load	Load Pa
WL 1500	1 500
WL 3000	3 000
WL A	A

for the low ambient temperature in accordance with [Annex E](#) with A as:

- T(-25),
- T(-15),
- T(-05),
- T(05),
- T A.

and for the resistance to wind induced vibrations in accordance with [Annex F](#) with A as:

- natural frequency of vibration,  $\omega_0$ : >10 Hz;
- logarithmic decrement of damping,  $\delta$ : >0,1.

The sampling methods are given in [Annexes D](#), [E](#), and [F](#).

Tests for reliability conducted in accordance to [Annex C](#) and for resistance to heat in accordance to [Annex G](#) are considered to satisfy the requirements of durability as specified in [5.7.1](#), [5.7.2](#) and [5.7.3](#).

## 7 Marking, labelling and packaging

The manufacturer shall give on each NSHEV the information in accordance with list entries a) to k):

- a) the name or trade mark of the manufacturer;

- b) the type and model;
- c) the year of manufacture (this may be in coded form);
- d) technical characteristics of the external energy supply (e.g. power, current, voltage, pressure), type of opening (see [5.1.2](#)); if integral gas containers are used they shall be marked with at least the following: mass and type of gas, fill ratio, nominal temperature;
- e) the temperature of the thermal initiation device (if fitted);
- f) the aerodynamic free area (see [B.3.5](#)) in square metres and limitations to application if relevant (e.g. wind direction dependent opening, with or without wind deflector, additional aerodynamic device);
- g) the classes for wind load, snow-load, low ambient temperature, reliability, heat exposure temperature and reaction to fire;
- h) a reference to this document and its year of publication, i.e. ISO 21927-2:2018;
- i) suitable for wall-mounted ventilator: with wind-sensitive control system only (if tested in accordance with [B.3.4.2](#));
- j) the range of installation angle relative to the horizontal; and
- k) dual purpose NSHEV, if relevant.

NSHEV delivered to site in a form of components shall be reassembled under the responsibility of the manufacturer. No cutting, drilling, milling or welding of these components are allowed for reassembling.

The manufacturer shall take into account that packaging, handling and storage conditions do not have any negative influences on the declared performances of the NSHEV.

Packaging should be done in such a way that the NSHEV has its declared performance after delivery.

## Annex A (normative)

### Classification

NOTE See [Clause 4](#).

#### A.1 Nominal activation condition/sensitivity

For the “nominal activation condition/sensitivity”, the presence of the initiation device according to [5.1.1](#), the “opening mechanism” according to [5.1.2](#) and “inputs and outputs” according to [5.1.3](#) shall be visually checked and described as present.

#### A.2 Response delay

The “response delay (response time)” shall be less than or equal to 60 s. It shall be tested for:

- reliability according to [Annex C](#);
- opening under (snow/wind) load according to [Annex D](#) and [E](#);
- low ambient temperature according to [Annex E](#); and
- opening under heat according to [Annex G](#).

It shall also be assessed in accordance with [Annex A](#), and described as less than or equal to 60 s.

#### A.3 Operational reliability

The NSHEV shall be classified as one of the following classes:

- Re 50;
- Re 1000;
- Re A.

The designation 50, 1000 and A in the above-mentioned classes represent the number of openings into the fire open position and closing under no applied load in accordance with [Annex C](#).

#### A.4 Effectiveness of smoke/hot gas extraction (aerodynamic free area)

The effectiveness of smoke/heat gas extraction — aerodynamic free area shall be tested and assessed in accordance with [Annex B](#). The aerodynamic free area  $A_a$  shall be larger than 0 m<sup>2</sup>.

#### A.5 Performance parameters under fire conditions

The resistance to heat and the mechanical stability in accordance with [Annex G](#) shall be classified as:

- B<sub>300</sub> 30;
- B<sub>600</sub> 30;
- B<sub>A</sub> 30;

and reaction to fire in accordance with [Annex H](#) as:

- class.

The designations 300, 600 and A in the above-mentioned classes represent the temperature (in °C) at which the NSHEV is tested in accordance with [Annex G](#).

## A.6 Performance under environmental conditions

The performance under load in accordance with [Annex D](#) shall be classified as:

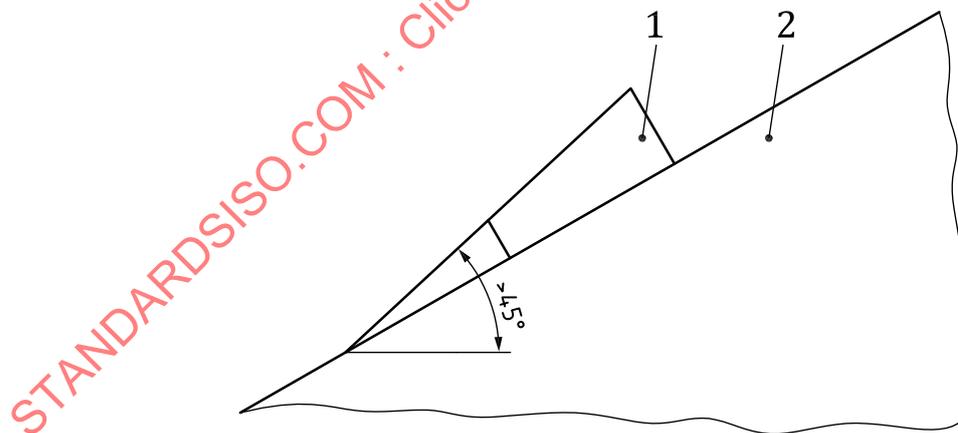
- SL 500;
- SL 1000;
- SL 1500;
- SL A.

The designations 500, 1000, 1500 and A in the above-mentioned classes represent the test snow load in Pa acting on the projection surface of the opening element(s) normal to the exit plane of the NSHEV, applied when the NSHEV is tested in accordance with [Annex D](#).

A NSHEV classified SL 0 can be installed in accordance with the manufacturer's instructions with a minimum angle of installation wider than 45° (combining roof pitch and vent pitch, see [Figure A.1](#), except where the snow is prevented from slipping from the NSHEV, for example, by wind deflectors).

Except for SL 0 for NSHEV fitted with three or four sided deflectors, the snow load classification should not be less than  $SL = 2\,000 \times d$ , where  $d$  is the depth of snow, in metres, which can be contained within the confines of the deflectors.

It is recommended that louvre-type NSHEV are classified not less than SL 500 when used in sub-zero temperature conditions.



### Key

- 1 NSHEV
- 2 roof

**Figure A.1 — Combined roof pitch and NSHEV pitch angle >45°**

The stability under wind load in accordance with [Annex F](#) shall be classified as:

- WL 1500;
- WL 3000;

- WL A.

The designations 1500, 3000 and A in the above-mentioned classes represent the test wind suction load in Pa for NSHEV opening outwards or the test wind pressure load in Pa for NSHEV opening inwards acting on the area given as the product of the external dimensions of the opening element(s) when the NSHEV is tested in accordance with [Annex F](#).

The low ambient temperature in accordance with [Annex E](#) shall be classified as:

- T(-25);
- T(-15);
- T(-05);
- T(05);
- T A.

The designations -25, -15, -05, 05 and A in the above-mentioned classes represent the number of °C at which the NSHEV is tested in accordance with [Annex E](#).

Class T(05) NSHEV are only regarded as suitable for use in construction works where the room temperature in the room underneath the NSHEV is 5 °C or above.

The resistance to wind induced vibrations of the wind deflectors tested in accordance with [Annex F](#) shall be given as:

- natural frequency of vibration,  $\omega_0$ : >10 Hz;
- logarithmic decrement of damping,  $\delta$ : >0,1.

## A.7 Durability

### A.7.1 Response delay (response time)

The durability regarding response delay shall be given as  $\leq 60$  s after being tested at least 49 times in accordance with [Annex C](#).

### A.7.2 Operational reliability

The durability regarding operational reliability shall be given as number of opening into the fire open position tested at least 49 times in accordance with [Annex C](#).

### A.7.3 Performance parameters under fire conditions

The durability regarding the performance parameters under fire conditions after being tested in accordance with [Annex G](#) shall be given as  $\Delta A_{\text{throat}} < 10$  %.

## Annex B (normative)

### Effectiveness of smoke/hot gas extraction (aerodynamic free area)

NOTE See [5.4](#) and [G.1](#).

#### B.1 Determination of the aerodynamic free area

The determination of the aerodynamic free area shall be determined according to the simple assessment procedure or according to the experimental procedure.

#### B.2 Simple assessment procedure

##### B.2.1 General

The aerodynamic free area in accordance with the simple assessment procedure shall be determined only by a notified testing laboratory.

##### B.2.2 Roof mounted NSHEV

For the types of NSHEV shown in Figure B.1 a) and with dimensions in accordance with [5.4](#), the discharge coefficient may be taken as  $C_v = 0,4$  for installation situations with an upstand height of at least 300 mm and for the opening angle specified in Figure B.1 a). An inflow of air into the fire room instead of a discharge of smoke from the fire room shall be avoided.

Small opening angles and/or other installation situations, e.g. see [Figure B.2](#), may lead to negative discharge coefficients.

This may necessitate a wind direction dependent opening of the NSHEV.

##### B.2.3 Wall-mounted NSHEV

For the types of NSHEV shown in Figure B.1 b) and the dimensions of which are in accordance with [5.4](#) the discharge coefficient in the no-wind condition given in [Table B.1](#) may be taken for the opening angles specified in [Table B.1](#). An inflow of air into the fire room instead of a discharge of smoke from the fire room shall be avoided.

This can necessitate a wind direction dependent opening of the NSHEV.

**Table B.1 — Discharge coefficients for wall-mounted NSHEV using the simple assessment procedure for various opening angles  $\alpha$**

$\alpha$	NSHEV opening to the outside	NSHEV opening to the inside
30°	0,25	0,20
45°	0,30	0,25
60°	0,40	0,30
90°	0,50	0,40

### B.3 Experimental procedure

#### B.3.1 General

Unless a simple assessment procedure of [B.1](#) is used,  $A_a$  shall be determined directly from measurements, or indirectly in accordance with [B.3.6](#) on a number of NSHEV or scaled down models of different sizes. The geometric area of typical roof mounted NSHEV, e.g. light dome NSHEV, is defined in Figure B.4 a). For NSHEV in continuous roof lights the geometric area is defined as the product of the free opening length parallel and the shortest free length normal to the roof light axis. The geometric area of wall-mounted NSHEV is the smallest area enclosed by the fixed frame, see [Figure B.7](#).

When testing wall-mounted NSHEV opening to the outside the installation described in Figure B.4 a) shall be used. When testing wall-mounted NSHEV opening to the inside the installation described in Figure B.4 b) shall be used. The test arrangement as shown in Figure B.4 b) may be used in horizontal position.

The test installation described above is the standard test arrangement. The aerodynamic free area determined using this standard test arrangement shall be valid for other NSHEV installations. If other test installations, e.g. with special inlet configurations, are used the results shall be valid only for the particular application. The installation shall be clearly documented in the test report and the manufacturer's installation documentation.

#### B.3.2 Test apparatus

A test apparatus with an open jet or a closed test section facility as shown in [Figure B.3](#) shall be used.

This consists of a settling chamber onto which the NSHEV can be mounted in accordance with Figure B.4 so that the mass flow through the NSHEV can be determined, and a side wind simulator by means of which the NSHEV may be subjected to a side wind. The flow in the settling chamber approaching the NSHEV shall be steady-state and uniform.

This will be achieved if the ratio of the geometric area of the NSHEV to the horizontal cross sectional area of the settling chamber  $A_v / A_{sc} \leq 0,15$  and the velocity,  $V_{sc}$ , distribution measured in the open hole (without NSHEV) at the points specified in [Figure B.6](#) varies by no more than  $\pm 10\%$  of the mean velocity  $V_{m,sc}$  in the plane of measurement of the velocity. The measurement shall be taken in an opening with an area of  $0,15 \times A_{sc}$ , the ratio of the sides being 2:1 and the opening being located in the centre of the cross-sectional area of the settling chamber. If testing NSHEV in a continuous roof light the cross section of the opening in the settling chamber shall be at least 1,5 times the geometric opening area of the NSHEV.

To obtain a uniform side wind condition, when the NSHEV is subjected to side wind, the tests shall be carried out in side wind simulation facilities. The following conditions in [Table B.2](#) shall be satisfied:

**Table B.2 — Conditions in accordance to side mind**

Open jet facilities	Closed test section facilities
— $A_{pr}/A_n \leq 0,3$	— $A_{pr}/A_n \leq 0,08$
— $H_n/H_v \geq 1,3$	— $H_n/H_v \geq 3$
— $B_n/B_v \geq 1,5$	— $B_n/B_v \geq 2$
— $V_n \geq 10$ m/s	— $V_n \geq 10$ m/s

Table B.2 (continued)

Open jet facilities	Closed test section facilities
— velocity at mid height of the up stand $h_{US}/2$ above the test section floor:	
$0,85 \times V < V \left( \frac{h_{US}}{2} \right) < 1,05 \times V$ $\text{with } V = \frac{V \left( \frac{H_v}{2} \right) + V \left( \frac{3H_v}{4} \right) + V(H_v) + V \left( \frac{5H_v}{4} \right)}{4}$	
where $H_v$ is maximum height of the NSHEV in the fire open position.	

All relative velocities  $V_1/V_n$  obtained at the indicated relevant measuring points of lines a1 to a6 in Figure B.5 a) in the entrance area to and at the middle of the test section, for open jet and closed test section facilities, shall lay within the range shown in Figure B.5 b).

All of the turbulence intensities  $I_{u,h_{US}}$  measured at the indicated relevant measuring points of lines a1 to a6 in Figure B.5 a) shall lay within the range shown in Figure B.5 c).

NOTE Using larger side wind velocities increases the accuracy of the measurements.

### B.3.3 Test specimen

Tests shall be carried out on full size NSHEV as supplied by the manufacturer and/or supplier, or on accurately scaled-down models. For testing scaled down models flow similarity shall be established. This is always achieved if the Reynolds numbers of the scaled down model and the full scale NSHEV are identical. The Reynolds number similarity usually requires model scales of 1:6 or larger. Smaller scales (down to 1/10) may be used if justification is given for the flow similarity.

When testing scaled-down models, all features of the NSHEV in contact with the airflow (e.g. opening elements or details of flaps) shall be included and shall satisfy the similarity requirement.

NOTE Experience has shown that it is difficult to model ridge vents and louvre type NSHEV.

It is not considered necessary to test all sizes of a range of similar NSHEV belonging to the same family, provided tests are carried out on a representative selection of sizes. The sizes for larger ranges (at least 8 sizes) to be investigated shall be chosen in such a way that the relative up stand height and length to width ratio covers the whole range of possible NSHEV evenly.

$$\text{Relative up stand height} = \frac{h_{US}}{d_{h,g}}$$

where

$h_{US}$  is up stand height;

$d_{h,g}$  is hydraulic diameter of the geometric opening.

For small ranges (less than 8 sizes) at least two sizes, the smallest and the largest NSHEV and, if necessary, the NSHEV with the most critical aspect ratio shall be investigated. For testing NSHEV differing in dimensions but belonging to the same range,  $A_a$  may be calculated for other sizes. The method of calculation is given in B.3.6.

For NSHEV designed as part of a continuous roof-light the test specimen shall be mounted on the rig with parts of the roof-lights to ensure the correct flow field. Those parts shall have a minimum width of half the external dimension of the NSHEV parallel to the line of the roof-light. For NSHEV intended for use in continuous roof lights the gable ends of the roof light ends shall be streamlined or fitted with a deflection device as shown in Figure B.8.

For roof mounted NSHEV not intended to be suitable for equal wind conditions from all directions (i.e. single flap NSHEV designed for installation on a sloping roof and relying on the interaction with the roof or other NSHEV to aid aerodynamic performance) the mounting and test conditions in the general test procedure can be replaced by specific mounting and test conditions that replicate the intended application of the NSHEV. The NSHEV shall be tested without and with side wind to determine the limits of the NSHEV's application, i.e. negative  $C_v$  which shall be clearly stated in the test report and in the manufacturer's installation documentation. The test arrangement shall be clearly documented in the test report.

### B.3.4 Test procedure

#### B.3.4.1 Roof mounted NSHEV

The outside ambient static pressure shall be quantified with and without wind using the following procedure. Make sure the settling chamber is airtight. Fit into the exit opening of the settling chamber and flush with the exterior of the settling chamber ceiling a thin plate with evenly spaced holes (diameter 50 mm) in order to get a geometric porosity (hole area/exit area of settling chamber) equal to  $(5 \pm 1) \%$ . Measure the static pressure in the settling chamber without wind,  $p_{int,v0}$ , and with wind  $p_{int,vw}$  in accordance with the side wind conditions specified below with reference to the atmospheric pressure  $p_{amb 1}$ .

$$p_{int,v0} = p_{amb 1} + \Delta p_{v0} \quad (B.1)$$

$$p_{int,vw} = p_{amb 1} + \Delta p_{vw} \quad (B.2)$$

Record the  $\Delta p_{v0}$  and  $\Delta p_{vw}$  values, remove the drilled plate, and fit the NSHEV on the settling chamber. Carry out the tests with and without wind.

For the no-side wind case set the full-scale NSHEV onto the settling chamber to get the internal static pressure:

$$p_{int} = p_{amb 2} + \Delta p_{v0} + \Delta p_{int} \quad (B.3)$$

where

$\Delta p_{int}$  is over the range  $\Delta p_{int} = (3 \text{ to } 12) \text{ Pa}$  with an accuracy of at least  $\pm 5 \%$ ;

$p_{amb 2}$  = atmospheric pressure at the time of the measurement.

Measure the ambient atmospheric pressure and temperature, the static pressure of the air in the settling chamber and the volume flow entering the settling chamber. Determine for each value of  $\Delta p_{int}$  the corresponding mass flow  $\dot{m}_{ing}$ .

Take not less than six readings of  $\Delta p_{int}$  and  $\dot{m}_{ing}$  for testing without side wind.

When testing scaled-down models at an increased pressure difference  $\Delta p_{int}$ , due to the Reynolds similarity requirement, the accuracy required of measurement shall be  $\pm 3 \%$  of the reading. The required accuracy of the mass flow measurement is  $\pm 2,5 \%$  of the reading. Measure the temperature and the pressure of the ambient air with an accuracy of  $\pm 0,5 \text{ K}$  and  $\pm 0,5 \%$ , respectively.

$$p_{int} = p_{amb 3} + \Delta p_{vw} + \Delta p_{int} \quad (B.4)$$

where

$p_{\text{int}}$  is over the range of  $\Delta p_{\text{int}} = 0,005 p_d$  to  $0,15 p_d$  with  $p_d$  calculated using the formula:

$$p_d = \frac{1}{2} \tilde{n}_{\text{air}} V_n^2;$$

$p_{\text{amb}3}$  = atmospheric pressure at the time of the measurement.

Testing full scale NSHEV at larger side wind velocities ( $V_n > 10$  m/s) the pressure difference  $\Delta p_{\text{int}}$  shall be increased according  $\Delta p_{\text{int}}/p_d = 0,082$ , e.g. if  $V_n = 14$  m/s,  $\Delta p_{\text{int}}$  is close to 10 Pa.

NOTE The larger  $\Delta p_{\text{int}}$  the better the accuracy of the pressure measurement.

Where fluctuations of the ambient pressure field due to the atmospheric wind may influence the test results the mass flow rate, the wind velocity and the static pressure measurements shall be carried out over a period of at least 10 min.

Measure  $\dot{m}_{\text{ing}}$ , take the average of two readings of  $\Delta p_{\text{int}}$  and  $\dot{m}_{\text{ing}}$  for testing with side wind. Determine the discharge coefficient with side wind  $C_{\text{vw}}$  from the regression line of the readings at  $\Delta p_{\text{int}}/p_d = 0,082$ . To determine  $\beta_{\text{crit}}$ , measure the  $C_{\text{vw}}$  value for various angles  $\beta$ .  $\beta_{\text{crit}}$  is obtained when measurements for angles  $\beta = \beta_{\text{crit}} \pm 5^\circ$  will lead to higher  $C_{\text{vw}}$ -values than determined for  $\beta_{\text{crit}}$ . In order to increase the accuracy of  $C_{\text{vw}}$  at  $\beta_{\text{crit}}$ , take no less than six readings of  $\Delta p_{\text{int}}$  and  $\dot{m}_{\text{ing}}$  with  $\Delta p_{\text{int}}$  over the range  $0,07 p_d$  to  $0,10 p_d$ . Determine the discharge coefficient with side wind  $C_{\text{vw}}$  from the regression line of the readings at  $\Delta p_{\text{int}}/p_d = 0,082$ .

Use the same procedure when measuring the discharge coefficient with side wind for scaled-down models. However, to ensure the similarity of the flow around the NSHEV for full size and model,  $\Delta p_{\text{int}}$  shall be increased, see above. This leads to an increase in the wind stagnation pressure in accordance with  $\Delta p_{\text{int}}/p_d = 0,082$  and thus to an increase in nozzle exit velocity as compared to full size testing. To avoid compressibility effects, do not test at a side wind velocity greater than 100 m/s.

The measurement signals usually fluctuate. They shall be averaged over a time period long enough for the pressure and air volume flow values to be respectively in the range of  $\pm 2,5\%$  and  $\pm 5\%$  for. The averaging technique shall be given in the test report.

#### B.3.4.2 Wall-mounted NSHEV

For wall-mounted NSHEV the test procedure of [B.3.4.1](#) shall be followed in the “without wind” condition only.

#### B.3.5 Evaluation of test results

Calculate the discharge coefficient using the formula:

$$C_v = \frac{\dot{m}_{\text{ing}}}{A_v \times \sqrt{2 \times \tilde{n}_{\text{air}} \times \Delta p_{\text{int}}}} \quad (\text{B.5})$$

From the  $C_v$ -values thus determined, calculate the mean discharge coefficients,  $C_{v0}$  (without side wind) and  $C_{\text{vw}}$  (with side wind). Calculate the aerodynamic free area using the lower value of the  $C_{v0}$ - and  $C_{\text{vw}}$ -values rounded to two digits:

$$A_a = A_v \times C_v \quad (\text{B.6})$$

Wall-mounted NSHEV have a value  $C_{v0}$  only.

### B.3.6 Calculation of the coefficient of discharge for a family of NSHEV

#### B.3.6.1 Discharge coefficient without wind

##### B.3.6.1.1 Basic considerations

The discharge coefficient without wind depends exclusively on the flow through the NSHEV. The flow situation is one of internal aerodynamics. It is common in the field of aerodynamics to calculate the aerodynamic free area,  $A_a$ , of the flow through an orifice using the contraction coefficient  $\mu$  which is given as:

$$\mu = A_a / A_{ex} \quad (B.7)$$

where

$A_{ex}$  = area of the exit plane = smallest cross-section area of NSHEV;  
using the geometric ratio  $m = A_{ex}/A_v$ , the discharge coefficient can be written as follows:

$$C_{v0} = A_a / A_{ex} = m \times \mu.$$

For a sharp edged orifice  $\mu$  depends only on the relative wall thickness of the orifice and — mildly — on the Reynolds-number. The relative wall thickness  $\delta$  is defined as the wall thickness (i.e. up stand height of a NSHEV,  $h_{US}$ ) divided by the hydraulic diameter  $d_h$  of the orifice:

$$\delta = h_{US} / d_h.$$

##### B.3.6.1.2 NSHEV with flap opening angles larger than 60°

These NSHEV include single and double flap NSHEV as used for roof mounting and louvre type NSHEV. The calculation procedure is as follows:

- determine  $C_{v0}$  for at least 4 sizes of a family of NSHEV in accordance with this annex;
- calculate  $\mu$  for these sizes and plot  $\mu$  vs.  $h_{US} / d_h$ ;
- from this plot determine  $\mu$  for the other sizes depending on their value of  $h_{US} / d_h$ ;
- calculate  $C_{v0} = m \times \mu$  and  $A_a$  for the other sizes.

##### B.3.6.1.3 NSHEV with flap opening angles 60° and less

Small opening angles are typical for wall-mounted ventilators of the window type with horizontal hinges. Here one shall distinguish between the exit area between the parallel lines of the fixed and movable frames and the two triangular areas at the sides of the open NSHEV that are perpendicular to the axis of rotation. The discharge coefficient  $C_{v0}$  depends not only on the opening angle  $\alpha$  and the aspect ratio of the NSHEV [length to width ratio ( $l/b$ )] but also on the relative thickness of the profile  $\delta_p$ , which is obtained here using the profile height  $h_p$ , i.e.

$$\delta_p = \frac{h_p}{d_p}$$

where  $d_h$  is calculated using the formula  $d_h = (4 \times A_v) / U_v$ , with  $U_v$  = boundary of the geometric area.

The discharge coefficients can be calculated in the following way:

- determine  $C_{v0}$  for at least 4 sizes of a range of NSHEV in accordance with [Annex B](#);
- $C_{v0}$  is plotted as a function of the dimensionless ratio  $(l/b) / \delta_p$ ;

- if the opening angle  $\alpha$  varies,  $C_{v0}$  is plotted three-dimensionally as a function of the dimensionless ratio  $(l/b) / \delta_p$  and as a function of  $\alpha$ .

For other dimensions within a range,  $C_{v0}$  is calculated from a three-dimensional interpolation (e.g. triangular interpolation in the space).

### B.3.6.2 Discharge coefficient with wind

#### B.3.6.2.1 Hinged single flap NSHEV

The discharge coefficient with wind depends mainly on the flow around the NSHEV. Hence its determination is a problem of external aerodynamics. For usual NSHEV the discharge coefficient depends mainly on the ratio of the height to the upper edge of the wind deflector  $h_{uwd}$  and the upper edge of the opened flap  $H_v$ , both above the roof, and — mildly — on the aspect ratio of the NSHEV.

If  $C_{vw} \geq C_{v0}$  for all NSHEV tested to calculate the necessary height of the wind deflectors, proceed as follows:

- determine the height ratio  $h_{uwd}/H_v$  from the measurements of this annex;
- plot  $C_{vw}$  vs.  $h_{uwd}/H_v$  for aspect ratios  $\leq 1,5$  and  $> 1,5$ ;
- determine the necessary  $h_{uwd} / H_v$  for the other sizes to obtain  $C_{vw} = C_{v0}$ .

If no wind deflectors are used, the height ratio,  $h_{us} / H_v$ , shall be used.

If  $C_{vw} < C_{v0}$  for one or more of the NSHEV tested the calculation procedure shall use the two parameters  $h_{uwd} / H_v$  (or  $h_{us} / H_v$  if no wind deflectors are used) and the aspect ratio. Triangular interpolation in the space  $h_{uwd} / H_v$  (or  $h_{us} / H_v$ ), aspect ratio, and  $C_{vw}$  or a similar calculation method shall be used.

#### B.3.6.2.2 Hinged double flap NSHEV, louvre type NSHEV and other NSHEV

The discharge coefficient depends mainly on the ratio of the height of the upper edge of the wind deflector  $h_{uwd}$  to the hydraulic diameter of the geometric area of the NSHEV  $d_{h,g}$  and — mildly — on the aspect ratio of the NSHEV.

If  $C_{vw} \geq C_{v0}$  for all NSHEV tested to calculate the necessary height of the wind deflectors, proceed as follows:

- determine the height ratio  $h_{uwd} / d_{h,g}$  from the measurements of this annex;
- plot  $C_{vw}$  vs.  $h_{uwd} / d_{h,g}$  for aspect ratios  $\leq 1,5$  and  $> 1,5$ ;
- determine the necessary  $h_{uwd} / d_{h,g}$  for the other sizes to obtain  $C_{vw} = C_{v0}$ .

If no wind deflectors are used the height ratio  $h_u / d_{h,g}$  shall be used.

If  $C_{vw} < C_{v0}$  for one or more of the NSHEV tested the calculation procedure shall use the two parameters  $h_{uwd} / d_{h,g}$  (or  $h_{us} / d_{h,g}$  if no wind deflectors are used) and the aspect ratio. Triangular interpolation in the space  $h_{uwd} / d_{h,g}$  (or  $h_{us} / d_{h,g}$ ), aspect ratio, and  $C_{vw}$  or a similar calculation method shall be used.

## B.4 Test to check the aerodynamic test installations

### B.4.1 General

In order to check and validate each test installation, four reference tests shall be carried out.

The tests should be conducted once a year or after any changes that are made to the test facility. The results of the most recent reference tests should be part of each test report.

### B.4.2 Reference test without side wind

The coefficient of discharge without side wind,  $C_{v0}$ , shall be measured for the installation shown in [Figure B.10](#). The  $C_{v0}$ -value obtained shall be:

$$C_{v0} = 0,62 \pm 0,01 \text{ for } \Delta p_{\text{int}} = 5 \text{ Pa, } 10 \text{ Pa, } 15 \text{ Pa, } 20 \text{ Pa}$$

### B.4.3 Reference tests with side wind

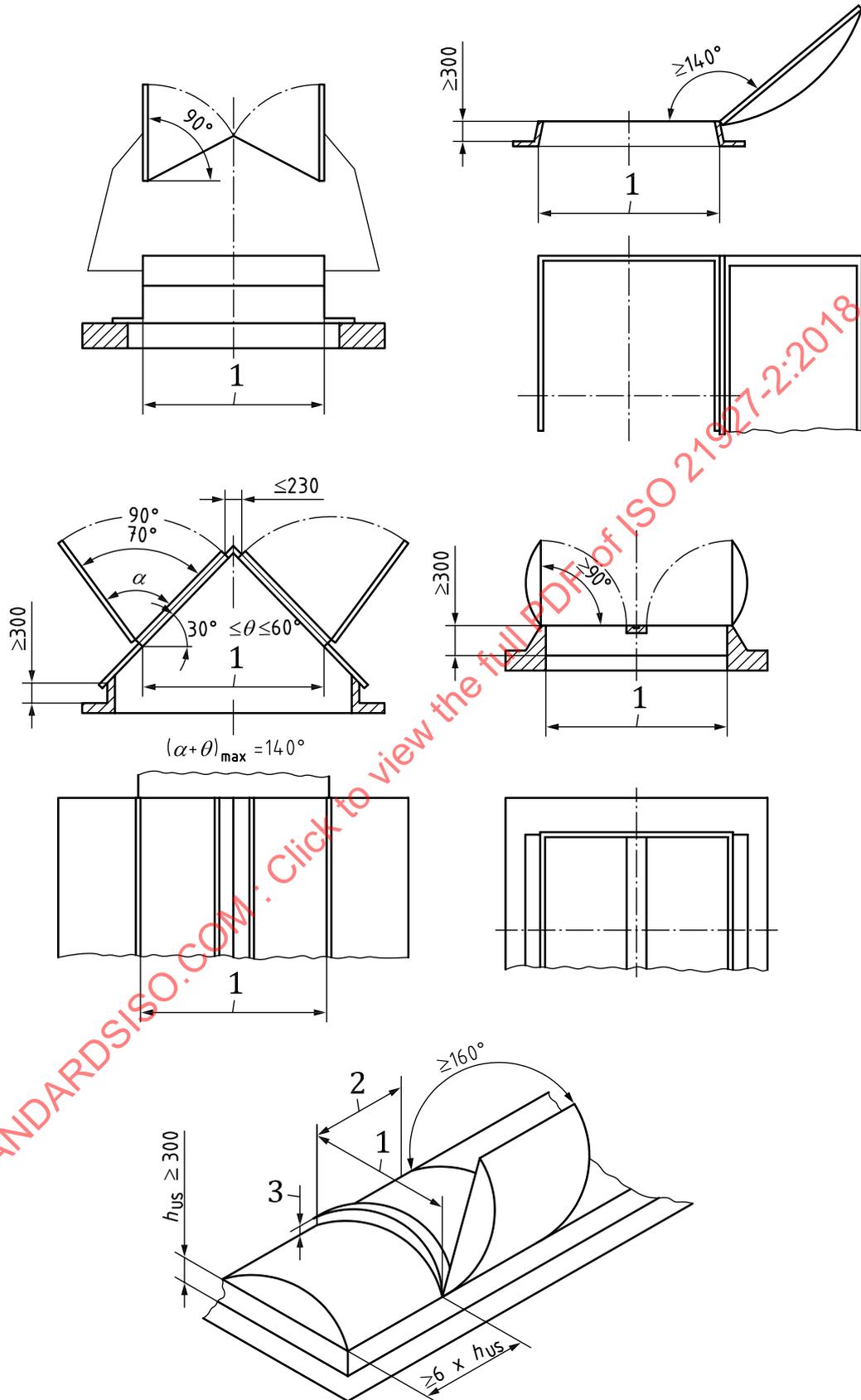
The coefficients of discharge with side wind,  $C_{vw}$ , shall be measured for the NSHEV specified in [Table B.3](#).

**Table B.3 — Characteristics of the reference NSHEV (full scale size), see [Figure B.9](#)**

Parameters	Single flap Opening 1,4 × 1,4	Single flap Opening 1,8 × 1,8	Simplified NSHEV
Length	1,4 m	1,8 m	1,4 m
Width	1,4 m	1,8 m	1,4 m
Upstand height	0,32 m	0,32 m	0,32 m
Opening design	Flap	Flap	None
Opening angle	140°	140°	None
Upstand	Vertical	Vertical	Vertical

### B.4.4 Evaluation of test results

The discharge coefficient for the 4 tests shall be determined in accordance with the test procedure given in [B.3.4](#). The discharge coefficients obtained shall be within the limits specified in [B.4.2](#) and in [Figure B.9](#).



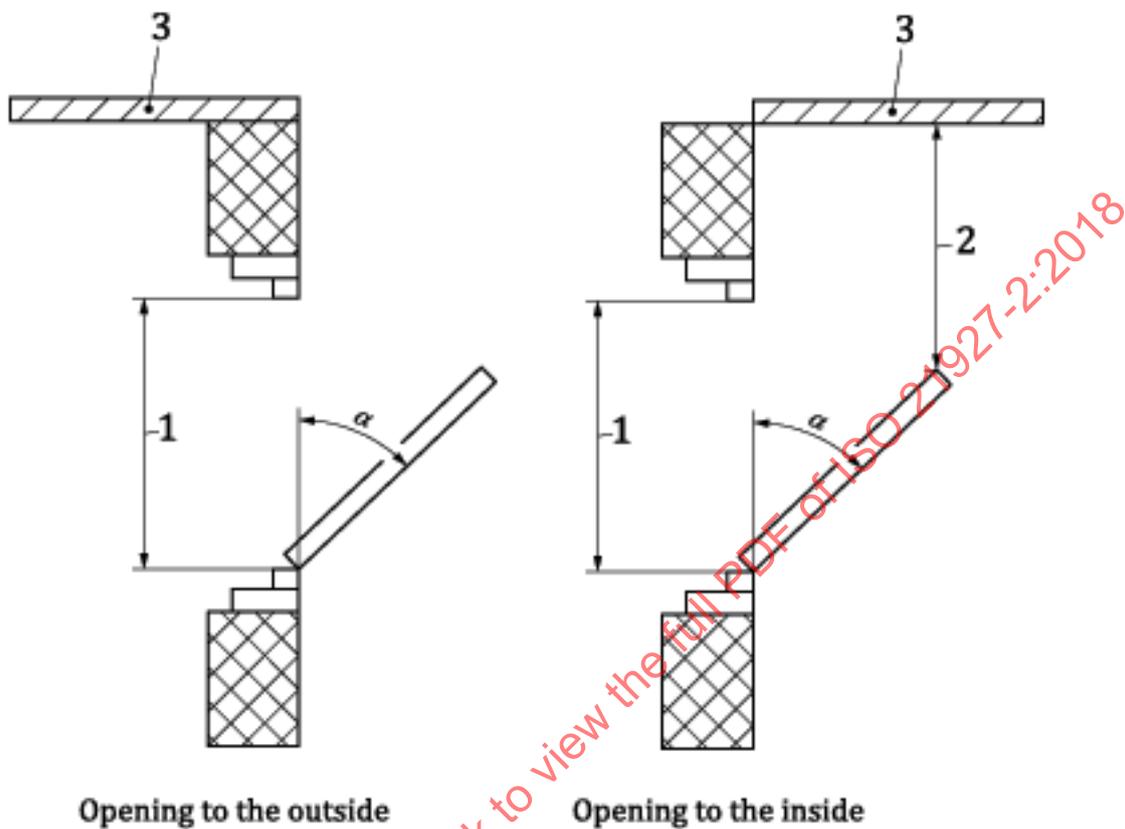
**Key**

1 length of geometric area

3 frame height (min. 70 mm)

2 width of geometric area

Figure B.1a) Types of NSHEV for the simple assessment procedure



**Key**

- 1 length of geometric area
- 2 distance between upper edges of open flap and ceiling (min. 500 mm)
- 3 ceiling
- $\alpha$  opening angle

Figure B.1b) Types of wall-mounted NSHEV for the simple assessment procedure

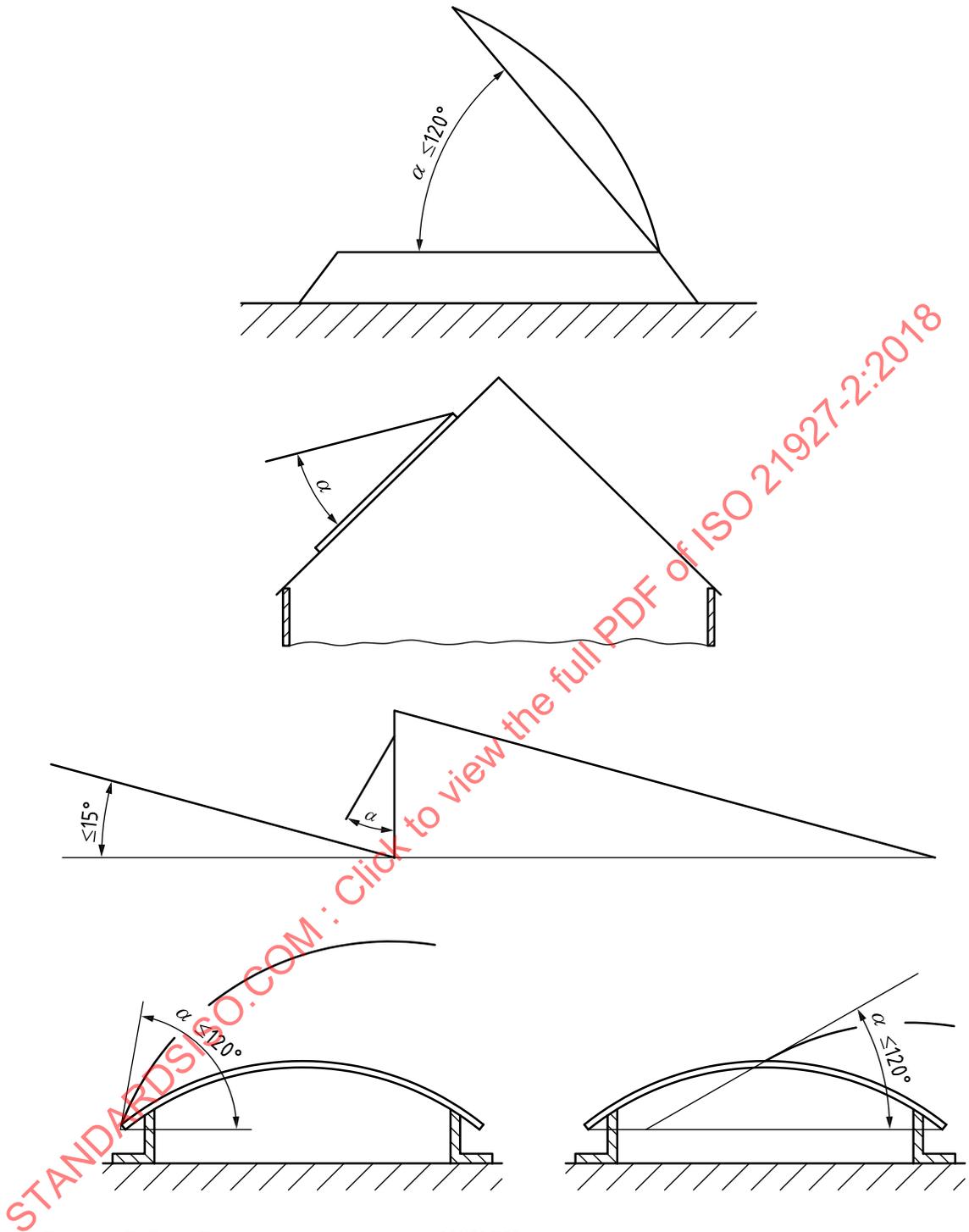
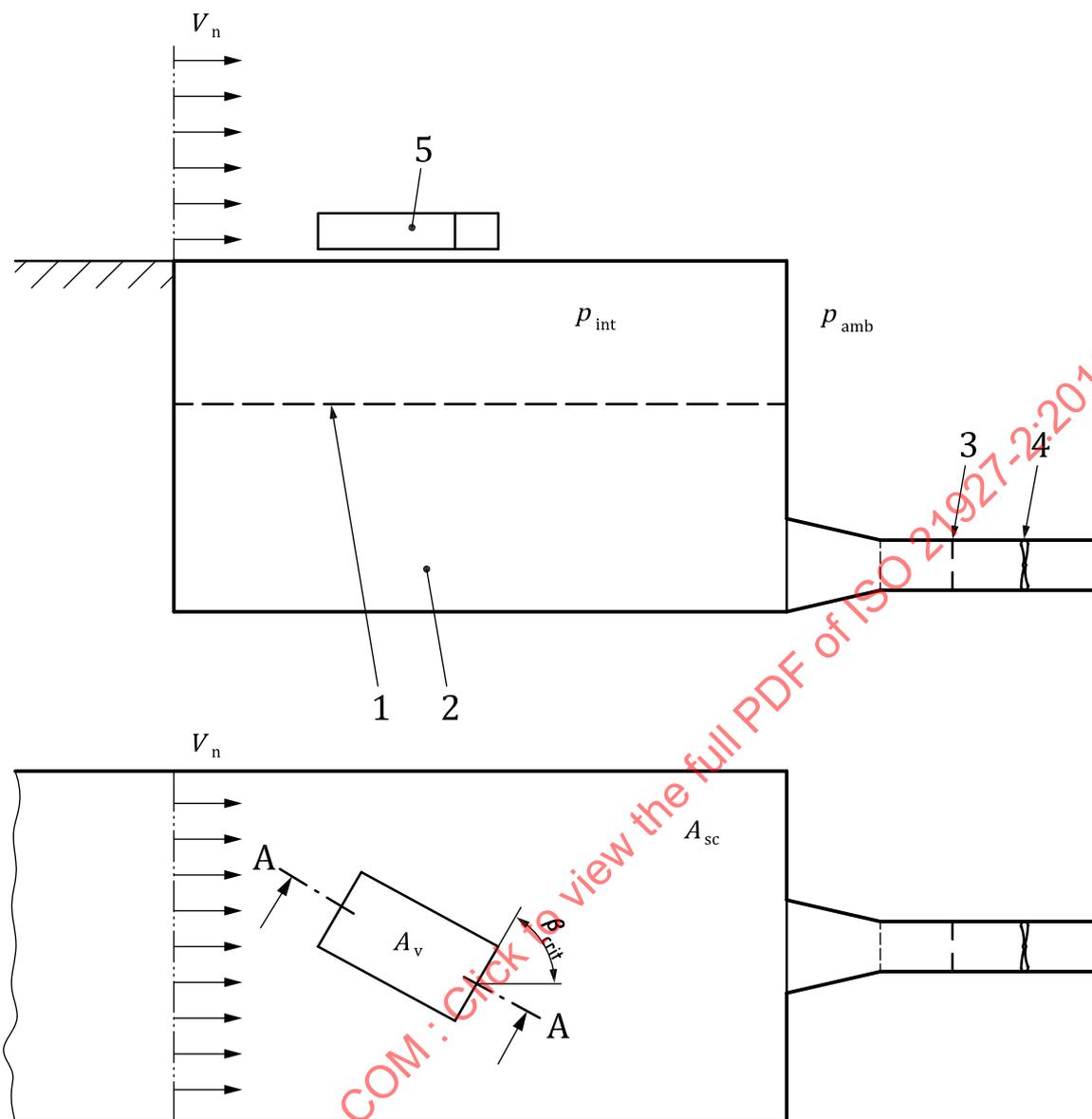


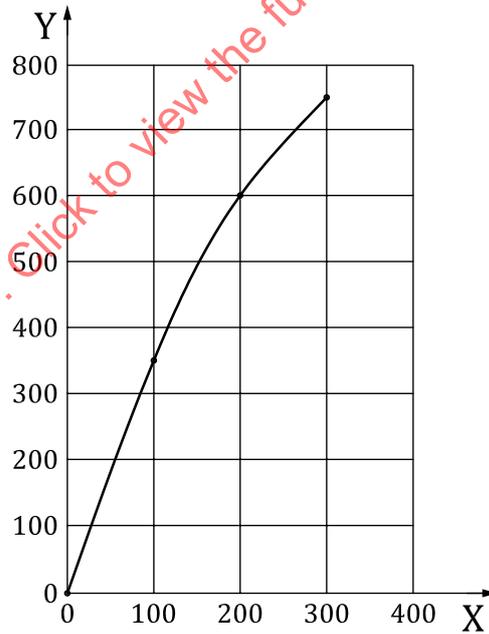
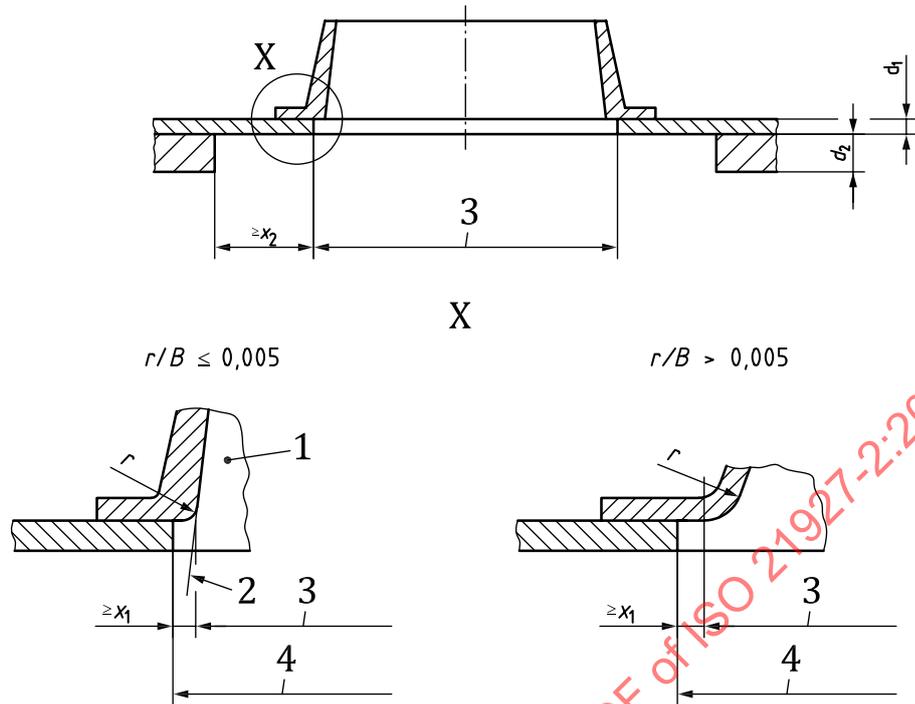
Figure B.2 — Examples of types of NSHEV probably leading to negative discharge



**Key**

- 1 screen
- 2 settling chamber
- 3 volume flow measurement
- 4 fan
- 5 NSHEV

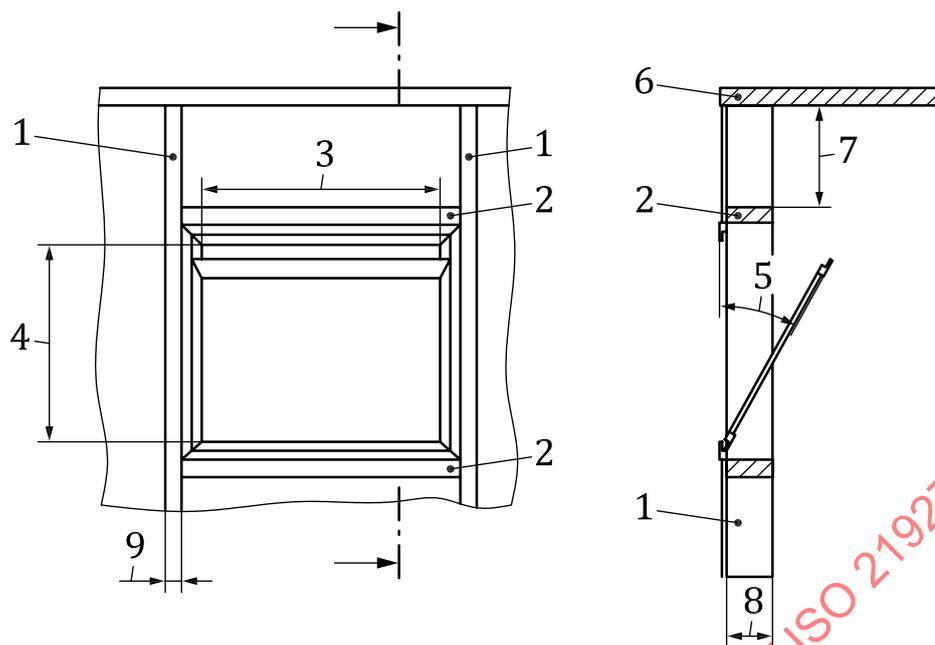
**Figure B.3** — Schematic drawing of test set up for the determination of  $A_a$



**Key**

- |                                |   |
|--------------------------------|---|
| 1 NSHEV                        | 5 distance measure $x_1$ min and $x_2$ min, in mm   |
| 2 tangent                      | 6 ceiling thickness $d_1$ and $d_2$ , in mm   |
| 3 geometric dimension of NSHEV | 7 diagram to determine the distance for mounting the NSHEV on the ceiling of the settling chamber |
| 4 ceiling dimension            |   |

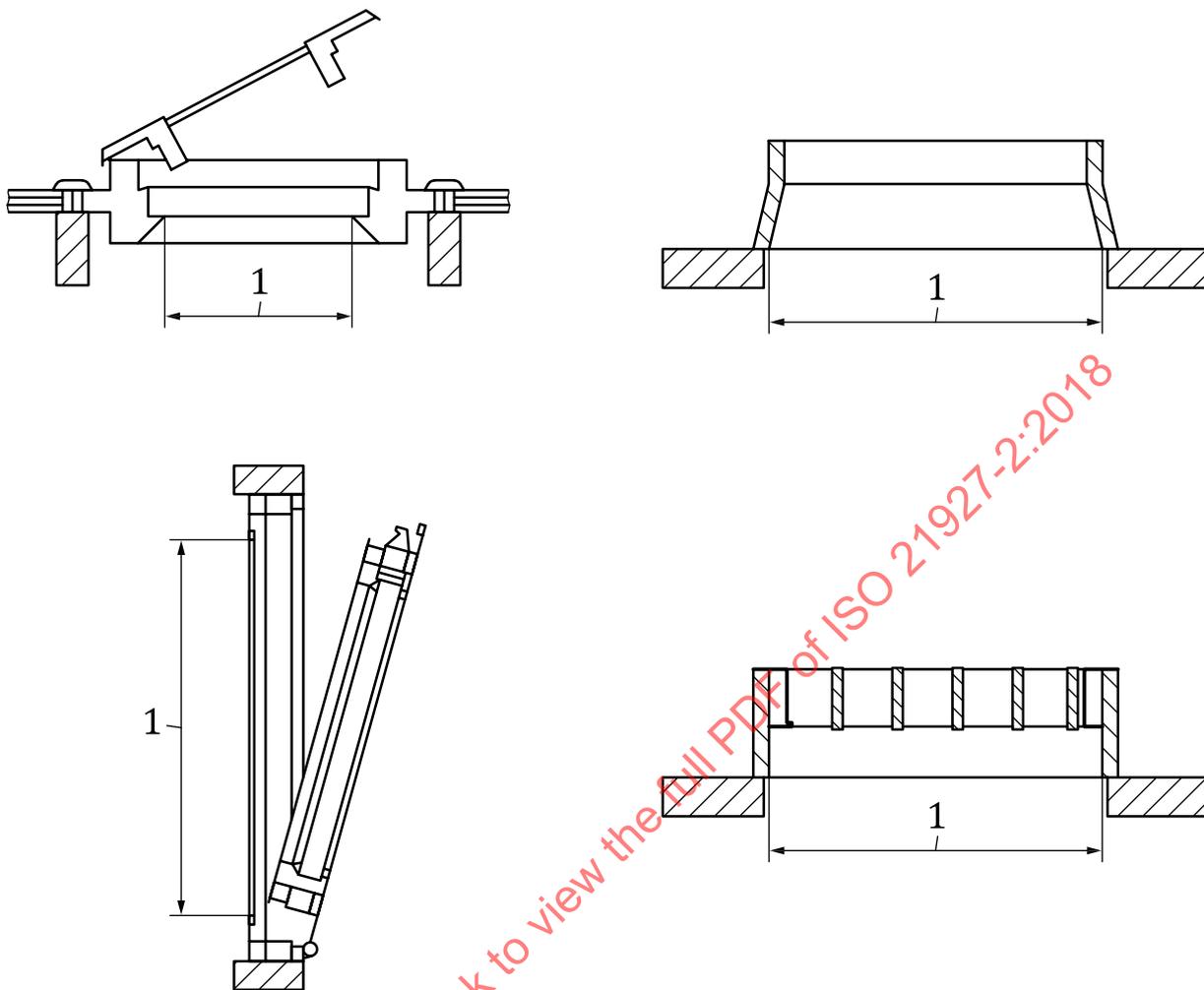
**Figure B.4a) Data for the mounting of roof mounted and wall-mounted NSHEV opening to the outside onto the settling chamber**



**Key**

- |   |                        |   |   |
|---|------------------------|---|---|
| 1 | mullion                | 6 | ceiling   |
| 2 | transom                | 7 | distance between upper transom and ceiling = 500 mm ± 50 mm |
| 3 | width                  | 8 | depth of mullion and transom = 150 mm ± 15 mm               |
| 4 | height                 | 9 | width of mullion and transom = 50 mm ± 5 mm                 |
| 5 | opening angle $\alpha$ |   |   |

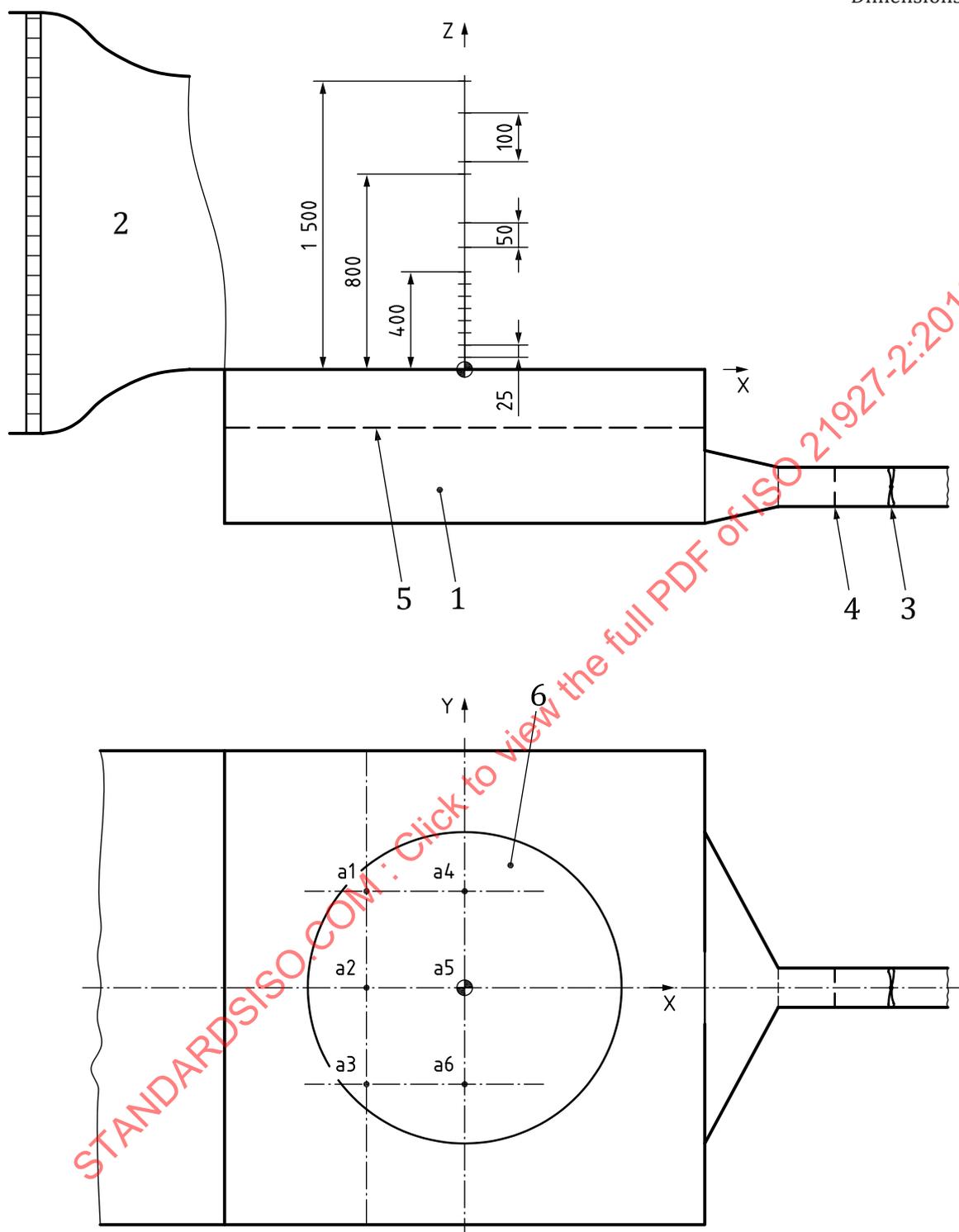
**Figure B.4b) Standard test arrangement for the mounting of wall-mounted NSHEV opening to the inside onto the settling chamber**



**Key**

- 1 length/height of geometric area ( $A_v = \text{length/height} \times \text{width}$ )

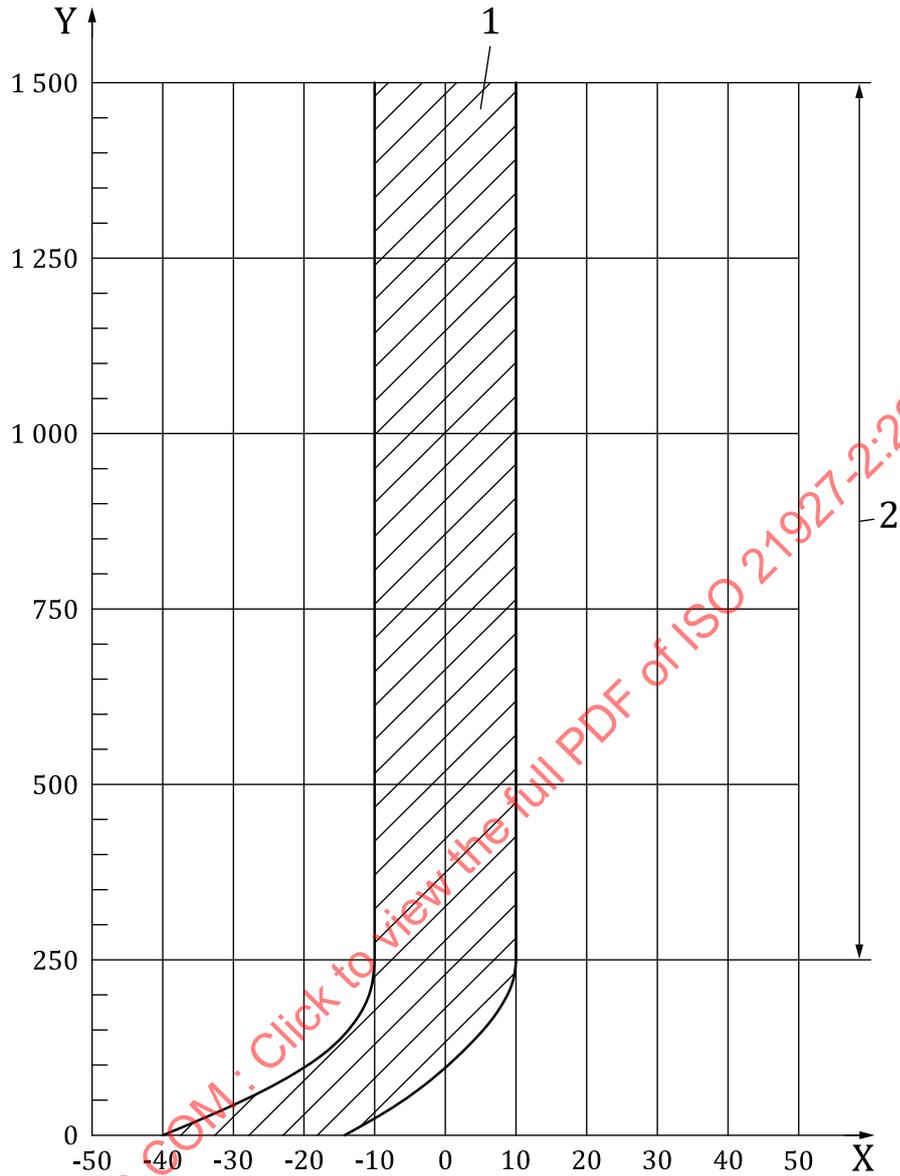
**Figure B.4c) Definition of geometric area**



**Key**

- |                    |                           |
|--------------------|---------------------------|
| 1 settling chamber | 6 volume flow measurement |
| 2 wind tunnel      | 7 screen                  |
| 3 fan              | 8 turntable               |

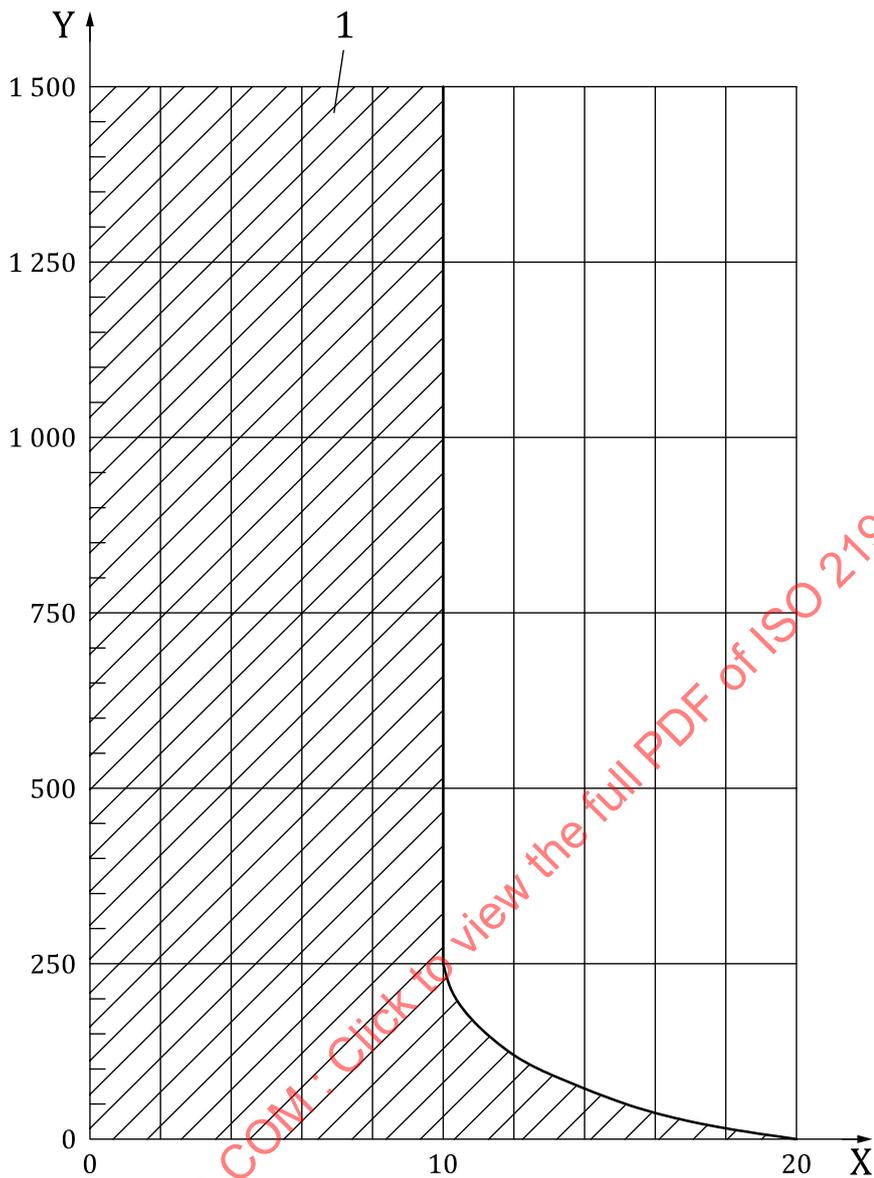
**Figure B.5a) Measuring positions for the side wind velocity and turbulence**



**Key**

- 1 permissible relative local air speed  $(V_1 / V_n) - 1$
- 2 area used to obtain the nozzle velocity  $V_n$
- Y height in mm
- X relative local air speed  $(V_1 / V_n) - 1$  in %

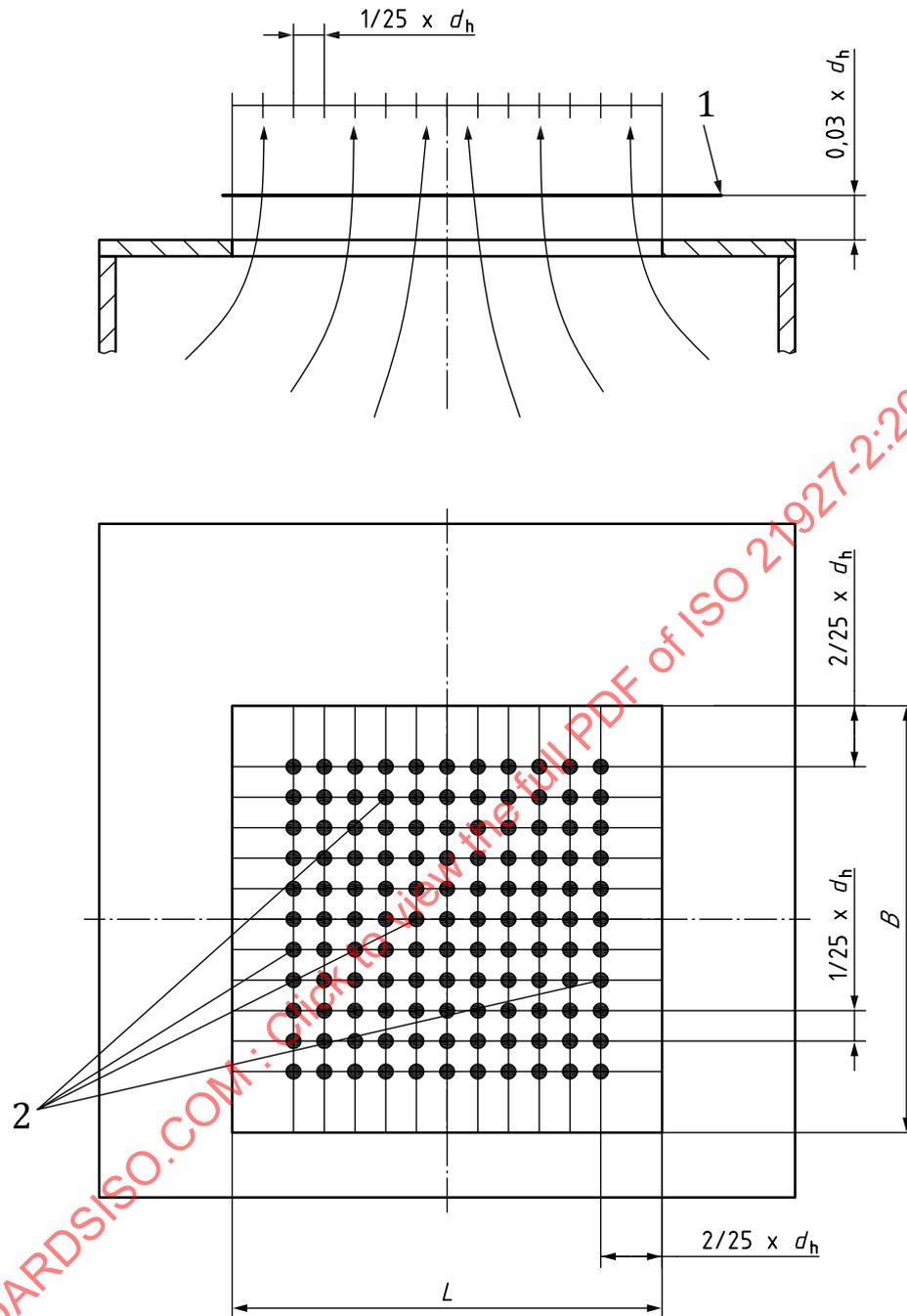
**Figure B.5b) Range of permissible relative local air speed**



**Key**

- 1 permissible local turbulence in %
- Y height in mm
- X local turbulence in %

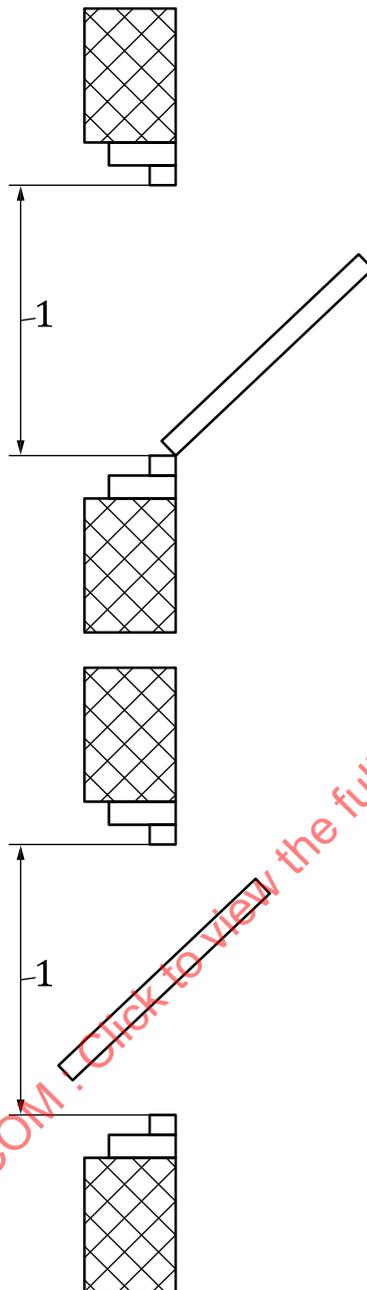
**Figure B.5c) Range of permissible local turbulence**



**Key**

- 1 plane of measurement
- 2 measuring points to determine  $V_{sc}$

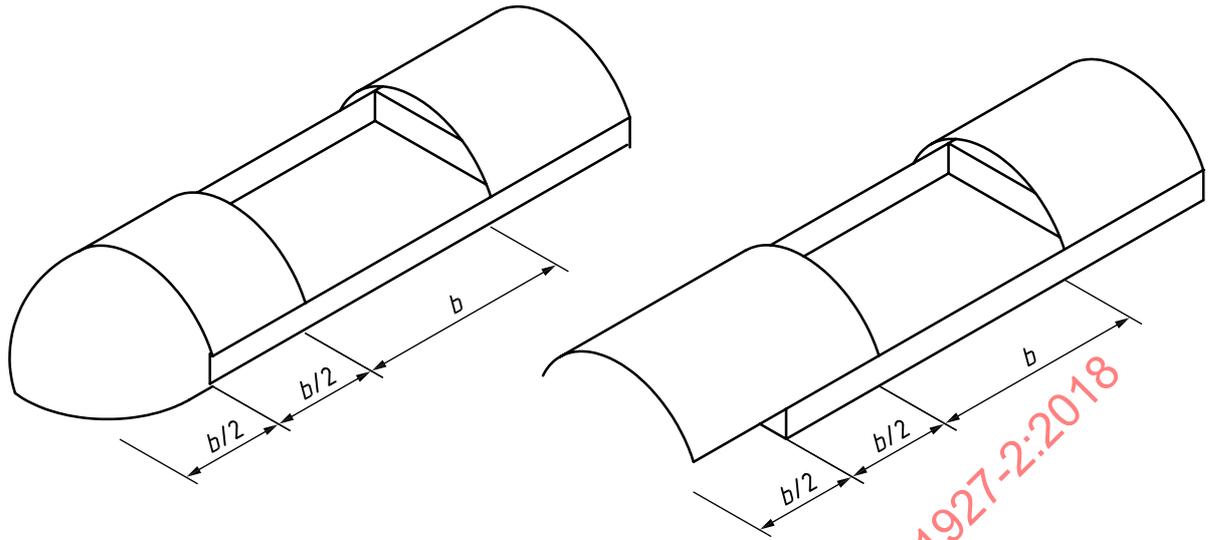
**Figure B.6 — Measuring positions for the flow velocity in the exit opening of the settling chamber**



Key  
1 length

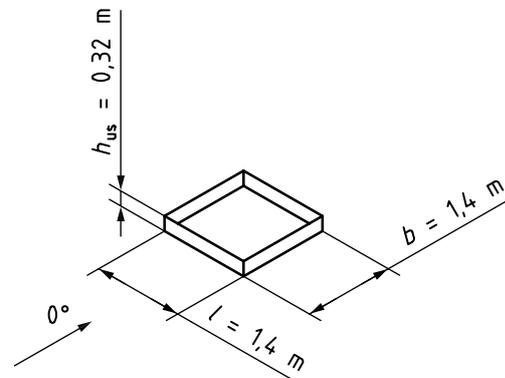
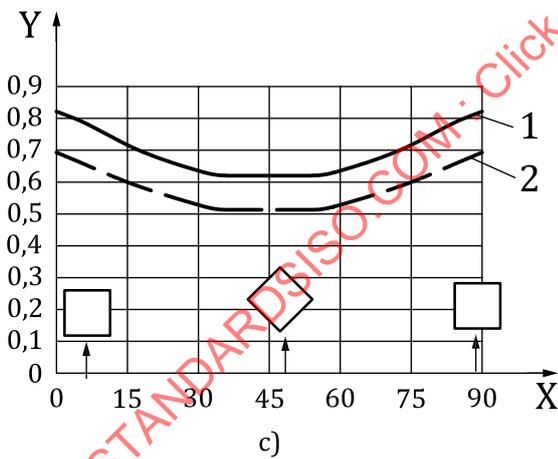
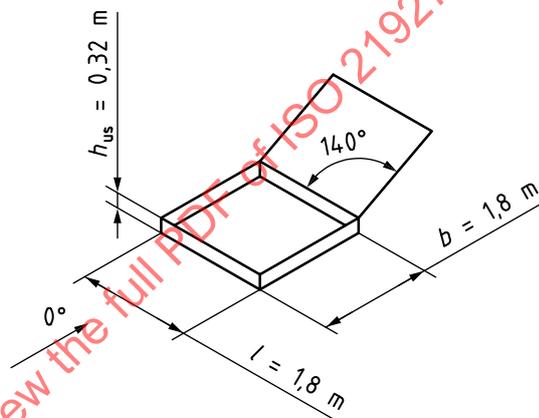
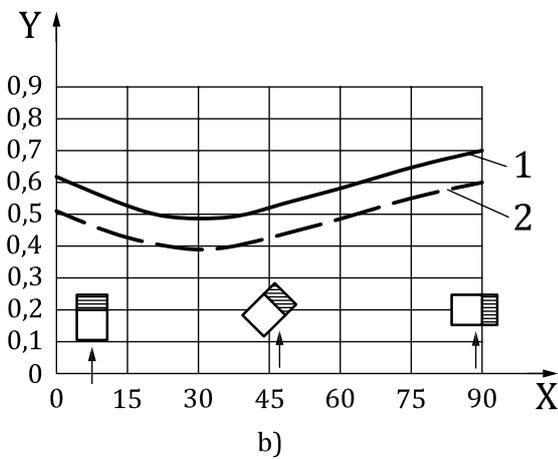
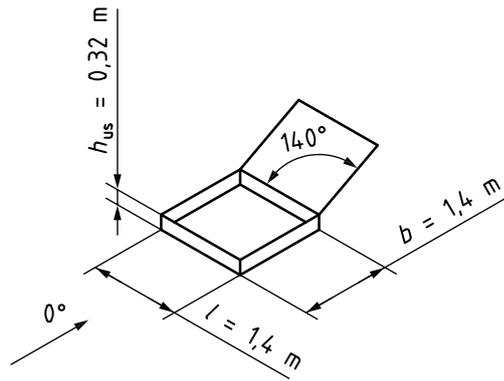
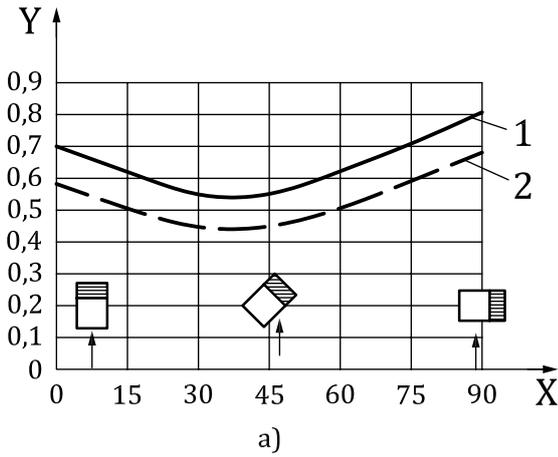
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Figure B.7 — Geometric dimension of wall-mounted NSHEV



**Figure B.8 — Aerodynamic boundary conditions and devices when testing SHEV for use in continuous roof-lights**

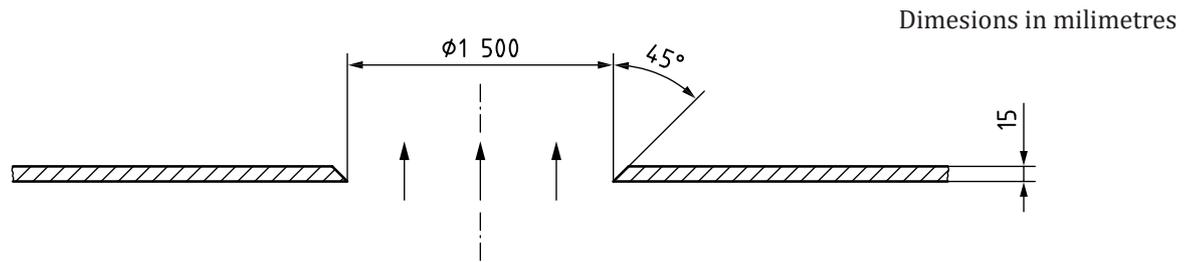
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**Key**

- |   |                                   |    |   |
|---|-----------------------------------|----|---|
| 1 | maximum $C_v$                     | a) | ventilator with a single plate opening ( $A_v = 1,4 \text{ m} \times 1,4 \text{ m}$ ) |
| 2 | minimum $C_v$                     | b) | ventilator with a single plate opening ( $A_v = 1,8 \text{ m} \times 1,8 \text{ m}$ ) |
| Y | discharge coefficient $C_v$       | c) | simplified ventilator ( $A_v = 1,4 \text{ m} \times 1,4 \text{ m}$ )                  |
| X | wind incidence angle ( $^\circ$ ) |    |   |

**Figure B.9 — Discharge coefficients for the reference tests with wind**

**Key**

1 flow

**Figure B.10 — Geometric details for full-scale installation for the reference test without side wind**

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## Annex C (normative)

### Test method for operational reliability and response time

NOTE See [5.2.1](#), [5.3](#), [5.7.1](#) and [5.7.2](#).

#### C.1 Objective of the test

The objective of this test is to determine the ability of the installed NSHEV to open and close for the number of cycles specified in [A.3](#).

#### C.2 Test conditions

If tests are conducted outdoors and if no other atmospheric conditions are specified, e.g. for the low temperature test, the following environmental conditions shall be applied:

- Temperature:  $(15 \div 35)$  °C;
- Relative humidity:  $(25 \div 75)$  %;
- Air pressure:  $(86 \div 106)$  kPa;
- Max. permitted wind velocity: 1 m/s.

For indoor testing in accordance with [Annexes C, D](#) and [F](#) the room temperature should be in the range of 15 °C to 35 °C.

#### C.3 Test apparatus

The NSHEV shall be mounted onto a test rig having an energy source to activate the opening and closing mechanism, and a device to automatically count the number of cycles.

#### C.4 Test specimen

A test on the NSHEV with the largest geometric area and a test on the NSHEV with the largest side length (both achieving the objective of the test) may be considered representative of all NSHEV in a particular range (where a NSHEV has both the largest area and the largest side length, only one test is necessary).

#### C.5 Test procedure

During the test, do not maintain, repair or replace any part involved in the opening or closing of the NSHEV. Mount the specimen NSHEV securely onto the test rig at the angle within the range of angles specified by the supplier and/or manufacturer which imposes the highest stresses on the NSHEV during use. Do not apply any external load to the NSHEV.

Using the NSHEV's energy source, or using an external energy source to simulate the effect of the NSHEV's energy source, open the NSHEV to the fire open position through the number of cycles in accordance with the reliability classification in [A.3](#). Following this, open the NSHEV to the fire open position through three cycles using the NSHEV's energy source. The fire open position shall be reached in no more than 60 s.

There are two types of NSHEV:

- type A, which shall be opened into their fire open position;
- type B, which shall be opened into their fire open position and shall be closed remotely.

If the NSHEV is designed to be remotely opened and closed for on-site testing purposes, the NSHEV shall be closed in the test remotely using the NSHEV's closing mechanism during each cycle.

If the NSHEV is a dual purpose NSHEV carry out 10 000 cycles to the normal comfort ventilation position prior to the above test.

If more than one energy source may be used, the most critical energy source shall be chosen for the test.

Report any maintenance, repair or replacement of any part not involved in the opening or closing. Such maintenance, repair or replacement shall not constitute a failure of the test.

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## Annex D (normative)

### Test method for opening under load

NOTE See [5.2.2](#) and [5.6.1](#).

#### D.1 Objective of the test

The objective of this test is to establish the ability of the NSHEV to open and remain open against an applied wind and snow load.

#### D.2 Test conditions

If tests are conducted outdoors and if no other atmospheric conditions are specified, e.g. for the low temperature test, the following environmental conditions shall be applied:

- Temperature:  $(15 \div 35)$  °C;
- Relative humidity:  $(25 \div 75)$  %;
- Air pressure:  $(86 \div 106)$  kPa;
- Max. permitted wind velocity: 1 m/s.

For indoor testing in accordance with [Annexes C, D](#) and [F](#) the room temperature should be in the range of 15 °C to 35 °C.

#### D.3 Test apparatus

Use a test rig onto which the NSHEV can be mounted and subjected to a test snow load applied by one of the following methods:

- plates (one or more per louvre blade/flap when testing louvre-type NSHEV);
- bags containing up to 5 kg each of solid particles or liquid; or
- for NSHEV with pivoting flaps, both the test snow load and the wind load may be replaced by equivalent torque leading to the same torque/opening angle relation. If the wind load is replaced by an equivalent torque the method to obtain the correct torque/opening angle relation shall be clearly documented in the test report.

Spread the loads evenly over the whole of the external surface of the individual elements of the opening parts of the NSHEV, to produce a uniformly distributed load equal to the appropriate load specified in [A.6](#).

For NSHEV in which, under practical conditions involving wind, flaps are opened into the wind flow, carry out the test with a side wind with a distribution of side wind speed  $(10 \pm 1)$  m/s taken over the projection area of the NSHEV, in the direction critical for opening, i.e. leading to the largest wind resistance against opening, in addition to the test snow load.

NOTE The torque/opening angle relation is usually obtained in a wind tunnel test by measuring the pressure distribution around the NSHEV flap for various opening angles.

#### D.4 Test specimen

A test on the NSHEV with the largest geometric area and a test on the NSHEV with the largest side length (both achieving the objective of the test) may be considered representative of all NSHEV in a particular range (where a NSHEV has both the largest area and the largest side length, only one test is necessary).

If a range of NSHEV includes different types of flaps, e.g. flaps of different weight, the NSHEV with the most critical type of flap shall be tested.

#### D.5 Test procedure

Mount the NSHEV onto the test rig at the most critical installation angle taking into account the range of installation angles specified by the manufacturer. Apply the appropriate load. Actuate the NSHEV and check that it opens, reaches the fire open position within 60 s and remains in the fire open position without an external energy supply, without damage, using the primary energy source. Reset the NSHEV and repeat the actuation test a further two times, applying the same opening requirement.

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## Annex E (normative)

### Test method for low ambient temperature

NOTE See [5.2.3](#) and [5.6.2](#).

#### E.1 Objective of the test

The objective of this test is to establish the ability of the NSHEV to operate at low ambient temperature.

#### E.2 Test apparatus

Use the test apparatus described in [D.3](#).

#### E.3 Test specimen

A test on the most critical NSHEV tested in accordance with [Annex D](#) may be considered representative of all NSHEV in a particular range, for the purpose of the ambient temperature test.

#### E.4 Test procedure

A test with a complete NSHEV shall be conducted.

Mount the NSHEV in a climatic chamber at the most critical installation angle within the manufacturer's recommended range of installation angles. Reduce the temperature in the climatic chamber to the appropriate value specified in [A.6](#). The NSHEV shall be cooled down to the temperature specified in [A.6](#) prior to testing. It shall be ensured that the deviation of the sample temperature during the performance of the test is not greater than  $\begin{matrix} +2 \\ -5 \end{matrix}$  °C of the appropriate value specified in [A.6](#). Open the NSHEV three times into its fire open position using the NSHEV's primary energy source. Roof-mounted NSEV shall be loaded with snow load in accordance with the snow load classification of the NSHEV in accordance with [Annex D](#).

## Annex F (normative)

### Test method for stability under wind load

NOTE See [5.6.3](#) and [5.6.4](#).

#### F.1 Objective of the test

The objectives of this test are to establish the integrity of the NSHEV under loads imposed by the wind and that the NSHEV remains closed and that it will open into its fire open position within 60 s after being subjected to the wind load.

#### F.2 Test conditions

If tests are conducted outdoors and if no other atmospheric conditions are specified, e.g. for the low temperature test, the following environmental conditions shall be applied:

- Temperature:  $(15 \div 35)$  °C;
- Relative humidity:  $(25 \div 75)$  %;
- Air pressure:  $(86 \div 106)$  kPa;
- Max. permitted wind velocity: 1 m/s.

For indoor testing in accordance with [Annexes C, D](#) and [F](#) the room temperature should be in the range of 15 °C to 35 °C.

#### F.3 Test apparatus

Use a test rig onto which the NSHEV can be mounted and subjected to a uniformly distributed load applied by one of the following methods:

- a) air pressure;
- b) air pressure bags;
- c) plates or bags containing not more than 10 kg of solid particles or liquids.

#### F.4 Test specimen

A test on the NSHEV with the largest geometric area and a test on the NSHEV with the largest side length (both achieving the objective of the test) may be considered representative of all NSHEV in a particular range (where a NSHEV has both the largest area and the largest side length, only one test is necessary).

#### F.5 Test procedure

##### F.5.1 Wind load

Mount the NSHEV on the test rig in accordance with the supplier's and/or manufacturer's recommendations. Apply a load using one of the methods given in [E.3](#), increasing the load from zero

to the appropriate upper limit specified in A.6, and maintain this load for  $(10 \pm 1)$  min. For multi-layer flaps apply this load to the outer layer to simulate the wind load correctly. Remove the load.

Roof mounted NSHEV and wall-mounted NSHEV opening to the outside shall be subjected to a suction load wall-mounted NSHEV opening to the inside shall be subjected to a pressure load.

On completion of the test, the NSHEV, in its normal operating position, shall be opened without the applied load and remain in the fire open position without an external energy supply.

## F.5.2 Vibration

The vibrational behaviour of wind deflectors concerning wind induced vibration shall be characterized by the structure's lowest natural frequency and the logarithmic decrement of damping of free oscillation. The natural frequency and the logarithmic decrement of damping can be determined, e.g. with an accelerometer fixed to the wind deflector.

For vibration measurements, the NSHEV shall be fixed and secured firmly to

- the concrete floor, or
- a steel floor, or
- a wood frame fitted on the floor, or
- a steel frame fitted on the floor.

The obtained acceleration versus time trace shall be evaluated to give the natural frequency and logarithmic decrement.

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## Annex G (normative)

### Test method for resistance to heat

NOTE See [5.2.4](#) and [5.6.4](#).

#### G.1 Objective of the test

The objective of this test is to establish the ability of the installed NSHEV to open within 60 s under exposure to heat and to remain in the fire open position with not more than 10 % reduction of the throat area.

The resistance to heat and the mechanical stability are given if all parts relevant for the aerodynamic performance of the NSHEV, e.g. wind deflectors and flaps, and all structural parts remain in place.

NOTE The aerodynamic performance is influenced even if a part of the flap or the whole flap is destroyed or falls down before the end of the test.

#### G.2 Test apparatus

##### G.2.1 Test furnace

Use a furnace to which the NSHEV is connected directly.

The furnace may be heated by any convenient means. The test apparatus shall not allow the combustion zone of flames to contact the NSHEV.

Suitable test furnaces are specified in EN 1363-1.

##### G.2.2 Temperature measurement

Measure the furnace temperature using four thermocouples located in accordance with [Figures G.1](#) to [G.3](#). The thermocouple No. 3 is used for information only for the working group to continue the work on a future revision of the standard. The thermocouples shall have measuring junctions of nickel chromium/nickel aluminium (type K) wire as defined in EN 60584-1 contained within mineral insulation in a heat resisting alloy sheath of diameter  $(3 \pm 0,2)$  mm, the hot junctions being electrically insulated from the sheath. The thermocouple hot junction shall project at least 25 mm from any given support tube if used. An example of a thermocouple is given in [Figure G.4](#).

##### G.2.3 NSHEV mount

###### G.2.3.1 Roof mounted NSHEV

Use a mount constructed from materials which do not distort when subjected to the test temperature, with an opening area equal in size to the geometric area of the NSHEV (including rooflight parts or glazed partition constructions, when existing, so that these parts are also exposed, see [G.3.2](#) and [G.3.3](#)), and with the mount surface pitched at the minimum recommended installation angle for the NSHEV. An example of roof-mounted NSHEV is given in the [Figures G.1](#) and [G.2](#).

###### G.2.3.2 Wall-mounted NSHEV

Wall-mounted NSHEV may be tested in a vertical furnace or a horizontal furnace. When using a vertical furnace [[Figure G.3 b](#)], mount the NSHEV in a vertical wall. When using a horizontal furnace

[[Figure G.3 a)], mount the test specimen in a holding device which is fixed on the top of the furnace with a horizontal opening from materials which do not distort when subjected to the test temperature, with openings on no more than two opposite sides each equal in size to the geometric area of the NSHEV (including the area of continuous partition construction, when existing, so that these parts are also exposed, see G.3.2), and with the mounting surface pitched at the installation angle for the NSHEV. An example of wall-mounted NSHEV is given in Figures G.3 a) and b).

It is possible to test up to two NSHEV in opposite sides in the same test. Then it is possible that one NSHEV fails and the other one passes the test, provided the two NSHEV do not influence each other and no part of the failed NSHEV drops down on the other NSHEV.

## G.3 Test specimen

### G.3.1 General

A test on the widest worst case NSHEV and a test on the longest worst case NSHEV (both with its largest geometric area achieving the objective of the test) may be considered representative of all NSHEV in a particular range given in Tables G.1 and G.2 (where a NSHEV is the widest and the longest, only one test is necessary). The NSHEV with the most critical material and most critical parts (e.g. with regard to high temperature and distortion under heat, weight) shall be selected for the test. Where a most critical combination cannot be identified, more than one test specimen might be necessary. If the same NSHEV can be equipped with the opening mechanism exposed to the furnace atmosphere or at the unexposed side, the NSHEV with the opening mechanism exposed to the furnace atmosphere shall be selected. The NSHEV with the opening mechanism at the unexposed side can be covered by the NSHEV with the opening mechanism exposed to the furnace atmosphere, if the fixation of the opening mechanism is equivalent.

The results of previous tests to this standard on similar ranges of products from the same manufacturer may be taken into account when selecting the test specimens for a product range.

### G.3.2 NSHEV mounted to a glazed partition construction

For wall and roof mounted NSHEV designed as part of a continuous glazed partition construction, the test specimen shall be tested as a part of the continuous glazed partition construction having a minimum width of 250 mm on all sides surrounding the NSHEV, including transoms/mullions and/or glazing profiles as representative.

The continuous glazed partition construction can be omitted if the NSHEV is a structurally self-supporting system and is independent of the continuous glazed partition construction, i.e. that static and dynamic forces will not be transferred to the continuous glazed partition construction, but directly to the load bearing structure. The materials of the filling of the continuous glazed partition construction shall be classified as Class A1 or A2 in accordance with EN 13501-1 and the melting point of this material shall be higher than the heat exposure classification temperature, otherwise the test shall include the continuous glazed partition construction.

NOTE These tests with additional parts of the continuous glazed partition construction give information about warping of the extrusions used under heat exposure.

### G.3.3 Roof mounted NSHEV as part of a continuous rooflight

For roof mounted NSHEV designed as part of a continuous rooflight the test specimen shall be tested with parts of the rooflight with a minimum width of 250 mm on either side of the NSHEV parallel to the line of the rooflight.

The continuous rooflight may be omitted if the NSHEV is a structurally self-supporting system and is independent of the continuous rooflight, i.e. that static and dynamic forces will not be transferred to the continuous rooflight, but directly to the load bearing structure of the roof. The materials of the filling of the continuous rooflight shall be classified as Class A1 or A2 in accordance with EN 13501-1

and the melting point of this material shall be higher than the heat exposure classification temperature, otherwise the test shall include the continuous rooflight.

NOTE The tests with additional parts of the rooflight give information about warping of the extrusions under heat exposure.

**G.3.4 Wall-mounted NSHEV**

Select the worst case of the wall-mounted NSHEV in accordance with [Tables G.1](#) and [G.2](#) for testing. All other opening types are covered by testing the worst case opening type.

**G.3.5 Roof mounted NSHEV**

Select the worst case of the NSHEV in accordance with [Table G.1](#) for testing. All other opening types are covered by testing the worst case opening type.

**Table G.1 — Top hung NSHEV, bottom hung NSHEV and side hung NSHEV**

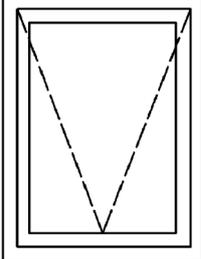
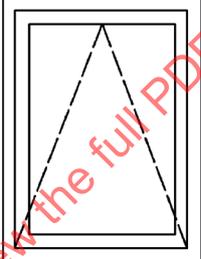
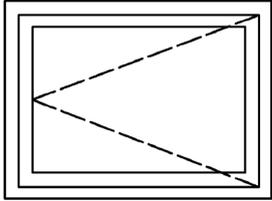
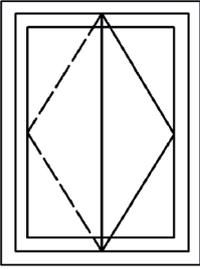
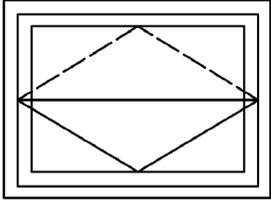
Range of NSHEV	Top hung NSHEV with the hinges at the top	Bottom hung NSHEV with hinges at the bottom	Side hung NSHEV with the hinges at the side
			
opening to the outside	Case 1: Worst case	Case 2: Covered by case 1	Case 3: Covered by case 6
opening to the inside	Case 4: Covered by case 5	Case 5: Worst case	Case 6: Worst case
<b>Key</b> a width/height b length			

Table G.2 — NSHEV with horizontal or vertical middle axis

Range of NSHEV	NSHEV with hinges in the middle of the top and the bottom	NSHEV with hinges in the middle at the sides
		
opening to the outside and the inside	<p style="text-align: center;">Case 8: Covered by case 7</p>	<p style="text-align: center;">Case 7: Worst case</p>
<p><b>Key</b> a width/height b length</p>		

### G.4 Test procedure

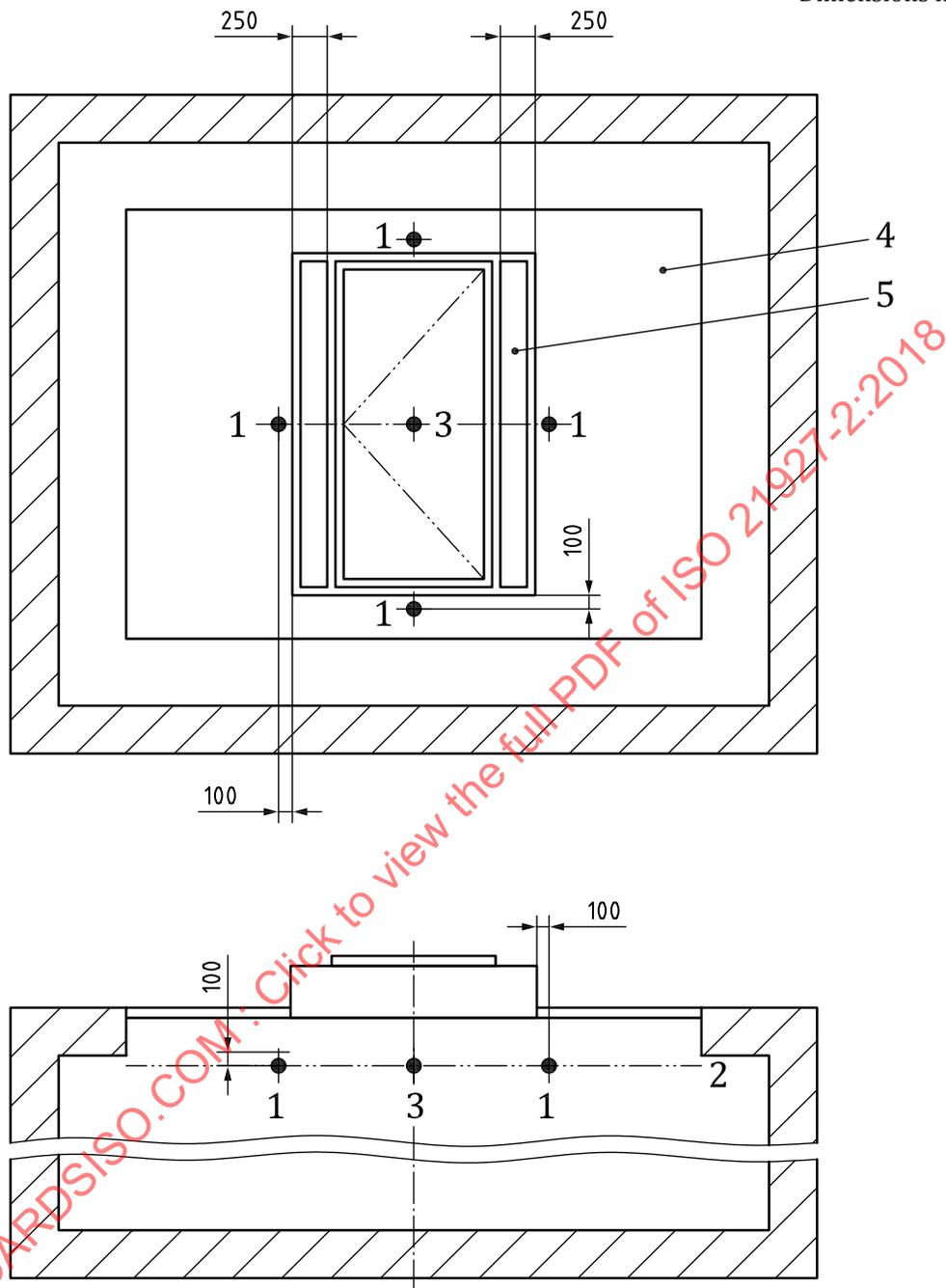
Fix the NSHEV securely to the furnace and ensure that the mounting opening lines up with the geometric area of the NSHEV.

Increase the furnace temperature from  $20_{-10}^{+10}$  °C following a gradient between limits defined by 0,8 K/s and 1,2 K/s to reach a mean temperature in the plane of measurement of  $(300_{-0}^{+60})$  °C within 5 min or  $(600_{-0}^{+60})$  °C within 10 min (all from the start of the test) as appropriate (see A.6). This temperature shall be maintained for the remaining test time (except for the 5 min following the NSHEV actuation). The total test time shall be 30 min. For the first 2 min after starting the burners no temperature tolerance is defined. For the first 5 min the NSHEV shall remain closed. The NSHEV shall be initiated manually into its fire open position within 60 s, 5 min after the furnace temperature starts to rise. If the NSHEV is fitted with a thermal device neutralize the thermal device from the opening mechanism which then will be operated manually.

For a period of 5 min after actuating the NSHEV, the tolerances applying to the furnace temperature are enlarged to  $\pm 100$  °C. The temperature/time-curve of the whole test procedure is shown in Figure G.5.

Check, at least by observation, that the throat area, see Figure G.6, has not been reduced by more than 10 % during the test and measure the opening at the end of the test.

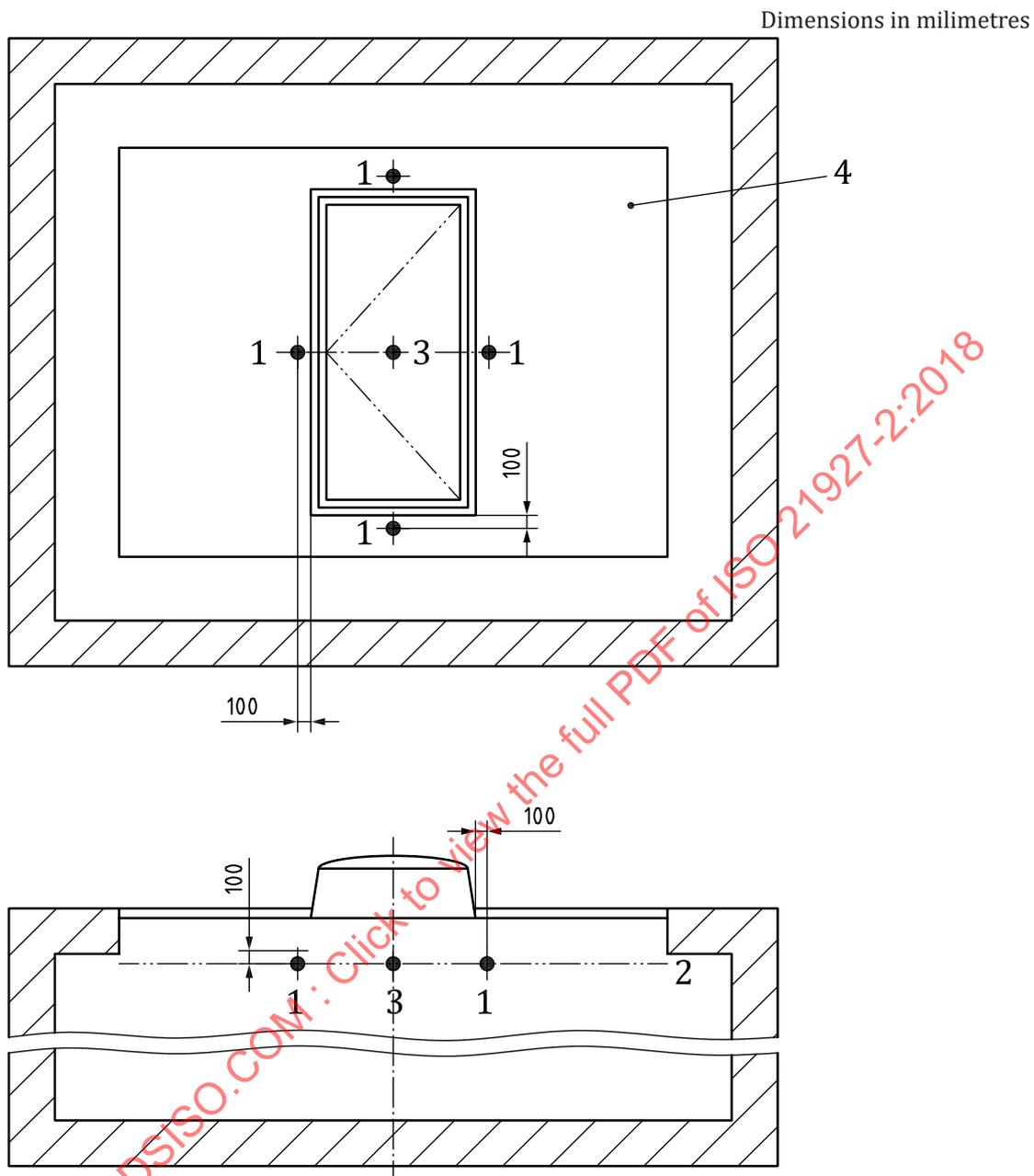
Dimensions in millimetres



**Key**

- 1 thermocouple
- 2 plane of measurement
- 3 thermocouple for information only (position: In the plane of measurement central under the NSHEV)
- 4 mount constructed above the furnace opening
- 5 rooflight parts

**Figure G.1 — Position of thermocouples for roof-mounted NSHEV with rooflight parts**



**Key**

- 1 thermocouple
- 2 plane of measurement
- 3 for information only (position: In the plane of measurement central under the NSHEV)
- 4 mount constructed above the furnace opening

**Figure G.2 — Position of thermocouples for roof-mounted NSHEV without rooflight parts**