INTERNATIONAL STANDARD

ISO 21927-1

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Smoke and heat control systems —

Part 1:
Specification for smoke barriers

Systèmes pour le contrôle des fumées et de la chaleur —

Partie 1: Spécifications des écrans de fumée

Reference number
ISO 21927-1:2008(E)

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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 21927-1 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*.

ISO 21927 consists of the following parts, under the general title *Smoke and heat control systems*:

— *Part 1: Specification for smoke barriers*

— *Part 2: Specification for natural smoke and heat exhaust ventilators*

— *Part 3: Specification for powered smoke and heat exhaust ventilators*

A Part 4, dealing with specifications for smoke ducts, a Part 5, dealing with specifications for smoke dampers, a Part 6, dealing with specifications for control panels and a part 7, dealing with specifications or guidelines for power supplies are planned.

Introduction

General

Smoke and heat exhaust ventilation systems (SHEVS) create a smoke-free layer above the floor by removing smoke and heat 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 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 fire fighting, reducing roof temperatures and retarding the lateral spread of fire is firmly established. To obtain these benefits, it is essential that SHEVS operate fully and reliably whenever called upon to do so during their installed life. A SHEVS is a scheme of safety equipment intended to perform a positive role in a fire emergency.

It is important that the components for smoke and heat exhaust systems be installed as part of a properly designed smoke and heat exhaust system.

SHEVS help to

— keep the escape and access routes free from smoke,

— facilitate fire fighting operations by creating a smoke-free layer,

— delay and/or prevent flashover and thus full development of the fire,

— protect equipment and furnishings and contents,

— reduce thermal effects on structural components during a fire,

— reduce damage caused by thermal decomposition products and hot gases.

For the purpose of this part of ISO 21927, a smoke barrier is deemed to be any form of barrier to the movement of fire effluent.

Smoke barriers control the movement of fire effluent within a construction works in the event of fire. Smoke barriers, when used within a smoke and heat control system, become a critical element of that system. If smoke barriers are not in their fire-operational position, the system does not perform as designed. However, even in the event that other elements of the SHEVS do not function, smoke barriers in the fire operational position provide essential smoke containment and channelling.

This part of ISO 21927 applies to smoke barriers used within smoke and heat control systems, which include other equipment, e. g. natural smoke and heat exhaust ventilators (ISO 21927-2) and powered smoke and heat exhaust ventilators (ISO 21927-3). Smoke barriers perform within specific time/temperature ranges.

Function of smoke barriers

The function of smoke barriers is to control the movement of fire effluent within construction works by forming a barrier. The functions of active or manually deployed smoke barriers are identical to those of static smoke barriers, but they also can be retracted and concealed when not in use.

Typical functions of smoke barriers are to

— create a smoke reservoir by containing and limiting the travel of the smoke;

- channel smoke in a pre-determined direction;
- prevent or retard smoke entry to another area or void.

Applications of smoke barriers

The primary applications of smoke barriers are listed below. However, as their application becomes more widespread, it is inevitable they will be put to a wider variety of uses. It is important to note that, within the scope of this part of ISO 21927, smoke barriers can contain smoke and gases in excess of 600 °C but are not intended to perform the same function as fire doors and shutters tested in accordance with ISO 3008 or smoke-control doors tested in accordance with ISO 5925-1.

Typical applications for smoke barriers are as

- smoke reservoir boundaries,
- channelling screens,
- void edge screens,
- void sealing screens,
- corridor containment,
- shop unit containment,
- escalator containment,
- stairwell containment,
- elevator well containment.

Types of smoke barrier

Construction-works elements can be used to create static smoke barriers and they can be augmented by smoke barriers covered by this part of ISO 21927.

This part of ISO 21927 applies to the following types of smoke barriers:

- **s**tatic **s**moke **b**arriers (SSB),
- **a**ctive **s**moke **b**arriers (ASB).

A wide range of different materials can be used to create smoke barriers. Typical materials used for static smoke barriers include fabric, glass, metal, fire-resisting board, fibreglass and mineral wool or any impermeable material capable of resisting smoke at temperatures required by the design.

Typical examples of active smoke barriers include roller, pleated, folding, hinged or sliding, using the types of material as described for static smoke barriers.

Static and active smoke barriers are categorized by type and performance in Clause 5.

In addition, an ASB product is deemed to include all controlling equipment, etc. This does not include external controls, for example a fire alarm or a sprinkler flow switch.

Smoke and heat control systems —

Part 1:
Specification for smoke barriers

1 Scope

This part of ISO 21927 specifies the product performance requirements, classifications and test methods for smoke barriers, which comprise the barrier itself, with or without associated activation and drive devices, designed for use in smoke and heat control systems. It covers only barriers installed in buildings, i.e. it does not cover barriers made of part of the building's structure. This part of ISO 21927 provides the test methods for, and conformity assessment of, the smoke barrier systems.

Smoke barriers are only covered by this part of ISO 21927 when calculation methods exist for the determination of the leakage rate of smoke. This requires the smoke barriers to be sufficiently fixed and guided on any free joints between two adjacent smoke barriers. Figure E.4 illustrates a design to which this part of ISO 21927 does not apply.

2 Normative references

The following referenced documents are indispensable for the application 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 834-1, *Fire-resistance tests — Elements of building construction — Part 1: General requirements*

ISO 5925-1:2007 *Fire tests — Smoke-control door and shutter assemblies — Part 1: Ambient- and medium-temperature leakage tests*

ISO 13943, *Fire safety — Vocabulary*

ISO/IEC 17000, *Conformity assessment — Vocabulary and general principles*

ISO/IEC 17050-1, *Conformity assessment — Supplier's declaration of conformity — Part 1: General requirements*

ISO/IEC 17050-2, *Conformity assessment — Supplier's declaration of conformity — Part 2: Supporting documentation*

3 Terms and definitions

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

3.1
active smoke barrier
smoke barrier that moves from its retracted position into its fire-operational position automatically when called upon to do so

3.2
barrier movement
travel distance (e.g. height, drop) of an active barrier from its retracted position to its fire operational position

3.3
channelling screen
smoke barrier installed beneath a balcony or projecting canopy to direct the flow of smoke and hot gases from a room opening to the spill edge

3.4
consumable power supplies
any form of power that, when not available, prevents an active smoke barrier from moving to the required fire operational position

3.5
deflection
movement of a smoke barrier when subjected to the buoyant force of the hot smoke, the movement of air, air pressure or any combination thereof

3.6
fail-safe
designed to return to a safe condition in the event of a failure or malfunction, etc.

3.7
fire operational position
final configuration of a device, e.g. a smoke barrier, specified by its designer to achieve and be sustained in the ultimate fire condition of the design

3.8
fitness for purpose
ability of a product, process or service to serve a defined purpose under specific conditions

3.9
free area
total area of all designed openings and clearance gaps in and/or around the perimeter of a smoke barrier

3.10
integrity
ability of a barrier to maintain its soundness for the purpose for which it is intended without the transmission of significant quantities of flames or hot gases to the non-exposed side

3.11
life safety application
application of the smoke and heat control system in its fire operational condition for the period of time required for the occupants of the premises to be alerted, and to be able to exit the premises, with the smoke and heat control system assisting in the protection of the means of escape

3.12
response time
time taken for an active smoke barrier to move to its fire operational position after initiation

3.13
smoke and heat exhaust ventilation system
SHEVS
set of components jointly selected to exhaust smoke and heat in order to establish a buoyant layer of warm smoke above cooler, cleaner air

3.14
smoke and heat control system
arrangement of components installed in a construction works to limit the effects of smoke and heat from a fire

3.15
smoke barrier
device to channel, contain and/or prevent the migration of smoke (fire effluent)

NOTE Smoke barriers can also be referred to as smoke curtains, smoke blinds or smoke screens.

3.16
smoke reservoir
region within a construction works limited or bordered by smoke barriers or structural elements so as to retain a thermally buoyant smoke layer in the event of a fire

3.17
spill edge
edge of a soffit beneath which a smoke layer is flowing and adjacent to a void, e.g. the edge of a balcony or canopy or the top edge of a window through which the smoke is flowing out of a room

3.18
static smoke barrier
smoke barrier permanently fixed in its fire operational position

3.19
void edge screen
smoke barrier deployed beneath the edge of a balcony or projecting canopy

NOTE Void edge screens can be used either to create a smoke reservoir beneath the balcony or canopy or to restrict the length of spill edge in order to create a more compact spill plume

3.20
void-sealing screen
smoke barrier deployed across a void to create a smoke reservoir beneath the smoke barrier

4 Symbols

$A_{g,a}$ to $A_{g,f}$	Area of the gaps between smoke barriers, or between barrier and structure, expressed in square metres
$A_{g,tot}$	Total free area of the smoke barrier system, calculated as the sum of the areas of the individual gaps between smoke barriers, or between barrier and structure, expressed in square metres
$A_{h,tot}$	Total area of the gaps in the head, obtained by summing the areas of the individual gaps, $g_{h,a}$ to $g_{h,f}$.
d_C	Horizontal deflection of a smoke barrier, measured at its bottom bar, expressed in metres
D	Distance of movement (drop) of smoke barrier, expressed in millimetres
D_l	Design depth of a smoke layer in a reservoir, expressed in metres
g	Acceleration due to gravity, expressed in metres per square second
g_e	Edge gap between the barrier and the surrounding construction, expressed in millimetres
$g_{h,a,\ldots}g_{h,f}$	Gaps the in header box, expressed in millimetres (see Figure 1)
g_j	Joint gap between adjacent barriers, expressed in millimetres
$g_{j,max}$	Maximum joint gap when barriers are in the fire operational condition, expressed in millimetres; $g_j = g_{j,max}/2$
h_B	Height of rise of a thermal line plume from an opening or balcony edge to the smoke layer, expressed in metres
h_O	Height of an opening
h_p	Height of rise of leakage gases from the base of the hot gas layer in the smoke reservoir to the ceiling in the adjacent protected area, expressed in metres
L_C	Length of the smoke barrier from top to bottom bar, measured along the fabric, expressed in metres
M_b	Mass per metre length of the barrier's bottom bar, expressed in kilograms per metre
M_B	Mass flow rate under a balcony, expressed in kilograms per second
M_C	Mass per square metre of the barrier fabric, expressed in kilograms per square metre
M_g	Mass of gas flowing through a gap, expressed in kilograms per second
M_p	Mass of gas flowing into the gas layer in a protected area after having leaked through gaps in smoke barriers, expressed in kilograms per second
t	Time, expressed in minutes
T	Absolute temperature of gases, expressed in kelvin
T_l	Absolute temperature of gas layer in a reservoir, expressed in kelvin
T_0	Absolute ambient temperature, expressed in kelvin
θ_l	Temperature rise above ambient of smoky gases in a reservoir, expressed in degrees Celsius
ρ_0	Density of ambient air, expressed in kilograms per cubic metre
W	Width of smoke barrier, expressed in millimetres

5 Product requirements

5.1 General

The smoke barrier requirements are intended to provide the SHEVS designers with smoke barriers that fulfil the system design requirements. Compliance with this part of ISO 21927 does not necessarily, by itself, ensure fitness for purpose for an application, as defined in ISO/IEC Guide 2.

The system design parameters dictate the minimum classification and performance of smoke barriers that can be used in any particular application. The criteria for the correct choice of smoke barrier shall take into account the total system, function and location requirements without hindering the means of escape or endangering the occupants.

5.2 Barrier types

5.2.1 General

Smoke barriers shall be defined as one of the following types:

- static smoke barrier: flexible material;
- static smoke barrier: rigid material;
- active smoke barrier: flexible material;
- active smoke barrier: rigid material.

5.2.2 Static smoke barriers (SSB)

Static smoke barriers shall be fixed in their fire operational position at all times and according to their design classification.

NOTE Static smoke barriers are used as alternatives and/or additions to the elements of the construction works that can act as permanent static smoke barriers.

5.2.3 Active smoke barriers (ASB)

Active smoke barriers shall move to the fire operational position upon external initiation and according to their design classification. Active smoke barriers shall be defined according to their application, e.g. life safety protection or property protection, method of operation and external initiations.

NOTE Active smoke barriers are used as alternatives and/or additions to elements of the construction works that can act as permanent static smoke barriers.

Active smoke barriers shall be categorized as follows:

- ASB1: smoke barriers that fail safe in/to the fire operational position (not lower than 2,5 m above the finished floor level or in any location hazardous to occupants or objects), in a controlled manner (see 6.4) when all consumable primary and auxiliary power sources are removed, in the event of wiring or system corruption, or any combination thereof;
- ASB2: smoke barriers that move to/stay in the fire operational position (not lower than 2,5 m above the finished floor level or in any location hazardous to occupants or objects), in a controlled manner (see 6.4) upon external initiation but requiring a consumable power source in order to move to or be maintained in the fire operational position;

— ASB3: smoke barriers, conforming to type ASB1, that can be deployed to any height (see 6.4);

— ASB4: smoke barriers conforming to ASB2, that can be deployed to any height (see 6.4).

In the majority of applications, active smoke barriers shall fail safe. But if it is necessary for the smoke barrier to remain retracted, even in the event of fail-safe, the system shall be so designed and tested.

ASB1 and ASB3 do not require fire-rated cables or cable systems.

Active smoke barriers without the fail-safe facility i.e. those requiring a power source to drive them down (ASB2 and ASB4), require fire-rated cables or cable systems.

In certain applications, smoke barriers are used for life-safety applications where types ASB1 and ASB3 may be more fit for purpose.

5.3 Auxiliary power supply

If batteries are used as the primary or auxiliary power source (types ASB2 and ASB4), batteries shall be submitted to an active battery test at intervals not exceeding 60 min. During this test, the connected load shall be at least 110 % of the normal motor current and shall be powered solely from the battery set. A fault-indicating signal shall be given as a volt-free contact and as an optical indication on the control panel upon

— battery set insufficiently charged,

— faulty battery set (e.g. short circuit),

— battery set not connected to load (e.g. open circuit).

Upon detection of a fault signal, the active smoke barrier shall move to the fire operational position.

Other stored energy systems shall have an equivalent level of monitoring and shall be capable of moving the barrier to its fire operational position upon detection of a fault signal.

Power supplies shall comply with regulatory requirements valid in the place of use.

5.4 Smoke (fire effluent) leakage

5.4.1 Openings, gaps and/or perimeter spaces

The free area through and around the complete system, materials and joints inherent in the product design shall be stated by the manufacturer.

All gaps in and around all types of smoke barrier shall be minimized to maintain the smoke-barrier containment efficiency as defined in 6.5.

Deflection of a smoke barrier can occur due to pressure differences or air movement. This can increase edge gaps or reduce the effective smoke-reservoir depth. The system design shall take this into consideration (see 6.5.2).

Care should be taken to ensure that any adjacent surfaces that form part of the barrier to smoke, e.g. false ceilings or fittings, have properties, e.g. resistance to temperature and permeability, at least equivalent to those of the smoke barrier.

NOTE The above criteria require consideration to ensure the efficiency of the smoke barrier to control the movement of fire effluent and aid the effectiveness of the SHEVS.

5.4.2 Permeability of materials

The smoke barrier shall be manufactured from materials that restrict the passage of smoke (see Annex C and 6.5.5).

Where a specific system leakage rate is required, a complete product shall be tested to ISO 5925-1 (see 6.5.5).

5.5 Reliability

The reliability of smoke barriers shall be determined in accordance with 6.3.

5.6 Response time

The response time of active smoke barriers shall conform to 6.4.

6 Performance requirements and classifications

6.1 General

Smoke barriers shall be tested in the orientation and use intended by the manufacturer for their application and installation.

6.2 Temperature/time classification

The temperature/time classifications of all smoke barriers shall be determined in accordance with the test methods in Annex D.

Smoke barriers shall be classified in accordance with the classification categories in Table 1.

Table 1 — Standard classification categories

Classification[a]	Temperature °C	Time min
D 30	600	30
D 60	600	60
D 90	600	90
D 120	600	120
DA	600	Actual time reached above 120

[a] See Annex F for the application of additional classification categories at 300 °C (DL).

The heat exposure at 600°C, designated “D”, represents the constant temperature of the smoke barrier test. The designations “30”, “60”, “90”, “120” represent the period of the smoke barrier test. A smoke barrier that meets the requirements of D 60 also meets the requirements of D 30; equally, a D 90, or D 120, smoke barrier also meets the requirements of all categories with shorter times. A DA smoke barrier meets all “D” requirements.

If smoke barriers are intended for operation at higher time/temperature ranges, they shall be classified in accordance with the classification categories in Table 2. The testing shall meet the time/temperature requirements of ISO 834-1.

Table 2 — Classification categories for smoke barriers operating at higher temperatures

Classification	Temperature °C	Time min
DH 30	Standard heating curve (ISO 834-1)	30
DH 60	As above	60
DH 90	As above	90
DH 120	As above	120
DHA	As above	Actual time reached above 120

The performance requirements of smoke barrier test specimens, when tested in accordance with Annex D, are as follows.

a) Test specimens shall conform to Clause A.1.

b) Test specimens shall maintain integrity, without either

1) permitting the penetration of a gap gauge (except for those free areas defined in 5.4.1 and 6.5);

2) resulting in sustained flaming;

3) collapsing.

c) Test specimens shall not release flaming droplets or particles within the first 600 s when tested in accordance with this part of ISO 21927.

Observation of any components or droplets falling during the test is recorded in the test report. When selecting a barrier for a particular application where falling components can be considered a significant threat to occupants, for example where people are expected to escape beneath smoke barriers, the full test report should be obtained and checked.

6.3 Reliability and durability of smoke barriers

6.3.1 Reliability and durability of smoke barriers — Static smoke barriers

The manufacturer/supplier shall provide verification that the materials used for static smoke barriers are fit for the purpose intended. For integrity and perforations, see Clause B.3; and for gaps, see 6.5.3.

This should be done taking into account, for example, breaking loads, tear strength, flexural strength and resistance-to-flexing requirements valid in the place of use.

6.3.2 Reliability of smoke barriers — Active smoke barriers

Active smoke barrier specimens conforming to Clause A.1 shall be tested in accordance with the reliability test in Annex B and shall complete the required number of cycles and shall then not allow the passage of either of the defined gap gauges (except for those free areas defined in 5.4.1 and 6.5).

6.4 Response time of active smoke barriers

Active smoke barrier specimens conforming to Clause A.1 shall be tested in accordance with the response time test in Annex B and shall operate within the velocity ranges specified in this subclause.

Active smoke barrier specimens types ASB1 and ASB2 shall commence movement immediately upon initiation or any initiation failure and move to their operational position, in all operating modes, at a velocity range of between 0,06 m/s and 0,30 m/s.

Active smoke barriers types ASB3 and ASB4 that are located in critical areas of a construction works, e.g. escape routes, entrances/exits to escalators or stairways, shall have a velocity range of 0,06 m/s to 0,15 m/s.

Active smoke barriers with long barrier movements that cannot be fully deployed within 60 s in order to conform to the requirements of this subclause, can, nevertheless, provide progressive protection. Such operation should not compromise SHEVS design, e.g. for a single barrier that is designed to protect multiple floors around an atrium, the protection to higher floors can be delayed when the fire occurs on a lower floor.

Precautions should be taken to ensure that descending barriers in such areas do not cause injury, panic, confusion, etc., e.g. by the use of visual or audible warnings, and partial and progressive descent of barriers should be considered.

The above criteria require consideration to ensure the efficiency of the smoke barrier to control the movement of fire effluent and aid the effectiveness of the SHEVS.

6.5 Smoke leakage (containment efficiency)

6.5.1 General

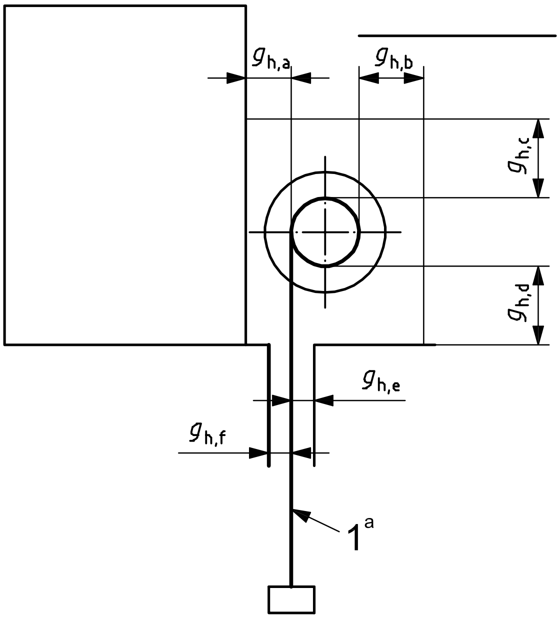
Smoke barriers have a functional requirement to channel, contain and/or prevent the migration of smoke (fire effluent). The provisions of 6.5.2 to 6.5.5 shall therefore be followed.

6.5.2 Gaps and leakage areas

Operational gaps and/or areas of leakage of a barrier shall be stated for the product by the manufacturer (see Figures 1 to 10, which illustrate possible operational gaps required by the design of roller type smoke barrier applications). These gaps can increase under fire conditions; see Annex E.

NOTE Barriers can require operational tolerances, e.g. static barriers installed in buildings with expansion characteristics or active barriers at corners.

The system designer, when calculating for a specific installation, should take containment efficiency into consideration.



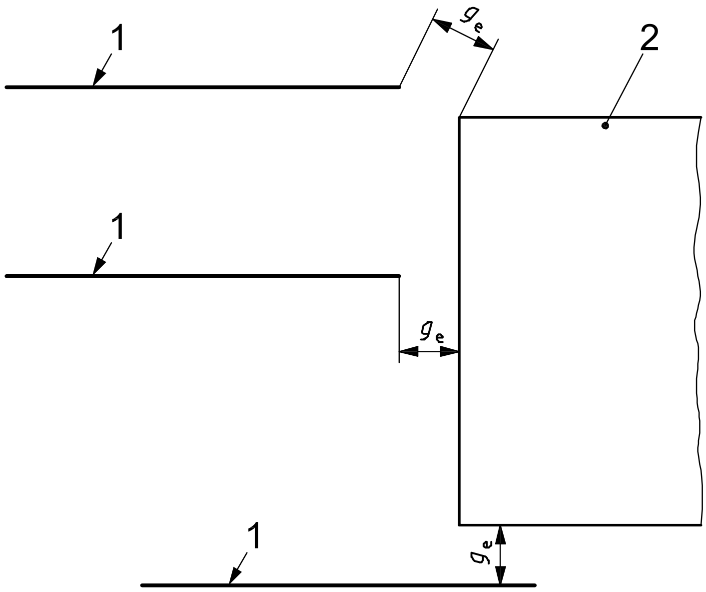
Key

1 barrier

$g_{h,a}$ to $g_{h,f}$ gaps in the header box

[a] Smoke flow through the head box is controlled by the smallest gap when the barrier is in the fire operational position. Gaps $g_{h,a}$ to $g_{h,f}$ are representative of the potential smallest gaps. It is recommended to use the gap, $g_{h,a}$ to $g_{h,f}$, with the smallest value.

Figure 1 — Potential gaps within a header box when barrier deployed



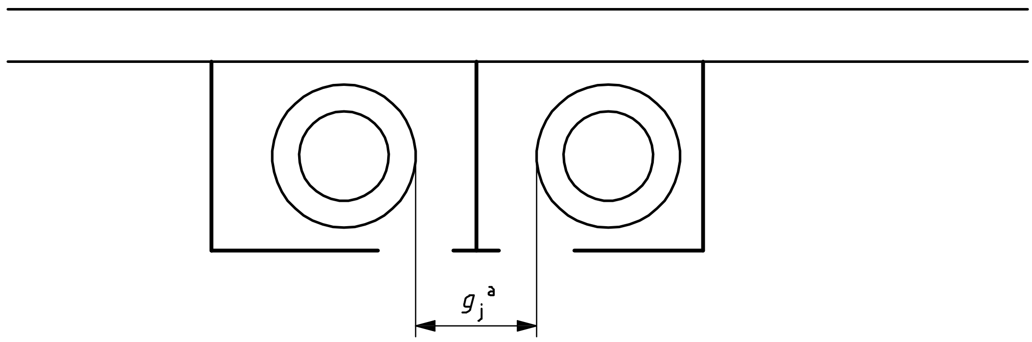
Key

1 barrier

2 wall

g_e edge gap between a barrier and the surrounding construction

Figure 2 — Potential edge gaps between the barrier and surrounding construction

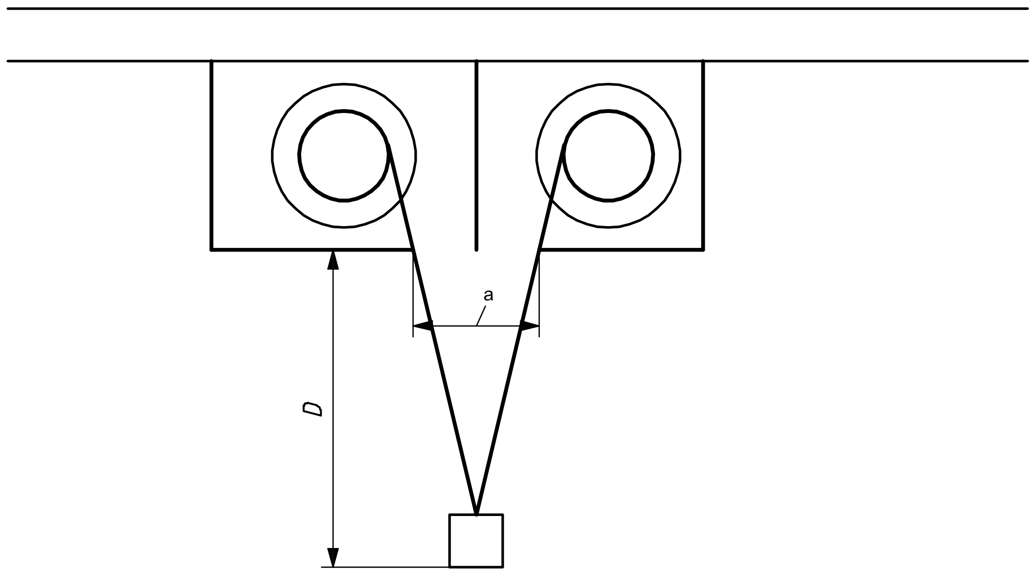


Key

g_j joint gap between barriers

a The gap is measured with the barriers in their fire operational position.

Figure 3 — Gaps between adjacent barriers when overlapped but not conjoined



Key

$g_{j,max}$ maximum gap when barriers are in the fire operational condition, expressed in millimetres

D distance of movement (drop) of smoke barrier, expressed in millimetres

a $g_j = g_{j,max}/2$.

Figure 4 — Gaps between adjacent barriers when overlapped and conjoined

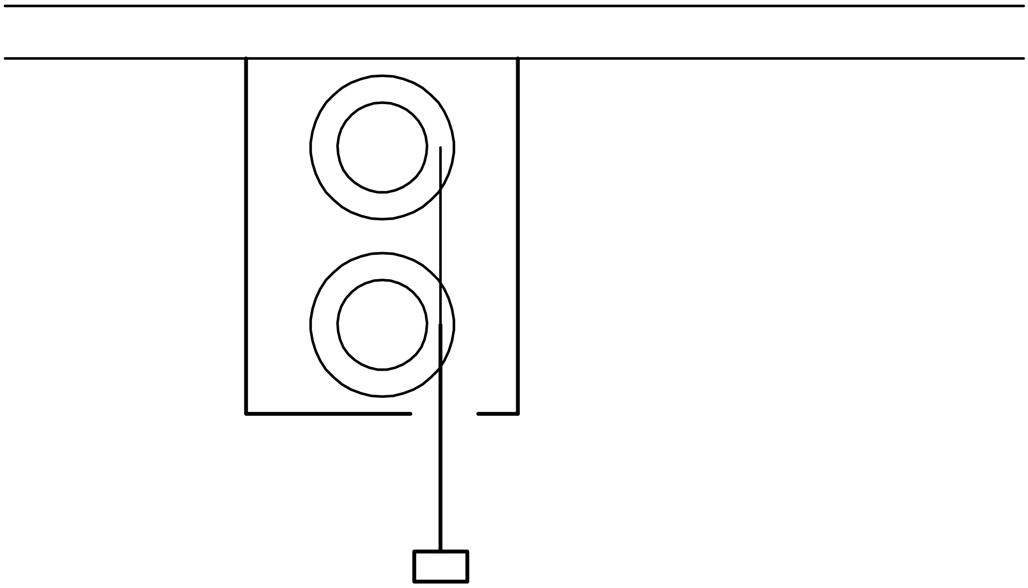
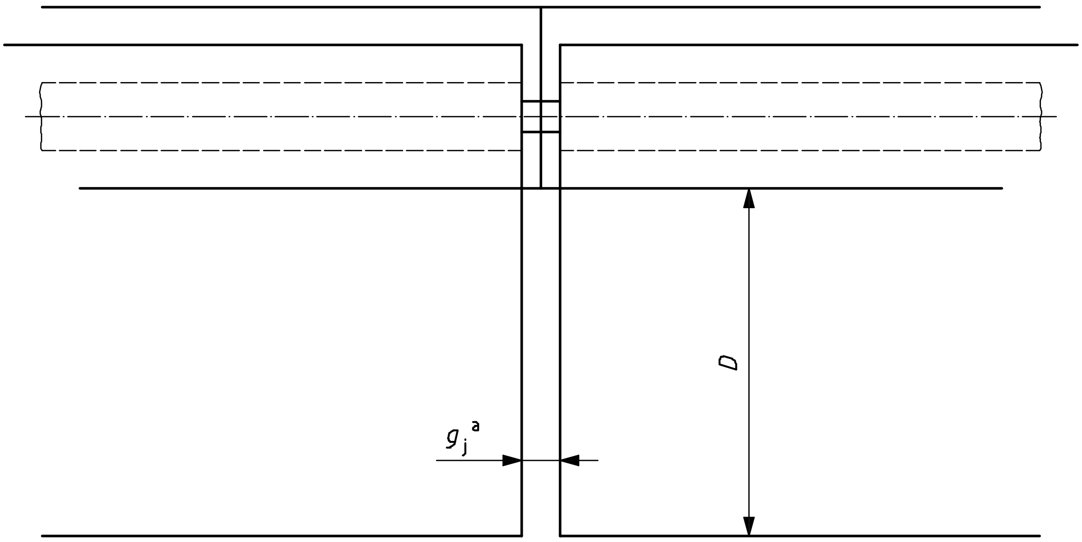


Figure 5 — Barriers overlapped with no gaps at the overlap

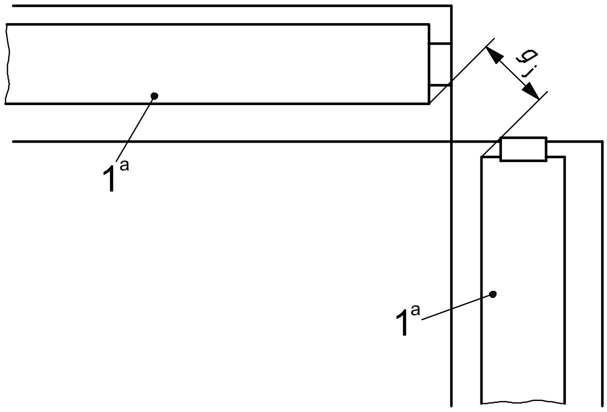


Key

g_j joint gap

a The gap shown is in the passive condition.

Figure 6 — Adjacent barriers with no overlap



Key

1 barrier

g_j joint gap

[a] To prevent independent barrier movement, the barrier bottoms are generally conjoined at the corner.

Figure 7 — Adjacent barriers at a corner

6.5.3 Openings, gaps and/or perimeter spaces

Smoke barriers that do not require functional tolerances shall have all gaps sealed to prevent smoke leakage.

Active smoke barriers shall be overlapped and conjoined where they are fixed in a straight line to prevent leakage. Where this cannot be achieved or if products are manufactured otherwise, the designer shall make allowances for increased leakage within his calculations (see Annex E).

For the typical roller barriers shown in Figures 1 to 9, the area, e.g. $A_{g,a}$, of an individual gap, expressed in millimetres, is calculated as given in Equation (1):

$$A_{g,a} = W_a \times g_{h,a} \tag{1}$$

where W_a is the width of the smoke barrier, expressed in millimetres, associated with $g_{h,a}$.

The total area, $A_{h,tot}$, of the gaps in the head is obtained by summing the areas of the individual gaps, $g_{h,a}$ to $g_{h,f}$, as given in Equation (2):

$$A_{g,tot} = \sum A_{g,a} + A_{g,b} + \ldots A_{g,f} \tag{2}$$

The area of each edge gap and joint gap, $A_{e,a}$ and $A_{j,a}$, respectively, expressed in square millimetres, is calculated as given in Equations (3) and (4), respectively:

$$A_e = D \times g_e \tag{3}$$

$$A_j = D \times g_j \tag{4}$$

where D is the distance of movement (drop) of the smoke barrier, expressed in millimetres.

The total areas of the edge gaps and the joint gaps, $A_{e,tot}$ and $A_{j,tot}$, respectively, expressed in square millimetres, are calculated by summing the areas of all the individual gaps.

The total free area, A_{tot}, of the smoke barrier system is calculated by summing the areas of the head gaps, the joint gaps and the edge gaps, as given in Equation (5):

$$A_{tot} = A_{g,tot} + A_{e,tot} + A_{j,tot} \quad (5)$$

For functional reasons, gaps can be required between the barrier and the construction works, and for angled and adjacent barriers. In these cases, any gap, based on the maximum travel distance specified by the manufacturer, should not exceed

a) 20 mm for barriers that travel up to and including 2 m;

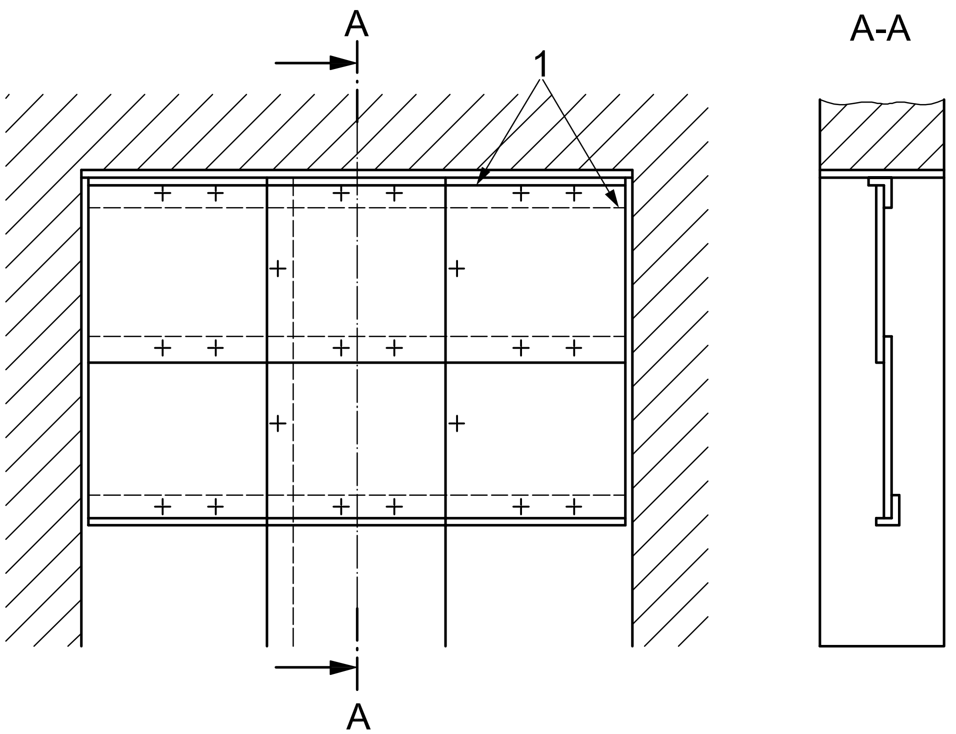
b) 40 mm for barriers that travel from 2 m up to and including 6 m;

c) 60 mm for barriers that travel more than 6 m.

For static barriers, the expansion and contraction characteristics of the construction works should be taken into account when calculating the gaps. The attachment of the barrier to the structure, the load and the temperature should be verified. The load includes the barrier's own mass, side pressure from the fire-side (20 Pa) and a safety coefficient. The minimum dilatation gap should be left. When panels are used to form the barrier, the connections should be tight and resistant to loading and temperature changes (see Figure 8).

Static and active smoke barriers can require functional tolerances, within the construction of the smoke barrier assembly itself, between the smoke barrier, another barrier and/or the construction works.

Any gaps within a smoke-barrier system should not prejudice the fitness for purpose of the system in accordance with the system design. Any gaps above or around the smoke-barrier assembly in the smoke reservoir should be sealed or minimized.



Key

1 barrier

Figure 8 — Example of a static smoke barrier, flexible or rigid material

6.5.4 Deflection

Static and active smoke barriers shall perform in accordance with the functional requirements of the system design, other SHEVS design requirements and construction works requirements for the intended application.

In all tests, the smoke barrier shall be mounted as in practice, including the specified barrier mass and tensioning force where required to reduce deflection. Deflection shall be assessed using a suitable method of calculating deflection to ensure that it is valid for the application. A method of calculating deflection is given in Annex E.

Smoke barriers in continuous, overlapped and conjoined runs provide additional resistance to deflection and smoke leakage. The gaps between adjacent smoke barriers conforming to 6.5.3 are maintained when conjoined (for example, by using conjoined bottom bars). Where this cannot be achieved or if products are manufactured otherwise, the designer shall make allowances for increased leakage within his calculations (see Annex E).

Care should be taken to ensure that the smoke barriers are positioned in the construction works in such a way as to minimize problems caused by deflection, e.g. barriers placed between curved columns can conform in the passive condition but, when subjected to deflecting conditions, move away from the columns creating large gaps and unacceptable smoke leakage.

Figure 9 shows a lightweight smoke barrier mounted adjacent to columns. Even with a heavy bottom bar or retained in guides, large side and lateral lift gaps can occur.

Figure 10 shows a lightweight barrier mounted adjacent to columns. When not retained, large side and lateral lift gaps occur.

6.5.5 Permeability of materials

Smoke barriers shall be manufactured from materials conforming to Annex C with a maximum leakage rate of 25 $m^3/h/m^2$ at 25 Pa and ambient and/or medium temperature[1]. If the leakage test is carried out only at one temperature (either ambient or medium temperature), then it is necessary that the product be declared for the temperature at which the test was carried out.

NOTE The permeability of materials is tested by samples with a size of (1×1) m^2 (see Annex C).

7 Conformity assessment

7.1 General

The compliance of a smoke barrier with the requirements of this part of ISO 21927 shall be demonstrated by

— initial type testing,

— factory production control by the manufacturer.

Conformity assessment for products in accordance with this part of ISO 21927 shall be according to ISO/IEC 17000, ISO/IEC 17050-1 and ISO/IEC 17050-2.

1) ISO 5925-1:2007 allows a test at ambient as well as at medium temperature. ISO 5925-1:1981 (which has been withdrawn) allowed only for a test at ambient temperature.

7.2 Initial type testing

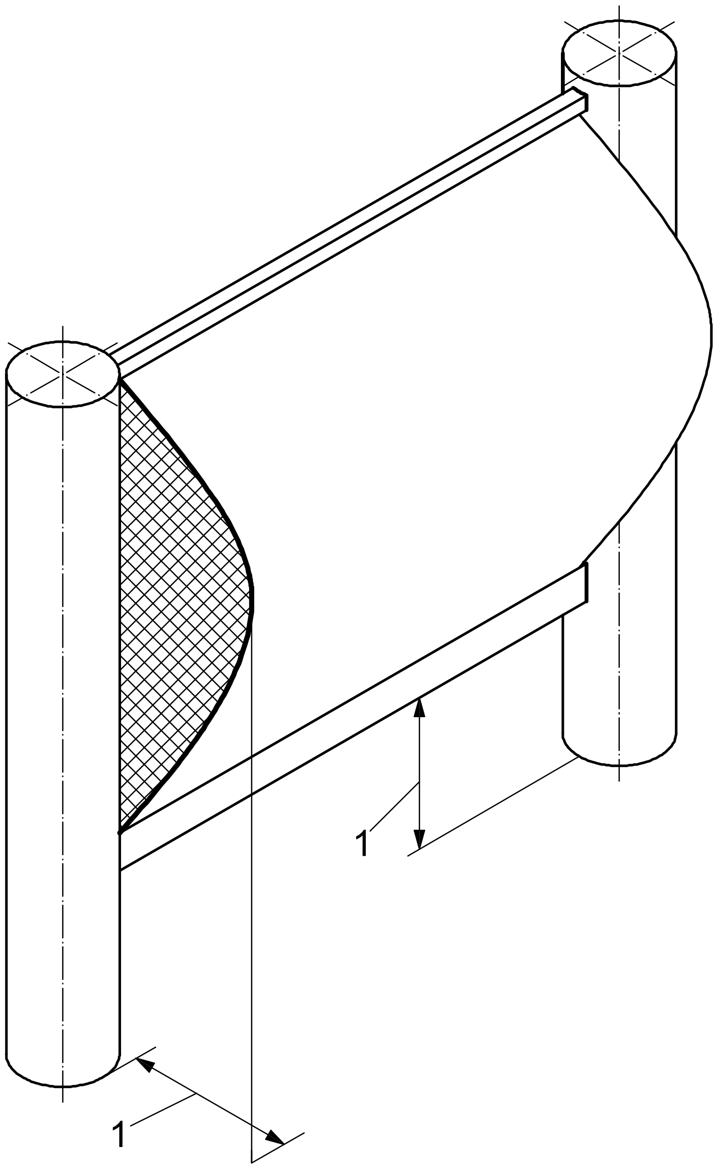
All characteristics given in Clauses 5 and 6 shall be subject to initial type testing, except as described in paragraph 2 of this subclause. Tests shall be carried out in accordance with Annexes A, B, C, D and, if required, F.

Tests previously performed in accordance with the provisions of this part of ISO 21927 [same product, same characteristic(s), test method, sampling procedure, etc.)] may be taken into account.

In addition, initial type testing shall be performed at the beginning of the production of a new product type or at the beginning of a new method of production (where these can affect the stated properties).

7.3 Factory production control (FPC)

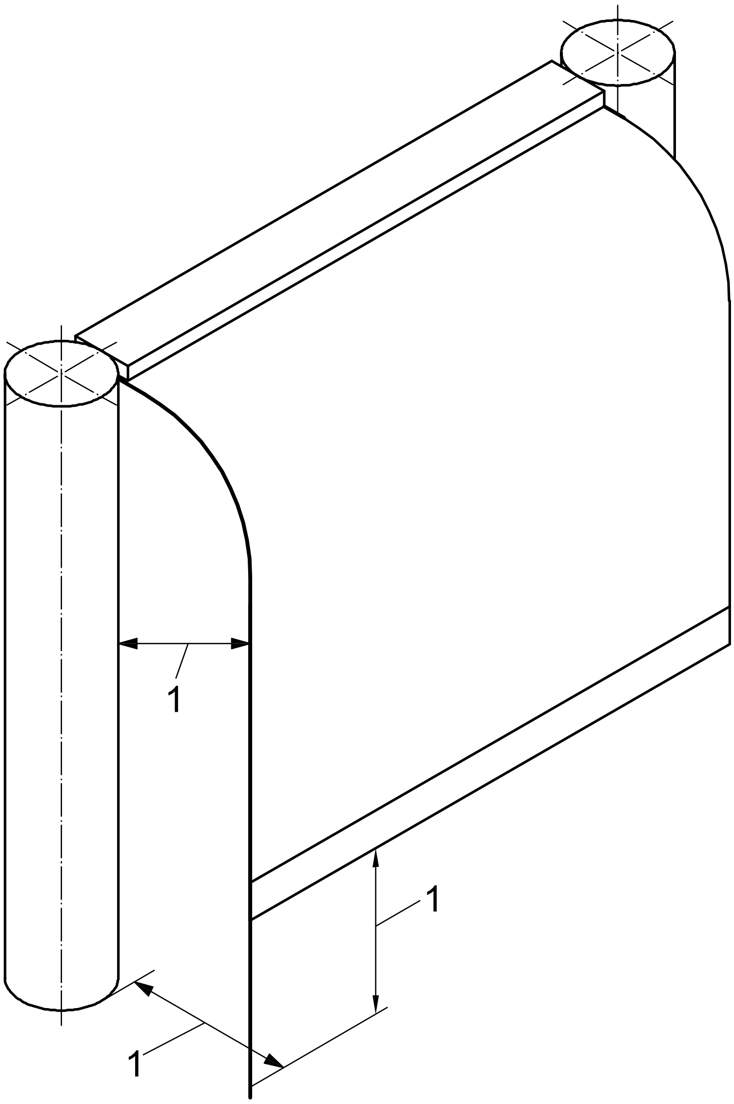
A FPC system conforming with the requirements of ISO 9001, and made specific to the requirements of this part of ISO 21927, is considered to satisfy the requirements of this part of ISO 21927.



Key

1 excessive gaps

Figure 9 — Example of excess gap caused by deflection



Key

1 excessive gaps

Figure 10 — Example of excess gap caused by deflection

8 Installation

The supplier shall provide appropriate installation information, which shall include the following:

a) fixing component information;

b) power requirements and connections (active smoke barriers only);

c) installation instructions, including perimeter requirements where applicable;

d) commissioning procedure;

e) operating instruction (active smoke barriers only);

f) warnings to avoid obstructions to operation (active smoke barriers only);

g) penetrations (static only);

h) operating instructions, with maximum operating and loading tolerance for the product, e. g. maximum barrier mass, bottom bar masses, minimum/maximum motor speeds, overlapping and conjoining, and fixing methods.

Care should be taken to ensure that the operation of an active smoke barrier is not obstructed, e.g. by cosmetic finishes, lighting, shelving, sales displays or racking.

9 Maintenance

In order to ensure continued compliance, reliability and integrity, smoke barriers shall be inspected, serviced and tested by personnel trained and qualified in the product.

The supplier shall provide maintenance and testing information, which shall include the following:

a) inspection and maintenance procedures;

b) recommended procedures for operational checks;

c) recommended check for obstructions to operation, e.g. by cosmetic finishes, lighting, shelving, sales displays or racking;

d) recommended check for the effects of corrosion, etc.;

e) recommended check for mechanical fastenings;

f) recommended check for power supplies and controls;

g) recommended check for penetrations, holes, etc.;

h) recommended check for anything that materially affects the performance of the product.

10 Marking and labelling

Smoke barriers conforming to this part of ISO 21927 shall be marked (on the product itself or on its accompanying commercial documents) with the following:

- number of this part of ISO 21927;
- product, i.e. static smoke barrier; active smoke barrier;
- barrier type, i.e. ASB1; ASB2; ASB3 or ASB4, as described in 5.2;
- installation and maintenance requirements;
- fire-resistance classification (D, DL or DH);
- response delay (active barriers only);
- openings, gaps and free areas (see 6.5.3);
- maximum material permeability (if less than 25 $m^3/h/m^2$), including the temperature (ambient and/or medium) at which the test was carried out, in accordance to the permeability test.

Annex A
(normative)

General testing requirements

A.1 Principle

Tests carried out in Annexes B, C and D shall be representative of all sizes and field of applications of the family, if products are to be grouped into families (see 7.2).

The supplier shall provide, with the test specimen, engineering drawings, calculations and parameters, e.g. equivalent smoke barrier dimensions (as defined in Clause B.2) and joints to prove that all sizes in the family are represented by the test specimen. An assessment shall be made to endorse proposed sizes and end uses of the finished product.

The following performance requirement tests shall be performed for smoke barriers:

a) reliability and durability of product (see Annex B for active smoke barriers only);

b) default operation to fire operation position (see Annex B for active smoke barriers only);

c) response time and performance (see Annex B for active smoke barriers only);

d) permeability to smoke (see Annex C);

e) temperature/time classification (see Annex D).

A.2 Test sequence for initial type testing

The tests shall be carried out in the following sequence:

a) reliability and durability;

b) default operation to fire position;

c) response time;

d) permeability;

e) temperature/time.

The same active smoke barrier shall be used for the reliability test (see Clause B.2) and subsequently the temperature/time test (see Annex D).

A.3 Test report

A test report shall be prepared in accordance with the appropriate requirements of Clauses A.1 and A.2 and shall include the following:

a) name or trademark, and address of the manufacturer and/or supplier;

b) name of the product (type and model);

c) date(s) of the test(s);

d) name(s) and address(es) of the testing organization;

e) full and detailed description of the test specimen, which shall include any comments regarding the family, the material integrity, mass and tensioning, if appropriate;

f) reference to the test method(s);

g) observations during the test(s);

h) approved fixing methods;

i) test results and classifications achieved.

These observations shall include any comments regarding the suitability of the smoke barrier to meet the functional requirements that can affect it or its fitness for purpose.

Annex B
(normative)

Reliability and response time tests

B.1 Test method for the reliability and the response time of the product and the durability of materials

The smoke barrier shall be tested in the reliability and response time tests with its intended control system used to govern speed of operation. Failure of the control system shall constitute failure of the test. Adjustable speed controls shall not be further adjusted during the test after initial setting.

B.2 Test specimen

B.2.1 Where the manufacturer produces only one size and type of product, only one specimen shall be tested.

B.2.2 Where the manufacturer produces a range of products, at least two specimens shall be tested separately as given in list items a) to e).

a) One specimen shall have a maximum width of 3 m and a barrier movement of 10 m (or the maximum barrier movement offered by the supplier if less than 10 m). This specimen shall be used for the tests in Annex D.

b) The other specimen shall have a minimum width of 10 m (or the largest width in the family if smaller than 10 m) and a minimum barrier movement of 3 m. Where the supplier offers a barrier movement smaller than the minimum barrier movement, the maximum barrier movement of the family shall be used. Where the supplier offers multiple active smoke barriers that overlap, physically interact or are mechanically connected, the specimen shall be assembled in the manufacturer's normal manner to simulate a single active smoke barrier of 10 m width. This specimen shall have a minimum barrier movement of 3 m or the largest in the family. Where it is not possible to test the largest unit in the family, the minimum test barrier movement shall be 60 % of the claimed maximum barrier movement.

c) All relevant test criteria shall be increased/compensated to simulate the claimed maximum barrier movement, e. g. an increase in the mass, the number of moving parts and the number of test cycles.

d) Tests on these two specimens shall be considered representative of all smoke barriers in their particular family.

e) Static barriers shall be tested in a 3 m × 3 m furnace using the manufacturer's stated methods of manufacture, fixings and sealing.

B.3 Procedure

Mount the specimens, using normal attachments in accordance with the sponsor's installation information.

Operate each ASB specimen 1 000 complete cycles using the primary energy source.

If the specimen uses any auxiliary power source for any part of its function, e.g. gravity, battery, generator, air reservoir, the 1 000 complete cycle test shall be followed by 50 complete cycles using the auxiliary power source to move the smoke barrier to its fire operational position.

NOTE A cycle is defined as moving the smoke barriers from the fully retracted position to the fire position and back to the fully retracted position.

No limit is set to the cycle period but the smoke barriers shall move to the fire operational position within the limits set in 6.4. However, the cycle period tested shall constitute the minimum cycle period for the specimen.

If movement to a non-fire operational position is also a requirement, the specimen shall be tested to show that the required number of cycles (1 000) can be achieved within the required cycle period.

No maintenance or repair shall be permitted during the test period.

A consumable energy source may be replaced or recharged as necessary during the 50-cycle period but not during any single cycle. Where the primary energy source is supplied via a battery, this source may be replaced by a power supply unit having an equivalent output.

Measure and record the cycle time and the time taken for each smoke barrier to reach the fire position at the beginning and end of the test period.

Measure and record the operating speeds in both directions of operation.

At the end of the test, examine and record the finished specimen in its fire position and verify against the test criteria. Inspect the condition of the specimen and verify the integrity of the materials used in accordance with ISO 834-1.

Check material for integrity and perforations, tears or cracks and whether a 6 mm diameter ball or a 15 mm × 2 mm strip can pass easily through either at the end of the test period.

Any actions and observations taken shall be recorded.

B.4 Test report

The test report shall be written and information provided in accordance with the requirements of Annex A.

Annex C
(normative)

Permeability of materials to smoke

C.1 Materials — Impermeable

The impermeability of the material, e.g. sheet metal, shall be confirmed in writing and may be deemed acceptable without test.

C.2 Materials — Permeable (permitting limited passage of smoke)

Barrier materials that have not previously shown imperviousness to smoke (or are not deemed acceptable according to Clause C.1) shall be tested in accordance with ISO 5925-1 using a 1 m^2 sample with edges tightly sealed.

The passage of smoke through materials shall be restricted and shall not exceed a leakage rate of 25 $m^3/h/m^2$ at ambient and/or medium temperature when tested using the test procedures defined in ISO 5925-1[2)]. If the leakage test is carried out only at one temperature (either ambient or medium temperature), then it is necessary that the product be declared at the temperature at which the test was carried out.

Materials likely to change performance when subjected to temperature/time shall be assessed.

C.3 Test procedure

Take a representative sample of material (see D.2.1) to include typical seams and joints and test to 25 Pa at ambient or medium temperature. The material shall be deemed to have passed if the leakage rate is less than 25 $m^3/h/m^2$ at 25 Pa and at ambient or medium temperature.

C.4 Test report

The test report shall be written and information provided in accordance with the requirements of Annex A, together with a statement whether the test in accordance with ISO 5925-1 was carried out only at one temperature (either at ambient or medium temperature).

2) ISO 5925-1:2007 allows a test at ambient as well as at medium temperature. ISO 5925-1:1981 (which has been withdrawn) allowed only for a test at ambient temperature.

Annex D
(normative)

Temperature/time resistance tests

D.1 Test equipment

The apparatus used in this test shall be in accordance with ISO 834-1 and shall include:

D.1.1 High-temperature furnace, with an aperture at least 3 m × 3 m, in accordance with ISO 834-1.

D.1.2 Support frame, with an aperture at least 3 m × 3 m, in accordance with ISO 834-1.

D.1.3 Pressure-measuring device, in accordance with ISO 834-1.

D.1.4 Furnace thermocouples, used to measure the average temperature at the exposed surface of the test specimen, in accordance with ISO 834-1.

There shall be at least one thermocouple for every 1,5 m^2 of exposed surface.

D.2 Test specimen requirements

D.2.1 Test specimen

The test specimen of an active smoke barrier shall be the same specimen previously tested in Annex B, being suitably modified with minimum intervention to reduce the drop to fit the furnace aperture with the offcut, if sufficiently large, being used for the permeability test in Annex C. The test specimen of a static barrier shall meet the requirements of this annex.

D.2.2 Test specimen materials

Materials used in the construction of the test specimen, the method of construction and all fixings shall be as defined in Annex A. All normal fixing methods shall be submitted for approval. The most critical normal fixing method shall be selected as representative of the family to cover all fixing methods. The smoke barrier shall be tested in the orientation and standard use of its application and installation as recommended by the manufacturer and/or supplier.

D.2.3 Support frame

The test specimen that is representative of the largest in the family shall be tested within the support frame (see Figures D.1 and D.2).

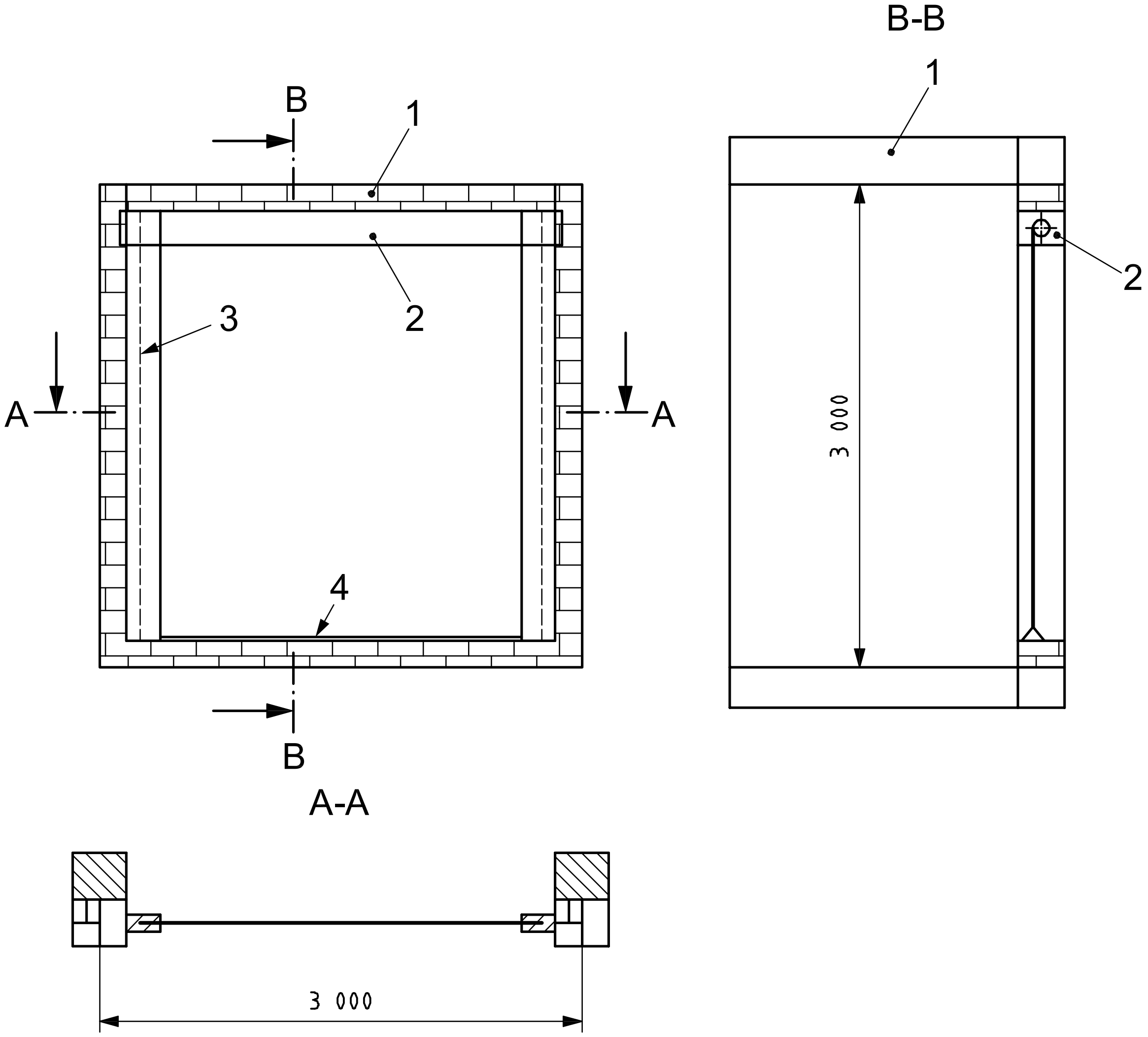
For barriers where the largest size is less than 3 m × 3 m, the largest barrier in the family shall be tested.

For barriers where the largest size is greater than 3 m × 3 m, a 3 m × 3 m specimen shall be tested. To represent deeper barriers, an additional load shall be applied evenly across the bottom of the barrier, equivalent to the additional mass per tested width of the deepest barrier in the family.

Barriers with any side guides and/or channels shall be tested with these as part of the test specimen (see Figure D.1). If the test sample is not provided with side channels, these shall be provided by either the sponsor/supplier or the test laboratory when necessary (see D.3.2).

Barriers with any tensioning device, e.g. bottom weight bar or tensioning device, shall be tested with these as part of the test specimen.

Dimensions in millimetres



Key

1 furnace
2 head box
3 side guides
4 bottom bar

Figure D.1 — Head box and side guides installed within the opening of the furnace

D.2.4 Hems and joints

For materials that in normal use have hems or joints, e.g. seams, welds or overlaps, the following requirements shall be incorporated into the test.

a) Barriers with horizontal joints shall be tested with a horizontal joint within 1 m of the barrier top.

b) Barriers with a vertical joint shall be tested with at least one joint located 0,75 m to 1,25 m from a vertical side of the barrier.

   Barriers that pass the test with horizontal joints are deemed to satisfy the test with vertical joints, provided that vertical and horizontal joints have the same construction.

c) Barriers with side hems shall be tested with at least one side hem.

D.3 Installation of test specimen into the support frame

D.3.1 General

The test specimen shall be installed according to the manufacture's instructions within the support frame using the chosen methods for attachment (see D.2.1).

D.3.2 Restraint

If the test specimen has no standard method of restraint, e.g. side channels (unrestrained) at the barrier edge, the following shall apply.

a) The specimen shall be installed so that the movement of the test specimen (e.g. the bottom bar towards and away from the furnace) is limited. The limiting method shall not apply additional loads (except those due to furnace pressure) to or from, or assist, the specimen.

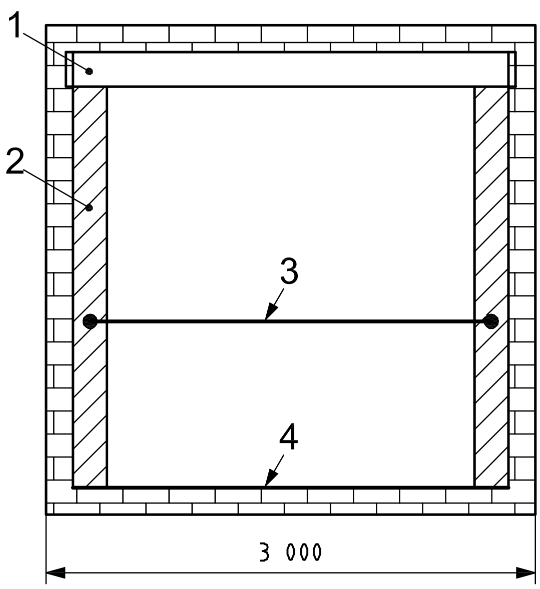
b) Any gaps between the test specimen edge and the support frame shall be covered. The covering method shall not excessively restrain the test specimen edge (see Figure D.1).

NOTE The installation into the support frame of side covers/baffles that overlap the unrestrained edge of the test specimen by a maximum of 200 mm is considered as an acceptable installation method (see Figure D.2).

D.3.3 Additional loads

Where appropriate (see D.2.2), an additional load shall be applied to the bottom of the test specimen so that the load experienced by the fixings and material reflects that of the tallest barrier in the family.

Dimensions in millimetres



Key

1 head box

2 side baffels

3 wire restraint

4 bottom bar

Figure D.2 — Smoke barrier with no side guides installed within the opening of the furnace with added side baffles to stop barrier movement during test

D.4 Test procedure

D.4.1 General

The testing shall be performed in accordance with ISO 834-1.

D.4.2 Furnace settings

The furnace shall be operated so that the neutral plane is 0,5 m above the bottom of the test specimen. The pressure at the top of the furnace shall not exceed 25 Pa.

D.4.3 D classification

D.4.3.1 General

The furnace shall be operated following the standard heating curve defined in ISO 834-1.

Once the average temperature furnace has reached 620 °C (circa 6 min, 40 s), the average temperature shall be maintained at 620 °C.

NOTE This ensures that the sample is subjected to a minimum furnace temperature of 600 °C.

D.4.3.2 Operating tolerances

The percentage deviation in the area of the curve of the average temperature recorded by the specified furnace thermocouples versus time, t, from the area of the specified temperature/time curve shall be within the following limits:

a) 15 %: for $5 < \ < 10$ min;

b) [15 – 0,5 (t – 10)] %: for $10 < t \leqslant 30$ min;

c) [5 – 0,083 (t – 30)] %: for $30 \leqslant \ < 60$ min;

d) 2,5 %: for $t > 60$ min.

At any time after the first 10 min of the test, the temperature recorded by any furnace thermocouple shall not normally differ from the specified average by more than 100 °C. Deviations from this requirement shall be considered acceptable if rapid burning occurs on the exposed surface of the test specimen, or if the barrier or edge seals are found to move during the test.

D.4.4 DH classification

The furnace shall be operated following the standard heating curve defined in ISO 834-1.

The operating tolerances shall be as defined in ISO 834-1.

D.4.5 Time classes

Control the average furnace temperature for the required time and for each D and DH classification. The five possible classes, corresponding to the five required times from the start of the test, are as follows:

a) 30 min,

b) 60 min,

c) 90 min,

d) 120 min,

e) $>$ 120 min.

At the end of the heating period, switch off the furnace and allow the test specimen to cool to ambient temperature.

D.5 Measurements and observations

D.5.1 Measurements

Furnace temperature and pressure measurements shall be made continuously and recorded at intervals of less than 1 min.

D.5.2 Integrity

Assessment of the integrity failure of the test specimen (where the test specimen includes all details in Clause D.2, but not gaps occurring between unrestrained edges and the support frame) shall be made

a) with gap gauges, against the criteria given in ISO 834-1,

b) with observations of sustained flaming against the criteria given in ISO 834-1,

c) with observations of collapse.

The time and nature of integrity failures shall be recorded.

D.5.3 General behaviour

The test specimen shall be continuously observed during and after the test. Details and the time of any of the following occurrences shall be recorded in the test report:

a) parts, components and flaming droplets falling from the test specimen;

b) changes to the fixing methods;

c) holes or cracks occurring in the test specimen.

D.6 Test report

The test report shall be written and information provided in accordance with the requirements of Annex A and ISO 834-1.

Annex E
(informative)

Deflection of smoke barriers

E.1 General

This annex shows how deflection can reduce the effectiveness of an active smoke barrier; a detailed explanation of the causes are given in Clause E.2. The designer should be aware, therefore, of how active smoke barriers react to fire pressure from hot, buoyant smoke that can make them unfit for purpose in a fire condition. Examples of deflection are shown in Figures E.1 to E.4.

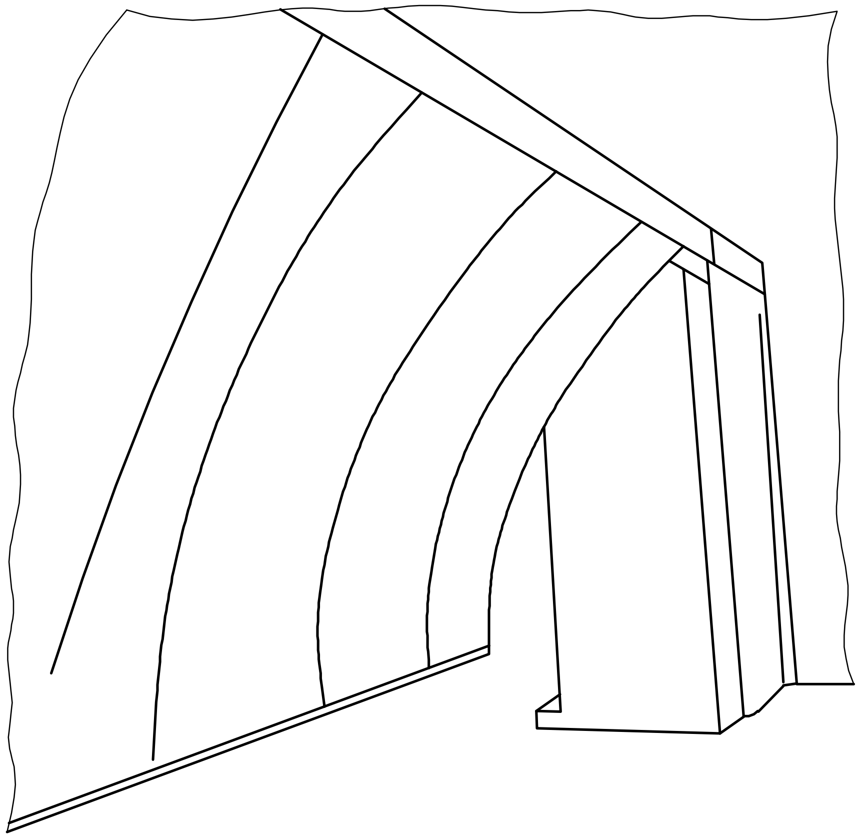


Figure E.1 — Curtain between columns — Enlarged gaps at sides and reduced effective smoke reservoir depth

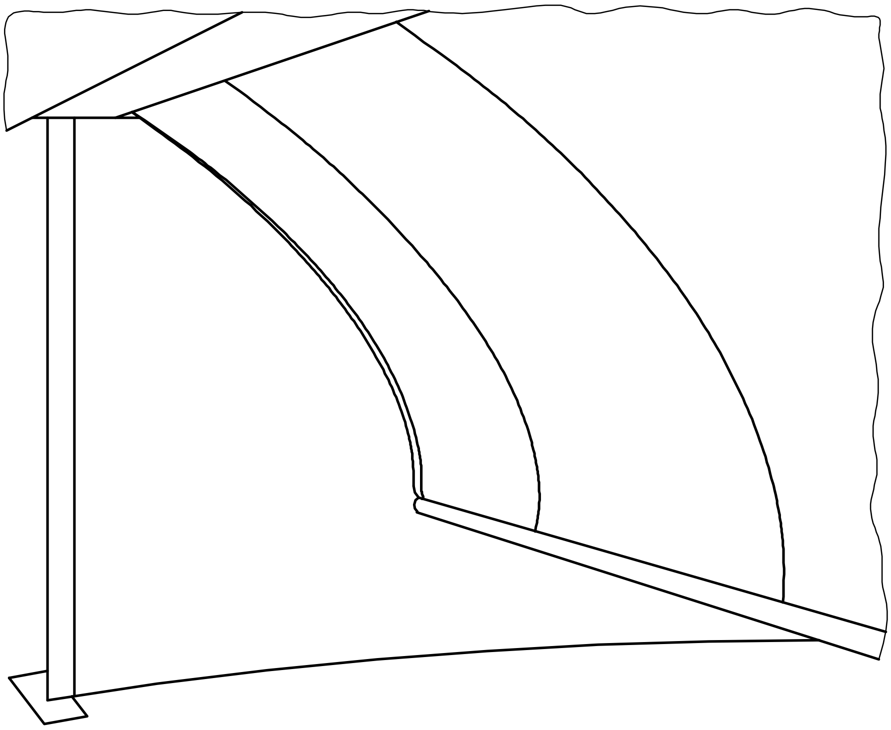


Figure E.2 — Curtain between walls — No gaps at sides but reduced effective smoke layer depth caused by curtain lift

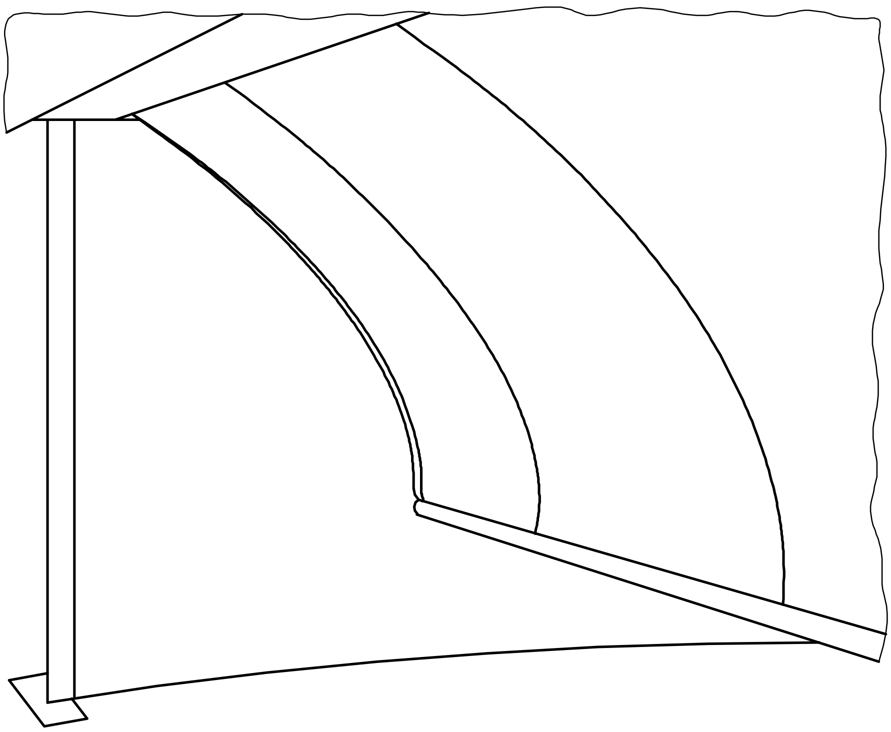
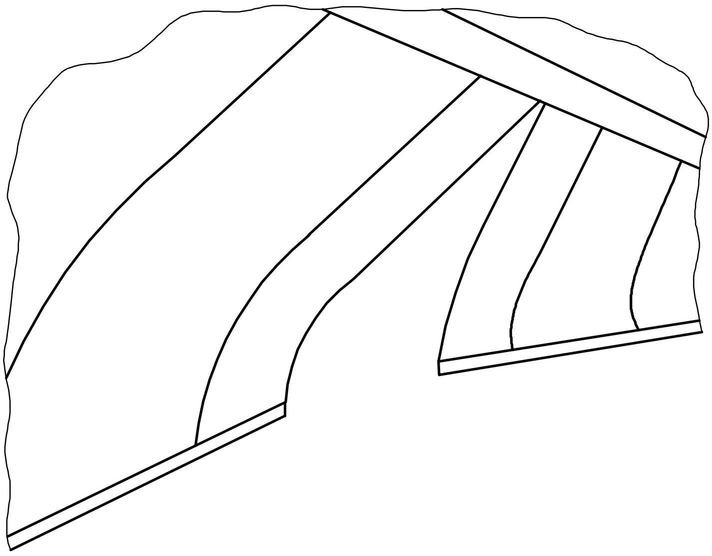


Figure E.3 — Curtain between columns — Enlarged gaps at sides and reduced effective smoke layer depth



NOTE This is an example of a smoke barrier design that is not covered by this part of ISO 21927.

Figure E.4 — Non-conjoined — Adjacent curtains, either in-line or angled

E.2 Principle

In smoke- and heat-exhaust ventilation systems, smoke barriers are used to create reservoirs that can contain smoke and hot gases. To fulfil this role, it is necessary that they resist the sideways deflection caused by the buoyancy-driven forces due to hot gases, or the fan-induced forces in mechanical extract systems.

If they do not resist these forces, gaps can occur beneath the barrier or between the barrier and the building structure, leading to the flow of hot gases from the reservoir into adjacent areas.

Theoretical and experimental work has shown that the deflection of a smoke barrier and the flow of hot gases through gaps in it can be related to the hot-gas layer contained by the barrier.

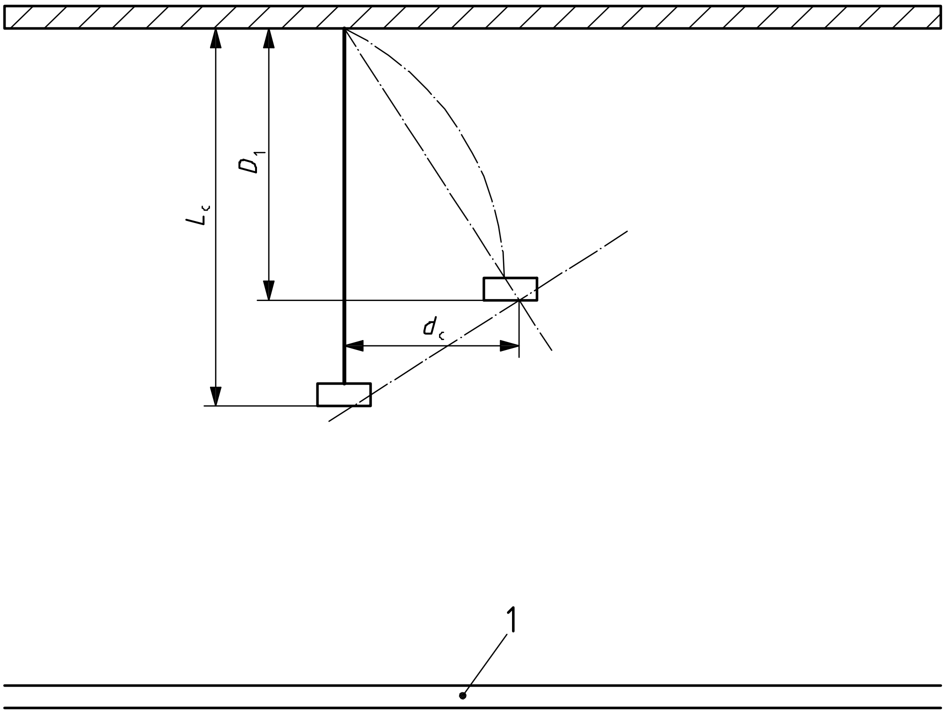
This annex considers the deflection of free-hanging, active smoke barriers only, as those that are fixed at both ceiling and floor and/or sides are effectively locked in place and are not subject to deflection. The method of calculation of the leakage through gaps in the barriers is valid for all types of barriers.

Free-hanging, active smoke barriers can be divided into two categories:

— those that act to contain a gas layer that does not extend below the bottom of the barrier, such as reservoir screens and channelling screens (see Figure E.5); these are referred to as “not reaching the floor";

— those that fall to floor level and act to completely seal areas away from a smoke compartment in which the gas layer extends below the bottom of the barrier, such as can be installed along balconies to form a closed atrium (see Figure E.6); these are referred to as “closing an opening”.

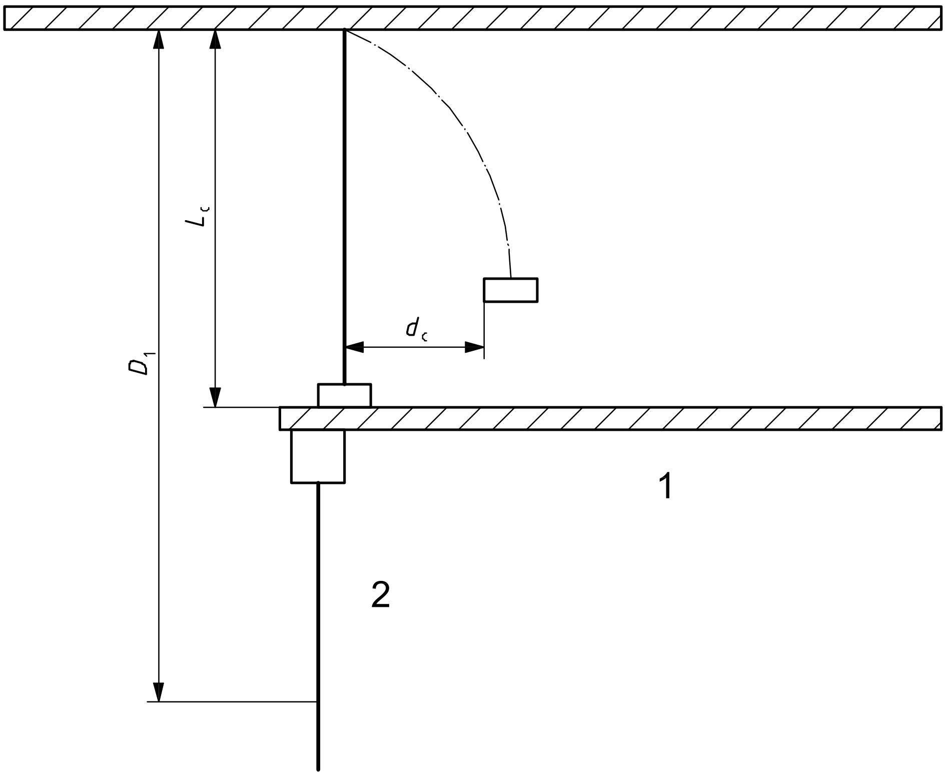
The pressure of gases acting on a smoke barrier causes it to deflect from the normal vertically hanging position. This horizontal deflection of the barrier causes the bottom of the barrier to rise, which can lead to leakage of gas underneath the barrier if the rise takes the bottom of the barrier above the base of the gas layer. Because the barriers are not rigid, they are also likely to bow in use, like a sail in the wind. Such bowing leads to a further rise of the bottom of the barrier.



Key

1 floor

Figure E.5 — Deflection of a smoke barrier that does not reach the floor



Key

1 floor

2 window

Figure E.6 — Deflection of a smoke barrier closing an opening

E.3 Barriers not reaching the floor

The deflection of the barrier, d_C, expressed in metres, is calculated as given in Equation (E.1); see also Figure E.5:

$$d_C = 1{,}2 \frac{\rho_0 \theta_l D_l^3}{3 T_l \left(2 M_B + M_C L_C \right)} \quad \text{(E.1)}$$

where

ρ_0 is the density of ambient air, expressed in kilograms per cubic metre;

θ_l is the temperature rise above ambient of the gases in the smoke layer, expressed in degrees Celsius;

D_l is the depth of the gas layer, expressed in metres;

T_l is the absolute temperature of gas layer in a reservoir, expressed in kelvin;

M_B is the mass per unit length of the barrier's bottom bar, expressed in kilograms per metre;

M_C is the mass per area of the barrier fabric, expressed in kilograms per square metre;

L_C is the length of the smoke barrier from top to bottom bar, measured along the fabric, expressed in metres;

The required barrier length, L_C, to contain a gas layer of depth, D_l, is calculated using an iterative procedure of the form given in Equation (E.2):

$$L_C = D_l + d_C \tan \left[\frac{\tan^{-1}\left(\frac{d_C}{D_l} \right)}{2} \right] \quad \text{(E.2)}$$

The procedure is as follows.

a) Assume a starting value for $L_C \geqslant D_l$.

b) Calculate d_C using Equation (E.1).

c) Calculate next value of L_C using Equation (E.2).

Repeat steps 1 to 3 with the new value of L_C, until successive values of L_C differ by 1 % or less.

To calculate the value for the length, $L_{C(\text{final})}$, modify the value for L_C by including a term to allow for bowing of the barrier, as given by Equation (E.3):

$$L_{C(\text{final})} = L_C + 1{,}7 \left(L_C - D_l \right) \quad \text{(E.3)}$$

E.4 Barriers closing an opening

The deflection of the barrier is calculated from Equation (E.4); see also Figure E.6:

$$d_C = 1{,}2 \frac{\rho_0 \theta_l \left(3D_l - 2h_O\right) h_O^2}{3T_l \left(2M_B + M_C L_C\right)} \tag{E.4}$$

where h_O is the height of the opening, expressed in metres, and other variables are as defined above.

The required barrier length, L_C, to contain a gas layer of depth, D_l, is calculated using an iterative procedure of the form given in Equation (E.5):

$$L_C = h_O + d_C \tan\left[\frac{\tan^{-1}\left(\frac{d_C}{h_O}\right)}{2}\right] \tag{E.5}$$

The procedure is as follows.

a) Assume a starting value for $L_C \geqslant h_O$.

b) Calculate d_C using Equation (E.4).

c) Calculate next value of L_C using Equation (E.5).

Repeat steps 1 to 3 with the new value of L_C, until successive values of L_C differ by 1 % or less.

To calculate the value for the length, $L_{C(\text{final})}$, modify the value for L_C by including a term to allow for bowing of the barrier, as given by Equation (E.6):

$$L_{C(\text{final})} = L_C + 1{,}7\ (L_C - h_O) \tag{E.6}$$

E.5 Smoke leakage through gaps in barriers

The leakage, M_g, expressed in kilograms per second, of smoke and hot gas through vertical gaps at the edges of smoke barriers can be related to the hot-gas layer that they contain by Equation (E.7):

$$M_g = \frac{2A_g}{3}\left(\frac{352{,}17}{T_l}\right)\left(\frac{2gD_l\theta_l}{T_0}\right)^{1/2} \tag{E.7}$$

where

A_g is the area of the gap, expressed in square metres (m^2);

T_l is the absolute temperature of the gases in the layer, expressed in kelvin;

T_0 is the absolute ambient temperature, expressed in kelvin;

D_l is the depth of gas in reservoir, expressed in metres;

g is the acceleration due to gravity, expressed in metres per second;

θ_l is the temperature rise above ambient of the gas, expressed in degrees Celsius;

The gases flowing through barrier gaps entrain air as they rise to the ceiling, and can cause the formation of a smoky gas layer within the area that the barriers are intended to protect. Such a gas layer is considerably cooler than that within the main reservoir. Where a smoke layer forms within the area intended to be protected by the smoke barriers, then it can be necessary to consider further measures to protect occupants. Such entrainment has not been closely studied, but preliminary research suggests that the mass entrained, M_p, expressed in kilograms per second, can be related to the mass flowing through the gaps to give a conservative estimate of the smoke rising to the ceiling, as given by Equation (E.8):

$$M_p = 6 M_g h_p \tag{E.8}$$

where

M_g is the mass of gas flowing through a gap in a smoke barrier, expressed in kilograms per second;

h_p is the height of rise from the base of the hot gas layer in the reservoir to the ceiling in the protected area.

NOTE Equation (E.8) is derived from a small number of experiments. It is desirable to extend the study further to confirm the derived correlation.

The temperature, θ_p, of the gas layer (ignoring any subsequent cooling) within the protected area is as given by Equation (E.9):

$$\theta_p = \frac{M_g \theta_l}{M_p} \tag{E.9}$$

where θ_l is the temperature above ambient of the smoke layer initially formed in the protected reservoir adjacent to the leakage, expressed in degrees Celsius.

Annex F
(normative)

Special classification categories at 300 °C

F.1 General

The use of the additional classification categories at 300 °C generally assumes that the exposed room (fire room) is fully sprinklered, with an automatically operating system. However, there can be other ways to achieve smoke gas temperatures of not much more than 300 °C.

The additional classification categories at 300 °C as given in Clause F.2 are intended, in particular, for wire-reinforced sheet-glass products, which might not otherwise be classified at 600 °C.

Precaution should be taken such that falling glass does not result in injuries to people, e.g. fire rescue teams, at least within the envisaged classification time. It is generally assumed that the temperature of the smoke gas in a sprinklered room is sufficiently low to prevent any parts of the smoke barrier from falling off.

F.2 Temperature/time classification

The temperature/time classifications of all smoke barriers shall be determined in accordance with the test methods in Annex D.

Smoke barriers may be classified in accordance with the classification categories in Table F.1.

Table F.1 — Additional classification categories at 300 °C

Classification	Temperature °C	Time min
DL 30	300	30
DL 60	300	60
DL 90	300	90
DL 120	300	120
DLA	300	Actual time

The heat exposure at 300°C, designated DL, represents the constant temperature of the smoke barrier test. The designations 30, 60, 90, 120 represent the period of the smoke barrier test. A smoke barrier that meets the requirements of DL 60 also meets the requirements of DL 30; equally, a DL 90 or DL 120 smoke barrier also meets the requirements of all categories with shorter times. A DLA smoke barrier meets all DL requirements as listed in Table F.1.

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