TECHNICAL REPORT

ISO/TR 5925-2

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2006-07-15

Fire tests — Smoke-control door and shutter assemblies —

Part 2:
Commentary on test method and the applicability of test conditions and the use of test data in a smoke containment strategy

Essais au feu — Assemblages porte et volet pare-fumée —

Partie 2: Commentaires sur la méthode d'essai et applicabilité des conditions d'essai et emploi des données d'essai dans une stratégie de confinement de la fumée

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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.

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.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

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/TR 5925-2 was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 2, *Fire containment*.

This second edition cancels and replaces the first edition (ISO/TR 5925-2:1997), which has been technically revised.

ISO/TR 5925 consists of the following parts, under the general title *Fire tests — Smoke-control door and shutter assemblies*:

— *Part 1*[1]*: Ambient and medium temperature leakage test procedure*

— *Part 2: Commentary on test method and the applicability of test conditions and the use of test data in a smoke containment strategy*

1) To be published. (Revision of ISO 5925-1:1981)

Introduction

Technical Committee ISO/TC92, *Fire Safety*, has prepared ISO 5925-1, a test specification for smoke control doors.

In a fire, the decomposition of materials results in the production of heat and fire gases containing smoke particles. The associated expansion of gases can lead to the creation of a pressure differential across door faces often influenced by wind pressures, mechanical or natural smoke extract systems, stack effect or a combination of these. This pressure differential induces the movement of smoke or air past any openings or gaps, including those in a door assembly. Schemes to keep areas within buildings free of smoke use various techniques, including barriers to its movement, exhausting, dilution, pressurization, either singly or in some suitable combination of all of these. Where the pressure differential across the door is positive, i.e. gases are being driven through any gap; standard tests have been developed to measure the leakage of smoke when such conditions exist. The test method does not deal generally with doors installed in conjunction with active smoke control methods, such as pressurization or exhaust, and this part of ISO/TR 5925 has been prepared to assist designers to specify doors that have the appropriate smoke control characteristics for the situation in which they are being used.

In addition to identifying when the door is likely to have a passive smoke control function, this part of ISO/TR 5925 tries to make it clear as to when ambient or medium temperature smoke control is appropriate, and when the threshold gap is significant.

Fire tests — Smoke-control door and shutter assemblies —

Part 2:
Commentary on test method and the applicability of test conditions and the use of test data in a smoke containment strategy

1 Scope

This Technical Report provides a commentary that explains the general philosophy and factors on which the test specified in Part 1 of ISO 5925 has been designed, to describe the limitations of its application and to provide some general guidance for those who use the result of the test. Smoke control-door and shutter assemblies can be used as part of a smoke containment strategy for the purposes of life safety or property protection.

2 Terms and definitions

For the purposes of this document, the terms and definitions given in Part 1 of ISO 5925 and the following apply.

2.1
door assembly
assembly comprising a fixed part (the door frame), one or more movable parts (the door leaves) and its hardware

NOTE The purpose of the door assembly is to allow or prevent access of persons and/or goods. The term hardware includes such items as hinges, latches, door handles, locks, keyholes (excluding keys), letter plates, sliding gear, closing devices, electrical wiring and any other items that can influence the performance of the assembly being tested.

2.2
shutter assembly
assembly comprising fixed parts, e.g. a barrel housing and vertical guides and one or more moveable parts, normally in the form of a curtain constructed from linked metal laths, or other flexible material and a barrel on which the curtain is wound together with any powered mechanism, e.g. an electric motor and its associate power supply

NOTE The shutter assembly is to allow the passage of goods, vehicles or persons, albeit where the shutter is normally closed in use, a personnel door should be provided for the passage of persons.

2.3
fire door
door or shutter assembly capable of maintaining for a specified period some, or all of the fire resistance criteria defined in ISO 3008, as appropriate for the door in use

2.4
smoke control door
door or shutter assembly whose primary function is to restrict the passage of smoke as determined by a test in accordance with Part 1 of ISO 5925

2.5
fire and smoke control door
door or shutter assembly meeting some, or all of the criteria for fire and smoke control as appropriate for the door in use

2.6
ambient temperature
for the purpose of this Technical Report, ambient temperature is an air temperature of (20 ± 10) °C

2.7
medium temperature
for the purpose of this Technical Report, medium temperature is an air temperature of (200 ± 20) °C

2.8
high temperature
temperature representative of a standardized fully developed fire which is as specified in ISO 834-1

NOTE For ease of use, doors are identified by a code letter/number and these are shown in Figure 1.

2.9
make-up air
air that is made available to dilute the fire gases in order to reduce their temperature

3 General principles

3.1 Smoke and its influence

Smoke is the term used to describe the airborne products of combustion generated by the fire, together with large volumes of air that become entrained into them due to their motion. These combustion products can contain solid and liquid particulates within a gaseous mass.

Almost all fires produce smoke, which, when enclosed by a building, has the potential to become extremely hazardous to its occupants and damaging to property. Most deaths in fires are due to smoke inhalation, rather than to the victim having been burned.

The gaseous combustion products, chiefly carbon dioxide and water vapour, usually include toxic gases, the most common being carbon monoxide, although hydrogen cyanide and other minor species can be present to some extent. Amongst these, irritant gases such as acrolein can have a significant effect on people attempting to escape fire.

The solid and liquid fractions of the products of combustion are also responsible for the poor visibility through smoke. This adds to the problems presented by the smoke. Not only is it physiologically hazardous in its own right, but escape through it is made more difficult by it obscuring escape routes. These fractions can themselves be irritants and can be particularly dangerous to people who are subject to asthma or other respiratory problems.

Smoke can also cause damage to property. Most fires produce soot and many generate corrosive gases such as hydrogen chloride. The effect of these on sensitive equipment can be responsible for large monetary losses due to equipment damage, the need for system clean-up and subsequent business interruption.

3.2 Smoke dynamics

All fires start from an ignition and grow at a rate generally determined by the environment in which the fire starts and the nature of the materials involved in the event. Sometimes the fire can smoulder for a considerable period, especially if the materials that have been ignited have a low rate of heat release or the environment does not readily sustain combustion. Smoke produced during such a fire has very little buoyancy and whatever buoyancy it has due to gas density differentials as a result of increased temperature is soon lost.

Smoke produced under these low temperature conditions is, therefore, subject to the movement dominated by the ambient air current, particularly any that is induced by mechanical means, such as ventilation and air conditioning. In the absence of ambient currents, these cool gases generally mix with the environment and do not stratify as is expected from hot buoyant gases.

Once the heat release increases, the smoke's buoyancy increases and it soon begins to dominate air currents in the enclosure. When the fire reaches a sufficient size, the smoke rises in a plume towards the ceiling. As it does so, it entrains large volumes of air, greatly increasing smoke volume but reducing its temperature and the concentration of chemical constituents.

The total entrained volume of air increases substantially with increasing height of the plume. With sufficient buoyancy, the smoke impinges the ceiling, spreading out radially to reach any side walls and then forms a layer that deepens as more smoke is produced.

Smoke flows out of the enclosure of origin through any upper openings that exist or develop. This outflow is balanced by an inflow of air usually at a lower level. The openings can exist by design or occur as a result of failure of one of the boundary elements.

An opening can be part of a smoke ventilation or extract system, where either vents open to allow smoke out or a fan-assisted ducting system exhausts the hot gases and smoke. In such cases, make-up air is required to come into the enclosure at a lower level, normally from designated sources, but also, possibly, from around doors. Doors designed to provide make-up air do not require smoke sealing around their perimeter.

Similarly, one of the boundary elements most likely to fail as a result of the exposure to hot gases is windows in the external façade, where high temperature differentials on the surface of the glass can lead to shattering. Under ideal environmental conditions, this exhausts the smoke, making the need for enclosure sealing unnecessary. However, unlike a designed-in vent that is designed to work in conjunction with winds from most directions, the failure of an external window on a façade with a wind imposed on it can have the opposite effect. Any wind-induced pressure in the enclosure can impose demands on the walls separating other parts of the building with respect to their ability to prevent smoke leakage through gaps.

Similarly, if the enclosure is unfenestrated or where the windows do not break as a result of the thermal exposure, then the pressure increases and the smoke layer deepens.

A normal door is the one element in the boundary of a structure that is naturally leaky, having a gap all around the moving leaf, unless a seal is introduced to restrict it. A smoke-control door is provided to restrict the flow of smoke, whether it is wind-induced or the result of natural buoyancy.

It should be recognized, however, that any smoke transferring through door gaps is likely to lose much of its heat energy in the process and, as a consequence, the temperature and buoyancy are also reduced. Experimental work has demonstrated that smoke leaving an enclosure via narrow gaps, such as those around a door leaf perimeter, soon become fully mixed with the air.

Within the enclosure, as new flammable material becomes involved as a result of increasing heat transfer to it, more air is required for the fuel volatiles to burn. If this is not available, either the fire does not grow any further or the fuel volatiles burn instead outside the enclosure of origin, i.e. after moving via windows to the open air or to an adjacent ventilated space, if it is available.

Without engineering intervention, it would be natural for the space containing the fire to contain hot buoyant gases and for the immediately adjacent, protected spaces to fill with clean air without any buoyancy.

4 Smoke control

4.1 Design objectives

Since smoke can have a major impact on the overall design of the building, it needs to be considered at the earliest possible stage of the design process. Normal escape provisions in buildings, e.g. restrictions on travel distances and emergency lighting provisions, do not assume significant levels of smoke management. Where good smoke management is introduced, either by exhaust, ventilation, pressurization or by containment, then these provisions may be relaxed. Any such relaxation has a profound influence on the building design/layout and, therefore, it is important that the method of smoke control to be used be nominated early in the design process.

Smoke-control systems for life safety are designed to maintain a tenable environment for occupants to facilitate their safe escape from the building to a place of relative safety or a refuge, preferably separated structurally from the area being evacuated. Smoke-control systems for property protection are generally designed to reduce the level of contamination in a space by keeping smoke logging down to acceptable levels.

There are a number of ways that smoke control can be achieved:

— natural ventilation;

— mechanical smoke exhaust;

— pressurization;

— smoke containment.

NOTE An alternative to pressurizing a space is to depressurize the adjacent spaces(s), but this is difficult to achieve in a fire, as the depressurization fans are generally overwhelmed by the fire gases.

The choice of system may be dictated by the area in which the smoke is to be controlled. With such "active" measures, then, natural or powered exhaust is more appropriate then "passive" smoke containment has a limited function, and can possibly make the situation worse by lack of the make-up air, and hence reduced entrainment and higher gas temperatures, as discussed in 4.2, unless separate provision is made for "make-up" air.

If, however, it is an adjacent space that is to be protected, then a method that has been used historically to keep such an area free of smoke has been pressurization of the space, especially staircases. Actively exhausting smoke from the area on fire also provides some protection to the adjacent spaces. This protection can be compromised if the smoke temperature in the space exceeds the operating temperature of the fan, causing it to cease operating. At such times, the space becomes vulnerable to smoke logging.

A simple-to-introduce alternative to exhaust or pressurization is the use of smoke containment, initially between the enclosure on fire and the space being protected or between adjacent protected areas.

4.2 Protection of adjacent and remote/removed spaces by smoke containment

For smoke containment to work, it is important that the elements bounding the enclosure of fire origin and the adjacent enclosures remain impermeable to the flow of smoke and hot gases for as long as is necessary to maintain tenable conditions for life safety or an adequately pollution-free environment for property protection. There are several fairly distinct stages in this scenario that it is important to address individually for each space in which smoke is contained.

4.2.1 Scenario within the room of fire origin

In the period immediately following a small ignition, assuming that the materials initially involved in the fire have a high thermal inertia and a relatively low rate of heat release, the smoke cools and mixes readily with the surrounding atmosphere. As such, the barrier formed by the bounding structure can initially experience exposure to cool, ambient smoke. As such, any seals designed to restrict that smoke, including seals around door edges or the sealing systems used to retain glass within the door leaf, are required to be effective at only ambient conditions. If the fire continues to grow in intensity and size, with a corresponding increase in the rate of heat release, then the plume becomes buoyant, increasing in both temperature and volume. The temperature of this plume becomes elevated and any ambient temperature test method for evaluating smoke containment can be inappropriate. It is possible by reference to the appropriate scenario in 4.2.2 to 4.2.4 to produce an estimate of the smoke temperature and hence identify the most suitable test regime to reproduce those conditions.

In addition to the heat release from the fire, there are many other features that influence these temperatures:

— height of the room;

— thermal losses to, or through, the boundary structure;

— availability of make-up air (dilution);

— presence of a suppression system.

In a single-storey enclosure, initially these elevated temperatures are imposed only on seals in the upper part of the enclosure and can be applied to linear-gap seals, glazing seals or service penetration seals for which no smoke-leakage tests currently exist, neither at ambient, nor elevated temperatures. Seals fitted around the perimeter of door assemblies are not exposed to smoke at these temperatures until the smoke layer has deepened to below door head height, although there are a number of gas temperature/buoyancy conditions as the smoke goes through the transition from smouldering to fully buoyant.

Once the gas layer descends below 2,7 m, especially if it has a temperature of around 200 °C, the temperature currently recommended in Part 1 of ISO 5925, the conditions are life threatening to the occupants of the space. If there is a risk of the smoke extending down to this height, then smoke management by exhaust and/or dilution is normally introduced to ensure that these temperatures and smoke layer heights do not develop or are not exceeded. It is only in a single-storey environment without smoke management that doors installed at ground-floor level are subjected to smoke at such temperatures and, even then, probably only over the upper part of the leaf.

However, doors can be installed at a higher level in such a space, e.g. off a gallery, balcony, a mezzanine or large unprotected accommodation stair, in which case the doors are subjected to smoke/gas temperatures greater than this, even before a flashover or full fire development has occurred in the enclosure. Doors in such locations can experience medium temperature conditions over their full height, including the threshold, at an early stage in a fire.

Following the full development of the fire, either following flashover or as a result of the free burning of the adjacent contents in an enclosure that is too large to flashover, a door can be expected to experience exposure to smoke and hot gases at, or near, fire temperatures. Within Part 1 of ISO 5925, there are no such conditions specified. In practice, there is no recognized method of quantifying leakage in the fully developed fire but experimental evidence indicates that intumescent seals, fitted to the leaf perimeter of a doorset, can be expected to restrict the flow of “hot” smoke.

Whilst fire-resisting, smoke-control doorsets do not play a constructive role in a natural, or powered smoke-exhaust system, vertical-drop steel rolling steel doors/roller shutters can play a useful function in such applications. As part of a smoke exhaust system, it is important that the buoyant smoke that collects at a high level in an enclosure is not allowed to traverse too far because the gases would be further diluted and lose their buoyancy as a result of a loss of their temperature differential compared to the ambient conditions outside the building. The egress velocity of the gases through vents is governed by the differential temperature and so this is important. To prevent this dilution and cooling, smoke screens or curtains are used to create a smoke reservoir, which aids the extraction. Partly dropped roller shutters can be used to act as smoke curtains or reservoir screens and may be used partially closed, thereby providing a source of input air for the smoke exhaust system at the bottom, but at the same time providing a barrier to reduce smoke spread nearer the top.The egress velocity of the gases through vents is governed by the differential temperature and so this is important.

From the above, it can be seen that doors in the boundary of an enclosure of fire origin are exposed to various smoke temperatures and over/under pressures, depending upon the level at which they are installed, the stage in the fire and the smoke-management measures that are incorporated.

Table 1 identifies, for doors in the space of fire origin, the appropriate exposure conditions to consider when determining the smoke-tightness requirements for the doors in these applications.

Table 1 — Summary of smoke exposure conditions for doors in the boundary of the space of fire origin

Smoke temperature	Door configuration [a]			
	A [b]	B [c]	C [d]	D [e]
Ambient	Briefly at the beginning and possibly over full height of door	Very briefly over the full height of the door	Briefly at the beginning and possibly over full height of the door	No exposure
Medium	For an extended period up to the onset of flashover over the upper 2/3rds of the door	For an extended period up to the onset of flashover over the full height of door, including the threshold	No exposure	Extended periods over full height [f]
High	For the period following flashover and over the majority of the door height	For the duration between flashover and extinguishment over full height	No exposure [g]	No exposure [g]

a See Figure 1.

b A: Door assemblies at ground-floor level within the boundary of an enclosure (GF1) without an "active" smoke-control system operating in the enclosure.

c B: Door assemblies at elevated positions within the boundary of an enclosure (E1) without an "active" smoke-control system operating in the enclosure.

d C: Door assemblies at ground-floor level within the boundary of an enclosure (GF1) with a properly designed "active" smoke-control system operating in the enclosure.

e D: Door assemblies at elevated positions within the boundary of the enclosure (E1) with a properly designed smoke-control system operating in the enclosure.

f The amount of the door subjected to medium temperature smoke depends upon position of neutral pressure axis within the space.

g Can experience these conditions if smoke control system is overwhelmed or fails.

4.2.2 Scenario within a ground-floor space adjacent to the enclosure of fire origin with no active smoke control in the enclosure

Whilst the boundary to the enclosure of fire origin remains imperforate, the adjacent, protected spaces are not likely to experience any smoke logging. However, if the door(s) to the fire enclosure (F1) are not sealed against the flow of smoke or are not fitted with a thermally activated fire seal, e.g. an intumescent seal, smoke initially percolates around the door edges, especially over the upper 2/3rds (above the neutral axis) and after a while, as the pressure differential between the spaces increases due to increased volumes of combustion gases and increased temperatures, the smoke starts to flow readily into the protected space through any gaps. Experimental work has shown[1] that small confined adjacent single-storey spaces on the ground-floor, such as corridors, smoke log quickly as a result of this leakage if the doors (and walls) are not effectively sealed.

Even if the door to the fire enclosure is fitted with a smoke seal, unless the seal has a resistance to high temperatures, it breaks down as the temperature increases in the fire compartment/enclosure and once more allows smoke and combustion gases to flow through unimpeded. Experimental evidence has also demonstrated that, even when the smoke seal fails due to the temperature of the gases imposed on the seal on the fire exposed side, these gases cool significantly as they lose energy to the surroundings and initially have a temperature that is only slightly, if at all, above ambient. During this period the adjacent space is filling with "ambient" temperature smoke.

If heat-activated (intumescent) seals are fitted, then this smoke flow can be significantly reduced in volume and its temperature remains at ambient levels.

If no heat-activated seals are fitted, then the temperature of the gases passing through the assembly gradually increase and the gases in the protected space start to become buoyant. The temperature of the air/smoke in this space eventually reaches medium temperature levels. Eventually, this space is fully involved in the fire if the fire breaks out of the enclosure of origin.

Door assemblies in the other walls of this protected space, possibly protecting vertical stairways, are, therefore, subjected to ambient-temperature, probably fully mixed smoke for the majority of the fire duration, but are likely subjected to medium-temperature smoke for extended periods if the doors to the room of fire origin are not. Eventually, the space becomes an extension of the fire enclosure, which is likely to be sooner if no heat-activated seals are fitted.

Table 2 identifies, for doors in the boundary of an adjacent space, the appropriate exposure conditions to consider when determining the smoke-tightness requirements for the doors in these applications.

Table 2 — Summary of the smoke exposure conditions for door(s) in the boundary of an adjacent ground-floor space separating it from other spaces

Smoke temperature	Door configuration [a]		
	A [b]	B [c]	C [d]
Ambient	For reasonably long period, over the full height of the door until the gases in the space become buoyant	Brief exposure following failure of the smoke seal due to heat and before hotter gases flow through in any volume	Possible brief exposure over full height between failure of the smoke seal and activation of the fire seal
Medium	For the majority of the duration, over the upper 2/3rds of the height, until the door separating the spaces fails	Prolonged exposure over the upper 2/3rds of the door for the period between failure of the smoke seal and failure of the fire door	No exposure
High	Very briefly prior to the loss of fire resistance in the separating door	Very briefly prior to the loss of fire resistance in the separating door	No exposure, except briefly prior to a loss of fire resistance in the separating door

[a] GF2; see Figure 1.

[b] A: When a door separating the space from the fire enclosure GF1 is not fitted with smoke- or heat-activated seals.

[c] B: When a door separating the space from the fire enclosure GF1 is fitted with smoke seals, but not heat-activated seals.

[d] C: When a door to the fire enclosure GF1 is fitted with smoke seals and heat-activated seals.

4.2.3 Scenario within a protected adjacent space at an elevated position relative to the base of the fire enclosure, with no active smoke control in the enclosure

The condition within these elevated spaces, i.e. those rooms or corridors that open out onto a gallery or mezzanine above the floor of the fire enclosure, are not significantly different from the conditions within the ground-floor protected spaces, except that the door to the fire enclosure is exposed to more onerous conditions, as indicated in Table 1. This door, by reference to Table 1, Door configuration B, is exposed, over its full height, to ambient-, medium- and high-temperature smoke that is more severe than for the doors separating ground-floor spaces. As a consequence, the space is expected to become smoke logged earlier, much earlier if the threshold is not sealed against ambient or hot smoke, and this, of course, enhances the exposure on the doors within the perimeter of this protected space, which is protecting still other spaces, e.g. stairways.

Table 3 identifies the appropriate exposure conditions for doors on the perimeter of an elevated space, depending upon the methods of sealing utilized on the door separating the space from the fire enclosure.

Door assemblies installed at elevated positions, e.g. off of mezzanines and galleries, are not used for make-up air and can be exposed to medium-temperature, buoyant smoke depending upon the expected depth of the reservoir, even when a natural or a powered smoke-control system is operating.

Table 3 — Summary of smoke exposure conditions for doors in the perimeter of a protected space at an elevated position relative to the floor of the fire enclosure

Smoke temperature	Door configuration [a]				
	A [b]	B [c]	C [d]	D [e]	E [f]
Ambient	For a moderate period over full height of door until gases in the fire compartment become warm and buoyant and flow readily into this protected space	Moderate duration of exposure both due to ambient smoke exploiting the threshold, followed by medium temperature smoke, both through the threshold and around the complete perimeter after breakdown of the seals	No exposure for most of the fire duration due to the seals but for a brief period after the seals break down and before medium temperature smoke enters the space	Moderate duration of exposure as a result of ambient temperature smoke exploiting the threshold from an early stage followed by medium temperature smoke through the threshold and around complete perimeter after breakdown of seals	Possible brief exposure over full height between failure of smoke seal and activation of fire seal
Medium	For most of the fire duration, initially over the upper 2/3rds but soon after over the whole height because of the high gas flow through the threshold	For a prolonged period due to the long duration of exposure of the separating door to warm smoke and the lack of a threshold seal	For a moderate period between failure of smoke seals and loss of fire resistance, which will exploit the threshold readily, and will probably be over full height of doors	For a prolonged period due to the prolonged exposure of the elevated separating door to warm smoke and the lack of a threshold seal	No exposure
High	For a brief period following failure of the fire resistance of the separating door	For a brief period after the separating door has lost its fire resistance	—	For a moderately long period due to threshold not being sealed against high temperature gases at all	No exposure until loss of fire resistance

[a] E2; see Figure 1.

[b] A: When a door separating the elevated space (E1) from the fire enclosure is not fitted with smoke- or heat-activated seals on any of its edges.

[c] B: When a door separating the elevated space from the fire enclosure is fitted with smoke seals across the head and down both jambs, but not heat-activated seals.

[d] C: When a door separating the elevated space from the fire enclosure is fitted with smoke seals on all edges, including the threshold but not fitted with heat-activated seals.

[e] D: When a door separating the elevated space from the fire enclosure is fitted with smoke seals and heat-activated seals with smoke and heat-activated seals over head and jambs only.

[f] E: When a door separating the elevated space from the fire enclosure is fitted with smoke- and heat-activated seals on all edges.

4.2.4 Scenario in protected ground-floor and elevated space adjacent to the enclosure of fire origin which is fitted with an active smoke control system

When the enclosure of fire origin is fitted with a smoke-control (management) system, the ground-floor doors to the enclosure are more likely to be the source of gratuitous or planned make-up air for the system. As such, the fitting of smoke seals should only be undertaken after full consultation with the designer(s) of the smoke control system, or at the very least, with the heating-and-ventilation-system designers. As a consequence, doors in any protected adjacent space are not subjected to any smoke attack and are probably better off not incorporating smoke seals. Heat-activated fire seals are beneficial in the event that the smoke-control system fails or is overwhelmed.

With a natural smoke-ventilation system, there can be a period of ambient smoke production that can threaten the doors separating the enclosure of fire origin from adjacent spaces before the temperature differentials become sufficiently established to cause the smoke egress to occur. With a powered smoke-exhaust system, even this risk is eliminated, depending upon how quickly the exhaust fans are brought into action.

Many smoke-management systems rely on creating a reservoir of warm smoke at the top of the enclosure of fire origin, from which the smoke is extracted either naturally or mechanically. It would be normal for the buoyant gases to be kept at a level well above any access door in this space but if the smoke-extract system is not 100 % effective due to wind effects or other causes, the doors at an elevated level in perimeter of the enclosure of fire origin are the first to come under attack.

Table 4 identifies, for this scenario, the appropriate exposure conditions to consider when determining the smoke-tightness of doors on the perimeter of a protected space when the enclosure of fire origin is fitted with a smoke management system.

Table 4 — Summary of smoke exposure conditions for doors separating adjacent spaces from other spaces

Smoke temperature	Door configuration	
	A [a]	**B** [b]
Ambient	No exposure [c]	No exposure [e]
Medium	No exposure [d]	Possible extended period of smoke exposure is inefficient
High	No exposure [d]	No exposure [d]

[a] Doors in protected spaces at ground-floor level (GF2).

[b] Doors in protected spaces at elevated positions (E2), relative to floor of enclosure of fire origin.

[c] Most smoke-extract systems require make-up air and whilst it is recommended that this be supplied via bespoke grilles, occasionally leakage around a door may be included and, for this reason, it is important not to fit smoke seals without a complete understanding of the doors function.

[d] Can be exposed to high-temperature smoke if the smoke-control system is overwhelmed or fails.

[e] Fitting of smoke seals on these doors, including the threshold, is recommended to prevent them from providing gratuitous input air at too high a level or to prevent egress of smoke if smoke extract system is not efficient enough to keep up with smoke production.

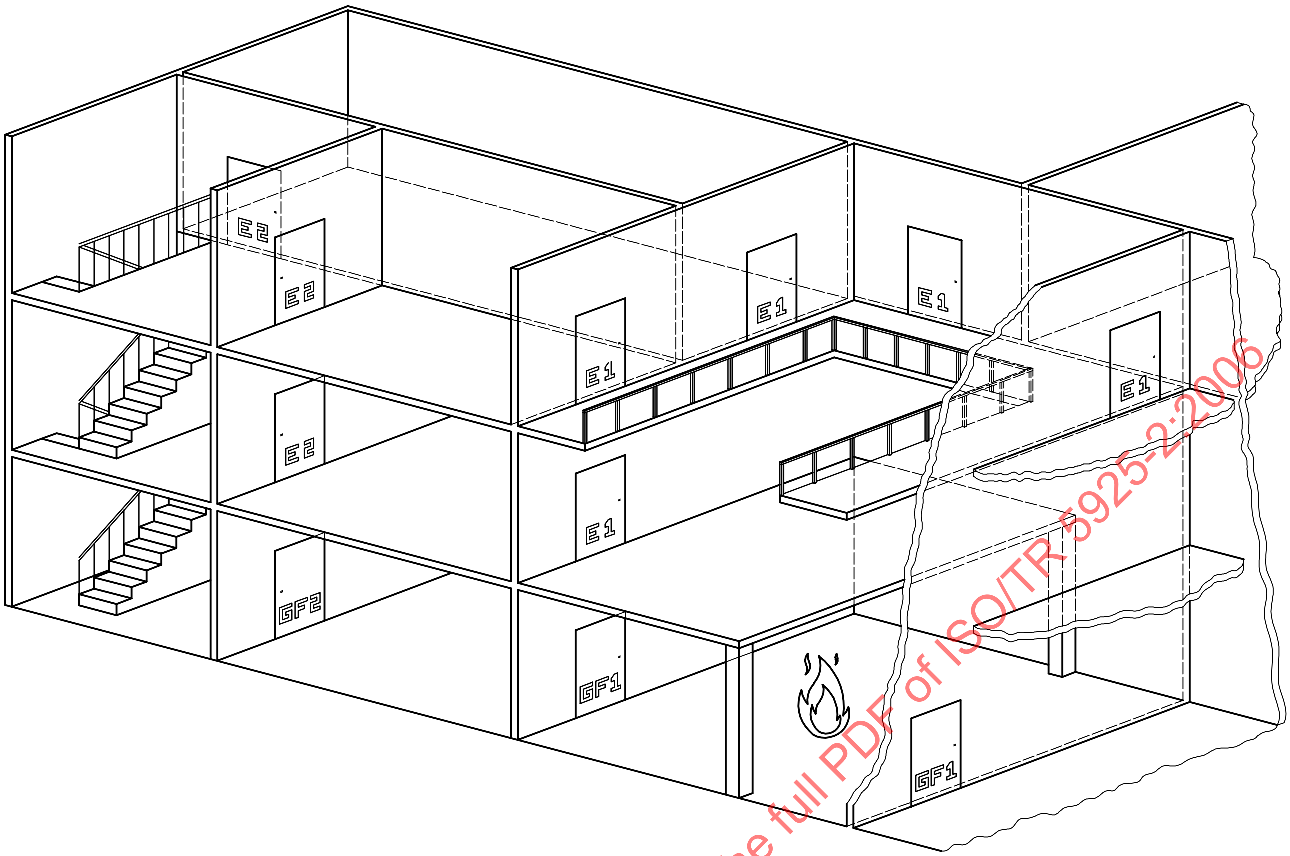

Figure 1 — Identification of the doors referred to in the analysis in Clause 4

5 Appropriateness of the test conditions and the selection of sealing system

It can be seen from Clause 4 that the smoke-control performance of a door varies immensely based upon its position in the fire enclosure, the smoke-management provisions in the building/space, the incorporation of fire seals, etc. When specifying the test-exposure conditions for a smoke-control door assembly and, to some extent, the criteria of failure, it is vital that the role and function of the assembly is fully understood. Failure to do so can result in the door not performing the function that it was designed for and, in extreme cases, the whole life-safety system to fail.

This Technical Report should be used to define the appropriate exposure conditions and test arrangement for the door or shutter assembly under consideration.

It can be seen that there is no simple smoke-sealing solution that is applicable to all situations. There is a large difference between the sealing requirements for doors opening onto mezzanines and galleries and those at ground-floor level, especially with respect to the requirement for a threshold seal. There is an equally large difference in the sealing arrangements required, depending upon whether the space is protected by a smoke-control/management system or not.

Heat-activated, normally intumescent, seals, which are generally considered as solely providing a method of satisfying the cotton-pad integrity test, when the latter is used, can be seen to play a major role in controlling hot smoke. This means that doors that do not incorporate intumescent seals, because the fire-resistance test does not require them, are likely to permit more hot smoke and combustion gases to enter the protected spaces than has previously been thought to be the case.

