BRITISH STANDARD

BS ISO TR 5925-2:1997

Fire tests — Smoke control door and shutter assemblies —

Part 2: Commentary on test method and test data application

ICS 13.220.50; 91.060.50

National foreword

This British Standard reproduces verbatim ISO TR 5925-2:1997 and implements it as the UK national standard.

The UK participation in its preparation was entrusted by Technical Committee FSH/22, Fire resistance tests, to Subcommittee FSH/22/5, Test procedures for doors, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the ISO/TR title page, page ii, pages 1 to 8 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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Contents

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Fire tests — Smoke control door and shutter assemblies —

Part 2:
Commentary on test method and test data application

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

Partie 2: Commentaires sur la méthode d'essai et l'application des données de l'essai

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Foreword

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The main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, 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).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 5925-2, which is a Technical Report of type 3, was prepared jointly by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 2, *Fire resistance*.

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

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

— *Part 2: Commentary on test method and test data application.*

Descriptors: Buildings, fire protection, smoke control, doors, fire doors, tests, fire tests, test results.

Introduction

Technical Committee ISO/TC 92 *Fire safety*, has prepared a test specification for smoke control doors as follows:

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

In a fire the decomposition of materials results in the production of heat and fire gases containing smoke particles. The consequent expansion of gases leads to the creation of pressure differential across door faces often assisted by wind pressures, mechanical or extract systems, stack effect or a combination of these. This pressure differential induces the movement of smoke past any openings or gaps including those in a door assembly. Schemes to keep building areas free of smoke use various techniques using obstructions to its movement, exhausting, dilution, pressurization either singly or in some suitable combination. Standard tests have been designed to measure the leakage of smoke when such conditions exist. They do not deal specifically with doors installed in conjunction with smoke control methods based on pressurization but, nevertheless, information obtained from these tests is likely to be helpful in assessing the suitability of such doors.

1 Scope

This Technical Report establishes a commentary which explains the general philosophy and factors on which the test specified in ISO/DIS 5925-1 has been designed, to describe the limitations of its scope, to provide some general guidance for those who use the results of the test and to emphasize certain practical aspects of the procedure for those who carry out the test. All concerned with testing fire doors should read this commentary before initiating the test and before making use of the test results.

2 References

ISO 834:1975, *Fire-resistance tests — Elements of building construction.*

ISO/DIS 834-1, *Fire-resistance tests — Elements of building construction — Part 1: General requirements.*

ISO 3008:1976, *Fire-resistance tests — Door and shutter assemblies.*

ISO/TR 3956:1975, *Principles of structural fire-engineering design with special regard to the connection between real fire exposure and the heating conditions of the standard fire-resistance test (ISO 834).*

ISO/DIS 5925-1, *Fire tests — Smoke control door and shutter assemblies — Ambient and medium temperature leakage test procedure.*

3 Definitions

For the purposes of this Technical Report, the definitions given in ISO/DIS 5925-1, together with the following, apply.

3.1
door and shutter assembly

a door and shutter assembly is an assembly comprising a fixed part (the door frame), one or more movable parts (the door leaves) and its hardware. 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 which may influence the performance of the assembly being tested

3.2
fire control door

a door assembly capable of maintaining for a specified period the fire resistance criteria defined in ISO 3008

3.3
smoke control door

a door assembly whose primary function is to restrict the passage of smoke as determined by ISO 5925 tests

3.4
fire and smoke control door

a door assembly meeting the criteria appropriate for fire control and smoke control door assemblies

3.5
ambient temperature

for the purpose of this standard ambient temperature is an air temperature of (25 ± 15) °C

3.6
medium temperature

for the purpose of this standard medium temperature is an average air temperature of (200 ± 20) °C

3.7
high temperature

a temperature representative of a standardised fully developed fire as specified in ISO 834

4 Fire and smoke

Fire produces heat and a variety of gaseous products some of these are exhibited as smoke. Smoke may be defined as the airborne solid and liquid particulates and gases evolved on the pyrolysis and combustion of materials. Although only the particulate matter is visible, other gases are also present ranging from the slightly irritating to the highly toxic. All these with the heated air may be termed as the fire gases and create a safety problem for the occupants exposed to them.

Smoke rises with the hot fire gases until it meets an obstruction, such as a ceiling, when it will flow radially. In a small room the depth of the smoke layer can increase fairly rapidly until it spreads down to the door head level. If the door is open smoke will spread rapidly to other areas, cool down by mixing with air and become less buoyant. If the door is closed the smoke depth will continue to increase in the room, the temperature of the environment will rise and the expansion of gases could lead to an increase in air pressure relative to the outside inducing smoke leakage through the available gaps. The pressure will be highest at the ceiling level and lowest next to the floor where it may often have a negative value producing a neutral axis in the middle third of the room height. This is often confirmed by observing smoke markings after a fire along the upper parts of the door frame where leakage has taken place from the fire side. The leakage around the edges will depend upon the size of gaps, if any sealing has been used and the pressure differential between the two faces.

When a door is directly exposed to elevated temperatures, deformation and deterioration can also occur. For doors with combustible facings, pyrolysis, delamination and local generation of smoke occur at temperatures above 200 °C. As the fire becomes fully developed, the door along with other exposed elements, is subjected to high temperatures and more rapid deterioration may occur. The ability of the door to resist the passage of smoke under these conditions for a certain time is a function of the door design and the effectiveness of high temperature seals, if provided.

5 The role of doors in fire

5.1 Door usage

Fire barriers are provided in buildings to separate different risk areas and prevent the transfer of fire from one side to the other. The presence of openings in such barriers can introduce a potential weakness. Building regulations and fire codes require a door assembly used in such openings to posses the ability to resist the passage of smoke, or heat and flames, or both. The precise role of the door will vary from one location to another and the following is an example of the designations of doors in different locations:

— FIRE ZONE OR COMPARTMENT DOORS

Doors in fire walls that divide a building into fire zones or compartments. Fire zones may be provided for life safety or property protection purposes or both;

— ROOM/CORRIDOR DOORS

Doors in walls or partitions between rooms and corridors;

— HORIZONTAL EXIT DOORS

Doors in walls which provide access to a temporary refuge area or the outside of a building;

— STOREY EXIT DOORS

Doors in enclosures to vertical means of communication between storeys;

— SMOKE BARRIER DOORS

Doors in long corridors or between specified smoke compartments.

Doors specified for above locations may be required to serve a fire control or smoke control or a combined fire and smoke control function. A compartment door is often likely to be treated as a “Fire control door” only, whereas storey exit doors will be required to fulfill both functions. Other doors in a building required as part of a fire protection scheme can be treated as one of the types mentioned above by analogy. Figure 1 shows some typical examples of the usage of different doors.

5.2 Smoke compartmentation

When considering the concept of fire resistance (see ISO 834 and ISO/TR 3956) one of the basic ideas is to restrict the spread of fire to different parts of the building by providing fire compartments. In the same way, the spread of smoke in a building can also be restricted to a limited zone, thereby, facilitating limited or full evacuation of the building depending upon circumstances. The sub-division of the building for this purpose can be termed as smoke compartmentation and each zone so formed is a smoke compartment. The boundaries of smoke compartments may often be contiguous with those of fire compartments, but in many cases the former are subdivisions within the latter. The size of a smoke compartment depends upon the evacuation needs, the amount of smoke that may be generated and the facilities for smoke control.

Each smoke compartment should be surrounded by a smoke barrier i.e. a construction capable of resisting the passage of smoke. The amount of leakage to a surrounding compartment should be limited to the maximum that can be tolerated either for escape or fire fighting operations.

5.3 The function of smoke control doors

Smoke control doors are provided in fire barriers to limit the passage of smoke and other combustion products from one side to the other thereby maintaining the integrity of the barrier and giving more time for escape and fire control. Smoke control door assemblies can also be used to prevent damage to sensitive equipment such as computers and telecommunication apparatus.

It is not the purpose of this series of standard methods of test to give recommendations concerning the proper provision and installation of doors in buildings. Such matters will normally be dealt with by the national codes of practice or by regulations. Some of important factors which can be used by the authorities to formulate codes are described.

Any door, without louvres and other openings, when in the closed position has the ability to obstruct the passage of smoke and other products of combustion. However, if it has not been specially designed it may only have a limited effectiveness as a smoke barrier. The standard fire resistance test of ISO 3008 has a requirement for evaluating the passage of hot gases through any openings in or around the door. The technique used does not monitor gas flow rate as such but only the effect of such a flow on the ignition of a selected combustible material. The methods specified in ISO 5925 are more precise and are able to quantify the leakage rate.

In most cases, smoke control door assemblies need to be provided with some closer mechanism to ensure that the door is shut when not in use or closes on the occurance of a fire. A fully or partially open door will allow smoke to pass through and unless steps are taken to ensure the closure of doors the purpose of smoke control could be negated.

Smoke control door assemblies need to be considered as part of the fire barrier system. Openings for services in shafts, walls, floors and ceilings and even some partition and ceiling constructions may allow the leakage of smoke unless care is taken in their design and installation. Any requirements for smoke control doors need to take into consideration smoke leakage through all potential routes.

6 Selection of test conditions

Smoke control door assemblies will need to function in different conditions depending upon the proximity to the seat of fire, the rate of smoke production and the environmental conditions. The technical committee responsible for preparing these standards has identified three typical situations for which standard test methods would be needed.

If a fire develops in a given room with a closed door, pressure due to fire on the affected side will increase and the ensuing pressure differential will tend to push the smoke-laden air through all available gaps into the adjacent area. This will be typical of a door separating a room from a corridor (room/corridor door). Pressure across a given door is likely to be the combination of the pressure due to "normal" conditions and the pressure created by the fire. Mechanical ventilation effects may introduce a pressure difference of approximately the same magnitude. In the event that the windows to the room are open, or break by heat, a wind generated pressure difference may also become a factor. Selection of an appropriate test pressure level has to be a compromise based on probabalistic considerations.

As the temperature increases not only will the pressure differential increase but also a pressure gradient will develop over the height of the room. According to ISO/DIS 834-1 (the revision in parts of ISO 834:1975), the maximum pressure differential used in a test on a 3 m vertical element is 20 Pa. The higher pressures in the upper part will cause more leakage to occur through clearances in the upper part of the door, with either no flow at the bottom or a flow in the reverse direction if opposing pressure conditions prevail. At a later stage the increasing heat is likely to cause the door to distort, and combustible materials to decompose and char, thus increasing the gap sizes through which smoke can pass. The severity of exposure can also be an important factor for the extent to which a door may allow the passage of smoke and hot gases.

The possible range of test conditions have been divided into three recognizable ranges, the near ambient conditions, the medium temperature range and the conditions of a fully developed fire. ISO/DIS 5925-1 apparatus can be used for smoke control doors with smoke laden gases in the temperature range from the ambient to 200 °C and replaces the special test which only dealt with ambient temperature conditions. The ambient situation occurs at the beginning of a fire or when the door is remote from the fire and smoke and fire gases have cooled down by the time they reach it. In either case the temperature of gases will be low and hardly any fire generated pressure gradient will exist over the height of the door. The test has therefore been designed to be carried out at or near to the ambient temperature conditions but over a range of possible pressure differences. At the other extreme, with a fully developed fire the door will be exposed to the full severity of heat and fire generated pressure, as in the standard fire resistance test of ISO 3008. In between these two extremes a variety of intermediate conditions will exist and a choice has been made for the medium temperature test, in which the temperature selected is such as to represent partial cooling of the gases but it is still sufficiently high to cause physical distress due to distortion or surface damage.

Figure 2 shows simple examples to represent various test condition. During the early stages of a fire, Figure 2 a), a door to a room will be exposed only to moderate heating conditions represented by the ambient temperature with other doors not receiving much heat. As the fire grows to full intensity the door will be subjected to the conditions of a fully developed fire simulated by the fire resistance tests. If the door to the fire room is open there will be little resistance to the spread of fire and smoke to the adjacent areas. If the door is closed then the leakage of smoke will be governed by the effectiveness of this door. An ordinary (unclassified) door will not provide much resistance to the transfer of fire and fire will be transmitted next door with only little delay. With a fire control door the transmission of the fire will be prevented if the door is properly mounted and in a closed position.

The doors directly exposed to a fire are assessed on the basis of their performance under the standard fire test conditions, if the door is of an unclassfied type high temperature conditions can be expected in the next space as well, Figure 2 b), and therefore any door in that area will also need to be assessed under high temperature conditions. However in practice doors further removed from the fire zone are to be subjected to the conditions represented by the medium temperature test as long as the first barrier remains intact, Figure 2 c). Doors further away may be subjected to little temperature rise and can be assessed by the ambient temperature test of ISO/DIS 5925-1.

In the simple layout in Figure 1 , doors A & B to the fire room need to be subjected to the full heating conditions for their assessment, whilst the other room doors need to be judged under medium temperature conditions for smoke leakage. The performance of the lobby door and stair doors will depend on their distance from the fire zone and the presence of intermediate barriers. Door E with a lobby approach is well protected and therefore the ambient temperature test should be appropriate for assessing its performance. When no lobby exists the medium temperature test of ISO/DIS 5925-1 is to be considered as suitable.

In some cases it may be almost impossible to predict which of the three standard situations adequately represent the role of a smoke control door assembly in a building. In many cases the door may indeed be subject to a variety of conditions in succession. There will be instances when a door is required for smoke control and fire control purposes, in such cases the door will need to be tested as a fire control door assembly in accordance with ISO 3008 as well as ISO 5925. However, there are many situations in a building where a fire safety authority can foresee clearly the role of a door in a particular location, or a fire safety engineer can predict the most likely scenario for its primary function. For example, it may be expected that in a residential occupancy the emphasis will lie on rapid evacuation and therefore the test conditions of ISO/DIS 5925-1 may be considered adequate. Access doors to lobbies, or stairways without a lobby approach, need to provide resistance to smoke penetration at medium temperatures, but with a degree of fire resistance to prevent vertical spread of fire. There may be other situations where the evacuation problems require the maximum safeguards as in health care buildings with special evacuation problems.

7 Test package

As with all fire tests the test conditions have been selected with a view to offering pragmatic solutions in the selection of suitable smoke control doors for use in buildings. The test conditions should not be assumed to represent the range likely to be met in "real" fires. This does not make them any less useful as an indication of the way in which a door in question will contribute to the protection of occupants and the building.

The ambient temperature test, ISO/DIS 5925-1, has been designed to be as simple as possible. It can be used not only as a smoke control test but also for any purpose where air leakage through a door assembly under the test conditions is of interest.

The medium temperature test, ISO/DIS 5925-1, uses the same apparatus but creates conditions under which door assemblies will be exposed to a moderately elevated temperature, defined as 200 °C. The test temperature level corresponds to temperatures at which doors of combustible materials suffer only limited damage due to charring or decomposition but distortion can take place and sealing materials can be affected. The temperatures may not be high enough for some intumescing materials to operate satisfactorily and therefore seals of other types will be needed to reduce smoke penetration. The test is able to make some distinction between doors able to resist heat damage and others.

The high temperature test is not available at present and when available will be an adjunct to the ISO 3008 test. The pressure conditions of ISO/DIS 834-1 need to be adjusted to give positive pressure over the whole height of the door to prevent air flow from the unexposed side. A partial enclosure attachment on the unexposed side will allow the aggregate leakage of hot gases from the door to be established by utilising a tracer gas technique. If the covering on the unexposed side is considered not to intefere with the measurement of the fire barrier properties of the door, a single test may be used for smoke control and for fire control measurements.

8 Some points relevant to tests

8.1 Selection of test specimens

If a test is to be carried out on a door specimen, then it is important to ensure that the complete door assembly chosen for the test is typical of the type under consideration. It is recommended that the door assembly should be selected from the normal manufacturing run under conditions which, as far as, possible afford random selection within the batch. This may not be possible where a door is in the development stage but in other cases the national authorities may wish to provide rules for making a selection. The door selected should be typical as regards door leaf and frame, hinges, door furniture including any essential closing devices, and door sealing systems, etc.

8.2 Allowance for use

The test procedures specified do not simulate the wear and tear to which a door may be subjected in practice. The requirement that the door should be opened and closed a certain number of times before the test is undertaken has been only included to ensure that the door is capable of operating correctly at the start of the test. The national authorities may wish to provide guidance on procedures to simulate door usage.

8.3 Extrapolation of results

Normally the results obtained from testing one type of fire door assembly cannot be used to assess results of another type. Even minor variations of the door furniture, e.g. hardware, may significantly affect test results, however, in the case of smoke control doors tested to ISO/DIS 5925-1 small variations are possible which have been listed in ISO/DIS 5925-1 :--, clause **11**.

It may be useful to express the test results in terms of the ratio of effective air flow area to the door leaf as suggested in ISO/DIS 5925-1.

9 Practical application of test results

It is not the purpose of this series of test methods to provide guidance on the acceptability of a door assembly. The acceptance process must be left to the appropriate authority, whether regulatory or advisory, which will take into consideration the use of the door and the safety requirements of the building where the door is to be installed.

The only criterion of performance provided by these tests is the leakage rate of gases under the prescribed conditions. Some of the factors to be considered when applying these flow rates are:

a) the pressure conditions in the building, specially the pressure differences between the exposed side of the door and the space to be protected against smoke;

b) the size of the space to be protected;

c) the ventilation conditions in the space to be protected;

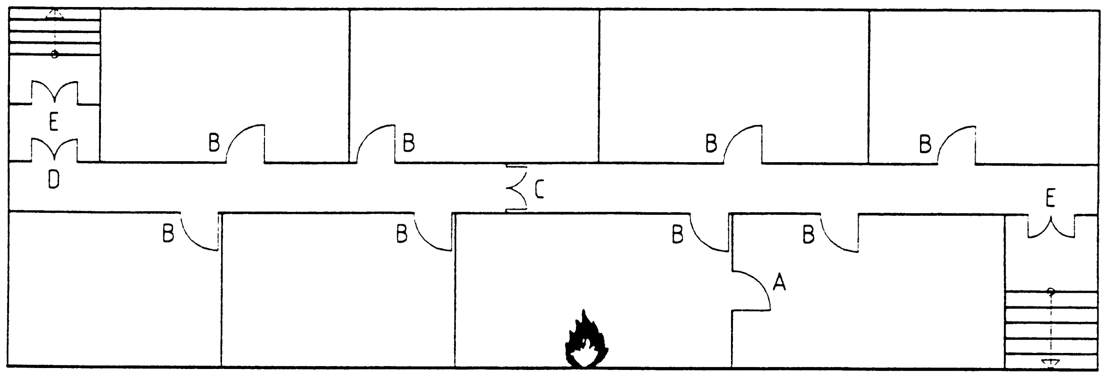
d) the illumination in the protected space;

e) the composition and nature of smoke;

f) the time needed for evacuation, etc.

Annex A shows an example of the type of calculation that may be made to determine leakage rates for a range of conditions and the resulting smoke concentration.

A concentration C – 1 % has been proposed as an acceptable level based on optical density considerations[1)].



A Compartment door

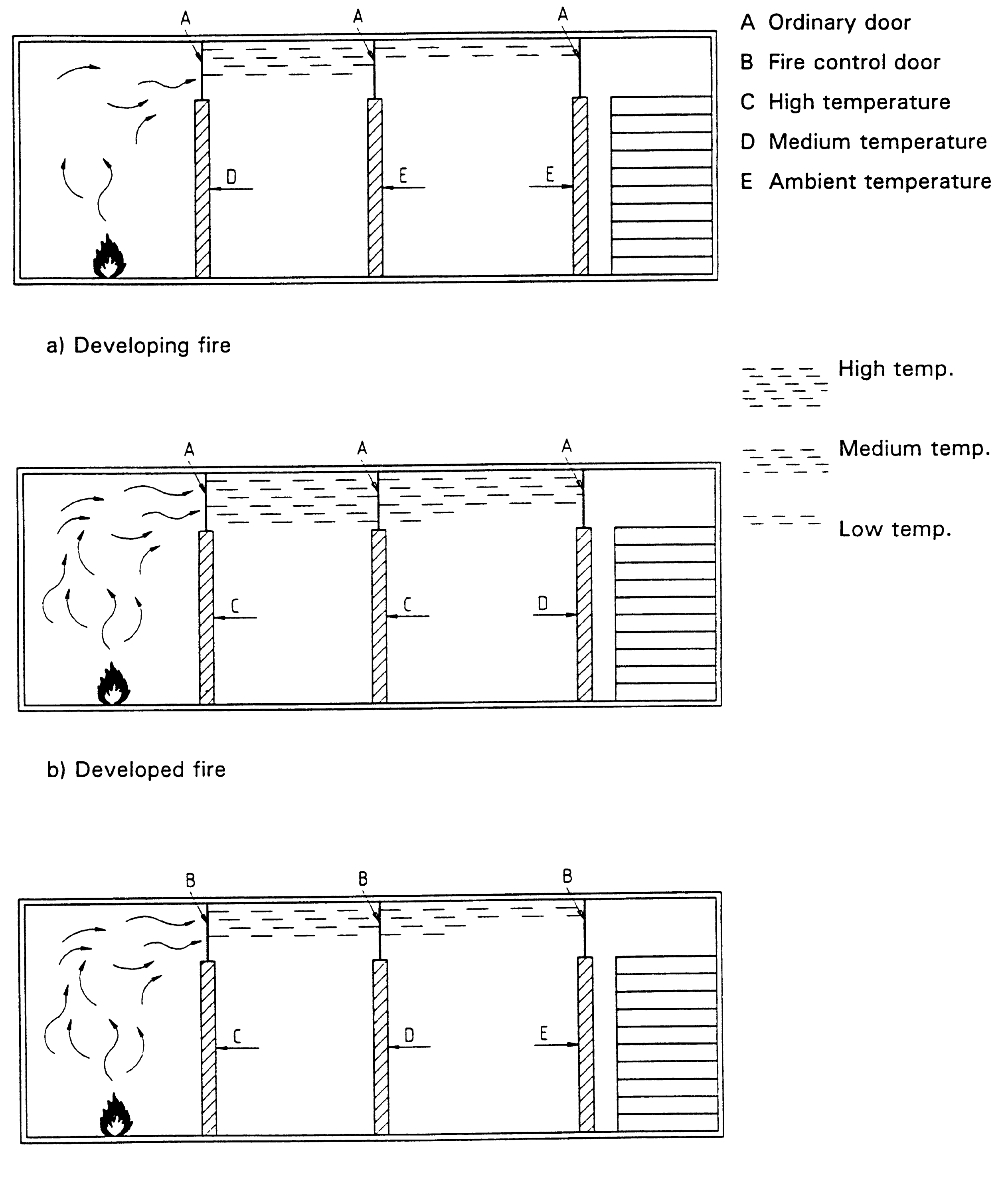
B Room/corridor door

C Corridor door

D Lobby door

Figure 1 — Examples of different doors

[1)] McGuire et al, Factors in controlling smoke in high buildings, Technical Paper No 341, Division of Building Research, National Research Council, Ottawa, Canada, 1971.



a) Developing fire

b) Developed fire

c) Developed fire

Figure 2 — Different fire scenarios

Annex A Estimation of smoke concentration

The smoke concentration "C" in the space to be protected can be determined as a function of time and the leakage rate "Q" by the following relationship:

$$C = (l - e^{-(l + n)\, t\, Q/V})/(n + l)$$

where

- Q is the leakage rate, in cubic metres per hours;
- V is the volume of space, in cubic metres;
- V_0 is the ventilation rate, in cubic metres per hours;
- t is the time, in hours;
- n $= V_0/Q$.

This relationship can also be expressed as

$$t = - V \{\ln [1 - C (n + 1)]\}/Q (n + 1)$$

If

$X = V_0/V$ (number of air changes per hour),

$Y = Q/V$ (smoke exchange rate per hour),

then

$$t = - \text{In } [1 - C (n + 1)/Y (n + 1)$$

This relationship enables times to be established for different smoke concentrations to be reached with a given smoke leakage and air change rates for a given space. Some sample values are shown in the attached table for a corridor 2 m wide, 2,5 m high and 20 m long, (giving a 100 m^3 space, with air changes varying from 2 to 10 with doors leakage rates in the range 10 m^3/h to 50 m^3/h and two values of critical smoke concentration, 1 % and 2 %, assuming complete mixing of air and smoke.

Table 1 — Time (minutes) to reach 1 % & 2 % smoke concentration

Number of air changes – X										
	Smoke concentration – 1 %					Smoke concentration – 2 %				
Y	2	4	6	8	10	2	4	6	8	10
1	49,5	216	574	∞	∞	114	703	∞	∞	∞
2	6,4	24,7	57,5	108	182	13,6	57	149	351	∞
3	2	7,4	16,5	29,8	48	4,2	16,1	38,1	74,3	133
4	1	3,2	7	12,4	19,5	1,9	6,8	15,4	28,6	47,7
5	0,5	1,7	3,6	6,3	9,9	1	3,6	7,8	14,1	22,8

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