

THE LPC DESIGN GUIDE for the FIRE PROTECTION of BUILDINGS



A Code of Practice for the Protection of Business

Each year in the UK there are losses of over £1 billion as a result of fire damage of buildings and their contents and from consequent business interruption. The principal objective of the *LPC Design Guide* is to provide those most closely concerned with the design and construction of industrial and commercial buildings with expert guidance and information which will enable them to plan and build premises which are inherently safer from the fire hazard.

Such buildings will, by virtue of their design, cope better if fire does break out. In the event that fires do occur in such premises, then those fires:

- will probably be confined to one compartment of the building, because of the *Guide's* provisions on compartmentation;
- will, for the same reason, result in less damage from flames and smoke;
- will be less severe on account of the *Guide's* emphasis on less combustible building materials;
- will be more easily extinguished and hence result in less damage from water;
- will pose less of a threat to the occupants of buildings;
- will be less likely to result in extensive interruption to business.

The *LPC Design Guide's* advice is firmly based on the risk assessment approach to fire safety issues. The aim will be to have buildings designed with a full appreciation of the occupancy risks and thus containing adequate levels of general fire resistance combined with effective limits on compartment areas. The *Guide* also gives due consideration to the control of fire spread by automatic sprinkler systems. In all cases the aim is to provide protection commensurate with the risk.

The *Guide* should be used in conjunction with other key documentation, such as the Building Regulations and documents approved thereunder, as well as with the wide range of other published standards. The *Guide* makes full reference to the provisions of such documentation.

The Background to the Design Guide

This publication had its origin in a number of different documents.

Forerunners were the *Standards of Construction* (1907) and the *Rules for the Construction of Buildings, Grades 1 and 2* (1978) of the insurers' then Fire Offices' Committee, which were themselves superseded by the Loss Prevention Council's *Code of Practice for the Construction of Buildings* (1992).

The *LPC Design Guide* was started as a looseleaf publication by the LPC in November 1996. Since then it has grown considerably and the decision was taken to change from the looseleaf format to the form of a conventional book.

Development into this present Year 2000 version was achieved via the efforts of the members of the LPC's Building Protection Steering Group, composed of members of the LPC's Risk Sciences department and representatives of the insurance industry. Their work proceeded with the encouragement and support of the Association of British Insurers and the book is evidence of the insurance industry's keen, continuing interest in the construction and maintenance of fire-safe commercial buildings.

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Fire Protection Association

Design Guide for the Fire Protection of Buildings

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Foreword

The *Design Guide for the Fire Protection of Buildings* has been prepared to allow architects and designers to take into account *business risk management issues in relation to* the fire protection of buildings. These relate mainly to protection of the business by minimising fire and smoke damage and business interruption. The *Design Guide* should be used in conjunction with the documents supporting building regulations and be regarded as being of equal importance. The financial losses occurring each year due to fire damage to buildings, contents and the consequent business interruption amount to in excess of *one billion* pounds per year. The overall objective of the *Design Guide* is to assist in reducing the financial loss by containing the fire to one compartment of the building, ensuring that when combustible materials are used in the construction of a building they do not make a significant contribution to the growth of a fire.

Emphasis is placed on the importance of early consultation between architects, *risk managers* and insurers and the value of risk assessment to fine tune the recommendations given in the *Design Guide*. Risk assessment enables appropriate, economical levels of performance to be set which result in adequate levels of fire resistance and practical limits on compartment areas. It also allows due consideration to be given to the control of fire spread by automatic sprinkler systems.

We hope that *this revised and extended Design Guide* will make an important contribution in assisting architects and others to understand the fundamental design philosophy in relation to property protection.

E.J. Denney
Executive Director
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1 Introduction

1.1 Objectives

The *Design Guide* primarily provides guidance on the principles of passive fire protection in connection with business risk management and is mainly concerned with the following:

- Contribution to fire growth;
- Fire resistance;
- Compartmentation;
- External fire spread.

The *Design Guide* extends beyond insurance considerations and presents wide-ranging recommendations for the fire protection of industrial and commercial buildings as part of the overall management of risk. It is therefore intended to assist building designers and other professional advisers in reconciling the provisions of national legislation standards with risk management objectives. It is fully supported by the insurance industry, and should be regarded as complimenting and augmenting regulatory documents.

When considering fire risk management and the application of the *Design Guide*, it is important that an effective risk assessment is conducted from which the appropriate protections can be determined. Importantly, this should be aimed not only at minimising the direct cost of fire damage to the assets of the business (buildings, plant and machinery, stock etc.), but also to preventing significant business interruption, thereby safeguarding the company's long-term trading position. The potential for environmental damage arising from an uncontrolled fire should also form a key element of the risk assessment process.

As stated, the primary objectives of the *Design Guide* are concerned with the provision of adequate passive fire protection measures, from which cost-effective protection of the assets of the business (property protection) may be obtained and business continuity achieved. It also recognises the fundamental importance of sprinklers (active protection), and where appropriate provides for reduced levels of passive protection in buildings where effective sprinkler systems are to be installed.

1.2 Scope

The *Design Guide* is applicable to:

- All new buildings, excluding dwelling houses, maisonettes and flats for which the provisions of the supporting documents to Building Regulations are considered to provide adequate property protection;
- Major extensions and the refurbishment and upgrading of existing buildings within the occupancy types covered.

The recommendations of the *Design Guide* dealing with compartmentation (Part 3) recognise that institutional and other residential buildings, including hotels, typically do not contain large undivided compartments.

In the United Kingdom the design and construction of new buildings and alterations to existing buildings are controlled by the following legislation of which the prime objective is life safety:

England and Wales: The Building Regulations;

Scotland: The Building Standards (Scotland) Regulations;

Northern Ireland: The Building Regulations (Northern Ireland).

The *Design Guide for the Fire Protection of Buildings* should be used by the building designer in conjunction with the documents supporting the appropriate regulations cited above.

This *Design Guide* adopts many of the structural fire resistance levels given in Approved Document B to the Building Regulations and provides guidance to enable these to be achieved. However, it is essential to recognise that that the approach of building regulations will often be inadequate to satisfy property and business protection objectives and the increased risk management standards required. Approved Document B states that ‘The protection of property, including the building itself, may require additional measures, and insurers will in general seek their own higher standards . . .’

Such additional measures, including increased levels of fire resistance are designed to ensure, amongst other things, that as far as possible the fire can be restricted to the compartment of origin throughout its duration. This is fundamentally different to building regulations, which are concerned with life safety and, where as a result, compartmentation may be inadequate to prevent major damage after escape from the building has been satisfactorily accomplished. This is particularly true for many large single-storey, industrial buildings in respect of which the building regulations have very little influence, and where means of escape requirements can often be satisfied without resort to any form of compartmentation.

The *Design Guide* replaced the *LPC Code of Practice for the Construction of Buildings* in November 1996, which was then withdrawn. Regular updating of the *Design Guide* is undertaken as required.

1.3 Risk management considerations

When considering building design and fire protection, it is strongly recommended that early and close liaison is established between the client, building designer and insurer. This will provide all parties with the opportunity of discussing and developing the most cost-effective passive and active fire protection measures appropriate to the specific property and business protection needs.

It is important that protection decisions are not merely based on prescriptive requirements aimed at life-safety or reduced insurance premium costs. A much broader approach taken from a wider risk management perspective in which the likely impact by fire on the assets of the business, the company's trading position and the environment is fully assessed should become standard best practice. This should include a cost benefit analysis in which due regard should be taken of the estimated financial and business exposures (estimated maximum loss). Also, protection expenditure should be correctly determined

and recognition taken of any potential tax allowances and other financial benefits which may be used to defray capital cost.

1.4 Risk assessment

The following guidance is included to provide designers with a broad view of how they may contribute to a risk assessment for property protection purposes.

The importance of carrying out such an assessment cannot be over emphasised, since the establishment of property protection objectives and criteria will enable the achievement of cost effective fire protection of the assets of the business.

It is also necessary to remember that a property protection risk assessment is more widely ranging than one carried out to establish the life safety and means of escape requirements to satisfy national legislation. In addition to the direct financial losses arising from a fire, the effect on the profitability of the business needs to be assessed. See 1.2 above.

It follows therefore that higher standards of fire protection will often be necessary to achieve acceptable property protection criteria and objectives than would be required to satisfy national building regulations.

1.4.1 RISK ASSESSMENT - THE AIMS

The purpose of the risk assessment is to identify and quantify the inherent risks and then determine the property protection objectives and criteria required to protect the residual risk to a level acceptable to the client and client's insurers.

1.4.1.1 The inherent risks

- The possibility of fire occurring due to the occupancy and/or processes intended for the building;
- The expected severity of a fire (fire load and fire development) due to the combustibility of the contents and any combustible elements of construction;
- The susceptibility of the building to fire spreading from adjacent buildings or external storage or plant;
- The susceptibility of the building to arson or malicious damage;
- Presence (or lack) of early warning systems;
- The insured values at risk;
- Contribution of the premises to the profitability of the business.

1.4.1.2 The property protection objectives and criteria

These should include consideration of the following:

- The overall fire resistance for the proposed structure;
- The sub-division of the building into fire-resisting compartments to limit the size of the direct monetary loss and the effect on the business;
- Protection of hazardous processes or critical business equipment;
- The availability of public fire brigade and water supplies;
- Automatic fire detection and protection systems;
- Lightning protection systems;

- Security of the premises against intruders and any potential threats of arson and malicious ignition.

1.4.2 THE RISK ASSESSMENT PROCESS

Insurers will identify with the client, the component parts of the business operation and the effect that loss of each will have, not only in direct financial loss terms but also on the profitability of the business. The loss of a vital piece of machinery or plant, e.g. effluent handling plant, may cause cessation of production, even though in itself, it may not constitute a fire hazard but will therefore require protection.

The following is a broad summary of the aspects of the business that will need consideration:

Occupancy

- Usage and manufacturing processes involved;
- Fire load arising from the occupancy, e.g. type of goods stored and storage heights proposed;
- Premises layout, e.g. proximity of production storage;
- Hazardous processes;
- Critical business processes, equipment and/or components and stock, e.g. electronic equipment, high value components etc.

Estimated values at risk

- Buildings;
- Contents excluding stock;
- Stock;
- Business interruption exposure.

Surroundings

- Exposure from other premises;
- Type of area, e.g. residential/industrial.

Fire protection

- Distance from the nearest public fire brigade;
- Availability of adequate water supplies for fire fighting;
- Fire detection/protection systems required to augment passive fire protection.

Security

Site security requirements.

1.4.2.1 Risk assessment - application of objectives and criteria

The property protection objectives and criteria will take account of the basic strategy of the *Design Guide* as explained in 1.4 below. The levels of fire resistance and protection required to satisfy the objectives and criteria can then be fine tuned by reference to the succeeding parts of this *Design Guide* in order to achieve cost effective fire protection of the assets of the business.

1.5 Basic strategy

The principles of the recommendations contained within this *Design Guide* are:

- (a) wherever practicable, to contain the spread of fire and smoke to a single compartment to minimise financial loss;
- (b) to prevent premature structural collapse of buildings and, with regard to high-rise buildings, minimise as far as practical progressive collapse;
- (c) to prevent the spread of fire into or from adjoining premises;
- (d) to identify levels of fire resistance appropriate to various occupancies;
- (e) to consider where active fire protection measures may complement passive fire protection measures.

Tables 2.1 and 2.2 in Part 2 in the *Design Guide* give recommendations on the levels of fire resistance required. The specified levels are based upon published data on typical fire loads and established time equivalency formulae, modified with appropriate factors to take into account difficulty of fire fighting, building height, rate of heat release etc. In addition, the experience gained from actual fires has been used to identify areas where increased levels of protection are required.

The limits on fire compartment size specified in Table 2.3 of Part 2 of this *Design Guide* take into account the likely fire load, the need to limit the area directly damaged by fire or smoke and, overall, to contain the costs of reinstatement. **The floor areas given in this *Design Guide* are for guidance, and a risk assessment to establish acceptable values should be carried out in each specific case.**

The acceptance of any deviation from the recommendations in this *Design Guide* is a matter for the judgement of individual insurers, who are likely to take into account other risk factors such as the values at risk, hazards arising from the occupancy, fire load (or rate of heat release up to a ventilation controlled fire) and the benefit of fixed active fire protection.

1.6 Fire safety engineering

The recommendations of the *Design Guide for the Fire Protection of Buildings* tend to follow a similar approach given in guidance documents to building regulations. Where fire safety engineering techniques are to be extensively employed in the design of a building, e.g. for complex buildings or buildings of novel design, it is essential that insurers are consulted at the earliest opportunity and are invited to participate during the Qualitative Design Review (QDR) (see 3.1.3.20 of Part 3 of this *Design Guide*).

1.7 Protection against lightning

Lightning has long been recognised as a peril to be considered and accounted for in building design. The building designer should ensure that adequate provision is provided with respect to lightning protection. Some areas of the UK are more prone to lightning strikes than others.

Climate change may have potential impacts on the UK building stock in the near and medium-term future. The effects of climate change are expected to lead to an increase in lightning strikes (with the forecast increase in storms, both in frequency and severity). This aspect is now of greater significance given the trend towards higher multi-storey buildings.

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2 General principles

2.1 Introduction

2.1.1 OBJECTIVES

This Part of the *Design Guide* represents the essential core of the document in which the general principles of passive and, where appropriate, active fire protections measures are established. Detailed guidance on how to achieve the levels of fire performance, which may be required, is contained in the subsequent Parts of the *Design Guide* and in the various documents referenced.

Definitions of terms used are given in succeeding parts of this *Design Guide*.

2.1.2 SCOPE

The levels of protection recommended apply to all new buildings, excluding single occupancy dwelling houses, maisonettes and flats, and should also be considered for major extensions to and the refurbishment and upgrading of existing buildings.

The *Design Guide* assumes that the design of the building complies with the relevant supporting documents to the appropriate building regulations. Where those supporting documents specify a higher performance requirement, this must take precedence over the recommendations of the *Design Guide*.

To achieve the basic strategy as described in Part 1.5 and to satisfy risk management objectives, careful consideration should be given to the following key factors at the design stage of the project:

- contribution to fire growth;
- fire resistance – structural;
- fire resistance – compartmentation;
- external fire spread.

2.2 Contribution to fire growth

The main objective in relation to all elements of construction, including roofs, is that they should not significantly contribute to the growth and spread of fire, either internally or externally. In this respect it is important that the complete building design is analysed to ensure that as a result of its behaviour in a fire no element of fire protection will be compromised.

This is equally applicable to internal non-structural features such as linings, ceilings and partitioning systems, thereby reducing the potential fire spread and growth.

This should be achieved by use of materials which are:

- (a) non-combustible or of limited combustibility (see Appendix 3A1 of Part 3) or, if timber, they comply with the fire resistance requirements given in this *Design Guide* (see Tables 2.1 and 2.2);
- (b) Loss Prevention Certification Board (LPCB) approved products which include combustible materials and have been tested and satisfy the requirements in accordance with LPS 1181 and have thereby been shown not to make a significant contribution to fire growth;

Table 2.1. Minimum fire resistance for elements of construction for multi-storey buildings.

Note: This table does not apply to compartment walls or floors between different occupancy types (purpose groups) or walls between different occupancies (buildings in different ownerships). Recommendations for fire resistance for these applications, including their supporting structure, are given in Table 2.2.

OCCUPANCY TYPE*	Minimum fire resistance (min)			
	Up to 5m high	5m to 20m high	20m to 30m high	More than 30m high
1a Residential (domestic) Flat/maisonette	Not covered in this <i>Design Guide</i>			
1b/1c Residential Dwelling house				
2a/2b Residential Institutional and other residential including hotels	30	60	90	120
3 Office not sprinklered sprinklered	30 30	60 30	not recommended ² 60	not permitted 120 ¹
4 Shop and commercial not sprinklered sprinklered	60 30	90 60	not recommended ² 60	not permitted 120 ¹
5 Assembly and recreation not sprinklered sprinklered	60 30	60 60	90 60	not permitted 120 ¹
6a/6b Industrial-all hazard groups⁴ not sprinklered sprinklered	60 30	90 60	not recommended ² 90	not permitted 120 ¹
7a Storage and other non-residential³ not sprinklered sprinklered	60 30	90 60	not recommended ² 90	not permitted 120 ¹
7b Car park for light vehicles	Not covered in this <i>Design Guide</i>			

* More information on occupancy types is given in Appendix 2A of this Part. This is based on the purpose groups given in Table D1 of Approved Document B, The Building Regulations 1991.

¹ Reduced to 90min for elements not forming part of the structural frame.

² In individual circumstances consideration may be given by insurers to increased fire resistance in place of sprinkler protection. Assessment of risk should be carried out in consultation with the insurer.

³ Extends to other occupancies where the risk assessment reveals a high fire load arising from storage incidental to the main occupancy type.

⁴ Refer to Notes 3 and 4 of Table 2.2.

- (c) products incorporating finishes conforming with Class 0 (as defined in the supporting documents to building regulations) on non-combustible cores/substrates (this requirement does not apply to columns and beams or portal frames).

Note: Further guidance on the design of roofs is given in Parts 5 and 6 of this *Design Guide* to assist in the achievement of acceptable performance.

2.3 Fire resistance - structure

In addition to dealing with contribution to fire growth, fundamental consideration should be given to the need for the correct level of fire resistance to be incorporated in the overall design of buildings. The level of fire resistance appropriate to the building under consideration should be determined by a risk assessment (see Part 1.4).

Unless otherwise stated, fire resistance requirements are related to integrity, insulation and – for loadbearing elements – loadbearing capacity also.

Minimum recommendations in respect of single-storey and multi-storey buildings are as follows:

(a) *Single-Storey Buildings*

- the recommendations relative to fire resistance for compartmentation given in Part 3, Table 3.1 of this *Design Guide*;
- the recommendations contained in Part 5: External exposure to fire.

Except for the above criteria, there are no minimum recommendations concerning the fire resistance of single-storey buildings and protection decisions should be based entirely on the outcome of a risk assessment.

(b) *Multi-Storey Buildings*

Table 2.1 gives minimum fire resistance times for the following elements of construction (in seven broad occupancy types):

- structural frame, beams and columns;
- loadbearing walls;
- floors;
- the recommendations contained in Part 5: External exposure to fire.

Note: The recommended fire resistance for shaft enclosures is equally applicable to non-loadbearing and loadbearing constructions.

For basements, unless otherwise stated in other sections of the *Design Guide*, the guidance in the appropriate supporting documents to building regulations should be followed.

Further guidance on levels of fire protection relating to various types of occupancy and features of construction is given in Parts 5, 6 and 7 of this *Design Guide*.

2.4 Fire resistance - compartmentation

2.4.1 OBJECTIVES

A principal objective of compartmentation in respect to this *Design Guide* is to prevent the spread of fire between adjoining buildings. Similar objectives apply to the subdivision of individual buildings into two or more fire compartments

either horizontally or vertically. The need for subdivision of individual buildings to give adequate property and business protection will depend on an assessment of a number of factors, including values at risk, the hazard arising from the occupancy, anticipated brigade response and, in the event of a fire, potential impact on the trading operation of the occupier (business interruption).

Compartmentation for means of escape is not considered in this *Design Guide* and reference should be made to documents supporting building regulations.

Note: Individual compartments may contain high hazard processes or high value equipment and Appendix 3C gives guidance on the approach which should be taken to protect such exposures.

2.4.2 GENERAL FEATURES

When considering vertical and/or horizontal compartmentation, the following principles should be followed:

- (a) For a compartment wall, in addition to the specification of structural elements of adequate fire resistance, it should be ensured that in practice the spread of fire will be prevented. Common faults are:
 - poor workmanship, especially inadequate attention to fire stopping (this can be avoided by using only approved and trained installers);
 - inadequate design, allowing a fire to spread over or around a fire wall;
 - insufficient attention to connected structures not protected for a similar period of fire resistance, leading to premature collapse of a fire wall;
 - inadequate design for provision of fire doors and shutters.

Similar considerations should be applied to the design of compartment floors.

- (b) In relation to compartment walls, due regard should be paid to any external exposure hazard, which may be reduced by ensuring that the roof and external wall to a prescribed distance on each side of the wall is of fire-resisting design.
- (c) Fire compartmentation systems should be validated by documented evidence that the required fire performance standard has been achieved under test conditions to approved British Standards or LPC procedures.
- (d) Regardless of the size of a compartment, separation in accordance with the recommendations of Table 2.2 should always be considered between:
 - manufacturing areas and warehousing facilities;
 - retail areas and storage/goods delivery accommodation.
- (e) Attention should always be given to the fire containment of hazardous processes or other identified features of risk (see Appendix 3C). The degree of fire separation should be determined according to the assessed level of hazard or risk, but should not be less than 60min fire resistance.
- (f) All framework and other supporting structures (as defined for Table 2.1) should be of or provided with a fire-resistance level consistent with the compartmentation design.

- (g) Subject to compliance with the fire-resistance requirements given in 2.4.3 and to the compartmentation requirements for floor openings given in Part 3, there is no restriction on the number of storeys which may be contained in one occupancy type.
- (h) All openings in compartment walls and floors should be protected to the appropriate fire resistance level specified in Part 3 of this *Design Guide*.
- (i) Where compartment walls and floors adjoin other elements of construction any gaps must be fire stopped to a fire resistance equal to that of the compartment wall or floor. (See Appendix 3D6 and 4-42.)
- (j) Cavity barriers of 30min integrity and 30min insulation and spaced at not more than 20m in each direction should be fitted to sub-divide the ceiling and other voids. Care should be taken to ensure that the cavity barrier can accommodate deflection of adjoining features of construction under fire conditions. (See Appendix 3D5 and 4-38.)
- (k) In occupancies where elements of construction may be subject to significant wear and tear, the robustness of the compartmentation should also be a consideration when selecting suitable building materials.

2.4.3 RECOMMENDATIONS

Tables 2.2 and 2.3 provide guidance for the fire resistance of compartment walls and compartment floors, and maximum compartment sizes. Table 2.2 specifies the level of fire resistance recommended for each occupancy type and applies to:

- (a) separation of adjoining buildings in different ownership;
- (b) separation of different occupancies;
- (c) separation of different occupancy types regardless of the size of the compartment;
- (d) restriction of compartment size within same occupancy types (see Table 2.3)

Where there are different occupancy types adjoining each other, the higher level of fire resistance should be selected (fire resistance is defined in 3.1.3). These tables and their associated general features outlined above should all be considered during the risk assessment.

Note: Part 3 of this *Design Guide* gives more detailed guidance on compartmentation.

Insurers may recommend additional protective measures in buildings which incorporate combustible insulated panels or linings not conforming to the requirements of LPS 1181, issue 2 or LPS 1208. Such measures may include, amongst others, reduced compartment sizes and/or increased fire resistance of compartment walls/floors, or sprinkler protection.

In buildings of more than one storey containing one occupancy type (other than types 4, 6, 7), fire resistance as specified in Table 2.1 will generally be applicable.

Table 2.2. Compartmentation-recommended fire resistance.

OCCUPANCY TYPE*	Minimum fire resistance (min)	
	Not sprinklered (or sprinklered on one side only or walls between different occupancies whether sprinklered or not)	Sprinklered ¹
1a Residential (domestic) Flat/maisonette	Not covered in this <i>Design Guide</i>	
1b/1c Residential Dwelling house		
2a/2b Residential Institutional and other residential including hotels ⁵	120	90
3 Office⁵	120	90
4a Shop and commercial	120	90
4b Retail warehouse and superstore^{2, 4}	240	120
5 Assembly and recreation⁵	120	90
6a Industrial - Ordinary hazard groups I and II^{3, 4}	120	90
6b Industrial - Ordinary hazard groups III and IIIs and High hazard process^{3, 4}	240	120
7a Storage and other non-residential	240	120
7b Car park for light vehicles	Not covered in this <i>Design Guide</i>	

Table 2.2

This table specifies the level of fire resistance recommended to comply with the provisions of 2.4.3. It should be noted that the compartmentation requirements detailed in the supporting documents to building regulations are different.

* More information on occupancy types is given in Appendix 2A of this Part. This is based on the purpose groups given in Table D1 of Approved Document B, The Building Regulations 1991.

¹ The reduced level of fire resistance is permitted where sprinkler protection is installed both sides of the compartment wall or floor. This must be designed and installed in accordance with the *LPC Rules for Automatic Sprinkler Installations* (incorporating BS 5306: Part 2).

This concession should not be permitted where control of the sprinkler protection either side of a compartment wall is in different ownership or rests with a different occupier.

² 'Retail warehouse and superstore' is not specifically defined, but refers to buildings containing storage arrangements similar to those encountered in storage occupancies.

³ For details of hazard groups see Tables 3 and 4, BS 5306: Part 2: 1990, *Specification for sprinkler systems*.

⁴ These additional subdivisions in occupancy types depart from those given in Appendix 2A, but are considered necessary for property and business protection aspects.

⁵ With respect to occupancy types 2, 3, and 5, less than 20m high, compartment walls provided to comply with the floor areas specified in Table 2.3 should have fire resistance not less than that specified for elements of construction in Table 2.1.

2.5 Compartment floor areas

The specification of maximum compartment size will depend on the assessment of a number of factors including values at risk, the hazard arising from the occupancy and the potential impact on the trading operation of the occupier (business interruption).

Table 2.3

Table 2.2 details the fire resistance levels necessary to satisfy the compartment floor areas specified. Further subdivisions are not required by this *Design Guide* unless the area is considered to be high risk or high value (see Appendix 3C).

Table 2.3. Guide to maximum recommended compartment floor areas in single and multi-storey buildings.

OCCUPANCY TYPE*	Floor area of any one compartment (m ²)	
	Not sprinklered	Sprinklered
1a Residential (domestic) Flat/maisonette	Not covered in this <i>Design Guide</i>	
1b/1c Residential Dwelling house		
2a/2b Residential Institutional and other residential including hotels	No recommendation other than hotels should be limited to 4000	No recommendation other than hotels should be limited to 8000
3 Office	4000	No recommendation
4 Shop and commercial	2000**/2000†	4000**/8000†
5 Assembly and recreation	2000**/4000	4000**/8000
6a/6b Industrial - all hazard groups¹	7000†	14000†
7a Storage and other non-residential^{1, 2}	4000†	8000†
7b Car park for light vehicles	Not covered in this <i>Design Guide</i>	

* More information on occupancy types is given in Appendix 2A of this Part. This is based on the purpose groups given in Table D1 of Approved Document B, The Building Regulations 1991.

¹ There may be specific limitations on floor area under other legislation, for example in respect of storage of LPG and certain chemicals.

² Extends to other occupancies where the risk assessment reveals a high fire load arising from storage incidental to the main occupancy type.

** Limits for multi-storey buildings.

† Regardless of the size of a compartment, separation in accordance with the recommendations of Table 2.2 should always be considered between:

- manufacturing areas and warehousing facilities;
- retail areas and storage/goods delivery accommodation.

The above table provides guidance on compartment sizes in various occupancies, which should be ratified with individual insurers. Buildings of complex design, for example, atrium buildings or high bay warehouses, will need special attention using fire engineering solutions. The table is not necessarily applicable to compartmenting areas of special risk or high value where additional subdivision may be required. (See Appendix 3C.)

2.6 External fire spread

An assessment should always be made of the possibility of external fire spread:

- between floors of a building;
- from other buildings/installations in close proximity.

Precautions would include the provision of fire-resisting external construction or general sprinkler protection, where indicated as necessary by risk assessment,

and reference should be made to Part 3, sections 3.3, 3.4, Appendix 3D and Part 5 for detailed guidance on the measures to be adopted where compartmentation may be compromised.

2.7 Sprinklers

Where reduced levels of passive fire protection are to be applied having regard to the presence of sprinklers, it is of paramount importance that the entire building under consideration be installed with sprinkler protection, designed to the hazards of the occupancy, and that such protection is maintained in effective working order at all times.

In particular, the following recommendations should apply:

- Sprinkler protection should be designed and installed to the *LPC Rules for Automatic Sprinkler Installations* (incorporating BS 5306: Part 2). Particular attention should always be given to ensuring continuity of available sprinkler protection for periods when maintenance is being undertaken, for example, via suitable dual water supply and valve arrangements.
- Duplicate or superior supplies (as defined in BS 5306:Part 2) should be provided for all systems and should be thoroughly checked to ensure their continued availability and adequacy at all times.
- Systems should be installed and maintained by a company certified by the Loss Prevention Certification Board (LPCB) to LPS 1048 and LPS 1050 as appropriate.
- Sprinkler installation(s) should be provided with remote alarm signalling linked to a central monitoring station which complies with the requirements of BS 5979 (1993) and/or which is listed as approved by the Loss Prevention Certification Board.
- All sprinkler control valves and any subsidiary stop valves should be fitted with anti-tamper alarms providing a remote warning of any unauthorised system shutdown.
- Adequate security measures must be adopted to ensure that access to the water supplies, pumps and all valves is restricted to authorised personnel. The risk of third party interference should not be overlooked and consideration must be given to the provision of appropriate security protection.

2.8 Smoke venting

In addition to structural fire protection measures, the results of the risk assessment for non-sprinklered buildings may identify the need for consideration to be given to smoke venting, either by a scheme of purpose-designed roof vents or by modifying the building air conditioning or ventilation equipment in appropriate circumstances.

The main *Design Guide* for single-storey industrial buildings is published by the Smoke Ventilation Association. Calculations assume a steady state fire condition and a fire size is selected which is appropriate to the hazard. Where the exact content of the building is not known, a heat output of 500kW/m² is used.

The main objectives of such a venting scheme in respect to property protection are to control smoke damage and to assist in achieving safe and effective control of the fire at the earliest opportunity by the fire brigade.

2.9 Automatic fire detection

Automatic fire detection systems provide early detection of outbreak of fire and subject to a prompt, organised response can enhance protection of the property and business risks. This will vary depending on the degree of fire load, inception potential, concentration of value and possibility of business interruption. These factors, together with the availability of water supplies and the proximity of the fire brigade, should be taken into consideration when assessing the value and effectiveness of automatic fire detection.

Systems should be designed and installed in accordance with an appropriate installation standard (for example BS 5839: Part 1: 1988 and LPC Rules RLS 1) by a company certified by LPCB to LPS 1014.

2.10 Fire mains and brigade access

Reference should be made to the supporting documents to building regulations which deal with the subjects of fire mains and brigade vehicle access. Where fire mains are installed, they should comply with BS 5306: Part 1.

In addition to the need for internal fire mains as covered in the supporting documents to building regulations, it may be necessary, arising from an assessment of the risk, for consideration to be given to the installation of an on-site external hydrant system, connected to an appropriate water supply, to facilitate early and effective firefighting operations.

2.11 Inspection and maintenance

In order for passive and active fire protections measures to perform the designed function, it is of paramount importance that correct maintenance is conducted. The designer can make a valuable contribution to the continuing loss prevention process by providing the building owner with a comprehensive manual covering all the systems installed in the building, together with a detailed maintenance plan.

Active protections such as sprinklers, automatic fire detection, smoke venting and intruder alarms are usually the first to receive consideration when maintenance schedules are drawn up. However, protections such as fire doors or automatic dampers installed to maintain the integrity of compartment walls and the passive protection provided by cavity barriers in roofs, floors and other hidden voids are equally important from the maintenance point of view. Fire stopping at the junctions of elements of structures or where cables and other services penetrate floors are further examples of protections requiring maintenance.

Regular inspection and maintenance of electrical systems and other building services by qualified contractors has an obvious benefit for the overall safety of buildings.

After any intrusive maintenance work it is important that all fire protection systems are reinstated and subsequently inspected and approved by suitable trained personnel.

2.12 Certified products and services

To comply with the recommendations of this *Design Guide* all fire protection products shall be certified by an accredited certification body, such as the Loss Prevention Certification Board or the British Board of Agrément (or other European technical approval bodies, subject to compliance with the requirements given in this *Design Guide*). It is vital that only certified products are specified by building designers, property developers and other specifiers. Other third party certification schemes for satisfying the recommendations given in this *Design Guide* are also allowed subject to the following conditions:

- (a) they are accredited by UKAS (or equivalent European organisation);
- (b) they undertake assessments to the appropriate part of ISO 9000;
- (c) they include in all cases as part of the assessment, product audits;
- (d) they include an evaluation of durability and longevity in their appraisal, appropriate to the context of use.

Certification of all fixed fire protection systems should be carried out to appropriate LPS standards, with ongoing inspection, test and maintenance to prescribed standards/schedules at specified intervals.

Information on approved products are given in the Loss Prevention Certification Board's *List of Approved Fire and Security Products and Services*.

All building systems should be installed by properly trained and, where appropriate, certified installers to ensure that the required level of performance will be achieved. Installers of passive fire protection products shall be certified in accordance with LPS 1231*. Care should be taken to ensure that the product or system selected is appropriate for the intended use and will be within the scope of the certification.

2.13 References

British Standards

BS EN 671-1:1985: *Hose reels with semi-rigid hose*.

BS 5041: *Fire hydrant systems equipment*; Parts 1-5.

BS 5306: *Fire extinguishing installations and equipment on premises, Hydrant systems*; Part 1:1976 (1988): *Hose reels and foam inlets*.

BS 5306: *Fire extinguishing installations and equipment on premises*, Part 2:1990: *Specification for sprinkler systems*.

BS 5839: *Fire detection and alarm systems for buildings*; Part 1:1988: *Code of Practice for system design, installation and servicing*.

BS DD240: *Fire safety engineering in buildings*.

Loss Prevention Council

List of Approved Fire and Security Products and Services (annual), Loss Prevention Certification Board.

* Scheme currently being prepared.

LPC Rules for automatic fire detection and alarm installations for the protection of property, Loss Prevention Council, 1991.

LPC Rules for automatic sprinkler installations, The Loss Prevention Council, 1990.

Loss Prevention Standards

LPS 1014, *Requirements for certification of fire detection and alarm system firms*.

LPS 1020, *Requirements for remote centres for fire alarm systems*.

LPS 1048, *Requirements for certificated sprinkler installers, supervising bodies and supervised installers*.

LPS 1050, *Requirements for automatic sprinkler system servicing and maintenance firms*.

LPS 1181, issue 2, *Requirements and tests for wall and ceiling lining materials and composite cladding materials*.

LPS 1208, *Fire performance requirements for metal-faced fire-resisting insulated panels*.

LPS 1231 *Requirements for the certification of installers of passive fire protection products*.*

Official documents

Department of the Environment and The Welsh Office, The Building Regulations 1991, *Approved Document B, Fire Safety*, HMSO.

Department of the Environment for Northern Ireland, The Building Regulations (Northern Ireland) 1994, *Technical Booklet E, Fire Safety*, HMSO.

Department of the Environment, Republic of Ireland, Building Regulations 1991, *Technical Guidance Document B*.

The Scottish Office, The Building Standards (Scotland) Regulations 1990, *Technical Standards*.

Other standards

ISO TR 10158 *Principles and rationale underlying calculation methods in relation to fire resistance of structural elements*.

Trade association publications

ASFPCM, *Fire protection for structural steel in buildings*, 1988.

HEVAC; Smoke Ventilation Association, *Guidance for the design of smoke ventilation for single-storey industrial buildings including those with mezzanine floors and high racked storage warehouses*.

TRADA, *Timber frame construction*, 1994.

Other guidance documents

Fire Research Technical Paper No 7, *Investigations into the flow of hot gases in roof venting*, 1963.

BRE Report, *The interaction of sprinklers and roof venting in industrial buildings: The current knowledge*, 1984.

CIB WG14 *Design Guide - Structural Fire Safety*, *Fire Safety Journal*, vol 10-2.

* In preparation

Appendix 2A Purpose groups specified in Approved Document B, The Building Regulations 1991

TITLE	GROUP	PURPOSE FOR WHICH BUILDING OR COMPARTMENT OF BUILDING IS INTENDED TO BE USED
Residential* (dwelling)	1(a)	Flat or maisonette.
	1(b)	Dwelling house which contains a habitable storey with a floor level which is more than 4.5m above ground level.
	1(c)	Dwelling house which does not contain a habitable storey with a floor level which is more than 4.5m above ground level.
Residential (institutional)	2(a)	Hospital, nursing home, home for old people or for children, school or other similar establishment used as living accommodation or for the treatment, care or maintenance of people suffering from illness or mental or physical disability or handicap, place of detention where such people sleep on the premises.
(Other)	2(b)	Hotel, boarding house, residential college, hall of residence, hostel, and any other residential purpose not described above.
Office	3	Offices or premises used for the purpose of administration, clerical work (including writing, book keeping, sorting papers, filing, typing, duplication, machine calculating, drawing and the editorial preparation of matter for publication, police and fire service work), handling money (including banking and building society work), and communications (including postal, telegraph and radio communications) or radio, television, film, audio or video recording, or performance (not open to the public) and their control.
Shop and Commercial	4	Shops or premises used for a retail trade or business (including the sale to members of the public of food or drink for immediate consumption and retail by auction, self-selection and over-the-counter wholesale trading, the business of lending books or periodicals for gain and the business of a barber or hairdresser) and premises to which the public is invited to deliver or collect goods in connection with their hire, repair or other treatment, or (except in the case of repair of motor vehicles) where they themselves may carry out such repairs or other treatments.
Assembly and Recreation	5	Place of assembly, entertainment or recreation; including bingo halls, broadcasting, recording and film studios open to the public, casinos, dance halls; entertainment, conference, exhibition and leisure centres; funfairs and amusement arcades; museums and art galleries; non-residential clubs, theatres, cinemas and concert halls; educational establishments, dancing schools, gymnasia, swimming pool buildings, riding schools, skating rinks, sports pavilions, sports stadia; law courts; churches and other buildings of worship, crematoria; libraries open to the public, non-residential day centres, clinics, health centres and surgeries; passenger stations and termini for air, rail, road or sea travel; public toilets; zoos and menageries.
Industrial	6	Factories and other premises used for the manufacturing, altering, repairing, cleaning, washing, breaking-up, adapting or processing any article; generating power or slaughtering livestock.
Storage and other non- residential†	7(a)	Place for the storage or deposit of goods or materials (other than described under 7(b)) and any building not within any of the purpose groups 1 to 6.
	7(b)	Car parks designed to admit and accommodate only cars, motorcycles and passenger or light goods vehicles weighing no more than 2500kg gross.

*Includes any surgeries, consulting rooms, offices or other accommodation, not exceeding 50m² in total, forming part of a dwelling and used by an occupant of the dwelling in a professional or business capacity.

†A detached garage not more than 40m² in area is included in purpose group 1(c); as is a detached open carport if not more than 40m², or a detached building which consists of a garage and open carport where neither the garage nor open carport exceeds 40m² in area.

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3 Compartmentation

3.1 Introduction to compartmentation

3.1.1 SCOPE

The objectives of compartmentation, as described in Part 2 of this *Design Guide*, are to prevent the spread of fire within or between buildings and to improve the level of asset and business interruption protection. The extent of compartmentation required can only generally be decided after a risk assessment has been completed as described in 1.3.

Close consultation with insurers in connection with the risk assessment as emphasised in Part 1 of this *Design Guide* will assist the identification of all relevant aspects of compartmentation.

This Part of the *Design Guide* addresses the requirements for the elements of construction used for containing fire to within the compartment of origin. It considers the following inter-related aspects:

- the functional requirements for compartment walls and compartment floors, the structural frame, and the interaction between these elements;
- the performance requirements needed where elements interface with services or closures for openings to prevent compartmentation being prematurely breached;
- those sections of the structural frame (i.e. all loadbearing elements) of the building, failure of which could compromise compartmentation and allow spread of fire;
- the general design of the complete building to reduce the risk of fire development and spread as a result of non-sympathetic distortions

The risk assessment will identify the need for adequate compartmentation and this together with the need to review the building as an entity (for guidance see Appendix 3D) will ensure that effective compartmentation is provided.

Details of the construction of the structural frame, floors or walls or the performance of doors, cavity barriers, services or fire stopping will be included in Part 6 of the *Design Guide*. Part 3 does identify the requirements that such elements may need to meet and recommends some design restrictions on the elements to be penetrated.

Compartmentation requirements specified in some cases are in excess of those needed for building regulations purposes, both in terms of levels of fire resistance and in certain cases, compartment sizes. The protection of property and business assets dictates that higher standards of fire protection are sometimes required than are specified in building regulations.

Within any compartment further subdivision may be required to meet operational or insurers' recommendations. The need for such sub-division will be identified in the outcome of the risk assessment and should be provided in accordance with the guidance given in Appendix 3C.

The designer must ensure that the building also meets the relevant building regulations for life safety.

3.1.2 PRINCIPLES OF COMPARTMENTATION

This Part of the *Design Guide* specifies the functional recommendations that should ensure the fire integrity of compartments, and includes guidance with respect to the interaction between walls, floors, structural framing and roofs, the interface with service and other penetrations, fire door and shutter assemblies and stairway enclosures.

3.1.2.1 *Compartmentation - fire resistance performance*

This Part of the *Design Guide* quantifies the performance of the walls and floors, identifying where the performance of some walls and floors is more critical, for example between separate occupancies, and where performance can be relaxed because the implications of failure are less great. It uses the basic fire resistance ratings given in Tables 2.1 and 2.2 which are summarised in Table 3.1. This Part needs to be read in conjunction with Part 6 of the *Design Guide* which considers each element in turn and give basic guidance on the critical design, construction issues and, where appropriate, lists of those constructions that are capable of satisfying the requirements.

3.1.2.2 *Compartmentation - integrity and insulation*

The integrity and insulation of compartmentation can be compromised by the behaviour of adjacent elements of construction. It is vital where any elements, which may have lower or non-existent fire resistance, adjoin or are adjacent to the compartment walls and floors that adequate fire protection is provided to each element involved. Guidance is given in sections 3.2, 3.3 and 3.4 on the methods of approaching the potential problems associated with the various elements and the interaction between them.

The potential for fire spread externally via the roof, as well as between the top of elements forming the compartmentation and the underside of the roof, is also considered and guidance given to eliminate or reduce the risk of a fire bypassing the wall. The potential behaviour of roofs in fire may need to be improved and in particular certain constructional details such as eaves, junctions at rooflights and adequate protection of combustible materials will require special attention.

Regardless of how well an individual element is designed and constructed and even, to some extent, how it is installed, prevention of fire spread can only be effective if the building itself behaves in a predictable manner. The interaction between the elements should not cause elements exposed to a fire to move and produce large gaps or to collapse prematurely. It is recommended that before a building is accepted as satisfying the compartmentation requirements an analysis is made of the behaviour of the building as a whole. Guidance is given in Appendix 3D.

3.1.2.3 *Prevention of smoke spread*

A number of recommendations are made in this *Design Guide* for the need adequately to control and prevent the leakage of smoke but in the absence of suitable test methods this is done by giving appropriate guidance. However, with respect to door assemblies and shutters, the use of BS 476: Part 31.1 is specified to give quantifiable leakage not exceeding $3\text{m}^3/\text{h.m}$.

It is not possible to quantify the smoke tightness of compartment walls or floors, as standard test procedure only exists for fire-resisting door assemblies. However, as smoke damage is a major contributor to fire losses, the qualitative smoke tightness of the elements and methods of jointing are considered for other methods of construction. Elements of construction that under fire test conditions generate large quantities of smoke on the unexposed face may not be regarded as meeting the recommendations of this *Design Guide*. For permeable materials, such as fibrous or open cell foams, their surfaces should be sealed by an impervious coating to prevent cold smoke leakage.

Table 3.1 Compartment walls and floors - recommended fire resistance levels

Separating function (see 3.2.2.1)	Appropriate table from Part 2 of <i>Design Guide</i> for specified fire resistance		Walls/floor openings - fire resistance (% of value given in Table 2.1 or 2.2)	
	Structural frame	Walls/floor ⁴	Integrity	Insulation
COMPARTMENT WALLS				
Different occupancies and/or ownership	2.2	2.2	No openings allowed except as stated in 3.2.2.1 (i)	
Between different occupancy types	2.2	2.2	100%	100% ¹ and ²
Restriction on compartment sizes	2.2	2.2	100%	100% ¹ and ²
High hazard or high value at risk (Appendix 3C)	2.1 or 2.2 ³	60min minimum	100%	100%
COMPARTMENT FLOORS				
Different occupancies or occupancy type	2.2	2.2	100%	100%
Floors in same occupancy type	2.1	2.1	100% ⁵	100% ⁵
High hazards or values (Appendix 3C)	2.1 or 2.2 ³	60min or 2.1 whichever is greater	100% ⁵	100% ⁵

¹ The maximum door or glazing size allowable must not exceed that specified in Part 4 of this *Design Guide*.

² Due to the difficulty of preventing the spread of smoke through rolling and folding metal doors it is recommended that a lobby be constructed on one or both sides of the door opening that is able to restrict the passage of smoke. Additional guidance is given in Part 4.

³ Where the high hazard or value is on an upper floor (Appendix 3C refers), the fire resistance of the wall or floor and its structural frame should not be less than 60min. If Tables 2.1 or 2.2 specify higher levels of resistance the values in the tables will apply. It will not be permissible to reduce the level of resistance to less than 60min even in buildings which are sprinkler protected. The floor areas given in Table 2.3 are not applicable to this type of subdivision and advice should be obtained from the insurer.

⁴ Loadbearing walls and floors should satisfy the loadbearing capacity, integrity and insulation criteria for a period equal to the fire resistance specified in the appropriate table. For non-loadbearing compartment walls, they should satisfy the integrity and insulation requirements for the required period.

⁵ For doors installed in vertical shafts (lift-shafts, stairwells etc), only 50% of the fire resistance specified in this table for floors is required. The walls making up the shaft shall maintain their loadbearing capacity for the same duration as the floor, but may have levels of integrity similar to those of the doors.

3.1.2.4 Protection of openings and services

Greater consideration of the design of the various ways of protecting openings and services in the compartmentation are given in the following sections of the *Design Guide*:

- 4.2 Fire-resisting door and shutter assemblies
- 4.3 Fire-resisting windows and glazed screens
- 4.4 Penetration by ducts and building services
- 4.5 Cavity barriers
- 4.6 Fire stopping and linear gap sealing
- 4.7 Protection of services

3.1.2.5 General requirements

The construction methods and materials are not only required to provide the level of fire resistance given in Part 2, but are also required to demonstrate:

- longevity and robustness in use relative to the environment;
- resistance to cold smoke leakage;
- easy erection and maintenance without the need for excessive supervision;
- stability under fire in respect of the ability to interface with other building elements such as doors, glazing and services.

Plans, or cross-section through buildings, are given to support and explain the requirements, see Figs. 3.7, 3.8 and 3.12.

3.1.3 DEFINITIONS

3.1.3.1 Accommodation staircase

A staircase that links one floor to another which, because it does not form part of a 'protected route' needed for means of escape, is not required by legislation to be of fire-resisting construction.

3.1.3.2 Building height

This is the height measured from the upper surface of the top floor to the ground level on the lowest side of the building. (For further information see The Building Regulations 1991, Approved Document B, Appendix C.)

3.1.3.3 Built-up roof

An asphalt, bituminised or PVC or polyethylene surfaced, multi-layer roofing system, usually with thermal insulation and laid on, among others, metal or concrete decking.

3.1.3.4 Compartment walls

Loadbearing and non-loadbearing vertical fire-resisting separating elements of construction designed to contain a fire within an area for a predetermined duration in order to minimise the risk of fire spread (previously known as fire-break walls).

Note: A compartment wall provided for property protection rather than means of escape considerations may or may not coincide with one required to satisfy the regulatory requirements.

3.1.3.5 Compartment floors

A fire-resisting floor used in the separation of one fire compartment from another (previously known as fire-break floor).

3.1.3.6 Evidence of performance

Evidence in the form of a result of an appropriate fire test, performed in a laboratory approved by the United Kingdom Accreditation Scheme (UKAS), for carrying out the test, or by an assessment from a suitably qualified and competent body that demonstrates that the construction satisfies the relevant criteria and, in the case of a fire-resisting element, for a suitable duration.

3.1.3.7 Extended field of application

The range of constructions to which the test evidence is deemed to be applicable following an analysis of the factors that influence the application using calculation techniques or judgements by a qualified professional.

3.1.3.8 Fire engineered solution

Where the performance of the building or the elements of a building has been established in a quantitative way which takes into account all relevant parameters and is in accordance with proven or published methodology (see BS DD 240).

3.1.3.9 Fire integrity

The ability of the element or combination of elements to restrict the spread of fire, smoke and combustion gases from the fire side to the non-fire side of a construction.

3.1.3.10 Fire load

Fire load is the sum of the individual calorific values of the materials used in the construction of the building and of the building contents.

3.1.3.11 Fire resistance

The ability of an element of building construction to withstand exposure to a standard temperature/time and pressure regime without loss of its fire-separating function (integrity and insulation) or loadbearing capacity or both for a given time. Except for non-separating elements where BS 476: Part 8 is accepted, all fire resistance ratings are expressed in respect of the anticipated performance with respect to BS 476: Parts 20, 21, 22, 23 or 24.

Note: The thermal exposure conditions are very similar between Part 8 and Part 20-22 test procedures but the pressure conditions have been changed, especially in respect of tests performed before 1981 when the pressure was probably applied only intermittently. As a consequence, for elements that incorporate gaps or that may develop cracks, tests in accordance with BS 476: Part 8 are likely to give more optimistic results than tests in accordance with the BS 476: Part 20 series and some adjustment of the requirements may be needed to compensate.

3.1.3.12 Fixed end

This is illustrated below:

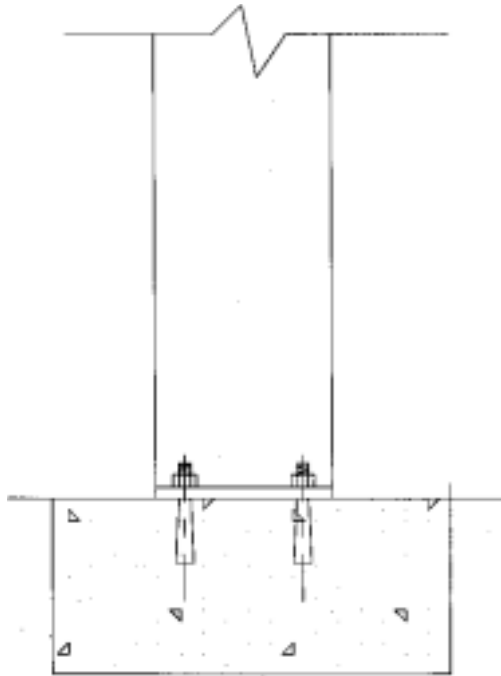


Figure 3.1. Fixed end.

3.1.3.13 Flexural element

A beam or loadbearing floor that is subjected primarily to bending stresses.

3.1.3.14 Masonry

Masonry elements are constructed from bricks or blocks made from fired clay, concrete with class 1 or class 2 aggregates or aerated concretes with densities between 480 and 1200kg/m³.

3.1.3.15 Materials of limited combustibility

A material performance specification that includes non-combustible materials, and for which the relevant test criteria are set out in Appendix 3A1.

3.1.3.16 Occupancy type

For the purpose of this *Design Guide*, occupancy type refers to the principal purpose and activity in the building, or part of the building and also to adjoining building(s).

3.1.3.17 Occupancy

For the purpose of this *Design Guide*, occupancy refers to the building or buildings on the premises which are occupied by the same company irrespective of the occupancy type or types involved, as defined in 3.3.16 above.

3.1.3.18 Pinned end conditions

This is illustrated below:

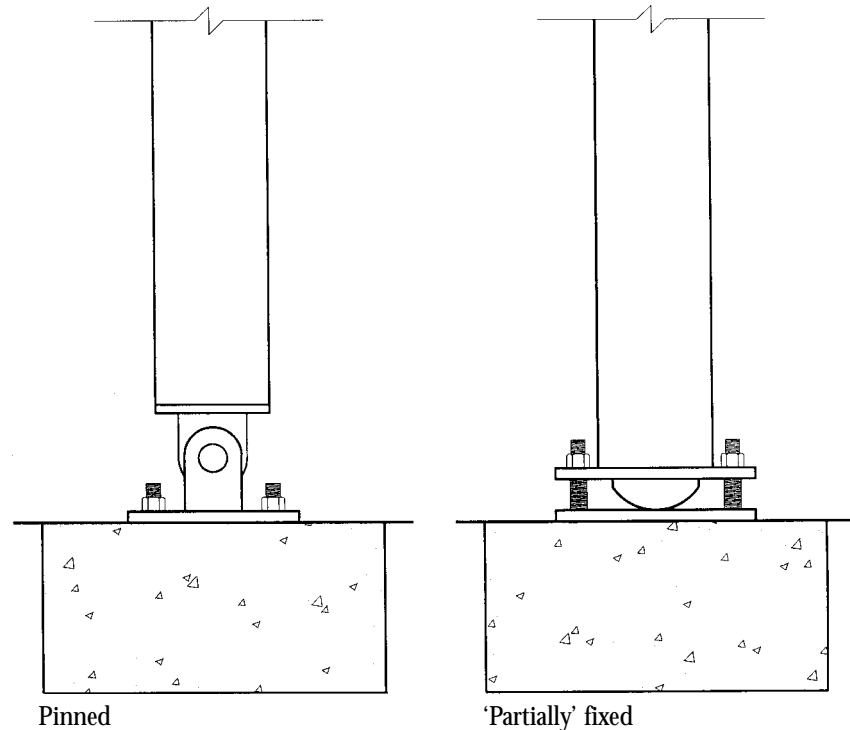


Figure 3.2. Portal frame base connection details.

3.1.3.19 Protected zone

The sections of the roof, external walls and supporting frame of single-storey buildings (and where applicable, multi-storey buildings), adjacent to and within a specified distance on each side of a compartment wall.

3.1.3.20 QDR

Qualitative Design Review: a process, normally carried out by a multi-disciplinary team, which sets out the fire safety objectives of a building as part of a fire safety engineering analysis.

3.1.3.21 Smoke-resistant lobby

An enclosure built around an opening in a compartment wall or floor, incorporating smoke control doors, which has been constructed so as to prevent the flow of smoke from one compartment to another.

3.2 Fire behaviour of the building

3.2.1 STRUCTURAL FRAME

The structural frame of a building encompasses all those elements of construction required to support the dead load of the building itself and the imposed design loads associated with the building use. The structural frame may therefore include columns, beams, floors and walls. If damage is to be restricted it is important that the structural frame performs its design function. The important objectives that the frame has to fulfill are detailed in 3.2.1.1 and 3.2.1.2.

3.2.1.1 Single-storey buildings

The essential requirement is for the maintenance of compartmentation. The portal or lattice frame supporting or adjacent to compartment walls should not contribute to the collapse of the wall or part of the wall. These should have the same fire resistance as specified for the compartment wall in Table 2.2 of this *Design Guide* and additional guidance for specific applications are given in 3.2.1.1.1.

There are no fire resistance requirements for portal or lattice frames that do not affect the fire stability of the compartment wall(s).

3.2.1.1.1 Interactions between walls and portal or lattice frames

(a) Compartment walls infilling between portal or lattice frame stanchions

Where compartment walls infill between portal or lattice frame columns in a building and run at right angles to the span, the columns of portal or lattice frames should be protected to provide the same level of fire resistance as the wall construction and:

- (i) where portal or lattice frames have fixed bases (see Fig. 3.1), the infill wall construction between the columns may then be of brickwork, concrete, blockwork or dry wall construction. Masonry walls should be restrained laterally at the head by means of ties attached to horizontal framing members protected to the same fire resistance level as required for the compartment wall, or;
- (ii) in the case of frames with lower levels of restraint, for example pinned or partially fixed bases (see Fig. 3.2) the infill wall construction should either be of masonry or blockwork construction and if a plastic damp-proof course is provided at the bottom of the wall it will allow the wall to tilt from the base rather than break half way up.

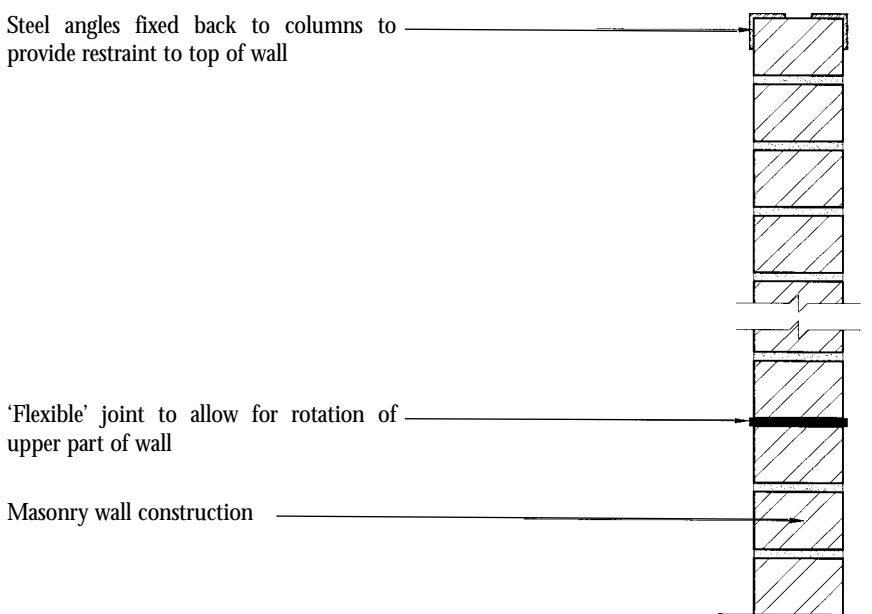


Figure 3.3. Masonry restraint method.

The masonry walls should be laterally restrained at the head by means of ties attached to horizontal framing members fixed back to the portal or lattice frame columns and protected to the same level of fire resistance as required for the compartment wall.

(b) Compartment walls running parallel to portal or lattice frames

Where compartment walls run parallel to the span of portal or lattice frames:

- (i) where a compartment wall is built up to the underside of a portal or lattice frame such framing should have the same level of fire resistance as that required for the compartment wall; and
- (ii) portal or lattice frames on each side of the wall together with the connecting lateral beams and any secondary supporting structure which is important to the stability of the wall spanning between those portal or lattice frames should be protected to the same level of fire resistance as the compartment wall (see Fig. 3.4.) (steel sections having an H_p/A ratio greater than 260 m^{-1} may not be able to be economically protected to the same standard); or

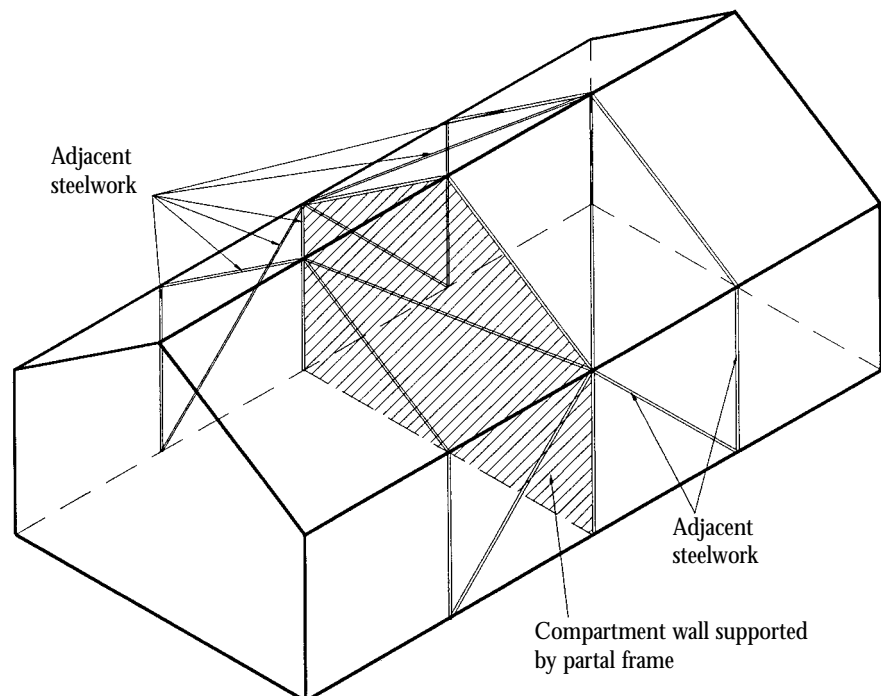


Figure 3.4. Compartment wall supported by portal frame and adjacent steelwork.

- (iii) the compartment wall should be designed to have sufficient loadbearing capacity in order to resist the overturning moment applied by the roof construction as the portal or lattice frames on one side collapse; or
- (iv) a section should be designed into the roof construction or supporting members adjacent to the point where the roof spans or bears on the compartment wall which has adequate strength in the cold state but which is weaker in the 'hot' state so that collapse

of the roof on one side of the wall takes place in a predictable way and applies no overturning moment to the compartment wall (see Fig. 3.5.).

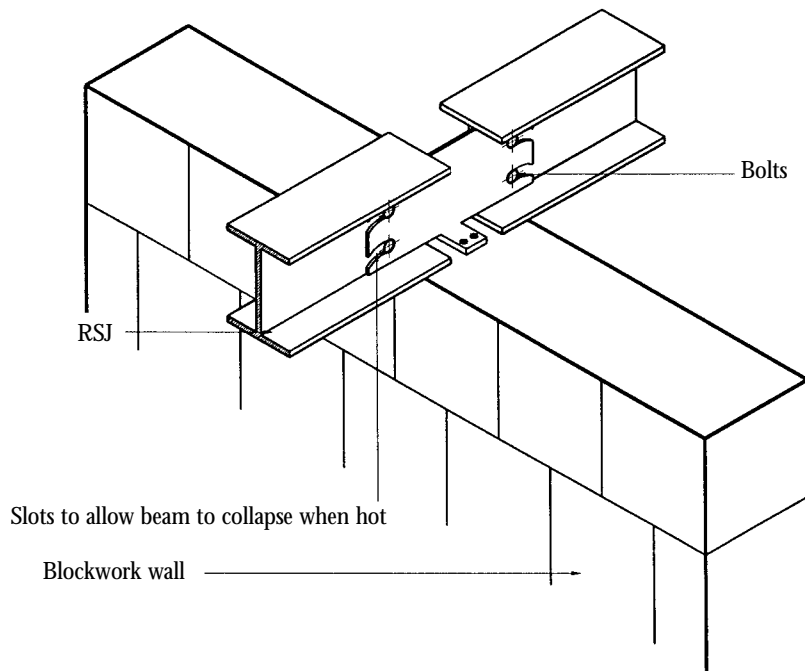


Figure 3.5. Example of 'hot state' designed in collapse mechanism.

3.2.1.2 Multi-storey buildings

The essential requirements are both the prevention of building collapse and the maintenance of compartmentation.

3.2.1.2.1 Prevention of building collapse

The loadbearing elements of structure should maintain their loadbearing capacity in order to prevent the premature collapse of the building. In some types of building, local failure of a loadbearing element can cause progressive structural collapse leading to complete destruction of the building.

The level of fire resistance required for loadbearing elements of structure is effectively a function of building size and fire load. For tall buildings the periods of fire resistance required are higher due to the potentially more serious consequences of collapse of part or all of the building structure.

3.2.1.2.2 Maintenance of compartmentation

Loadbearing elements of the structure may support or even form part of the compartment walls or compartment floors that enclose compartments. Where such elements form part of the wall or floor they should not compromise the level of separation and under fire attack they, together with any associated construction, should satisfy the integrity and insulation requirements of BS476: Part 21 to the levels recommended in this *Design Guide* appropriate to the element, as well as loadbearing capacity.

It is important that, under fire exposure, the thermally induced deflections experienced by the loadbearing elements, either supporting or local to the fire

compartment, do not disrupt the compartmentation by causing failure of the compartment walls or floors or by causing excessive gaps to open up between the appropriate elements of structure.

To cater for thermally induced deflection, loadbearing elements of the frame should be provided with adequate levels of fire resistance either as a feature of the basic design or, in the case of a building alteration, by the application of suitable additional fire protection.

3.2.1.2.3 Protection to aid reinstatement post-fire

Post-fire reinstatement of the structural frame should be achievable quickly and effectively with minimum interruption to adjacent occupancies. By providing loadbearing elements of structure with an appropriate level of fire resistance the costs involved with reinstating the building after a fire are likely to be reduced. Inadequate protection of loadbearing elements of structure would be likely to result in large deflections of the structural frame both locally to the fire compartment and globally throughout the rest of the building. Large residual deflections after a fire would render most building structures unusable and fit only for demolition.

Further information detailing the way in which particular types of construction behave when exposed to fire gives some indication of the capacity of the various forms of loadbearing element to be reinstated after a fire (see Appendix 3A2).

3.2.1.2.4 Design and construction of the structural frame

It is important that the structural frame has a fire resistance not less than that of the compartment walls or compartment floors in order that it will not compromise the fire compartmentation. Similarly the frame should not distort sufficiently to cause gaps and fissures to develop that may compromise the compartmentation. Finally the interaction between the elements and the frame should not cause a three-dimensional failure of the compartmentation. The following sections give guidance on how the frame should be designed and constructed to ensure that the required performance is obtained.

3.2.1.2.4.1 Establishing the level of fire resistance

The minimum fire resistance requirements for loadbearing elements of construction are given in Part 2 of this *Design Guide*. Where a fire engineered solution is used in the design of the building then the recommendations of the tables in Part 2 continue to apply unless the fire engineered solution takes into account acceptance by the insurers, for example, by the insurance representative who is on the QDR team.

Where the loadbearing element supports a compartment wall or compartment floor it should be capable of supporting the load for the period of fire resistance stated in Table 2.1 or Table 2.2 without the resulting deflections compromising the compartmentation (see Appendix 3D for detailed guidance); neither should they compromise the ability of the element to satisfy the relevant criteria.

Where a loadbearing element of structure is common to more than one compartment (i.e. is part of a compartment wall) then the fire resistance required by the element should be the greater (or greatest) of the fire resistances determined for each of the compartments that the element divides.

Note: The fire resistance of elements forming the structural frame, whether separating or not, is evaluated with respect to the criteria of BS 476: Part 21: 1987 (the test procedures for determining the fire resistance of loadbearing elements).

Care needs to be exercised when applying the results of BS 476: Part 21 tests to the elements in practice. The test is only capable of evaluating columns and walls with a maximum height of 3m, and beams and floors with a maximum span of 4.5m and heated length of 4m. The furnace test also normally utilises restraint and fixity conditions much simpler than those to be found in practice.

Due to these size restrictions the results obtained in a test to BS 476: Part 21 should not be used to assume the performance of elements significantly larger than those tested, in respect of height and span, without the results being the subject of an extended field of application analysis to ensure that the as-built construction will perform as anticipated.

The only exception to this is when the materials and/or form of construction is the subject of a British Standard or design guide that takes the fire case into account, for example BS 5628: Part 2, BS 5268: Parts 4.1 and 4.2, BS 5950.

When an extended field of application analysis is being performed the possibility of extra loads being applied to the structure needs to be considered. For example, as a result of the transfer of load from other elements, such as non-loadbearing compartment walls. These, whilst being free standing in the 'cold' state, may require restraint to be provided by the adjacent structural members in the 'hot' state.

3.2.1.2.4.2 Accommodating or controlling fire-induced deflection

All loadbearing structural elements will deflect or exhibit distortion under fire exposure. It is important that the fire-induced deflections of loadbearing elements do not disrupt the compartmentation provided to retain the fire within the area of origin.

3.2.1.2.4.3 Junction between separating elements and beams and floors

Where compartments are enclosed by loadbearing compartment walls and loadbearing compartment floors, the transfer of load from one element to another under fire conditions is possible. Care should be taken to ensure that such load transfer can be accommodated by the adjacent structure.

In cases where non-loadbearing compartment walls are used, load transfer from a deflecting compartment floor construction or beam could cause disruption of the non-loadbearing element and lead to a premature integrity failure.

In order to prevent the transfer of vertical loads to non-loadbearing compartment walls beneath a floor it is important:

- (i) to ensure that adequate clearance is provided between the soffit of floors and beams and the tops of any non-loadbearing compartment walls over which they pass; or

- (ii) to provide higher levels of fire resistance to the loadbearing floors or beams than those required in Tables 2.1 and 2.2 in order to reduce the anticipated degree of deflection; or
- (iii) to use protected loadbearing columns to support the flexural element thereby restricting its deflection at the non-loadbearing compartment wall location.

These three concepts are shown in Figure 3.6.

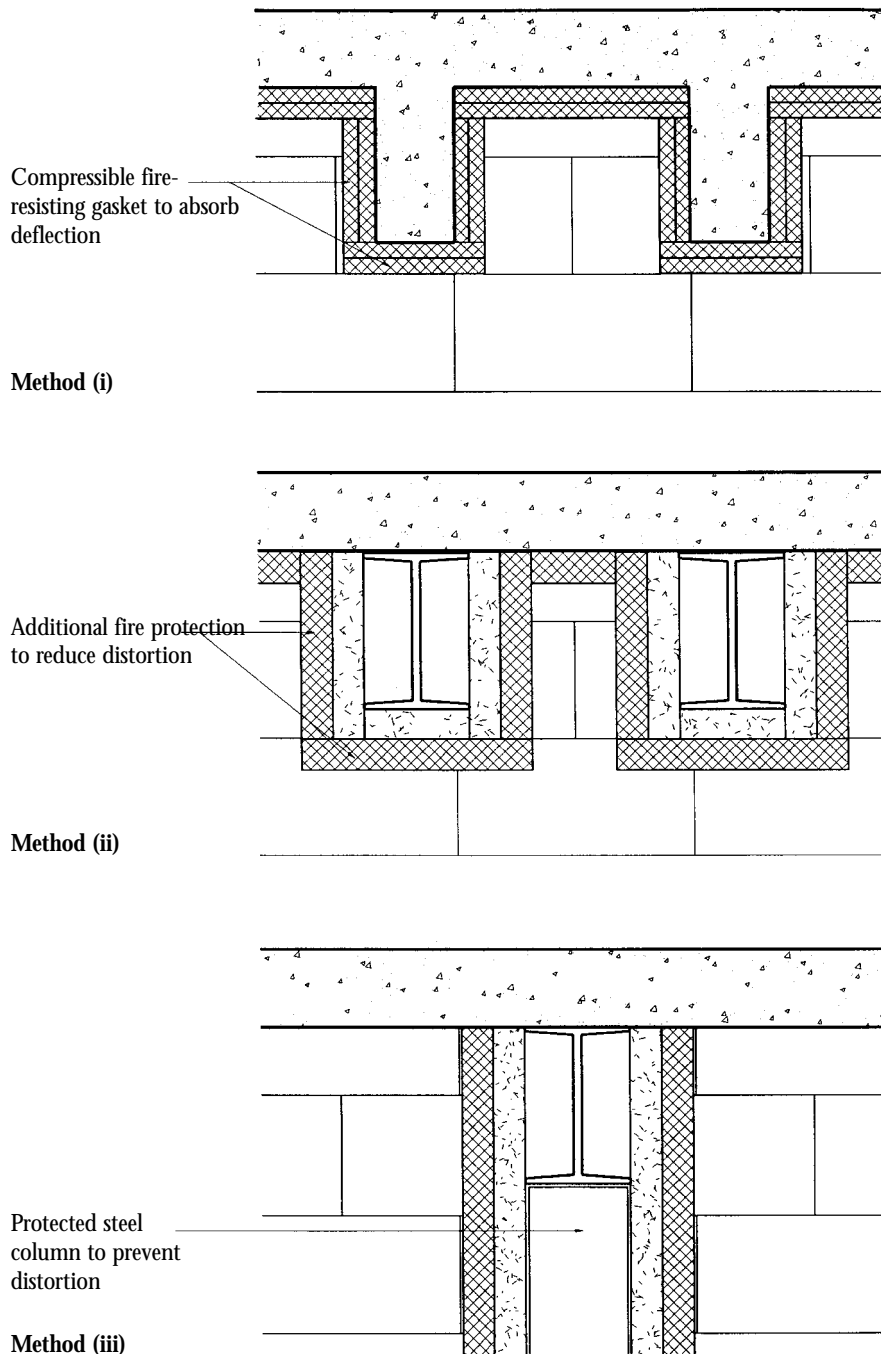


Figure 3.6. Accommodating or preventing distortion of floor between supports

Where clearance is being provided to accommodate differential movements between loadbearing elements and other components then, as a rule of thumb, a minimum clearance of $\text{span}/40$ (note: BS 5628: Part 8 recommends $L/100$) should be allowed mid-span of the flexural element to accommodate thermally induced deflections, where 'span' equals the span of the flexural element between supports. This clearance can be reduced proportionately at locations remote from the mid-span location of the flexural element. The clearance gap should be adequately fire stopped (see recommendations given in Part 4 of this *Design Guide*).

Similarly, where a non-loadbearing compartment wall abuts a loadbearing compartment wall or column, deflection of the loadbearing element could disrupt the non-loadbearing wall. As a rule of thumb a minimum clearance of $\text{height}/40$ should be allowed at mid-height of the loadbearing element to accommodate any lateral thermally induced deflections, where 'height' is equal to the vertical height between the upper and lower end fixings of the loadbearing element.

3.2.1.2.4.4 Design and construction of structural elements

Further recommendations on the design and construction of loadbearing structural elements constructed from the common materials will be given in a later Part of the *Design Guide*.

3.2.2 COMPARTMENT WALLS

3.2.2.1 Objective and function

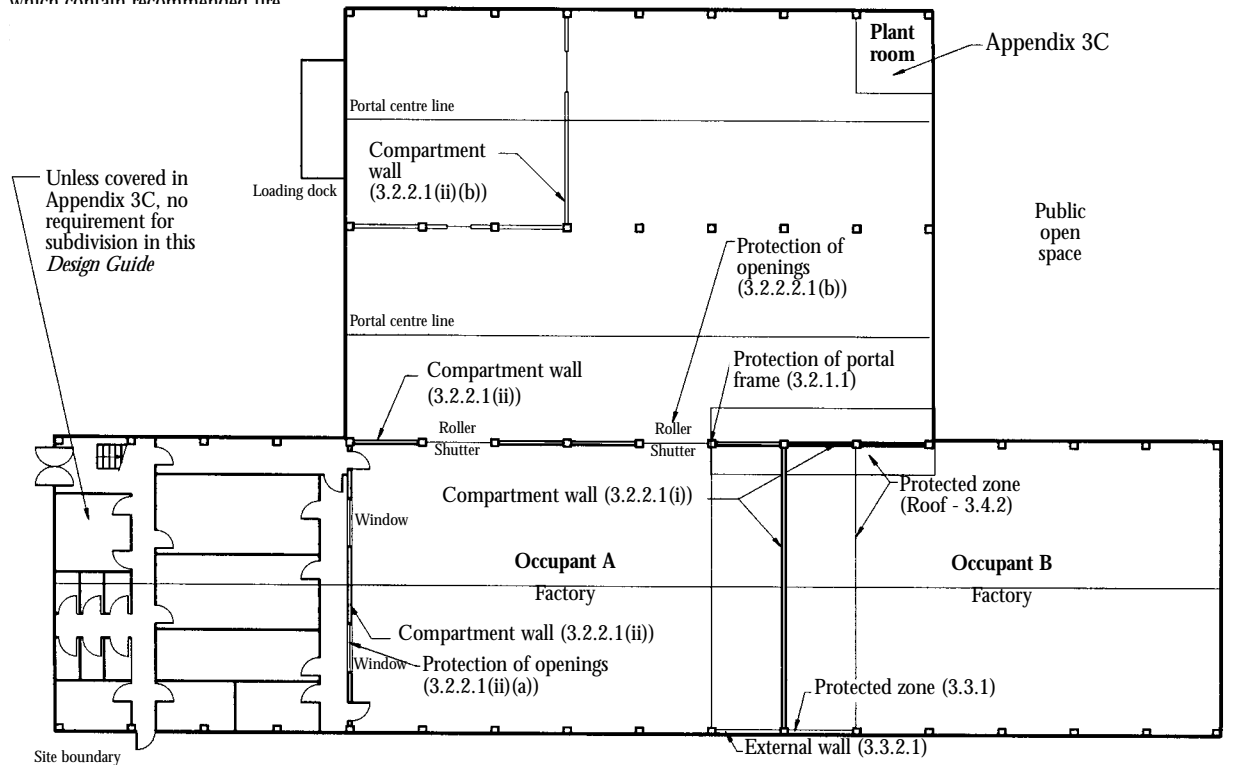
The compartment wall is a vital element in restricting the lateral spread of fire.

For the purposes of this *Design Guide*, compartment walls fall into two main categories:

- (i) walls designed to separate different occupancies not in the same ownership or occupied by the same company, which, in addition (to meet the recommendations of this *Design Guide*) do not contain any openings for doors, glazing or services (except insulating, secure doors fitted with an emergency access device for means of escape);
- (ii) walls separating different areas of the same occupancy, i.e. all buildings occupied by the same company, which contain openings for doors, glazing and services:
 - (a) walls designed to separate occupancy types, for example industrial (factory) from commercial (office), storage from retail or commercial etc;
 - (b) walls designed to restrict the compartment sizes within an occupancy to those areas recommended in Table 2.3;
 - (c) walls designed to separate hazards and/or concentrations of values or sensitive equipment within an occupancy. Some guidance is given in Appendix 3C, but advice from the insurer should be obtained in each case.

Whilst the above have the same fundamental objective of resisting the spread of a developed fire they do need to have slightly different functions, as shown in Figs. 3.7 and 3.8:

Figure 3.7. Plan of Factory A with integral office block sharing site with Factory B. (Numbered references are to sections which contain recommended fire



3.2.2.2 Fire resistance requirements

Table 3.1 gives guidance on the application of the levels of fire resistance and insulation required for walls as recommended in Part 2 of this *Design Guide* and the following general requirements should be noted.

3.2.2.2.1 Recommendations for compartment walls

The following general recommendations should be noted for consideration with the construction of all compartment walls.

Throughout the period of fire resistance specified the wall should:

- maintain its integrity, insulation and, if appropriate, loadbearing capacity requirements (as specified in BS 476: Part 20-23:1987) given in Table 3.1, note 4;
- not deflect in such a way to compromise the level of separation (Appendix 3D gives guidance on ways of eliminating deflection);
- not permit the spread of flame and smoke through, over or around it;
- following a fire, be capable of being reinstated with minimum disturbance to the adjoining building(s);
- be constructed of materials which have longevity and are sufficiently robust to resist accidental and mechanical damage. (See Appendix 3B.)

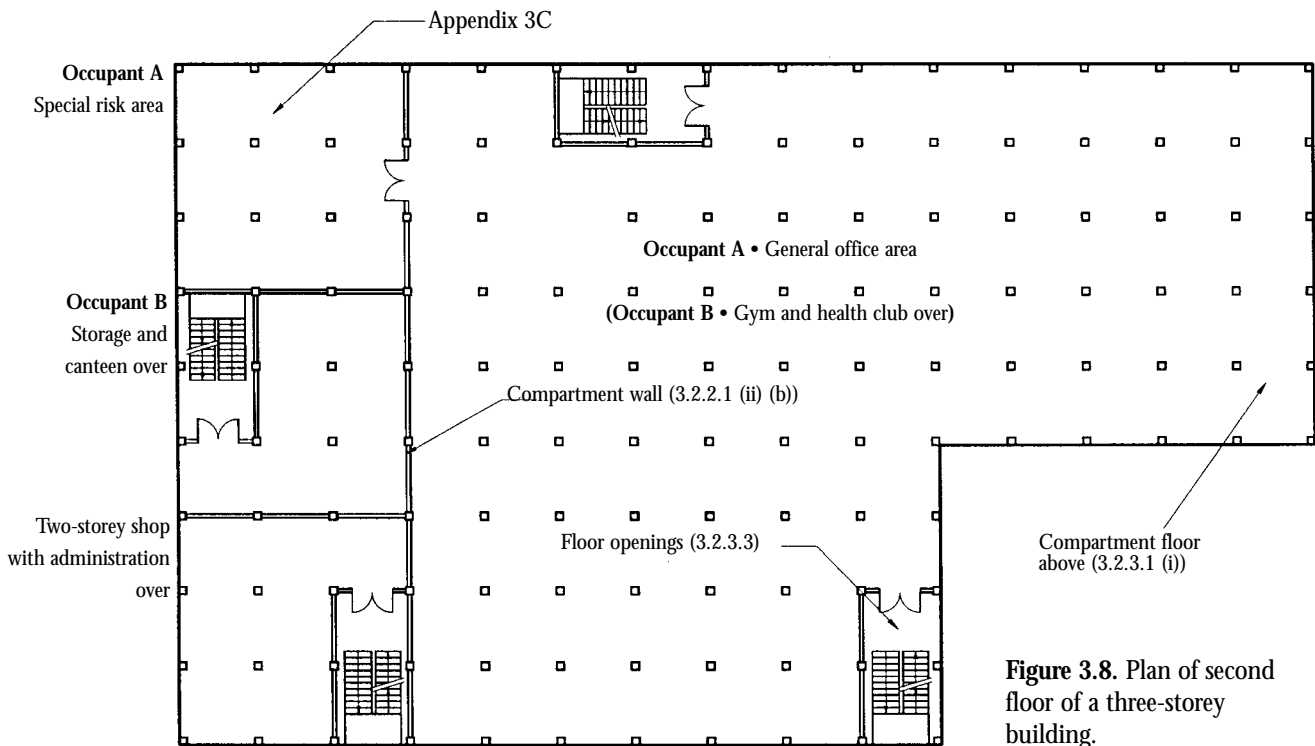


Figure 3.8. Plan of second floor of a three-storey building.
(Numbered references are to sections which contain recommended fire performance criteria.)

3.2.2.2.2 Openings in walls for doors and services

Openings in walls given in 3.2.2.1 are allowed, subject to compliance with the detailed requirements for openings specified in Part 4 of this *Guide* and to the following conditions:

- Doors should not be provided in walls separating different occupancies (i.e. type (i) walls) unless unavoidable to ensure adequate means of escape. In such cases the doors should fully satisfy the requirements in this section and in Part 4 of this *Design Guide* for fire resistance, insulation and smoke leakage.
- Service openings should not be provided in walls separating different occupancies.
- Openings in walls type (ii) may be protected by:
 - insulated doors or shutters (LPCB approved doors should be used when available); or
 - uninsulated LPCB approved folding doors, shutters and other non-insulated doors.

Where uninsulated doors are used the following should be considered:

- (i) the provision of a lobby, having an enclosure (walls and roof), with doors at each end of the lobby and providing a fire resistance not less than that for the compartment wall (the ability of doors in such an arrangement to provide the required fire resistance should be established by test or assessment); or

- (ii) a door assembly provided on each face of the compartment wall, which have been tested or assessed to give a combined fire resistance not less than the wall at the intended spacing, this spacing being greater than or equal to the thickness of the wall, as depicted in Fig. 3.9; or

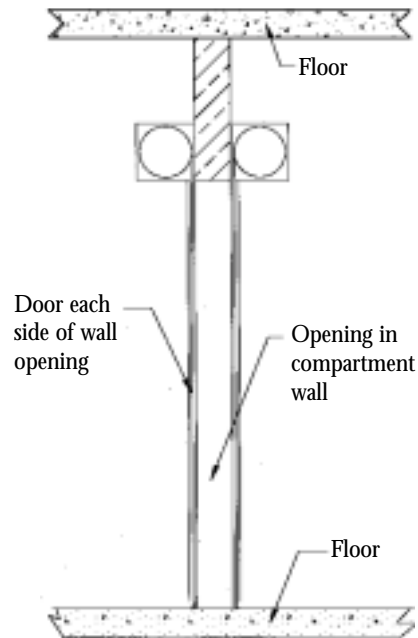


Figure 3.9. Door on each side of opening.

- (iii) full sprinkler protection of the compartments; or
- (iv) the creation of a clear zone on each side of the opening in which no combustible goods or fixed combustible material will be placed (see Fig. 3.10.) Further guidance is given in Part 4 of this *Design Guide*.

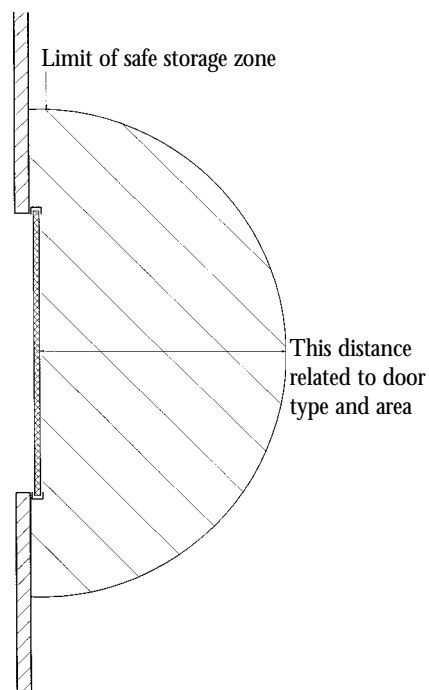


Figure 3.10. Method of defining radiation hazard zone.

- As far as possible, and particularly where the need is identified by the risk assessment, doors and shutters should comply with the smoke leakage requirements specified in Part 4. The provision of a smoke-resistant lobby on one or both sides of the opening may be an acceptable alternative where the doors cannot satisfy the smoke leakage requirements. The enclosing walls and ceiling of such a lobby should meet the requirements in 2.2, Contribution to Fire Growth.
- Where openings for the passage of pipes, ducts or cables are needed to provide essential services, the service penetration shall maintain the integrity and insulation characteristics of the wall and the service should satisfy the insulation requirement for at least 150mm and preferably 500mm on either side of the compartment wall.
- Conveyor openings and openings for air distribution ducts should be given special attention where they pass through compartment walls and floors. Reference should be made to Part 4 of this *Guide* where appropriate guidance is given.

3.2.2.2.3 Glazed areas

The provision of glazed areas is permitted in compartment walls of type (ii) given in 3.2.2.1 above and doors installed in compartment walls, subject to:

- the specified level of fire resistance being provided;
- compliance with the requirements in Note 1 of Table 3.1;
- compliance with LPS 1158, issue 2, subject to size or aspect ratio restrictions given in Part 4 of this *Design Guide*;
- the passage of smoke through the assembly or produced from the glazing itself being prevented for the period of fire resistance specified;
- extrapolation being only permitted in accordance with the conditions laid down in LPS 1158, issue 2;
- doors containing glass should be covered within the scope of LPCB approval and the test or assessment should have been made incorporating the configuration and size of glass proposed.

3.2.3 COMPARTMENT FLOORS

3.2.3.1 Objectives and function

Compartment floors are an important element in restricting the vertical spread of fire within or between occupancies.

Compartment floors can be compromised if the enclosure of any shaft, e.g. lift, stairwell etc., is inadequately protected, or holes for the passage of services, e.g. pipes, cables etc. are not fire protected to the same standard as the floor.

Most floors have an inherent level of fire resistance due to the need to carry the load imposed by the contents but may also be compromised if any penetration, edge junction or duct is not sealed to resist fire and smoke.

There are three types of compartment floors:

- (i) floors designed to separate different occupancies or different occupancy types;

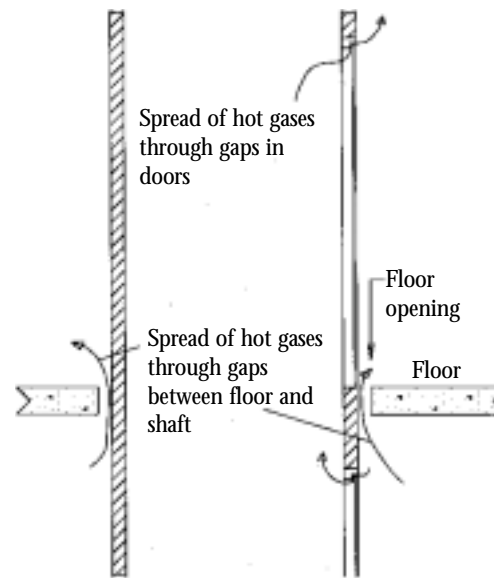


Figure 3.11. Spread of fire through floor openings and shafts.

- (ii) floors in the same occupancy type, i.e. occupied by the same company or more than one company carrying on the same type of business;
- (iii) floors of type (ii) in compartments containing high hazards or values or plant and equipment which is identified in the risk assessment as being vital to the business.

3.2.3.2 Fire resistance recommendations - floors

Table 3.1 gives guidance on the levels of fire resistance required for each type of floor. The Table should be read in conjunction with Part 2 of this *Design Guide* and the following general requirements should be noted.

3.2.3.2.1 General recommendations

The following general recommendations should be noted for consideration with the construction of all compartment floors:

- (a) Throughout the period of fire resistance specified the floor should:
 - not deflect to the extent of compromising the compartmentation;
 - resist the spread of flame or smoke through or around the floor;
 - maintain its loadbearing capacity, integrity and satisfy the insulation criteria over all surfaces.
- (b) The recommendations for protection of any opening, e.g. stair or lift shafts, ducts, conveyors, cable and pipe openings, edge junctions and similar features, are given in 3.2.3.3.
- (c) The floor and any floor opening should be capable of reinstatement with the minimum interruption, particularly floors between different occupancies or occupancy types.

3.2.3.3 Fire resistance recommendations - floor openings

- Table 3.1 gives guidance on the levels of fire resistance and insulation required for enclosures to floor openings and doors thereto. The Table should be read in conjunction with Part 2 and the general requirements in 3.2.3.3.1 below should be noted.

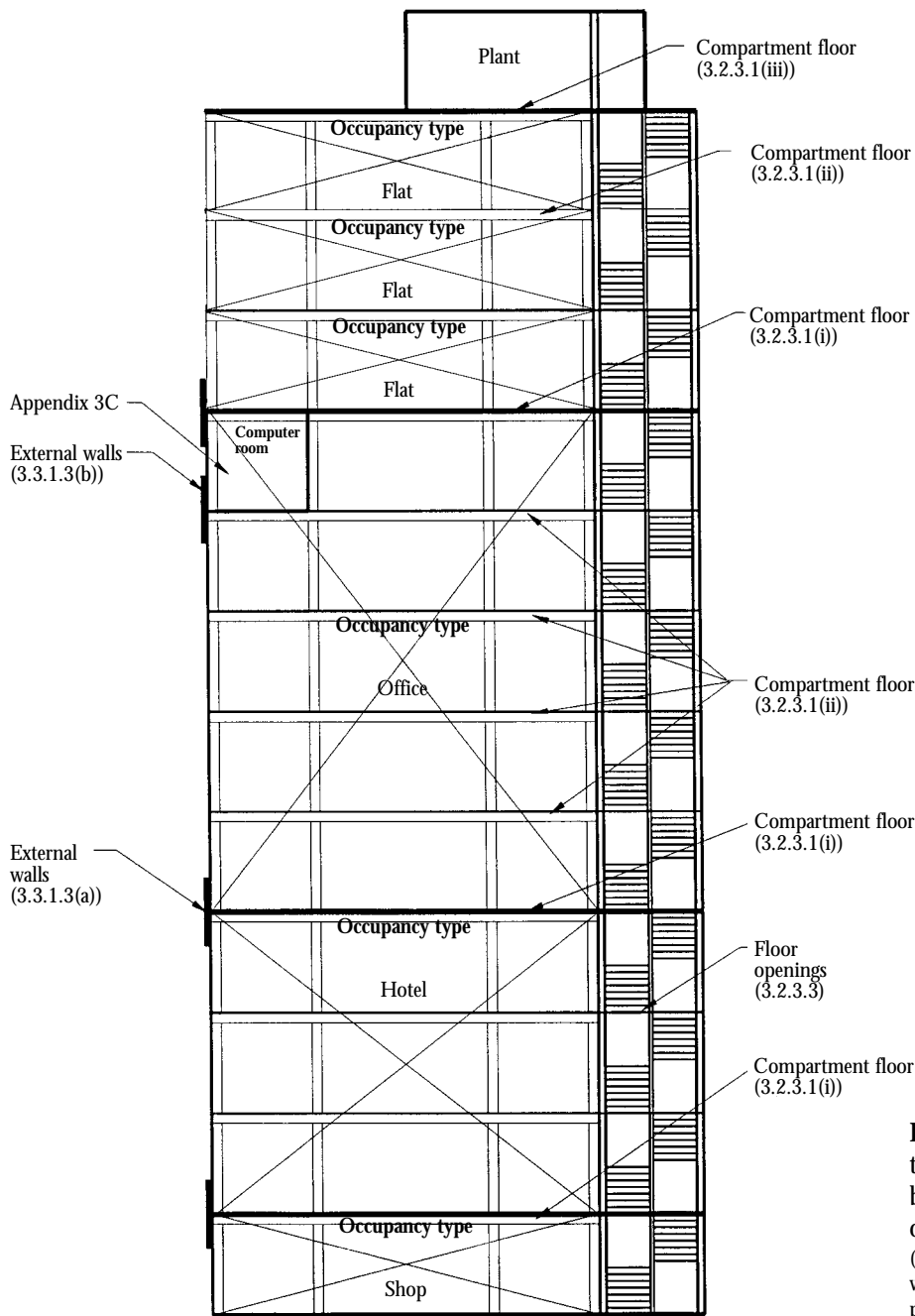


Figure 3.12. Cross-section through multi-storey building containing different occupancies.
(Numbered references are to sections which contain recommended fire performance criteria.)

- As far as possible, and particularly where the need is identified by the risk assessment, doors in vertical shafts should comply with the smoke leakage requirements specified in Part 4. It is recommended that openings for escalators protected by escalator shutters should be surrounded on each upper level by a suitable non-combustible, insulated lobby able to restrict the passage of smoke. The provision of active fire protection may, in some circumstances, be deemed to be a suitable alternative to such an enclosure.
- Conveyor and escalator openings and penetrations for the passage of pipes, cables etc. should be protected to the same standard as that

required for shafts and ducts. It is preferred that all pipes and cables are routed within fire-resisting ducts.

3.2.3.3.1 General recommendations for the protection of floor openings

- (a) Services may pass through ducts which have fire resistance not less than 50% of that for the compartment floor subject to the provision of a fire barrier penetration sealing system having the same fire resistance as the duct (Fig. 3.13) .

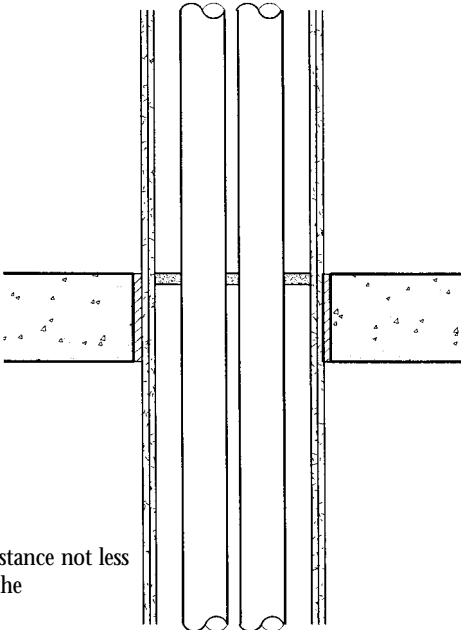


Figure 3.13. Alternative methods of routing services.

Duct having a fire resistance not less than 50% of that for the compartment floor

If no fire barrier is provided the duct should have equal fire resistance to the floor (Fig. 3.14).

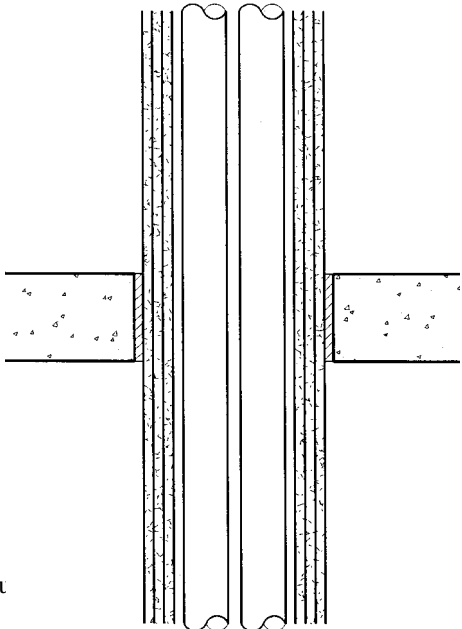


Figure 3.14. Alternative methods of routing services.

Duct fire resistance eq no penetration seal

- (b) Any services passing through a compartment floor which are not within a fire-resisting duct should pass through a penetration sealing system which satisfies the requirements for integrity and insulation for the specified periods. The insulation criteria should additionally be satisfied for a distance of at least 150mm and preferably 500mm into the compartment above and 100mm into the compartment below (Fig. 3.15).

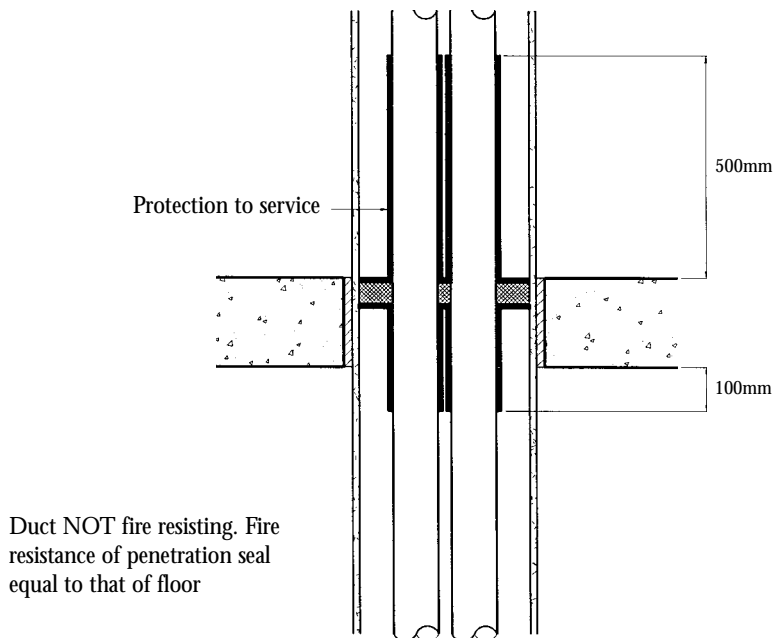


Figure 3.15. Alternative methods of routing services.

- (c) The enclosure and the floor should be capable of reinstatement with the minimum of interruption after a fire.
- (d) The materials of construction should have longevity and be robust to resist accidental and mechanical damage (see Appendix 3B).

3.3 Compartmentation - the function of external walls

3.3.1 OBJECTIVE AND FUNCTION

The external walls have a limited but important part to play in restricting the spread of fire around compartment walls and floors. This function is achieved by ensuring that the external wall is fire stopped to the compartment wall or floor and other elements involved. In addition the external wall and its supporting frame must have adequate fire resistance in the protected zone. See Fig. 3.16.

The protected zone along the external wall is the distance between the compartment wall and the next structural member on each side of the compartment wall. This may need to be extended if fire exposure from an adjacent building is likely to compromise compartmentation. If the next nearest structural member is within 1.0m of the compartment wall the protected zone should be extended to the next structural member.

3.3.1.1 Preventing external fire spread by-passing a compartment wall or floor

The protection provided by a compartment wall or floor can be rendered ineffective by fire as a result of:

- (i) the external wall collapsing and effectively leaving the compartment wall or floor unsealed; or
- (ii) the external wall being penetrated by a fire close to its junction with a compartment wall or floor, subjecting the external wall to the protected space to direct flame impingement or radiation from the egressing plume.

Guidance for compartment walls and floors is given below.

3.3.1.2. External walls - horizontal fire spread

In order to reduce the risk of horizontal fire spread the external wall and subsidiary supporting frame and bracing on each side of the of the compartment wall, should, within the protected zone, satisfy the integrity criterion, as adjudged by the gap or cotton pad criteria for a period not less than 30min and insulation for not less than 15min from inside to outside and in addition, outside to in, when tested to BS 476: Part 22:1987 (see Fig. 3.16). If part of the wall is less than 1.0m from the relevant boundary as defined in the documents supporting building regulations, higher levels of performance will be required.

Appendix 3D of this *Design Guide* provides guidance on the protection of the structural frame close to the compartment wall, this being required in order that stability is not compromised.

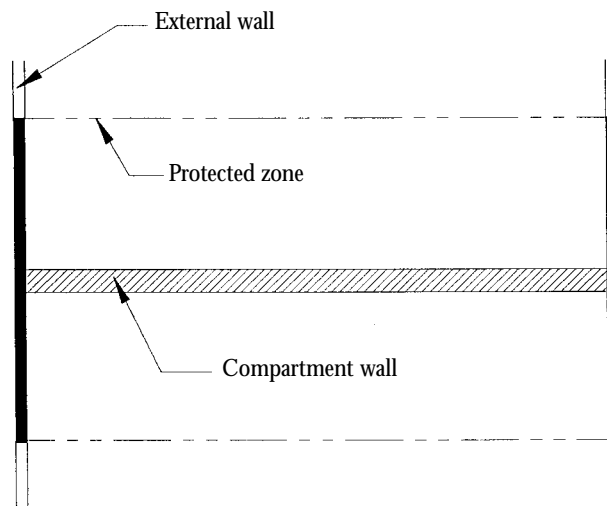


Figure 3.16. Plan of protected zone adjacent to compartment wall.

3.3.1.3 External walls - vertical fire spread

Without substantially affecting the nature or aesthetics of the building it is generally difficult to build in measures that will prevent vertical spread as a result of fire by-passing the compartment floor by egressing from the windows below and re-entering via the windows above. However, where each floor is sprinklered the risk of fire spread is smaller.

It is important to assess the risk in order to identify whether additional protection is necessary to overcome or reduce the potential threat to floors containing operations which are vital to the business.

Where the building is not sprinkler protected the following measures are recommended for consideration:

- (a) the external walls to the ground floor should have at least 30min fire resistance in terms of integrity and 15min insulation. Windows should be fire-resisting glazed assemblies and have fire resistance in terms of integrity of 30min. Secondary glazed with fire-resisting glass in fire-resisting frames that meets that standard may also be used. Glazed systems should be approved by LPCB in accordance with LPS 1158, issue 2. If part of the wall is less than 1.0m from the relevant boundary as defined in the supporting documents to building regulations, higher levels of performance will be required. In addition, consideration should be given to protecting the external walls and windows to upper floors to the same standard where appropriate;
- (b) where floors contain high values or equipment which is vital to the business, the external walls to such floors should comply with (a) above.

Note: Balconies, deflectors or upstands and downstands may not be completely effective but should be considered.

3.4 Compartmentation - control of roof exposure hazard

3.4.1 GENERAL

This part of the *Design Guide* deals with roofs that span over or are supported on compartment walls.

The possibility of fire spread via the roof over a compartment wall must be considered as part of the risk assessment process in order to ensure that the assets of the business and its ability to continue trading are adequately protected.

Additionally, the review of the likely performance of the 'building as a single entity', as recommended in 3.2 and amplified in Appendix 3D, will help to ensure that the protection of the structure and roof framework is adequate to prevent deflection and early collapse of the compartment wall.

Consideration should be given to the establishment of a protected zone on one or preferably both sides of the compartment wall and the necessity will depend on the identified fire load on each side of the compartment wall together with the long-term trading needs. It may be necessary to consider the provision of active fire protection, e.g. sprinklers, where it is not practical to provide extensive passive protection to the part of the roof in the protected zone.

Similarly the extension of the compartment wall above the roof might be an acceptable solution in some instances. In all cases attention to detail is essential to ensure that all junctions of the roof with other elements of the building are properly fire stopped.

3.4.2 PROTECTED ZONE

It is important that all roofs and the supporting framework, within a protected zone on one or both sides of the compartment wall, are provided with adequate fire resistance or alternative protection to prevent the early spread of fire from one side to the other. Consideration should always be given to extending a compartment wall above the roof. It is generally recognised that a minimum distance of 0.5m is desirable in order to prevent rapid fire spread once the fire has penetrated the roof covering.

This Clause should be considered in conjunction with: 3.2 - Fire behaviour of the building, clause 3.2.1.2.4; 3.3 - Compartmentation - the function of external walls; 5.4 - Fire spread from adjacent buildings, clause 5.4.3; and 5.5 - Fire spread from inside to outside building to external fabric, clause 5.5.3.

For the purposes of this section, a protected zone along the roof should be considered as:

Compartment wall built at right angles to the ridge line

The distance between the compartment wall and the next structural member on each side of the wall.

If the next nearest structural member is within 1.0m of the compartment wall the protected zone should be extended to the next structural member.

Compartment wall built parallel to the ridge line

The distance from the wall will depend on the outcome of the risk assessment but in occupancy types 4(b), 6(b) and 7 given in Table 2.2 it should not be less than 5.0m. This distance may be reduced if other acceptable measures are taken, for example, if sprinkler protection is provided.

3.4.3 FIRE RESISTANCE - ROOF AND FRAMEWORK

The level of fire resistance required within the protected zone will as stated be dependent on the needs identified in the risk assessment. In some cases, for reasons of practicality, it may be necessary to consider a combination of active and passive protection. In all cases it is paramount that the roof and framework do not compromise the compartmentation and that a fire is prevented in all cases from by-passing the compartment wall.

Therefore within the protected zone of the roof the following protection should be considered:

- (a) The roof and any subsidiary supporting framework within the protected zone, unless having at least 30min fire resistance, should be protected by a ceiling having fire resistance with integrity not less than 30min and also satisfy the insulation requirements for at least 15min. (The provision of a roof comprising panels complying with grade A of LPS 1181, issue 2 meets this requirement.) In such cases the roof framing should conform to (c) below.
- (b) For parts of the roof outside the protected zone, these should be constructed of materials permitted in 2.2, Contribution to fire growth in this *Design Guide*.

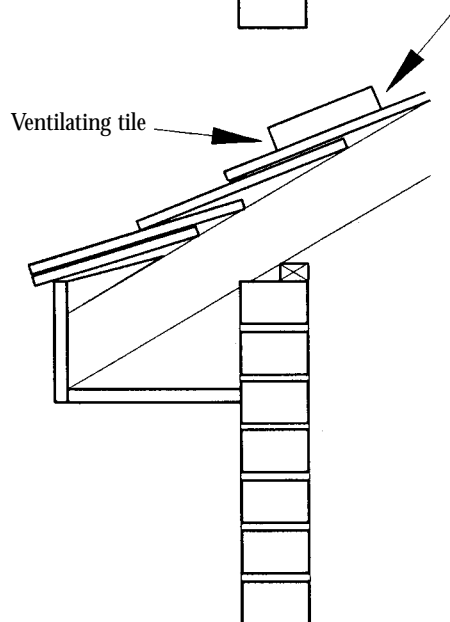
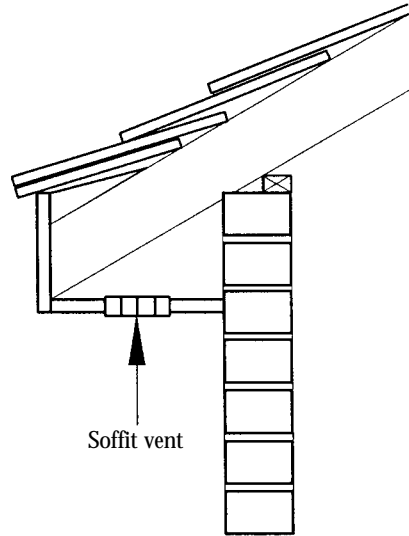
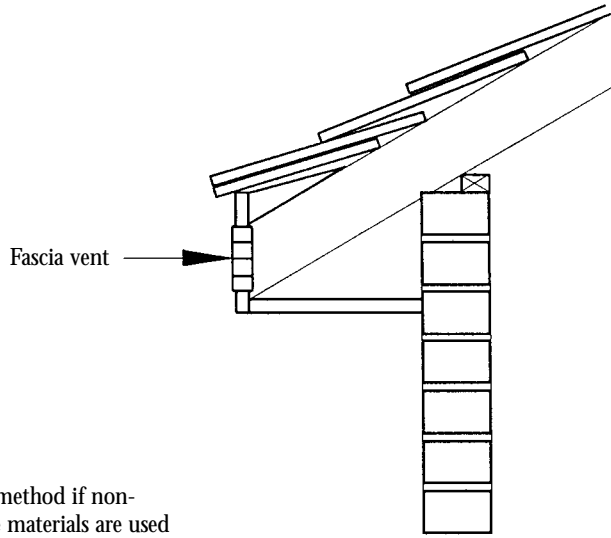


Figure 3.17. Alternative ways of ventilating pitched roofs.

- (c) The supporting purlins and any bracing members should have a fire resistance in respect to loadbearing capacity of not less than 30min. Alternatively, it may be considered that the provisions of 3.2 requiring bracing of the wall to the structural frame will prevent distortion and subsequent deflection of the wall.
- (d) Requirements for the protection of the portal frame where it is incorporated in the compartment and external walls are described in 3.2 and 3.3.
- (e) Where the roof is supporting plant, it shall have the fire resistance specified in Table 2.1 (documents supporting building regulations may also in some limited circumstances require fire resistance).
- (f) Roof lights should not be provided within the protected zone unless they have at least 30min fire resistance in terms of integrity.
- (g) Roof vents should not be provided in the protected zone.

3.4.4 OTHER REQUIREMENTS

- (a) A lattice framed roof requires detailed attention to fire stopping where it spans along a compartment wall. In this case it should have equal fire resistance to that required for the wall.
- (b) Where the wall is built up to the underside of a portal frame any gap between the top of the frame and the roof deck should be fire stopped to the same standard as the wall. Where the wall is built up to the underside of the roof deck, any gaps should be filled by a system to the same standard as the wall.
- (c) In every case where internal ceilings are provided the compartment wall must pass through the ceiling and be sealed to the underside of the roof deck or covering.
- (d) Any ventilation incorporated in a roof which overhangs the external wall is vulnerable to penetration by flames rising up the external wall. Such flames may originate from an external fire at ground level or by a flame or hot gas plume egressing from non-fire rated windows in the facade below. Ventilation should be provided by means of ventilated roof tiles above the eaves. Partially protected vents set in the fascia or down facing vents in the soffit boards should be avoided but may be acceptable if the soffit boxes and any thermal insulation in the roof space are constructed from non-combustible materials (see Fig. 3.17).

Fascia or soffit boards should ideally be constructed from non-combustible materials. Plastic fascias or soffits are not recommended but timber may be used provided it is not less than 19mm thick.

3.5 References

British Standards

- BS 476: *Fire tests on building materials and structures*
Part 11: 1982: *Method for assessing the heat emission from building materials*
Part 12: 1991: *Method of test for ignitability of products by direct flame impingement*
Part 20: 1987: *Method for determination of the fire resistance of elements of construction (general principles)*
Part 21: 1987: *Methods for determination of the fire resistance of loadbearing elements of construction*
Part 22: 1987: *Methods for the determination of the fire resistance of non-loadbearing elements of construction*
Part 24: 1987: *Method for determination of the fire resistance of ventilation ducts*
Part 31.1: 1983: *Methods for measuring smoke penetration through doorsets and shutter assemblies. Method of measurement under ambient temperature conditions*
- BS 5268: *Structural use of timber*
Part 4: Section 4.1: 1978: *Recommendations for calculating fire resistance of timber members*
Part 4: Section 4.2: 1989: *Fire resistance of timber structures. Recommendations for calculating fire resistance of timber stud walls and joisted floor constructions*
- BS 5628: *Code of practice for use of masonry*
Part1: 1992: *Structural use of unreinforced masonry*
Part2: 1995: *Structural use of reinforced and prestressed masonry*
Part3: 1985: *Materials and components, design and workmanship*
- BS 5950: *Structural use of steelwork in building*. Part 8: 1990: *Code of practice for fire resistant design*.
- BS 8110: *Structural use of concrete*:
Part 1: 1985: *Code of practice for design and construction*.
Part 2: 1985: *Code of practice for special circumstances*.

Loss Prevention Council

Loss Prevention Standards

- LPS 1158, issue 2, *Requirements and tests for fire-resisting glazing systems*.
- LPS 1181, issue 2, *Requirements and tests for wall and ceiling lining materials and composite cladding materials*.
- LPS 1208, *Fire performance requirements for metal-faced fire-resisting insulated panels*.

Trade association publications

Fire Resistant Glass and Glazed Systems Association, *Code of Practice for Fire Resistant Glazing*.

Official documents

The Building Regulations 1991, *Approved Document N: Glazing materials and protection*.

Appendix 3A1

Materials of limited combustibility

For the purposes of this *Design Guide*, materials of limited combustibility are:

- (a) any non-combustible material;
- (b) any material of density 300kg/m^3 or more which, when tested to BS 476: Part 11, does not flame and the rise in temperature on the furnace thermocouple is not more than 20°C ;
- (c) any material with a non-combustible core at least 8mm thick having combustible facings (on one or both sides) not more than 0.5mm thick (where a flame spread rating is specified, these materials should also meet the appropriate test requirements);
- (d) any material of density less than 300kg/m^3 which, when tested to BS 476: Part 11, does not flame for more than 10s and the rise in temperature on the centre (specimen) thermocouple is not more than 35°C and on the furnace thermocouple is not more than 25°C .

Appendix 3A2

Synopsis of the behaviour of materials when exposed to fully developed fire

BRICKWORK

Clay bricks withstand temperatures in the region of 1000°C or more without damage but under very severe and prolonged heating the surface of a brick may fuse. Spalling can occur with some types of bricks particularly of the perforated type.

A loadbearing brick wall exposed to fire will suffer a progressive reduction in strength due to deterioration of the mortar in the same manner as concrete. Severe damage is more likely to be caused by the expansion or collapse of other members. Small expansion cracks in the structure may close up after the building has cooled.

CAST IRON

Because of their heavy mass and low design stresses, cast iron members generally show good performance in fires.

The members should be carefully examined for signs of cracking. A permanent

loss of strength can occur when the temperature of a cast-iron member exceeds 600°C but because of their large thermal mass this requires a fire of such severity that rebuilding will probably be necessary.

CONCRETE

The colouration of concrete at various depths is a clue to both the maximum surface temperature attained and the time/temperature profile of the fire. Care and experience are required when considering spalled surfaces. The interpretation will depend on judgement as to whether spalling occurred during the period of maximum heat exposure or subsequently, and as to the allowance to be made for this factor. The extent of the change of colour varies with the type of fine and coarse aggregate but changes will occur to some degree in practically all types of concrete in the UK. Wetting the affected concrete surface will enhance the colours. Some types of stone show similar colour changes.

The pink colour change which occurs at around 300°C with most natural aggregates used in the UK is very important as it coincides with the temperature below which the compressive strength is not significantly reduced. Higher temperatures up to approximately 500°C may be endured by lightweight concrete before significant loss of strength occurs. In a concrete member, only the temperature of the outside layers increases initially and the temperatures of the internal concrete will be comparatively low, unless the fire exposure is prolonged, as concrete is a poor conductor of heat.

Temperature rise to a greater depth will occur if extensive spalling occurs during fire exposure. Natural aggregate concretes heated to 300°C or above, and lightweight aggregate concretes heated to 500°C or above, may need to be replaced in critical areas during reinstatement.

STEEL REINFORCEMENT

Steel reinforcement loses strength at high temperatures in an identical manner as discussed below for steel loadbearing elements. Loss of effective concrete section in prestressed members may significantly alter the intended design stress profile in addition to permitting a higher temperature in any adjacent steel tendons, with consequent increased stress loss.

STEEL

When a building has been exposed to fire the structural steelwork may suffer from any or all of the following effects:

- (a) expansion of heated members relative to others which restrain this movement, leading to distortion of the heated member or including distortion to adjacent members - particularly at connections;
- (b) increased ductility, reduced strength and plastic flow while the metal is at a high temperature;
- (c) change, persisting after cooling, in the mechanical properties of the metal, resulting in large permanent distortion of members after a fire.

The coefficient of linear thermal expansion of steel is nominally $14 \times 10^{-6}/^{\circ}\text{C}$ between 0 and 1000°C. In a fire this may be sufficiently small for it to be taken up by elastic deformation, expansion joints etc, or may be severe enough for

the movement to cause permanent distortion of the framework or extensive cracking of bearing walls. This will very much depend on the extent of the fire duration and the length/height of the section.

The temperature at which the stress capacity of mild steel falls to the design stress is generally taken to be about 550°C (for a design factor of safety of about 2). At stress levels less than the maximum permitted in design, this 'critical' temperature will rise. The effects of constraint and continuity can also raise the 'critical' temperature. Unless temperatures of 650°C are exceeded, there will be no deterioration in the mechanical properties of mild and micro-alloyed steels on cooling. After heating, cold-drawn and heat-treated steels lose their strength more rapidly than mild and micro-alloyed steels and, on cooling from temperatures in excess of about 300°C and 400°C respectively, part of this loss of strength will be permanent.

In general, any steel members which have not distorted can be considered to be substantially unaffected by the heat to which they have been subjected. However, it should be realised that in certain cases some degradation in strength will have occurred. Members should be examined for cracks around rivet or bolt holes if expansion movements have taken place. It will usually, however, be the cleats, rivets and especially bolts which will have suffered and not the main members.

Decisions on reinstatement may need to be taken in the light of expert engineering and metallurgical advice.

TIMBER

Although timber can be defined as 'combustible' it is recognised as 'not easily ignitable' in the sizes generally used in construction. Timber above a density of 400kg/m³ can be considered to have a flame spread characteristic of class 3. This can, if necessary, be upgraded to class 1 or class 0 by pressure impregnation treatments and/or surface coatings, but such treatments need to be third party approved, which should establish long-term durability.

Without a source of ignition, timber will not ignite spontaneously during short-term exposure until a temperature of 450-500°C is reached. During this heating period and any subsequent cooling period:

- the strength characteristics of the timber are unaffected except in the outer region exposed to fire;
- distortion of timber elements, structural and non-structural, will be minimal;
- the coefficient of linear thermal expansion of timber is negligible for all practical purposes;
- the thermal conductivity property of timber is low and it will act as an insulant to other elements.

If timber is exposed to a flame it must reach a temperature of about 300°C before ignition takes place in the short term. Once ignited either by spontaneous ignition or by direct flame timber will burn:

- at a known rate producing a charred surface which protects the timber below the char line;

- will only lose strength at a rate proportional to the loss of section;
- the coefficient of linear thermal expansion of timber is still negligible;
- the rate at which a section is reduced by charring can be calculated using the principles set out in BS 5268: Part 4: Section 4.1.

An assessment of the strength of the remaining structure following a fire is relatively simple:

- if the timber has not charred the strength of the timber is unaffected. Only cleaning of surface finishes may be necessary;
- if the timber has been subjected to flame and charring has occurred the residual section can be checked for size and the new capacity of the structure calculated, taking into account any fissures that may have developed. If the capacity of the section is acceptable in both ambient and future fire conditions, the charring to the surface can be removed and the timber cleaned and redecorated.

Appendix 3B - Robust materials

Some examples of robust materials to be used in conjunction with the *Design Guide for the fire protection of buildings*

This Appendix gives some guidance on robust materials that could be used for compartment walls and floors to give sufficient resistance to impact and other mechanical damage. (A performance-based standard LPS 1221 will be prepared to replace the guidance given in this Appendix.)

Requirements in this Appendix are intended to apply to industrial and storage applications where robustness to mechanical damage is particularly critical.

PRODUCT DESCRIPTION	DIMENSIONS
Brick and blockwork less than 100mm thick*.	Density not less than 600 kg/m ³ and not *Subject to a slenderness ratio (thickness/height) not less than 0.025.
Studs	
timber	> 47mm x 89mm softwood > 400kg/m ³
steel section - 1mm thick	> 50mm x 150mm mild steel channel or Z
Joists	
timber	> 47mm x 225mm softwood > 400kg/m ³
steel	> 70mm x 250mm mild steel - 1mm thick
Boards/Linings	
<i>Gypsum based</i>	
Plasterboard	19mm thick as a single layer
"	12mm thick as part of a multiple layer
Reinforced plasterboard	15mm thick as a single layer
"	10mm thick as part of a multiple layer
Glass reinforced Gypsum	12mm thick as a single layer
"	9mm thick as part of a multiple layer
<i>Calcium silicate based</i>	
Flexural strength (dry) 5-7.5 (N/mm ²)	15mm as a single layer
Flexural strength (dry) 5-7.5 (N/mm ²)	10mm as part of a multi-layer system
Flexural strength (dry) Above 7.5 (N/mm ²)	12mm as a single layer
Flexural strength (dry) Above 7.5 (N/mm ²)	9mm as part of a multi-layer system
Composite Boards	
Gypsum based chipboard	15mm as a single layer
"	10mm as part of a multi-layer system
Cement based chipboard	12mm as a single layer
Fire resisting glazing	
Wired glass (fire and safety)	6mm
Laminated fire resisting glass	12mm or greater
Solid fire resisting monolithic glasses	10mm thick or greater
Glazing installed behind permanent screen protection (See Approved Document N, The Building Regulations 1991)	
Metal-faced insulated panels	
Steel faced mineral wool panels. Density of mineral wool not less than 100kg/m ³ and a minimum thickness of 100mm. Thickness of steel not less than 0.7mm.	

Appendix 3C

Protection of areas containing critical business equipment, or of high risk or high values

C1 INTRODUCTION

Premises that contain critical business equipment, components or stock, the loss of which will have a significant impact upon business profitability and/or the ability of the company to continue trading after an interruption, such as fire or explosion, will require special consideration.

The outcome of the risk assessment process will be the identification not only of the above-mentioned criticalities but also of other vital plant, machinery, goods, components and processes as well as general and trade hazards that pose a threat to the assets of the business. In some cases the threat will be capable of elimination, the interruption will be of short duration or the damage easily and quickly reinstated with little impact upon trading. In other instances the threat will be significant and require enhanced passive and possibly active fire protection to ensure that any damage and interruption will be reduced to an acceptable level.

A further reason for considering these features is to ensure that appropriate protection is provided to safeguard the area itself or to prevent a fire emanating from the hazard quickly involving the rest of the building. Thus in some cases compartmentation in accordance with Table 2.2 and Table 2.3 will be required whereas in others sub-division, in some cases at a lower standard of fire resistance, of a larger compartment will be adequate.

Insurers should be consulted to establish the standards and nature of the protection required where critical business equipment etc. is identified in the risk assessment.

C2 GENERAL CONSIDERATIONS

Consideration should be given to areas where the fire risk, i.e. the fire load (or the rate of heat release up to a ventilation-controlled fire), is significantly higher than in the rest of the building, as well as to features which are well known as potential ignition hazards. In addition, other areas will contain critical business equipment and/or high value machinery, plant and equipment etc. loss of which may give rise to a significant business interruption. There will also be special risks that will need separate consideration as detailed below.

C3 SPECIAL RISKS

Risks requiring special consideration include areas containing:

- (a) high hazards resulting in a higher fire load including:
 - storage of highly combustible substances or flammable liquids;
 - processes in which such substances or liquids are used;
 - deep fat frying and other high risk processes in food factories as described more fully in Part 7.2 to which reference should be made for guidance on the specific protection recommended.

- (b) concentrations of value including:
 - items of plant and machinery where replacement is likely to be delayed for a long period and significant business interruption will result;
 - critical electronic data processing and control equipment;
 - bulk storage of goods or stock;
 - storage of components of high individual value and/or business criticality.
- (c) general and trade hazards which could give rise to rapid fire spread and cause serious damage or business interruption. These could include:
 - boilers, particularly those used for process purposes;
 - fuel oil storage tanks located inside the premises;
 - emergency electricity generators;
 - main electrical switchgear and transformers;
 - waste collection/storage rooms;
 - packing material storage.

C4 RECOMMENDED FIRE RESISTANCE

Table 3.1 specifies the levels of fire resistance that should be considered and the minimum level of fire resistance (60 min) to be adopted. No reduction in this minimum figure should be considered even in buildings that are sprinkler protected.

Moreover it should be emphasised that this figure is the minimum and there will be instances when an increased level will be necessary in order to ensure adequate property protection. In buildings where the fire load under consideration is significant and occupies a large proportion of the building, fire resistance levels equivalent to those for full compartmentation (refer Tables 2.2 - compartmentation and 2.3 - floor area) will be required. If it is significant but only occupies a relatively small area, sub-division to a reduced level of fire resistance may be acceptable.

In every case it is important that the passive fire protection provided will maintain its integrity and insulation for the period specified.

C5 ACTIVE FIRE DETECTION AND PROTECTION

Appropriate consideration should be given to the provision of detection and active protection measures suitable for the hazard in question. Specific guidance is available in the documents listed in the references in Part 2.13.

Active protection, for example, should be considered in buildings where compartmentation or sub-division cannot be provided.

In many instances the provision of an automatic fire detection system will be essential, particularly if the area concerned is not frequently visited or the earliest possible warning is required, e.g. computer systems.

C6 SPECIAL CONSIDERATIONS

Fire resistance

In order to maintain protection at the specified level of fire resistance it is important that the materials selected are sufficiently robust for the environment in which they are located. In addition, protection should be provided against mechanical or accidental damage when necessary.

Particular attention must be paid to the specification and installation of fire-stopping materials in order to maintain the fire integrity of the compartment or sub-divided space and ensure that the hazard is fully protected for the entire design period. Careful selection of materials is important to ensure that there is no early failure.

Susceptible equipment and stock will require full protection against heat damage by conduction or radiation on the non-fire side of the enclosure. Where necessary the level of insulation should be the same as for fire integrity and this is equally applicable to doors and service installations as described in Part 4.

Smoke

The areas or equipment etc. under consideration in this Appendix may either be capable of producing large volumes of smoke or will be very sensitive to smoke and each scenario may result in serious business interruption. Reference should be made to 3.1.2.3 - Prevention of smoke spread.

Particular care should be taken to ensure that all joints are sealed and seals around services are properly selected and fitted. Doors should conform to the recommendations in 4.2.6 regarding smoke control doors.

Equally important is the specification of suitable protection for service ducts that pass through or emanate from the enclosing walls of such areas.

Water damage

Where appropriate, precautions should be taken to protect sensitive areas and rooms against ingress of fire extinguishing water. Particular attention should be paid where concealed spaces are provided beneath floors for the passage of services.

Concealed spaces

Where appropriate it may be necessary to consider fire-resisting ceilings or subdivision of the concealed space into smaller areas. It is vital that the materials are appropriate and that effective fire and smoke control is provided. If fire-resisting ceilings are to be considered any light fittings should have equal fire resistance. For this reason it is preferred that the area above the ceiling of any room under consideration be considered as part of the room and that enclosing walls are extended beyond the ceiling up to the underside of the roof or floor above. Cavity barriers should not be considered for the extension of the compartment or sub-dividing walls above the ceiling and the wall should be of the same construction for its full height.

Appendix 3D

The building as an entity

D1 GENERAL PRINCIPLE

Regardless of how well an individual element is designed and constructed and even, to some extent, how it is installed, the reduction of fire spread can only be effective if the building itself behaves in a predictable manner. The interaction between the elements should not cause elements to move and produce large gaps or to collapse prematurely. It is recommended that before a building is accepted as satisfying the compartmentation requirements an analysis is made of the behaviour of the building as a whole.

A full appraisal of the behaviour of a building would require all aspects of the structural behaviour to be considered together with all possible fire scenarios. However it is not possible to take the full range of possible conditions into account and it is the recommendation of this *Design Guide* that the appraisal only considers the behaviour of the building when the individual elements are exposed to the heating and pressure regimes specified in BS 476: Part 20, unless it can be established that the conditions do not apply in which case the anticipated response may be modified. As an example, it could be completely inappropriate to use the pressure regime specified in BS 476: Part 20 for tall compartments or external fires and therefore results from this test may be pessimistic in respect of the flow of heat or gases through the construction.

Using this assumption as the basis for the building appraisal, it will therefore be possible to use the results obtained from fire-resistance testing to BS 476: Parts 20 to 24 to estimate the likely response of the building.

Fire-resistance testing generally only considers single elements in isolation and evidence generated as a result of the test is therefore only of limited value in determining the ultimate behaviour of the building. A detailed analysis of the behaviour of a building is beyond the scope of this document but an understanding of basic structural engineering, combined with the material behaviour identified in Appendix 3A2 would allow a reasonable prediction to be made of the behaviour of the structure as a whole. The objective of this analysis would be to establish whether the overall fire integrity can be significantly reduced due to gaps occurring as adjacent elements deflect in the hot state. Similarly the spread of smoke is increased by such movements.

The following facts should be considered when carrying out an appraisal of the behaviour of the structure under fire exposure.

- (1) Structural deflections are primarily thermally induced.
- (2) Changes in load do not significantly affect thermal deflections.
- (3) Deflections can cause significant problems when there is a need to ensure compatibility of movement between adjacent members.
- (4) Deflections can cause adjacent non-heated members to be damaged or collapse, and may cause gaps to occur between elements. These gaps will cause an integrity failure and assist in fire and smoke spread if they are not anticipated and accommodated at the design stage.

Text continues on page 60.

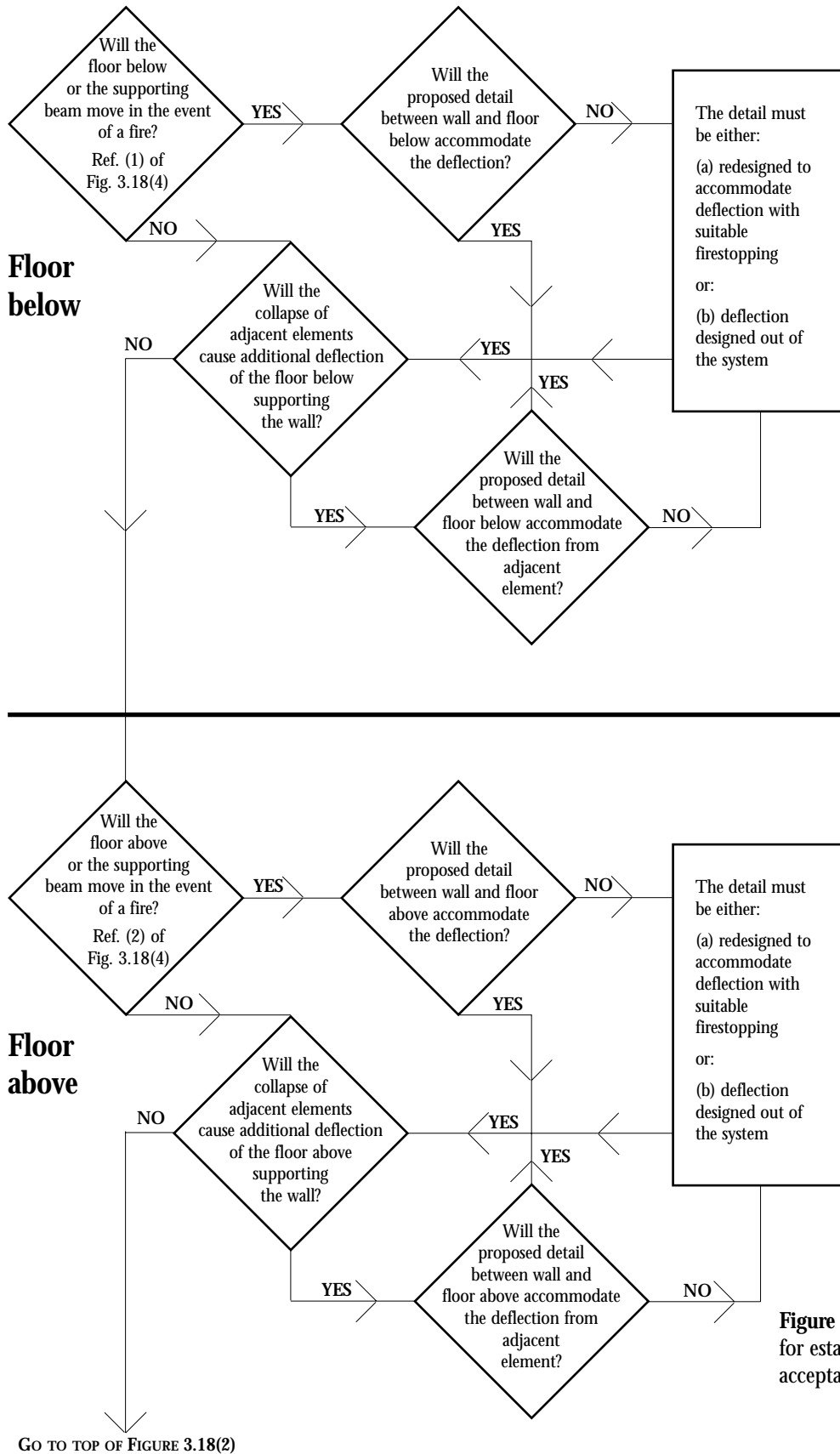


Figure 3.18(1). Decision tree for establishing the acceptability of a

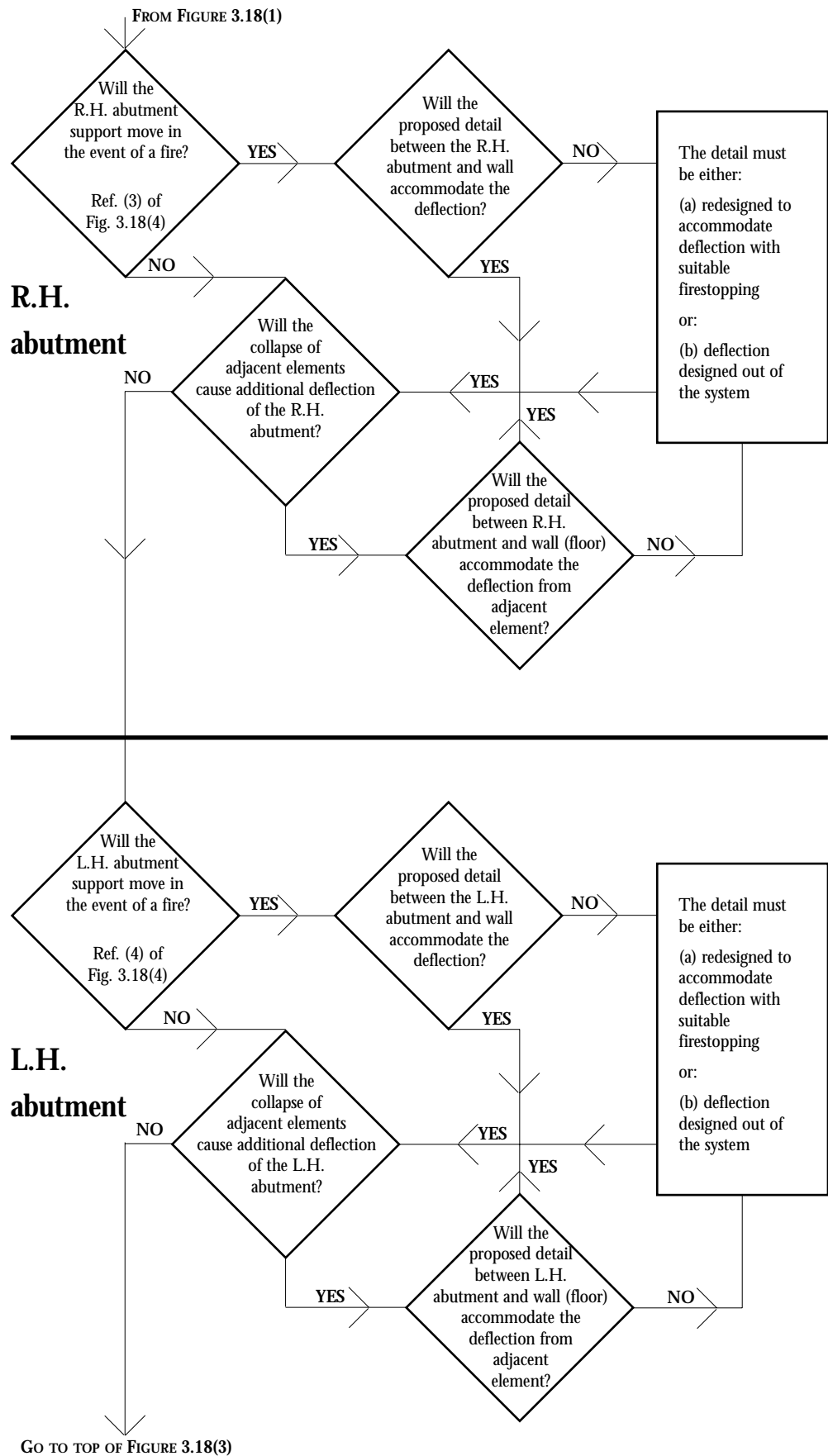


Figure 3.18(2)

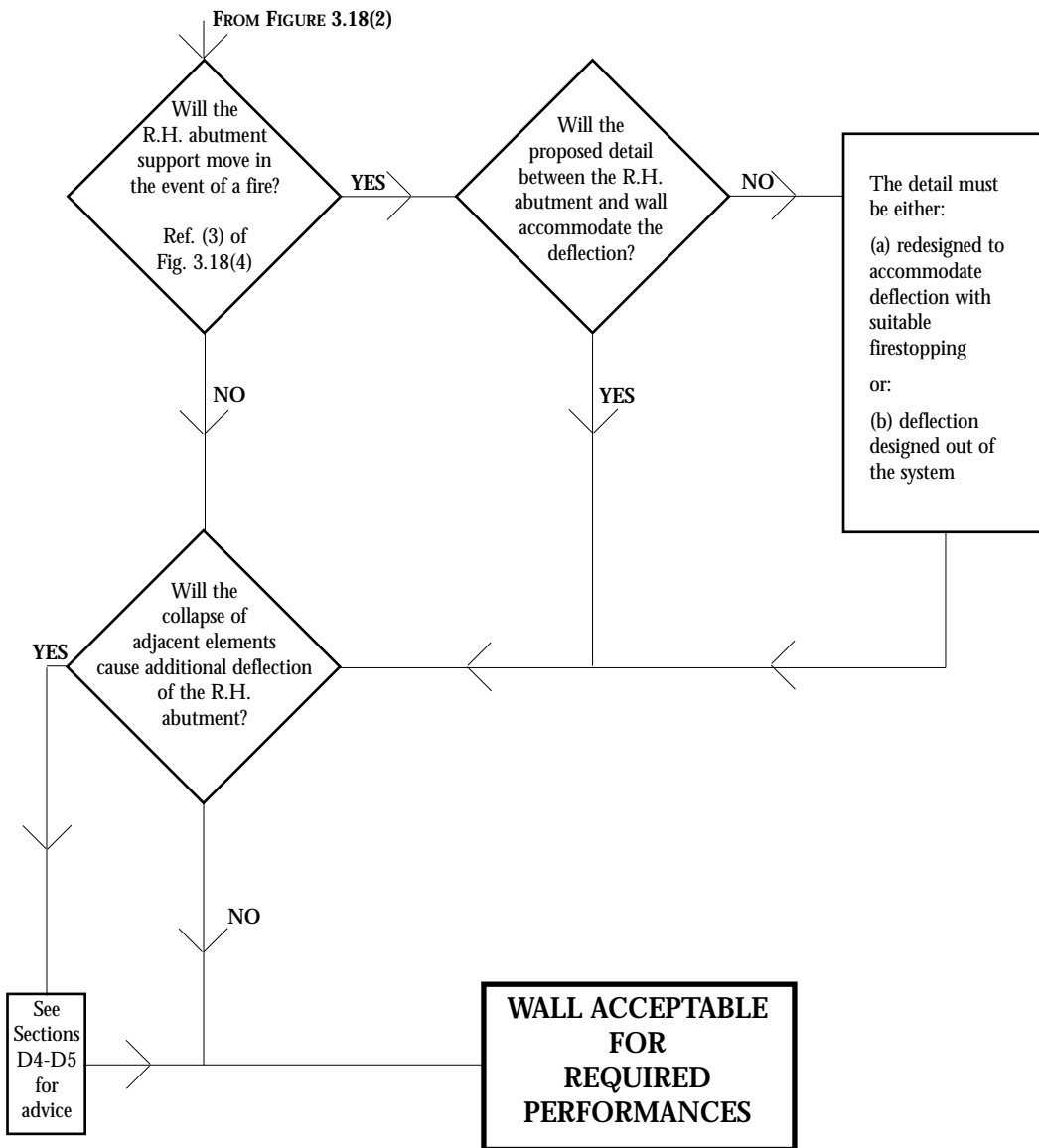


Figure 3.18(3)

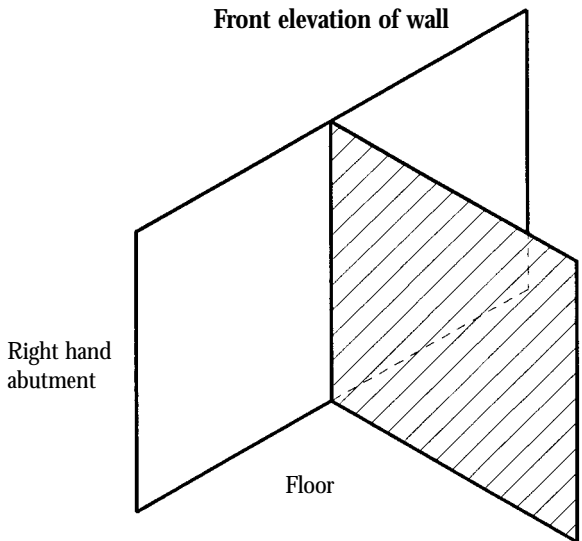
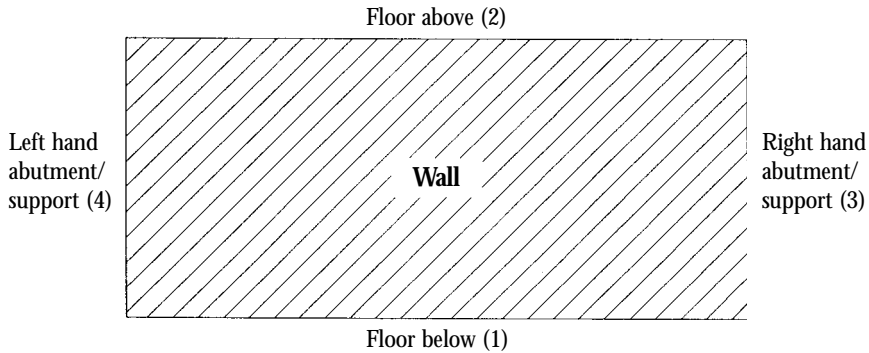


Figure 3.18(4). Key to decision tree shown in Fig. 3.18(1)-3.18(3)

- (5) Unprotected steelwork, whether or not forming the structural frame part of a separating element, will deflect to a greater extent than protected steelwork.
- (6) Deflections should be designed out of the system by using suitable levels of restraint so they do not occur.
- (7) If (6) is not possible then the magnitude of the deflections should be calculated or estimated and then the structure should be designed accommodate these deflections.

These principles give the appraiser guidance on issues relating to maintenance of compartmentation during a fire which need to be considered when assessing the likely damage in a building. There are a number of issues relating to the performance of windows, ducts and other penetrations, and possible disruption in these elements as a result of thermally induced movement should also feature in the appraisal.

Part 6 will give further information on the behaviour and support requirements for such elements.

D2 THE DESIGN PROCESS

The only way that the performance of a building in its entirety can be guaranteed is if each individual element is guaranteed to work in its environment. To establish this it is necessary to carry out a brief analysis of each element when considering its performance in the context of the elements bounding it. This is achieved by considering each edge of a separating element in turn to see if it can retain the fire integrity along that edge. In the case of a non-separating element, the behaviour at each end should be considered in turn to ensure that any movement does not reduce the integrity at or near the junction, nor produce any significant change in the restraint conditions. A decision tree approach, as given below, is recommended.

D3 THE DECISION TREE APPROACH

A decision tree has been established to assist in the appraisal of a building. This is detailed below:

There are a number of comments relating to this decision tree given in Figure 3.18(1)-3.18(3):

- (i) if it is possible to follow the flow diagram straight down the left-hand side to the end point then the construction as tested is suitable without the need for any design or construction changes;
- (ii) if the design needs to be changed, as a result of a 'yes' decision, indicating that the performance would be adversely affected by the movement, then the decision will need to be made either to prevent the deflection, or to accommodate it, and D4 and D5 should be consulted for recommendations as to how this may be achieved.

D4 DESIGNING OUT THE DISTORTION

Should the appraisal indicate that the anticipated distortion cannot be accommodated by either the elements bounding the wall or floor under consideration, then the distortion should be restricted. There are a number of

ways that this can be done dependent upon the practicality, cost or effectiveness of the various methods. A list of the possible options is given below:

- (i) apply protection to the distorting element in excess of any protection required for it to satisfy the fire resistance test;

Note: according to BS 476:Part 21, the loadbearing capacity criteria for any element can be satisfied and yet have large resultant deflections. A floor with a span of 4m is able to deflect 133mm and still comply with the requirements of the above fire test Standard. A non-loadbearing element has no limit on the deflection as long as the distortion does not cause gaps to develop within the structure of the element.

- (ii) use a construction that has a greater cross-section than is needed to satisfy the loadbearing or stability requirement for the element. This will mean that the element will be subjected to lower stress levels and will have a greater stiffness, remain cooler due to increased thermal inertia and hence reduce its tendency to bow. In a situation where fire attack could be from either direction this will, in practice, mean that extra thickness is required on both sides;
- (iii) increase the restraint on vertical elements either by restraining it on the cool, protected side of the construction, or to add protection to adjacent elements on the hot face including any bracing so that they may provide additional restraint of the deflecting element. In the case of horizontal elements additional protected supports may be provided, see 3.2.1.2.7 (iii);
- (iv) when collapse is inevitable the structural joints should be designed so that the collapse takes place in a known manner, away from the critical location allowing the members or elements immediately adjacent to the wall or floor to remain plane. An example is described in 3.2.1.1.1 (b), (iii) and shown in Fig. 3.5.

The analysis and the subsequent selection of a suitable system for controlling the deflection may well require input from a suitably qualified fire safety engineer or a structural engineer fully conversant with the fire engineered construction.

D5 ACCOMMODATING THE DISTORTION

Should the appraisal indicate that the distortion cannot be prevented by design, it is important that the structure can accommodate the anticipated distortion. It may be possible to incorporate this into the basic design, for example; where two adjacent elements are predicted to bow then the size of the gap can be restricted if, in the case of two dissimilar elements, the stiffer of the two passes over the end of the less stiff element, rather than the other way round. Frequently the gap will need to be sealed with a linear gap sealing system that is able to meet both the cold performance requirements and maintain the fire and smoke resistance in the 'hot' condition.

D6 SELECTING A JOINT SEALING SYSTEM

Where the thermal distortion cannot be prevented by restraint, then the sealing system between the elements should be able to accommodate the maximum

predicted deflection resulting from non-sympathetic distortions. In the case of a joint between two vertical elements the gap will probably increase as the fire duration increases. With the joint between a vertical element and a horizontal element where a seal is put in place to accommodate the vertical movement of the floor then the gap will reduce as the fire duration increases. At this maximum gap width the flexible seal is required to maintain the integrity, with respect to the cotton pad criterion of BS 476:Part 20:1987, and insulation of the compartment for the designated durations given in Part 2: General Principles. Generally the seal will need to become more effective as the environment heats up, rather than less effective. This would tend to indicate that intumescent sealing systems are better than inert seals, especially where the gap is opening up.

Where sealing the gap between elements which separate different occupancies, the seal should also resist the spread of both hot and cold smoke. It is unlikely that a mineral fibre seal, which will lose its binder during the heating process, will have the necessary impermeability to restrict the flow of smoke unless it is subsequently coated with a high-temperature sealing material. Where there is anticipated movement between the elements in normal service the seal should, in use, be capable of accommodating the service movement. Where the materials are different in nature, for example timber and concrete, the seal should be supported by evidence of performance, or a field of application, that covers the following:

- (i) duration of fire resistance;
- (ii) the maximum anticipated gap width;
- (iii) the materials forming the gap.

The design of a detail capable of accommodating the deflection will depend on the system being installed and will therefore be particular to the element being appraised. The detail should be capable of tolerating the deflection without a premature reduction in the insulation or integrity at the joint. The detail should be assessed by a suitably qualified fire safety engineer to ensure its performance, if the application is not covered by the direct field of application for the seal.

If fire stopping is to be used and is to be located between walls (or walls and floors) of different material types, then the fire-stopping material should have been tested with the different material types being used as the substrate.

Further information on the selection of fire-stopping and/or linear gap-sealing systems and materials is given in 4.5.

D7 EXAMPLES OF HOW TO PERFORM A COMPLETE BUILDING APPRAISAL

Consider the following example relating to a large single occupancy portal or lattice framed retail building where separation between the storage and display areas is required.

D7.1 FIRE PERFORMANCE

It is necessary to establish the required fire resistance performance for the separating element. Table 3.1 provides guidance in this selection process by identifying which of Tables 2.1 or 2.2 or the provisions of Appendix 3C is

applicable. The performance requirement of the wall shown in Fig. 3.4, a separating element, is maintenance of integrity and insulation as laid down in 3.2.2.2, even when the structure has collapsed, on the fire exposed side.

The structural elements supporting the separating element should have a similar fire resistance as the structural elements in the plane of the separating element. This will ensure that no heat-induced structural deflection of the portal or lattice frames or purlins will adversely affect the performance of the separating wall and resist any overturning moment as a result of the wall being heated.

D7.2 PREVENTING INTERNAL FIRE SPREAD

The proposed arrangement of loadbearing elements (and their fire protection) to the elements needed to maximise the separation function of the wall shown in Fig. 3.4 is as follows:

The portal or lattice frame surrounding the separating element is protected against fire within a protected zone to limit structural deformation and will not therefore move significantly in the case of a fire and impose loads on the wall.

Within the protected zone the portal or lattice frames adjacent to the separating element and the roof purlins between this and the wall should also be protected and cross-braced to prevent any torsional loads being transferred to the portal supporting the separating element. This will prevent loads being transferred to the portal surround and supported wall, as a result of collapse of the roof which would otherwise cause twisting and deflections of the supporting elements.

D7.3 PREVENTING EXTERNAL FIRE SPREAD BY-PASSING THE WALL OR FLOOR

External fire spread can by-pass compartmentation and various measures need to be taken to prevent this.

Protection of the external cladding in a protected zone on either or both sides of the compartment wall is provided to prevent external spread along the wall as recommended in 3.3.1.2 and shown in Fig. 3.16. This will prevent the fire from burning back into the adjacent compartment, on the other side of the compartment wall.

Fire spread from floor to floor via the external wall is covered in 3.3.1.3.

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4 Protection of openings and services

4.1 Introduction

4.1.1 SCOPE

This part of the *Design Guide* deals with the protection of openings or gaps in compartment walls and compartment floors and the protection of services. The following are covered:

- Fire-resisting doors, including escalator/horizontal rolling shutters, laterally operating shutters, rolling shutters, closures for conveyors and lift landing doors.
- Fire-resisting windows and glazed screens.
- Ducts and other building services.
- Cavity barriers.
- Fire stopping and linear gap sealing.
- Protection of services.

This *Design Guide* does not deal with means of escape issues and, consequently, some of the relaxations allowed for uninsulated constructions such as doors and glazing may not be appropriate if the escape route runs along a compartment wall incorporating uninsulated constructions. Reference to integrity and insulation made in this part of the *Design Guide* relates to the performance criteria of BS 476:Part 20:1987 or prEN 1363-1

This part of the *Design Guide* refers to a number of draft ISO (DIS or CD) or CEN standards (prEN). Where there exist equivalent British Standard tests or ad-hoc procedures based on procedures similar to the draft ISO or CEN standards these may also be deemed to be acceptable.

4.1.2 PRINCIPAL DESIGN CONSIDERATIONS

The fundamental principle used in this part of the *Design Guide* is that openings have to at least maintain the integrity of the compartment wall or floor for the periods specified in Tables 2.1, 2.2 and 3.1. The requirements for insulation will depend on the overall risk assessment. However, when there is a possibility that combustible materials may be in direct contact with any part of the surface, then the insulation requirements specified in Tables 2.1, 2.2 and 3.1 should be met in full. Some reduction in insulation may be allowed if combustible materials will not be in direct contact but are unable to be outside the safe distances given in 4.2 and 4.3. In respect to doors, it is probably unlikely that their surfaces will be in direct contact with combustible materials.

Where there is a requirement for smoke control either as regards compartmentation or separation of critical equipment etc as detailed in Part 3 and Appendix 3C it should be ensured that all openings or gaps are suitably sealed against penetration of smoke. Reference should be made to 4.2.6 for guidance.

References to occupancy or occupancy types are those which are defined in Part 2 and Part 3 of this *Design Guide*.

This part of the *Design Guide* is drafted on the basis that if the recommendations given in Parts 1 to 3 are to be followed then the provisions given in Part 4 shall be complied with. All products covered in this part of the *Design Guide* should be manufactured within the factory production control standards specified in ISO 9002 as a minimum by independently certified firms. **Products that do not cannot be claimed to meet the recommendations given in this *Design Guide*.**

Doors and dampers that remain open in service and have to close to seal an opening in compartment walls or floors should be provided with an automatic closing device connected to a smoke detection system. (Fusible link may still be incorporated as a backup.) Doors and dampers shall be sufficiently robust to maintain their intended function for at least 20 years. With respect to doors, this will be deemed to be satisfied if the door can satisfy the requirements of 4.2.9.2. Dampers will need to meet fully the requirements of LPS 1162. Subject to routine maintenance and correct installation, LPCB approved products can be deemed to meet that requirement. All other systems used for the protection of openings or services shall maintain their intended function for at least 20 years.

Restrictions on opening sizes are based on both sensible extrapolation of test results in respect to integrity and additionally, for uninsulated constructions, radiation, together with acceptable and practical safe distances to combustible materials.

4.1.3 DEFINITIONS

4.1.3.1 Air transfer grille

Non-ducted grille installed in doors or partitions to allow air to transfer naturally from one room or zone to another without connection to a mechanical ventilation system.

4.1.3.2 Automatic closing mechanism

Closing device operated by smoke detectors (sited on both sides of the compartment wall) forming part of an automatic fire detection system. The operation of such a detector should activate both visual and audible warnings and cause the door or shutter assembly to close automatically without any delay. A fusible link operated mechanism may be fitted additionally.

4.1.3.3 Automatic door closer

A device fitted to the face or edge of a door and its frame to ensure that the door automatically closes each time it is used.

4.1.3.4 Building services

Electrical cables, pipes, ducts, trunking etc.

4.1.3.5 Cavity barriers

A fire-resisting barrier, not less than 100mm high, installed in a ceiling void, platform floor void or roof space, that is able to provide the required fire resistance and other requirements of this *Design Guide*, as appropriate.

4.1.3.6 Conveyor closer

A device or system that in the event of a fire will close automatically and seal the openings in compartment walls or floors that, when tested to BS 476: Part 22: 1987, satisfies the appropriate fire resistance and other requirements of this *Design Guide*.

4.1.3.7 Double door

In the context of this *Design Guide*, the use of two or more door assemblies in series, that is, in tandem, in order to provide increased fire resistance with respect to one or more criteria.

4.1.3.8 Fire-resisting damper

A damper installed in an air distribution system that, when tested to prEN 1366-2 or ISO 10294-1, provides the required fire resistance and other requirements of this *Design Guide*, as appropriate.

4.1.3.9 Fire-resisting door or shutter assembly

A door or shutter, of any design and construction which, when tested to methods 6, 7 or 8 given in BS 476: Part 22: 1987¹ or prEN 1634-1, provides the specified level of fire resistance and any other requirements of this section of the *Design Guide*, as appropriate to its design and use.

4.1.3.10 Fire-resisting duct

A duct used for the distribution of air that, when tested to BS 476: Part 24: 1987 (ISO 6944: 1985) or prEN 1366-1, provides the required fire resistance and other requirements of this *Design Guide*, as appropriate.

4.1.3.11 Fire-resisting smoke extraction ducts

A duct, which passes through compartment walls or floors, which in the event of a fire is designed to extract smoke to outside the building. For the purposes of this *Design Guide*, this duct shall satisfy the requirements of EN 1366-1 and prEN 1366-8.

4.1.3.12 Fire-resisting glazed screen assembly

An assembly of glass panes, mounted in a steel or timber frame, which when installed forms part of a fire compartment wall, that when tested to method 10 of BS 476: Part 22: 1987¹ provides the required fire resistance and meets the requirements of LPS 1158 or equivalent and in addition other requirements of this *Design Guide*.

4.1.3.13 Fire-resisting service duct

A duct used to enclose building or other services, that when tested to prEN 1366-5, provides the required fire resistance and other requirements of this *Design Guide*, as appropriate.

¹ Test evidence generated with respect to BS 476: Part 8: 1972 before 1 January 1988 remains valid subject to the test having been performed after 31 December 1981, the date at which testing became effectively harmonised under the guidance of the DoE.

4.1.3.14 Fire stopping

A sealing material designed to make good any imperfections in fit such that the required fire resistance of the wall or floor, in terms of integrity, and insulation if appropriate, is maintained.

4.1.3.15 Lateral shutter

A door comprising a horizontally moving curtain primarily used for closing off large openings such as occur at the entrance to individual shops in shopping centres.

4.1.3.16 Linear gap fire seal

A fire-resisting barrier, installed in a gap not more than 100mm wide in a wall or floor, or around building services, that is able to provide the required fire resistance and other requirements of this *Design Guide*, as appropriate. Linear gap seals may be static in action or may be intended to allow movement between adjacent construction elements under normal service conditions, and under fire conditions maintain the integrity and where specified insulation of the gap.

4.1.3.17 Penetration seal

A system for sealing any void in a compartment wall or floor through which building services pass which, when tested to prEN 1366-3, provides the integrity requirement specified in this *Design Guide*.

4.1.3.18 Radiation reducing curtain

For the purposes of this *Design Guide*, an insulated curtain that is able to keep its unexposed face surface radiation below 20kW/m^2 when exposed to the time-temperature curve of BS 476: Part 20: 1987 for the appropriate fire resistance periods given in Table 2.2 of this *Design Guide*.

4.2 Fire-resisting door and shutter assemblies

This section replaces the LPC Rules for the Construction and Installation of Firebreak Doors and Shutters, which is now withdrawn.

4.2.1 TYPES OF DOOR AND SHUTTER ASSEMBLIES

This section describes the requirements covering the performance of doors and shutters that may be installed in compartment walls, shafts or enclosures around openings in compartment floors as defined in Parts 2 and 3 of this *Design Guide*. It is however recommended to designers that these guidelines also be used for fire-resisting walls which are not regarded as compartment walls in the context of this *Design Guide*.

The requirements are expressed in terms of performances in respect of the criteria given in BS 476: Part 22 together with any additional requirements laid down in the *Design Guide* and by denoted certification bodies for timber and mineral cored door assemblies. It is strongly recommended that only steel-faced doors and those industrial doors approved by LPCB are specified.

This section also includes requirements for escalator roller shutter doors installed in enclosures surrounding openings in compartment walls and floors.

Conveyor closers, used for the protection of openings in compartment floors where mechanical transport systems pass through, are also covered. Lateral shutters shall meet the requirements for uninsulated doors given in 4.2.4.1.

Examples of door and shutter assemblies covered are shown in Table 4.1, which in addition gives typical applications for these within the context of this *Design Guide*.

4.2.2 GENERAL DESIGN AND USE CONSIDERATIONS

The effectiveness of a door in retaining its fire-resisting capability is dependent upon its conditions of use and it is an insurance requirement that doors in compartment walls be maintained in efficient working order and be kept closed except during working hours (whether or not automatic closing devices are fitted).

It is also important that doors and shutters are kept free of goods that might obstruct their operation and that their operation (including that of any automatic closing devices fitted) is regularly checked. When not in frequent use doors and shutters should be kept closed.

Door openings used for the passage of fork lift trucks and the like should be provided with adequate protection, for example, bollards or recessed guides to prevent mechanical damage to the door/shutter assembly, frame and wall opening.

In order to prevent any health and safety risk to employees, it is recommended that personnel doors be provided, adjacent to large industrial doors and shutters used for the passage of goods, to facilitate escape.

To reduce any potential, especially where identified by the risk assessment, for additional damage caused by flowing extinguishing water or hazardous liquids, the floor of the building should be dished or all door openings provided with ramped raised sills to contain such liquids in the building on fire.

The occupancy types listed in Table 4.1 are not necessarily the only ones that the various assemblies can be used in. However, in respect to formulating the recommendations in this part of the *Design Guide*, it has been assumed that the following are the typical applications. Table 4.1 is not an exhaustive list of door types or potential applications.

4.2.3 SIZE OF OPENINGS

4.2.3.1 *The influence of size on the fire resistance of door and shutter assemblies*

Test results alone should not be accepted for door and shutter assemblies above the tested size unless allowed for in the field of application of prEN 1634-1.

The fire resistance rating of a door assembly is greatly influenced by its size. The larger the leaf, or opening element, the greater is the potential distortion and, hence, the size of any through-gap that develops as a result. This can directly influence the integrity rating.

All over-size LPCB certified doors are subjected to an engineering analysis and maximum opening sizes are given which for the purpose of this *Design Guide* shall not be exceeded unless the scope of the certification has been extended to cover specific applications. This information is given in the Loss Prevention Certification Board's *List of Approved Fire and Security Products and Services*.

Table 4.1. Typical applications for various types of fire-resisting doors and shutters.

Door type	Application	Occupancy type ²
Timber and mineral cored, timber faced doors	Means of escape, access compartment walls and shafts	All occupancy types covered in this <i>Design Guide</i>
Hinged steel door	Means of escape, access compartment walls and shafts	All occupancy types covered in this <i>Design Guide</i>
Roller shutter doors and lateral operating shutters	Access only, not means of escape ¹	Shop and commercial; retail warehouses and superstores; industrial; storage
Folding shutter and industrial lift doors	Access only, not means of escape ¹	Industrial; storage; commercial; retail
Sliding door	Access only, not means of escape ¹	Industrial; storage; commercial; retail.
Lift landing door	Access to lift cabin (outer door)	All multi-storey buildings
Escalator shutter	Floor openings	Floors in same occupancy type only
Conveyor closer	Conveyor and other mechanical transfer systems	Industrial; storage

¹ As the recommendations in this part of the *Design Guide* are for all doors to be fitted with automatic closers (4.1.2), this type of door may be considered suitable for access through compartment walls but unsuitable for protecting means of escape.

² The occupancy types listed are not necessarily the only ones that the door can be used in. However, in respect to formulating the recommendations in this part of the *Design Guide*, it has been assumed that these are the typical applications.

4.2.3.2 Maximum opening size

Regardless of the above advice on the extended field of application for increasing the size of assemblies based upon the test result, the recommended maximum opening sizes for the various door types are as given in Table 4.2.

It is assumed in setting these sizes that the opening into which the assembly is fitted is formed by the use of a lintel that complies with BS 8110 for the appropriate fire resistance duration. If an alternative form of construction is used the lintel together with any applied fire protection shall have a proven level of fire resistance at the intended span and taking into account the attachment of the door or shutter assembly, and any loads applied.

For the purposes of this *Design Guide*, in order to ensure that it is used in applications for which it is suited it is recommended that no door opening should exceed the following sizes:

Table 4.2. Recommended maximum allowable openings size of any single door assembly with respect to this *Design Guide*

Door type ¹	Height (m) ³	Width (m) ³
Timber doors (single leaf)	2.8	1.1
Timber doors (double leaf)	2.8	2.2
Hinged steel door (single leaf) ²	3	1.5
Hinged steel door (double leaf) ²	3	3
Roller shutter doors ²	7	7
Lateral-operated shutters ⁴	4.6	15
Folding shutter and industrial lift doors ²	7	7
Sliding door ²	4	4
Lift landing door (non-industrial)	3	3
Escalator shutter	Max width 5m	Max length 15m
Conveyor closer	1.5	3

¹ For specific requirements see 4.2.12.

² If the door is uninsulated, the safe distances given in Fig. 4.1 and the separation between adjacent doors given in Fig. 4.4 should be complied with. A radiation profile, an example of which is given in Fig. 4.2 should be derived for the specific door to establish safe distances away from the centre of the door. If this cannot be undertaken, then the method shown in Fig. 3.11 of Part 3 of this *Design Guide* can be used with the radius of the profile being the same as the safe distance given in Fig. 4.1.

³ These limits are for guidance based upon examination of available test data on the various door and shutter types, and it is essential to establish by assessment the integrity, insulation or radiation performance of the specific assembly when installed in a particular form of compartment wall construction. However, these limits may be exceeded in the following circumstances:

- (i) In respect to insulating door assemblies any increase in dimensions shall be substantiated by an independent assessment, undertaken to confirm that the integrity requirements will still be satisfied and that the door continues to satisfy the insulation requirements in full.
- (ii) In respect to uninsulated doors, some increase in dimensions may be acceptable when double doors are installed, subject to an independent assessment being undertaken to confirm that the integrity requirements will still be satisfied and that the distance from combustible materials is not less than given in Fig. 4.3.

⁴ Recommended maximum size subject to risk assessment by insurer on an individual case-for-case basis.

4.2.3.3 Restraint on the leaf and direction of exposure

When a door is used at sizes close to its maximum permitted size then the achievement of the required fire resistance at this size will often vary dependent upon the restraint provided to prevent distortion of the leaf, leaves or curtains. This restraint can take a number of forms:

- (i) nature, type and make of retaining devices such as latches, locks etc;
- (ii) door closing devices, for example, overhead face fixed closers;
- (iii) intumescent seals, particularly in respect of insulated leaf assemblies; where pressure forming leaf/frame edge seals are used;
- (iv) control of leaf-to-frame gaps, particularly in respect of metal faced assemblies, where the expansion of the leaf into the fixed frame causes the assembly to lock into a closed position. It is imperative that the assembly is installed in an identical way to that which was tested or subsequently assessed and no substitution of hardware or intumescent seals is permitted without being the subject of a fire engineering

judgement. Control of the door-to-frame gaps is also important as significant changes in these gaps can affect the effectiveness of seals, reduce the amount of penetration of latch/lock fore-ends or upset the predicted expansion/restraint behaviour.

Further guidance on these aspects is to be found in Part 6 of this *Design Guide*.

4.2.4 UNINSULATED DOORS

4.2.4.1 General

Uninsulated doors or shutter assemblies, that is, those evaluated by means of the procedures given in clause 8 of BS476: Part 22, can reduce the effectiveness of a fire-resisting wall as a result of:

- (i) loss of integrity;
- (ii) heat transfer by means of conduction;
- (iii) heat transfer by means of radiation.

As door assemblies are moving elements the likelihood of fire spread as a result of conduction is effectively ignored in this *Design Guide* and in UK fire legislation since combustible materials should not be in contact with them.

Note: Redundant non-insulating door assemblies must not be allowed to be treated as other parts of the structure which should meet the insulation requirement, for example, compartment walls. No combustible goods shall be permitted to be stored in contact with such doors after they have become redundant and safe storage distances shall continue to be observed.

4.2.4.2 Integrity

The door or shutter assembly shall provide the integrity rating appropriate for its intended position and use (see Tables 2.2 and 3.1), and as determined by the methods described in clause 8 of BS476: Part 22.

Integrity losses generally occur in uninsulating doorsets and shutter assemblies as a result of the development of gaps between the frame and the leaf, or between adjacent leaves. Size of the assembly can influence the generation of such gaps.

4.2.4.3 Radiation

Even when the door or shutter assembly is fully closed the high temperature exhibited by the unexposed face is able to cause fire spread by radiation heat transfer. The safe storage distance is influenced by the intensity of the radiation, the area of the radiating surface and the height/width ratio and the susceptibility of the stored material/goods, furniture etc to ignition by radiation. **This is discussed further in Appendix 4.2B.**

The unexposed face temperatures used in establishing the safe storage distances given in Fig. 4.1 are derived empirically using test data generated from steel, single skin roller shutters but would be similar for steel, uninsulated flush doors.

The safe distance for storing combustible materials from the face of the assembly is based on the thermal conductivity of the door, its emissivity, its area

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and aspect ratio, and guidance as to what is that safe distance is given in Fig. 4.1 below. This is based on a lateral separation between adjacent doors of not less than 3m and relates to doors having the same height and width since this represents the worst case in terms of maximum radiation intensity at the centre of the door.

Where double door assemblies are installed one on each side of the opening, that is, in tandem, then the distance from combustible materials may be reduced, see Fig. 4.3. If further reduction is required, then consideration should be given to the incorporation of a lobby, see 4.2.14, or by single doors

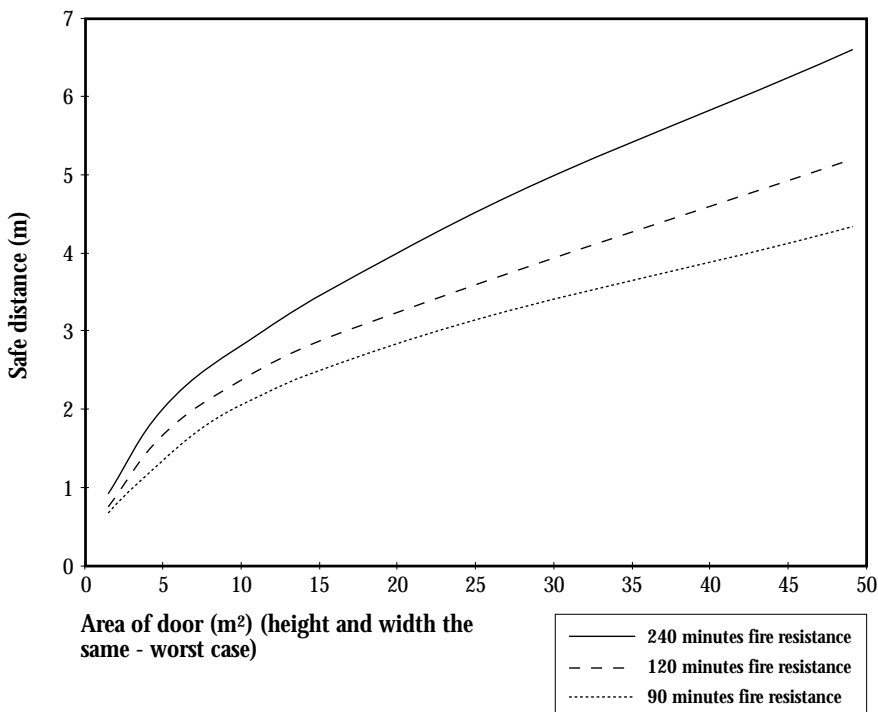


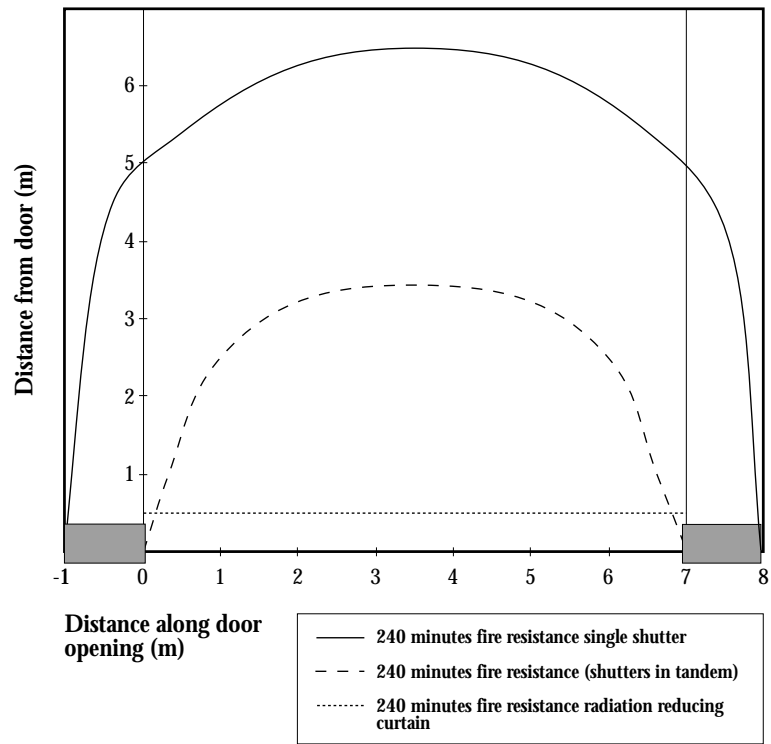
Figure 4.1. Safe distance for combustible materials from single shutters.

incorporating some insulation that reduces radiation (radiation reducing).

Figure 4.1 shows the safe distances (m) for combustible materials from an uninsulated 90, 120 and 240 minute fire-resisting shutter doors based on area of door (m²). (This value is just in excess of the distance where the auto-ignition of cotton fabrics will occur - 25kW/m² - and is based on the peak value of radiation at the centre of the door and assumes that the height and width are the same, as this represents the worst case.)

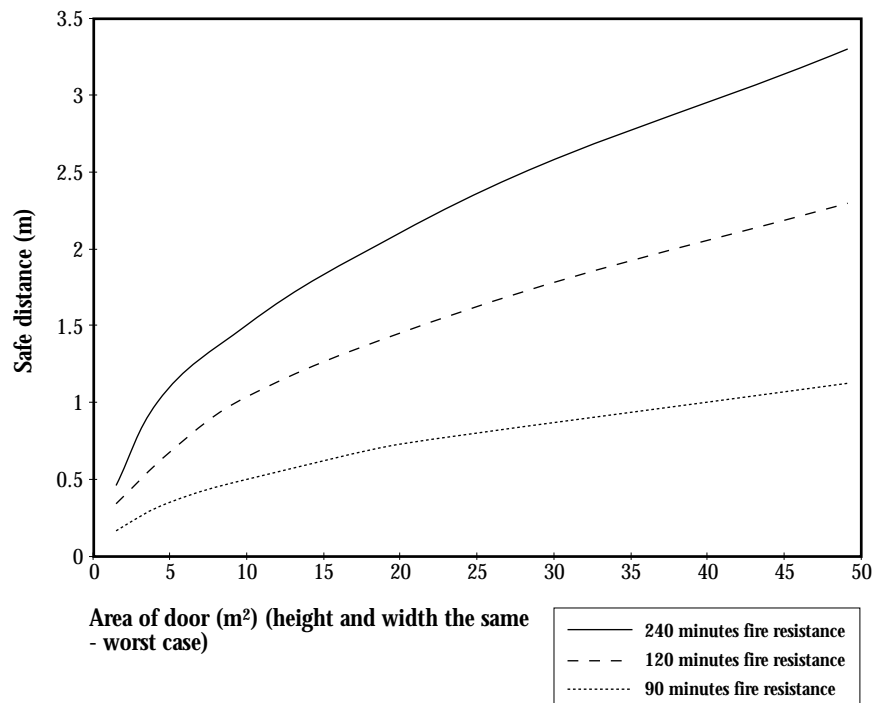
As shown in Fig. 3.10 of Part 3 of this *Design Guide*, a reduction in radiation occurs away from this central position and this is shown below in Fig. 4.2. for a 7m by 7m roller shutter door. Any combustible material should be outside the profiles shown.

Figure 4.2. Radiation profile showing safe distance for storage of combustible material from a 7m by 7m shutter - single, double and radiation reducing shutter.



For guidance, the safe distances for 90, 120 and 240 minute fire-resisting double roller shutters (two shutters in tandem, one on each side of the wall opening) is shown in Fig. 4.3. This relates to doors having height and width the same since this represents the worst case in terms of maximum radiation intensity at the centre of the door.

Figure 4.3. Safe distance for combustible materials (roller shutters in tandem).



Note: The safe distances recommended for uninsulated doors may be reduced if the compartments on each side of the compartment wall are fully sprinkler protected.

4.2.5 INSULATED DOORS

4.2.5.1 *General*

Insulated doors or shutter assemblies, that is, those evaluated by means of the procedures given in clause 6 of BS476: Part 22, provide higher levels of effective fire separation than uninsulated doors during the period through to when they fail the integrity criteria. This is due to the low unexposed face temperature permitted under the 'insulation' criteria, that is, a maximum rise of 180 deg C anywhere, which automatically reduces the risk of either a conduction or radiation induced ignition on the protected face. Fire can therefore only spread to the protected side if a loss of integrity occurs. This is symbolised on the unexposed face by:

- (i) continuous flaming at any position;
- (ii) the flow of critical levels of hot gas, such that it would ignite the cotton pad test;
- (iii) the development of gaps in excess of 25mm in two directions or the development of a gap greater in width than 6mm, as long as it is at least 150mm long.

Insulating doors can typically either be of timber construction, generally up to 60min fire resistance, or of a timber faced, and possibly lipped, mineral cored and/or framed construction, or be of an insulated steel faced flush door or a metal framed stile and rail construction incorporating insulating glass. In all cases the cotton pad integrity test shall always be used to establish the integrity of the construction regardless of the method of manufacture.

In the context of this *Design Guide* a door is considered to be insulating even when it includes a vision panel glazed with fire glass that does not satisfy insulation for the full integrity period as long as it does not exceed 10% of the leaf area and does not extend below 850mm above floor level.

4.2.5.2 *Integrity and insulation*

- The door assembly shall provide the integrity rating appropriate for its intended position and use when evaluated in respect of clause 6 of BS476: Part 22. A loss of integrity will generally occur at gaps which develop between the leaf and the frame or between leaves. Such gaps result from distortion and deflection, particularly differential movement between the components. This is influenced by the size of the leaf. Without an engineering judgement any increase in leaf sizes shall be restricted to that allowed in the field of application rules in prEN 1634-1.
- The frame shall satisfy the maximum temperature rise criterion, in case combustible materials are located close to the opening. The mean temperature rise criteria is not appropriate for door assemblies or any glazed vision panel complying with the relaxation given in 4.2.5.1

above as material should not be stored directly in contact with the face of the door assembly.

- Glazing shall comply with 4.3.
- Heat activated seals generally play a more important role in maintaining the integrity of insulated door assemblies when compared to non-insulating constructions. The type, quality and positions of these seals¹ should not be changed from those given in any test report or approved in any field of application assessment covering the product, without expert guidance. Changes in these seals may well be used to justify using the assembly at a size greater than that tested or covered by the field of application or extended application but this constitutes an engineering judgement.

4.2.5.3 Maximum opening size

The performance of timber doors is inter-related to the height and width ratio for any particular mode, configuration, hardware/ironmongery and seal combination and this relationship is frequently expressed in the form of an 'envelope' of approval sizes. Such an 'envelope' is given in Appendix 4.2A to this part of the *Design Guide* and when checking whether a particular size of door is approved it is important that it lies within the envelope of approved size. These envelopes are generated taking into account both the direct field of application and, when appropriate, also the extended field of application.

With respect to insulated steel doors, because of the risk of reducing the integrity rating as a result of differential distortion/deflection, it may only be possible to allow a small increase in height and width above the tested size unless an engineering analysis is undertaken. Some guidance is given in the field of application rules of prEN 1634-1. Additional furniture may also be required to control distortion in larger door assemblies. It is therefore important to test the largest possible size of door. (The deformation of such doors may well exceed that of an uninsulated steel door.)

4.2.6 SMOKE CONTROL DOOR ASSEMBLIES

4.2.6.1 Smoke control doors

- All timber and mineral cored and steel single and double leaf doors that enclose areas of special risk or high value as defined in Appendix C of Part 3 of this *Design Guide* should as far as is practical not exceed the specified level of leakage for smoke at ambient temperature of 3m³/h/m at a pressure of 25Pa when tested in accordance with BS 476: Part 31.1.
- Industrial doors that are too large to test, that enclose areas of special risk or high value as defined in Appendix C of Part 3 of this *Design Guide*, should be constructed in such a way to restrict the passage of

¹ Only intumescent seals with proven ageing performance should be used in door assemblies designed to meet the requirements of this guide. Further information on the selection of intumescent seals for door/frame sealing is to be found in Part 6 of the *Design Guide*, or in the Intumescent Fire Seals Association (IFSA) Information Sheet No 1, 'The Role of Intumescent Materials in the Design and Manufacture of Timber Based Fire-resisting Doorsets'. Information on the ageing resistance of intumescent sealing materials is available in the Intumescent Fire Seals Association's Information Sheet No 4.

smoke. (It is not practical at this time to define a leakage limit for industrial doors.)

- Smoke seals make a significant contribution to life safety but can also reduce smoke contamination of the building and any goods or equipment stored within.
- In order to achieve the specified level of leakage all leaf frame perimeter seals need to be fitted almost continuously and all apertures in the leaf/shutter, for example, glazed openings, need to be sealed with a suitable sealant.
- A threshold seal should be fitted to assemblies bordering large spaces as smoke cooling will take place and smoke will penetrate the gap at the base.
- When smoke control is deemed desirable because of the high value, or critical nature of the products or equipment in the protected space, intumescent edge seals will reduce the spread of hot smoke, even though the seals may not be needed to achieve the integrity rating because this is determined by means of gap gauges rather than a cotton pad, for example, assemblies tested to BS 476: Part 22: clause 8, uninsulated doors.
- Information on the selection and installation of smoke seals is given in the Intumescent Fire Seals Association (IFSA) Information Sheets No 3 and 3A, 'Guide to the Use of Smoke Seals in Doorsets'.
- While not providing similar levels of smoke control in the absence of being able to satisfy the criteria given above with respect to BS 476: Part 31.1, a suitable lobby may be considered as an alternative. Fire-resisting doors installed in a suitable lobby may also reduce spread of smoke although not necessarily as effectively as doors tested to BS 476: Part 31.1.

4.2.7 INTERACTION WITH WALL CONSTRUCTION

The performance of a fire door assembly can be substantially affected by the type of wall in which it is installed, together with the method of fixing the door to the wall, because this influences the restraint available to resist deflection/distortion. Any deviations from the fixing specification tested shall be the subject of an extended field of application analysis or an additional fire test. With respect to masonry or concrete walls, it is generally accepted that the following rules apply:

- (i) A test result obtained for a non-insulating fire-resisting door or shutter assembly in a wall made of masonry or concrete (without any cavity) is applicable to the same type of supporting construction with a thickness and density equal to or greater than that of the supporting construction used for the test. However, this rule is only applicable if the method of fixing provides the same or higher mechanical strength than that used in the test. This may not always be the case, as a fixing suitable for clay bricks may be unsuitable when used for aerated concrete. Any deviations from the fixing specification tested shall be the subject of an extended field of application analysis or an additional fire resistance test shall be undertaken.

- (ii) Decreasing the density of masonry or concrete from what was tested can reduce the insulating character of an insulated door assembly and should only be permitted following an analysis of the influence such a change will make.
- (iii) Industrial doors tested in masonry or concrete walls shall not be installed in dry lined, stud construction walls as they do not have the same strength or thermal characteristics, unless tests have been taken with the door installed in such systems. However, if an industrial door has only been tested in a dry lining system, it cannot be assumed that a similar result will be achieved if it is installed in a masonry or concrete wall. When installing insulating metal doors the influence that the supporting construction will have is more complex and in all cases the influence of a significant change in the wall type will need to be considered. Timber frames are unlikely to be affected by such changes.
- (iv) In the case of doors tested in dry lining systems, these require an assessment when any deviations from that tested are undertaken except when the deviation consists of adding additional linings.
- (v) Industrial doors may be fixed directly to protected steelwork constructions provided:
 - any expansion provisions required for the door assembly are still incorporated; and
 - the steelwork is protected to at least the same fire resistance as that required for the door and compartment wall. The fixing of fire-resisting industrial doors to unprotected steel is not permitted within this *Design Guide*.

Unless all the above recommendations are implemented, a premature loss of integrity may occur, and the appropriate level of fire resistance specified in this Design Guide may not be achieved.

4.2.8 SPECIFIC CONSIDERATIONS WHEN SPECIFYING FIRE-RESISTING DOORS AND SHUTTERS

4.2.8.1 Use of multiple doors

Where it is not possible to achieve the level of fire resistance at the required size and to satisfy the insulation and/or radiation criteria to provide the necessary storage distances it may be possible to use two door assemblies in tandem, with a space between them in order to meet the specified fire resistance. The use of this technique shall, however, be considered carefully when assemblies incorporate critical components that are made from temperature sensitive materials, for example, glass vision panels, aluminium overhead closers etc.

Soda-lime glass slumps once its mean temperature reaches approximately 700°C and consequently the effect of putting two doors in tandem will not be additive in respect to fire resistance. In practice, two glazed doors will only add a brief extra duration above the fire resistance of a single door (see Part 6 for further information on fire-resisting glass and its behaviour).

The safe storage distance for combustible materials will be significantly reduced when two non-insulating door or shutter assemblies are installed in tandem,

see Fig. 4.3. This method is particularly recommended when combustible materials are likely to be stored close to the edges of the door opening.

4.2.8.2 Separation between adjacent doors

The information on safe distances to combustible materials is based on a minimum separation between adjacent doors of 3m. For doors having an opening area of less than 16m² this can be reduced to 1m. This is shown in Fig. 4.4 below.

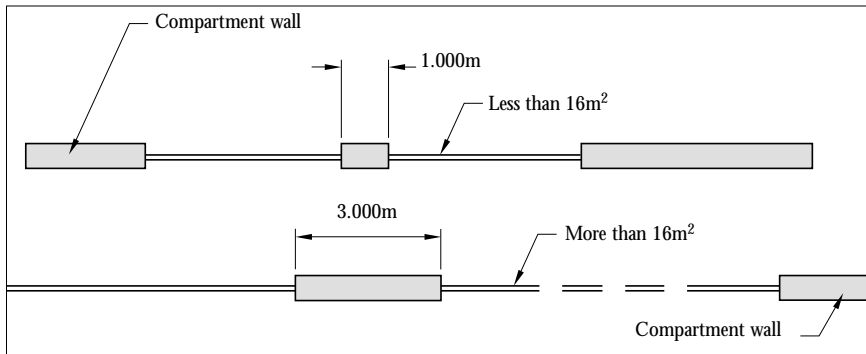


Figure 4.4. Minimum separation between adjacent doors in a compartment wall.

4.2.8.3 Door control devices

4.2.8.3.1 Door closers

All hinged doors installed in compartment walls should be fitted with an automatic door closer, whether or not the door is on an escape route. The door closer shall have been tested in conjunction with a leaf/frame combination of the type to be used and with identical configuration. Some overhead face fixed closing devices can, when fitted to the protected face of non-insulating leaves, fail and cause the damping fluid to ignite. It is important that this does not occur. All overhead self closing devices shall meet the requirements of BS 6459: Part 1.

4.2.8.3.2 Electromagnetic hold open devices

Any door installed in a compartment wall which for convenience needs to be held open in normal use shall be fitted with an automatic release mechanism which is connected directly to a smoke detector system, either contained within the device or mounted separately in an appropriate position and not rely on fusible links for operation. The device should comply with BS 5839: Part 3: 1988 where appropriate. Permanent hold open devices shall not be fitted.

4.2.8.3.3 Powered operated doors

These shall meet the requirements of the Workplace (Health, Safety and Welfare) Regulations 1992.

4.2.8.4 Other recommendations

- all industrial doors shall as a minimum be fitted with a fusible link. As far as possible, it is recommended that such doors are additionally fitted with an automatic closing device, connected to a smoke detector.
- whenever possible, doors fitted in tandem, and having automatic self-closing devices, should be arranged to close simultaneously;
- all hinged rebated double leaf doors fitted with any type of self-closing mechanism must close in the correct order;

- no automatic closing device or system should interfere with the manual opening and closing of the door(s) or shutter(s)

4.2.8.5 Intumescent sealed air transfer grilles

Where a fire-resisting door assembly needs to incorporate an air exchange grille this shall not compromise the fire resistance of the assembly. The grille, normally consisting of a matrix of intumescent materials, shall have evidence of performance to demonstrate that it satisfies the relevant criteria in the position in which they are to be installed. The grilles may not adequately prevent the flow of cold smoke and therefore should not be used in doors protecting areas of special risk or high value as defined in Appendix C of Part 3 of this *Design Guide*. Where the door has a dual life-safety and property protection role then cold smoke protection shall be provided within the grille.

4.2.9 DURABILITY

4.2.9.1 Resistance to impact

Doors installed in compartment walls in occupancy types 4(b), 6(a), 6(b) and 7(a) (see Table 2.2 in Part 2) should satisfy the requirements for the impact test described in LPS 1056, issue 4, appendix B. All non-metallic doors should at least be rated as Heavy Duty or better when evaluated by the methods given in DD171: *Guide to specifying the performance requirements for hinged or pivoted doors*.

4.2.9.2 Cyclic testing

All doors and shutters assemblies installed in compartment walls, shafts or compartment floors should be cyclic tested to the number of opening and closing cycles given in Table 4.3:

Table 4.3. Opening and closing cycles recommended for various door types

Door type	Number of opening and closing cycles
Timber doors	200,000
Hinged steel door	200,000
Roller shutter doors and laterally operated Lateral shutters	5,000
Folding shutter and industrial lift doors	5,000
Sliding door	5,000
Lift landing door	200,000
Escalator shutter	5,000
Conveyor closer	5,000
Doors either normally locked closed or permanently held open	500

Doors subjected to cyclic testing should still be able to close correctly at the end of the cyclic testing. Doors that meet this requirement are deemed to have

sufficient durability to meet the recommendations of this *Design Guide* (some routine maintenance may be carried out during the cyclic testing). The above values assume a 20 year life cycle.

4.2.10 DOOR HARDWARE

4.2.10.1 General

Hardware fitted to fire-resisting door and shutter assemblies falls into two categories:

(i) Essential hardware

That hardware that ensures that the leaf/leaves or curtains are retained in position during the fire and is essential to the achievement of the fire resistance exposure; and

(ii) Non-essential hardware

That hardware that is fitted to an assembly in order for it to provide its in-use function but which makes no contribution to its fire resistance, for example, an overhead closing device fitted to a latched door.

When establishing the suitability of an item of hardware which is different from that tested it is important that any item of 'essential' hardware is able to make an equivalent level of contribution and that any 'non-essential' item will not negate the fire resistance by failing prematurely. Latches and/or lock units which contain low melting or even flammable components are likely to ignite and closing devices fitted to the protected face of non-insulating doors that incorporate flammable damping fluids can also 'burst', resulting in ignition of the fluid. It is important that such matters are considered at the time of specification or approval.

It can be seen that any change in the selection of hardware, whether 'essential' or 'non-essential' can have a serious effect on the performance of the assembly. In the case of hinged or pivoted doors, for example, the type design, number and location of latches, hinges or pivots can drastically influence the performance.

All door furniture for timber and mineral cored doors, including edge seals, should be subjected to third party certification to determine its suitability for the intended application (for example, by Certifire in accordance with their technical schedules TS 13, TS 17, TS 18, TS 22, TS 23, TS 24, or equivalent) and be listed in the LPCB's *List of Approved Fire and Security Products and Services*. Door furniture for industrial doors and all steel doors shall be restricted to that used in the fire test and shall be covered within the LPCB certification.

As a consequence, any substitution of hardware or its position on the door should be verified by alternative test evidence on an identical type of assembly or a fire engineering assessment that the fire resistance of the door will still be maintained. Additionally, it is important that test data is available to show that the hardware is able to meet the cyclic requirements given in 4.2.9.2 above. All items should satisfy the appropriate British Standard (BS) or prEN equivalent which invariably specifies the cycling test requirements. The category appropriate to the requirements given for the assembly in Table 4.1 should be used when specifying. The mechanical strength of critical items of furniture

such as latches should not be less than that installed in the fire test specimen. This is particularly critical for hinged steel doors.

All doors installed in compartment walls shall be physically latched shut or held shut by the door closer when in the closed position. In the case of sliding doors, these shall be retained in the closed position by ensuring that the leading edge engages tightly within the door frame. Rolling shutters shall be closed by their own weight and by ensuring that fire attack on the roller box mechanism and, if fitted, the electrical operating equipment, will not cause the curtain to rise.

4.2.11 MAINTENANCE OF DOOR AND SHUTTER ASSEMBLIES

Doors, shutters and other forms of closures, together with their frames, should be regularly inspected and serviced in accordance with the manufacturers' recommendations and any conditions imposed by the certification authority (see LPS 1197, issue 1). Non-metallic door assemblies should be maintained in accordance with the recommendations given in BS 8214: *Code of practice for fire door assemblies with non-metallic leaves*.

4.2.12 REQUIREMENTS FOR SPECIFIC DOOR TYPES

4.2.12.1 General

All doors installed in compartment walls for the purposes of this *Design Guide* shall satisfy the requirements given above. Specific requirements for each type of door is given below:

4.2.12.2 Timber doors

'Timber' or mineral cored, timber faced and edged leaves should satisfy the requirements in TRADA Certification Ltd's schedule of requirements, *Fire resisting door assemblies with non-metallic leaves*, dated Jan 1996 (or equivalent) and are listed in the LPCB's *List of Approved Fire and Security Products and Services* as complete door assemblies and also satisfy the appropriate requirements of BS 8214:1990. The frame into which such a leaf is hung, and the exact specification of any heat activated, intumescent seals, are vital to the performance and evidence of performance must be available to justify any change from the tested specification. It is unlikely that a 'timber' leaf will ever provide an equivalent level of fire resistance when hung in a metal frame and specific evidence shall always be available to substantiate the performance of such assemblies.

It may be possible to achieve the level of fire resistance given in Tables 2.1 or 2.2 of Part 2 of this *Design Guide* (see 4.2.8.1) by using two leaves 'in tandem' to form a lobby arrangement with a fire-resisting door at each end.

4.2.12.3 Hinged steel doors

Hinged steel doors should meet the requirements of LPS 1056. If the doors are uninsulated, then distances for storage of combustible materials shall be not less than given in Fig. 4.1.

4.2.12.4 Roller shutter doors and laterally operating shutters

Roller shutter doors and laterally operating shutters should meet the requirements of LPS 1056. The distances for storage of combustible materials

shall be not less than given in Figs. 4.1 and 4.2, or 4.3 when the door is installed in tandem.

4.2.12.5 Folding shutter and industrial lift doors

Folding shutter doors should meet the requirements of LPS 1056. The distances for storage of combustibile materials for folding shutter doors shall be not less than given in Fig. 4.1.

4.2.12.6 Sliding door

Sliding doors should meet the requirements of LPS 1056. The distances for storage of combustibile materials shall be not less than given in Fig. 4.1.

4.2.12.7 Lift landing door

The door should have a fire resistance of not less than 50%¹ of the values given in Tables 2.1 or 2.2 and should meet the requirements of LPS 1056.

4.2.12.8 Escalator shutter

All escalators should be protected by escalator shutters that meet the requirements of LPS 1056. The safe distance for combustibile materials is dependent on the height, width and construction of the balustrades. Serious consideration should be given to the use of insulated constructions if combustibile materials are to be placed near the opening protected by the escalator shutter.

The uninsulated lath will radiate heat towards the ceiling and due consideration should be given to combustibile items above the protected opening. The end of the shutter lath which passes down to the floor is normally on the walkway and no storage is envisaged to be in close proximity to this part of the door.

It is the recommendation of this *Design Guide* that escalators are only specified by the designer when all of the compartments served by the escalator are fully sprinkler protected.

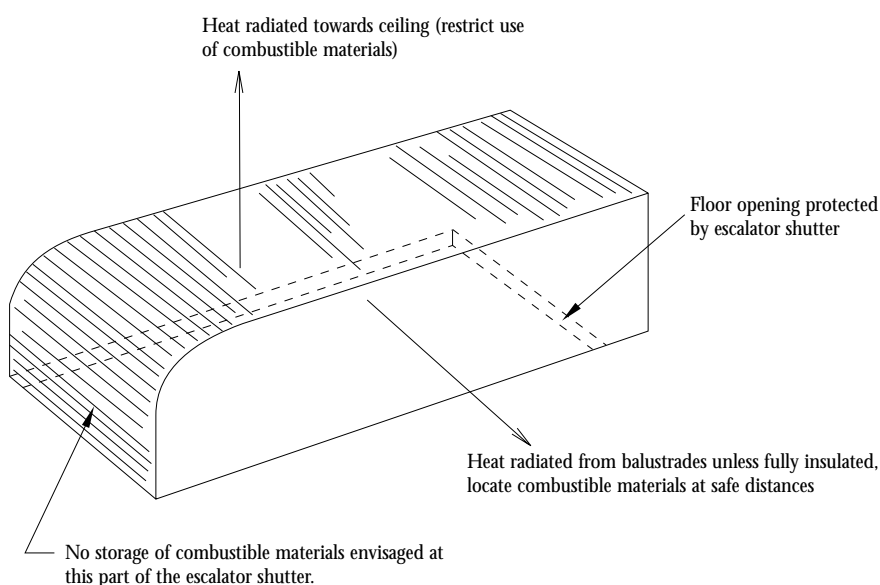


Figure 4.5. Escalator shutters
- 4.2.12.8.

¹Subject to a minimum fire resistance of 60min.

4.2.12.9 Conveyor closer

It is important to ensure that if a fire occurs, no combustible goods on a conveyor that passes through a compartment wall can be ignited or cause an ignition on the non-fire side by allowing fire spread along a belt, for example. It is strongly recommended that any closer should include a method to ensure that the opening in the wall or floor is not closed until the aperture is clear of goods. Closers that operate only from a fusible link system are unable to meet this requirement. Closers that satisfy the integrity requirements specified in Table 2.2 and insulation for not less than 60min with respect to BS476: Part 22. (The European test method for conveyor closers is not sufficiently advanced to be referenced at present.) If this preferred option is not possible, the following options should be considered:

- (i) Two uninsulated closers may be used, arranged not less than 1.5m apart in a fire-resisting enclosure. This enclosure should be constructed from non-combustible materials and have a fire resistance in terms of integrity or insulation of not less than 50% of the compartment wall or floor.
- (ii) A mechanical device to push items off the conveyor on the non-fire side away from the immediate area of the opening in the event of a fire being detected.

4.2.13 DOORS INSTALLED IN VERTICAL SHAFTS

Doors installed in vertical shafts (lift shafts or stairways) should have fire resistance in terms of integrity of not less than 50% of the values given in Tables 2.1 or 2.2 for compartment floors¹. This 50% value is based on the fact that the aggregate of fire resistance into the shaft and fire resistance out again from the shaft into the compartment above equals the fire resistance required for the compartment floor. It is important that the door has been tested separately from each side to ensure compliance with the recommendations of this *Design Guide*.

4.2.14 USE OF LOBBIES

In order to meet the fire resistance requirements for compartment walls specified in Tables 2.1 and 2.2, if a door assembly is unable to meet the required fire resistance level or distance from combustible materials, then consideration needs to be given to the provision of a lobby as shown in Fig. 4.6, provided the aggregate fire resistance is not less than that specified in Tables 2.1 and 2.2.

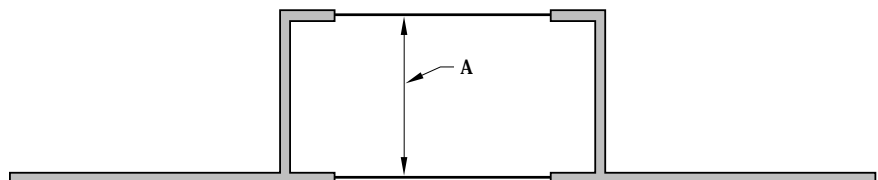


Figure 4.6. Minimum depth of lobby (see Table 4.4).

- The depth of the lobby will depend on a number of factors, but should not be less than that given in Table 4.4. Particular care needs to be taken when doors are glazed with non-insulating glass, see 4.2.8.1, and

¹Subject to a minimum fire resistance of 60min.

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the dimensions of the lobby given are calculated to ensure that premature failure of the glass remote from the fire should not occur.

- The walls and ceiling/roof to the lobby and the junction to the compartment wall shall have a fire resistance equal to that of the wall in which the door assemblies are installed and be constructed from 'robust' materials (see Appendix 3B, Part 3 of this *Design Guide*).

Table 4.4 Minimum fire resistance for doors installed in lobbies and depth of lobby

Door type	Depth of lobby (Dim A of Fig 4.6) (m)	Integrity for each assembly (Table 2.1 or 2.2)	Recommended maximum area of door opening (m ²)
Timber doors (unglazed, single leaf)	no restrictions	60% ¹	See Table 4.2
Timber doors (glazed, single leaf)	2.5m*		
Timber doors (unglazed, double leaf)	no restrictions		
Timber doors (glazed, double leaf)	2.8m*		
Hinged steel door (unglazed, single leaf)	no restrictions	50%	
Hinged steel door (glazed, single leaf)	2.0m		
Hinged steel door (unglazed, double leaf)	no restrictions		
Hinged steel door (glazed, double leaf)	2.25m		

¹ Each door used for the construction of such lobbies should, when tested, achieve an integrity rating 10% greater than that which equals 50% of the compartmentation separating duration, for example, 66min for 120min barriers.

* This can be reduced to 1.5m if insulated glass is fitted which has an insulation rating equal to 50% of the compartmentation separating duration.

- The fire resistance shall be established from the appropriate direction and in the case of the ceiling/roof of the lobby this shall be from above. For fire above, test evidence relating to floors with fire below can be used provided the upper side is protected in the same manner.
- Lobbies used for enhancing the fire resistance shall not be ventilated. Should means of escape or firefighting recommendations require a vent, such a vent shall be protected by a suitable damper or intumescent grille (see 4.2.8.4)

Appendix 4.2A

Expressing the approved size of door leaves by means of a size envelope

Conventionally hung or pivoted fire-resisting door assemblies, particularly those with single point latching/locking at approximately mid-height on the opening stile(s), are generally approved for use at sizes which are expressed as the maximum height, or the maximum width that can be supplied without invalidating the performance level claimed. However, unless these dimensions are restricted unnecessarily the maximum approved height will not normally be permitted in combination with the maximum approved width. Maximum height will normally be given at the nominally conventional width and the maximum width at the nominally conventional height, although the 'conventional' height and width will to some extent be related to the tested size.

This interrelationship between dimensions is often expressed as an envelope of approved size. The approved height for any given fire resistance rating is indicated on the vertical axis and the approved width is indicated on the horizontal axis.

An example of a 'typical' envelope of approved sizes is given in Fig. 4.7.

This graph represents the envelope of assessed sizes for the construction. Any combination of width and height that falls within the graph axes and the dark line on the graph are assessed. Point A represents the point of maximum height and its conventional width, whilst point B represents the maximum width and the conventional height.

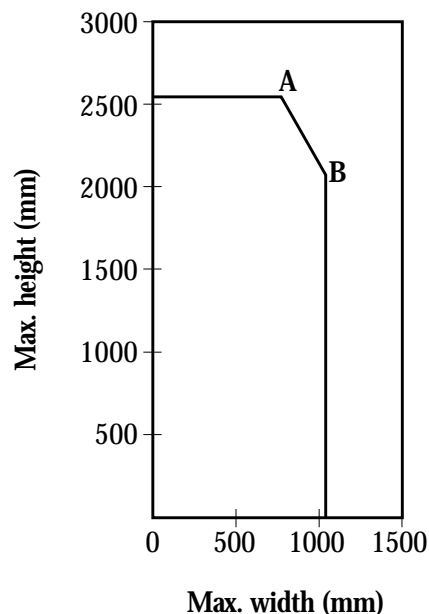


Figure 4.7

The size of the envelope is defined as much by the restraint applied to the leaf, that is, the number and types of fixings and the type and nature of any intumescent seals fitted, as it is on the leaf construction. As such, no form of leaf construction has a 'universal' envelope but may well have a range of size envelopes reflecting the mode, the configuration, the hardware, the seals and possibly the presence of glazed apertures if they are of a significant size.

Appendix 4.2B

Calculation of safe distances for combustible materials

The intensity of radiation is the product of the surface temperature of the assembly and the emissivity of the surface. The unexposed face temperature of the door or shutter assembly is, in turn, dependent upon the thermal conductivity of its construction. The standard temperature/time conditions used in establishing the fire resistance of such assemblies (as given in BS476: Part 20) do not necessarily represent a worst case. Many fires will exhibit temperatures in excess of those given in this standard and this may need to be taken into account in critical situations.

The safe distance for storage of combustible materials from uninsulated doors have been calculated from data from fire resistance tests using *Radiate* (version 1.2). These figures are intended to give guidance only and it is recommended that the actual safe distances are determined when the actual width and height of the door assembly is known. The figures given are based on the worst case, that is when the door opening height and the width is the same.

As doors are normally used for access, it is appropriate to anticipate that combustible materials will not be stored directly in front of the door opening but, nonetheless, these values should be taken into account by the building designer. Where there is a possibility that combustible materials may be located by the compartment wall and near the edge of the opening, doors installed in tandem may be considered.

To give a direct comparison between single doors and doors in tandem, the curves given in Figs. 4.1 and 4.3 are combined and shown below:

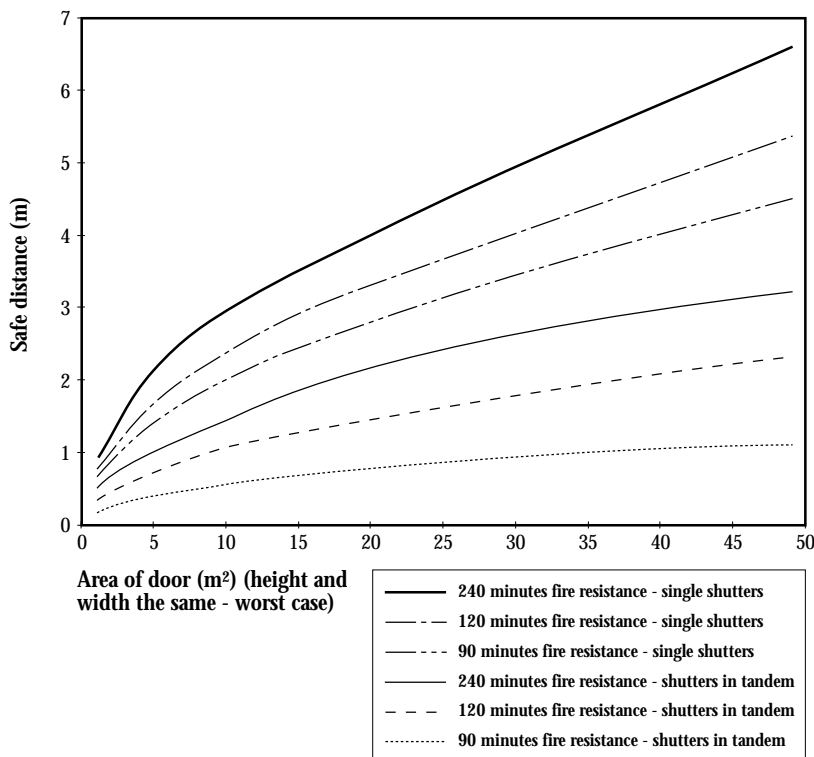


Figure 4.8. Comparison between safe distances for combustible materials from single shutters and shutters in tandem.

The separation specified in 4.2.8.2 and shown in Fig. 4.4 has been based on ensuring that the radiation profile, an example of which is given in Fig. 4.2 does not overlap with the radiation profile from an adjacent door, since in this situation the peak radiation intensity and consequent safe distance increases. It can be seen from Fig. 4.2 that part of the profile can cover part of the compartment wall when single shutters are used.

4.3 Fire-resisting windows and glazed screens

The use of fire-resisting glazing, particularly since the introduction of monolithic clear fire-resisting glazing, is becoming more widespread. This part of the *Design Guide* gives recommendations on the application of fire-resisting glazing when incorporated in compartment walls defined in 3.2.2. As a general rule, all fire-resisting glazing used for this application should be independently certified to meet the requirements of LPS 1158, issue 2 (or equivalent) and in addition the recommendations given in this *Design Guide* and should be listed in the LPCB's *List of Approved Fire and Security Products and Services*.

The various types of glasses are described in more detail in Appendix 4.3A and Part 6 of this *Design Guide* and it is important for the designer to refer to these for detailed guidance on the various parameters that can influence the performance of glazing under fire conditions.

4.3.1 TYPES OF GLASS, FRAMES AND GLAZING SYSTEMS

Fire-resisting glazed screens and windows are permitted in compartment walls subject to compliance with the fire resistance requirements specified in Tables 2.1, 2.2 and 3.1 as appropriate. Insulated glazing should be used when the recommended safe distances cannot be complied with.

There are limitations on the size of glazed screens and windows and in every case this must be confirmed by the field of application derived from LPS 1158 for the system to be used or by reference to the test evidence for the type of glass, framing and glazing system to be used. In the absence of such evidence expert independent analysis must be sought to establish the maximum pane and screen size acceptable.

Framing materials will normally be restricted to the use of timber and steel but other materials may be acceptable subject to compliance with LPS 1158 and satisfactory test evidence.

There are two major categories of fire-resisting glass;

- (i) non-insulating glass; where the glass (both wired and non-wired types) is inherently conductive and monolithic in form and is able both to transmit and emit radiation from the unexposed face in significant quantities during fire exposure;
- (ii) insulating glass; where a multi-layer glass incorporates transparent materials that, in the event of a fire, become active and significantly reduce the conduction and the ability of the glass to either transmit or emit radiant heat (some resin bonded laminated glass products may produce excessive smoke).

Each of these glass types can then be further categorised and further information is given in Appendix 4.3A.

4.3.2 GENERAL DESIGN AND USE CONSIDERATIONS

The following aspects should be given consideration in order that the glazed assembly will provide the required level of fire resistance.

- It is essential that the use of glazed assemblies in compartment walls is supported by test certification or expert independent assessment against LPS 1158 of the glass, framing and glazing system as a complete unit.
- No substitution of components is acceptable unless supported by appropriate test evidence or an independent expert assessment against LPS 1158 of such components in a complete assembly.
- The type, thickness and maximum size of the glass, together with the type and dimensions of the framing and the bead profile of the glazing system used, are all critical factors. Therefore any changes from that tested to any of these aspects or to the shape or orientation of any glass, for example, horizontal to vertical, can only be made if subjected to a new test or independent assessment of the complete glazed element to confirm that the fire resistance and, where applicable, insulation levels are maintained.
- Slumping of the glass due to high temperatures constitutes an integrity failure and must be avoided except to the extent permitted by the test or extrapolation given in the field of application. Reference to Appendix 4.3A should be made to establish the important design parameters, such as the maintenance of a cool edge and/or clamping of the glazing in the frame.
- It is important that provision is made to restrict or prevent the spread of smoke through glazed screens and recommendations are made in 3.1.2.3.
- Care should be taken to ensure that screens and windows are not sited in positions where they may be susceptible to accidental damage unless appropriate precautions are taken.

Note: Reference should be made to Appendix 4.3A for further guidance on the specific approach to achieving the above requirements.

4.3.3 GUIDANCE ON LIMITS ON OPENING SIZES AND FIRE RESISTANCE OF GLAZED SCREEN ASSEMBLIES

4.3.3.1 *Maximum size of individual glass panels/blocks*

The maximum size of any individual pane for any specific installation or requirement should be established by test, and information should be sought from the individual glazing manufacturer.

Glass blocks may be used in walls up to the areas approved by the field of application given in the test standard or test report.

4.3.3.2 Guidance on maximum fire resistance of glazed screen assemblies

The recommendations given in Table 4.5 have been based on available information and the designer should establish with the specific manufacturer the appropriate fire resistance levels. Requirements for fire resistance levels are given in Table 3.1 which refers, as appropriate, to Tables 2.1 and 2.2. Fire resistance levels below 90 minutes have limited application in this *Design Guide*. The ratings are given for pane sizes not less than 1.2m² in area and these may increase significantly when used in small pane sizes. Restrictions imposed by the field of application of test evidence given in LPS 1158 shall be noted.

Table 4.5 Maximum fire resistance

GLASS TYPE	Fire resistance - integrity (min)	
	Timber framing	Steel framing
Georgian wired polished glass (integral wires)	60	60 ¹
Laminated wired glass (non-integral wire)	30	30
Modified toughened soda-lime glass	30 ¹	30 ¹
Laminated clear glass	30	30
Borosilicate glass	60	120
Clear ceramic	60	240
Insulated laminated glass	60	60 ^{2, 3}
Insulated gel glass	30	90 ³

¹ These durations may be exceeded by gluing or pressure glazing the panes in position but these will require permanent marking in use as required in Appendix 4.3A.

² Although only stated as the maximum integrity rating, this may require an insulating frame to control deflection and prevent exhaustion of the active inter-layer near the edges.

³ Multiple panes in separate frames can be used to extend duration. At 90min weight is an important consideration.

These durations are given in relation to single panes, individually glazed and do not necessarily apply to all manufacturers' products. If the pane is sharing a framing member with an adjacent pane, or panes, then the duration may need to be reduced or a smaller pane size be used. For all durations over 30min there will inevitably be a maximum size allowed and a restriction on the aspect ratio except for clear ceramic glass. As the duration increases towards the 90min levels the pane size may be severely restricted and manufacturers' evidence of performance needs to be obtained and examined carefully. In timber framing the glazing system is critical for all 60min applications (see Appendix 4.3A).

4.3.3.3 Guidance on maximum area (based on safe distances to combustible materials)

Subject to meeting any other requirements laid down in the *Design Guide*, there is no restriction on the use of glazed screens consisting of insulating glass fixed into insulated frames. Where the glass and the frame is uninsulating then the heat transfer to the protected area as a result of radiation can present a risk and needs to be restricted. Figure 4.9 gives guidance on the safe storage distance for various areas of uninsulated glazing.

This guidance is based on the area of the opening and the safe distance to combustible materials when glazed screens are installed in compartment walls. **These distances are in excess of what may be regarded as safe for means of escape and are based on the assumption that the glazed screens do not form the boundary of an escape route.**

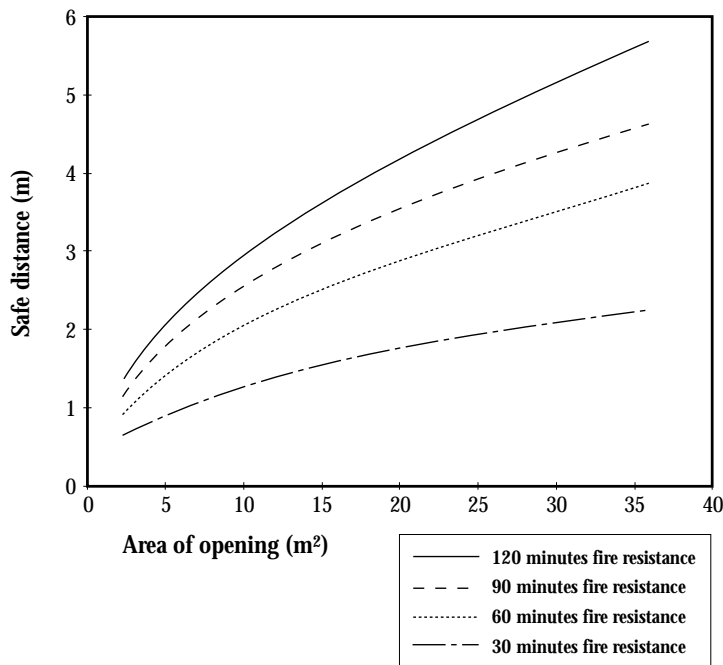


Figure 4.9. Safe distance for combustible materials from a 6mm thick monolithic non-insulating fire-resisting glazed screen.

4.3.4 INTERACTION WITH WALL CONSTRUCTION

The performance of a glazed screen or window can be substantially affected by the type of wall in which it is installed, together with the method of fixing the framing to the wall, because this influences the restraint available to resist deflection/distortion. With respect to masonry or concrete walls, it is generally accepted that the following rules apply:

- A test result obtained for a non-insulating glazed screen tested in a solid masonry or concrete wall is applicable to the same type of construction with a thickness and density equal to or greater than that used in the test.
- With an insulated glazed element the influence of any decrease in density of the surrounding construction must be taken into account when assessing the unexposed face temperature.
- In all cases the fixings used shall provide an equivalent level of restraint and fixity to that demonstrated in the test. Any change in the restraint level shall be the subject of an extended field of application analysis or an additional fire resistance test.
- Walls providing reduced levels of restraint may be acceptable when the glazed element incorporates a continuously framed surround which is independent of the wall into which it is installed. The risk of an

integrity failure developing between this frame and the wall shall be the subject of an extended application analysis, as will the ability of the wall to restrain the glazed element.

4.3.5 SPRINKLER IMPLICATIONS

The maximum fire resistance currently achievable from common forms of fire-resisting glass is 120min and consequently this restricts its application in this *Design Guide*, particularly in respect of its use in compartment walls in non-sprinklered retail warehouses and superstores; industrial-ordinary hazard groups III and IIIs and high hazard process; storage and other non-residential where 240min fire resistance is required. Clear ceramic glass may however be used, subject to satisfactory performance in any personnel safety situations, as laid down, for instance, in Approved Document N to the Building Regulations 1991 (the current Regulations in England and Wales).

The integrity of glazing systems in a sprinkler protected fire compartment is not known, and consequently the use of glazing in such occupancy types should be restricted to those glasses that are not sensitive to thermal differentials caused by water spray. It is considered that the following glass types will not be adversely affected by water spray in the early stages of a fire and may be used in the boundary of a sprinklered compartment, subject to compliance with the fire resistance levels specified in Tables 2.1 or 2.2 and Table 3.1:

- (i) integral wired, soda-lime glass (GWPP);
- (ii) glasses of borosilicate composition;
- (iii) clear ceramics;
- (iv) multi-layer insulating glasses (not less than 4 glass layers).

Other types of glass may be used if there is evidence to show that they are not adversely affected by the application of sprayed water on the fire exposed side either at the beginning or during the fire exposure period.

4.3.6 DURABILITY

All monolithic glasses are stable and unaffected by moisture, temperature fluctuations or chemicals and as such are considered to be durable.

Laminated insulating glasses, with clear intumescent interlayers are prone to humidity or moisture ingress problem which, while not necessarily reducing the fire resistance, may lead to them being considered to be aesthetically unacceptable. Such glasses should be edge sealed and then sealed in place by means of suitable impermeable sealants, for example, silicone, to prevent degradation by moisture.

Some intumescent based glazing systems may be adversely affected by humidity and chemical attack and intumescent materials should only be used when supported by evidence showing that they are not prone to failure in use (see IFSA Information Sheet No 4 for further information).

Glass, as history has shown, is a durable material and is unaffected by almost any conditions. The interlayers, particularly in intumescent glasses, are more likely to be degraded by the effects of moisture and chemical, but they are protected in all cases by the layer of glass on either side. Many gaskets are inert,

for example, ceramic fibre glazing tape, but when active gaskets are used, for example, intumescent, then only those materials that have been shown not to degrade significantly during exposure to moisture or chemical should be used. If this is not possible then all gaskets shall be sealed with a silicone capping that shall be maintained in good condition.

4.3.7 FRAMING

The framing system, whether for a window or a glazed screen, is an integral part of the complete element and as such its specification is vital to the achievement of the desired fire resistance. Where possible the framing system should be of a tested design, supplied by the manufacturer in compliance with the tested specification and preferably either factory glazed, or glazed on site by the manufacturer's nominated installers.

Framing systems may be of timber for durations up to 60min, or be of steel sections or constructed from cementitious members for durations up to 240min, as appropriate. Framing systems shall comply with LPS 1158 (or equivalent) and additional requirements referenced in this part of the *Design Guide*, and be listed in the LPCB's *List of Approved Fire and Security Products and Services*. Restrictions imposed by the field of application of test evidence given in LPS 1158 shall be noted.

It may be possible for the window or screen to be site constructed to conform with a published specification but in all cases the glazing of such assemblies must be undertaken by trained staff because of the critical nature of fire-resistant glazing.

It is important that the design of any glazed screen or large window is able to withstand the appropriate loadings either in accordance with BS 6180: 1995, covering barrier loads, and/or BS 5234 and rated as Heavy Duty or better in respect of physical strength. Guidance as to the requirements of these standards is to be found in the FRGSA Information Sheet No 3, 'Guide to the design of glazed fire-resisting screens and partitions in respect of impact and crowd loads'.

4.3.8 DOUBLE GLAZED UNITS

Double glazed units shall only be accepted if there is evidence of performance to support their use. In a fire if two panes of non-insulating fire-resisting glass are un-vented the expansion of the air between the units can cause them to 'burst' during the early stages of fire exposure. This does not apply to integral wired glass, which will fracture and release the pressure in a double glazed unit in the first few minutes of a fire. When aluminium spacers are used between panes these will melt out leaving the panes loose in the glazing pocket, leading to a premature integrity loss and, even worse, a loss of the cool edge which is vital if extended periods of fire resistance are to be satisfied. Even when a pane of fire-resisting glass is incorporated in a double glazed unit with a non-fire-rated pane the unit may only achieve the claimed level of fire resistance in one direction, normally with the non-fire-resisting glass being sacrificial and facing the anticipated direction of fire attack. When the evidence is presented with respect to the fire exposure only being on one face of a non-symmetrical

element but where, in practice, fire exposure may be from either face, then a fire engineered assessment of the influence of a change in the direction will be required.

4.3.9 SURFACE DECORATION

The use of applied decorative or security films is not recommended unless they have been shown by test not to compromise the integrity when affixed to the protected face. Etching of fire-resisting glass with logos or as a form of manifestation is not permitted on non-insulating, clear glasses. Etching of integral wired glass does not impair its fire performance.

4.3.10 MAINTENANCE

Windows and glazed screens are fixed elements and, as such, do not require any conventional maintenance other than perhaps an annual check to ensure that all of the beads are firmly in place and any gaskets have remained undamaged. However, cleaning will take place and the use of excessive liquids may well damage intumescent materials or even some of the glasses that contain intumescent interlayers, and for that reason all cleaning schedules should use special cleaning materials or use only minimal amounts of water and be dried off before any gaskets can be adversely affected. During the cleaning process, particularly with unwired monolithic glasses, it is important that no scratches are caused by diamond rings or other sharp instruments as these may impair the fire resistance.

Any cracked or badly scratched glass shall be replaced immediately. If the glass and glazing system carries a metal plate then it is important that any replacement is done by competent installers because of the special needs that this plate will indicate.

Appendix 4.3A

Information concerning glazing

This appendix provides some important information that needs to be taken into account by the building designer before specifying a fire-resisting glazed screen assembly.

NON-INSULATING GLASSES

The most obvious sub-division of the non-insulated glasses is between those that incorporate wire and those that do not. Glasses without wires are generally known as monolithic clear glasses. However, even these divisions require further sub-divisions if performance guidelines are to be given. The following sub-categories are needed;

Integral wired glass - where the wire is introduced into the molten glass at the time of manufacture

Non-integral wired glass - where the wire is cold bonded into a resin interlayer between two panes of soda-lime glass

Monolithic clear glasses - where the glass is a single pane without wires and is of one of the following types:

- soda-lime composition;
- borosilicate composition;
- ceramic composition.

INSULATED GLASSES

This grouping covers a range of glasses that are capable of providing a significant reduction in the temperatures measured on the unexposed face of the glass during exposure to the fire, due to the activation of thermally activated material. Two sub-categories exist:

- specialist laminated glasses - incorporating both clear intumescent interlayers and human impact safety interlayers;
- 'gel' glasses - where two layers of glass are spaced apart and the void filled with a heat activated gel.

Note: Some laminated products may produce excessive smoke from the protected face. Such glasses are restricted in use in Part 3 of the *Design Guide*.

OTHER GLASS TYPES

For reason of strength, safety or to provide intermediate levels of insulation a number of other laminated glass types are available such as those that follow:

- wired glass/toughened glass laminates (strength);
- clear ceramic/soda-lime glass laminates (safety);
- borosilicate/insulating glass laminates (security);
- soda-lime/intumescent interlayer/soda-lime laminates (partial insulation).

This is not an exhaustive list and others may be available. The combustible nature of some of the laminating materials may mean that the fire resistance of these products are uni-directional. Any tendency for the product only to be able to provide the required level of fire resistance from just one direction shall be established and taken into account when specifying or approving such products.

In addition, there are other glasses known as partially insulating, but as this *Design Guide* does not specifically give recommendations for such products, these are not included at present.

GLASS BLOCKS

Walls constructed from glass blocks are able to satisfy the integrity criteria for up to 60min and insulation for 30min. No guidance is given in respect of the use of these in this document but if substantiated by evidence of performance appropriate to their intended use (see 2.1 and 2.2 of Part 2 of this *Design Guide*), then they may be considered suitable.

INFLUENCE OF FRAMING SYSTEM

- Glass does not inherently have any level of fire resistance and any fire resistance duration claimed will be related to a particular form of framing system and invariably a specific glazing system. With the

exception of clear ceramic glass, exposure of monolithic glasses to high temperatures causes glass to lose stiffness and start to flow. The amount of flow can be controlled by the edge conditions and a 'cool edge' can help resist the tendency for panes to slump, or clamping/gluing techniques may be used in a similar manner.

- Timber framing, which is insulating, is able to contribute to the production of a cool edge although, because the timber erodes away it can make little contribution to any clamping system.
- Steel framing is conductive and needs to be used in conjunction with highly insulating glazing systems if it is to produce a 'cool edge' but being strong it can be used to produce a clamping system.

Any glass intended to be used in a fire-resisting glazed screen will achieve different levels of fire resistance in the two framing systems and results are not therefore interchangeable unless the change has been the subject of a fire engineering analysis.

It has to be recognised that it is very difficult to achieve 60min integrity in timber framed glazing applications when using non-insulating glass. As such there are only a handful of glass/glazing systems that are capable of providing evidence of performance at this level and in all cases such evidence needs to be obtained and examined or a fire safety engineered analysis be undertaken.

INFLUENCE OF EDGE COVER

Edge cover has an important influence on the fire-resisting capabilities of glazed screens and vision panels and detailed guidance, taking into account the various parameters involved, is given in Part 6 of the *Design Guide*.

INFLUENCE OF GLAZING SYSTEM ON MAXIMUM SIZE

In order to maintain the 'cool edge', see above, needed to extend the duration of fire resistance, the glazing system shall be chosen for its ability to retain the glass in position at the specified size, for the appropriate period and detail guidance is given in Part 6 of this *Design Guide*. Where intumescent materials are used in glazing systems they shall be of a type for which evidence of durability exists. Further information on the subject of intumescent materials for use in glazing systems is to be found in the joint IFSA/FRGGSA Information Sheet No 2, 'The Role of Intumescent Materials in Timber and Metal Based Fire-resisting Glazing Systems'.

In order to achieve the extended durations at medium to large pane sizes, that is, above 1.2m², some tested glazing systems incorporate high temperature adhesives or are pressure glazed systems. Because of the risk of these not being used in any subsequent reglazing operation, following accidental breakage or similar, the use of systems which rely upon such adhesives is deprecated. When used such systems shall carry a permanently attached metal plate advising of the need to use adhesives of the correct specification in any reglazing.

4.4 Penetrations by ducts and building services

4.4.1 GENERAL

It is important to note that in respect to compartment walls separating different occupancies (those buildings owned or occupied by different companies), no penetration of the wall by ducts or services is allowed if the recommendations given in Part 3 of this *Design Guide* are to be followed (see 3.2.2.1 (i) and 3.2.2.2.2).

The requirements given in this section therefore apply to ducts and services passing through walls and floors separating different occupancy types or separation within the same occupancy type.

4.4.2 PROTECTION OF DUCTS

4.4.2.1 Air distribution ducts

- Air distribution ducts should be protected in accordance with BS 5588: Part 9 and the additional requirements given in this part of the *Design Guide*.
- Where fire-resisting dampers are used, these shall be tested in accordance with ISO 10294-1:1996 or EN 1366-2 and also satisfy the requirements given in LPS 1162. Where the use of the damper falls outside the field of application section of EN 1366-2, additional tests or assessment shall be undertaken to validate the suitability of the application. The required integrity of the dampers shall not be less than that given in Table 2.1 or Table 2.2. To meet the recommendations of this *Design Guide* all fire dampers, as well as being fitted with a fusible link, shall be linked to a fire detection and alarm system approved by the LPCB to appropriate standards. Dampers that rely only on a fusible link to close are not acceptable in order to claim compliance with the recommendations of this *Design Guide*.
- Where fire-resisting ducts are used, these should be tested in accordance with BS 476:Part 24:1987(ISO 6944:1985) or EN 1366-1 and have a fire resistance in terms of stability, integrity and insulation of not less than that specified in Table 2.1 or Table 2.2. Where the duct falls outside the field of application section of EN 1366-1, further testing or assessment shall be undertaken to validate the suitability of the application.

4.4.2.2 Smoke extraction ducts

- These shall be tested in accordance with EN 1366-1 and prEN 1366-8¹ and meet the fire resistance specified in Tables 2.1 and 2.2. These tests are designed to ensure that fire-resisting compartmentation is maintained where smoke extracting ductwork passes through compartment walls and floors and do not show the efficiency of the complete smoke extraction system to extract smoke under fire conditions. This aspect is outside the scope of the *Design Guide*.

¹ This standard is currently being developed.

- Care should be taken to ensure that the use of a smoke extraction system does not adversely affect the response time of sprinklers. Advice from a sprinkler specialist should be sought.

4.4.2.3 Service ducts

- Service ducts used to enclose pipes and cables passing through compartment walls and compartment floors should be tested in accordance with prEN 1366-5¹. Where the duct falls outside the field of application section of prEN 1366-5, further testing or assessment shall be undertaken to validate the suitability of the application.
- Where no penetration seals are fitted (see Fig. 3.14), the service duct shall have an integrity and insulation performance of not less than that given in Table 2.1 or Table 2.2.
- Unless containing pipes containing volatile fluids, service ducts are not required to have fire resistance where the penetration seal is able to provide the same fire resistance as required for the compartment wall or floor.
- Pipes containing volatile fluids shall be contained within a service duct having a fire resistance of not less than 60min in terms of integrity and insulation, with the penetration at the compartment wall or compartment floor being protected by a penetration seal having a fire resistance the same as the compartment wall or compartment floor.

4.4.3 PENETRATION SEALS

4.4.3.1 General

It is important that when a vertical or horizontal compartmenting element is penetrated by a service, the fire resistance of the construction is not decreased. In the case of the element being penetrated by fire-resisting service ducts, the seal between the duct and the element forms part of the test assembly and the same form of sealing system shall be used in practice. Combustible services shall be so arranged that they are not located nearer than 500mm to air distribution ducts that are protected by uninsulated dampers, unless the outer surface of the duct is suitably insulated.

Where metal pipes, plastic pipes or cables penetrate such elements, it is important that a sealing system is used that is appropriate to the service(s) in question. More detailed information, important to the designer, is given in Part 6. For a small penetration passing through a small aperture then the fire resistance can generally be maintained by a suitable sealant.

Where a large number of different services are involved and the aperture is larger, then a complete system incorporating a bulkhead barrier in combination with the appropriate sealing materials is normally used.

4.4.3.2 Performance requirements

All penetrating services shall satisfy the following fire resistance requirements:

¹ Standard currently being developed.

Table 4.6. Fire resistance requirements for seal and service.

Building occupancy type (see Table 2.1)	Integrity	Insulation	Length of service to be insulated
2,3,4 & 5	As in Table 2.1 or Table 2.2	As in Table 2.1 or Table 2.2	150mm ¹ each side
6 & 7	As in Table 2.1 or Table 2.2	As in Table 2.1 or Table 2.2	500mm ¹ each side.

¹ Metal pipes of less than 13mm diameter are exempted from this requirement as are penetrations consisting of up to four cables each with a core diameter no greater than 4mm.

The fire resistance shall be established by means of testing to prEN 1366-3, ISO DIS 10295 or similar ad-hoc procedures based upon the methodology of BS 476: Part 20. The test shall have been performed using services and a substrate that covers the intended application within the field of application of the result. Where the test was performed on a small specimen (for example, 1m by 1m) the effect of deflection/distortion of the element and the method of supporting the service sealing system shall be considered to see if it meets these requirements.

4.4.3.3 Specific penetration seal applications

There are a number of sealing systems available and further guidance in respect of these is given in Part 6 of the *Design Guide*.

Examples of such seals or sealing systems is given below:

- cementitious materials
- gunnable or hand applied sealants (ablative and intumescent)
- mineral and ceramic fibre gaskets
- mineral fibre batts (coated and uncoated)
- sealing blocks/bricks
- pre-fabricated intumescent/resilient foam sandwiches
- pipe closing collars
- cable transits
- sealing bags or pillows¹
- pipe wraps²

¹ Sealing bags or pillows may only be allowed if they are covered by a management procedure that includes frequent examination and a permit system usable by all tradesmen installing new services. This may also be needed for any system where new services are being frequently added, for example, communication rooms.

² Pipe wraps are not acceptable for use in compartment walls or floors.

All other tested systems may be used subject to correct installation, preferably by approved installers.

4.4.3.3.1 Plastic pipes

Plastic pipes, being of low melting point, can readily cause a breach of the compartmentation unless properly sealed. All plastic pipes passing through compartment walls or floors shall be properly sealed by a suitable pipe closing collar. The device fitted shall be supported by test evidence for the required duration that relates to the following parameters:

- orientation - vertical/horizontal;
- pipe diameter;
- wall thickness;
- type of plastic (this is extremely important, even a foamed version of a specific plastic may perform differently from the standard version);
- whether pipe is closed or open on both the fire and the protected face.

Further details on how these factors influence performance are given in Part 6.

4.4.3.3.2 Cable trays and cables

The evidence of performance shall relate to the type of cable tray to be used, together with the number and distribution of cables. The cables shall be of a core diameter and insulation thickness and type covered by either the field of application report (derived from the test data) or approval certification.

4.4.3.3.3 Metal pipes

The risk of fire spread by means of pipes penetrating compartment walls or floors is generally as a result of insulation failure on the service or an integrity loss due to loss of integrity due to a breakdown of the sealing system. When installing sealing systems around pipes the evidence of performance shall be appropriate for:

- pipe diameter;
- pipe material;
- orientation;
- end conditions (open or closed);
- support conditions.

The nature of the material in the pipe may need to be considered in certain circumstances, for example, volatile liquids or gases.

4.5 Cavity barriers

4.5.1 GENERAL

Hidden voids have the potential to allow the concealed spread of fire to parts of a building remote from the place of origin (the seat of the fire). Because the fire may be hidden, detection and firefighting can be very difficult. For this reason the recommendations in this *Design Guide* are that large or critically positioned hidden voids (as defined below) be sub-divided using fire-resisting cavity barriers in order to restrict lateral fire spread. Cavity barriers may also be appropriate for closing voids where they bypass lines of compartmentation that do not separate different occupancies or occupancy types.

To satisfy the recommendations of this *Design Guide*, cavity barriers shall not be used as an extension of compartment walls separating different occupancies (buildings in different ownership) and preferably shall not be used above

compartment walls separating different occupancy types (but see note 2 of Table 4.7). In these cases the compartment wall shall always be extended up to the compartment floor or roof above.

In such cases the compartment line must be continued up to the adjacent roof, floor or wall with any small gaps being filled with a fire-stopping system or linear gap seal that provides the same fire resistance level, in terms of integrity and insulation, as specified in Table 2.2. This shall be able to accommodate any fire-induced or in-service deflection. (See definitions for difference between a cavity barrier and fire stop.) Similar restrictions apply to the use of cavity barriers above compartment walls separating storage areas from occupancy types 4 or 6 (see Table 2.1) or below a fire-resisting wall on a platform floor.

4.5.2 APPLICATIONS

The main recommended applications of cavity barriers, with respect to this *Design Guide*, are summarised below. They shall be:

- installed in line with compartment walls or floors, except between different occupancies or different occupancy types (see Note 2, Table 4.7), to maintain the fire resistance of the compartment whilst absorbing any mechanically or thermally induced movements;
- used to provide sub-divisions in voids between ceilings and floors, voids in platform floors and in roof spaces above suspended ceilings, whilst absorbing any mechanically or thermally induced movements.

Examples of where specific applications for cavity barriers would occur are:

- any large* cavity within a wall, floor or ceiling must be separated from large cavities in adjacent walls, floors or ceilings. This applies whether these building elements are fire-resisting or not;
- hidden voids above suspended ceilings[†];
- cavities below floors[†];
- resistance should have a cavity barrier in the same plane as the element;
- cavities in walls[†].

Where cavities are narrow (100mm or less), then fire stopping or linear gaps seals may be a more appropriate solution than cavity barriers; it must, however, be ensured that the product used can accommodate any fire-induced or in-service movement that may occur (see 4.6.3).

4.5.3 PERFORMANCE REQUIREMENTS

4.5.3.1 Fire resistance

The fire resistance levels required for cavity barriers are given in Table 4.7.

* For the purposes of this *Design Guide*, a large cavity is one that has a height or depth greater than 600mm.

† Where the cavity extends more than 20m in any direction, including around corners.

Table 4.7. Fire resistance requirements for cavity barriers.

Application	Fire resistance (min)		Location
	Integrity	Insulation	
Compartment walls separating different occupancies	NOT ALLOWED		
At compartment walls or floors separating different occupancy types ²	It is recommended that the compartment walls are extended right up to the floor or roof above, but see note ² below.		Compartment wall or floor
Sub-division in roof/floor voids	30	30 ¹	Spaced at not more than 20m apart or in line with walls above or below
Sub-division of wall voids	30	30	In line with all fire separating walls and floors

¹ Some cavity barriers are available that provide reduced insulation performance. The insulation requirements may be relaxed, and the use of these barriers may be appropriate where:

- there are no combustibles used in the construction of the building within 3m of the barrier; and
- it is impossible, or highly unlikely, that combustibles will at any time be stored within 3m of either side of the barrier (this does not apply to flammable liquids; where these may be present, fully insulating barriers shall always be used).

² It is recommended that in these applications the compartment wall is extended right up to the underside of the floor or roof. Where it is necessary to leave an opening above a compartment wall for the passage of services, it is important that the cavity barrier is constructed from robust materials, to a high standard of workmanship and is able to accommodate suitable penetration seals for the specific service. Cavity barriers constructed totally from flexible fibrous materials should not be used in this application, although they can be used above fire-resisting partitions that are not separating different occupancies or occupancy types. The fire resistance of the cavity barrier shall meet fully the levels of fire resistance given in Table 2.1 or 2.2.

Cavity barriers used to sub-divide roof or floor voids should, wherever possible, be placed so as to coincide with the fire-resisting partitions in the compartment above the floor or below the ceiling, in order to continue the line of fire protection. This may require location of barriers at less than the maximum 20m spacing in Table 4.7. Where a compartment has many fire-resisting partitions, it should not be necessary to have a cavity barrier above every one, so long as the maximum limit on void dimensions is not exceeded.

Where any large vertical voids reach roof height the opportunity should be taken to cap them below roof level, so providing additional protection to the roof structure.

The fire resistance of cavity barrier systems can be established either by fire resistance testing or assessment against the principles for non-loadbearing separating elements in BS 476: Part 22: 1987 or EN 1364-1. Any evidence of performance for cavity barriers must be able to demonstrate the suitability of:

- any joint systems that are to be used in the barrier material (either vertical or horizontal, as appropriate);
- the barrier fixing system, which must be appropriate to the structure from which the barrier is to be supported (for example, steel, timber, steel roof decking etc);

- the barrier itself, in the orientation in which it is to be used;
- any mechanism or detail included to accommodate the transit of services, beams, ducts etc. through the cavity barrier (for example, penetration sealing systems);
- that the barrier can be used in conjunction with a compartment wall without reducing the fire resistance of the wall. This would necessitate the testing of the cavity barrier and compartment wall together with the top edge of the wall being tested unrestrained to represent installed conditions.

Where a barrier is to be used at a height greater than that for which either test or a field of application assessment evidence exists, then the suitability of the cavity barrier for that application must be established by an independent fire safety engineering analysis.

4.5.3.2 Surface spread of flame

Both exposed surfaces of any cavity barrier shall satisfy the class '0' provisions in building regulations.

4.5.4 ACCOMMODATING DEFLECTION

Cavity barriers may be required to provide fire resistance when the building structure which bounds the barrier is distorting under the influence of the fire. An example of this would be a cavity barrier above a steel framed suspended ceiling, where the ceiling may bow downwards as the steel heats up, due to linear thermal expansion and loss of strength. It must be ensured that the barrier can accommodate this deflection whilst maintaining fire resistance. Alternatively, the distortion of the elements bounding the void may be restricted by the application of additional fire protection (see Part 3).

Rigid barriers must be able to cope with any load transfer from above, if the soffit of the void distorts, whilst both rigid and flexible barriers may need either to restrain or to accommodate the deflection of the adjoining structure at their base.

It is not feasible to state what degree of distortion will need to be allowed for in the above situations within this document; the type of element, its degree of exposure, end conditions and loading will all affect its distortion. Wherever possible the building designer should make or obtain an analysis of the anticipated deflection in fire and match the cavity barrier system to that deflection. Where this is not feasible, then as guidance, a horizontal fire-resisting loadbearing and/or separating element may bow up to a distance of $L/40$ at mid-span, if uniformly loaded, at its designed fire resistance. It can be assumed that the deflection of horizontal elements would be in a downwards direction.

It must be ensured that the support to the barrier will be capable of holding the barrier in place for the required period of fire resistance, without gaps opening up between it and the soffit of the cavity. This may be affected by:

- the inherent fire resistance of the support;
- applied fire protection; or
- the protection provided by the barrier itself.

4.6 Fire stopping and linear gap sealing

4.6.1 GENERAL

Gaps can be present in fire-resisting compartment walls and floors for the following reasons:

- as joints to accommodate in-service movement;
- due to imperfections in fit or manufacturing clearances;
- around items installed in the element subsequent to its construction etc.

4.6.1.1 Fire stopping

It is essential that the fire protection provided by the element is not reduced by joints or gaps and where such gaps are made or develop then the fire protection shall be restored at the earliest possible time, by filling these gaps using an appropriate sealing system. This may, if appropriate, simply be a restoration of the material from which the element is constructed, subject to it being able to meet the requirements, or it may be by means of a proprietary fire-stopping product. To ensure compliance with the recommendations given in this *Design Guide*, all gaps should be sealed by a system that, when tested to prEN 1366-3 or ISO DIS 10295-1, or similar procedures, achieves the fire resistance in terms of integrity and insulation given in Table 2.1 or Table 2.2. For sealing gaps around fire-resisting air distribution ducts, such seals should have been tested as part of the duct protection system in accordance with BS 476: Part 24: 1987 or prEN 1366-1.

Note: Where parts of a composite separating element (for example, a foam-cored sandwich panel system) have been removed, then conventional fire-stopping systems may not be suitable to restore its fire resistance. In such cases expert advice should be sought.

4.6.1.2 Linear gap sealing

'Linear gaps' is the term used to describe gaps which are of a fairly constant width, which is small compared to their length (commonly a length/width ratio of 10:1 or more), and may have to accommodate movement, either in-service or in the case of fire. Linear gap sealing systems, when used in compartment walls or floors separating different occupancies, should have been evaluated in large scale furnaces with the joint length not being less than 2.5m. Linear gap seals evaluated in small scale tests may be used for other compartment walls provided it can be shown that they will maintain the required integrity and insulation at the height/span at which they will be used in the building. Guidance on selection of specimen size for test is given in ISO CD 10295-2.

4.6.2 PERFORMANCE REQUIREMENTS

For fire-stopping and linear gap seals used in compartment walls or floors, the following fire resistance levels are applicable:

Table 4.8. Fire resistance levels for fire stopping and linear gap seals.

Application	Integrity (min)	Insulation (min)
Gaps not greater than 15mm wide	As for Table 2.2	15
Gaps over 15mm wide	As for Table 2.2	As for Table 2.2

4.6.3 DESIGN CONSIDERATIONS

It is unlikely that all the different conditions under which a fire-stopping system or linear gap sealing system will be expected to provide fire resistance will be replicated in fire resistance tests. As guidance, the following factors need to be considered when specifying sealing systems:

- the width of the gap to be sealed;
- the available depth of support to the seal;
- the type of construction on either side of the gap. It is important to know whether differential movement will occur and/or whether the surface erodes during heating;
- the depth of seal required to achieve the level of fire resistance;
- the orientation of the gap,
for example, vertical gap/horizontal element
vertical gap/vertical element
horizontal gap/vertical element;
- the requirement for joints in the seal (if pre-formed);
- the possibility of the loss of the arrises on the gap edges, through charring, melting or spalling;
- environmental conditions (especially moisture resistance);
- the ability of the seal to restrict the passage of both hot and 'cold' smoke;
- resistance to mechanical damage;
- the longevity of the seal, so that it will perform satisfactorily for the life of the building, subject to maintenance in accordance with the manufacturers' instructions;
- the adhesion to the surface to which the seal is to be applied (including adhesion in the hot state);
- the ability of the seal to accommodate in-service movement, and its ability to perform its fire-resisting function in a gap at the limits of that movement.

Of particular importance is the ability of the seal to accommodate the deflection of the structure on either side, due either to load transfer or to thermally-induced distortion. As stated in 4.5.4, due to the wide range of building elements in which these gaps may be present, it is not possible for the document to state with any reliability what magnitude of deflection may need to be accommodated. It is therefore recommended that this is determined from an engineering analysis of the element(s) by suitably qualified persons. However, where this is not feasible, as guidance conventional fire resistant elements may be expected to deflect by around $L/40$ at mid-span or height

(where L is span or height) if non-loadbearing or uniformly loaded within their design parameters. Horizontal elements will tend to distort in a downwards direction, whilst vertical elements with a steel structure normally distort towards the fire at mid-height. Where fire resistance test evidence for the element is available then this should provide deflection data taken during the test, and should always be consulted by the designer or specifier of these seals.

Where differential movement takes place in service or during fire exposure then a flexible product is preferred to a rigid sealant. Where erosion takes place of one or both surfaces forming the gap then an intumescent seal may be more suitable than ablative materials. In vertical joints a seal with good adhesive properties is likely to be more successful than a 'non-sticky' product.

Foamed-in-place polyurethane foams are not suitable for linear gap seal applications.

4.7 Protection of services

4.7.1 GENERAL

In order to comply with the recommendations of this *Design Guide*, all materials and components used in the construction of a building should not make a significant contribution to fire growth. With respect to services, this objective may be achieved by either using services that have been formulated and constructed to meet that objective, or alternatively, to protecting the service installation from a fire condition. Large quantities of combustible services may significantly increase the fire load in any compartment and adequate precautions need to be taken.

Combustible services must therefore be adequately protected or formulated to ensure that they cannot contribute to a developing fire or propagate the spread of fire. In addition, combustible services shall not be placed closer than 500mm to unprotected air distribution steel ducts. This section makes recommendations on how this objective can be satisfied.

4.7.2 PROTECTION OF ELECTRICAL CABLES

4.7.2.1 Cables located in ceiling voids

Cavity barriers should be provided in each direction at not more than 20m centres and have the fire resistance specified in Table 4.7. Where cables located in a ceiling void have a total cross-section area (conductor, insulation, armour, sheath etc) greater than $0.1\text{m}^2/\text{m}$ width of cavity then they should be protected by an imperforate fire-resisting ceiling having a fire resistance of 30min in terms of integrity and insulation when tested to method 9 of BS 476: Part 22: 1987.

Where the depth of the ceiling void is greater than 600mm and the total area of cables exceeds $0.2\text{m}^2/\text{m}$ width of cavity then the following alternatives should be considered:

- the ceiling should have a fire resistance of 60min in terms of integrity and insulation when tested to method 9 of BS 476:Part 22:1987;

- or
- electrical cables should have been tested and approved to IEC 332-3 (HD 405.3; BS 4066-3) or other specification acceptable to LPC;
- or
- the cavity be protected by an automatic gaseous or sprinkler system;
- or
- the cables are sealed in trunking, ducting etc (not acceptable for applications requiring prolonged operation during a fire).

Cables should not be located nearer than 500mm to air distribution ducts unless the outer surface of the duct is suitably insulated.

4.7.2.2 Cables located in voids below platform floors (for communication room applications see 4.7.3)

Where cables are located within a void below a platform floor, cavity barriers should be provided as follows:

Table 4.9. Cavity barrier spacing in platform floors.

Depth of void (mm)	Distance between cavity barriers in each direction	Fire resistance
Less than 600mm	20m	see Table 4.7
Greater than 600mm	10m	see Table 4.7

Because of the potential continuous addition and/or replacement of cables, the effectiveness of cavity barriers may well be reduced and it is important that cavity barriers located in the voids of platform floors are checked at regular intervals and any damage is rectified by specialist contractors.

Where the total area of cables (conductor, insulation, armour, sheath etc) exceeds $0.2\text{m}^2/\text{m}$ width of cavity, or in service additional cables may be provided to exceed $0.2\text{m}^2/\text{m}$ width of cavity then the following additional measures should be considered:

- the platform floor should have fire resistance of 15min integrity and insulation when exposed to the heating conditions of BS 476: Part 20: 1987;
- or
- the electrical cables specified should have been tested and approved to IEC 332-3 (HD 405.3; BS 4066-3) or other specification acceptable to LPC;
- or
- the cavity is protected by an automatic gaseous or sprinkler system;
- or
- the cables are sealed in trunking, ducting etc (not acceptable for applications requiring prolonged operation during a fire).

4.7.2.3 Services located in vertical shafts

All combustible services not otherwise protected (electrical cables in sealed

trunking, ducting etc) should be located in a fire-resisting service shaft meeting the requirements given in clause 4.4.2.3. The temperature of the service shall be kept below their auto-ignition temperature.

4.7.3 CABLES IN COMMUNICATION ROOMS

Communication rooms are for the purposes of this *Design Guide* regarded as high risk and high value and reference should be made to Appendix 3C of Part 3 of this *Design Guide*. Cavity barriers shall meet the requirements given in 4.7.2.1 or 4.7.2.2 above, and in addition the following shall be considered:

Because of the substantial number of cables generally involved in communication rooms, with the consequent increase in fire load and where cables are installed in a cavity of 300mm or greater, then the following shall be considered:

- the cavity is protected by an automatic gaseous (connected to a fire detector and alarm system) or a sprinkler system;
- or
- cables used should have been tested and approved to UL 910 or other specification acceptable to LPC;
- and
- the platform floor should have fire resistance of 15min integrity and insulation when exposed to the heating conditions of BS 476: Part 20: 1987.

4.7.4 CABLES FOR USE IN EMERGENCY CIRCUITS

These should be tested in accordance with prEN 50200, including a 15min duration water spray test. For those cables used for fire detector and alarm systems these shall be classified PH 90.

4.7.5 PIPES WITHIN FLOOR AND CEILING VOIDS AND VERTICAL SHAFTS

4.7.5.1 Pipe insulation

The insulation used to insulate pipes carrying any type of fluid (liquid or gas), whether flammable or not, should conform to the basic requirements of this *Design Guide* that materials should not make a contribution to fire growth.

In addition, the insulation should be impervious to liquids, for example, oil leaking from another pipe.

4.7.5.2 Pipes containing volatile fluids

- (i) These should be enclosed in a separate fire-resisting service duct as described in 4.4.3.
- (ii) The temperature of the pipes shall be kept below critical temperatures for the fluid.
- (iii) Where it is not practical to provide protection against leakage, the provision of automatic shut-off valves close to the compartment wall is advisable to assist the control of any leakage.
- (iv) Such pipes should not be routed in concealed spaces over rooms containing critical business.

- (v) Flammable gases should not be routed below floors unless suitable leakage detection and ventilation is provided.
- (vi) Electrical cables and equipment should not be sited in the same under floor void as pipes containing flammable fluids.

4.8 References

Draft CEN/CENELEC Standards

- BS EN 1363-1 *Fire resistance tests, Part 1 General requirements.*
- BS EN 1364-1 *Fire resistance tests for non-loadbearing elements, Part 1 Walls.*
- BS EN 1366-1 *Fire resistance tests for service installations, Part 1 Ducts.*
- BS EN 1366-2 *Fire resistance tests for service installations, Part 2 Dampers.*
- prEN 1366-3 *Fire resistance tests for service installations, Part 3 Penetration seals.*
- prEN 1366-5 *Fire resistance tests for service installations, Part 5 Service ducts.*
- prEN 1366-8 *Fire resistance tests for service installations, Part 8 Smoke extraction ducts.*
- prEN 1634-1 *Fire resistance tests for door and shutter assemblies, Part 1 Fire doors and shutters.*
- prEN 50200 *Method of test for resistance to fire of unprotected small cables for use in emergency circuits.*

ISO Standards

- ISO 9002 *Quality management and quality assurance standards, Quality systems. Model for quality assurance in production, installation and servicing.*
- ISO 10294-1:1996 *Fire resistance tests - Fire dampers for air distribution systems Part 1: Method of test.*
- ISO DIS 10295-1 *Fire tests for building elements and components - Fire resistance testing of service installations - Part 1: Penetration seals.*
- ISO CD 10295-2 *Fire tests for building elements and components - Fire resistance testing of service installations - Part 2: Linear gap seals.*

IEC Publication

- IEC 332-3 Technical report, *Tests on electrical cables under fire conditions, Part 3: Tests on bunched wires or cables.*

British Standards

- BS 476: *Fire tests on building materials and structures*
 - Part 8: 1972 (date restriction) *Test methods and criteria for the fire resistance of elements of building construction.*
 - Part 20: 1987 *Method for determination of the fire resistance of elements of construction (general principles).*

Part 21: 1987 *Methods for determination of the fire resistance of loadbearing elements of construction.*

Part 22: 1987 *Methods for the determination of the fire resistance of non-loadbearing elements of construction.*

Part 24: 1987 *Method for determination of the fire resistance of ventilation ducts.*

Part 31.1: 1983 *Methods for measuring smoke penetration through doorsets and shutter assemblies. Method of measurement under ambient temperature conditions.*

BS 4066: *Tests on electric cables under fire conditions*

Part 3: 1994 *Tests on bunched wires or cables (Implements CENELEC HD 405.3 SI:1993).*

BS 5268: *Structural use of timber*

Part 4: Section 4.1: 1978 *Recommendations for calculating fire resistance of timber members.*

Part 4: Section 4.2: 1989 *Fire resistance of timber structures. Recommendations for calculating fire resistance of timber stud walls and joisted floor constructions.*

BS 5839: *Fire detection and alarm systems for buildings*

Part 3: 1988 *Specification for automatic release mechanisms for certain fire protection equipment.*

BS 6459: *Door closers*

Part 1: 1984 *Specification for mechanical performance of crank and rack and pinion overhead closers.*

BS 8110: *Structural use of concrete*

Part 1: 1985 *Code of practice for design and construction.*

BS 8214: 1990 *Code of practice for fire door assemblies with non-metallic leaves.*

BSI DD 171: 1987 *Guide to specifying performance requirements for hinged or pivoted doors (including test methods).*

Loss Prevention Council

List of Approved Fire and Security Products and Services (annual), Loss Prevention Certification Board.

Loss Prevention Standards

LPS 1056, *Requirements and tests for fire doors, lift landing doors and shutters.*

LPS 1158, issue 2, *Requirements and tests for fire-resisting glazing systems.*

LPS 1162, *Requirements and tests for fire dampers.*

LPS 1181, issue 2, *Requirements and tests for wall and ceiling lining materials and composite cladding materials.*

LPS 1197, *Requirements for maintenance and repair of doors and shutters.*

LPS 1208, *Fire performance requirements for metal-faced fire-resisting insulated panels.*

Official documents

The Building Regulations 1991, Approved Document N, Glazing materials and protection.

Workplace (Health, Safety and Welfare) Regulations 1992.

Trade association publications

Association of Builders Hardware Manufacturers, Code of Practice for Hardware Essential to the Optimum Performance of Timber (non-metallic) Fire-resisting Doorsets.

Fire Resistant Glass and Glazed Systems Association, Code of Practice for Fire Resistant Glazing.

Guild of Architectural Ironmongers, Code of Practice for Architectural Ironmongery Suitable for use on Fire-resisting Self Closing, Timber and Emergency Exit Doors.

Intumescent Fire Seals Association, IFSA Information Sheet No 1, The Role of Intumescent Materials in the Design and Manufacture of Timber Based Fire-resisting Doorsets.

Intumescent Fire Seals Association, IFSA Information, Sheet No 3, Guide to the Use of Smoke Seals in Doorsets.

Intumescent Fire Seals Association, IFSA Information Sheet No 4, The Ageing Performance of Intumescent Seals.

Other standards

TRADA Certification Ltd schedule of requirements, Fire resisting door assemblies with non-metallic leaves, dated Jan 1996.

UL910 Underwriters Laboratories Inc, Test for flame-propagation and Smoke-Density Values for Electrical and Optical-Fiber Cables Used in Spaces Transporting Environmental Air.

Other guidance sources

Radiate version 1.2, International Fire Consultants, Firewise software . This is a computer program allowing the rapid evaluation of fire hazard from fire barriers such as glazed screens, doors, partitions, external facades etc.

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5 External fire exposure

5.1 Scope

The recommendations contained in this section should be applied equally regardless of whether the hazard identified during the risk assessment process is presented by buildings, plant or storage on the same, or an adjacent, site.

This section addresses the exposure risk to buildings which may arise either through thermal radiation or the spread of fire due to the close proximity of:

- buildings of equal height;
- buildings of greater height;
- buildings of lower height;
- buildings containing a hazardous occupancy;
- combustible materials stored in open yards;
- hazardous plant;
- afforestation and/or vegetation.

Fire spread frequently occurs across open spaces, especially when combustible or highly flammable materials are stored in open yards, and appropriate steps need to be taken when this scenario exists.

A further aspect considered is that of the risk of arson attack (or malicious ignition). Not all premises are especially exposed to the threat of malicious or intentional ignition but it is important that due consideration is given particularly if the premises are in an area of known risk or an environmentally or politically sensitive occupancy type is involved.

Whilst this guidance is primarily concerned with fire protection, the risk of explosion should not be ignored as part of the risk assessment. Explosions may be the primary or secondary events to the outbreak of fire in some occupancy types and suitable explosion protection should be considered in such cases. In addition the risk of fire resulting from an explosion in adjoining premises should not be overlooked.

Particularly hazardous processes, for example, processes in chemical works and the like, with severe fire development and explosion risks, will require expert consideration and compliance with appropriate legislation.

5.2 Introduction

The external fire exposure risk on any premises requires appropriate consideration to ensure that adequate property protection is provided.

The extent of the risk of external fire spread is mainly dependent upon:

- the distance from the exposing buildings;
- the wall and/or roof construction of the exposed and the exposing buildings;
- the percentage area of the doors and windows in the walls of both buildings;

- the occupancy type; and
- the presence, or lack, of combustible materials or hazardous processes or storage in adjacent open yards.

The risks of fire spread due to convected heat, thermal radiation, flame impingement and flying brands should all be considered. However, since radiated heat can cause ignition at a much greater distance than convected heat or flame impingement, the risk posed by thermal radiation is of primary concern. Fire spread due to flying brands should especially be considered if the roofs are combustible and/or outdoor storage is present. The possibility that doors and windows may be open at the time of the fire should not be overlooked.

The hazards identified during the risk assessment can be effectively controlled by ensuring that spread of fire is prevented or reduced by the provision of :

- a fire-resisting external envelope to the building which is adequate to protect against fire spreading from adjacent buildings, outdoor storage and plant or from floor to floor via the windows up the outside of the building; and/or
- automatic sprinkler protection; and/or
- sufficient separation between the building and potential external sources of fire to prevent spread into the building; and
- good standards of fire safety management and external housekeeping.

Risk control measures of this type will help to reduce the risk of arson or malicious fire raising to acceptable levels.

Other assessment features to be considered are:

- the speed of fire detection;
- the speed of attendance of the fire service and their ability to be able to prevent fire spread; and
- the availability of adequate water supplies.

5.2.1. COMMENTARY

5.2.1.1 National building regulations

Such regulations only make provisions regarding external fire exposure where buildings are within specified distances from the boundary and, in particular, give the following information:

- the level of fire resistance which should be provided; and
- the percentage of the walls which may be unprotected, that is, consist of non-fire-resisting construction.

It should be borne in mind that the unprotected areas of the walls and roof acceptable for the provisions of national building regulations may not provide adequate property protection. In such cases, subject to the risk assessment, compliance with the recommendations of 2.2, or the increased levels of fire resistance recommended in 5.4 of the *Design Guide* may be appropriate.

Note: The boundary under consideration may be the site boundary or a notional boundary drawn between buildings on the same site.

5.2.1.2. Health and safety

Health and safety requirements and other fire precautions arising under health and safety or fire precautions legislation may impose greater separating distances where hazardous plant or storage is involved.

5.3 Definitions

5.3.1 CRITICAL BUSINESS EQUIPMENT

Equipment, often having a high value, upon which the business is wholly or largely dependent for the successful conduct of its operations and even the short term loss of use of which could have serious long term financial implications. Such equipment may, among others, include electronic administration, control or communications systems, heating apparatus and waste or effluent removal systems.

5.3.2 CRITICAL BUSINESS PROCESS

A process reliant on unique or specially designed machinery, or parts, or raw materials which have limited or seasonal availability, as regards which, loss of use or non-availability for a long period of time may threaten either severe diminution of market share or the ability to continue trading.

5.3.3 EXPOSED BUILDING

A building situate adjacent to and within such a distance of another building as to be at risk from fire spreading from the adjacent building.

5.3.4 EXPOSING BUILDING

The building which poses the potential threat of fire spread to an adjacent exposed building.

5.3.5 HIGH RISK BUILDING

A building in which highly combustible or highly flammable materials are stored or used in sufficient quantity to cause a significant threat of fire spread to exposed adjacent buildings.

5.3.6 HIGH VALUE AT RISK

Equipment or stock which has a high individual value relative to the percentage floor area of the building in which it is contained.

5.3.7 PROPERTY PROTECTION

Includes protection from the risk of fire of both the assets of the business and of the ongoing profitability of the company (business interruption).

5.4 Fire spread from adjacent buildings

5.4.1 GENERAL CONSIDERATIONS

This part of the *Design Guide* assumes that building separation and boundary distances are determined using methods described in the Building Research Establishment Report: *External fire spread* (see 5.7, References). In addition,

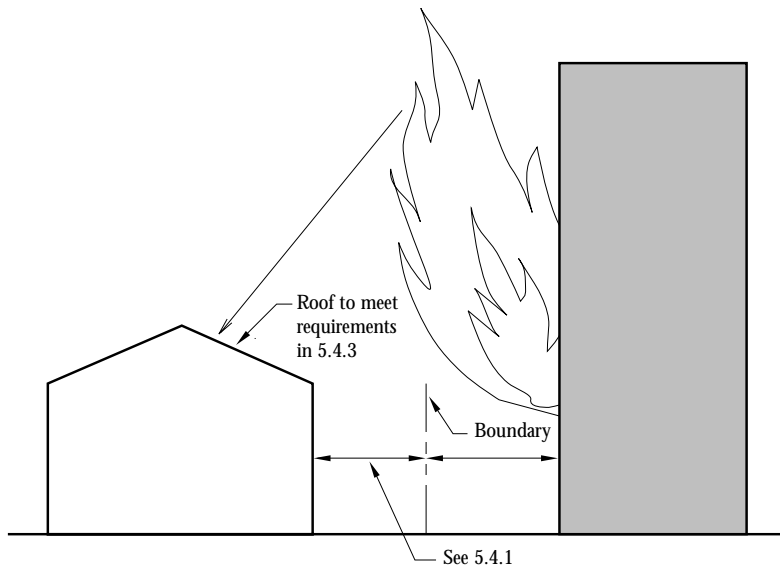


Figure 5.1. External fire exposure from adjacent building to roof (see 5.4).

this *Design Guide* gives further recommendations necessary to ensure adequate property protection. It should be noted that, for the purposes of this *Design Guide*, a boundary is assumed to exist between buildings on the same site and the methodology in the above report should be followed to establish the separating distance.

An important consideration as regards all premises is the potential for fire spread via roofs whether from buildings on the same site or from adjacent or adjoining property. Internal compartmentation may be compromised if a fire is able to spread unchecked across a roof. Whilst not being regarded as as severe a hazard as that of radiation, the risk of fire spread via burning brands from an adjacent building must not be overlooked. The effect of high winds should also be taken into account when assessing the potential for fire spread across roofs particularly in areas exposed to the elements.

Note: This *Design Guide* does not include guidance on other important aspects concerned with roofs, for example, waterproofing, and reference should be made to appropriate technical guidance to ensure that this and other design considerations are addressed.

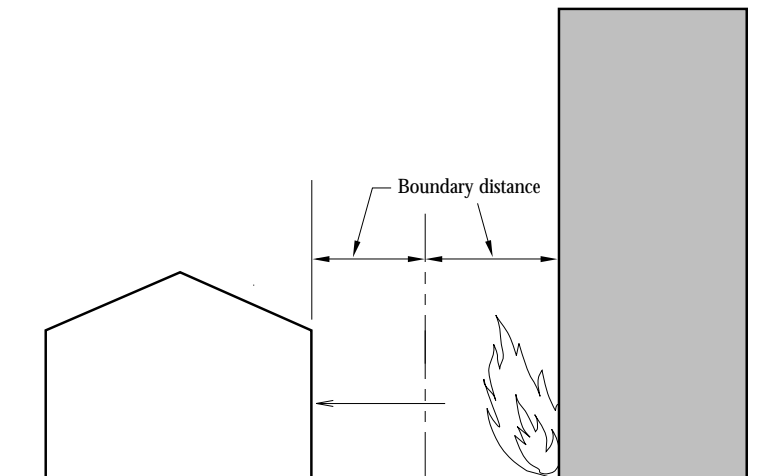


Figure 5.2. External fire exposure from adjacent building to external wall (see 5.4).

5.4.2 WALLS

In some instances it may be necessary to adopt both passive and active, that is, sprinkler, protection to ensure that adequate property protection is provided. The outcome of the risk assessment should identify the extent of the passive and active protection necessary.

5.4.2.1 Walls - passive fire protection

Implementation of the recommendations contained in Parts 2, 3 and 4 of this *Design Guide* will ensure as far as possible that in many instances buildings are adequately protected from both radiation and fire spreading from exposing buildings or premises. Where there is exposure from an adjacent high risk necessitating the provision of a higher level of fire resistance, attention to the following will assist the provision of suitable protection:

- (1) If the separating distance between the buildings is less than 10m or critical business equipment or processes are at risk consideration should be given to the provision of walls meeting the fire resistance and insulation provisions of Table 2.1 of this *Design Guide* subject to a minimum of 30min integrity and 15min insulation. Doors and windows should have fire resistance of not less than 30min in terms of integrity.

The presence of small areas of non-fire-resisting glazing and doors in the exposed building may be acceptable particularly if apertures in the wall are small and in total do not exceed 10 per cent of the wall area.

Note: In some situations a distance of 10m may be inadequate to provide appropriate protection and consideration should be given to increasing the separating distance to ensure adequate property protection is provided. In some instances it may be appropriate to refer to the provisions of section 20 of the London Building Act 1939 (with addendums) for guidance.

- (2) Buildings that overlook adjacent low rise buildings, the roof construction of which does not comply with 5.4.3 or is not fire-resisting, should be protected by ensuring that the envelope of the building has fire resistance as described in (1) above. The protection should extend a minimum height of 10m above the roof of the adjacent building. See Fig. 5.3.

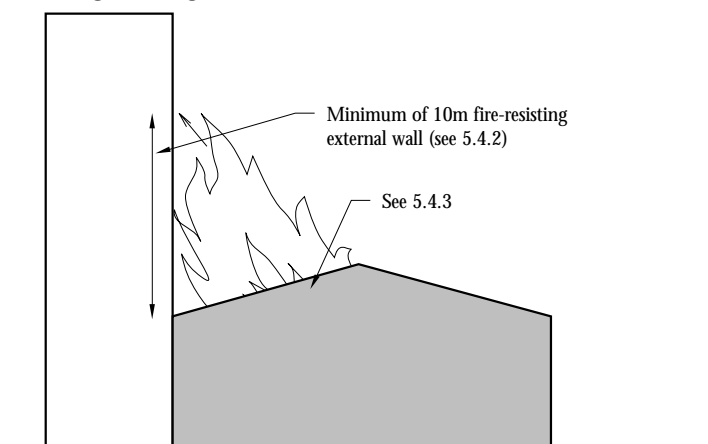


Figure 5.3. External fire exposure from roof to adjacent building (see 5.4).

- (3) Exposure from a building at right angles, whether it be a different occupancy or within the same occupancy, requires special consideration. The external wall in both buildings should meet the conditions specified in 3.3.1.2 for a distance of not less than 10m in each direction from the corner. See Fig. 5.4.

Note: See 5.4.2.2 regarding the alternative of automatic sprinkler protection.

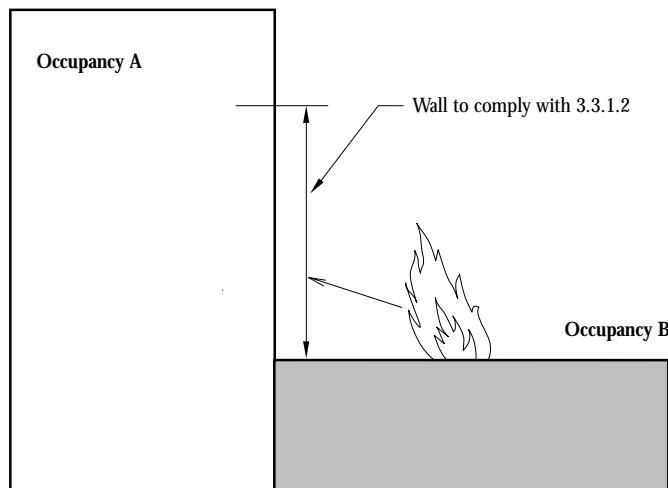


Figure 5.4. Fire exposure from building at right angles (plan view).

5.4.2.2 Walls - sprinkler protection

The following aspects must be born in mind when considering the provision of sprinkler protection in the exposed building:

- (i) the sprinkler protection should be suitable for the occupancy hazard in the building;
- (ii) it should not be compromised by an external fire in exposing buildings or outdoor storage;
- (iii) an external fire may result in exposure along the length, or throughout the height, of the exposed building and cause a large number of sprinkler heads to open thereby rendering the sprinkler installation ineffective;
- (iv) sprinkler protection alone will not prevent fire spread along the external surface of walls and therefore exposed buildings should have an external envelope which complies with 2.2 or 5.4.2.1 as regards walls;
- (v) where compartmentation, and the protected zone on either side, is at risk of being by-passed by fire spreading from an exposing building on the same site, sprinkler protection of both buildings should be considered as an alternative to the provision of fire-resisting construction;
- (vi) where an external hazard may increase the risk of compartment walls being compromised the distances specified in 3.3.1.2 and 3.3.1.3 should be increased as necessary.

Note: Sprinkler systems in adjacent buildings in different ownership should be treated with caution in view of the lack of any continuing guarantee of

efficiency and maintenance and to account for periods when the installation may be turned off.

5.4.3 ROOFS - GENERAL

The materials used in the construction of roofs of all buildings should preferably conform to the recommendations contained in 2.2 of this *Design Guide* but at the very least should not permit the rapid spread of fire across the external surface when exposed to radiation or fire emanating from adjacent buildings.

See 5.5.3 for further guidance.

5.4.3.1 Roofs - passive fire protection

Roofs of low rise buildings should, in addition to complying with the protected zone criteria in connection with compartmentation as detailed in 3.4, be constructed in accordance with the following provisions to resist spread of fire by radiation or other means from adjacent or adjoining buildings:

- (i) Careful selection of materials, and detailing, particularly, as regards pitched roofs, at eaves and for all buildings at the junctions with roof lights and roof ventilators is essential to ensure that fire is not able to spread via any weaknesses at these points.
- (ii) With respect to external fire exposure the roofing system, comprising the roof covering, thermal insulation and roof deck should be classified not less than EXT.F.AC or EXT.S.AC when tested in accordance with BS 476: Part 3: 1958.
- (iii) The provision of rooflights or ventilators in any roof may assist rapid fire spread to inside the building or to nearby roofs or buildings and they should therefore be classified not less than EXT.F.AC or EXT.S.AC when tested in accordance with BS 476: Part 3: 1958. However the following should be noted:
 - The following wording appears in Approved Document B 1991, Section 14.6: 'When used in rooflights, a rigid Thermoplastic sheet product made from polycarbonate or from plasticised PVC, which achieves a Class 1 rating for surface flame spread when tested to BS476 Part 7, 1971 or 1987, can be regarded as having an AA designation.'
 - It may not be possible to maintain the prescribed underpressure conditions when testing ventilators. For the purpose of this *Design Guide*, ventilators used in roofs may be tested and classified without complying with the underpressure conditions prescribed in BS 476: Part 3: 1958.
- (iv) In buildings containing high values or critical business equipment or processes, rooflights and ventilators should not have a dimension greater than 1m and be spaced not less than 3m apart in any direction. This restriction does not apply to rooflights or ventilators having a rating of EXT.F.AA or EXT.S.AA when tested in accordance with BS 476: Part 3: 1958.

5.4.3.2 Roofs - sprinkler protection

Subject to the risk assessment, it may be possible to relax some of the requirements given in 5.4.3.1 when the building is fully sprinkler protected. However, the recommendations and restrictions in relation to the protected zone shall still be met and, in addition, the following should be noted:

- the provision of a properly designed automatic sprinkler installation in an exposing building should prevent a fire breaking out through the roof from inside the building;
- it should be noted that an external roof fire will not be controlled by a sprinkler system and the exposed building may be severely damaged as a result of external fire spread. Roofs of buildings which are so exposed should be constructed of materials described in 5.4.3.1;
- reference should be made to 5.5.3.2 where the guidance on fire spreading from inside the building and igniting the roof is equally applicable.

5.4.3.3 Roofs - smoke ventilation

In non-sprinklered single storey buildings, where a properly designed and installed automatic smoke extraction system is installed, serious deformation or collapse of the roof may well be delayed as a result of the release of some of the hot gases.

As non-automatic smoke extraction systems rely on the swift response of the fire brigade, no reduction in the performance requirements given in 5.4.3.1 is recommended unless shown to be justified by the risk assessment. In addition, it is recommended that the design of the ventilator ensures that any combustible materials used in the roof construction cannot be ignited by hot gases passing through the opened vent (see 5.4.3.1).

Where a roof presents a severe exposure hazard to an adjoining building on the same site it is essential that the location of the ventilators does not increase the exposure risk.

Note: This *Design Guide* recommends that no reliance is made on venting the fire through openings caused by collapsed plastic rooflights. Where the designer wishes to extract smoke and hot gases a properly designed smoke extraction system should be installed.

5.5 Fire spread from inside building to external fabric

5.5.1 GENERAL CONSIDERATIONS

The risk of fire spread from inside the building to the external fabric requires consideration to ensure that adequate property protection is provided to prevent the following:

- compartmentation, both vertical and horizontal, being compromised;
- fire spread up the outside of a building resulting in damage to several floors;
- fire piercing the roof construction and spreading across the roof surface. (NB. Horizontal compartmentation may also be compromised.)

Multi-storey buildings are usually occupied for relatively low hazard purposes but still contain significant quantities of combustible materials which assist rapid vertical fire spread from floor to floor.

5.5.2 WALLS - GENERAL

The materials used in the construction of walls should not contribute to the growth or spread of fire, not only as regards the external surface, but also as regards insulation materials since, if they are not in accordance with the provisions of 2.2 of this *Design Guide*, radiation or a fire spreading from an adjacent building may cause significant damage.

5.5.2.1 Walls - passive fire protection

In general, compliance with the guidance in Part 2 will ensure provision of adequate protection to the walls but where critical business equipment or processes or high values are present or compartmentation may be compromised, consideration should be given to the following:

- (i) Section 3.3.1.3 (External walls - vertical fire spread) gives guidance on the approach which is recommended to reduce the exposure risk to compartmentation between occupancy types caused by vertical external fire spread.
- (ii) The guidance given in 3.3.1.3 is equally applicable where compartmentation is not a consideration but it is necessary to reduce a potential threat to business interruption.
- (iii) Horizontal fire spread along the external walls is covered in 3.3.1.1 and 3.3.1.2 as regards maintenance of the integrity of compartment wall protection where fire may break out of the building and spread back inside bypassing the compartment wall.

Note: Higher levels of performance may be needed to satisfy the building regulations where the building is within 1m of a boundary.

5.5.2.2 Walls - sprinkler protection

Automatic sprinkler protection is a very effective way of controlling fire spread and preventing fire breaking out of one floor and back into the floors above.

If the entire building is sprinkler protected it may be sufficient that the recommendations of 2.2, and Part 3 if applicable, are complied with as regards the building envelope and that, except to satisfy the provisions of national building regulations, the provision of fire-resisting construction will not be required.

5.5.3 ROOFS - GENERAL

The materials used in the construction of roofs should at least restrict the ability of a fire to penetrate the roof decking and involve the external insulating and weatherproofing materials. The performance level needed will depend upon the criticality of the use of the building. It should not be forgotten that significant deformation or collapse of a roof when exposed to a fire from below can seriously disrupt effective firefighting operations.

5.5.3.1 Roofs - passive fire protection

The guidance given in 5.4.3 above should be followed as applicable to ensure that roof construction provides appropriate protection. In addition the following recommendations should be noted:

- In vulnerable areas containing critical business equipment, or processes where the roof covering may be exposed to fire from within the building, for example, for 1m around rooflights, the roofing system should be classified not less than EXT.FAA or EXT.S.AA when tested in accordance with BS476: Part 3: 1958 unless the restrictions on size of rooflights detailed in 5.4.3.1 (iv) apply.

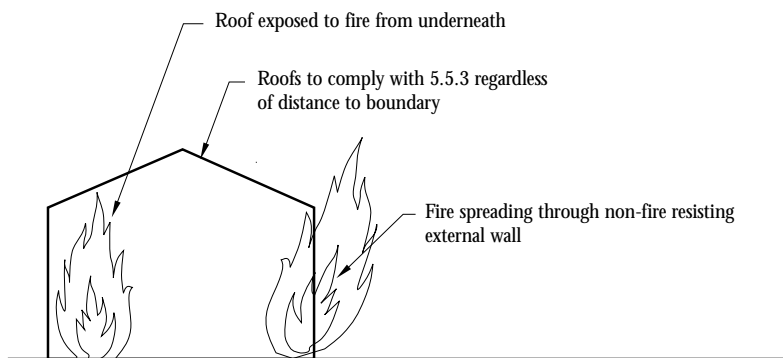


Figure 5.5. External fire exposure - fire inside spreading to roof.

- Section 3.4 of this *Design Guide* gives guidance regarding protection against fire bypassing compartment walls. In addition, the roof construction in the protected zone defined in 3.4.2 shall provide at least 30min integrity and 15min insulation when tested to method 9 of BS 476: Part 22: 1987.¹
- Rooflights in the protected zone defined in clause 3.4.2 shall be avoided unless they provide 30 minutes integrity when tested to method 9 of BS 476:Part 22:1987.¹ Unprotected ventilators shall not be located within the protected zone.

5.5.3.2 Roofs - sprinkler protection

The recommendations contained in 5.4.3 are applicable but, in order to ensure that the passive fire protection recommended in 5.4.3.1 and 5.5.3.1 is not compromised, no reduction in the standards of fire resistance specified should be considered.

¹ It is important that only fire-resisting roof decking systems and roof-lights that have been tested in the horizontal orientation are used in the protected zone. Constructions that have only been tested in the vertical may fail prematurely if used horizontally. Method 9 of BS 476: Part 22 describes a method of test for ceiling membranes but this can be taken to be horizontal partitions. Where a roof is not designed for means of escape, and can therefore be tested without load, this test is considered the most applicable.

5.6 Outdoor exposure risks and arson protection

5.6.1 GENERAL CONSIDERATIONS

Where premises are identified as being at risk to an arson attack or from an accidental fire occurring in outdoor storage or processes it is especially important that:

- suitably designed standards of security and fire safety management are established at the design stage to reduce the potential threat;
- these standards are clearly defined before any decision is taken regarding the fire resistance of the external envelope of the building; and
- consideration is given to the siting of buildings and outdoor storage or processes in relation to each other and to the site boundary.

Note: In practical terms, the method referred to in 5.4.1 for determining boundary distances does not take into account the storage of combustible materials between the building and the boundary and, therefore, the boundary distance thus determined may not adequately deal with this risk.

This approach should enable a more cost effective approach to be taken to the whole question of protection against these types of fire.

Notes:

1. Buildings which otherwise comply with the provisions of this *Design Guide* may be compromised if insufficient consideration is given during the risk assessment process to the potential for an arson attack on or malicious ignition in the building. In addition, the risk of fire spreading and involving buildings on the site as a result of accidental ignition occurring in outdoor storage or processes must be considered.
2. The provision of an 'apron' or clear area around the building designed or furnished with features to deter the storage of goods or materials can be an effective prevention of fire spread.
3. It is essential that good standards of security and fire safety management are established and maintained. Guidance on these aspects should be sought from insurers.

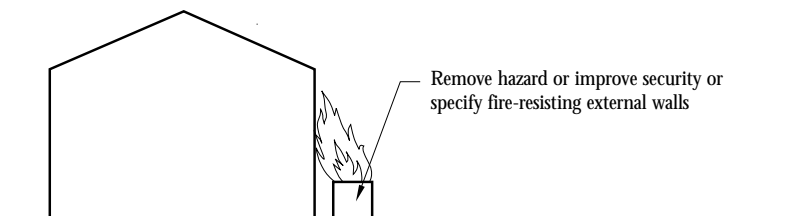


Figure 5.6. External exposure from arson attack (see 5.5).

5.6.2 RECOMMENDED PROTECTION AGAINST MALICIOUS IGNITION

This section of the *Design Guide* gives guidance on the additional fire resistance which should be considered to ensure adequate property protection is provided against the risk of fires which are started deliberately.

The introduction and maintenance of good standards of housekeeping and fire safety management is essential in all premises and will help to reduce the impact of a fire started maliciously. In support of such standards, however, it is essential that the relevant standards of fire protection detailed in this *Design Guide* are applied to all buildings, whether or not a risk of malicious ignition exists. These standards should be increased as detailed below where an unacceptable risk is identified.

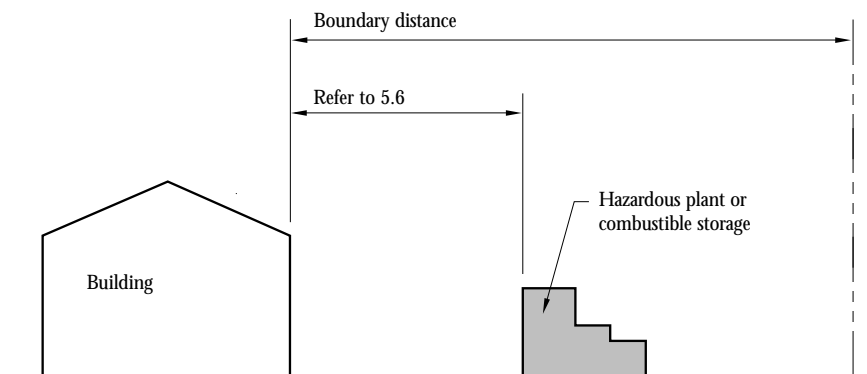


Figure 5.7. Outdoor exposure or arson risk.

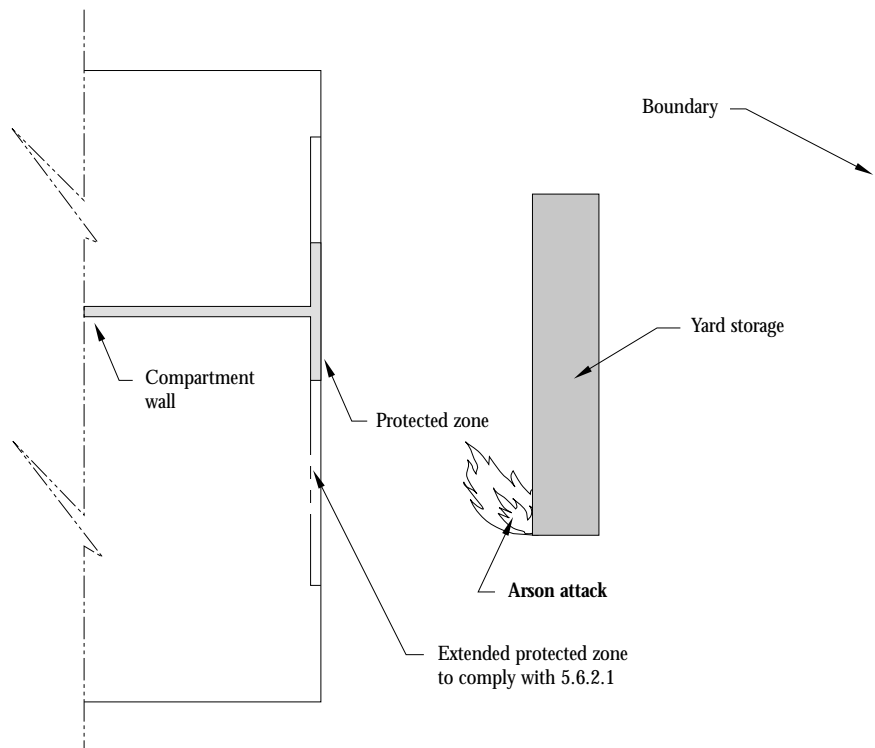
5.6.2.1 Passive fire protection

The materials used in the construction of the external walls and roof of the building(s) should conform to 2.2 and 5.5.3 respectively of this *Design Guide* in order to control and minimise the growth and spread of a fire. In many premises this will give adequate protection, including those potentially at risk to arson attack, providing good standards of fire safety management and security are practised.

However on premises where combustible materials, for example, wood pallets, waste bins, stock and the like, cannot be kept a safe distance from the buildings, the following additional protection should be considered:

- (1) The sections of the external walls and roof which are at risk from nearby combustible materials should have a fire resistance of not less than 30min integrity and 15min insulation.
- (2) Where it is important to protect high values or critical business equipment or processes, consideration should be given to increasing the levels in (1) above to 60min fire resistance as regards both integrity and insulation.
- (3) It is equally important that windows and doors have similar levels of resistance as regards integrity or that they are not put at risk by storage etc.
- (4) The length of the protected zone on either side of the compartment wall may need to be extended to prevent fire in external storage compromising the separation provided.

Figure 5.8. Extension of protected zone to reduce risk of fire spread from arson attack on combustible materials stored in yard (plan).



- (5) The provision of soffits and barge boards, including any proposed ventilators, which will resist the passage of fire for a suitable period. The following recommendations should be considered:
- provision of soffits and barge boards of materials conforming to 2.2;
 - the guidance given in 3.4.4 (d) of this *Design Guide* concerning the siting of ventilators; and
 - the provision of effective cavity barriers where walls, whether or not compartment walls, are bypassed by the soffit box.

5.6.2.2 Sprinkler protection

The provision of automatic sprinkler protection in buildings can be taken into account when deciding the level of fire protection required to overcome the threat posed by external storage.

It is, however, especially important that the effectiveness of the sprinkler installation is not impaired as a result of a large number of sprinkler heads operating simultaneously following the failure of a large section of the external wall or roof.

The guidance on sprinkler protection given in 5.4 and 5.5 should be followed and it should be noted that there will be occasions when it will be advisable for the external walls and/or roof to be of fire-resisting materials even though the building is sprinkler protected.

5.6.3 EXPOSURE TO FIRE FROM EXTERNAL ACCIDENTAL SOURCES

The site layout of all premises should take account of the threats presented not only on the premises but also from adjacent premises. As regards the premises in question the comments made in other parts of this section are equally applicable to the prevention of fire spread from accidental fires. The creation of 'fire breaks', that is, clear areas, between buildings and storage or to protect against fire spread from adjacent sites can be very effective.

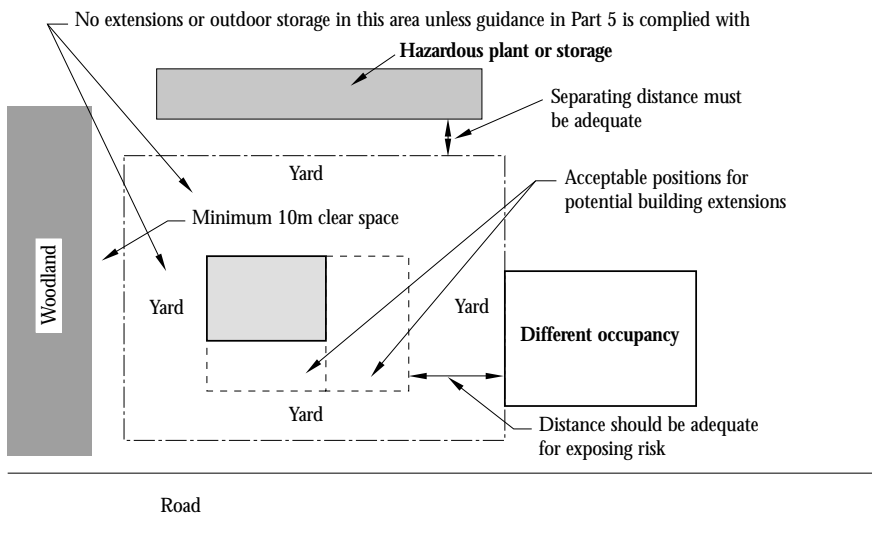


Figure 5.9. Outdoor exposure and arson risk - plan view (see 5.6).

Surrounding property may present potential threats to the fire safety of the premises but with well considered planning at an early stage the risks imposed can be eliminated or at least controlled or reduced to acceptable levels capable of protection.

To combat threats to the buildings posed by accidental external sources of fire the designer may therefore wish to consider specifying an external cladding system having fire resistance and insulation as specified in 5.4.2.1. However as previously stated it is preferred that adequate provision be made to prevent storage of combustible materials nearer than 10m from the building and at suitable distance from surrounding property or boundary fences or walls.

5.7 Reference

BRE report: *External fire spread: building separation and boundary distances*, Fire Research Station, 1991

**PLEASE READ THIS
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IMPORTANT

These data sheets are only intended to give generic information

Data on specific products must be obtained from the manufacturer

6 Construction design and data sheets

6.0.1 INTRODUCTION

The purpose of the construction design and data sheets is to provide:

- Information on generic building products with regard to their main application in respect of this *Design Guide*.
- Main function of each product group in relation to this *Design Guide*.
- General advice on what evidence of performance shall be sought by the building designer to ensure compliance with the recommendations given in this *Design Guide*.
- Generic data on a broad range of building product types.

The data sheets are limited mainly to fire performance and those other factors which may affect fire performance, e.g. durability. They do not deal with health and safety issues.

6.0.2 PERFORMANCE OF PASSIVE FIRE PROTECTION PRODUCTS

The following factors have been chosen, as appropriate, to obtain a relative comparison between products in each group:

- Contribution to fire growth (pre-flashover)
- Surface spread of flame
- Fire resistance
- Contribution to fire load (post flashover)
- Integrity
- Temperature rise
- Smoke resistance
- Loading and deflection
- Ability to accommodate services
- Durability

Because of the proprietary nature of most passive fire protection products, it is not generally possible to give specific information on fire resistance levels achievable. The designer should always obtain information directly from the product manufacturer or his agent.

To assist the building designer in the selection of appropriate products, a simplified rating system has been included for broad based guidance.

- (☆☆☆☆☆) Excellent performance in relation to this specific application and product group.
- (☆☆☆☆) Good performance in relation to this specific application and product group.
- (☆☆☆) Satisfactory performance in relation to this specific application and product group.
- (☆☆) Not recommended where this specific performance requirement is important.
- (☆) Unacceptable where this specific performance requirement is important.

It must be stressed that ratings given are for guidance only, as specific proprietary products may be different from those indicated. In addition, ratings given in one data sheet must not be compared directly with that given in another data sheet where the typical end use application may be different. The importance of independent third party product certification which includes regular product quality audits cannot be over emphasised.

6.0.3 CONTENTS

This part of the *Design Guide for the Fire Protection of Buildings* covers a number of broad applications for passive fire protection products:

- 6.1 Structural frames
- 6.2 Roofs
- 6.3 Compartment walls
- 6.4 External walls
- 6.5 Compartment floors
- 6.6 Fire doors
- 6.7 Service sealing
- 6.8 Fire resistant glazing
- 6.9 Protection of air distribution systems

6.0.4 PRODUCTS COVERED IN THIS PART OF THE *DESIGN GUIDE*

Product	Data sheet number
6.1 Structural frames	
Structural steelwork frame/portal frame	6.1.1
Reinforced concrete frame/portal frame - cast in-situ	6.1.1
Reinforced concrete frame/portal frame - precast	6.1.1
Reinforced concrete - pre-stressed	6.1.1
Timber frame	6.1.1
Steelwork - trussed assemblies	6.1.1
Concrete - trussed assemblies	6.1.1
Timber - trussed assemblies	6.1.1
6.2 Roofs	
Roofs - composite panels - polyurethane	6.2.1
Roofs - composite panels - polyisocyanurate	6.2.1
Roofs - composite panels - mineral wool cored (rock fibre)	6.2.1
Roofs - built up constructions - mineral wool insulant	6.2.1
Roofs - drylining protected systems - calcium silicate boards	6.2.1
Roofs - drylining protected systems - gypsum board	6.2.1

Product	Data sheet number
6.3 Compartment walls	
Compartment walls - masonry, bricks	6.3.1
Compartment walls - masonry, blockwork	6.3.1
Compartment walls - stud partitions, unreinforced gypsum plasterboard linings	6.3.2
Compartment walls - stud partitions, reinforced gypsum plasterboard linings	6.3.2
Compartment walls - stud partitions, calcium silicate board linings	6.3.2
Compartment walls-stud partitions, cement based board linings	6.3.2
Compartment walls-stud partitions, wood based board linings	6.3.2
Compartment walls-stud partitions, steel sheet linings	6.3.2
Cavity barriers - calcium silicate and cement based boards	6.3.3
Cavity barriers - unreinforced gypsum based boards	6.3.3
Cavity barriers - reinforced gypsum boards	6.3.3
Cavity barriers - mineral wool quilt	6.3.3
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External walls - composite panels, mineral wool core	6.4.1
External walls - built-up panels	6.4.1
External walls - calcium silicate boards	6.4.1
External walls - gypsum board lined	6.4.1
6.5 Compartment floors	
Compartment floors, gypsum based board and skim	6.5.1
Compartment floors, lath and plaster skim	6.5.1
Compartment floors, concrete	6.5.1
Compartment floors, permanent steel formwork	6.5.1
Compartment floors, woodwool slab soffit	6.5.1
Compartment floors, proprietary suspended ceiling	6.5.1
Compartment floors, timber ceiling	6.5.1
Compartment floors, proprietary boards	6.5.1

Product	Data sheet number
6.6 Fire doors	
Fire doors, hinged and pivoted, timber door assemblies	6.6.1
Fire doors, hinged and pivoted, timber and mineral cored composites	6.6.1
Fire doors, hinged and pivoted, steel and glass architectural doorsets	6.6.1
Fire doors, hinged and pivoted, steel flush doorsets	6.6.1
Fire doors, industrial metal doors, roller shutters - barrel horizontally mounted, shutter vertically opening	6.6.2
Fire doors, industrial metal doors, roller shutters - barrel vertically mounted, shutter horizontally opening	6.6.2
Fire doors, industrial metal doors, metal folding doors	6.6.2
Fire doors, industrial metal doors, metal sliding doors	6.6.2
Fire doors, industrial metal doors, large flush steel hinged doorsets	6.6.2
Fire doors, conveyor closures	6.6.2
6.7 Service sealing	
Service sealing, penetration seals, small penetrations, mineral fibre fire stopping	6.7.1
Service sealing, penetration seals, small penetrations, cementitious materials	6.7.1
Service sealing, penetration seals, small penetrations, composite foam/intumescent gaskets	6.7.1
Service sealing, penetration seals, small penetrations, proprietary mastics and sealants	6.7.1
Service sealing, penetration seals, large penetrations, cementitious slabs	6.7.1
Service sealing, penetration seals, large penetrations, fire protection boards	6.7.1
Service sealing, penetration seals, large penetrations, perforated steel faced protection boards	6.7.1
Service sealing, penetration seals, large penetrations, uncoated mineral fibre slabs	6.7.1
Service sealing, penetration seals, large penetrations, coated composite mineral fibre slabs	6.7.1
Service sealing, penetration seals, large penetrations, fire pillows	6.7.1
Service sealing, penetration seals, closing devices for sealing of low melting point services, metal cased pipe collars	6.7.1

Product	Data sheet number
Service sealing, penetration seals, closing devices for sealing of low melting point services, pipe wraps	6.7.1
Service sealing, penetration seals, closing devices for sealing of low melting point services, cable sealing assemblies	6.7.1
Service sealing, fire stopping, mineral fibre	6.7.2
Service sealing, fire stopping, cementitious materials	6.7.2
Service sealing, linear gap seals, intumescent mastics	6.7.2
Service sealing, linear gap seals, non-intumescent mastics	6.7.2
Service sealing, linear gap seals, composite foam/intumescent gaskets	6.7.2
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Fire resistant glazing, glass, unwired, monolithic float glasses of boro-silicate composition	6.8.1
Fire resistant glazing, glass, unwired, edge controlled, toughened, clear, monolithic glasses of soda/lime composition	6.8.1
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Protection of air distribution systems, steel ducts protected by fire protection systems and self-supporting duct systems constructed from fire protection boards, calcium silicate board with dry density 450-500kg/m ³	6.9.2
Protection of air distribution systems, steel ducts protected by fire protection systems and self-supporting duct systems constructed from fire protection boards, calcium silicate board with dry density 640-650kg/m ³	6.9.2
Protection of air distribution systems, fire resisting ducts, calcium silicate board with dry density 875-890kg/m ³	6.9.2
Protection of air distribution systems, steel ducts protected by fire protection systems and self-supporting duct systems constructed from fire protection boards, cement/steel composite board	6.9.2
Protection of air distribution systems, steel ducts protected by fire protection systems and self-supporting duct systems constructed from fire protection boards, rock fibre mineral wool	6.9.2

6.0.5 PRODUCTS NOT COVERED IN THIS PART OF THE *DESIGN GUIDE*

It has not been possible to cover all types of products in this part. Absence of a specific product type does not necessarily mean that it cannot meet the requirements of the *Design Guide for the Fire Protection of Buildings*.

Examples of products not covered are:

- Products not intended to have any fire protection function
- Unique products
- Constructions made up typically of a large number of materials and components delivered to site that require complete assembly on site. Where such constructions contain combustible materials, considerable caution is advised and the building designer should seek independent advice on the system's suitability for the specific application in respect to this *Design Guide*.

- Products where *insufficient data* were available to include them in this Part, or where new applications are still being developed for existing materials. (Absence from this part of the *Design Guide* should not be taken to suggest that such products could not meet the requirements.)

6.0.6 ACCURACY OF INFORMATION

The information given in this part of the *Design Guide for the Fire Protection of Buildings* is intended to provide broad based guidance only. Whilst every effort has been made to ensure the information is accurate, the designer should check with the product manufacturer or supplier to verify the actual level of performance. In respect to [boxed] values, these are only intended to give a very approximate indication of performance.

The information given in these data sheets is based in all cases on independent specialist knowledge based on available data. Individual manufacturers or trade associations have not been involved so as to achieve as impartial a view as possible.

Sheet No: 6.1.1

6.1 Structural frames

Main application in respect to this *Design Guide*:

1. Providing a robust framework through which all relevant building forces and imposed loads are transmitted to ground.
2. Providing a load-bearing infrastructure to support other building components and fire safety provisions, e.g. compartment floors.

FUNCTION OF STRUCTURAL FRAMES

- To maintain a load-bearing capacity under fire conditions for the duration defined in Table 2.1 and 2.2 of the *Design Guide*, thus ensuring that the building structure retains its stability for a reasonable period.
- To maintain a load-bearing capacity for the duration defined in Tables 2.1/2.2 of the *Design Guide*, thus ensuring that all other fire safety systems exist within a robust infrastructure such that they can remain functional.
- Not to contribute unduly to the growth and development of fire within the building.
- To withstand the loading and deflection to be experienced in use and during fire exposure whilst maintaining the requirements above.
- To maintain the load-bearing performance over the lifetime of the building, in respect of realistic impact and/or ambient conditions.

EVIDENCE OF FIRE PERFORMANCE

The evidence of performance should cover the following;

- **Fire resistance performance (load-bearing capacity).** The ability of the structural frame (or its constituent components in combination) to maintain the requisite load-bearing capacity and resist undue deflection, deformation and collapse. This shall be verified by evidence of performance in accordance with BS 476: Part 21^{1g}, EN 1365 Part 3 (beams)^{27c}, or Part 4 (columns)^{27d} under conditions appropriate to the final construction use of the frame. The large sizes of structural frames are typically incompatible with the sizes of fire resistance test furnaces. Fire performance is determined on the basis of fire resistance tests in accordance with BS 476: Part 21^{1g}, EN 1365 Part 3 (beams)^{27c}, or Part 4 (columns)^{27d} on the individual components of the frame. Careful interpretation of these fire test results or engineered assessment is necessary to permit their application in the context of a frame assembly. A detailed and considered Engineering Assessment or Field of Application Report is essential. Connection details, interactions, boundary conditions and restrictions in use all need to be evaluated by a competent person.

BEFORE READING
THIS DATA SHEET
PLEASE REFER TO
THE
INTRODUCTION

IMPORTANT
THESE DATA SHEETS ARE ONLY INTENDED TO GIVE GENERIC INFORMATION.
DATA ON PROPRIETARY PRODUCTS MUST BE OBTAINED FROM THE MANUFACTURERS

Suitable fire resisting load-bearing capacity performance may also be verified by appropriate structural fire engineering design in accordance with accepted engineering principles as detailed in various British Standard design codes. Evidence should be requested to ensure that the design both complies with the recommendations, and that the design has been checked and assessed by a competent person.

- Structural frames are often required only to support the roof of a building. Whilst, it is generally not required that the stability of the roof be assured for the full duration described in Table 2.1 of this *Design Guide*, consideration must be given to the consequences of roof collapse on the overall stability of the building. In particular, attention should be paid to the stability of those structural members which rely on the roof members for stiffness and support. The effect of roof collapse on the load paths within the structural frame also need to be considered. It is likely that collapse of the roof will transmit additional loads (including overturning moments) to the structural frame. The structural frame needs to be capable of withstanding these additional forces for the required period of fire exposure. Otherwise the roof structure itself may need to be protected from the effects of fire.
- **Contribution to fire growth.** When the exposed surfaces of the structural frame are integral with a wall or a ceiling, whose surfaces are required to achieve a surface spread of flame characteristics, the frame surfaces shall not reduce or negate the surface characteristic.
- In some instances, the orientation, topography and surface properties of the frame may be such that an inherent resistance to the spread of flame is assured to the satisfaction of a competent person. Otherwise, the frame surfaces shall achieve a surface spread of flame classification of Class 1 as defined in BS 476: Part 7^{1d} appropriate to the surface they form part of. The same surface shall also achieve a fire propagation Index (I) of not more than 12 and a sub-index (i) of not more than 6 when tested to BS 476: Part 6^{1c}. Note that the combination of these various performance parameters is described as being Class 0 in the Approved Document B of the Building Regulations 1991 England and Wales²⁹. Alternatively, the exposed surface of the frame may be designated as being of limited combustibility, as defined by BS 476: Part 11^{1e}. The frame materials shall not add to the fire load within the building.
- **Loading and deflection.** The structural frame shall be so constructed such that the occurrence of a deflection of span/30 during fire conditions shall not cause the opening of gaps or undue cracks which could permit fire spread. Frames shall not suffer distortions such as to cause transfer of loads (direct or thermally induced) from the frame to adjacent non-loadbearing members such as partitions and walls. The thermal expansion of structural frames shall not impose lateral thrusts on walls such as could cause their collapse. Compliance with the requirement shall be demonstrated through a combination of an engineering awareness of load paths and fire test evidence in accordance with BS 476: Part 21^{1g}, EN 1365 Parts 3 (beams)^{27c} or 4 (columns)^{27d} together with an associated Field of Application Report.

- **Durability.** Evidence shall be available to verify that the materials used in the construction of the structural frame are not going to be adversely affected by ambient conditions and, if appropriate, abuse (e.g. low energy impacts) during the anticipated life of the building.

OVERVIEW OF STRUCTURAL FRAMES

Structural frames provide the load-bearing skeleton for a building. Many other building elements such as walls, floors and roofs achieve their stiffness and stability either directly or indirectly from the structural frame. In general terms, structural frames may be categorised as follows;

1. Assemblies of columns and beams
2. Trussed assemblies
3. Monolithic rigid frames (pitched roof portals)

Structural frames are constructed using steelwork, reinforced concrete or timber. The fire performance of the structural frame is a function of both its structural form and the construction material used.

1. ASSEMBLIES OF BEAMS AND COLUMNS

The fire performance of structural frames, which are assemblies of beams and columns, is a function of the fire resistance of the individual beams and columns as well as the nature of the fixings connecting them.

The load-bearing fire resisting performance of individual beams and columns is measured in BS 476: Part 21^{1g}, EN 1365 Part 3 (beams)^{27c} or Part 4 (columns)^{27d}. Fire tests are conducted on representative structural members under conditions of applied load. The end conditions of the test specimen, in terms of the degree of fixity present, are usually less rigid than those end conditions likely to be encountered by such members within a structural framework. Accordingly, fire tests predict levels of fire performance, which may be viewed as conservative. The application of individual fire test results to a full frame needs to carefully consider the end fixing.

Simple (or pinned) joints between the beams and columns are only capable of resisting shear and axial loads. They are unable to resist applied moments and lateral forces, e.g. wind. Such forces need to be resisted by horizontal bracing members. Frames containing simply connected members cannot utilise the moment resistance of the joints to increase the fire resistance rating of the frame beyond the fire resistance ratings of the individual beams and columns.

Beams and columns connected by a series of rigid joints are capable of withstanding shear, axial load and applied moments. Such rigid frames can utilise load-shedding and moment redistribution to achieve higher fire resistance ratings than those ratings achieved by individual beams or columns.

This data sheet considers the following:

- 1.1 Structural steelwork
- 1.2 Reinforced concrete: cast in-situ
- 1.3 Reinforced concrete: precast
- 1.4 Reinforced concrete: pre-stressed
- 1.5 Timber

1.1 STRUCTURAL STEELWORK

The fire performance of structural steelwork frames constituted of individual beams and columns connected together is a function of the fire resistance of the individual beams and columns as well as the nature of the fixing connection between them.

The load-bearing fire resisting performance of individual steel beams and columns is measured in BS 476: Part 21^{1g}, EN 1365 Part 3 (beams)^{27c} or Part 4 (columns)^{27d}. Fire tests are conducted on representative steel members under conditions of applied load. As steel loses its strength at elevated temperatures, structural steelwork is typically afforded insulation from the effects of fire through application of a protective material or coating.

In terms of fire performance, typical bolted connections between steelwork beams and columns can be considered as semi-rigid connections, which are capable of resisting moments to a limited extent.

To be considered as a fully rigid frame, beams and columns need to be connected by welded joints. Alternatively joints constructed by bolted connections using thick end plates and local stiffeners can be considered as fully rigid. Fully rigid frames or monolithic frames are discussed in their own right elsewhere in this *Design Guide*.

FIRE PERFORMANCE DATA

- **Load-bearing capacity.** Typically steelwork frames will be protected from the effects of fire. The degree of protection required will be deduced from fire tests on individual beams and columns to BS 476: Part 21^{1g}, EN 1365 Part 3 (beams)^{27c} or Part 4 (columns)^{27d}, or by reference to the ASFPFCM Yellow Book³² if the section size and duration are known, albeit this gives a pessimistic view of the protection needed in practice. Unprotected structural steelwork frames consisting of rigid connections can achieve fire resistance ratings of up to 60min. Such performance needs to be carefully validated by a competent person and specialist computer software is usually necessary. (☆☆☆)
- **Contribution to fire growth.** Class 0 and non-combustible. (☆☆☆☆☆)
- **Contribution to fire load within building.** Steelwork is not combustible and does not add to the fire load within the building. (☆☆☆☆☆)
- **Loading and deflection.** Steelwork expands on heating and careful consideration should be given to the resulting thermal movements. Special joints may be necessary to accommodate thermal movements or alternatively insulation protection provided. (☆☆☆)
- **Durability.** Resistant to substantial impacts and when decorated it is resistant to atmospheric degradation. (☆☆☆☆☆)

1.2 REINFORCED CONCRETE: CAST IN-SITU

Assemblies of cast in-situ concrete beams and columns are generally provided with reinforced connections and such frames can be considered as rigid in the context of fire performance. Therefore the dominant parameters influencing the fire performance of a concrete frame are the size of the frame (its spans) and the thickness of cover afforded to the reinforcing steel.

FIRE PERFORMANCE DATA

- **Load-bearing capacity.** The fire resistance of the frame will largely be a function of the thickness of cover afforded to the reinforcing steel. In broad terms, concrete frames with cover depths of 20mm will achieve at least one hours fire resistance, whilst frames with 50mm cover will achieve two hours fire resistance. (☆☆☆☆)
- **Contribution to fire growth.** Class 0 and non-combustible. (☆☆☆☆)
- **Contribution to fire load within building.** Concrete is not combustible and does not add to the fire load within the building. (☆☆☆☆)
- **Loading and deflection.** Concrete has a relatively low coefficient of thermal expansion. Further, it has poor conductivity which means that it is slow to heat up. Concrete frames, therefore, suffer only minimal thermal movements. (☆☆☆☆)
- **Durability.** Resistant to the most substantial impacts and durable in use. (☆☆☆☆)

1.3 REINFORCED CONCRETE - PRECAST

The fire resistance of individual precast beams and columns will be similar to their cast in-situ equivalent. However, precast concrete frames may have a lesser degree of joint fixity, continuity and rigidity.

FIRE PERFORMANCE DATA

- **Load-bearing capacity.** The fire resistance of the frame will largely be a function of the thickness of cover afforded to the reinforcing steel. In broad terms, concrete frames with cover depths of 30mm will achieve at least one hours fire resistance, whilst frames with 60mm cover will achieve two hours fire resistance. (☆☆☆)
- **Contribution to fire growth.** Class 0 and non-combustible. (☆☆☆☆)
- **Contribution to fire load within building.** Concrete is not combustible and does not add to the fire load within the building. (☆☆☆☆)
- **Loading and deflection.** Concrete has a relatively low coefficient of thermal expansion. Further, its poor conductivity means that it is slow to heat up. Concrete frames, therefore, suffer only minimal thermal movements. (☆☆☆☆)
- **Durability.** Resistant to the most substantial impacts and durable in use. (☆☆☆☆)

1.4 REINFORCED CONCRETE - PRE-STRESSED

Pre-stressed concrete members rely on the retention of stress within their steel tendons to deliver the required load and moment carrying capacity. In basic terms pre-stressed members may be treated similarly to ordinary reinforced concrete, with the depth of cover being the primary influence on behaviour. However, the performance of pre-stressed members needs to be assured as their failure under fire conditions will be sudden, unlike ordinary reinforced concrete which will fail in a ductile manner. Fire resistance ratings should be determined through testing to BS476: Part 21^{1g}.

It should be noted that pre-stressed members will not regain their strength on cooling after exposure to fire conditions and expert advice should be sought regarding their re-instatement past fire.

FIRE PERFORMANCE DATA

- **Load-bearing capacity.** The fire resistance of the frame will largely be a function of the thickness of cover afforded to the reinforcing steel. (☆☆)
- **Contribution to fire growth.** Class 0 and non-combustible. (☆☆☆☆)
- **Contribution to fire load within building.** Concrete is not combustible and does not add to the fire load within the building. (☆☆☆☆).
- **Loading and deflection.** Concrete has a relatively low coefficient of thermal expansion. Further, its poor conductivity means that it is slow to heat up. Concrete frames, therefore, suffer only minimal thermal movements, subject to the steel tendons being suitably protected. (☆☆☆☆)
- **Durability.** Resistant to the most substantial impacts and durable in use. (☆☆☆☆)

1.5 TIMBER

The fire performance of timber structural members within a frame is dominantly a function of two variables; timber density and the cross-sectional size of the timber member.

Timber beams and columns should be of sufficient size to enable them to retain their structural stability during the fire period. Allowance shall be made for the reduction in cross-sectional area of the members which will result from pyrolysis and charring of the members.

Unless information to the contrary is available timber beams should be assumed as being of ordinary density (softwood) and taken to char at a rate of 0.66mm per minute of exposure to fire test conditions. Hardwood timber beams, i.e. higher density timbers (650kg/m^3), can be taken to char at a lesser rate of 0.5mm per minute. Timber columns should be assumed to char at a rate some 25% higher than timber beams. Fire performance shall be demonstrated through appropriate structural design calculations to BS 5268: Part 4: Section 4.1^{5a} or through satisfaction of the load-bearing criteria during test to BS 476: Part 21^{1g}, EN 1365 Parts 3 (beams)^{27c} or 4 (columns)^{27d} for the duration specified in Tables 2.1/2.2 of this *Design Guide*.

The joints between beams and columns will suffer deterioration at elevated temperatures. In addition to basic pyrolysis of the timber, mechanically fixed joints can suffer loss of material strength, increased conduction of heat into the timber with associated charring and loss of bond between the charred timber and the mechanical fixing. In order to be assumed rigid, the above mechanisms need to be taken into account and the joint details need to be verified by a competent person.

FIRE PERFORMANCE DATA

- **Fire resistance performance (load-bearing capacity).** Although timber is combustible, it burns at a relatively slow and determinate rate. It is possible to ascertain the load-bearing capacity of the charring section after a period of exposure to fire. Detailed calculations are described in BS 5268: Part 4: Section 4.1: 1978^{5a}. Alternatively, beams and column whose fire resisting load-bearing capacity has been verified through testing to BS 476: Part 21^{1g}, EN 1365 Part 3 (beams)^{27c} or Part 4 (columns)^{27d} may be assembled as a frame, subject to the use of suitable jointing details and compliance with the test assessment or Field of Application report. (☆☆☆☆)
- **Contribution to fire growth.** Timber members achieve a Class 3 surface spread of flame rating and are combustible, unless treated chemically or physically coated. Verification of performance of the treated timbers shall be confirmed through testing, together with due consideration of long term durability of said treatments. Alternatively, the spread of flame on surfaces of the beams/columns adjacent to ceilings/walls can be restricted through suitable engineering detailing. Certain treatments have been accredited with causing a loss of strength. (☆☆)
- **Contribution to fire load within building.** Timbers of sufficient size to constitute a structural frame are not readily ignitable. The ratio between such timber's surface area and its volume will greatly restrict its burning rate. The structural timber frame, although combustible, will only slightly increase the fire load within the building. (☆☆☆☆)
- **Loading and deflection.** Timber shrinks on exposure to heat and accordingly will not impose thermally induced thrusts on the adjacent structure. The potential for openings and shrinkage cracks needs to be considered. (☆☆☆☆)
- **Durability.** Resistant to substantial impacts and durable in heated and ventilated internal conditions. (☆☆☆☆)

2. TRUSSED ASSEMBLIES

Truss structures are capable of carrying higher levels of loading per unit span per unit self-weight than traditional beams and columns. Trusses achieve this saving in unit weight because they are made up of many smaller members connected together. As a result, however, the thermal inertia of a typical truss is significantly lower than would be expected of a beam with similar load carrying capabilities. However, their lower thermal inertia make trusses particularly vulnerable to fire attack.

Trussed assemblies may be used in lieu of either beams or columns or both. For example, trussed beams may be used in conjunction with traditional column.

- 2.1 Steelwork trussed assemblies
- 2.2 Concrete trussed assemblies
- 2.3 Timber trussed assemblies

2.1 STEELWORK TRUSSED ASSEMBLIES

The majority of truss frame construction is steelwork. Prefabricated trusses may be assumed to have rigid connections, for the purposes of fire safety design. The low thermal inertia of the truss's constituent members means that unprotected steel trusses are likely to heat up quickly on exposure to fire conditions. This limits the fire resisting performance that can be achieved without application of protection to insulate the truss against the effects of heat. The high number of members constituting a truss, together with their small sectional size means that application of protective materials to steel trusses is difficult in practice. Surface coatings are more popular than boarded protection.

FIRE PERFORMANCE DATA

- **Load-bearing capacity.** Unprotected steel trusses will heat up quickly on exposure to those conditions prescribed in BS 476: Part 21^{1g}, pr EN 1365 Part 3 (beams)^{27c} or Part 4 (columns)^{27d}. Although, under such conditions, trusses have reserves of strength available as a result of their high stiffness (and an associated capacity for moment redistribution), their fire performance is limited. Additional fire protection is usually required before steel trusses can achieve higher fire resistance ratings. (☆☆)
- **Contribution to fire growth.** Class 0 and non-combustible. (☆☆☆☆☆)
- **Contribution to fire load within building.** Steelwork does not add to the fire load within the building. (☆☆☆☆☆)
- **Loading and deflection.** Steelwork expands on heating and careful consideration should be given to the lateral thermal thrusts expected at the bearing points of a truss. Special joints may be necessary to accommodate thermal movements or alternatively such movement prevented by providing insulation against the effects of heat. (☆☆☆)
- **Durability.** Resistant to substantial impacts. (☆☆☆☆☆)

2.2 CONCRETE TRUSSED ASSEMBLIES

The fire performance of prefabricated concrete trusses is governed by the depth of concrete cover provided to the reinforcing steel. The small section sizes encountered make concrete trusses particularly susceptible to destructive spalling on exposure to fire, with a resulting loss in cross-sectional area and stability. The fire resisting properties of concrete trusses should ideally be established through fire testing and engineering assessment to BS 476: Part 21^{1g}, EN 1365 Part 3 (beams)^{27c} or Part 4 (columns)^{27d}.

FIRE PERFORMANCE DATA

- **Load-bearing capacity.** Given the absence of destructive spalling, concrete trusses can achieve reasonable fire resistance ratings. (☆☆☆☆)
- **Contribution to fire growth.** Class 0 and non-combustible. (☆☆☆☆☆)
- **Contribution to fire load within building.** Concrete does not add to the fire load within the building. (☆☆☆☆☆)

- **Loading and deflection.** Concrete has a relatively low coefficient of thermal expansion. Further, its poor conductivity means that it is slow to heat up. Concrete trusses, therefore, suffer only minimal thermal movements. (☆☆☆☆☆)
- **Durability.** Resistant to substantial impacts. (☆☆☆☆☆)

2.3 TIMBER TRUSSED ASSEMBLIES

Timber trusses members need to be sufficiently sized to allow for the reduction in their cross-sectional area which will result from their pyrolysis and charring on exposure to fire conditions.

Fire performance shall be demonstrated through appropriate structural design calculations to BS 5268: Part 4: Section 4.1^{5a} or through satisfaction of the load-bearing criteria during test to BS 476: Part 21^{1g}, EN 1365 Part 3 (beams)^{27c} or Part 4 (columns)^{27d} for the duration specified in Tables 2.1/2.2 of this *Design Guide*.

Timber trusses are particularly reliant on the integrity of the joints between individual members. Steel plated mechanically fixed joints suffer a loss of material strength at elevated temperatures and also conduct heat into the timber members, leading to higher rates of charring local to the connection. This can hasten loss of connection between the charred timber and the mechanical fixing. Timber truss joint details need to be verified by conducting a fire test or alternatively by the undertaking of an engineering assessment by a competent person.

FIRE PERFORMANCE DATA

- **Fire resistance performance (load-bearing capacity).** Although timber is combustible, it burns at a relatively slow and determinate rate. It is possible to ascertain the load-bearing capacity of the individual charred sections of a truss after a period of exposure to fire. Detailed calculations are described in BS 5268: Part 4: Section 4.1: 1978^{5a}. Timber trusses may have their fire resisting load-bearing capacity determined by test to BS 476: Part 21^{1g}, EN 1365 Part 3 (beams)^{27c} or Part 4 (columns)^{27d}. Particular attention should be given to the fire behaviour of the joints and a detailed Engineering Assessment or Field of Application report is necessary. (☆☆☆)
- **Contribution to fire growth.** Timber members achieve a Class 3 surface spread of flame rating and are combustible, unless treated chemically or physically coated. Verification of performance of the treated timbers shall be confirmed through testing, together with due consideration of long term durability of such treatments. Alternatively, the spread of flame on the surface of a truss can be restricted through suitable engineering detail. (☆☆)
- **Contribution to fire load within building.** Timber trusses are combustible and will modestly increase the fire load within a building. (☆☆)
- **Loading and deflection.** Timber shrinks on exposure to heat and accordingly will not impose thermally induced thrusts on the adjacent structure. The potential for openings and shrinkage cracks needs to be considered. (☆☆☆)
- **Durability.** Resistant to substantial impacts. (☆☆☆☆☆)

3. MONOLITHIC RIGID FRAMES

Monolithic frames are those where the beam/column interface may be assumed fully rigid. Such frames include concrete frames (cast monolithically) and steel or timber portal frames, with rigid connections between columns and beams. In monolithic frames, the floor slab is also often integral to the structural frame, providing it with increased stiffness.

- 3.1 Reinforced concrete monolithic rigid frames
- 3.2 Steelwork monolithic rigid frames
- 3.3 Timber monolithic rigid frames

3.1 REINFORCED CONCRETE MONOLITHIC RIGID FRAMES

As it is impractical to subject full size frames to fire testing, an understanding of frame behaviour is derived principally from theoretical models. Although, such models are extremely sensitive to the material models chosen, they confirm the formation of plastic hinges at the mid-span of the heated beams, when their reinforcing steel reaches a sufficient temperature. Redistribution of moments towards the supports then occurs. Final failure only takes place when excessive temperatures are reached in the steel reinforcement at the supports, which is generally on the upper (and cooler) surface. Accordingly, monolithic concrete frames can resist collapse despite very long periods of exposure to fire conditions.

FIRE PERFORMANCE DATA

- **Load-bearing capacity.** Excellent resistance to collapse and deflection for substantial periods of exposure to fire conditions. (☆☆☆☆☆)
- **Contribution to fire growth.** Class 0 and non-combustible. (☆☆☆☆☆)
- **Contribution to fire load within building.** Concrete does not add to the fire load within the building. (☆☆☆☆☆)
- **Loading and deflection.** Concrete has a relatively low coefficient of thermal expansion. Further, its poor conductivity means that it is slow to heat up. Concrete frames, therefore, suffer only minimal thermal movements. (☆☆☆☆☆)
- **Durability.** Resistant to substantial impacts. (☆☆☆☆☆)

3.2 STEELWORK MONOLITHIC RIGID FRAMES

In fire safety terms, steel portal frames are unusual in that the structural columns very often only support the roof beams. (See Figure 1). As there is no requirement for roofs to have a fire resisting capability, other than within the protected zone, portal frames only need to achieve a fire performance in those instances where the collapse of the columns could lead to failure of walls or floors and the potential spread of fire either within the building or externally to adjacent properties.

The rafters of a single-storey portal frame are generally unprotected and quickly lose their strength on exposure to fire. Under such conditions, the roof members could no longer sustain the loads acting upon them nor continue to act as a prop for the columns. The roof members will deflect downwards, pushing the column members outwards. Steel portals must be designed to ensure that this outward thrust is not sufficient to cause the columns to fail outwards.

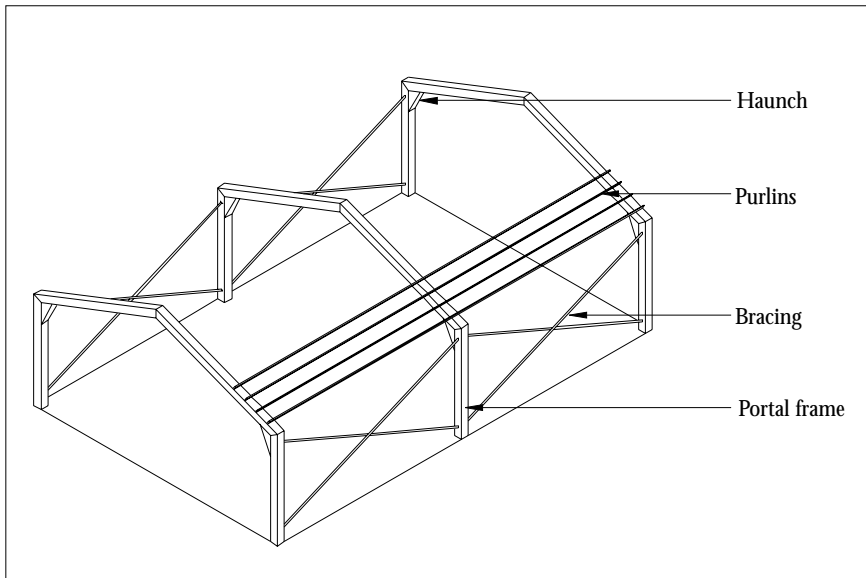


Figure 1. Typical portal frame construction.

Further, the rigidity of the beam/column connection within the portal frame, is such that the downwards movement of the roof beams will impose a significant overturning moment on the columns. Columns must be designed to resist this imposed moment for a sufficient duration. Whilst at ambient conditions the base of portal frames are designed as simple pinned connections, under fire conditions these connections must be designed to resist the overturning moment caused by roof failure.

FIRE PERFORMANCE DATA

- **Load-bearing capacity.** The fire resisting load-bearing capacity of steel portal frames when exposed to the heating conditions defined in BS 476: Part 20^{1f} should be confirmed through appropriate fire engineering design to BS 5950: Part 8⁹. (☆☆☆)
- **Contribution to fire growth.** Class 0 and non-combustible. (☆☆☆☆☆)
- **Contribution to fire load within building.** Steelwork does not add to the fire load within the building. (☆☆☆☆☆)
- **Loading and deflection.** Steelwork expands on heating and careful consideration should be given to the resulting thermal movements, particularly at the column heads. The column needs to be sufficiently sized to cope with the lateral thrust from the roof members. (☆☆)
- **Durability.** Resistant to substantial impacts. (☆☆☆☆☆)

3.3 TIMBER MONOLITHIC RIGID FRAMES

The timber beam and column members within portal frames need to be sufficiently sized to allow for the reduction in their cross-sectional area which will result from their pyrolysis and charring on exposure to fire conditions. Where roof timbers are smaller than column timbers, there is a potential that the roof may collapse before the columns. It is important that the load-bearing capacity of the columns is such that they are able to carry any additional loads or moments created by failure of the roof members.

Fire performance shall be demonstrated through appropriate structural design calculations to BS 5268: Part 4: Section 4.1^{5a} or through satisfaction of the load-bearing criteria during test to BS 476: Part 21^{1g}, EN 1365 Part 3 (beams)^{27c} or Part 4 (columns)^{27d} for the duration specified in Tables 2.1/2.2 of this *Design Guide*.

If the continuity of the beams/columns is important to structural performance, the beam/column joint must be adequately protected from the effects of fire. Often this can be achieved simply by increasing timber sizes at the joint, allowing for some sacrificial burning. Steel plated mechanically fixed joints suffer a loss of material strength at elevated temperatures and also conduct heat into the timber members, leading to higher rates of charring local to the connector. This can hasten loss of connection between the charred timber and the mechanical fixing. Timber joint details need to be verified by conducting a fire test or alternatively by the undertaking of an engineering assessment by a competent person.

FIRE PERFORMANCE DATA

- **Fire resistance performance (load-bearing capacity).** Although timber is combustible, it burns at a relatively slow and determinate rate. It is possible to ascertain the load-bearing capacity of the charred section after a period of exposure to fire. Detailed calculations are described in BS 5268: Part 4^{5a}. Timber portal frames are typically too large to have their fire resisting load-bearing capacity determined by to BS 476: Part 21^{1g}, EN 1365, Part 3 (beams)^{27c} or Part 4 (columns)^{27d} although the results from such a test may be integrated within engineering calculations to confirm fire performance. Particular attention should be given to the fire behaviour of joints and an Engineering Assessment or Field of Application report is necessary. (☆☆☆)
- **Contribution to fire growth.** Timber members achieve a Class 3 surface spread of flame rating and are combustible, unless treated chemically or physically coated. Verification of performance of the treated timbers shall be confirmed through testing, together with due consideration of long term durability of said treatments. Alternatively, the spread of flame on element surfaces can be restricted through suitable engineering detail. (☆☆)
- **Contribution to fire load within building.** Timbers of sufficient size to constitute a structural frame are not readily ignitable nor predisposed to rapid burning. Structural timber frames modestly increase the fire load within the building. (☆☆☆☆)
- **Loading and deflection.** Timber shrinks on exposure to heat. Nonetheless vertical displacement of the roof members will impose a lateral thrust on the columns and this needs to be taken into account in design. (☆☆☆☆)
- **Durability.** Resistant to substantial impacts. (☆☆☆☆☆☆)

INSTALLATION

The installation of structural frames should be executed and completed by a suitably qualified person to the required standard appropriate to the system used. It is advisable that where fire performance is required then an inspection by an independent body may be carried out on the completed work.

SUMMARY OF PERFORMANCE DATA

Type of structural frame	Load bearing capacity	Contribution to fire growth	Contribution to fire load within building	Load and deflection	Durability
1. Assemblies of beams and columns					
1.1 Structural steelwork	☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆	☆☆☆☆☆
1.2 Reinforced concrete cast in-situ)	☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆
1.3 Reinforced concrete precast	☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆
1.4 Reinforced concrete pre-stressed	☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆	☆☆☆☆☆
1.5 Timber	☆☆☆☆	☆☆	☆☆☆☆	☆☆☆	☆☆☆☆
2. Trussed assemblies					
2.1 Steelwork	☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆	☆☆☆☆☆
2.2 Concrete	☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆
2.3 Timber	☆☆☆	☆☆	☆☆	☆☆☆	☆☆☆☆☆
3. Monolithic rigid frames					
3.1 Reinforced concrete	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆
3.2 Steelwork	☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆	☆☆☆☆☆
3.3 Timber	☆☆☆	☆☆	☆☆☆☆	☆☆☆	☆☆☆☆☆

Sheet No: 6.2.1

BEFORE READING
THIS DATA SHEET
PLEASE REFER TO
THE
INTRODUCTION

6.2 Roofs**Composite panels (sandwich panels), built up systems and external claddings protected by dry-lining systems**

Main application in respect to this *Design Guide*:

Roofs of industrial buildings and other single storey buildings

FUNCTION OF ROOFS

- To make no significant contribution to a developing fire (see Part 2.2), whilst meeting any imposed requirements for thermal insulation
- To prevent fire spread over the top of a compartment wall by meeting the fire resistance requirements appropriate to the protected zone (see index of this *Design Guide* for references).
- Not be capable of spreading flame on their internal or external surfaces
- To prevent the combustion of the insulating core from accidental or malicious ignition of combustible materials
- To prevent, as far as possible, the passage of smoke
- To withstand wind loading, rain penetration and deflection to be experienced in use whilst maintaining the requirements above.
- To maintain the satisfactory performance over the lifetime of the building, or for a shorter duration if allowed for in the fire safety management plan, in respect of realistic impact and/or ambient conditions.
- To maintain the above functions when breached by openings for roof lights, roof ventilators etc. In respect to this, the advice from the cladding manufacturer should be obtained regarding the compatibility with such systems.

EVIDENCE OF PERFORMANCE

To ensure that insulated cladding panels for roofs meet in full the fire performance requirements of this *Design Guide*, it is important for the building designer to specify products that have been approved by LPCB to LPS 1181²⁴ and listed in the *List of Approved Fire and Security Products and Services*¹⁹. In addition, for portions of the roof that are part of the protected zone (see 3.4.2), these shall have sufficient fire resistance to resist fire inside to outside. Appropriate test is BS 476: Part 22: 1987, clause 9^{1h}.

Contribution to fire growth. For composite constructions such as insulated panels used for roofs, these shall have been tested to the wall and ceiling lining test described in LPS 1181²⁴ (a large scale reaction-to fire test)⁸. Even when a

IMPORTANT

THESE DATA
SHEETS ARE ONLY
INTENDED TO
GIVE GENERIC
INFORMATION.

DATA ON
PROPRIETARY
PRODUCTS MUST
BE OBTAINED
FROM THE
MANUFACTURERS

non-combustible insulant is used, combustible materials may still be used in the roof construction, e.g. vapour barrier or joint seals and the use of the wall and ceiling lining test may still be appropriate. Roof claddings protected by dry lining systems are generally constructed from either non-combustible or materials of limited combustibility, and consequently meet the requirements of 2.2 of this *Design Guide*.

Note: Tests undertaken to BS 476: Part 33: 1993 (ISO 9705)^{1k} are not deemed to be suitable for external cladding systems constructed from composite panels for ensuring compliance with this Design Guide.

Surface spread of flame. The internal and external surfaces of roofs shall have a surface spread of flame of Class 1 to BS 476: Part 7^{1d} and be rated Class 0 as defined in England and Wales Building Regulations, Approved Document B²⁹; or other national regulations. This must be verified by test.

External fire exposure. With respect to external fire exposure the roofing system, comprising the roof covering, thermal insulation and roof deck should be classified not less than EXT.F.AC or EXT.S.AC when tested in accordance with BS 476: Part 3^{1a}.

The provision of roof lights or ventilators* in any roof, may assist rapid fire spread to inside the building or to nearby roofs or buildings and they should therefore be classified not less than EXT.F.AC or EXT.S.AC when tested in accordance with BS 476: Part 3^{1a}.

The following wording appears in Approved Document B²⁹ Section 14.6: 'When used in rooflights, a rigid Thermoplastic sheet product made from polycarbonate or from plasticised PVC, which achieves a Class 1 rating for surface flame spread when tested to BS 476 Part 7^{1d} . . . can be regarded as having an AA designation.'

In buildings containing high values or critical business equipment or processes, rooflights and ventilators should not have a dimension greater than 1m and be spaced not less than 3m apart in any direction. This restriction does not apply to rooflights or ventilators having a rating of EXT.F.AA or EXT.S.AA in accordance with the above test.

Fire resistance. For the parts of the roof adjacent to compartment walls defined in 3.2.1 of this *Design Guide*, that is those within the *protected zone*, these shall have a minimum fire resistance of not less than 30 minutes integrity and 15 minutes insulation. This must be verified by test to BS 476: Part 22^{1h}, clause 9, to meet the recommendations in this *Design Guide*. *Designers should not accept tests to clause 5 of that standard for roof applications.*

Care must be taken at the junction of the roof and compartment wall to maintain fire resistance and to allow for hot movement (see page 3.2.1.1 and 3.1.1.2).

The fire resistance should be increased to 60 minutes integrity and 60 minutes insulation for storage buildings or other occupancy types deemed to be high risk by the risk assessment.

Some claims for high fire resistance may only indicate integrity performance and the designer should enquire on the insulation achieved in each case.

* *It may not be possible to maintain the prescribed underpressure conditions when testing ventilators. For the purpose of this Design Guide, ventilators used in roofs may be tested and classified without complying with the underpressure conditions prescribed in BS 476:Part 3^{1a}.*

It is important that only fire resisting roof decking systems and roof lights that have been tested in the horizontal orientation are used in the protected zone. Constructions that have only been tested in the vertical may fail prematurely if used horizontally and Method 9 of BS 476: Part 22^{1h} must be used. Where a roof is not designed for means of escape, and can therefore be tested without load, this test is considered the most applicable.

Resistance to smoke. There are no suitable test methods to base a performance requirement on, but it should be recognised that some ability to prevent smoke leaking outside the building is still desirable from an environmental point of view.

This data sheet considers in detail the following generic roofing products:

1. Composite panels
 - 1.1 Polyurethane cored
 - 1.2 Polyisocyanurate cored
 - 1.3 Mineral wool cored (rock fibre)
2. Built up roofs
 - 2.1 Mineral wool insulant
3. Roof claddings protected by dry lining systems
 - 3.1 Calcium silicate lined system
 - 3.2 Gypsum board lined system

1. COMPOSITE PANELS

These generally encapsulate all surfaces and edges of the insulating core by steel facings. Insulating cores are typically polyurethane, Polyisocyanurate, or mineral wool. Facings are generally ribbed (profiled), with the longer edge having a deep rib to interlock with adjacent panels, with weather tightness being a particular feature of the design, but this can be developed to provide good fire integrity as well. 'Fire rated' panels are often provided with factory applied fire seals at the joints to help maintain joint integrity. They arrive at site fully assembled and only need to be fixed to the structural supports.

FIRE PERFORMANCE DATA

Composite panels

1.1 Polyurethane (PUR) cored

Contribution to fire growth. Should not be regarded as meeting the requirements of Part 2.2 of this *Design Guide*, as if they are exposed to a sufficient size ignition source, may still make a significant contribution to fire growth. (☆☆)

Fire resistance. Provided they have adequate joint design, particularly in respect to adequacy of interlock between adjacent panels and provision of factory applied fire seals, is capable of providing (30 minutes integrity and 15 minutes insulation (thickness not less than 80mm)). (☆☆☆)

Smoke resistance. There are currently no test methods available to measure this parameter. However, as the joints have to be weather tight and provided the deformation under fire conditions can be controlled, some containment of

smoke may be anticipated. The core material will generate smoke if heated and consequently it is important to ensure adequate joint integrity under fire conditions. (☆☆☆)

Strength and impact resistance. Should have adequate resistance to impact for most industrial applications provided only steel faced panels are used. (☆☆☆☆)

Durability. The coatings applied to the steel can be regarded as provided adequate resistance to corrosion for most industrial applications. Compatibility between the metal and the insulant used may have to be confirmed by the manufacturer. (☆☆☆☆)

FIRE PERFORMANCE DATA

Composite panels

1.2 Polyisocyanurate (PIR) cored

Contribution to fire. Only specially formulated PIR foams that have been tested and approved to LPS 1181²⁴ can be regarded as meeting the requirements of 2.2 of this *Design Guide*.

Standard PIR foams (☆☆)

LPCB approved systems to LPS 1181-2²⁴ (☆☆☆☆)

Fire resistance. Provided it has adequate joint design, particularly in respect to adequacy of interlock between adjacent panels and provision of factory applied fire seals, is capable of providing 30 minutes integrity and between 15 minutes and 30 minutes insulation depending on thickness. A thickness of at least 100mm is required to provide 30 minutes insulation performance. (☆☆☆)

Smoke resistance. There are currently no test methods available to measure this parameter. However, as the joints have to be weather tight and provided the deformation under fire conditions can be controlled, some containment of smoke can be anticipated. The core material will generate smoke if heated and consequently it is important to ensure adequate joint integrity under fire conditions. (☆☆☆)

Strength and impact resistance. Should have adequate resistance to impact for most industrial applications provided only steel faced panels are used. (☆☆☆☆)

Durability. The coatings applied to the steel can be regarded as providing adequate resistance to corrosion for most industrial applications. Compatibility between the metal and the insulant used may have to be confirmed by the manufacturer. (☆☆☆☆)

FIRE PERFORMANCE DATA

Composite panels

1.3 Mineral wool cored (rock fibre)

Contribution to fire growth. Although not all mineral wool products are entirely non-combustible, particularly those with higher resin content, they can for all practical purposes be regarded as being non-combustible and therefore meet fully the requirements of Part 2.2 of this *Design Guide*. (☆☆☆☆☆)

Fire resistance. Provided it has adequate joint design, particularly in respect to adequacy of interlock between adjacent panels, subject to the panel thickness and the density, can easily provide 60 minutes integrity and 60 minutes insulation and can be regarded as having unrestricted application in respect to this *Design Guide*. (☆☆☆☆☆)

Smoke resistance. There are currently no test methods available to measure this parameter. However, as the joints have to be weather tight and provided the deformation under fire conditions can be controlled, some containment of smoke from the fire can be anticipated. Any smoke generated from the mineral wool core will be minimal. (☆☆☆☆)

Strength and impact resistance. Should have adequate resistance to impact for most industrial applications provided only steel faced panels are used. (☆☆☆☆)

Durability. The coatings applied to the steel can be regarded as providing adequate resistance to corrosion for most industrial applications. Compatibility between the metal and the insulant used may have to be confirmed by the manufacturer. (☆☆☆☆)

2. BUILT UP ROOFS

These are delivered to site as a range of components to be fixed together and assembled on site. These components comprise profiled outer metal skins, supporting grid, insulation, insulated internal panel and suitable fixings. Fire performance may be compromised by poor detailing or installation. For this reason, mineral wool is particularly recommended unless a combustible insulant can be adequately protected from the fire, e.g. by a suitable internal lining. For this reason, guidance is given only on built-up systems that use mineral wool as insulants. Mineral wools comprise both glass fibres and rock fibres.

FIRE PERFORMANCE DATA

Built up roofs

2.1 With a mineral wool insulant

Contribution to fire growth. Although not all mineral wool products are entirely non-combustible, particularly those with higher resin content, they can for all practical purposes be regarded as meeting fully the requirements of Part 2.2 of this *Design Guide*, unless combined with combustible facing materials, where additional evaluation would be required. (☆☆☆☆☆)

Fire resistance. The level of fire resistance would very much depend on the type of mineral wool used, as well as joint design and therefore a level of fire resistance should not be assumed. The designer should demand test data in all cases. Currently, the designer may find that little test data to clause 9 of BS 476: Part 22^{1h} exists. (dependent on mineral wool used).

Smoke resistance. There are currently no test methods available to measure this parameter. However, as the joints have to be weather tight and provided the deformation under fire conditions can be controlled, some containment of smoke from the fire can be anticipated. Any smoke generated from the mineral wool core itself will normally be minimal. (☆☆☆☆)

Strength and impact resistance. Should have adequate resistance to impact for most industrial applications provided only steel faced panels are used. (☆☆☆☆)

Durability. The coatings applied to the steel can be regarded as providing adequate resistance to corrosion for most industrial applications. (☆☆☆☆)

3. EXTERNAL CLADDINGS PROTECTED BY DRY LINING SYSTEMS

These typically comprise drylining materials such as gypsum or calcium silicate boards supported on a steel grid or channel system. The grid system is attached to the sheeting rails. Channel systems may be independent of the structural frame supporting the external cladding. Some systems offer fibre cement profiled sheets as an alternative to steel cladding sheets. To ensure adequate protection from an external fire, either a fire protection board will be provided on the cavity face of the external skin (fixed to the sheeting rail) and/or mineral wool insulation be suspended in the cavity.

FIRE PERFORMANCE DATA

Dry lining protected systems

3.1 Calcium silicate lined systems (mineral wool insulation in cavity if 60 minutes fire resistance required)

Contribution to fire growth. These systems are constructed from non-combustible materials or materials of limited combustibility and therefore meet fully the requirements of Part 2.2 of this *Design Guide*. (☆☆☆☆)

Fire resistance. Systems currently offered for roof applications tend to cover internal fire exposure only and are based on membrane ceilings. They can provide typically between 30 minutes and 120 minutes fire resistance. (☆☆☆☆)

Smoke resistance. There are currently no test methods available to measure this parameter. However, as the joints in the external cladding have to be weather tight and provided the deformation under fire conditions can be controlled, some containment of smoke from the fire can be anticipated. Any smoke generated from the lining or mineral wool insulation will be minimal. (☆☆☆☆)

Strength and impact resistance. The lining will have reasonable resistance to impact for most industrial applications. (☆☆☆)

Durability. Under normal service conditions, product performance would be expected to remain unchanged during the life-time of the building. Any damaged panels must be replaced by trained installers immediately. (☆☆☆☆)

FIRE PERFORMANCE DATA

Dry lining protected systems

3.2 Gypsum board lined systems

Contribution to fire growth. These systems can be regarded as meeting fully the requirements of Part 2.2 of this *Design Guide* provided the insulation material used in the cavity is limited to mineral wool. (☆☆☆☆)

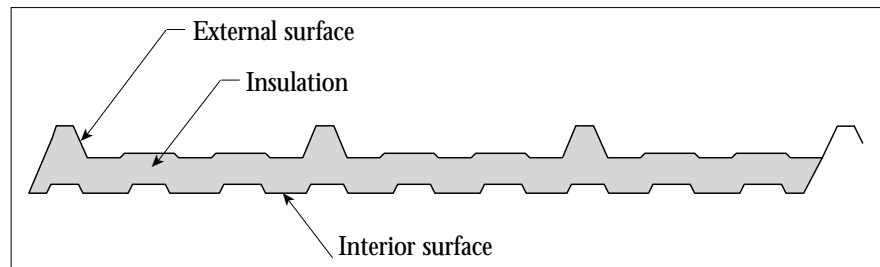
Fire resistance. Designer will have to consult with the manufacturer to determine what specification is needed to cover protected zone applications. Test data currently appear to cover external wall applications only.

Smoke resistance. There are currently no test methods available to measure this parameter. However, as the joints in the external cladding have to be weather tight and provided the deformation under fire conditions can be controlled, some containment of smoke from the fire can be anticipated. Any smoke generated from the lining or mineral wool insulation will be minimal. (☆☆☆☆)

Strength and impact resistance. The lining will have reasonable resistance to impact for most industrial applications. (☆☆☆)

Durability. Under normal service conditions, product performance would be expected to remain unchanged during the life-time of the building. Any damaged lining panels or insulation must be replaced by trained installers immediately. (☆☆☆☆)

Figure 1. Typical composite cladding panel.



The above drawing is intended to illustrate a typical composite panel. This would not necessarily be a fire rated panel. In the above design, total encapsulation of the insulant would only occur once the panel is installed.

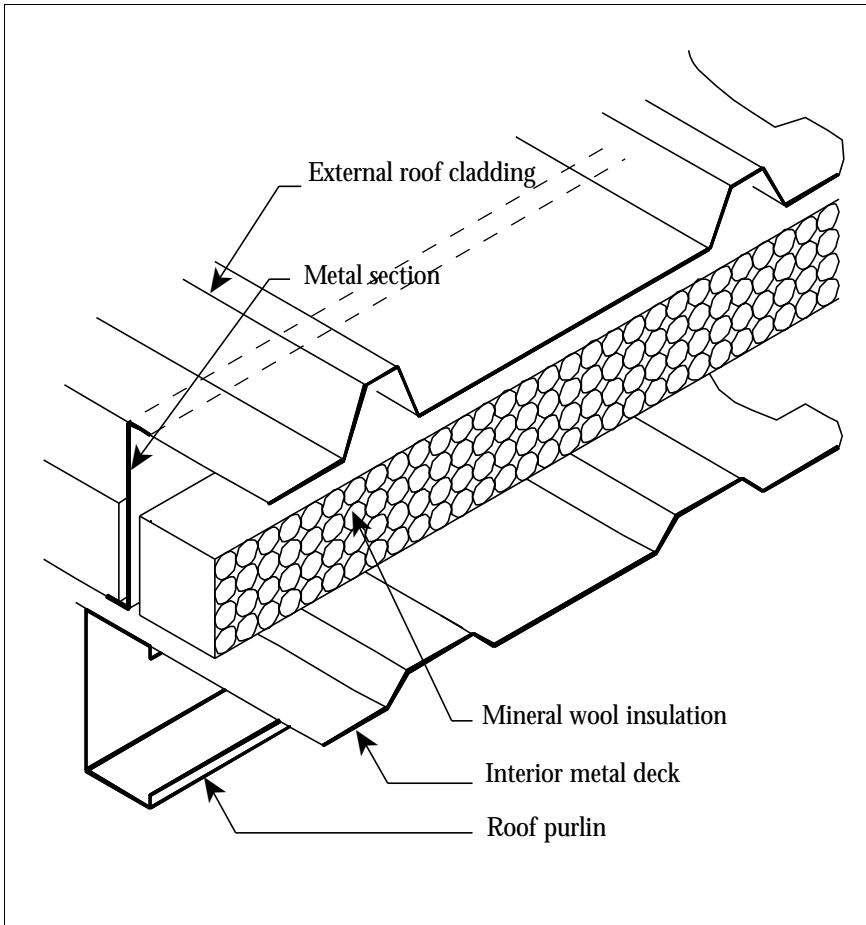


Figure 2. Typical built-up roofing system.

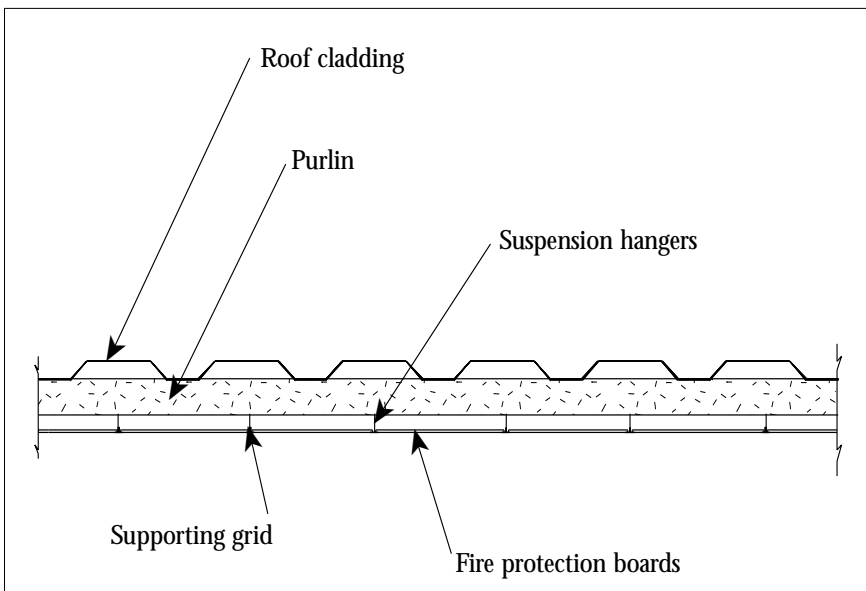


Figure 3. Dry lining system protecting roof from an internal fire.

SUMMARY OF DATA

Table 1 below summarises the assessed abilities of roof cladding systems to satisfy the identified performance requirements.

Table 1

Type of roof system	Contribution to fire growth	Fire resistance	Smoke resistance	Strength and impact resistance	Durability
Composite panel 1.1 polyurethane (PUR) cored	(☆☆)	(☆☆☆) Dependent on panel thickness and joint design	(☆☆☆)	(☆☆☆☆)	(☆☆☆☆)
Composite panel 1.2 polyisocyanurate (PIR) cored	(☆☆)	(☆☆☆) Dependent on panel thickness and joint design	(☆☆☆)	(☆☆☆☆)	(☆☆☆☆)
Composite panel <i>LPCB approved</i> 1.2 polyisocyanurate (PIR) cored	(☆☆☆☆)	(☆☆☆) Dependent on panel thickness and joint design	(☆☆☆)	(☆☆☆☆)	(☆☆☆☆)
Composite panel 1.3 mineral wool cored panel	(☆☆☆☆☆)	(☆☆☆☆☆)	(☆☆☆☆)	(☆☆☆☆☆)	(☆☆☆☆)
Built up roof systems 2.1 mineral wool core only	(☆☆☆☆☆)	Dependent on mineral wool used and joint design. Currently little test data exists for this type of system	(☆☆☆☆)	(☆☆☆☆)	(☆☆☆☆)
Dry-lining protected 3.1 calcium silicate board	(☆☆☆☆☆)	(☆☆☆☆☆)	(☆☆☆☆)	(☆☆☆)	(☆☆☆☆)
Dry-lining protected 3.2 gypsum board	(☆☆☆☆☆)	Designer should consult manufacturer for specification needed to satisfy <i>Design Guide</i> requirements for protected zone applications	(☆☆☆☆)	(☆☆☆)	(☆☆☆☆)

SOURCES FOR FURTHER INFORMATION

EPIC (Engineered panels in construction), 95 York Street, London, W1H 1DU.

Association of Specialist Fire Protection, Association House, 253 Ash Road, Aldershot, Hampshire GU12 4DD.

Built-up Systems Association, 117 Columbia Drive, Lower Wick, Worcester, WR2 4XX.

EURISOL (UK Mineral Wool Association), 39 High Street, Redbourn, Herts AL3 7LW.

The Metal Cladding and Roofing Manufacturers Association, 18 Mere Farm Road, Noctorum, Birkenhead, Merseyside L43 9TT.

Sheet No: 6.3.1

6.3 Compartment walls

Walls of masonry and concrete bricks/blocks

Main application in respect to this *Design Guide*:

Provide horizontal fire separation between compartments within a building as required by Table 2.2 of the *Design Guide*. These compartment walls may be required to separate special risks from the rest of the building, to reduce the area at risk and to prevent fire spreading to adjacent properties within a multi-user complex.

FUNCTION OF COMPARTMENT WALLS

- To maintain the integrity of the wall for the duration specified in Table 2.2 of the *Design Guide*.
- To restrict the rise in temperature on the unexposed face to those levels required to prevent fire spread for the duration specified in Table 2.2 of the *Design Guide*.
- To ensure that it does not make a significant contribution to the growth or intensity of the fire.
- To restrict the passage of smoke for the same duration as integrity.
- To withstand the loading and deflection to be experienced in use and during fire exposure whilst maintaining the requirements above.
- To be able to accept the services described in Data sheets 6.7 and 6.9 without detriment to the fire separation provided, e.g. integrity, temperature rise and smoke restriction. To achieve the smoke restriction all penetrations shall be fully sealed.
- To maintain the separating performance over the lifetime of the building, or for a shorter duration if allowed for in the fire safety management plan, in respect of realistic impact and/or ambient conditions.

EVIDENCE OF FIRE PERFORMANCE

In the absence of a Loss Prevention Standard (LPS) covering compartment walls of masonry and concrete construction they shall comply with all of the following:

- **Fire resistance performance.** The compartment wall shall comply with the requirements given in relevant codes and standards needed to provide the fire separation specified in Table 2.2 of the *Design Guide* for both integrity and insulation at the height at which it is to be installed.

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Alternatively test evidence generated in accordance with BS 476: Part 21^{1g} or EN 1365 Part 1^{27a} (loadbearing walls), preferably supported by a field of application report identifying any structural changes needed to provide the performance at the required height.

- **Contribution to fire growth.** The construction shall meet the requirements of Part 2.2 of this *Design Guide*.
- **Smoke resistance.** The compartment wall will be impermeable and any gaps within the wall or between the compartment wall and any wall built-up to it shall be sealed with an appropriate linear gap seal (see Data sheet 6.7.2).
- **Surface spread of flame.** The surface of the compartment wall shall have a surface spread of flame of Class 1 to BS 476: Part 7^{1d} and be rated Class 0 as defined in England and Wales Building Regulations, Approved Document B²⁹; or other national regulations. Alternatively the product shall be designated as being of limited combustibility.
- **Loading and deflection.** The compartment wall shall be supported by calculations or design information from recognised codes or standards (e.g. Eurocode 6, DD ENV 1996: Part 1.2¹⁸) indicating that it can withstand the anticipated loading and deflections in use and during fire exposure without producing gaps through which smoke and fire could spread.
- **Accommodation of services.** Evidence shall be available to substantiate that the penetration by services (these should be kept to a minimum in compartment walls) will not impair the achievement of any of the above performance requirements.
- **Durability.** Evidence shall be available to show that the materials used in the construction of the wall are not going to be adversely affected by the ambient conditions, and any impacts and abuse, reasonably foreseeable during the anticipated life of the building.

BRICKS

Clay bricks

Walls constructed from clay bricks have high levels of fire resistance. Standard size of a clay brick is 215mm x 102.5mm x 65mm. Clay bricks should comply with BS 3921³. Main types are:

Solid:	Bricks having no holes, depressions, perforations or cavities.
Perforated:	Perforations not exceeding 25% of volume of brick.
Frogged:	Bricks having a frog on one or both faces, these frogs not exceeding 20% of volume of brick.
Hollow:	Bricks that have holes in excess of 25% of the gross area of the brick.
Cellular:	These have holes in excess of 20% and are closed at one end.

CALCIUM SILICATE BRICKS

A compacted and moulded mixture of sand and lime combined chemically when subjected to high pressure steam in autoclaves. Size is same as for clay bricks. Types are solid or frogged.

CONCRETE BRICKS

Made by compacting concrete under high pressure into brick shaped moulds. Concrete bricks should comply with BS 6073¹⁰.

FIRE PERFORMANCE DATA

All products listed in this section are considered together in respect of meeting the requirements except where indicated.

- **Fire resistance.** The thickness of walls constructed from the materials listed in the first column required to achieve the indicated fire resistance is given in Table 6.3.1.1. of this data sheet.

Table 6.3.1.1 Fire resistance of brickwork compartment walls*

Material #	Thickness of wall (mm) to achieve a fire resistance of:		
	90 minutes	120 minutes	240 minutes
Brickwork of solid clay bricks	95	100	170
Brickwork of solid concrete or sandlime bricks	95	100	200

* The thickness of walls given in this table relates to walls of 3m height. For walls of greater heights, these will need to be increased. Further guidance is given below:

- In order to meet the recommendations given in BS 5628 : Part 1⁸, walls should not exceed a slenderness ratio (height/thickness) of 27. The current thinking is set out in Eurocode 6¹⁸ which, for the materials, does not place any limit on the wall height/thickness other than the requirements necessary to meet normal design criteria, i.e. wind and loading.

Information on hollow blocks is not included as the design varies with manufacturer, and information should be obtained direct from the manufacturer.

- **Contribution to fire growth.** Nil, all products are non-combustible. (☆☆☆☆☆)
- **Smoke resistance.** The products are impermeable and do not produce smoke, assuming any gaps are adequately sealed. (☆☆☆☆☆)
- **Spread of flame.** All products are Class 0. (☆☆☆☆☆)
- **Loading and deflection.** The wall shall have the correct slenderness ratio for its height and fire resistance, taken from appropriate codes. (☆☆☆☆☆)
- **Penetration by services.** The construction is strong enough to accept any fixings or support needed for penetration sealing systems and the surface does not erode during exposure and any sealant with the correct performance can be used to seal single pipes or cables. (☆☆☆☆☆)
- **Durability.** All products listed are considered durable and robust in use. (☆☆☆☆☆)

BLOCKS

Solid:	Blocks that do not contain formed holes or cavities.
Cellular:	Blocks having one or more formed holes or cavities which do not pass completely through the block.
Hollow:	Blocks having one or more formed holes or cavities which pass completely through the block. Fire resistance performance will depend on thickness of concrete and designers are urged to demand test evidence from the block manufacturer. This type of block may be filled with a foamed plastic insulant to improve thermal properties. However, such a product can still be regarded as meeting the recommendations of Part 2.2 of this <i>Design Guide</i> .
Concrete:	Blocks are typically made from cement, dense or lightweight aggregate and water. Autoclaved aerated concrete blocks are now commonly used and these are made from carefully prepared mixtures of cement and a finely graded sand or pulverised fuel ash, together with chemical admixtures to aerate the mixture.

Compartment walls constructed from bricks or blocks can be regarded as being sufficiently robust to be used in all applications covered in this *Design Guide*.

FIRE PERFORMANCE DATA

All products listed in this section are considered together in respect of meeting the requirements except where indicated:

- **Fire resistance.** The thickness of walls constructed from the materials listed in the first column required to achieve the indicated fire resistance is given in Table 6.3.1.2.

Table 6.3.1.2. Fire resistance of blockwork compartment walls*.

Material #	Thickness of wall (mm) to achieve a fire resistance of:		
	90 minutes	120 minutes	240 minutes
Blockwork of solid pre-cast concrete blocks of dense aggregate	90	100	†
Blockwork of solid pre-cast concrete blocks of lightweight aggregate	100	100	†
Blockwork of solid autoclaved aerated concrete blocks of density 600kg/m ³	95	100	215

* The thickness of walls given in this table relates to walls of 3m height. For walls of greater heights, these will need to be increased. Further guidance is given below:

In order to meet the recommendations given in BS 5628: Part 1⁸, walls should not exceed a slenderness ratio (height/thickness) of 27. The current thinking is set out in Eurocode 6 which, for these materials, does not place any limit on the wall height/thickness other than the requirements necessary to meet normal design criteria, i.e. wind and loading. All other performance requirements are satisfied in a similar manner to Bricks and the ratings given apply.

Information on hollow blocks is not included as the design varies with manufacturer, and information should be obtained direct from the manufacturer.

† Unable to achieve this rating

- **Contribution to fire growth.** This group of products are non-combustible and therefore will meet the recommendations given in Part 2.2 of this *Design Guide*. (☆☆☆☆☆☆)

- Penetration by services.** The construction is strong enough to accept any fixings or support needed for penetration sealing systems and the surface does not erode significantly during exposure and any sealant with the correct performance can be used to seal single pipes or cables. Where the blocks are hollow it may not be so easy to seal large penetrations and a special perimeter seal may be required. (☆☆☆☆☆☆)

All other performance requirements are satisfied in a similar manner to bricks and the ratings given for them apply.

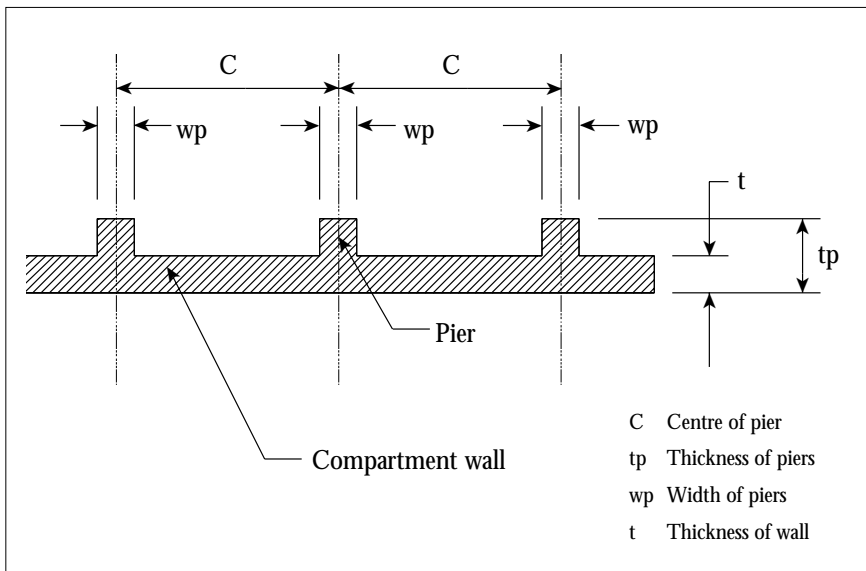


Figure 1. Wall stiffened by piers.

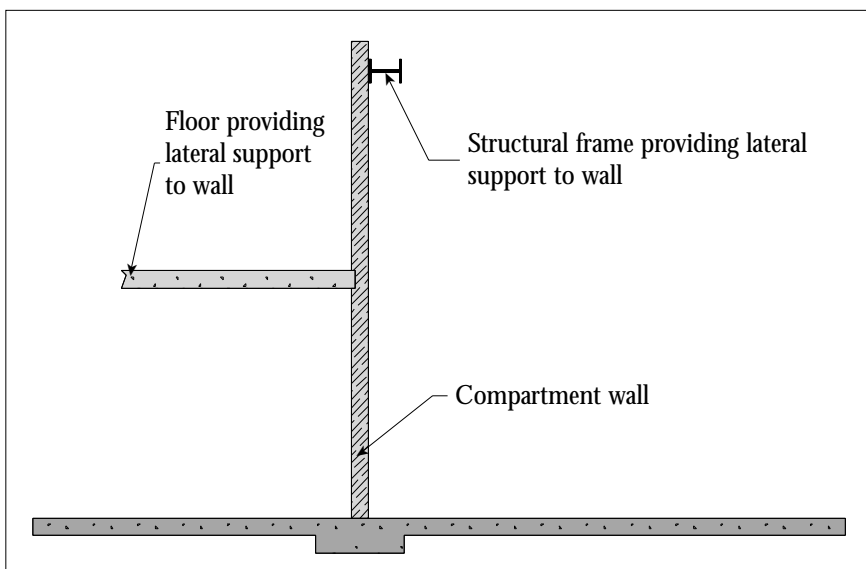


Figure 2. Lateral support to wall.

SUMMARY OF DATA
Minimum thickness compared to maximum allowable height for masonry compartment walls
(based on a maximum allowable slenderness ratio of 27 given in BS 5628: Part 1⁸)

Key to shaded values for nominal fire resistance				Maximum allowable height of compartment wall (simple resistance to lateral movement) (m)	Maximum effective height when wall is stiffened between lateral supports (m)
*	60-90min	120min	240min		
Stiffness coefficient (k)					
1	1.2	1.4	2		
Thickness of compartment wall (mm) (based on stiffness coefficient)					
75*	63*	54*	38*	2	2.7
110	92*	79*	55*	3	4
150	125	107	75*	4	5.3
185	154	132	93*	5	6.7
225	188	161	113	6	8
260	217	186	130	7	9.3
300	250	214	150	8	10.7
335	279	239	168	9	12
370	308	264	185	10	13.3
410	342	293	205	11	14.7
445	371	318	223	12	16
480	400	343	240	13	17.3
520	433	371	260	14	18.7
555	463	396	278	15	20

* This thickness will give a fire resistance less than the minimum accepted for compartment walls in this *Design Guide*.

- For a wall stiffened by piers or intersecting walls, the thickness of the wall for a given height may be reduced. Further information is given in BS 5628: Part 1⁸.
- Although it may be adequate structurally, the thickness shall not be less than that required to give the required level of fire resistance.
- Where a wall is stiffened by piers, the effective thickness t_{ef} may be calculated as: $t_{ef} = k \times t$. The influence on wall thickness is shown in the above table.

(See Figures 1 and 2.)

INSTALLATION

The installation of walls of masonry and concrete bricks/blocks should be executed and completed by a suitably qualified person to the required standard appropriate to the system used. It is advisable that where fire performance is required then an inspection by an independent body may be carried out on the completed work.

Sheet No: 6.3.2

6.3 Compartment walls

Dry lined studwork walls

Main application in respect to this *Design Guide*.

Provide horizontal fire separation between compartments within a building as required by Table 2.2 of the *Design Guide*. These compartment walls may be required to separate special risks from the rest of the building, to reduce the area at risk and to prevent fire spreading to adjacent properties within a multi-user complex.

They may also be used for the construction of protected stairways, shafts or corridors within buildings.

FUNCTION OF COMPARTMENT WALLS

- To maintain the integrity of the wall for the duration specified in Table 2.2 of the *Design Guide*.
- To restrict the rise in temperature on the unexposed face to those levels required to prevent fire spread for the duration specified in Table 2.2 of the *Design Guide*.
- The construction shall not make a significant contribution to the growth or intensity of the fire.
- To restrict the passage of smoke for the same duration as integrity.
- To be not capable of spreading flame on their surface.
- To withstand the loading and deflection to be experienced in use and during fire exposure whilst maintaining the requirements above.
- To be able to accept the services described in Data sheets 6.7 and 6.9 without detriment to the fire separation provided, e.g. integrity, temperature rise and smoke restriction. To achieve the smoke restriction all penetrations shall be fully sealed.
- To maintain the separating performance over the lifetime of the building, or for a shorter duration if allowed for in the fire safety management plan, in respect of realistic impact and/or ambient conditions.

Studwork walls are made up of a number of components, namely the stud framework, board linings (single or multiple), board fixings and in many situations an insulating infill. These all make a contribution and these components are considered separately in this guide.

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EVIDENCE OF FIRE PERFORMANCE:

In the absence of a Loss Prevention Standard (LPS) covering compartment walls of studwork construction, they shall comply with all of the following:

- **Fire resistance performance***. The wall may be loadbearing or non-loadbearing in use. The wall shall comply with the requirements given in relevant codes and standards needed to provide the fire separation specified in Table 2.2 of the *Design Guide* at the height at which it is to be installed. There are three components to fire resistance, loadbearing capacity, integrity and insulation and the contribution of the components to these are considered individually.

Alternatively, compliance with test evidence generated in accordance with BS 476: Part 21¹⁹ or EN 1365 Part 1^{27a} (walls), preferably supported by a field of application report identifying any structural changes needed to provide the performance at the required height.

- **Temperature rise (insulation)**. The studwork wall should restrict the temperature rise on the unexposed face.
- **Smoke resistance**. The studwork wall will be impermeable and any gaps within the wall or between the compartment wall and any wall built-up to it shall be sealed with an appropriate linear gap seal (see Data sheet 6.7.2).
- **Surface spread of flame**. The surface of the wall shall have a surface spread of flame of Class 1 to BS 476: Part 7^{1d} and be rated Class 0 as defined in England and Wales Building Regulations, Approved Document B²⁹; or other national regulations. Alternatively the product shall be designated as being of limited combustibility.
- **Loading and deflection resistance**. The studwork construction shall be supported by calculations or design information from recognised codes or standards (e.g. Eurocode 6¹⁸) indicating that it can withstand the anticipated loading and deflections in use and during fire exposure without producing gaps through which smoke and fire could spread. Shall conform to calculations and design criteria in recognised codes and standards.
- **Contribution to fire load**. The construction shall not make a significant contribution to the fire load.
- **Ability to accommodate services**. Evidence shall be available to substantiate that the penetration by services (which should be kept to a minimum in compartment walls) will not impair the achievement of any of the above performance requirements.
- **Distortion generation**. Evidence should be provided to show that any distortion which may be induced in the surrounding construction as a result of installing the chosen studwork system has been taken into account.
- **Durability**. Evidence shall be available to show that the materials used in the construction of the wall are not going to be adversely affected by the ambient conditions, and any impacts and abuse, reasonably foreseeable during the anticipated life of the building.

*Note: For timber stud walls BS5268 : Part 4 : Sections 4.1 and 4.2^{5a, 5b} need to be referred to.

1. STUDS

There are only two commonly used materials for studs, namely timber or lightweight folded or rolled steel, the latter of which is normally galvanised. This section of the data sheet compares the relative behaviour of these two materials in respect of their contribution to fire protection when used as components for commercially available dry lining systems. (See Figures 1 and 2). Timber studs are normally able to be used for constructions with fire resistance rating between 30 and 90 minutes. Lightweight steel studs are nominally used over the range 30 to 240 minutes.

1.1 Timber studs

1.2 Lightweight metal studs

1.1 TIMBER STUDS

For comparison purposes it is assumed that the timber studs are made of softwood with a nominal density of 450kg/m³ when dry.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Whilst not having a direct implication on the integrity of the studwork wall, softwood studs demonstrate little deflection or expansion when heated and therefore make an ideal support to board joints etc. (☆☆☆☆☆)
- **Temperature rise (insulation).** Softwood is naturally insulating and as a consequence there is no conductivity between the front and rear faces of a studwork wall at stud positions. Even when gaps become exploited due to shrinkage of boards the lack of conductivity of the stud material will prevent an undue temperature rise on the unexposed face. (☆☆☆☆☆)
- **Smoke resistance.** This property is not directly applicable to a structural member but timber is an impermeable material and therefore smoke should not be able to exploit any joints in the lining. The timber studwork would during the late stages of a fire contribute a small volume of smoke, but again this would be insignificant in respect of the total volume of hot smoke that would be exploiting any gap in the linings at this stage of the fire. (☆☆☆☆)
- **Surface spread of flame.** Not an applicable criterion for studs which are hidden below the surface of the linings.
- **Loading and deflection resistance.** Timber is relatively stable at high temperatures, although drying out as a prelude to burning, will cause a stud to shrink on its heated face whilst the unaffected section remains large, this will not induce significant distortion. Distortion may become a problem when the residual cross-sectional area reduces and is not strong enough to resist the shrinkage. Timber studs do not have an expansion problem under fire because the natural insulation characteristics of wood means that the stud does not experience a significant rise in temperature. Any applied loading shall be in accordance with either test or assessment evidence which takes into account the expected degradation of the assembly and char rates of the

timber used. The cross-sectional areas of studs are typically small and hence they are not usually found in loadbearing applications. In instances where they are loadbearing, bending moment deflection and bearing load calculations should be carried out. In loadbearing applications timber sheeting is usually applied across the studs on bracing and the outer skin of the fire protective lining is applied over this bracing. Again test or assessment evidence of performance of such design enhancements should be provided. (☆☆☆)

- **Contribution to fire load.** Timber is a combustible material, but the volume of timber used within 10m² of studwork walling is only approximately 50kg. This itself is not released until there is a failure of the lining which is quite a long way into the fully developed fire phase. (☆☆☆☆)
- **Distortion generation.** Timber is relatively stable at high temperatures, although drying out as a prelude to burning, will cause a stud to shrink on its heated face whilst the unaffected section remains large, this will not induce significant distortion. Distortion may become a problem when the residual cross-sectional area reduces and is not strong enough to resist the shrinkage. Timber studs do not have an expansion problem under fire because the natural insulation characteristics of wood means that the stud does not experience a significant rise in temperature. As a consequence there will not be any restrained distortion induced deflections as a result of heating a timber stud frame. (☆☆☆☆)
- **Durability.** Timber in the dry conditions experienced in many modern commercial buildings is unlikely to suffer and decay. Similarly the conditions in these buildings are such that insect infestation would not be anticipated and even less likely inside the frames protected by linings. Wood, when properly sized is strong enough to resist most anticipated impacts. There are many timber framed buildings hundreds of years old still in an excellent state of preservation. (☆☆☆☆)

1.2 LIGHTWEIGHT METAL STUDS

For comparison purposes it is assumed that these are of lightweight cold formed steel 'c' shaped or 'z' shaped studs.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** As for timber studs, the stud itself does not make a direct contribution to integrity. It should be noted however that steel does expand and does suffer differential distortion when heated. This distortion may cause joints to open prematurely thereby causing a reduction in the potential protection afforded by the boards. (☆☆☆)
- **Temperature rise (insulation).** Steel is a conductive material and will readily transfer heat from the rear face of the exposed board to the board on the unexposed face. This will be made worse as board shrinkage occurs and the face of the stud is directly exposed to the heat. With longer duration periods of fire resistance it is common to use additional board fillets affixed to the studs which increase the degree of insulation they provide. (☆☆)

- **Smoke resistance.** Steel is non-permeable and therefore will not directly be the cause of cold smoke permeating from one side of the construction to the other, but distortion may cause gaps to open when the stud gets hot and the resistance to warm or hot smoke may be reduced. (☆☆☆)
- **Surface spread of flame.** This is not an applicable property as the metal stud is inside the lining.
- **Loading and deflection resistance.** Lightweight metal studs have such a small cross-sectional area that they are rarely used for loadbearing applications. As such the use of steel studs is generally restricted to non-loadbearing constructions and therefore this section is not applicable. They are able to carry dead loads associated with the construction but being steel they go through a metallurgical phase change at around about 500°C which causes them to lose half of their strength. (☆)
- **Contribution to fire load.** Steel is non-combustible and will therefore make a zero contribution to the fire growth within the building. (☆☆☆☆☆)
- **Distortion generation.** Steel has a high coefficient of expansion and therefore when it gets hot it is likely to be fairly disruptive to the construction. Steel when heated only on one face can induce quite significant distortions, which again have a disruptive influence on the linings and may reduce their potential protection. Steel studs, when adequately fixed can resist normal impacts, but in order to accommodate expansions they are sometimes less than perfectly fixed and may suffer impact damage. (☆☆)
- **Durability.** Most steel studs are galvanised therefore not expected to suffer any degradation due to rusting, especially in modern commercial environments. (☆☆☆☆☆)

2. LININGS FOR STUD PARTITIONS

This section considers the likely performance of the following common lining materials and their ability to meet the performance requirements outlined earlier;

- 2.1 Unreinforced gypsum plasterboard linings (normally used for 30 to 90 minute ratings)
- 2.2 Reinforced gypsum plasterboard linings
- 2.3 Calcium silicate board lining (normally used for 30 to 240 minutes)
- 2.4 Cement based board linings
- 2.5 Wood based board linings (normally used for 30 to 60 minute ratings)
- 2.6 Steel sheet linings (normally used for 30 to 240 minute integrity ratings*)

Observations are made in respect of generic material and it is pointed out that individual manufacturers products may be better or worse than the analysis given and it is recommended that manufacturer's product data is consulted for full details of the likely performance of proprietary products.

* Insulation is only likely to be satisfied for 5 to 10 minutes without the addition of cavity insulation.

2.1 UNREINFORCED GYPSUM PLASTERBOARD LININGS

Plasterboard, a gypsum core of various thicknesses from 9 to 19mm with a paper face auto-adhered to both faces is the most traditional of the applied facings. The paper provides the strength to the board in the cold state, but contributes nothing in the hot state.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Low propensity to crack but may do so; normally considered good. (☆☆☆☆)
- **Temperature rise (insulation).** Gypsum has excellent resistance to temperature rise until all the water of crystallisation is driven off. (☆☆☆☆)
- **Smoke resistance.** Unless damaged the boards are considered to be impermeable, although joints and edge details will need to be developed to meet this requirement. (☆☆☆☆)
- **Surface spread of flame.** Class 0 surface, core of limited combustibility. (☆☆☆☆)
- **Loading and deflection resistance.** Only limited ability to withstand deflection and the individual project design details need to be reviewed if a system is to meet this requirement. Linings are non-load carrying. (☆☆)
- **Contribution to fire load.** The contribution is limited to the facings which is effectively negligible. (☆☆☆☆)
- **Ability to accommodate services.** Normally rigid enough to accept sealants around single services but support will be needed to retain special closing devices and sealing systems. (☆☆)
- **Distortion generation.** Gypsum based products are inert and will not impose any deflection on the wall when heated. (☆☆☆☆)
- **Durability.** Not suitable for use in wet conditions, but generally durable in normal environments, although prone to impact damage. (☆☆)

2.2 REINFORCED GYPSUM BASED BOARDS

Reinforced gypsum boards may or may not incorporate paper facings to each side.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** The material is unlikely to crack when heated and has excellent integrity performance. (☆☆☆☆)
- **Temperature rise (insulation).** Gypsum based products have an excellent resistance to temperature rise until the water of crystallisation has been lost. (☆☆☆☆)
- **Smoke resistance.** Unless damaged the boards are considered impermeable although joints and edges may require special treatment. (☆☆☆☆)

- **Surface spread of flame.** Normally Class 0 or limited combustibility. (☆☆☆☆☆)
- **Loading and deflection resistance.** The fibres incorporated in reinforced gypsum boards enable it to withstand deflection more than normal plasterboard. The material is, however, inert and it will not impose deflections on the framework. (☆☆)
- **Contribution to fire load.** The contribution to fire growth is nil for non-paper faced products and negligible for paper faced board. (☆☆☆☆☆)
- **Ability to accommodate services.** Stronger than unreinforced gypsum boards and some service penetration closing devices may be fixed directly to the lining. (☆☆☆☆☆).
- **Distortion generation.** As for reinforced plasterboard. (☆☆☆☆☆)
- **Durability.** More resistance to impact damage but otherwise similar to unreinforced gypsum plasterboard. (☆☆☆)

2.3. CALCIUM SILICATE BOARD LININGS

These are monolithic boards designed to provide fire protection to elements of structure. Boards range from 4mm to more than 20mm in thickness but those most commonly used for stud walls are between 6 and 15mm.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Normally good, especially for low density boards with a low propensity to crack when heated. (☆☆☆☆☆)
- **Temperature rise (insulation).** Generally more conductive than some other barrier materials and may need to be used in conjunction with insulation to achieve ratings. (☆☆☆)
- **Smoke resistance.** Unless damaged they are considered impermeable although joints and edges may require special treatment. (☆☆☆☆☆)
- **Surface spread of flame.** Normally Class 0 or limited combustibility. (☆☆☆☆☆)
- **Loading and deflection resistance.** Only limited ability to withstand deflection and design details will need to be given to meet this requirement. (☆☆)
- **Contribution to fire load.** There is no contribution from calcium silicate. (☆☆☆☆☆)
- **Ability to accommodate services.** Rigid enough to accept sealants around services and stiff enough to take pipe collars and penetration sealing systems. (☆☆☆☆☆)
- **Distortion generation.** The expansion and/or contraction can induce distortion in thin studs. (☆☆☆)
- **Durability.** Generally considered inert although some are susceptible to water and subsequent freezing which should be used only in frost free areas. Low density products are prone to some impact damage. (☆☆☆)

2.4. CEMENT BASED BOARD LININGS

These are a fairly modern invention to produce a high strength board which is also capable of resisting fire. Such boards are normally between 10 and 20mm thick.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Normally good but high density cement boards can crack and bow significantly leading to a loss of integrity, particularly at joints between boards. (☆☆☆)
- **Temperature rise (insulation).** The lower density boards are moderately insulating, but as the density increases so does the conductivity and some cement boards rely heavily on insulation infills if they are to satisfy insulation. (☆☆)
- **Smoke resistance.** The boards are impermeable and exhibit good smoke resistance with respect to cold smoke but the distortion may result in a loss of hot smoke resistance at joints. (☆☆☆☆)
- **Surface spread of flame.** Normally Class 0 or with limited combustibility. (☆☆☆☆☆)
- **Loading and deflection resistance.** The higher density of these boards results in a strong board which is able to resist deflection but due to the propensity to distort it could induce deflection. (☆☆☆)
- **Contribution to fire load.** The contribution is low to negligible. (☆☆☆☆☆)
- **Ability to accommodate services.** As for calcium silicate boards. (☆☆☆☆)
- **Distortion generation.** Cement boards do have a tendency to distort when heated which due to the strength of the boards can induce deflection in studs. (☆☆☆)
- **Durability.** These boards have a high impact resistance and good resistance to ambient conditions. (☆☆☆☆☆)

2.5. WOOD BASED BOARD LININGS

These are generally restricted by their cost and difficulty in achieving the regulatory levels of surface spread of flame. This section covers linings of chipboard, plywood or MDF (medium density fibreboard) or waferboard. Any other form of wood based product will need to be checked against the manufacturer's claims. Wood based boards will normally be between 10 and 25mm thick for stud wall applications.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Timber burns away at a predictable rate which in the case of board materials is normally between 0.7 and 1mm/min. It is possible to select linings with adequate burn-through resistance to meet any normal requirement but weight will prohibit its use at periods in excess of 60 minutes. Well selected insulation can extend the period of integrity. (☆☆☆☆)

- **Temperature rise (insulation).** Timber exhibits excellent insulation characteristics up until a few minutes before burn through. (☆☆☆☆☆)
- **Smoke resistance.** Timber boards are impermeable and will provide good resistance to smoke spread but in the latter stages of a fire the construction will produce some smoke. (☆☆☆☆)
- **Surface spread of flame.** In its normal state timber has a Class 3 surface spread of flame (☆). Needs to be surface coated, manufactured with integral flame retarding salts or be impregnated to achieve the Class 1 or Class 0 ratings often required. Treated timber, whilst not meeting the requirements of Part 2.2 of this *Design Guide*, does reduce the extent of fire damage across the surface. (☆☆☆)
- **Loading and deflection resistance.** Timber boards are quite strong at thicknesses in excess of 10mm and can both accept load and resist deflection. (☆☆☆☆)
- **Contribution to fire load.** Regardless of how much fire retardance is incorporated, timber will add significantly to the fire load. (☆)
- **Ability to accommodate services.** It must be recognised that timber, when used as the substrate to any associated sealing system, will burn away, albeit that it provides good fixings for sealing systems. (☆☆☆)
- **Distortion generation.** Timber will shrink on its heated face inducing distortion which will generally reduce as the wood is consumed. (☆☆☆)
- **Durability.** In internal environments timber linings have excellent impact resistance and durability, hence their extensive use as doors. (☆☆☆☆☆)

2.6. STEEL SHEET LININGS

Steel is used as a lining material in stud-framed systems, particularly in industrial environments. It will normally be used in conjunction with mineral wool slabs for insulation and sometimes as a facing to other boards. This section relates to its use as an individual, rather than a composite lining.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Up until 2 hours steel has excellent resistance to penetration by fire. (☆☆☆☆☆)
- **Temperature rise (insulation).** Steel is highly conductive and has a poor resistance to temperature rise, relying extensively on cavity insulation if the steel lined construction is to provide insulation. (☆)
- **Smoke resistance.** Steel is impermeable to smoke but joints need to be well sealed. (☆☆☆☆☆)
- **Surface spread of flame.** Steel is non-combustible. (☆☆☆☆☆)
- **Loading and deflection resistance.** Flat steel sheet in the thickness used for linings/facings (assumed to be less than 2.5mm) is unable to resist deflection very significantly, but when profiled the resistance increases dramatically. (☆☆☆☆)
- **Contribution to fire load.** Nil. (☆☆☆☆☆)

- **Ability to accommodate services.** Metal facings are able to be cut, formed and accept fixings to aid the sealing of service penetrations. (☆☆☆☆)
- **Distortion generation.** The high expansion rate of steel can induce distortions as a result of restrained expansion. When significant levels of insulation are incorporated in the cavity then differential expansions can induce bowing. (☆☆)
- **Durability.** When properly treated, i.e. post construction galvanising or suitably primed and decorated, steel sheet has good durability in internal environments. Steel has good impact resistance. (☆☆☆☆)

3. CAVITY INSULATION

A third, and sometimes important component in a studwork wall is cavity insulation. This insulation may be incorporated to enhance the fire resistance (the critical function) or purely to provide improved thermal or acoustical performance (non-critical functions). This section only compares the two common forms of glass based and rock (or stone) based mineral fibres with respect to fire.

Insulation should never be incorporated in a construction that has been satisfactorily tested without it, as the increased temperature differentials that could result may actually induce more deflection or distortion and if the insulation does not contribute anything to the overall performance this may have a negative effect. Always consult the manufacturer, the LPC or an independent advisor.

Glass fibre quilts will only nominally make a contribution to fire resisting constructions of up to 30 minutes. Rock or stone wool may be used for constructions from 30 to 240 minutes, the actual rating depending on the density and thickness, also the type of lining. For high fire resistance levels, the Rock or stone wool would have a density typically in excess of 100kg/m³.

3.1 MINERAL WOOL QUILT/BATT OF GLASS FIBRES

Glass fibre products are usually incorporated for thermal or acoustic purposes in steel framed construction. They are available in quilts semi-rigid and rigid slabs, but the density and binder content tends to increase as the rigidity increases.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Because of the modest temperatures that glass fibres melt at (around 650-700°C) glass fibre insulation is unable to make a significant contribution to integrity. (☆☆)
- **Temperature rise (insulation).** Glass fibres can only make a contribution to insulation whilst the linings stay in position and the cavity temperature remains below the sintering temperature of the glass fibres. (☆☆)
- **Smoke resistance.** All forms of mineral fibre insulation are permeable to a degree and have a low resistance to smoke spread. (☆☆)
- **Surface spread of flame.** Not a relevant property.

- **Loading and deflection resistance.** Not a relevant property.
- **Contribution to fire load.** The binders will contribute to the fire but the contribution is low. (☆☆☆☆)
- **Ability to accommodate services.** Services can be passed through it easily but unless the insulation is a rigid, or at least a thick semi-rigid slab it may be difficult to seal to and the melting point of the glass restricts the seal duration. (☆☆)
- **Distortion generation.** The insulation will not cause distortion of the wall. (☆☆☆☆)
- **Durability.** Generally considered to be excellent although weak with respect to impact. (☆☆☆☆)

3.2 MINERAL QUILT/BATT OF ROCK OR STONE FIBRES

Mineral wool or rock fibres or stone fibres are generally incorporated in order to make a contribution to fire resistance but can be used for acoustic and thermal purposes also. As for glass fibre it comes in a range of forms, densities and thicknesses.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** The product does shrink when hot, leaving gaps between rolls/boards/slabs as it does so. The material is normally used to enhance the integrity rating but its permeability, shrinkage and joint problems reduce its contribution. (☆☆☆☆)
- **Temperature rise (insulation).** The product's high resistance to melting and natural insulation characteristics makes a good contribution to reducing the temperature rise of constructions. (☆☆☆☆)
- **Smoke resistance.** As for glass fibre based wool.
- **Surface spread of flame.** Not a relevant criterion.
- **Loading and deflection resistance.** Not a relevant criterion.
- **Contribution to fire load.** As for glass fibre based wool.
- **Ability to accommodate services.** Services can be passed through easily but unless the insulation is rigid, or at least semi-rigid it may be difficult to seal. (☆☆☆☆)
- **Distortion generation.** The insulation will not cause distortion of the wall. (☆☆☆☆)
- **Durability.** As for glass fibre wool.

INSTALLATION

The installation of dry lined studwork should be executed and completed by a suitably qualified person to the required standard appropriate to the system used. It is advisable that where fire performance is required then an inspection by an independent body may be carried out on the completed work.

SUPPORTING DATA

Table 1 below summarises the assessed relative abilities of the featured materials to satisfy the identified fire performance requirements.

Table 1. Performance abilities.

Requirements performance (integrity)	Fire resistance rise (insulation)	Temperature resistance	Smoke spread of flame	Surface deflection resistance	Loading and to fire load	Contribution accommodate services	Ability to generation	Distortion	Durability
Dry lined studwork Compartment walls									
1. STUDS									
1.1 Softwood studs	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	N/A	☆☆☆	☆☆☆☆☆	N/A	☆☆☆☆☆	☆☆☆☆☆
1.2 Lightweight metal studs	☆☆☆	☆☆	☆☆☆☆	N/A	☆	☆☆☆☆☆☆	N/A	☆☆	☆☆☆☆☆☆
2. LININGS									
2.1 Unreinforced gypsum plasterboard linings									
	☆☆☆☆	☆☆☆☆☆	☆☆☆☆	☆☆☆☆☆☆	☆☆	☆☆☆☆☆☆	☆☆	☆☆☆☆☆☆	☆☆☆☆
2.2 Reinforced gypsum based boards									
	☆☆☆☆☆	☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆☆☆	☆☆	☆☆☆☆☆☆	☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆
2.3 Calcium silicate board linings									
	☆☆☆☆☆	☆☆☆	☆☆☆☆☆☆	☆☆☆☆☆☆	☆☆	☆☆☆☆☆☆	☆☆☆☆	☆☆☆☆	☆☆☆☆
2.4 Cement based board linings									
	☆☆☆	☆☆	☆☆☆☆☆	☆☆☆☆☆☆	☆☆☆	☆☆☆☆☆☆	☆☆☆☆	☆☆☆☆	☆☆☆☆☆☆
2.5 Wood based board linings									
	☆☆☆☆	☆☆☆☆☆	☆☆☆☆	☆☆☆	☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆	☆☆☆☆	☆☆☆☆☆☆
2.6 Steel sheet linings									
	☆☆☆☆☆	☆	☆☆☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆	☆☆	☆☆☆☆
3. CAVITY INSULATION									
3.1 Mineral wool quilt/batt of glass fibres									
	☆	☆☆	☆	N/A	N/A	☆☆☆☆	☆☆	☆☆☆☆	☆☆☆☆☆☆
3.2 Mineral wool/batt of rock or stone fibres									
	☆☆☆☆	☆☆☆☆☆	☆	N/A	N/A	☆☆☆☆	☆☆☆☆	☆☆☆☆	☆☆☆☆☆☆

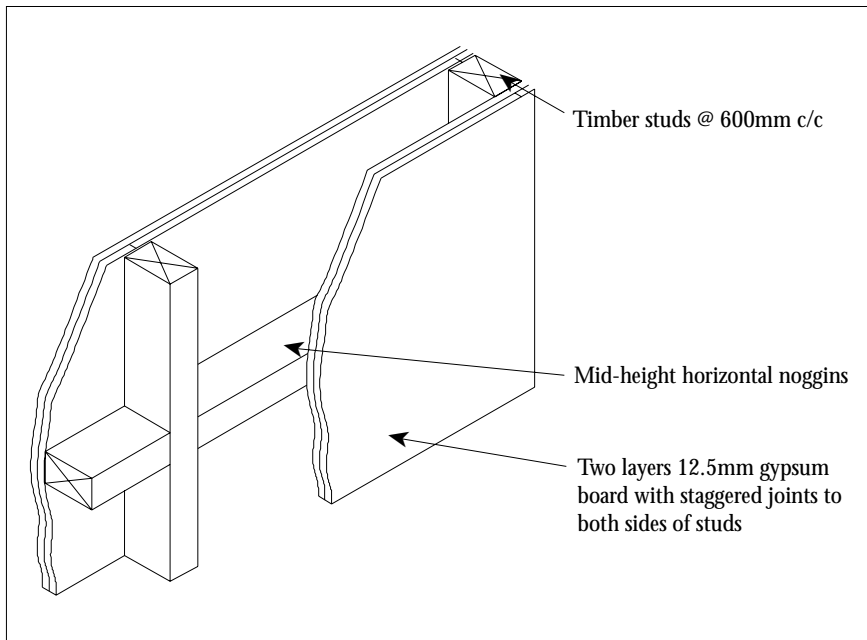


Figure 1. Typical timber stud partition - 90 minutes fire resistance.

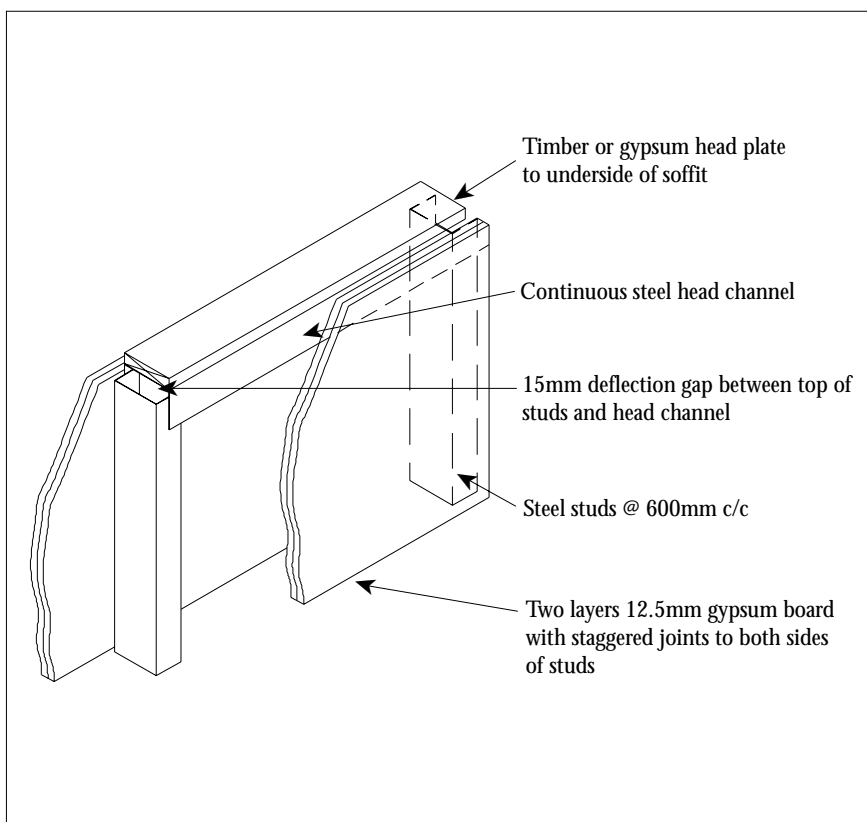


Figure 2. Typical steel stud partition - 60 minutes fire resistance (head detail showing deflection gap).

SOURCES FOR FURTHER INFORMATION

Association of Specialist Fire Protection, Association House, 253 Ash Road, Aldershot, Hampshire GU12 4DD.

EURISOL (UK Mineral Wool Association), 39 High Street, Redbourn, Herts AL3 7LW.

Sheet No: 6.3.3

BEFORE READING
THIS DATA SHEET
PLEASE REFER TO
THE
INTRODUCTION

6.3 Compartment walls**Cavity barriers**

Main application in respect to this *Design Guide*

- Maintaining the fire separation in roof spaces or floor voids where such voids run past compartment walls.
- Sub-dividing voids above ceilings or below floors or within walls to restrict unseen spread of fire (normally a regulatory requirement).

FUNCTION OF CAVITY BARRIERS

- To maintain the integrity of the barrier for the duration defined in Table 4.7 of the *Design Guide*. Cavity barriers installed between non-fire resisting elements to prevent rapid fire spread through voids, only require a 30 minute integrity as the elements to which they are attached will have failed before then. Restricting smoke spread is as important as maintaining integrity.
- To restrict the rise in temperature on the unexposed face to those levels required to prevent fire spread for the duration defined in Table 4.7 of the *Design Guide*.
- To restrict the passage of smoke for the same duration as integrity.
- To be not capable of spreading flame on their surface.
- To withstand the loading and deflection to be experienced in use and during fire exposure whilst maintaining the requirements above.
- To be able to accept the services described in Data sheet 6.7.1 without detriment to the fire separation provided, e.g. integrity, temperature rise and smoke restriction. To achieve the smoke restriction all penetrations shall be fully sealed.
- To maintain the separating performance over the life time of the building, or for a shorter duration if allowed for in the fire safety management plan, in respect of realistic impact and/or ambient conditions.

EVIDENCE OF FIRE PERFORMANCE

Evidence of performance shall comply with all of the following:

- **Fire resistance performance (cavity barriers larger than 1m in any direction)**. The ability of the barrier to maintain integrity and keep the unexposed face temperature below hazardous levels shall be supported by test evidence generated in accordance with BS476: Part^{1h}, EN 1364-1²⁶ with edge fixings appropriate to its use and preferably supported by a Field of Application Report identifying any restrictions in use.

IMPORTANT
THESE DATA
SHEETS ARE ONLY
INTENDED TO
GIVE GENERIC
INFORMATION.
DATA ON
PROPRIETARY
PRODUCTS MUST
BE OBTAINED
FROM THE
MANUFACTURERS

- **Fire resistance performance (cavity barriers less than 1m in any direction).** The ability of the barrier to maintain integrity and keep the unexposed face temperature below hazardous levels shall be supported by test evidence generated to the test methodology given in BS476 : Part 20^{1f}, EN 1363-1²⁵ in a furnace with a minimum dimension of 1m. In such tests both vertical (or two opposite horizontal edges) shall be unrestrained. Barriers tested in this way *shall* be supported by a Field of Application Report identifying any restrictions in use.
- **Smoke resistance.** The barrier should have at least one impermeable face and the method of fixing shall be such that no gaps exist. Preferably the barrier shall have been tested to the methodology of BS476 : Part 31.1^{1j} and demonstrated a leakage rate of not more than 10m³/m²/hr.
- **Contribution to fire growth.** The surface of the cavity barrier, including any substrate, shall have a surface spread of flame of Class 1 to BS 476: Part 7^{1d}, and be rated Class 0 as defined in England and Wales Building Regulations, Approved Document B²⁹, or other national regulations. Alternatively the product shall be designated as being of limited combustibility.
- **Loading and deflection.** The method of installation of vertical barriers shall be able to accommodate vertical deflection of L/30 of its mean height, or span, without producing gaps through which smoke or fire could spread.
- **Accommodation of services.** Evidence shall be available to substantiate that the penetration by services will not impair the achievement of any of the above performance requirements.
- **Durability.** Evidence shall be available to show that the materials used in the construction of the barrier are not going to be adversely affected by the ambient conditions and, if appropriate, abuse (e.g. low energy impacts) during the anticipated life of the barrier.

The most common generic types of material used for fire resisting cavity barriers are as follows:

1. Calcium silicate and cement based boards
2. Unreinforced gypsum based boards
3. Reinforced gypsum boards
4. Mineral wool quilt
 - 4.1 Mineral wool quilt (not less than 40mm thickness minimum density 60kg/m³)
 - 4.2 Semi-rigid mineral wool slab (density 100kg/m³) not less than 25mm thickness
5. Steel faced fibre reinforced cement boards
6. Vermiculite sprayed mesh
7. Glass fibre based curtains

1. CALCIUM SILICATE AND CEMENT BASED BOARDS

There are a number of suitable products for use as cavity barriers. For large cavity barriers these take the form of a non-loadbearing partition with structural studs being used to support the boards and form joints. For small cavity barriers an appropriate sized board may be simply fixed to the boundary or edge members. Boards of less than 12mm thickness are not suitable for small, single sheet cavity barriers because of their lack of robustness.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Normally good, especially for low density boards with a low propensity to crack when heated. (☆☆☆☆☆)
- **Temperature rise (insulation).** Generally more conductive than some other barrier materials and may need to be used in conjunction with insulation to achieve ratings. (☆☆☆)
- **Smoke resistance.** Unless damaged they are considered impermeable although joints and edges may require special treatment. (☆☆☆☆☆)
- **Contribution to fire growth.** Normally Class 0 or limited combustibility and meet Part 2.2 of this *Design Guide* (☆☆☆☆☆).
- **Loading and deflection.** Only limited ability to withstand deflection and design details will need to be given to meet this requirement. (☆☆)
- **Ability to accommodate services.** Rigid enough to accept sealants around services and stiff enough to take pipe collars and penetration sealing systems. (☆☆☆☆)
- **Durability.** Generally considered inert although some are susceptible to water and subsequent freezing which should be used only in frost free areas. Low density products are prone to some impact damage. (☆☆☆)

2. UNREINFORCED GYPSUM BASED BOARDS

Generally as for calcium silicate boards except minimum thickness of single layer boards shall be 19mm.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Low propensity to crack but not totally immune; normally considered good. (☆☆☆☆☆)
- **Temperature rise (insulation).** Gypsum has excellent resistance to temperature rise until all water is driven off. (☆☆☆☆☆)
- **Smoke resistance.** Unless damaged, boards are considered to be impermeable, but joints and edge details will need to be developed to meet this requirement. (☆☆☆☆)
- **Contribution to fire growth.** Class 0 surface, core of limited combustibility. (☆☆☆☆☆)
- **Loading and deflection.** As for calcium silicate. (☆☆)
- **Ability to accommodate services.** Normally rigid enough to accept sealants around single services but support will be needed to retain special closing devices and sealing systems. (☆☆☆)
- **Durability.** Not suitable for use in wet conditions, but generally durable although prone to impact damage. (☆☆☆)

3. REINFORCED GYPSUM BOARDS

Generally as for calcium silicate, except minimum thickness of single layer boards shall be 12mm.

FIRE PERFORMANCE DATA

The performance of reinforced gypsum boards is the same as unreinforced gypsum except for:

- **Fire resistance (integrity).** The material is unlikely to crack when heated and has excellent integrity performance. (☆☆☆☆☆)
- **Ability to accommodate services.** Stronger than unreinforced gypsum and some devices such as cable transits and pipe collars may be fixed directly to the board. (☆☆☆☆☆)
- **Durability.** More resistant to impact than normal gypsum board. (☆☆☆☆☆)

4. MINERAL WOOL QUILT

The advantage of mineral wool barriers is their ability to be bent, curled or rolled for getting into small spaces when retro-fitted.

FIRE PERFORMANCE DATA

4.1 Mineral wool quilt

(Not less than 40mm thickness. Minimum density 60kg/m³)

- **Fire resistance (integrity).** The integrity of the basic quilt is good, but joints between quilts and fixings at the perimeter must be well done. The quilt must not be damaged by over stretching. Wire reinforcement helps to prevent this. (☆☆☆☆☆)
- **Temperature rise (insulation).** Mineral wool quilt is naturally insulating but damage or poor installation and jointing can compromise this. (☆☆☆☆☆)
- **Smoke resistance.** Only good if foil backed and prone to be leaky at joints and around perimeter. (☆☆)
- **Contribution to fire growth.** Non combustible BS 476: Part 4^{1b} or Class 0. (☆☆☆☆☆)
- **Loading and deflection.** Whilst not strong in tension, if fitted with anticipated deflection in mind it can accommodate deflection below and compression from above. (☆☆☆☆☆)
- **Ability to accommodate services.** It is not easy to make a fire seal where services pass but most manufacturers have an approved detail which should be used. (☆☆)
- **Durability.** The basic materials are durable but due to fibrous nature they are prone to damage in adverse environmental conditions. (☆☆☆)

FIRE PERFORMANCE DATA**4.2 Semi-rigid mineral wool slab***(Density 100kg/m³ not less than 25mm thickness)*

- **Fire resistance (integrity).** Joints can compromise fire integrity but generally considered to be excellent. (☆☆☆☆☆)
- **Temperature rise (insulation).** Well fitted slab of the correct thickness has excellent fire insulation characteristics. (☆☆☆☆☆)
- **Smoke resistance.** Good because of density but excellent when coated and jointed properly. (☆☆☆☆☆)
- **Contribution to fire growth.** Class 0 or limited combustibility. (☆☆☆☆☆)
- **Loading and deflection.** Able to accommodate lateral movement, but not as good as quilt in accommodating 'in-plane' deflection. (☆☆☆)
- **Ability to accommodate services.** Semi-rigid mineral wool batts are used extensively as bulk-heads in many penetration systems because of its ability to allow sealants to be used. (☆☆☆☆☆)
- **Durability.** Impact and environmental both normally considered excellent. (☆☆☆☆☆)

5. STEEL FACED FIBRE REINFORCED CEMENT BOARDS

Strong and robust but has the disadvantage of being heavy and the structure must be able to accept the weight.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** These materials have excellent integrity resistance. (☆☆☆☆☆)
- **Temperature rise (insulation).** Generally poor and needs to be used with insulation material to achieve ratings. (☆)
- **Smoke resistance.** Impermeable but joints and edges may require special treatment. (☆☆☆☆☆)
- **Contribution to fire growth.** Class 0 and non combustible and meets the requirements of Part 2.2 of this *Design Guide*. (☆☆☆☆☆)
- **Loading and deflection.** Very strong and able to accept loads and may, when fixed, restrain deflection. Installation method needs to be designed if it is to accommodate deflection. (☆☆☆)
- **Ability to accommodate services.** Rigid enough to accept sealants around services and stiff enough to provide support and to allow fixing of pipe collars and penetration sealing systems. (☆☆☆☆☆)
- **Durability.** Excellent, particularly suitable for industrial applications. (☆☆☆☆☆)

6. VERMICULITE SPRAYED MESH

A supporting wire mesh is installed initially to which a sprayed vermiculite coating is applied. Attention to detail regarding coating thickness and 'plug holing' voids should be observed on site post application.

Access needed for spray equipment. More dependent upon quality of application than some alternatives and trained operators required. Recommended thicknesses should be obtained from the manufacturer

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Good when evenly applied and spraying tends to produce good edge sealing. (☆☆☆☆)
- **Temperature rise (insulation).** Vermiculite has excellent insulation characteristics albeit only as good as the application on site. (☆☆☆☆)
- **Smoke resistance.** When evenly applied the product should be impermeable and joint free. (☆☆☆☆)
- **Contribution to fire growth .** Generally non-combustible or of limited combustibility. (☆☆☆☆)
- **Loading and deflection.** Able to resist lateral deflection, but needs special design details to accommodate 'in-plane' deflection. (☆☆)
- **Ability to accommodate services.** Not able to accept fixings and therefore special provisions need to be made albeit small services can be sealed with sealants .(☆☆)
- **Durability.** Not immune from damage albeit the basic material is stable in use. (☆☆)

7. GLASS FIBRE BASED CURTAINS

These are not recommended for applications in excess of [30] minutes as their ability to protect the property can be low where structure is adversely affected by radiant heat.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Good up to the stated rating albeit joints need to be correctly made. (☆☆☆☆)
- **Temperature rise (insulation).** They offer very little insulation and should only be used where the structure adjacent is non combustible. (☆)
- **Smoke resistance.** When jointed properly the coated fabric is excellent. (☆☆☆☆)
- **Contribution to fire growth.** Generally Class 0. (☆☆☆☆)
- **Loading and deflection.** Can be fitted to readily accommodate deflection. (☆☆☆☆)
- **Ability to accommodate services.** Poor due to the thinness of the membrane. Special methods are available but trained installers are essential. (☆)
- **Durability.** Not completely exempt from damage but the materials are stable in use. (☆☆☆☆)

RECOMMENDED THICKNESSES OF MATERIALS

It is not possible to give or recommend a thickness for the various materials as the size of the barrier will often dictate the thickness needed to provide the integrity rating. Even within a generic group, the various products will require

different thicknesses to satisfy the restriction on temperature rise for the appropriate duration.

The manufacturers' LPCB approval, test evidence and/or Field of Application Report should be referred to when specifying or auditing a cavity barrier installation. Where the robustness of the product is of concern minimum thicknesses are shown in this Data sheet for each generic type of product.

SUMMARY OF PERFORMANCE DATA

Table 1 overleaf summarises the assessed relative abilities of the featured materials to satisfy the identified performance requirements.

INSTALLATION

Cavity barriers are only as good as the structure to which they are attached and the materials used are only as good as the design and quality of the construction of the barrier. When using board materials, double sided partition type barriers are recommended. Where a single sided construction is contemplated for large cavity barriers the structural studs and/or elements of structure to which they are attached shall be fully protected with respect to fire attack from the side opposite to the board (Figure 1a). When using 'curtain' type materials these shall be fitted so as to protect their supporting members or be fixed only to existing protected members (Figure 1b). It shall be recognised that pre-fabricated roof members, e.g. metal plate jointed timber trusses, have an inherently low fire resistance and cavity barriers in such roofs should be fixed and act independently of the roof system.

Bracing is present in many roofs. Often this bracing penetrates the cavity barrier. The installation must accommodate any anticipated movement of that brace, either in use or in a fire, taking into account that roof members are rarely fire protected, except when required by Part 5.5 of the *Design Guide*, and are therefore liable to significant movement. Metal bracing shall be treated like a metal pipe penetration (Data sheet 6.7.1) and timber bracing shall be fire protected for at least 100mm either side of the barrier (see Figure 2).

Where the construction bounding the roof is liable to deflect in a fire the edge fixings or, in the case of flexible barriers, the barrier itself shall be able to accommodate deflections up to $L/30$. Examples of how this may be achieved are given in Figures 3, 4 and 5.

IMPORTANT NOTE: When fixing cavity barriers to fire protected supporting members it is vital that the fixings do not compromise the protection to the member and in all cases any fire protection removed shall always be made good.

The installation of cavity barriers should be executed and completed by a suitably qualified person to the required standard appropriate to the system used. It is advisable that where fire performance is required then an inspection by an independent body may be carried out on the completed work.

IDENTIFICATION

Any LPCB approved barrier or installation should carry a permanent mark identifying the LPCB approval number. It is recommended that non LPCB approved barriers shall be clearly indelibly marked with the manufacturer's or installer's name and a statement of the fire integrity and insulation rating.

Table 1. Summary of data.

Requirements	Fire resistance (integrity)	Temperature rise (insulation)	Smoke resistance	Contribution to fire growth	Loading and deflection	Accommodating services	Durability - impact resistance	Durability - environmental conditions	Minimum thickness
Cavity barrier materials									
1. Calcium silicate and cement based boards	☆☆☆☆☆	☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆	☆☆☆☆	☆☆☆	☆☆☆	7mm
2. Unreinforced gypsum based boards	☆☆☆☆	☆☆☆☆☆	☆☆☆☆	☆☆☆☆☆	☆☆	☆☆☆☆	☆☆☆	☆☆☆	19mm
3. Reinforced gypsum boards	☆☆☆☆☆	☆☆☆	☆☆☆☆	☆☆☆☆☆	☆☆	☆☆☆☆	☆☆☆☆	☆☆☆	12mm
4. Mineral wool quilt									
4.1 Mineral wool quilt (not less than 40mm)	☆☆☆☆	☆☆☆☆	☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆	☆☆☆	☆☆☆	40mm
4.2 Semi-rigid mineral wool slab (not less than 25mm)	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆	☆☆☆☆☆	☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	25mm
5. Steel faced fibre reinforced cement boards	☆☆☆☆☆	☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	
6. Vermiculite sprayed mesh	☆☆☆☆	☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆	☆☆	☆☆☆	☆☆☆	
7. Glass fibre based curtains	☆☆☆☆	☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆	☆☆☆☆	☆☆☆☆	

Figure 1a. Example of protection to structural members which incorporate the cavity barrier.

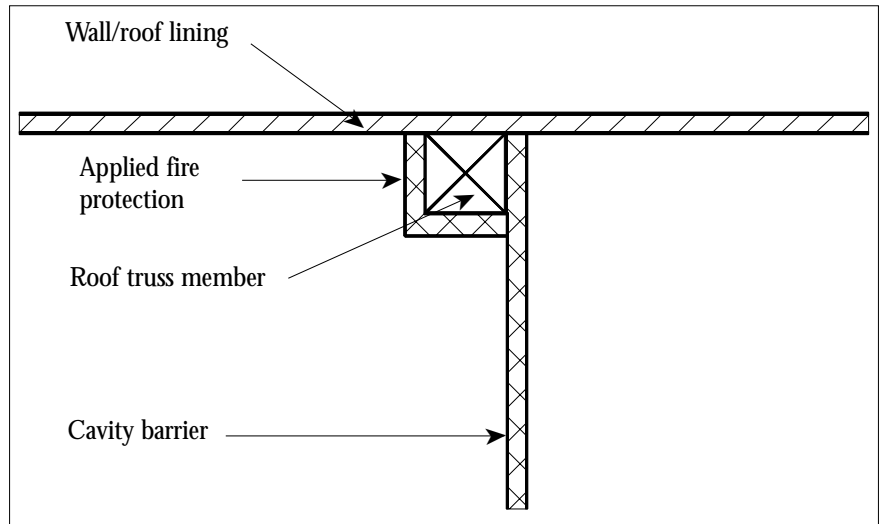


Figure 1b. Example of protection to structural member which supports fire resisting curtain.

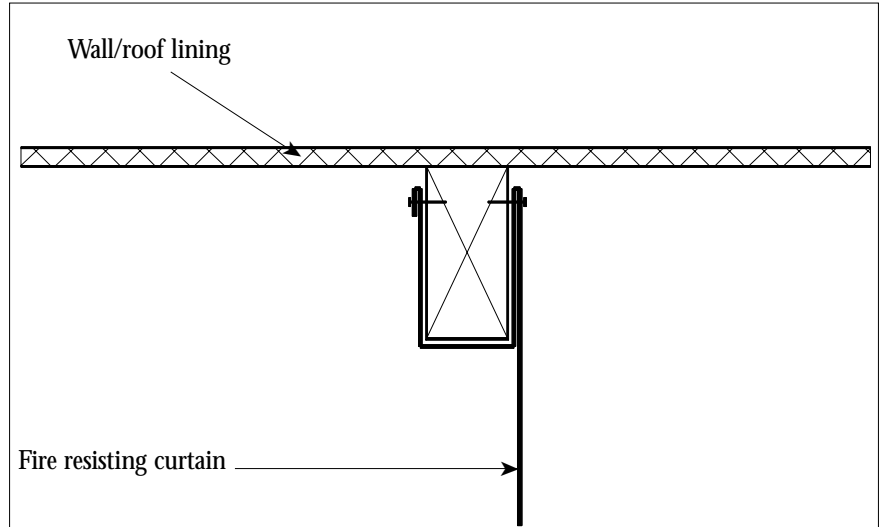
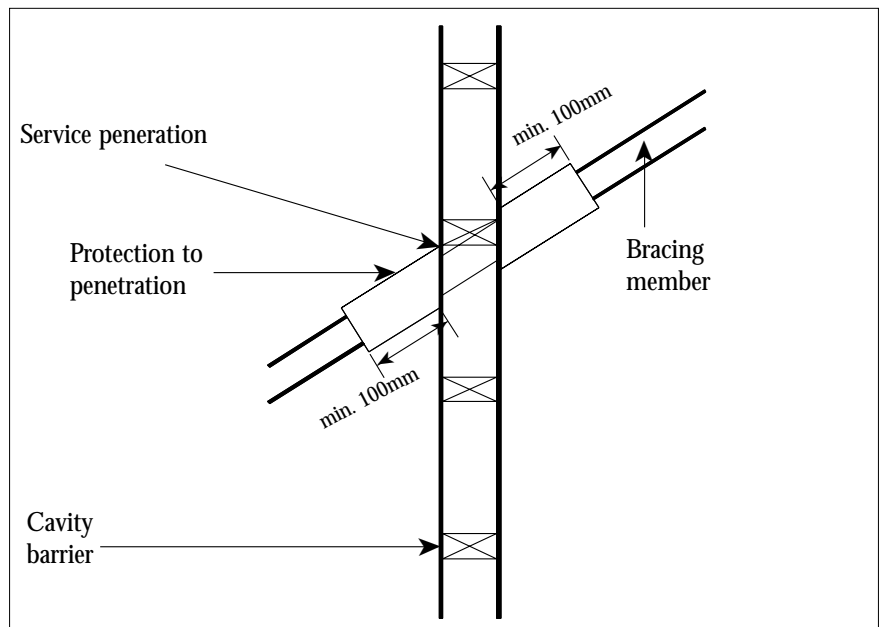


Figure 2. Timber bracing shall be fire protected for at least 100mm either side of the barrier.



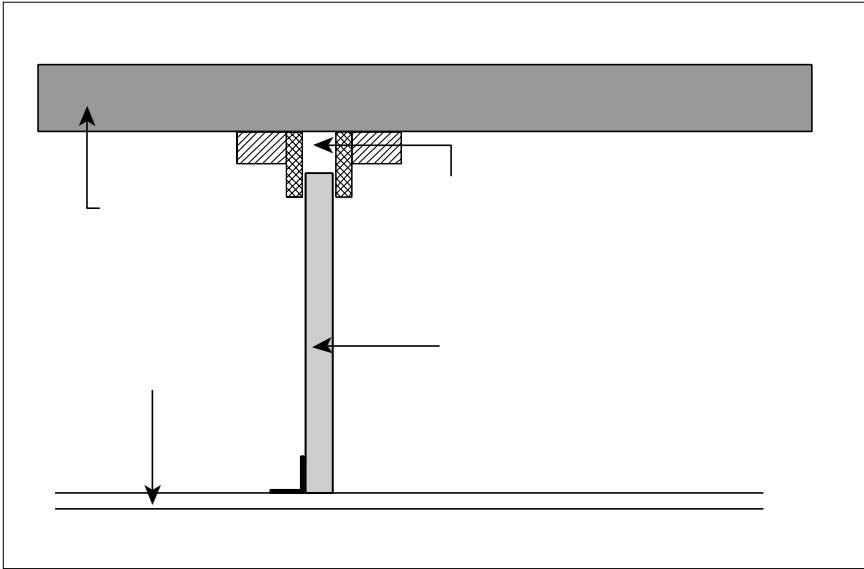


Figure 3. Example of cavity barrier in ceiling void (fire protection board).

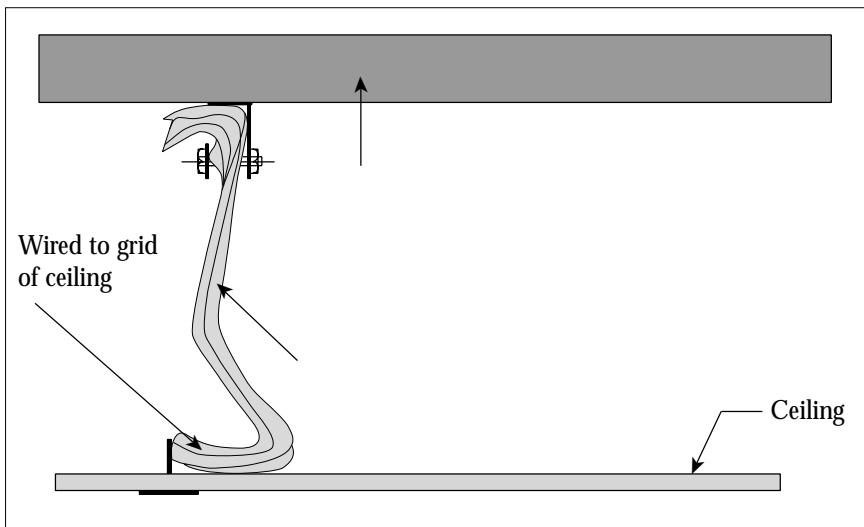


Figure 4. Example of cavity barrier in ceiling void (mineral wool).

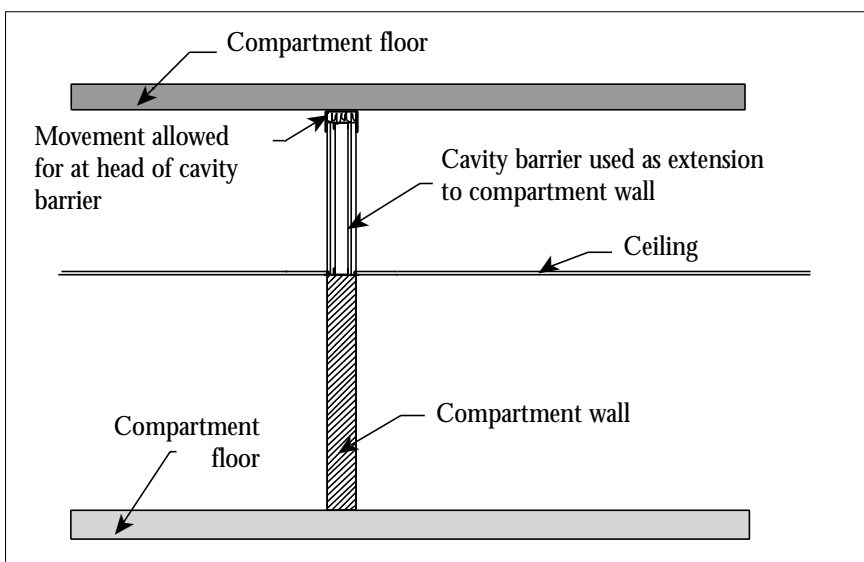


Figure 5. Metal stud partition used as cavity barrier above masonry compartment.

Sheet No: 6.4.1

BEFORE READING
THIS DATA SHEET
PLEASE REFER TO
THE
INTRODUCTION

6.4 External walls**Composite panels (sandwich panels), built up panels and external claddings protected by dry lining systems**

Main application in respect to this *Design Guide*.

External walls of industrial buildings and other single storey buildings

FUNCTION OF EXTERNAL WALLS

- To make no significant contribution to a developing fire (see Part 2.2), whilst meeting any imposed requirements for thermal insulation
- To prevent fire spread around a compartment wall by meeting the fire resistance requirements appropriate to the protected zone (see index of this *Design Guide* for references). This will require selection of a system that can resist fire from either side.
- To be not capable of spreading flame on their internal or external surfaces.
- To prevent the combustion of the insulating core from accidental or malicious ignition of combustible materials adjacent to the external surface.
- To prevent as far as possible the passage of smoke.
- To withstand wind loading, rain penetration and deflection to be experienced in use whilst maintaining the requirements above.
- To maintain the satisfactory performance over the lifetime of the building, or for a shorter duration if allowed for in the fire safety management plan, in respect of realistic impact and/or ambient conditions.
- To maintain the above functions when breached by openings for doors and windows. In respect to this, the advice from the cladding manufacturer should be sought regarding the compatibility with other systems.

IMPORTANT
THESE DATA
SHEETS ARE ONLY
INTENDED TO
GIVE GENERIC
INFORMATION.

DATA ON
PROPRIETARY
PRODUCTS MUST
BE OBTAINED
FROM THE
MANUFACTURERS

EVIDENCE OF PERFORMANCE

To ensure that insulated cladding panels for external walls meet in full the fire performance requirements of this *Design Guide*, it is important for the building designer to specify products that have been approved by LPCB to LPS 1181²⁴ and listed in the *List of Approved Fire and Security Products and Services*¹⁹. In addition, for parts of the external wall that are part of the protected zone (see Part 3.3.1), these shall have sufficient fire resistance to resist fire from both inside and outside. Appropriate test is BS 476:Part 22^{1h}, clause 5. Where there is a risk of combustible materials being stored close to the external face, or there is a risk of fire spread from a building at right angles, then the protected zone (i.e. part of the external wall that has to have fire resistance) may have to be extended. Guidance is given in Part 5 of this *Design Guide*.

Contribution to fire growth

For composite constructions such as insulated panels used for external walls, these shall have been tested to the wall and ceiling lining test described in LPS 1181²⁴ (a large scale reaction-to fire test). Even when using a non-combustible insulant, combustible materials may still be used in the external wall construction, e.g. vapour barrier or joint seals and the use of the wall and ceiling lining test may still be appropriate. External claddings protected by dry lining systems are generally constructed from either non-combustible or materials of limited combustibility, and consequently meet the requirements of Part 2.2 of this *Design Guide*.

Note: Tests undertaken to BS 476:Part 33:1993/ISO 9705^{1k} are not deemed to be suitable for external cladding systems constructed from composite panels for ensuring compliance with this Design Guide.

- **Surface spread of flame.** The internal and external surfaces of external walls shall have a surface spread of flame of Class 1 to BS 476: Part 7^{1d} and be rated Class 0 as defined in England and Wales Building Regulations, Approved Document B²⁹; or other national regulations. This must be verified by test.
- **Fire resistance.** For the parts of the external wall adjacent to compartment walls defined in 3.3.1.2 of this *Design Guide*, i.e those within the *protected zone*, these shall have a minimum fire resistance of not less than 30 minutes integrity and 15 minutes insulation, regardless of the distance to the relevant boundary. This must be verified by test to BS 476: Part 22^{1h}, clause 5, and tests must be undertaken from both the internal and external sides to meet the recommendations in this *Design Guide*.

Where there is a potential risk of an arson attack from outside of the building, then it is recommended that the fire resistance be not less than 30 minutes integrity and 30 minutes insulation. This should be increased to 60 minutes integrity and 60 minutes insulation for storage buildings or other occupancy types deemed to be high risks by the risk assessment.

Where part of the external wall is not part of the unprotected area, then the provisions for fire resistance in the supporting documents to building regulations shall also be met.

Some claims for high fire resistance may only indicate integrity performance and the designer should enquire on the insulation achieved in each case.

- **Resistance to smoke.** There are no suitable test methods to base a performance requirement on, but it should be recognised that some ability to prevent smoke leaking outside the building is still desirable from an environmental point of view.

This data sheet considers in detail the following generic external wall cladding products:

1. Composite panels
 - 1.1 Polyurethane cored
 - 1.2 Polyisocyanurate cored
 - 1.3 Mineral wool cored
2. Built up panels
(detailed appraisal not possible)
3. Drylining protected system
 - 3.1 Calcium silicate lined system
 - 3.2 Gypsum board lined system

1. COMPOSITE PANELS

These generally encapsulate all surfaces and edges of the insulating core by steel facings. Insulating cores are typically polyurethane, polyisocyanurate, or mineral wool. Facings are generally ribbed (profiled), with the longer edge having a deep rib to interlock with adjacent panels, with weather tightness being a particular feature of the design, but this can be developed to provide good fire integrity as well. 'Fire rated' panels are often provided with factory applied fire seals at the joints to help maintain joint integrity. They arrive at site fully assembled and only need to be fixed to the structural supports.

1.1 POLYURETHANE (PUR) CORED

FIRE PERFORMANCE DATA

Contribution to fire growth. Should not be regarded as meeting the requirements of Part 2.2 of this *Design Guide*. If they are exposed to a sufficient size ignition source, may still they make a significant contribution to fire growth. (☆☆)

Fire resistance. Provided it has adequate joint design, particularly in respect to adequacy of interlock between adjacent panels and provision of factory applied fire seals, is capable of providing (30 minutes integrity and 15 minutes insulation (thickness not less than 80mm)). (☆☆☆)

Smoke resistance. There are currently no test methods available to measure this parameter. However, as the joints have to be weather tight and provided the deformation under fire conditions can be controlled, some containment of smoke can be anticipated. The core material will generate smoke if heated and consequently it is important to ensure adequate joint integrity under fire conditions. (☆☆☆☆)

Strength and impact resistance. Should have adequate resistance to impact for most industrial applications provided only steel faced panels are used. (☆☆☆☆)

Durability. The coatings applied to the steel can be regarded as providing adequate resistance to corrosion for most industrial applications. Compatibility between the metal and the insulant used may have to be confirmed by the manufacturer. (☆☆☆☆)

1.2 POLYISOCYANURATE (PIR) CORED

FIRE PERFORMANCE DATA

- **Contribution to fire.** Only specially formulated PIR foams that have been tested and approved to LPS 1181²⁴ can be regarded as meeting the requirements of Part 2.2 of this *Design Guide*.
Standard PIR foams. (☆☆)
- LPCB approved systems to LPS 1181-2²⁴. (☆☆☆☆)
- **Fire resistance.** Provided it has adequate joint design, particularly in respect to adequacy of interlock between adjacent panels and provision of factory applied fire seals, is capable of providing 30 minutes integrity and between 15 minutes and 30 minutes insulation depending on thickness. A thickness of at least 100mm is required to provide 30 minutes insulation performance. (☆☆☆☆)
- **Smoke resistance.** There are currently no test methods available to measure this parameter. However, as the joints have to be weather tight and provided the deformation under fire conditions can be controlled, some containment of smoke can be anticipated. The core material will generate smoke if heated and consequently it is important to ensure adequate joint integrity under fire conditions. (☆☆☆☆)
- **Strength and impact resistance.** Should have adequate resistance to impact for most industrial applications provided only steel faced panels are used. (☆☆☆☆)
- **Durability.** The coatings applied to the steel can be regarded as providing adequate resistance to corrosion for most industrial applications. Compatibility between the metal and the insulant used may have to be confirmed by the manufacturer. (☆☆☆☆)

1.3 MINERAL WOOL CORED

FIRE PERFORMANCE DATA

- **Contribution to fire growth.** Although not all mineral wool products are entirely non-combustible, particularly those with higher resin content, they can for all practical purposes be regarded as meeting fully the requirements of Part 2.2 of this *Design Guide*, unless combined with combustible facing materials, where additional evaluation would be required. (☆☆☆☆☆☆)
- **Fire resistance.** Provided it has adequate joint design, particularly in respect to adequacy of interlock between adjacent panels, subject to the panel thickness and the density, stone fibre mineral wool for example can easily provide 60 minutes integrity and 60 minutes insulation. (☆☆☆☆☆☆)
- **Smoke resistance.** There are currently no test methods available to measure this parameter. However, as the joints have to be weather tight and provided the deformation under fire conditions can be controlled, some containment of smoke from the fire can be anticipated. Any smoke generated from the mineral wool core will be minimal. (☆☆☆☆☆☆)

- **Strength and impact resistance.** Should have adequate resistance to impact for most industrial applications provided only steel faced panels are used. (☆☆☆☆)
- **Durability.** The coatings applied to the steel can be regarded as providing adequate resistance to corrosion for most industrial applications. Compatibility between the metal and the insulant used may have to be confirmed by the manufacturer. (☆☆☆☆)

2. BUILT UP PANELS

These are delivered to site as a range of components to be fixed together and assembled on site. These components comprise profiled outer metal skins, sheeting rails, insulation, insulated internal panel and suitable fixings. Fire performance may be compromised by poor detailing or installation. For this reason, mineral wool is particularly recommended unless a combustible insulant can be adequately protected from the fire, e.g. by a suitable internal lining.

FIRE PERFORMANCE DATA

As this type of system is totally dependent on both the specific design and the standard of workmanship on site, it is considered inappropriate to give an indication of performance capability. The absence of this information within this data sheet does not necessarily mean that such systems are not capable of meeting the requirements of this *Design Guide*.

3. EXTERNAL WALL CLADDINGS PROTECTED BY DRY LINING SYSTEMS

These typically comprise drylining materials such as gypsum or calcium silicate boards supported on a steel grid or channel system. The grid system is attached to the sheeting rails. Channel systems may be independent of the structural frame supporting the external cladding. Some systems offer fibre cement profiled sheets as an alternative to steel cladding sheets. To ensure adequate protection from an external fire, either a fire protection board will be provided on the cavity face of the external skin (fixed to the sheeting rail) and/or mineral wool insulation be suspended in the cavity.

FIRE PERFORMANCE DATA

Dry lining protected systems

3.1 CALCIUM SILICATE LINED SYSTEMS TYPICALLY WITH MINERAL WOOL INSULATION IN CAVITY

- **Contribution to fire growth.** These systems are constructed from non-combustible materials or materials of limited combustibility and therefore meet fully the requirements of Part 2.2 of this *Design Guide*. (☆☆☆☆)
- **Fire resistance.** Systems can provide typically between 30 minutes and 120 minutes fire resistance depending on specification for both internal and external fire applications. (☆☆☆☆)
- **Smoke resistance.** There are currently no test methods available to measure this parameter. However, as the joints in the external cladding have to be weather tight and provided the deformation under fire conditions can be controlled, some containment of smoke from the fire can be anticipated. Any smoke generated from the lining or mineral wool insulation will be minimal. (☆☆☆☆)

- **Strength and impact resistance.** The lining will have reasonable resistance to impact for most industrial applications. (☆☆☆)
- **Durability.** Under normal service conditions, product performance would be expected to remain unchanged during the life-time of the building. Any damaged panels must be replaced by trained installers immediately. (☆☆☆☆)

Dry lining protected systems

3.2 GYPSUM BOARD LINED SYSTEMS TYPICALLY WITH MINERAL WOOL INSULATION IN CAVITY

FIRE PERFORMANCE DATA

- **Contribution to fire growth.** These systems can be regarded as meeting fully the requirements of Part 2.2 of this *Design Guide* provided the insulation material used in the cavity is limited to mineral wool. (☆☆☆☆☆)
- **Fire resistance.** Systems currently offered for external wall applications tend to cover internal fire exposure only. Therefore it is recommended that if such a system is specified for protected zone applications, then a system having at least 60 minutes fire resistance in terms of integrity and insulation be specified. (☆☆☆)
- **Smoke resistance.** There are currently no test methods available to measure this parameter. However, as the joints in the external cladding have to be weather tight and provided the deformation under fire conditions can be controlled, some containment of smoke from the fire can be anticipated. Any smoke generated from the lining or mineral wool insulation will be minimal. (☆☆☆☆)
- **Strength and impact resistance.** The lining will have reasonable resistance to impact for most industrial applications. (☆☆☆)
- **Durability.** Under normal service conditions, product performance would be expected to remain unchanged during the life-time of the building. Any damaged lining panels or insulation must be replaced by trained installers immediately. (☆☆☆☆)

Figure 1. Typical composite cladding panel.

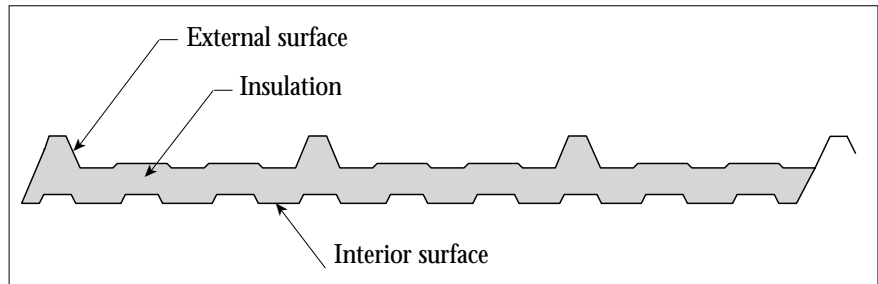


Figure 2. Example of built up cladding panel system.

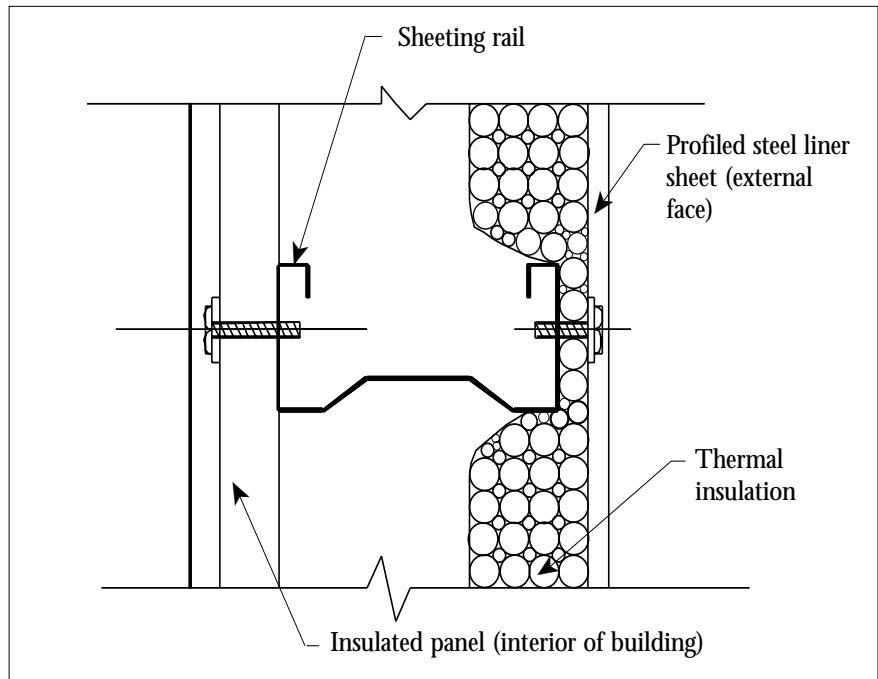
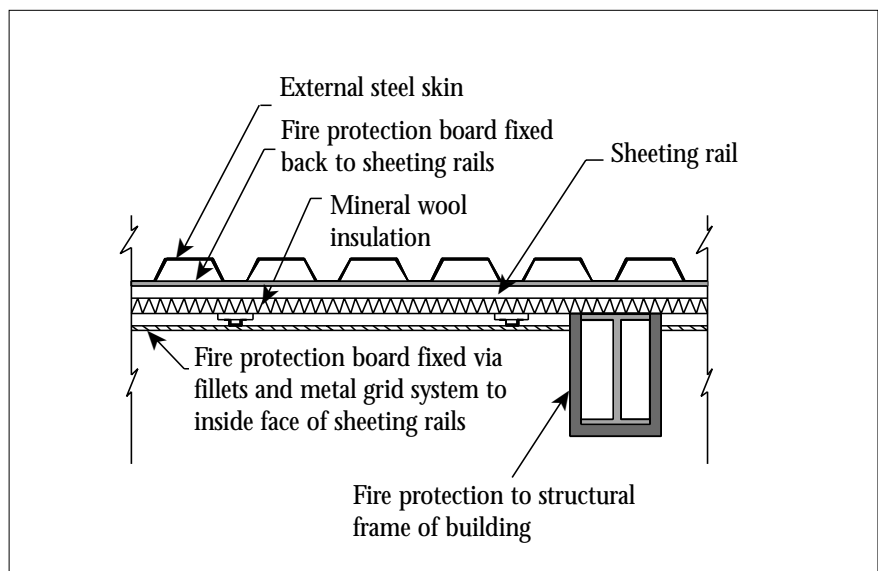


Figure 3. Dry lining system protecting external wall from external and internal fire.



The above drawing is intended to illustrate a typical composite panel. This would not necessarily be a fire rated panel. In the above design, total encapsulation of the insulant would only occur once the panel is installed.

SUMMARY OF DATA

Table 1 below summarises the assessed abilities of external wall cladding systems to satisfy the identified performance requirements.

Table 1

Type of external wall system	Contribution to fire growth	Fire resistance	Smoke resistance	Strength and impact resistance	Durability
Composite panel Polyurethane (PUR) cored	(☆☆)	(☆☆☆) (rating assumes adequate joint detail, not all products will provide fire resistance)	(☆☆☆)	(☆☆☆☆)	(☆☆☆☆)
Composite panel Polyisocyanurate (PIR) cored	(☆☆)	(☆☆☆) (rating assumes adequate joint detail, not all products will provide fire resistance)	(☆☆☆)	(☆☆☆☆)	(☆☆☆☆)
Composite panel LPCB approved Polyisocyanurate (PIR) cored	(☆☆☆☆)	(☆☆☆) Check LPCB approval for rating	(☆☆☆)	(☆☆☆☆)	(☆☆☆☆)
Composite panel Mineral wool cored panel	(☆☆☆☆)	(☆☆☆☆)	(☆☆☆☆)	(☆☆☆☆)	(☆☆☆☆)
Built up panel system	Designers should check with the manufacturer of the system regarding the system's ability in terms of these performance parameters				
Dry lining protected Calcium silicate board	(☆☆☆☆)	(☆☆☆☆)	(☆☆☆☆)	(☆☆☆)	(☆☆☆☆)
Dry lining protected Gypsum board	(☆☆☆☆)	(☆☆☆) This rating is due to the fact that most of the systems documented in manufacturers' handbooks do not provide systems for protecting from outside fire, an important consideration when considering malicious ignition from outside.	(☆☆☆☆)	(☆☆☆)	(☆☆☆☆)

SOURCES FOR FURTHER INFORMATION

EPIC (Engineered panels in construction), 95 York Street, London, W1H 1DU.

Association of Specialist Fire Protection, Association House, 253 Ash Road, Aldershot, Hampshire GU12 4DD.

Built-up Systems Association, 117 Columbria Drive, Lower Wick, Worcester, WR2 4XX.

EURISOL (UK Mineral Wool Association), 39 High Street, Redbourn, Herts AL3 7LW.

The Metal Cladding and Roofing Association, 18 Mere Farm Road, Noctorum, Birkenhead, Merseyside L43 9TT.

Sheet No: 6.5.1

6.5 Compartment floors

Main application in respect to this *Design Guide*:

Maintaining a horizontal barrier to prevent fire spread.

FUNCTION OF COMPARTMENT FLOORS

- To maintain a load-bearing capacity under fire conditions for the duration defined in Table 2.2 of the *Design Guide*, thus ensuring that the building structure maintains its stability for a reasonable/ acceptable period.
- To maintain a load-bearing capacity for the duration defined in Table 2.2 of the *Design Guide*, thus ensuring that the circulation/escape routes remote from the fire storey remain accessible.
- To provide an imperforate barrier, whose integrity is ensured for the duration defined in Table 2.2 of the *Design Guide*, against vertical fire spread.
- To restrict an increase in temperature on the upper unexposed surfaces of the floor, thereby preventing the spread of fire via conducted heat for the period defined in Table 2.2 of the *Design Guide*.
- To restrict smoke spread between floors, ideally for a period equal to integrity.
- Not to be capable of spreading flaming on its lower surface (i.e. the ceiling of the room underneath).
- Not to contribute unduly to the growth and development of fire within the room underneath.
- To withstand the loading and deflection to be experienced in use and during fire exposure whilst maintaining the requirements above.
- To maintain the integrity of the barrier to fire, whilst accommodating the passage of services and ducts through the compartment floor. To achieve smoke restriction, all penetrations shall be fully sealed.
- To maintain the separating performance over the lifetime of the building, in respect of realistic impact and/or ambient conditions.

EVIDENCE OF FIRE PERFORMANCE

The evidence of performance shall comply with the following:

- **Fire resistance performance (load-bearing capacity).** The ability of the floor assembly (or its constituent components in combination) to maintain its load-bearing capacity and resist undue deflection, deformation and collapse shall be verified by test or engineering assessment evidence of performance in accordance with BS 476: Part 21^{1g}, EN 1365 Part 2^{27b}, under conditions appropriate to the end use of the floor and preferably supported by a Field of Application Report identifying any restrictions in use.

BEFORE READING
THIS DATA SHEET
PLEASE REFER TO
THE
INTRODUCTION

IMPORTANT
THESE DATA SHEETS ARE ONLY INTENDED TO GIVE GENERIC INFORMATION.

DATA ON PROPRIETARY PRODUCTS MUST BE OBTAINED FROM THE MANUFACTURERS

For timber floors suitable performance against this criterion may also be verified by appropriate structural fire engineering design codes in accordance with BS 5268: Part 4: section 4.1^{5a}. Such design must be checked/assessed by a competent person.

- **Fire resistance (integrity).** The ability of the floor assembly (or its constituent components singly or in combination) to maintain a barrier against fire spread, flaming on the unexposed face and/or collapse shall be verified by test evidence or engineering assessment in accordance with BS 476: Part 21^{1g}, EN 1365 Part 2^{27b}, under conditions appropriate to the end use of the floor and preferably supported by a Field of Application Report identifying any restrictions in use.
- **Temperature rise (insulation).** The ability of the floor assembly (or its constituent components singly or in combination) to resist the transfer of conducted heat to the unexposed surface to such an extent that excessive temperatures are reached on the upper surface. This shall be verified by test or engineering assessment evidence in accordance with BS 476: Part 21^{1g}, EN 1365 Part 2^{27b}, under conditions appropriate to the floor's end use and preferably supported by a Field of Application Report identifying any restrictions in use.
- **Smoke resistance.** The floor assembly shall have at least one impermeable face and the method of fixing shall be such that no gaps exist.
- **Surface spread of flame and contribution to fire growth.** The exposed surface of the floor, i.e. the soffit of the ceiling underneath, shall achieve a surface spread of flame classification of Class 1 as defined in BS 476: Part 7^{1d}. The same surface shall also achieve a fire propagation Index of not more than 12 and a sub-index of not more than 6 when tested to BS 476: Part 6^{1c}. Note that the combination of these various performance parameters is described as being Class 0 in the Approved Document B to the Building Regulations 1991 England and Wales²⁹. To comply with the requirements of Part 2.2 of this *Design Guide*, the exposed surface of the floor (i.e. the ceiling under) shall be designated as being non-combustible, BS 476: Part 4^{1b}, or of limited combustibility, as defined by BS 476: Part 11^{1e}. Class 0 surface on a non-combustible substrate is also permissible.
- **Loading and deflection.** The compartment floor shall be so constructed such that the occurrence of a deflection of span/30 during fire conditions shall not cause the opening of gaps or undue cracks which could permit fire spread, nor shall such deflection cause the transfer of loads (direct or thermally induced) from the floor to adjacent non-loadbearing members such as partitions and walls. Compliance with the requirement shall be demonstrated through a combination of an engineering awareness of load paths and fire test or engineering assessment evidence in accordance with BS 476: Part 21^{1g}, EN 1365 Part 2^{27b} together with an associated Field of Application Report.

- **Accommodation and passage of services.** Evidence shall be available to verify that the penetration of the compartment floor by services will not impair the various fire performance parameters described above.
- **Durability.** Evidence shall be available to verify that the materials used in the construction of the compartment floor are not going to be adversely affected by ambient conditions and, if appropriate, abuse (e.g. low energy impacts) during the anticipated life of the floor.

OVERVIEW OF COMPARTMENT FLOORS

A floor is an assembly which consists of a combination of one or more of the following components (see also Figure 1):

1. Lower surface (ceiling)
2. Structural supports
3. In-fill materials
4. Upper surface (flooring)

The potential contribution of each component of the floor to the overall fire performance of the construction needs to be evaluated. It is important to remember that evaluation of performance is based upon fire exposure from beneath the floor and thus the exposure conditions may be summarised as follows:

Lower surface (ceiling) - always directly exposed to fire*

Structural assembly - may be directly exposed to fire

In-fill materials - generally not exposed directly to fire

Upper surface (flooring) - generally not directly exposed to fire

FLOOR COMPONENTS

1. LOWER SURFACE (CEILING SURFACE)

- 1.1 Gypsum based boards and skim
- 1.2 Lath and plaster
- 1.3 Concrete
- 1.4 Permanent steel formwork
- 1.5 Permanent woodwool shuttering
- 1.6 Proprietary suspended ceilings
- 1.7 Timber ceilings
- 1.8 Proprietary boards

1.1 GYPSUM BASED BOARDS AND SKIM

The fire performance of gypsum boards is a function of board thickness and fixing details. The thickness of board necessary will depend upon the tolerance of the structure being protected. Gypsum boards incorporating reinforcement are normally able to provide a similar level of protection at a reduced thickness

** Care must be taken to ensure that the protective contribution made by this membrane is not negated by fitting such as recessed lighting fittings that are not protected themselves. If such items are installed then the structural assembly will be unduly exposed to the fire conditions. Only tested light fittings should be permitted to be used.*

which may be important when weight is a consideration. Boards should be fixed directly to the structural members through a fillet if the temperature of the structural member is critical. The following fixings for structural boards are recommended:

Thickness of board	Nail length	Spacing
9.5mm	30mm	150mm centres
12-15mm	40mm	150mm centres
19-25mm	60mm	150mm centres

Different fixing techniques may be used, provided that the boards are held with an equivalent degree of fixity to that upon which the evidence of performance is based. Gypsum boards incorporating reinforcement are typically able to provide a significant level of protection at a reduced thickness which may be important when self weight is a consideration.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Low propensity to cracking, but not totally immune; normally considered good. Reinforced gypsum boards have a higher integrity potential than standard grade board, particularly when used horizontally. (☆☆☆☆)
- **Temperature rise (insulation).** Gypsum boards have excellent resistance to temperature rise until all of the water of vaporisation is driven off. (☆☆☆☆)
- **Surface spread of flame.** Class 0 and limited combustibility. (☆☆☆☆)
- **Smoke resistance.** If undamaged, boards may be considered impermeable. Joints need to be filled and taped according to manufacturer's proven methods to maintain this characteristic. (☆☆☆☆)
- **Loading and deflection.** Only capable of withstanding limited deflection and design details need to be given to meet this requirement. Reinforced board is more able to tolerate deflection. (☆☆)
- **Ability to accommodate services.** Normally rigid enough to accept sealants around single services, but support would be needed to restrain closing devices and sealing systems. (☆☆☆)
- **Durability.** Not suitable for use in wet conditions, but generally may be considered durable with resistance to reasonable impacts. (☆☆☆)

1.2 LATH AND PLASTER

Existing ceilings of 15-22mm plaster on wood lath may possibly contribute up to 20 minutes to the fire resistance of a timber floor under BS 476 temperature and pressure conditions. Greater thicknesses of plaster may not be beneficial in increasing protection levels, temperature and pressure as the increased self-weight may promote failure. However, condition and key is critically important and a visual inspection and engineering assessment by a competent person is required, before any fire performance may be assumed. *In the absence of the above, the default assumption should be that lath and plaster is ineffective in fire terms.*

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** High propensity to cracking when aged; must be inspected and evaluated on a case by case basis. (☆☆)
- **Temperature rise (insulation).** Lath and plaster ceilings have good resistance to temperature rise until all the water is driven off. (☆☆☆☆)
- **Surface spread of flame.** Class 0 and limited combustibility. (☆☆☆☆)
- **Smoke resistance.** If undamaged, lath and plaster ceilings may be considered impermeable. (☆☆☆☆)
- **Loading and deflection.** Capable of withstanding reasonable deflections. (☆☆☆☆)
- **Ability to accommodate services.** Normally difficult to penetrate and prepare controlled opening for the acceptance of sealants around single services. Support would be needed to restrain closing devices and sealing systems. (☆☆)
- **Durability.** Not suitable for use in wet conditions, but generally may be considered durable to reasonable impacts. (☆☆)

1.3 CONCRETE

The underside of a compartment floor might simply consist of a concrete soffit. Such a ceiling soffit may be smooth or profiled. Concrete ceilings are an integral part of the concrete floor structure and the fire resisting properties should be evaluated accordingly.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Little propensity to cracking. (☆☆☆☆)
- **Temperature rise (insulation).** Good resistance to temperature rise. (☆☆☆☆)
- **Surface spread of flame.** Class 0 and non-combustibility. (☆☆☆☆)
- **Smoke resistance.** Completely impermeable. (☆☆☆☆)
- **Loading and deflection.** Generally structurally capable of withstanding deflection. (☆☆☆☆)
- **Ability to accommodate services.** Rigid enough to accept sealants around services, without needing support to restrain closing devices and sealing systems. (☆☆☆☆)
- **Durability.** Highly durable. (☆☆☆☆)

1.4 PERMANENT STEEL FORMWORK

Seldom exposed as a ceiling surface, except occasionally in industrial or plant areas. Widely associated with a cast in-situ concrete flooring system, with related fire performance properties.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** No propensity to cracking. (☆☆☆☆)
- **Temperature rise (insulation).** In isolation poor resistance to temperature rise, but concrete substrate acts as an effective heat sink. (☆☆☆☆)

- **Surface spread of flame.** Class 0 and non-combustible. (☆☆☆☆☆)
- **Smoke resistance.** Completely impermeable. (☆☆☆☆☆)
- **Loading and deflection.** Generally structurally capable of withstanding deflection. (☆☆☆☆☆)
- **Ability to accommodate services.** Rigid enough to accept sealants around services, without needing support to restrain closing devices and sealing systems. (☆☆☆☆☆)
- **Durability.** Durable. (☆☆☆☆☆)

1.5 PERMANENT WOODWOOL SHUTTERING

Typically encountered only in existing buildings and a hangover from a construction technique used several decades ago. A concrete floor was cast in-situ onto woodwool formwork, which was left in place and coated with a skin of plaster. Difficulties associated with the construction technique give rise to problems of poor compaction and air pockets within the floor structure. This directly reduces the reliability of such floors under fire conditions. Special care is needed, if such a flooring system is to be retained as a compartment floor. A full inspection by a competent person should be sought.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** High propensity to cracking when aged; must be inspected and evaluated on a case by case basis. (☆)
- **Temperature rise (insulation).** Reasonable resistance to temperature. (☆☆☆)
- **Surface spread of flame.** Class 0 and limited combustibility, by virtue of the plaster skim. (☆☆☆☆☆)
- **Smoke resistance.** If undamaged, ceiling may be considered impermeable. (☆☆☆☆☆)
- **Loading and deflection.** Capable of withstanding reasonable deflections. (☆☆☆☆☆)
- **Ability to accommodate services.** Normally difficult to penetrate and prepare controlled opening for the acceptance of sealants around single services. Support would be needed to restrain closing devices and sealing systems. (☆☆)
- **Durability.** Not suitable for use in wet conditions, but generally may be considered durable to reasonable impacts. (☆☆☆)

1.6 PROPRIETARY SUSPENDED CEILINGS

A large number of proprietary ceiling systems may be used to contribute to the fire performance of the floor assembly. Care must be taken to ensure that such systems are assembled strictly in accordance with a strict specification, whose fire performance has been verified by test or assessment by a competent person. *Often, light fittings etc. are installed that can eliminate the contribution to fire resistance that a suspended ceiling can make.* Many proprietary ceiling systems have been verified for their contribution to the fire resistance rating achieved by a steel beam which is protected by the ceiling. Should such a ceiling system

be used in conjunction with a timber beam assembly, then its expected contribution to fire performance may be significantly less than that indicated by the results of the steel beam test. The scope of the Field of Application Report accompanying the Fire Test Report needs to be studied carefully to ensure compatibility with associated construction. Regardless of whether a proprietary suspended ceiling system is expected to perform a fire resisting function, all suspended ceilings should be examined for their propensity to collapse under fire conditions and the effect of such a collapse on the fire safety strategy. All cavities created between the suspended ceiling and the structural floor assembly need to be controlled in extent and sub-divided by cavity barriers (see Data sheet 6.3.3) where necessary.

FIRE PERFORMANCE DATA

As the fire performance of suspended ceilings is product specific, no general summary can be provided here.

1.7 TIMBER CEILINGS

Although unusual, such timber ceilings are used for compartment floors, e.g. when a timber compartment floor has exposed joists and is not underdrawn by a ceiling. Timber ceiling systems are restricted by their propensity for surface spread of flame and fire propagation. However, various treatments are available to enhance performance in this regard. Where the fire performance of a timber ceiling depends on such treatments, consideration should be given to their durability within the given environment and their compatibility with the substrate in question. Each timber species behaves differently.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** High propensity to shrinkage, cracking and charring when exposed to fire. The integrity of a timber ceiling depends on its thickness. (☆☆)
- **Temperature rise (insulation).** Timber is naturally insulating until it is fissured just prior to burn through. (☆)
- **Surface spread of flame.** Class 3 and combustible, unless treated chemically or physically coated. Verification of performance of the treated timbers shall be confirmed through testing, together with due consideration of long term durability of said treatments. (☆)
- **Smoke resistance.** If undamaged and well jointed, ceiling is relatively impermeable. (☆☆☆)
- **Loading and deflection.** Capable of withstanding reasonable deflections. (☆☆☆☆)
- **Ability to accommodate services.** Readily accommodates services, but support would be needed to restrain closing devices and sealing systems as the timber around the services becomes eroded. (☆☆)
- **Durability.** Not suitable for use in wet conditions, but generally may be considered durable and resistant to reasonable impacts. (☆☆☆☆)

1.8 PROPRIETARY BOARDS

A range of proprietary boards, including calcium silicate and cement based boards, may be used successfully in compartment floors to improve the fire

performance. The verification of such systems is important. Workmanship and fixing are critical factors and the Fire Test, engineering assessment or Field of Application Report need to be studied in this regard.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Generally good, especially for low density boards with a low propensity to cracking when heated. (☆☆☆☆☆)
- **Temperature rise (insulation).** Fair resistance to temperature increase, many board systems require an additional insulation contribution from the floor assembly. (☆☆☆)
- **Surface spread of flame.** Typically Class 0 and limited combustibility. (☆☆☆☆☆)
- **Smoke resistance.** If undamaged, proprietary board ceilings are relatively impermeable. Joints and edges may require special treatment as advised and proven by manufacturers. (☆☆☆☆☆)
- **Loading and deflection.** Only limited capacity to withstand deflection and design details will need to be given by a competent person to meet this requirement. (☆☆☆☆)
- **Ability to accommodate services.** Normally rigid enough to accept sealants around single services, but support will be needed to retain closing devices and sealing systems. (☆☆☆)
- **Durability.** Not suitable for use in wet conditions, but generally may be considered durable to reasonable impacts. (☆☆☆)

2. STRUCTURAL SUPPORTS

The principal contribution of the structural assembly to the fire performance of the compartment floor is in its provision of a load-bearing framework, upon which the upper and lower surfaces are fixed. The fire resistance of the structural assembly is determined through either testing or engineering assessment to BS 476: Part 21^{1g}, EN 1365 Part 2^{27b}, or appropriate structural fire engineering design by a competent person in accordance with the appropriate British Standard Code of Practice.

2.1 Timber assemblies

2.2 Steel assemblies

2.3 Concrete assemblies

2.1 TIMBER ASSEMBLIES

The fire performance of timber structural members within a flooring system is a function of three variables:

Timber grade

Timber density

Cross-sectional size of the timber member.

Timber floor joists should be of sufficient size to enable them to retain their structural stability during the fire period. Allowance shall be made for the reduction in cross-sectional area of the members which will result from

pyrolysis and charring of the members. Unless information to the contrary is available timber members should be assumed to be softwood and taken to char at a rate on all exposed surfaces of 0.66mm per minute of exposure to fire conditions. Hardwood timber members, i.e. higher density timbers generally those with a density $> 650\text{kg/m}^3$, can be taken to char at a lesser rate of 0.5mm per minute. On narrow sections the char rate is enhanced by the rounding of the exposed corners (arises) and the permitted increase in stress is reduced. Fire performance shall be demonstrated through appropriate structural design calculations to BS 5268: Part 4, Section 4.1^{5a} where these factors are taken into account, or through satisfaction of the load-bearing criteria during test to BS 476: Part 21^{1g}, prEN 1365 Part 2^{27b} in a floor with a similar level of protection, for the duration specified in Tables 2.1/2.2 of this *Design Guide*.

FIRE PERFORMANCE DATA

- **Fire resistance performance (load-bearing capacity).** Although timber is combustible, it burns at a relatively slow and determinate rate. It is possible to ascertain the load-bearing capacity of the charring section after a period of exposure to fire. High strength class materials generally lose loadbearing capacity faster than low grade timbers. Detailed calculations are described in BS 5268: Part 4, Section 4.1^{5a}. Alternatively, assemblies whose fire resisting load-bearing capacity has been verified through testing or engineered assessment to BS 476: Part 21^{1g}, EN 1365 Part 2^{27b} may be used. In practice, timber members need to be at least 38 mm thick to achieve a loadbearing fire resistance rating of 30 minutes. Timber sections generally become uneconomical for durations in excess of 90 minutes unless fully protected. (☆☆☆☆)
- **Surface spread of flame.** If the timber assembly is exposed on the underside, there is a need to control its propensity to surface flaming and fire propagation. Timber members achieve only a Class 3 surface spread of flame rating and are combustible, unless treated chemically or physically. Verification of performance of the treated timbers shall be confirmed through testing, together with due consideration of long term durability of said treatments. Some treatments can cause the char rate to increase. (☆)
- **Contribution to fire load.** Whilst being combustible the quantity of timber in a timber structural floor is usually low relative to the contents of the compartment formed and when protected by linings this cannot be released until after the lining has failed. (☆☆☆)

2.2 STEEL ASSEMBLIES

Steel loses its strength and stiffness at elevated temperatures. The fire resistance of steel structures is a function of the temperature reached within the steel and the load being carried. The applied loading, span, section size and support details are important influences on behaviour under fire conditions. Given the above information, it is possible to ascertain the load-bearing capacity of the heated steel assembly after a period of exposure to fire. Detailed calculations are described in BS 5950: Part 8⁹. Alternatively, assemblies whose fire resisting load-bearing capacity has been verified through testing or engineering assessment to BS 476: Part 21^{1g}, EN 1365 Part 2^{27b} may be used.

FIRE PERFORMANCE DATA

- **Fire resistance performance (load-bearing capacity).** Steel members lose strength as the temperature increases, but retain more than 50% of their tensile strength at temperatures up to 550°C. (☆☆☆☆)
- **Surface spread of flame.** Class 0 surface spread of flame and non combustible. (☆☆☆☆)
- **Contribution to fire load.** Steel makes no contribution to the fire load. (☆☆☆☆)

2.3 CONCRETE ASSEMBLIES

Concrete loses its strength and stiffness at elevated temperatures. Concrete, however is a poor conductor of heat and this delays its temperature increase on exposure to fire conditions. The main influence on the fire resistance of a concrete floor system is the temperature reached within the reinforcing steelwork. This is controlled by the depth of concrete cover protecting the reinforcement. Other factors such as the degree of imposed load, span and support conditions do exert an influence and minimum cover specifications are related to these concrete floor details. One would normally expect concrete members with minimum cover depths of 25mm to achieve 30 minutes fire resistance and cover depths of 50mm to achieve 60 minutes fire resistance. Should concrete assemblies be used as a compartment floor above a space with a high combustibility fire load, e.g. hydrocarbon fuel stores, then in addition to fire resistance, the potential for destructive spalling of the floor needs to be considered. A specific fire test and/or expert advice may be necessary to quantify the hazard and identify protection measures. Guidance on the fire resistance of concrete floor slabs and floor assemblies is given in BS 8110:Part 2¹³.

FIRE PERFORMANCE DATA

Concrete assemblies form both the structural and separating function and therefore concrete assemblies are adjudged against all relevant criteria below.

- **Load-bearing.** Concrete members are capable of achieving substantial periods of fire resistance if correctly designed and detailed. (☆☆☆☆)
- **Surface spread of flame.** Class 0 and limited combustibility. (☆☆☆☆)
- **Contribution to fire load.** None. (☆☆☆☆)

3 IN-FILL MATERIALS

The fire performance of compartment floor systems may be upgraded and improved by incorporating insulating materials within the body of the floor structure. These materials reduce the flow of heat through the compartment floor and protect particular components within the floor assembly. For example, incorporation of an insulating layer within a floor assembly reduces the heat flow to the upper flow surface, thereby reducing the damage to the floor surface and increasing the level of protection to the unexposed surface.

The fitting of insulating infill offers a useful means of increasing the fire resistance of a compartment floor in a manner which does not intrude on the visual appearance of the floor. It is also a useful upgrading technique.

None of the in-fill materials contribute significantly to the fire load.

In order to be effective, infill materials must be distributed throughout the entire floor assembly, making suitable contact with the structural members to be protected. Particular care should be taken at cornices. Infilling materials may also increase sound insulation.

- 3.1 Inert granular dry pugging
- 3.2 Mineral wool
- 3.3 Concrete/ gypsum plaster

3.1 INERT GRANULAR DRY PUGGING

Infill materials, e.g. crushed shells, will reduce the heat flow through the floor assembly and increase its fire resisting properties with respect to insulation. Granular infill, however relies on the lower surface of the floor or an intermediate lining, e.g. a pugging board, for support and once the lower surface (ceiling) fails under fire conditions, the contribution of a loose infill becomes ineffective.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Poor integrity in its own right, relies on support from the ceiling membrane. (☆)
- **Temperature rise (insulation).** Good resistance to temperature rise. (☆☆☆☆☆)
- **Surface spread of flame.** Class 0 and limited combustibility. (☆☆☆☆☆)
- **Smoke resistance.** Permeable. (☆)
- **Loading and deflection.** Completely flexible. (☆☆☆☆☆)
- **Ability to accommodate services.** Cannot accept sealants around services, which would need to be sealed at the upper or lower floor surfaces. (☆)
- **Durability.** Durable. (☆☆☆☆☆)

3.2 MINERAL WOOL

Mineral fibre insulation is suitable for provision of increased insulation within a compartment floor. Mineral fibre insulation is semi-rigid and may support its own weight. If mineral fibre in-fill is suitably fixed to the structural floor assembly, it may be considered to make a continuing contribution to the fire performance of the compartment floor, after the lowermost surface has failed and dropped away. Mineral fibre in-fill may be independently fixed with nails to the structural assembly or alternatively supported on expanded metal lath, which is itself supported by the structure, either by nails (min. 20mm long) or by suitable laying over a number of structural members. A range of proprietary in-fill materials are available and dependant on density and thickness, can make a valuable contribution to fire resistance.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Good resistance to cracking. (☆☆☆☆☆)
- **Temperature rise (insulation).** Good resistance to temperature rise. (☆☆☆☆☆)

- **Surface spread of flame.** Class 0 and limited combustibility. (☆☆☆☆☆)
- **Smoke resistance.** Fairly impermeable. (☆☆)
- **Loading and deflection.** Flexible. (☆☆☆☆☆)
- **Ability to accommodate services.** Slab is typically rigid enough to accept sealants around services, but insufficiently stiff to restrain closing devices and sealing systems. (☆☆☆)
- **Durability.** Durable. (☆☆☆☆☆)

3.3 CONCRETE/GYPSUM PLASTER

The infilling of a floor system with lightweight concrete/gypsum plaster can significantly increase the fire resistance rating of the floor. Such infilling would typically only be needed for applications where 60 minutes fire resistance were required. The concrete/gypsum plaster infill is trowelled between the structural members onto an expanded metal lathing which is directly supported by the structure (using min. 20mm nails).

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Little propensity to cracking. (☆☆☆☆☆)
- **Temperature rise (insulation).** Good resistance to temperature rise. (☆☆☆☆☆)
- **Surface spread of flame.** Class 0 and limited combustibility. (☆☆☆☆☆)
- **Smoke resistance.** Completely impermeable. (☆☆☆☆☆)
- **Loading and deflection.** Withstands limited deflection. (☆☆☆)
- **Ability to accommodate services.** Rigid enough to accept sealants around services, but would need support to restrain closing devices and sealing systems. (☆☆☆☆)
- **Durability.** Durable. (☆☆☆☆☆)

4 UPPER SURFACE (FLOORING)

The upper surface of the compartment floor is typically the defining plane above which one is seeking to protect. The upper surface will obviously rely on the floor's structural assembly to remain in position and perform its function. Any anticipated fire performance by the upper surface is by definition limited by the performance of the structural floor assembly itself. The surface spread of flame characteristics of floors are not controlled in the *Design Guide* or regulations. Floor linings rarely make a significant contribution to fire load.

- 4.1 Timber floors (tongued and grooved boarding)
- 4.2 Timber floors (plain edged boarding)
- 4.3 Timber floors (sheeting)
- 4.4 Proprietary raised panelled floors

4.1 TIMBER FLOORS (TONGUED AND GROOVED BOARDING)

Well fitting tongued and grooved floor boarding, typically 21mm thickness, can provide useful protection against the transfer of heat and smoke under fire conditions.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Propensity to shrinkage, cracking and charring when exposed to fire. The integrity of a timber floor depends on its effective thickness which is normally taken to be to the upper most face of the tongue. (☆☆☆)
- **Temperature rise (insulation).** Solid timber has an excellent resistance to temperature increase compromised by the gaps that develop after the tongues are burnt through. (☆☆☆)
- **Smoke resistance.** Tongued and grooved floors are relatively impermeable to cold smoke leakage whilst tightly jointed. (☆☆☆)
- **Loading and deflection.** Capable of withstanding reasonable deflections. (☆☆☆☆)
- **Ability to accommodate services.** Readily accommodates services. (☆☆☆☆)
- **Durability.** Durable and resistant to reasonable impacts. (☆☆☆☆☆)

4.2 TIMBER FLOORS (PLAIN EDGED BOARDING)

Square edged boarding is less able to restrict the transfer of smoke and hot gases. It can be upgraded through overlaying with not less than 3.2mm standard hardboard (Type S to BS 1142:Part 2) or 4mm plywood, nailed at 150mm centres, or other suitable membrane. The comments below relate to the non-upgraded construction.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Propensity to shrinkage, cracking and charring when exposed to fire. The integrity of a timber floor depends on the thickness of the boards and the tightness of the board joints. (☆☆)
- **Temperature rise (insulation).** The excellent resistance to temperature increase is badly compromised by the gaps. (☆)
- **Smoke resistance.** Needs to be overdrawn if floor is to be impermeable. (☆)
- **Loading and deflection.** Capable of withstanding reasonable deflections. (☆☆☆☆)
- **Ability to accommodate services.** Readily accommodates services. (☆☆☆☆)
- **Durability.** Durable and resistant to reasonable impacts. (☆☆☆☆☆)

4.3 TIMBER FLOORS (SHEETING)

In order to carry the design loads across the common joist spans timber based sheet materials are normally at least 15mm thick. Joints need to be protected and sealed independently or by alignment with the floor's structural assembly.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Propensity to shrinkage, cracking and charring when exposed to fire. The integrity of timber flooring depends on its thickness and the number of joints and how they are

constructed. Most sheet materials will be tongued into each other giving a predictable integrity resistance until the tongue burns through. Backed up joints will not compromise the integrity rating. (☆☆☆☆)

- **Temperature rise (insulation).** Excellent resistance to temperature increase which is less compromised by the joints than with board materials. (☆☆☆)
- **Smoke resistance.** If joints are protected floor is impermeable to cold smoke. (☆☆☆☆☆)
- **Loading and deflection.** Capable of withstanding reasonable deflections. (☆☆☆☆☆)
- **Ability to accommodate services.** Readily accommodates services. (☆☆☆☆)
- **Durability.** Durable and resistant to reasonable impacts. (☆☆☆☆☆)

4.4 PROPRIETARY RAISED PANELLED FLOORS

Proprietary raised panelled floors need to be evaluated on an individual basis. Particular attention needs to be given to the cavity created between the floor and the structural floor below. Cavity barriers may be required to limit the potential spread of fire. Consideration may also need to be given to the structural stability of the raised floor given a fire within the cavity. Any calculation that they make to fire separation is not taken into account in the evaluation of a compartment floor.

FIRE PERFORMANCE DATA

Proprietary systems to be evaluated on an individual basis.

INSTALLATION

The installation of compartment floors should be executed and completed by a suitably qualified person to the required standard appropriate to the system used. It is advisable that where fire performance is required then an inspection by an independent body may be carried out on the completed work.

SOURCES FOR FURTHER INFORMATION

Association of Specialist Fire Protection, Association House, 253 Ash Road, Aldershot, Hampshire GU12 4DD.

EURISOL (UK Mineral Wool Association), 39 High Street, Redbourn, Herts AL3 7LW.

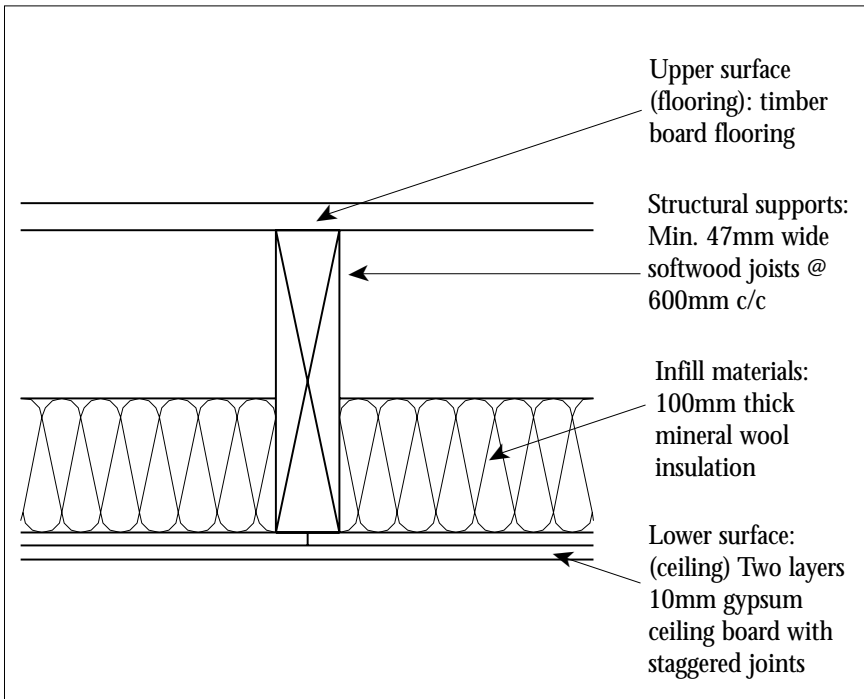


Figure 1. Typical 60 minute timber compartment floor with gypsum based board ceiling.

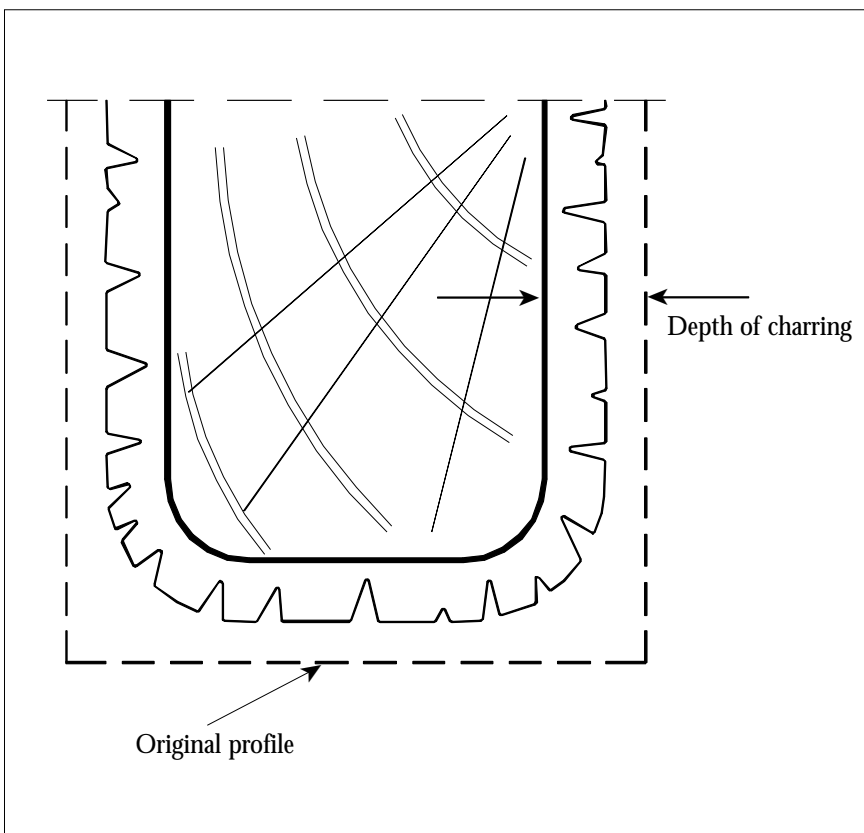


Figure 2. Rounding of arises by charring.

SUMMARY OF PERFORMANCE DATA

	Fire resistance (integrity)	Temperature rise (insulation)	Surface spread of flame	Smoke resistance	Loading and deflection	Ability to accommodate services	Durability	Fire resistance performance (loadbearing capacity)	Contribution to fire load
1. Lower surface (ceiling)									
1.1 Gypsum based boards and skim	☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆	☆☆	☆☆☆	☆☆☆	N/A	N/A
1.2 Lath and plaster	☆☆	☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆☆☆	☆☆	☆☆☆	N/A	N/A
1.3 Concrete	☆☆☆☆☆☆	☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆☆☆	N/A	N/A
1.4 Permanent steel formwork	☆☆☆☆☆☆	☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆☆☆	N/A	N/A
1.5 Wood wool shuttering	☆☆	☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆☆☆	☆☆	☆☆☆	N/A	N/A
1.6 Proprietary suspended ceilings	Proprietary systems to be evaluated on an individual basis.								
1.7 Timber ceilings	☆☆	☆☆	☆☆	☆☆☆☆	☆☆☆☆☆☆	☆☆	☆☆☆☆	N/A	N/A
1.8 Proprietary boards	☆☆☆☆☆☆	☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆	☆☆☆	N/A	N/A
2. Floor components. Structural supports									
2.1 Timber assemblies	N/A	N/A	☆☆	N/A	N/A	N/A	N/A	☆☆☆☆	☆☆☆
2.2 Steel assemblies	N/A	N/A	☆☆☆☆☆☆	N/A	N/A	N/A	N/A	☆☆☆☆	☆☆☆☆☆☆
2.3 Concrete assemblies	N/A	N/A	☆☆☆☆☆☆	N/A	N/A	N/A	N/A	☆☆☆☆☆☆	☆☆☆☆☆☆
3. Floor components in-fill materials									
3.1 Inert granular dry pugging	☆☆	☆☆☆☆☆☆	☆☆☆☆☆☆	☆☆	☆☆☆☆☆☆	☆☆	☆☆☆☆☆☆	N/A	N/A
3.2 Mineral wool	☆☆☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆☆☆	☆☆	☆☆☆☆☆☆	☆☆☆☆	☆☆☆☆☆☆	N/A	N/A
3.3 Concrete/gypsum plaster	☆☆☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆	☆☆☆☆	☆☆☆☆☆☆	N/A	N/A
4 Floor components upper surface (flooring)									
4.1 Timber floors (tongue and grooved boarding)	☆☆☆☆	☆☆☆☆	N/A	☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆	☆☆☆☆☆☆	N/A	N/A
4.2 Plain edged boarding	☆☆	☆☆	N/A	☆☆	☆☆☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆☆☆	N/A	N/A
4.3 Timber floors (sheeting)	☆☆☆☆	☆☆☆☆	N/A	☆☆☆☆☆☆	☆☆☆☆☆☆	☆☆☆☆	☆☆☆☆☆☆	N/A	N/A
4.4 Propriety raised panel floor	Proprietary systems to be evaluated on an individual basis.								

Note: Although there is no requirement for controlling floor linings it would be expected that timber based materials would reflect their normal characteristics with respect to the surface spread of flame.

Sheet No: 6.6.1

6.6 Fire doors

Fire resisting hinged and pivoted fire doors

Hinged and pivoted doors, provided primarily for the purpose of allowing access and egress by persons, come in four main types:

- Timber doorsets (ratings up to 90 minutes)
- Timber and mineral board composite doorsets
- Steel and glass architectural doorsets (commercial applications only)
- Steel flush doorsets

These are all covered in this data sheet.

Main application in respect to this *Design Guide*:

- Maintaining the fire separation of compartment walls and separating walls, including large cavity barriers when a door assembly is incorporated for the passage of persons or objects.
- Maintaining the fire separation in shafts or service ducts which penetrate compartment floors.
- Maintain the protection provided by walls forming a protected route or protected stairway for means of escape purposes.

FUNCTION OF FIRE RESISTING DOORS

- To maintain the integrity of the wall into which the door is installed for the duration defined in Tables 2.1/2.2 of the *Design Guide*. Doors installed between the accommodation and the protected escape route only require a 30 minute integrity.
- To restrict the rise in temperature on the unexposed face to those levels required to prevent fire spread for the duration defined in Tables 2.1/2.2 of the *Design Guide*, whether as the result of restricting temperature rise on the unexposed face or by controlling the heat flux.
- To restrict the passage of smoke for the same duration as integrity.
- Not to produce an undue contribution to the fire growth relative to the risk associated with the environment into which the door is installed.
- To be strong enough to be rated as suitable for severe duty applications when installed in industrial situation or other duty as dictated by their position.
- To maintain the separating performance over the life time of the building, or for a shorter duration if allowed for in the fire safety management plan, in respect of realistic impact and/or ambient conditions.

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INTRODUCTION

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DATA ON
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EVIDENCE OF PERFORMANCE

Doorsets in compartment walls should always be fitted with a latch. Where the door is to be easy to use it is preferred that it is fitted with a latch but is held open by electro-magnetic hold-open devices linked to the fire detection system.

Hinged and pivoted fire resisting doorsets that comply with LPS 1056²⁰ plus, where appropriate, evidence of smoke resistance to BS476: Part 31.3^{1j}, can be used without restriction subject to being installed in compliance with the conditions specified in the approval.

Alternatively the evidence of performance shall comply with all of the following:

- **Fire resistance performance.** The ability of the door assembly to provide integrity and keep the unexposed face temperature below hazardous levels shall be supported by evidence generated in respect of the test methodology given in BS476: Part 20^{1f}, EN 1364-1²⁶. Tested fire doors shall be supported by a Field of Application Report identifying the maximum sizes, modes of operation and configuration at which they may be used whilst maintaining the fire resistance rating required and identifying any restrictions in use, particularly with respect to the associated construction into which they may be installed.
- **Smoke resistance.** The door assembly shall have been tested to the methodology of BS476: Part 31.1^{1j} and have demonstrated a leakage rate of not more than 3m³/m²/hr.
- **Contribution to fire growth.** The rate of heat release of any door leaf or door core shall not exceed, in any 10 minute period, the rate of heat release produced by the equivalent of a 50mm thick solid softwood leaf, as may be released by some polymeric materials.
- **Strength and impact resistance.** Personnel doorsets for use in industrial applications shall be rated as severe duty with respect to the British Standard DD171¹⁷ or as heavy duty for other applications, or withstand the impact requirements in LPS1056²⁰ for all other door types.
- **Durability.** Evidence shall be available to show that the materials used in the construction of the fire door assemblies including any seals, are not going to be adversely affected by the ambient conditions and, if appropriate, damage during the anticipated life of the doorset. Intumescent seals that have been part of the IFSA ageing programme are considered to satisfy the durability requirement.

The basic types of door construction addressed in this data sheet are as follows;

1. Timber door assemblies
2. Timber and mineral board composites
3. Steel and glass architectural doorsets
4. Steel flush doorsets

1. TIMBER DOOR ASSEMBLIES

There is a wide range of different timber door constructions, but all have the common characteristic that the leaf has solid timber edges to the leaf. Within

the leaf may be a variety of core materials ranging from particle boards (flaxboard/chipboard) to strips of solid timber (lamins or lamels). Facings may consist of chipboard (up to 5mm), plywood (up to 10mm) or fibre boards (hardboard or MDF). In all cases an intumescent seal shall be fitted between the leaf edge and the frame, and the type, size and quantity of such seals is often an important factor in the performance.

Frames may be of softwood, hardwood or steel (hollow or filled with concrete) although as steel expands and bows in the opposite direction to timber it is important to establish that evidence of performance exists to substantiate the performance of the door in question when hung in a metal frame. Concrete back-filled frames are more compatible with timber leaves than hollow frames. Softwood frames are normally restricted to 30 minute performance, as are some low density hardwoods.

The performance of timber door assemblies is extremely interrelated to the type and nature of the hinges, latches, closers and other items of hardware and the method of fixing is equally important. Only hardware that has been approved for use with the leaf in question shall be used. Timber doors may or may not incorporate a glazed vision panel which may be glazed with non-insulating or insulating glass.

The performance of timber door assemblies is a complex issue, the final performance being a product of a number of seemingly unrelated design features such as lipping details, adhesives, vision panels, hardware, intumescent seals, etc. Guidance is given in BS 8214¹⁵, 'Code of practice for fire door assemblies with non-metallic leaves', and this is recommended to anybody involved in the specification or approval of timber fire resisting door assemblies. Other useful publications are given in the reference section in this data sheet.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** When the assembly is used with the correct/specified intumescent seals the integrity is excellent, albeit timber doorsets normally only provide 60 minutes integrity at conventional thicknesses but can provide 90 minutes with thicker leaves and high density frames. (☆☆☆☆)
- **Temperature rise (insulation).** Timber has naturally good insulation properties and the unexposed face will remain cool right up until the time when integrity losses develop. Metal frames normally compromise the natural insulation characteristics as may some items of door hardware. (☆☆☆☆)
- **Smoke resistance.** Timber door leaves and frames are impermeable and provide an excellent barrier to smoke spread. Without special smoke seals the gap between the leaf and the frame will leak unacceptable levels of smoke. Modern smoke seals are capable of achieving the regulatory recommended leakage rate of 3m³/m (of perimeter)/hr when evaluated for cold smoke leakage in accordance with BS 476: Part 31.1^{1j} when correctly fitted, although hardware must only be allowed to interrupt the smoke seal for short distances, (≤ 150 mm). Intumescent seals make an excellent contribution to resisting the leakage of hot smoke. Timber doors smoke a little on the unexposed face when integrity failure is near. (☆☆☆☆)

- **Contribution to fire growth.** Wood, or wood based materials do burn and therefore contribute to the fire growth. The burning is, however, steady and predictable and wood is generally taken as the 'norm' against which other combustible materials are compared. Compared with the contents of a room the contribution from a timber door would appear to be modest albeit in a small room it could be more significant. (☆☆☆)
- **Strength and impact resistance.** Timber doors are never going to be as strong as metal doors, but when fitted with heavy duty hinges, by means of the correct screws, into solid timber (rather than particle board) they are capable of being rated as severe duty. Timber doors are vulnerable to small body impacts, albeit some facing materials, e.g. plywood, are more robust than others. The use of applied metal facings to improve their performance needs to be considered carefully as they can induce deflection and conductive paths and the use of such facings should always be the subject of a test or an extended field of application report. (☆☆☆)
- **Durability.** Intumescent seals that have been the subject of long term ageing trials, such as the IFSA ageing programme, and have also been part of the LPC/BBA evaluation may be considered as durable, but all other seal types may need to provide separate evidence of performance. The IFSA Information Sheet No. 4³⁷ should be consulted. (☆☆☆☆)

2. TIMBER AND MINERAL BOARD COMPOSITES

These door types will often be hard to distinguish from 'timber' doors as all exposed surfaces are normally timber faced. These timber edgings or facings are, however, normally specially chosen and they should not be changed, or over decorated without considering the consequences. Generally the performance will be similar to timber doors except where identified below.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** The reason that mineral boards are incorporated in this type of door is to improve its burn-through resistance and hence increase its integrity rating. Such doors, depending on the specification, will satisfy integrity for up to 120 minutes (or greater). (☆☆☆☆)
- **Temperature rise (insulation).** The mineral board components do not generally exhibit the same high levels of insulation as timber doors albeit they provide some level of insulation for longer. (☆☆☆)
- **Smoke resistance.** These door assemblies are just as impermeable as timber doors and the performance of the set is very dependent upon the behaviour of the edge seals. These are identical to those used in timber doorsets and are therefore capable of similar high levels of smoke reduction. Unlike timber doors these mineral cored assemblies will not issue much smoke, even when close to integrity failure. (☆☆☆☆☆)
- **Contribution to fire growth.** Mineral boards are either non-combustible or of limited combustibility and therefore make no significant contribution to fire growth. (☆☆☆☆☆)

- **Strength and impact resistance.** The basic material will be weaker in bending but be marginally more resistant to impact than timber due to its density and construction. The material is more vulnerable to screw fixing failures and fixings shall comply with the manufacturer's recommendation if the performance is to be maximised. (☆☆☆☆)
- **Durability.** The material has similar behaviour to wood and would be expected to perform in a similar manner in respect of long term performance. (☆☆☆☆)

3. STEEL AND GLASS ARCHITECTURAL DOORSETS

These doors would only normally be used in commercial buildings and are not recommended for use in industrial applications. The door leaves consist of steel tubular framed structures which are infilled with glass panels. The glass can be insulating or non-insulating and the frame can be non-insulating or have some insulating properties. It is recommended that such doors are limited to 90 minute applications.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Steel doors are prone to distortion and whilst the glass is reasonably inert it cannot provide any significant restraint to resist the tendency to distort. It is important that the leaf is as symmetrical as possible, is provided with as much restraint from door hardware (e.g. multi-point latching and closing devices) as is compatible with its use and that the edge gaps are those that are needed to ensure that the leaf expands and locks into the frame. Pressure forming intumescent materials may help to provide some restraint. If the distortion is constrained then there should not be a gross loss of integrity.

Uninsulating doors when tested to BS 476: Part 22^{1h} will not use the cotton pad for measuring integrity and in EN1634-1^{28c} will only be evaluated by means of the cotton pad until the time when the unexposed face temperature exceeds the insulation temperature. The gap gauge will then be used. Whilst metal framed doors may be attributed levels of integrity sometimes greater than those claimed by timber door assemblies, if the pad were to be used in lieu of the gap gauge then the actual integrity protection may be theoretically less in risk terms. (☆☆☆)

- **Temperature rise (insulation).** Whilst insulating glass can be installed in order to satisfy the insulation criteria of the fire resistance test it is difficult to provide this for periods in excess of 2 hours in door assemblies. The metal frame will normally get hotter than timber or mineral/timber doors if it is to have sufficient strength and robustness, i.e. not incorporate a thermal break in the framing members. (☆☆)
- **Smoke resistance.** The amount of smoke leakage may depend upon the quality of the glazing details. A well sealed glazing pocket should not allow much smoke to leak out but a loose glazing rebate may leak significant quantities of smoke. As with all doors the quality of the smoke seal fitted in the leaf/frame rebate will govern the amount of smoke that will pass through the door assembly. The glass and steel framing will remain impermeable throughout. Very little smoke will be

given off from the protected face except for that due to the breakdown of any painted finish (which can be significant for certain finishes) or a small quantity of smoke/steam from insulating glass near to the time at which integrity and insulation will be lost. (☆☆☆)

- **Contribution to fire growth.** None of the materials are combustible and therefore the contribution will be nil. (☆☆☆☆☆)
- **Strength and impact resistance.** Doors that incorporate large areas of glass are always vulnerable to impact damage. The steel framing will be sufficiently strong to resist all anticipated damage and insulated glass in thicknesses greater than 12mm will be able to resist all impacts except for very local ones, especially from sharp instruments. (☆☆☆)
- **Durability.** Glass and steel are extremely durable materials in a normal environment. Intumescent laminated glasses are vulnerable to moisture degradation if not properly sealed and when installed particularly in high humidity environments. Any intumescent edge seals that have been the subject of long-term ageing trials, such as the IFSA ageing programme may be considered as durable, but other seal types may need to provide evidence of performance. The IFSA Information Sheet No. 4 should be consulted³⁷. (☆☆☆☆)

4. STEEL FLUSH DOORSETS

Flush steel doors consists of metal skins on either side of a leaf which may incorporate a variety of internal constructions to hold the skins apart. Such doors are normally non-insulating with respect to fire and the internal structure will usually consist of metal spacers, mineral wool, paper honeycomb or polymeric material. When the door is to satisfy the insulation criteria then the infill material will have enhanced fire properties and will then normally consist of fire insulating board or mineral fibre boards. Even metal insulating doors will frequently have frame temperatures and leaf edge temperatures in excess of the normal temperature rise criteria of 180 deg C, although normally remaining below 350°C. Doors so constructed will normally meet the heat flux requirements given in this *Design Guide* for the fire protection of buildings. Metal flush doors will normally be able to be provided for all application and configurations that timber doors can be, including unlatched in use. The restriction of use for unlatched doors given at the beginning of this data sheet should be noted. Metal doors may include a vision panel which may be glazed with a non-insulating glass or an insulated glass, depending upon its use and application.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Steel faced flush doors hung in metal frames are able to provide long durations of integrity resistance, albeit if the leaf is uninsulating and the door is tested in accordance with BS 476: Part 22^{1h} compliance with the integrity criteria may have been adjudged by means of a gap gauge rather than by means of the cotton pad. This has a lower 'real' level of protection than the cotton pad. Any fire resistant glazing incorporated may become a limiting factor in respect of integrity (☆☆☆☆)

Note: Foamed plastic cores may lead to an early and dramatic integrity failure under certain pressure conditions and this needs to be taken into consideration when specifying such doors.

- **Temperature rise (insulation).** Most metal doors will not provide significant levels of insulation when exposed to a fire and even insulating doors will often have only partly insulated edge zones and frames. Glazed vision panels will compromise insulation unless these are glazed with insulating glass. (☆☆)
- **Smoke resistance.** Subject to being fitted with suitable edge smoke seals and having any vision panels tightly glazed flush metal doors are considered to be impermeable. Unless intumescent seals are fitted (normally only to the edges of insulating leaves) the assemblies will not significantly restrict the leakage of hot smoke. Certain decorative finishes may result in smoke being given off from the unexposed face once the temperature on this face gets hot. (☆☆☆☆)
- **Contribution to fire growth.** Other than the contribution from any plastic core materials, metal doors make a negligible contribution to fire growth. Even the core material may not make a contribution if it is fully encapsulated. The total contribution even when the core becomes involved will be modest albeit it could be fairly vigorous in the short term. (☆☆☆☆☆)
- **Strength and impact resistance.** Unglazed metal flush doors must represent the strongest and most impact resistant form of fire door on the market. Normal clear monolithic glass in vision panels could compromise this in respect of hard body impacts but laminated glasses can reinstate the impact resistance. (☆☆☆☆☆)
- **Durability.** Steel door would be rated as durable bearing in mind limitations relating to intumescent glasses and edge seals (if fitted) mentioned in previous section. (☆☆☆☆)

RECOMMENDED THICKNESSES OF DOORS

It is not possible to give recommended thicknesses for the various ratings of doors as the duration and construction dictates the final thickness of the leaf.

The manufacturer's LPCB approval, test evidence and/or Field of Application Report should be referred to when specifying or auditing a fire resisting doorset for use in compliance with the requirements of the LPC *Design Guide for the Fire Protection of Buildings*.

Figure 1. Typical fire resisting flush doorset identifying components, including ironmongery.

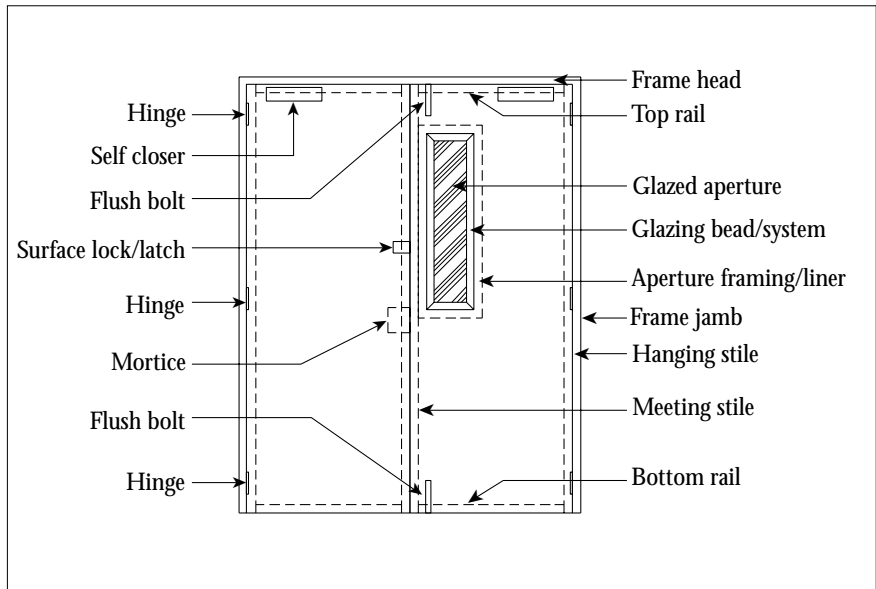
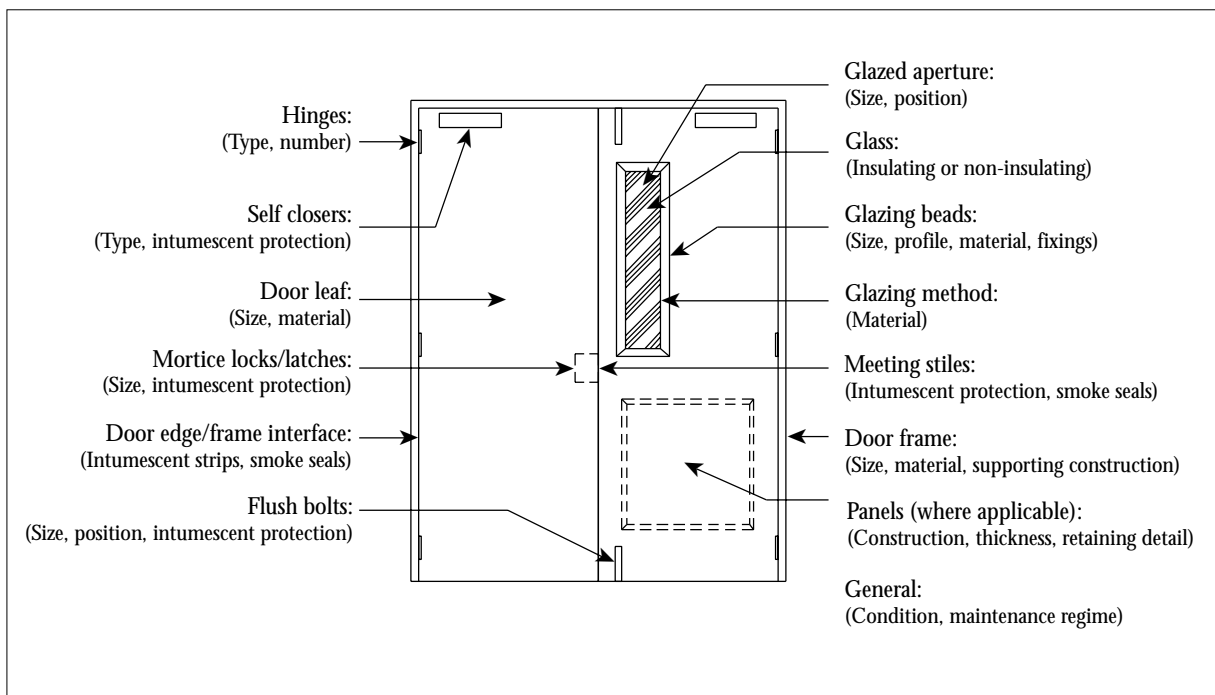


Figure 2. Fire resisting doorsets - identifying components and measures essential to fire resisting performance.



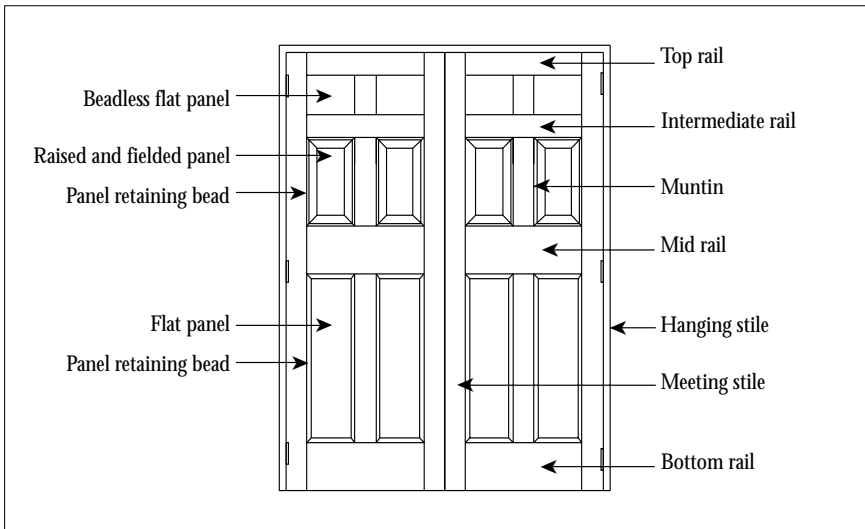


Figure 3. Typical fire resisting panelled (joinery) doorset identifying components.

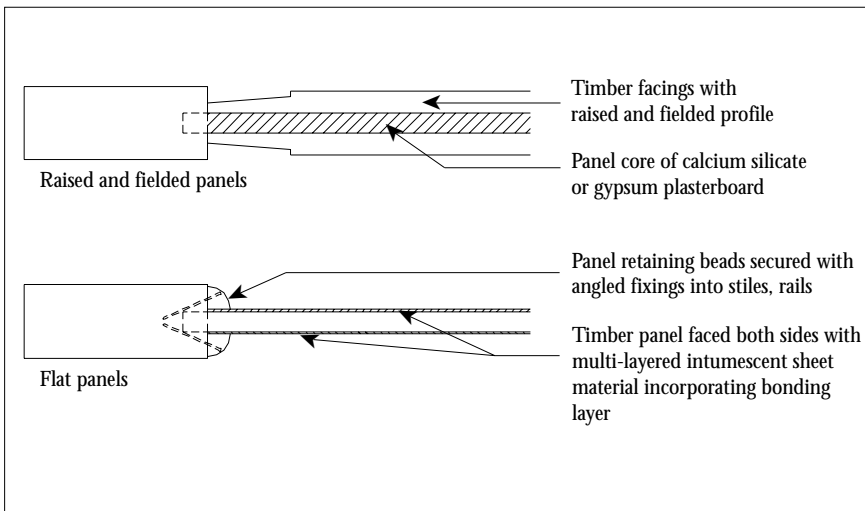


Figure 4. Typical methods of constructing or upgrading panels to achieve fire resisting performance in panelled (joinery) doors.

SUMMARY OF PERFORMANCE DATA

Table 1 below summarises the assessed relative abilities of the featured door types to satisfy the identified performance requirements.

Table 1 - Summary of performance data

Requirements	Fire resistance (integrity)	Temperature rise (insulation)	Smoke resistance	Contribution to fire growth	Strength and impact resistance	Durability
Hinged and pivoted firedoors						
1. Timber door assemblies	☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆	☆☆☆	☆☆☆☆
2. Timber and mineral board composites	☆☆☆☆	☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆	☆☆☆☆
3. Steel and glass architectural doorsets	☆☆☆	☆☆	☆☆☆	☆☆☆☆☆	☆☆☆	☆☆☆☆
4. Steel flush doorsets	☆☆☆☆	☆☆	☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆

INSTALLATION

Fire resisting door assemblies are only as good as the structure into which they are installed and the quality of the installation. Lightweight constructions do not provide as much restraint to support the frame as do masonry or blockwork constructions. Evidence of performance should be related to the nature of the construction into which it is installed and the fixings shall be appropriate to the construction into which it is being attached if the requisite level of restraint is to be provided.

For assemblies which are hung on site, the gaps between the edge of the leaf and the frame, or the floor are important and should comply with those given in the approval or field of application report. As stated the door hardware is often critical to the performance, and door closers, particularly in the case of large leaves or unlatched doors, are often vital to the performance.

IDENTIFICATION

Any LPCB approved fire resisting door assembly should carry a permanent mark identifying the LPCB approval number. It is recommended that non LPCB approved doors shall be clearly indelibly marked with the manufacturer's or installer's name and a statement of the fire integrity and insulation rating, if appropriate.

Non-metallic fire doors should be marked in accordance with clause 5 of BS 8214¹⁵. A convenient way of doing this is by a colour coded plastic plug, typically located on the upper part of the hinged edge.

Sheet No: 6.6.2

6.6 Fire doors

Fire resisting industrial metal doors

Main application in respect to this *Design Guide*.

Maintenance of fire compartmentation when a compartment wall is penetrated by apertures designed for the passage of goods or vehicles either at a size, in an environment or for a duration not capable or suitable for timber personnel doors.

FUNCTION OF INDUSTRIAL METAL FIRE RESISTING DOOR AND SHUTTER ASSEMBLIES

Industrial metal doors and shutters are preferred to timber, or timber and mineral constructed doors, in industrial environments because of their inherent robustness. Their performance objectives should essentially align with those of timber hinged and pivoted personnel assemblies, albeit it is recognised that their method of construction makes it harder for industrial metal doors and shutters to provide the same level of thermal insulation as a timber door which is recognised in the British Standard BS476: Part 22^{1h} where a separate, potentially less onerous method of determining compliance with the integrity criterion is permitted for non-insulating constructions. The function is, however, similar:

- To maintain fire separation, in terms of integrity, as required for the wall as specified in Table 2.2 of the *Design Guide*.
- To restrict the rise in temperature on the unexposed face, either to comply with the criteria of the test or such that radiation induced fire spread can be controlled by the maintenance of a safe storage zone (see 4.2.4 in the *Design Guide*.)
- To restrict the passage of smoke, as far as practical for the same duration as integrity.
- Not to produce an undue contribution to the fire growth relative to the risk associated with the environment into which the door is installed.
- To be strong enough to be rated as suitable for severe duty applications or meet the impact requirements of LPS 1056²⁰.
- To maintain the satisfactory performance over the lifetime of the building, or for a shorter duration if allowed for in the fire safety management plan, in respect of realistic impact and/or ambient conditions.

EVIDENCE OF FIRE PERFORMANCE

Fire resisting industrial door or shutter assemblies that comply with LPS 1056²⁰ can be used without restriction subject to being installed in compliance

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IMPORTANT
THESE DATA SHEETS ARE ONLY INTENDED TO GIVE GENERIC INFORMATION. DATA ON PROPRIETARY PRODUCTS MUST BE OBTAINED FROM THE MANUFACTURERS

with the conditions specified in the approval and meet the requirements of this *Design Guide*, particularly in respect to distances from combustible materials for uninsulated doors.

Alternatively the evidence of performance shall comply with all of the following.

- **Fire resistance performance (integrity).** The ability of the door assembly to provide integrity shall be supported by evidence of performance generated in respect of the test methodology given in BS476: Part 22^{1h} or prEN 1634-1^{28c}. Tested fire doors *shall* be supported by an engineering assessment or a Field of Application Report identifying the maximum sizes, and, if appropriate, configuration at which they may be used whilst maintaining the fire resistance rating required and identifying any restrictions in use, particularly with respect to the associated construction into which they may be installed, which in the case of metal doors is often critical to the performance.
- **Temperature rise (insulation).** The ability of the door assembly to satisfy the insulation criteria shall be supported by evidence of performance generated in respect of the test methodology given in BS476: Part 22^{1h} prEN 1634-1^{28c} unless it was tested as a non-insulated door assembly to clause 8, in which case the insulation rating will be zero. Whilst a field of application document should be used to justify the fire performance of the assembly, insulation is not necessarily a size dependent phenomenon. For industrial doors a reduced level of insulation is allowed for in the LPC *Design Guide for the Fire Protection of Buildings* whereby safe storage distances are maintained which are governed by the heat flux from the assembly and therefore the radiation level shall be reported. *There is no reason why uninsulated doors cannot be used provided the safe distances given in Figs 4.1 and 4.3.*
- **Smoke resistance.** The door assembly shall have been tested to the methodology of BS476: Part 31^{1j} and have demonstrated a leakage rate of not more than 5m³/m²/hr for large hinged metal doors or sliding doors or 5m³/m²/hr for shutters, for use in industrial or retail environments. Intumescent seals can help reduce leakage of hot smoke. A draft EN standard is currently being produced dealing with ambient and hot smoke leakage measurements (prEN1634-3^{28d}).
- **Contribution to fire growth.** The materials used in the construction of all industrial doors shall meet the requirements of Part 2.2 of this *Design Guide*.
- **Strength and impact resistance.** Door assemblies for use in industrial applications shall as a minimum be rated as severe duty (DD 171¹⁷). As such they shall satisfy any impact tests or abuse tests that are appropriate to severe duty applications. *Preferably, doors shall satisfy the impact requirements of LPS 1056²⁰.*
- **Durability.** Evidence shall be available to show that the materials used in the construction of the fire door assemblies including any seals, are not going to be adversely affected by the ambient conditions and, if appropriate, damage during the anticipated life of the doorset. Intumescent seals, if fitted, that have been part of the LPC/BBA

evaluation are considered to satisfy the durability requirement. If a door is to be reliable it is important that the hardware required to make it function is of a suitable strength and grade. Currently standards only exist for hinged and pivoted fire doors.

OVERVIEW OF INDUSTRIAL DOORS

Industrial metal doors and shutters provided primarily for the purpose of allowing passage of goods and vehicles and also to permit access and egress by persons as appropriate, come in the following main types:

1. Roller shutters
 - 1.1 Barrel horizontally mounted, shutter vertical opening
 - 1.2 Barrel vertically mounted, shutter horizontally opening
2. Metal folding doors
3. Metal sliding doors
4. Large flush steel hinged doorsets
5. Conveyor closures

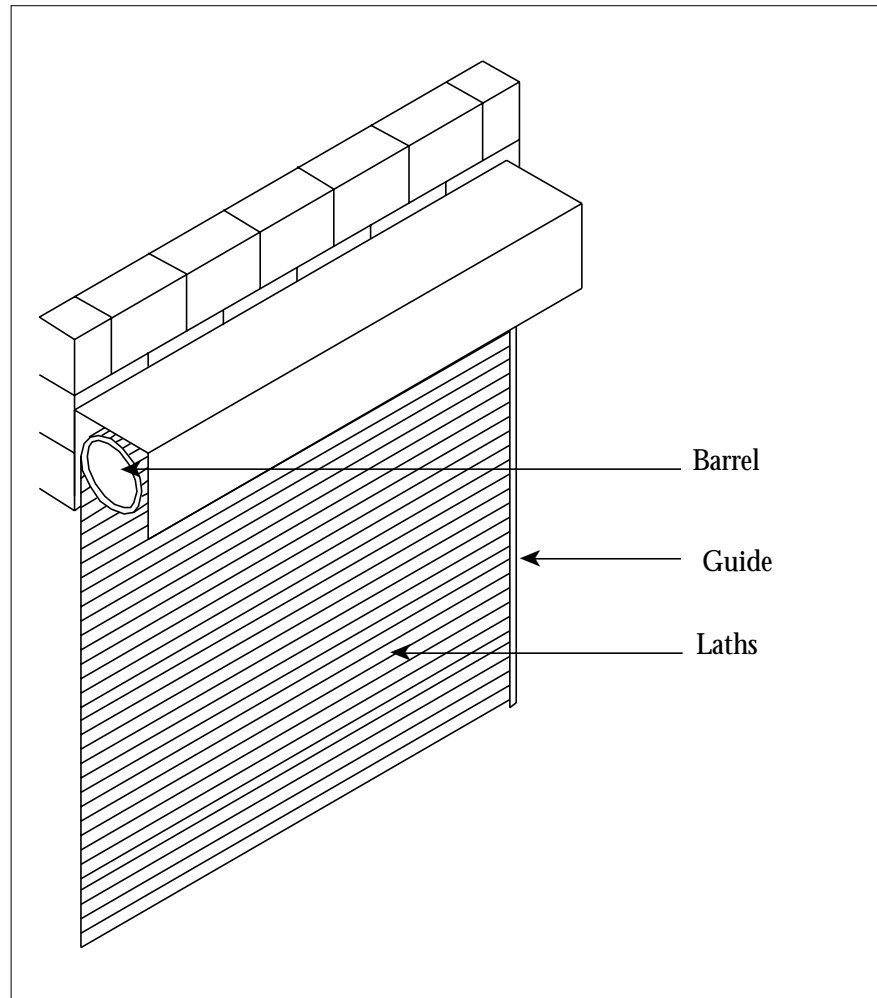
1. ROLLER SHUTTERS

Roller shutters come in two main types, vertical opening (see Figure 1) and horizontal opening, and are used extensively because of the size of aperture they are able to close-off. Roller shutters consist of steel interlocked laths that form a flexible curtain which is able to be rolled, either manually, or more likely by an electric, high torque, low speed motor onto a barrel housed in a box attached to the wall. Guides ensure that the edges of the curtain are located in the vertical or horizontal position at the edges keeping them in contact with the walls.

1.1 ROLLER SHUTTERS – BARREL HORIZONTALLY MOUNTED, SHUTTER VERTICALLY OPENING

- **Fire resistance performance (integrity).** Because the laths interlock and the ends of the laths are retained within the guide channels the curtain is able to provide high durations of integrity in terms of the method of evaluation used. If the assembly overall is to satisfy the integrity requirement it is important that the barrel shaft diameter, wall thickness and method of support for the barrel assembly is adequate for the size of door to be installed. LPCB cover this aspect in their assessment. (☆☆☆☆☆)
- **Temperature rise (insulation).** Due to the lack of insulation in the construction, shutters make a poor contribution to controlling temperature rise. The radiation from these shutters is significant but a double curtain can reduce the level of radiation and reduce the risk of ignition on the protected side if required. (☆)
- **Smoke resistance.** There are many leakage paths for smoke in a roller shutter, e.g. between laths, through the guides, and as a consequence they cannot significantly restrict the leakage of smoke as determined by BS476: Part 3^{1j}. Shutters are used, in a partially rolled position, as smoke curtains but this is more for life safety rather than property protection. (☆)

Figure 1 Steel vertical roller shutter



- **Contribution to fire growth.** Roller shutters are of an all steel construction and make no contribution to fire growth. (☆☆☆☆☆)
- **Strength and impact resistance.** Being of an all steel construction, shutters are generally robust, although the laths can be damaged by hard impacts, e.g. forklift truck forks, which could impair the operability and integrity. (☆☆☆☆☆)
- **Durability.** Roller shutters do require a motor to make them work and they do have to 'function' if they are to provide the fire barrier required. They are therefore reliant on maintenance to ensure they will always work when required. There are no seals to breakdown. They may generally be considered to be durable. (☆☆☆☆☆)

1.2 ROLLER SHUTTERS – BARREL VERTICALLY MOUNTED, SHUTTER HORIZONTALLY OPENING

The performance of these is going to be very similar to vertical roller shutters and therefore the performance is considered to be as given above. Only where the performance is significantly different is it addressed in the comments below.

- **Fire resistance performance (integrity).** LPCB certified vertically hung, horizontal opening roller shutters provide similar levels of integrity to that described above. (☆☆☆☆☆)
Those that fall outside the scope of LPCB certification may not achieve such high levels of performance and should be viewed with some caution. (☆☆☆)
- **Temperature rise (insulation).** Due to the lack of insulation in the construction, shutters make a poor contribution to controlling temperature rise. The radiation from these shutters may be significant when used in large spans but a double curtain can reduce the level of radiation and reduce the risk of ignition on the protected side if required. (☆)
- **Smoke resistance.** The comments in respect of leakage apply but in addition these are not able to be used as smoke curtains because of their orientation. (☆)
- **Contribution to fire growth.** Roller shutters are of an all steel construction and make no contribution to fire growth. (☆☆☆☆☆)
- **Strength and impact resistance.** Sliding metal doors are robust with respect to hard body impacts, but can be dislodged from tracks and guides if hit by a heavy body impact. However, they are more robust than many other forms of construction. (☆☆☆☆☆)
- **Durability.** The horizontal shutter is very dependent upon the guide in the floor not becoming blocked by rubbish or debris, nor for stored goods to be in their way. As a result their effective use requires even higher levels of maintenance than the vertical shutter. (☆☆)

2. METAL FOLDING DOORS

The main advantage of metal folding doors is that they do not require a lot of clear space for them to operate in, as does a hinged or pivoted door leaf. Their primary disadvantage is that they are not readily self-closing and that makes them vulnerable to poor operation, although the use of electro-magnetic locks can ensure that management control is exhibited over the use of the doors. These doors are no longer commonly used and are not a preferred method of closing-off apertures in fire walls, but it is acknowledged that there are a number of them still in use and indeed in some applications they may be the only option available.

FIRE PERFORMANCE DATA

- **Fire resistance performance (integrity).** Whilst the individual leaves are joined to each other by means of continuous hinges which do not leave a gap, there will always be a generous clearance gap at the head. As steel expands, however, this gap is likely to get less as the door gets hot and it will normally satisfy the integrity criteria as adjudged by the gap gauge for extended periods. The closing edge is more likely to fail than the edge of a roller shutter albeit a guide is normally provided at this edge for the door to close into. (☆☆☆☆☆)
- **Temperature rise (insulation).** The metal folding door is only capable of folding back onto itself because of the thinness of the metal used to form the individual leaves. This is unable to provide any significant insulation. (☆)

- **Smoke resistance.** The gaps around these doors in the cold state prevent these doors from being used as smoke control doors as determined by BS476 : Part 31^{1j}. (☆)
- **Contribution to fire growth.** Being of an all metal construction they make no contribution to the growth of a fire. (☆☆☆☆☆)
- **Strength and impact resistance.** Being constructed from reasonably thick steel sheet the doors are fairly robust, albeit the slide mechanism can get damaged by accidental impact and make them hard to operate. (☆☆☆)
- **Durability.** With minimal maintenance folding shutter doors can last for a long time, but guides need to be kept clear of debris. Because of the lack of being able to be self-closed they do not have the reliability of other types of doors and are not recommended for that reason. (☆☆)

3. METAL SLIDING DOORS

Metal sliding doors are not generally accepted for means of escape applications due to the difficulty of operating them in an emergency and a separate personnel door normally needs to be used in conjunction with them if they are installed on an escape route. Sliding doors, like folding doors, are hard to seal around their edges although they can be made to self-close more readily, by means of weights and pulleys or hydraulically activated devices. They can be constructed either of a thick sheet steel braced around the edges, or as a tray and lid construction incorporating a suitable form of insulation, normally mineral wool or lightweight board. Because they are only supported by the running gear at the head and possibly by guides at the bottom, they are free to distort over their height when heated.

FIRE PERFORMANCE DATA

- **Fire resistance performance (integrity).** Because of the method of supporting sliding doors there is a potential for large gaps around the edges. If the door assembly were to be evaluated as an insulating door, i.e. by means of the cotton pad test, it would fail early but by good detailing of the edges, sliding doors can achieve longer durations when evaluated using the gap gauge. (☆☆☆☆)
- **Temperature rise (insulation).** The solid steel constructions have no significant insulation properties and even the flush steel doors will transmit heat around the edges and through any stiffeners. (☆)
- **Smoke resistance.** Because of the way that the doors are hung and operate they are unable to provide any significant resistance to cold or hot smoke. (☆)
- **Contribution to fire growth.** Because the doors are of an all metal construction they make no contribution to fire growth. (☆☆☆☆☆)
- **Strength and impact resistance.** Sliding metal doors are robust with respect to hard body impacts, but can be dislodged from tracks and guides if hit by a heavy body impact. However, they are more robust than many other forms of construction. (☆☆☆☆)
- **Durability.** Because they are hung on rolling gear that can fail if not maintained properly they are not 100% reliable in the long term but other than the suspension system there is little that can go wrong. (☆☆☆☆)

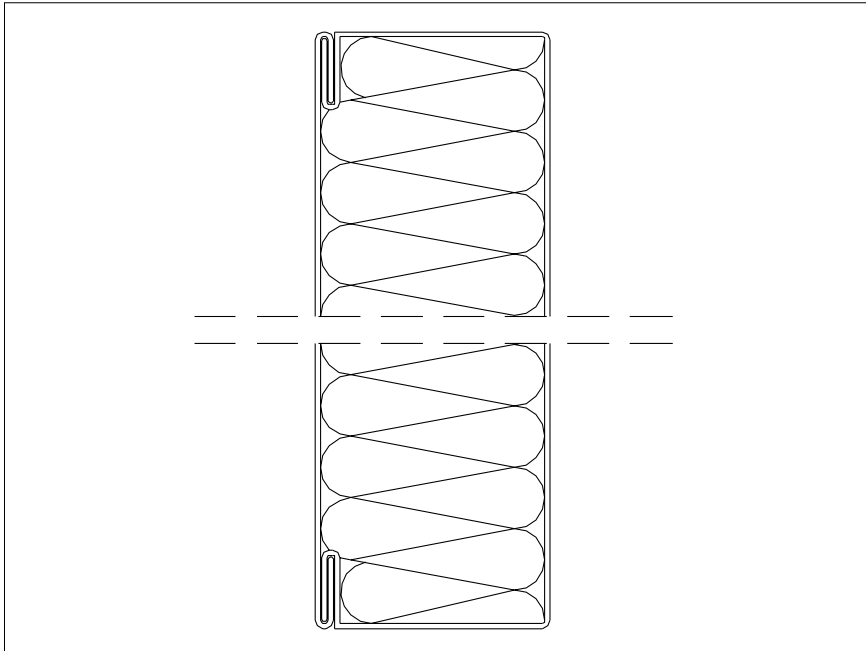


Figure 2. Steel doors: tray and lid construction.

4. LARGE FLUSH STEEL HINGED DOORSETS

Large hinged metal flush doors are constructed in a similar manner to personnel doors (see Data sheet 6.6.1) except that the components are generally larger in order to construct the bigger leaf. In some cases, because the furnace aperture in the BS476: Part 20^{1f} test is only required to be 3m x 3m the evidence in support of large doors may be directly extrapolated from tests on personnel sized doors. Large hinged doors normally incorporate multi-point latching to provide the stability that the large leaf requires. Such doors are invariably of the tray and lid form of construction (see Figure 2). In terms of performance they will exhibit similar characteristics to the smaller leaf sized assemblies described in 6.6.1, which are given below. Even when incorporating insulation in the main body of the leaf the frame and leaf edges are likely to reach temperatures in excess of the normal temperature rise criteria of 180 deg C, although normally remaining below 350°C. Industrial metal doors are unlikely to include a vision panel except possibly a very small one for communication purposes and this will generally be glazed with a non-insulating glass.

FIRE PERFORMANCE DATA

- **Fire resistance performance (integrity).** Large steel faced flush doors hung in metal frames are able to provide long durations of integrity resistance, albeit if the leaf is uninsulating and the door is tested in accordance with the gap gauge criteria of BS 476: Part 22^{1h}, prEN 1634-1^{28c}. Any fire resistant glazing incorporated may become a limiting factor in respect of integrity, as it is more likely to fail than the steel. Multi-point latching will invariably be required with large leaves. (☆☆☆☆)

Note: Foamed plastic cores may lead to an early and dramatic integrity failure under certain pressure conditions and are not recommended in order to satisfy the requirements of this Design Guide.

- **Temperature rise (insulation).** Most metal doors will not provide significant levels of insulation when exposed to a fire and even insulating doors will often have only partly insulated edge zones and frames. Glazed vision panels will further compromise insulation unless these are glazed with insulating glass. They should however satisfy the heat flux criteria given in Part 4.2.4 of the *Design Guide*. (☆☆)
- **Smoke resistance.** Subject to being fitted with suitable edge smoke seals and having any vision panels tightly glazed, flush metal doors are considered to be impermeable. Unless intumescent seals are fitted (normally only fitted to the edges of insulating leaves) the assemblies will not significantly restrict the leakage of hot smoke. Certain decorative finishes may result in smoke being given off from the unexposed face once the temperature on this face gets hot. (☆☆☆☆)
- **Contribution to fire growth.** Other than the contribution from any plastic core materials, metal doors make a negligible contribution to fire growth. Even the core material may not make a significant contribution if it is fully encapsulated. The total contribution even when the core becomes involved will be modest albeit it could be fairly vigorous in the short term. (☆☆☆☆☆)
- **Strength and impact resistance.** Unglazed metal flush doors may be considered as potentially the strongest and most impact resistant form of fire door on the market. Normal clear monolithic glass in vision panels could compromise this in respect of hard body impacts but laminated glasses can reinstate the impact resistance. (☆☆☆☆☆)
- **Durability.** Steel door leaves would be rated as durable, subject to limitations relating to intumescent glasses and edge seals (if fitted) mentioned in previous section. In order for them to be reliable it is important that all hardware fitted to the door is selected on the basis of it being suitable for (severe) duty, and of a grade adequate for the size and weight of the door. (☆☆☆☆☆)

5. CONVEYOR CLOSURES

Purpose made systems that are designed specifically for closing off apertures penetrated by track based product transport systems.

Conveyor belts or overhead rails, used for transporting goods or products from one part of a factory or site to another, often have to pass through a compartment wall. The conveyors are used because they form part of an automated continuous process of manufacture, packing and storing. Such conveyors cause a breach in the compartmentation in a number of ways:

- (i) they create a hole in the compartment wall which is difficult to close-off in the event of a fire as the transport system runs through it;
- (ii) in the event of the product being transported getting involved in the fire and burning, the flaming product could be transported to the protected side of the compartment wall;
- (iii) because the product and the transport system is passing through the wall, even if some type of shutter has been installed in the line of the compartmentation, there is a risk of the product being half way through the wall when the power is lost thereby preventing the shutter from closing;

- (iv) if the shutter used does not provide insulation in the event of a fire the combustible product that has only just cleared the shutter is prone to a radiation induced ignition.

With so many potential routes of fire spread it can be seen that spread via these routes cannot always be prevented by the use of either vertical roller shutters or sculpted sliding doors, particularly if they do not provide insulation in the event of a fire. This section of the data sheet considers the performance of those purpose made devices that are designed specifically for closing off apertures penetrated by track based product transport systems. Such devices are characterised by the following:

- (i) they are intelligent in operation and able to seek a gap between items such that they are not able to prevent the closures from fully closing;
- (ii) they will have special provision for loosing off the track, sometimes even to the extent of guillotining through the belt;
- (iii) they are insulating to the extent that a combustible product that has just passed through the aperture when the system stops will not ignite due to conduction or radiation.

The comments made do not relate to simple roller shutters or sliding doors.

FIRE PERFORMANCE DATA

- **Fire resistance performance (integrity).** The closure is normally fitted with both compressible, high temperature gaskets and intumescent seals to ensure that the closure fits closely around the transportation system. This level of sealing is required because of the possible close proximity of combustible goods to the protected face of the wall. The intelligent system seeks a gap between products to ensure that when activated the integrity is never compromised. (☆☆☆☆☆)
- **Temperature rise (insulation)** Because of the need to protect combustible products adjacent to the closure the closure blades generally comply with the insulation criteria across their full width, including the edges. Some of the systems incorporate methods and materials for preventing the rise in temperature on the transportation system as well as the closure. (☆☆☆☆☆)
- **Smoke resistance.** The quality of seal achieved is somewhat dependent upon the profile and complexity of the transportation system. The use of high temperature compressible gaskets and intumescent seals around the perimeter of the closure leaves/leaf means that the device is able to significantly reduce the spread of both cold and hot smoke. (☆☆☆☆☆)
- **Contribution to fire growth.** As these closures are normally constructed with a metal internal frame, clad on both sides with a suitable insulation board the device will make very little contribution to fire growth. (☆☆☆☆☆)
- **Strength and impact resistance.** The closures are clad generally with an insulating board on the outer faces, albeit possibly further faced with a thin metal sheet, and as such are probably not quite as strong as an all steel closing device. However, the devices are generally made for a specific application and it would be easy to introduce enhanced strength at this stage. (☆☆☆☆☆)

- **Durability.** The devices are required to operate in the event of a fire and it is important that any device specified has demonstrated its ability to be cycled an appropriate number of times. Maintenance will need to form part of the management process to ensure that these closures operate when required. (☆☆☆☆)

SUMMARY OF PERFORMANCE DATA

Type of industrial metal doors	Fire resistance (integrity)	Temperature rise (insulation)	Smoke resistance	Contribution to fire growth	Strength/impact resistance	Durability
1.1 Barrel horizontally mounted, shutter vertical opening	☆☆☆☆	☆	☆	☆☆☆☆	☆☆☆☆	☆☆☆☆
1.2 Barrel vertically mounted, shutter horizontally opening						
LPCB approved	☆☆☆☆	☆	☆	☆☆☆☆	☆☆☆☆	☆☆
Non-LPCB approved	☆☆☆	☆	☆	☆☆☆☆	☆☆☆☆	☆☆
2. Metal folding doors	☆☆☆☆	☆	☆	☆☆☆☆	☆☆☆	☆☆
3. Metal sliding doors	☆☆☆☆	☆	☆	☆☆☆☆	☆☆☆☆	☆☆☆☆
4. Large flush steel hinged doorsets	☆☆☆☆	☆☆	☆☆☆☆	☆☆☆☆	☆☆☆☆	☆☆☆☆
5. Conveyor closures	☆☆☆☆	☆☆☆☆	☆☆☆☆	☆☆☆☆	☆☆☆☆	☆☆☆☆
Purpose made systems <i>not simple roller shutters or sliding doors</i>						

INSTALLATION

Fire resisting door and shutter assemblies are only as good as the structure into which they are installed and the quality of the installation. Lightweight constructions do not provide as much restraint to support the frame as do masonry or blockwork constructions and may not be suitable for the heaviest forms of construction, e.g. roller shutters. Evidence of performance should be related to the nature of the construction into which it is installed and the fixings shall be appropriate to the construction to which it is being attached if the requisite level of restraint is to be provided.

For assemblies which are constructed on site, the gaps between the edge of the leaf and the frame, or the floor are important and should comply with those given in the approval, test, assessment or field of application report. As stated the door hardware is often critical to the performance, and the door closers, particularly in the case of large leaves or unlatched doors, are often vital to the performance, and should be selected with the correct duty in mind.

IDENTIFICATION

Any LPCB approved fire resisting door or shutter assembly should carry a permanent mark identifying the LPCB approval number. It is recommended that non-LPCB approved doors shall be clearly indelibly marked with the manufacturer's or installer's name and a statement of the fire integrity and insulation rating, if appropriate.

SOURCES FOR FURTHER INFORMATION

Door and Shutter Manufacturers Association, 42 Heath Street, Tamworth, Staffordshire B79 7JH.

List of Approved Fire and Security Products and Services, The Loss Prevention Certification Board, Melrose Avenue, Borehamwood, Hertfordshire WD6 2BJ.

Sheet No: 6.7.1

6.7 Service sealing

Penetration seals

Main application in respect to this *Design Guide*.

- Maintaining the fire resistance separation provided by compartment walls, floors and protected shafts when penetrated by services, i.e. pipes or cables.
- Maintaining the fire protection provided by protected corridors or stairways when penetrated by services.
- Maintaining the fire separation provided by cavity barriers in roof voids etc., when penetrated by services.

FUNCTION OF A PENETRATION SEALING SYSTEM

- To maintain the integrity of the wall/floor/barrier for the duration defined in Part 2.4 of the *Design Guide*.
- To restrict the rise in temperature on the surface of the wall/floor or barrier and in certain situations, e.g. compartment walls, on the service itself.
- To restrict the passage of smoke for the same duration as the system integrity.
- To be not capable of spreading flame on their surface (large penetration seal).
- To withstand the deflection and any differential movement experienced in use and during fire exposure between the service, the sealing system and surrounding construction whilst maintaining the requirements above.
- To be capable of interfacing with the appropriate associated construction and remain in place.
- To maintain the fire separation over the life time of the building, or for a shorter duration if allowed for in the fire safety management plan, in respect of realistic impact and/or ambient conditions, including during the addition, removal, replacement or maintenance of services.

EVIDENCE OF FIRE PERFORMANCE

Evidence of performance shall comply with all of the following:

- **Fire resistance performance (integrity).** The sealing system and any associated 'bulkhead' barrier shall be able to maintain integrity and this ability shall be supported by test evidence generated by ad-hoc testing using the methodology of BS476: Part 22^{1h}, or to the CEN standard EN 1364-1²⁶ with fixings to the associated construction appropriate to its use and preferably supported by a Field of Application Report identifying any restrictions in use.

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- **Temperature rise (insulation).** The sealing system and any associated “bulkhead” barrier shall be able to maintain the unexposed face temperature below hazardous levels, and this ability shall be supported by test evidence as for integrity. In the case of services penetrating compartment walls, restrictions on the temperature rise extends to the first 500mm of the service either side of the wall.
- **Smoke resistance.** The sealing system should be impermeable and the method of installing shall be such that no gaps exist. Preferably the wall/ceiling/floor with the system installed shall have been tested to the methodology of BS476 : Part 31^{1j} and demonstrated a leakage rate of not more than 10m³/m²/hr, although in practice this may only be controlled by a visual check.
- **Contribution to fire growth/surface spread of flame.** The surface of any bulkhead barrier, shall have a surface spread of flame of Class 1 to BS 476: Part 7^{1d}, and be rated Class 0 as defined in England and Wales Building Regulations, Approved Document B²⁹, or other national regulations. Alternatively the product shall be designated as being of limited combustibility.
- **Deflection and differential movement.** The method of installation of the penetration sealing system shall be able to accommodate deflection of the service in use and under fire conditions. In the case of large bulkhead barriers they should be sufficiently strong to withstand human impact and demonstrate compatibility with associated construction. The sealing system shall be able to be easily formed or otherwise able to accommodate any irregularity in the aperture and have sufficient ability to hold itself in place.
- **Interface with associated construction.** The sealing system and the method of installation shall be such that it can accommodate irregularities in the aperture and have the ability to remain fixed in place during normal conditions and in a fire.
- **Durability.** Evidence shall be available to show that the materials used in the construction of the seal are not going to be adversely affected by the ambient conditions and, if appropriate, abuse (e.g. low energy impacts) during the anticipated life of the barrier.

GENERAL

Whilst the above functions cover all penetration sealing applications, there are three distinct types of penetration sealing systems:

1. Small penetrations

Where a single, or at the most a small number of services pass through a small hole and where the hole is sealed by a single material, i.e. a sealant or gasket.

2. Large penetrations

Where a number of penetration services pass through a large hole and where most of the hole is filled with a barrier through which the services pass.

3. Closing devices for sealing of low melting point services

Where a plastic pipe or other thermally softening service passes through a fire resisting construction and is closed off by a thermally activated closing device, e.g. a pipe collar or a cable sealing systems where a cable passes through a built-in modular sealing system.

Any device which satisfies the appropriate part of LPS 1132²¹; Part 1 (Small penetrations), Part 2 (Large penetrations), Part 3 (Closing devices))* is deemed to meet the requirements of the LPC *Design Guide for the Fire Protection of Buildings*, the performance functions of which are as described above.

It is important when selecting a material or sealing system to ensure that it has the evidence of performance appropriate to both the service and the associated construction. In both cases the heat conduction through the service or the material being penetrated, the melting of insulation or the erosion of the surrounding construction being exposed to fire will all influence the ability of the seal to maintain the fire performance.

The specification of penetration sealing systems is a complex matter. Issues which need to be considered include the size of any gap, the nature of the construction being penetrated, the nature, size and distribution of the services, localised conditions, the target fire performance period and other criteria. More detailed information is available in the Intumescent Fire Seals Association Approved Document on the subject of fire stopping and penetration sealing³³.

1. SMALL PENETRATIONS

The basic types of generic materials encountered in such applications and covered in this data sheet are as follows:

- 1.1 Mineral fibre fire stopping
- 1.2 Cementitious materials
- 1.3 Composite foam/intumescent gaskets
- 1.4 Proprietary mastics and sealants

1.1 MINERAL FIBRE FIRE STOPPING

The flexibility and essentially non-combustible nature of the rock or stone wool has caused it to be used for 'stuffing' gaps in or between elements to act as a firestop for some considerable time, but it is variable in use and installer dependent.

FIRE PERFORMANCE DATA

The regulatory guidance is to 'fire stop' any hole through which the service passes and mineral wool (rock or slag fibre) is specified.

- **Fire resistance (integrity).** When installed correctly, i.e. the void being fully filled and the fibre well compressed, the material is able to provide good levels of integrity. However, the material is prone to inadequate installation and is therefore very installer dependent. Material may also become detached when subjected to cyclic differential movement between the service and the element. (☆☆☆☆)

* Revised version currently being prepared

- **Temperature rise (insulation).** Mineral wool has good insulating properties when installed correctly at the proper density and thickness but as above, the temperature rise would be increased by poor installation. (☆☆☆☆)
- **Smoke resistance.** Mineral wool is not particularly impermeable unless capped off with a sealant and as such it will permit the leakage of smoke. When it gets hot the resins will break down and produce smoke. (☆☆☆)
- **Contribution to fire growth.** Not an issue on small penetrations.
- **Deflection and differential movement.** Mineral wool is able to accommodate movement because of its resilience and recovery, although in cyclic differential movement situations it may creep and become loose. (☆☆☆☆)
- **Interface with associated construction.** Mineral wool, unless under high degrees of compression, has a low adhesion to the associated construction but is able to accommodate irregular apertures. (☆☆☆)
- **Durability.** Mineral wool has excellent longevity properties. (☆☆☆☆☆)

1.2 CEMENTICIOUS MATERIALS

Plasters and sand/cement compounds are used to make good imperfections in fit to prevent exploitation in fire. They remain rigid during the life of the building.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Cementitious materials have excellent integrity performance when installed correctly and with sufficient depth. When the material is thick the differential movement between the associated construction and the service may lead to cracking. (☆☆☆☆)
- **Temperature rise (insulation).** Cementitious materials, with the exception of gypsum based products, are relatively conductive when heated and this can lead to the temperature rise criteria being exceeded. They can be applied to the surface of the service but are not easy to apply and brittle coatings may get damaged. (☆☆)
- **Smoke resistance.** Cementitious materials are impermeable and unless cracked will have excellent smoke restricting properties. (☆☆☆☆)
- **Contribution to fire growth/surface spread of flame.** Not an issue on small penetrations.
- **Deflection and differential movement.** Being rigid in nature the materials are not able to accommodate differential movement, although being strong in nature they may be able to resist failing until distortion is significant. (☆☆)
- **Interface with associated construction.** Cementitious material have a high adhesion (except possibly on smooth surfaces), but are unable to respond to melting of services, e.g. cables or erosion of the construction. (☆☆☆☆☆)

- **Durability.** Most cementitious materials would be considered durable, both to physical impact and chemical/moisture attack, albeit gypsum based products may be prone to degradation with respect to the latter. (☆☆☆☆)

1.3 COMPOSITE FOAM/INTUMESCENT GASKETS

Flexible foamed polymeric materials are excellent gap fillers, but unfortunately have very little tolerance to high temperature exposure. This can be overcome by sandwiching the foam with intumescent materials which can fill the gap left by the degrading foam.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** The principle of these systems is that the intumescent quantities are chosen such that the intumescent material is able to replace the hole produced by the foam melting or burning. (No allowance is made for such as plastic pipes melting away). As such, as long as the product is manufactured and installed within the field of application generated by the test evidence, it has adequate integrity for the application. (☆☆☆☆)
- **Temperature rise (insulation).** Subject to the depth of seal being sufficient to maintain integrity these are able to satisfy the temperature rise requirements. (☆☆☆☆)
- **Smoke resistance.** Subject to the foam being of a closed cell type the smoke resistance is excellent. Closed cell foams are, however, harder to compress. Open cell foams will restrict smoke but not as well as closed cell. (☆☆☆☆)
- **Contribution to fire growth/surface spread of flame.** Not an issue on small penetrations.
- **Deflection and differential movement.** These products have an excellent compressibility and recovery with an outstanding ability to accept movement. (☆☆☆☆)
- **Interface with associated construction.** The product can normally be sourced with sufficient depth of foam and thickness of intumescent to follow an irregular aperture and the degree of compression normally ensures that it stays in place. (☆☆☆☆)
- **Durability.** The foam and most forms of intumescent are able to withstand normal environmental conditions which is supported, in part, by ageing tests performed by the Intumescent Fire Seals Association. (☆☆☆☆)

1.4 PROPRIETARY MASTICS AND SEALANTS

Sealants and mastics are designed to fill gaps but they need to be specially formulated if they are to resist fire, normally by the inclusion of intumescent compounds. The chemical constitution of various mastics and sealants can lead to considerable performance differences between products. Appropriate supporting test evidence should be sought.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** The ability of the sealant to maintain integrity is governed by the width of the gap around the service to be sealed and the depth to which the sealant has been applied. Evidence of performance must be available to demonstrate that the integrity can be maintained for the appropriate depth of sealant and gap width. The nature of the service(s), e.g. metal pipe or plastic cable, will also affect the performance. Intumescent sealants if specified correctly are able to compensate for melting or erosion of the cable or the construction. (☆☆☆☆)
- **Temperature rise (insulation).** Sealants, particularly intumescent based, are normally capable of meeting the temperature rise criteria provided that they are installed to the correct thickness. (☆☆☆☆)
- **Smoke resistance.** Sealants are normally impermeable to smoke when installed. (☆☆☆☆)
- **Contribution to fire growth/surface spread of flame.** Not an issue with small penetrations.
- **Deflection and differential movement.** Elastomeric sealants normally have a high adhesion and a good tolerance to cyclic movement, as long as it is not extreme. Non-mastic variants are less able to respond to cyclic movement. (☆☆☆☆)
- **Interface with associated construction.** Being semi-fluid in nature they are able to be applied to any aperture regardless of how irregular it is and the mastic type have high adhesion properties. Rigid setting sealants will normally have a good adhesion. (☆☆☆☆)
- **Durability.** Subject to the sealant being able to resist moisture, most sealants will have good or better durability, being resistant to degradation and/or displacement by nature of the adhesive characteristics. (☆☆☆☆)

2. LARGE PENETRATIONS

Normal practice with a large penetration is to utilise a barrier 'bulkhead' to fill the majority of the large aperture, the penetrating services pass through this barrier and are sealed into it as required. This section compares the materials used for the construction of the bulkhead and assumes that the method of sealing the service into the barrier will be in compliance with the guidance given previously for small penetrations. The sealant used must be compatible with the behaviour and nature of the bulkhead barrier and generally the proprietary sealing gaskets and mastic sealants will be found to be most suited for this purpose.

The basic types of generic materials encountered in such applications and covered in this data sheet are as follows:

- 2.1 Cementitious slabs
- 2.2 Fire protection boards
- 2.3 Perforated steel faced fire protection boards
- 2.4 Uncoated mineral fibre slabs
- 2.5 Coated composite mineral fibre slabs
- 2.6 Fire pillows

2.1 CEMENTICIOUS SLABS

These slabs are normally constructed by spraying or plastering onto a suitable mesh which can be easily cut to accommodate services, but which can be subsequently sprayed or plastered with a cementitious mixture to provide a barrier.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** When the cementitious material is applied to the mesh after the services have been inserted a good seal is maintained and assuming that the depth of sprayed/plastered material is adequate for the duration then the system should provide the required duration of integrity. Services that are subsequently installed will not be as easy to seal or even may not be able to be installed (due to the mesh) and care will need to be applied when reinstating the seal. (☆☆☆☆)
- **Temperature rise (insulation).** This will be dependent upon the thickness and nature of the cementitious material and compliance with the temperature rise criterion is applicator sensitive. The areas adjacent to conductive services, e.g. steel pipes, may suffer enhanced heat transfer local to the service. (☆☆☆)
- **Smoke resistance.** The cementitious material when sprayed/plastered after installation of the service will be impermeable to smoke. Post-sprayed installations may leak unless the new penetration is itself sealed by an impermeable material. (☆☆☆)
- **Contribution to fire growth/surface spread of flame.** Undecorated cementitious materials would be expected to have a nil surface spread of flame. (☆☆☆☆☆)
- **Deflection and differential movement.** Cementitious materials are inherently rigid and whilst the reinforcement will probably allow the barrier to flex rather than collapse, the cementitious material may well crack. The barrier is unlikely to accept much differential movement between the service and the barrier. (☆☆)
- **Interface with associated construction.** Being sprayed or plastered-in when wet there will be a high degree of auto-adhesion and tolerance of irregular apertures. (☆☆☆☆☆)
- **Durability.** Cementitious barriers are likely to be more able to accept impacts or loads in use than other barrier materials, subject to thickness of slab and the reinforcing mesh being strong enough. The materials will generally be inert, although gypsum based materials may be degraded by moisture if condensation or water leaks are present. (☆☆☆☆)

2.2 FIRE PROTECTION BOARDS

This section relates to bulkhead barriers formed from calcium silicate, gypsum or cement based proprietary boards. There is a wide range of such products and the advice given is of a general nature and individual manufacturers should be consulted for a more detailed appraisal of specific product attributes.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** The integrity of these bulkhead barriers will only be as good as the seal that is made around the service and between boards forming the barrier. Some of the boards may crack when heated and when they do then integrity may well be lost at that time or soon after. (☆☆☆)
- **Temperature rise (insulation).** If the temperature rise is to be controlled this will generally require the use of a twin board system used in conjunction with a suitable insulation material as the boards are both relatively thin and fairly conductive. Gypsum based boards are likely to provide the most effective restriction of temperature rise during short term exposures. (☆☆)
- **Smoke resistance.** Fire protection boards are impermeable and when properly sealed at services and at board joints a high level of smoke resistance will be provided. (☆☆☆☆☆)
- **Contribution to fire growth/surface spread of flame.** Undecorated fire protection boards would be expected to have a nil surface spread of flame. (☆☆☆☆☆)
- **Deflection and differential movement.** Being rigid in nature fire protection boards are not readily capable of accommodating either differential movement or deflection. (☆)
- **Interface with associated construction.** Fire protection boards are not easily shaped to fit an irregular aperture nor are they able to provide any adhesion. In order to carry out their function they need to be sealed into the opening with a sealant that will make good any imperfections in fit and provide the required fixity. (☆)
- **Durability.** Fire protection boards are probably unable to provide impact and loading resistance without additional support brackets. Many of the materials will be inert, but some gypsum based boards may be degraded by water leaks if present. (☆☆☆☆)

2.3 PERFORATED STEEL FACED FIRE PROTECTION BOARDS (COMPOSITE STEEL/CEMENT)

Has a dry density of about 2300kg/m³ and supplied in thicknesses of 6mm, 9.5mm and 13mm. Particularly applicable where high resistance to impact is required.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** The integrity of these boards will be very similar to normal fire protection boards. (☆☆☆)
- **Temperature rise (insulation).** Metal faced boards are unlikely to provide significant levels of insulation. (☆)
- **Smoke resistance.** As for fire protection boards. (☆☆☆☆☆)
- **Contribution to fire growth/surface spread of flame.** Non-combustible. (☆☆☆☆☆)

- **Deflection and differential movement.** As for fire protection boards. (☆)
- **Interface with associated construction.** These are difficult to fit into any aperture that is not rectangular. (☆)
- **Durability.** These barriers are strong and capable of taking most envisaged impacts and loads. The materials are also inert. (☆☆☆☆☆)

2.4 UNCOATED MINERAL FIBRE SLABS

Mineral fibre slabs are normally of a rock or stone wool composition as glass fibre melts at too low a temperature to make an extended contribution to fire resistance and ceramic fibre is rarely manufactured in a form suitable for the manufacture of bulkhead barriers. The comments in this section relate to rock or stone wool rigid slabs of nominal density 100kg/m³.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Mineral fibre bats accept services readily because of the way they can be deformed around small pipes and cables, and their ability to be cut around large penetrating services. Assuming the bat has been specified with adequate thickness the fire integrity of such barriers should be excellent. (☆☆☆☆☆)
- **Temperature rise (insulation).** Mineral fibre is naturally insulating. An impermeable proprietary coating can reduce the temperature rise even more. (☆☆☆☆)
- **Smoke resistance.** The smoke resistance of an uncoated mineral wool slab is poor but can be improved by the use of a coating. See 2.5 below. At high temperatures the resin binder will itself produce smoke on the non-fire side. (☆☆)
- **Contribution to fire growth/surface spread of flame.** This material will meet the requirements of Part 2.2 of this *Design Guide*. The surface of mineral wool has a Class 1 surface spread of flame. (☆☆☆☆☆)
- **Deflection and differential movement.** The natural resilience of mineral fibre gives it excellent tolerance to both deflection and differential movement. (☆☆☆☆☆)
- **Interface with associated construction.** The mineral fibre bats are flexible and easy to form and the compressible nature improves adhesion. (☆☆☆☆☆)
- **Durability.** Whilst it is not strong with respect to loading or resistance to impact, the material is durable, although water leaks may cause a loss of strength once waterlogged. (☆☆☆☆)

2.5 COATED COMPOSITE MINERAL FIBRE SLABS

This section assumes that barriers consist of coated slabs or blocks, normally with a rock or stone wool slab core, and as such the comments above apply. Comments made are generally to identify the difference between the coated and uncoated-coated barriers.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Coated bats are likely to provide increased integrity ratings, possibly at a reduced thickness. (☆☆☆☆☆)
- **Temperature rise (insulation).** Coated slabs, especially those incorporating intumescent based coatings are likely to provide excellent insulating characteristics. (☆☆☆☆☆)
- **Smoke resistance.** A coated proprietary barrier will normally have excellent smoke resistance. (☆☆☆☆☆)
- **Contribution to fire growth/surface spread of flame.** The surface spread of flame rating is entirely dependent upon the nature of the applied coating, but this will normally be good. (☆☆☆☆☆)
- **Deflection and differential movement.** As for uncoated products. (☆☆☆☆☆)
- **Interface with associated construction.** As for uncoated products. (☆☆☆☆☆)
- **Durability.** Proprietary barriers normally incorporate jointing methods that make them more able to resist loads and impacts and would normally provide enhanced resistance to moisture. (☆☆☆☆☆)

2.6 FIRE PILLOWS

Whilst originally envisaged as temporary barriers, they are often used for permanent large penetrations. They contain a large variety of infill materials. The size and shape of the pillow combined with the type of infill material used mean that performance characteristics vary considerably between manufacturers. Many use intumescent as an infill and the following comments are based upon this type of pillow. They are only suitable for sealing apertures in vertical elements. They are not recommended for horizontal apertures. All comments below regarding performance are made subject to management control to ensure that the pillows are in place at the time of the fire.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** The fact that the pillows rest together means that they are capable of providing adequate levels of integrity. (☆☆☆☆☆)
- **Temperature rise (insulation).** The dimensions of an activated fire pillow are such that the temperature criterion would normally be satisfied. (☆☆☆☆☆)
- **Smoke resistance.** The use of pillows is never likely to produce as good a seal as a solid board or bat. (☆☆☆)
- **Contribution to fire growth/surface spread of flame.** Not known and manufacturers information should be used.
- **Deflection and differential movement.** Fire pillows, being flexible, have excellent tolerance to movement although in cyclic differential movement or excessive deflection they may creep and become loose. (☆☆☆)

- **Interface with associated construction.** Whilst being able to be formed around irregularities, it is often difficult to fit the last few pillows. Because of their width/depth and the fact that they are only used in vertical walls means that they are stable and remain in place easily. (☆☆☆☆)
- **Durability.** Because of the variety of coverings and infill materials, little can be said about the durability of fire pillows. Unless there is a strict management control it is impossible to ensure that they will be in place when fire breaks out. The lack of fixing also means that they are not robust with respect to impacts. (☆☆)

3. CLOSING DEVICES FOR SEALING OF LOW MELTING POINT SERVICES

This data sheet considers the performance of two devices used for closing-off plastic pipes that pass through fire resisting walls and floors;

3.1 Metal cased pipe collars

3.2 Pipe wraps

Both work by containing a pressure forming intumescent material around the periphery of a plastic pipe which expands and fills the space left when the pipe melts out.

There are a number of factors that affect the ability of the device to close off a melting plastic pipe:

- Pipe material
- Pipe diameter
- Wall thickness
- Orientation
- End conditions.

For any device it is important that evidence of performance is obtained that covers the specific type of pipe being sealed, i.e. pvc, upvc, polypropylene, polyethylene or ABS. The use of cable sealing systems is also considered.

Thermally softening services may typically include plastic pipes and sheathing to electrical cables.

3.1 METAL CASED PIPE COLLARS

These consist of a circular steel canister enclosing pressure forming intumescent material. If specified correctly the intumescent included in the device is designed to be capable of filling the void left by the melting or degrading plastic pipe. The canister shall be mounted directly onto the construction being penetrated.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** If the pipe collar has been correctly specified against the evidence of performance appropriate to the factors listed above, the active intumescent material shall be sufficient to maintain the integrity for the desired period. The method of fixing of the collar to the associated construction is critical and must take into account degradation and/or deflection of the element and heat transfer down the fixings. If any of the factors mentioned are not taken into account this could lead to a loss of integrity. (☆☆☆☆☆☆)

- **Temperature rise (insulation).** If the device has been correctly specified the intumescent that closes the pipe off will normally satisfy insulation criterion. The metal collar may lead to a rise in unexposed face temperature on the flange if it were to be built into the surrounding construction and were to span the thickness of the construction. However the rise in temperature would not usually represent a significant risk. (☆☆☆☆)
- **Smoke resistance.** The ability of a pipe collar to resist smoke will depend upon the fit of the collar to the pipe and to the associated construction. Both would be easy to seal with a suitable mastic, but in their natural state smoke tightness should not be assumed, albeit the gaps will be small. Cast-in collars provide a good seal to smoke leakage. (☆☆☆☆)
- **Contribution to fire growth/surface spread of flame.** Not applicable.
- **Deflection and differential movement.** The only accommodation for movement is generally as a result of flexing of the pipe. The collar is normally fitted rigidly to the construction and tight to the pipe. (☆☆)
- **Interface with associated construction.** Pipe collars with flanges are able to accommodate irregularities in the aperture being penetrated by the pipe as they are fixed direct to the face of the element and the flange seals of the gap. The selection of fixings is vital if the closer is to maintain the seal. Closures that are cast into the element obviously make good any irregularities. (☆☆☆☆)
- **Durability.** Pipe collars of the best quality, when properly fixed, are robust and provide protection to the intumescent materials incorporated and provide excellent durability. Lower specification collars may be slightly less robust and offer less protection to the intumescent material, but if this is graphite based, because of the natural durability of these materials this should not compromise the performance. (☆☆☆☆)

3.2 PIPE WRAPS

Pipe wraps rely on the surrounding construction to restrain the intumescent in a similar manner to a pipe collar. The surrounding construction must be analysed to establish its resistance to erosion/degradation before fitting the wrap otherwise it may be rendered ineffective as the construction degrades. Wraps are very installer dependent and are generally not a preferred robust solution in the context of the *Design Guide*. To achieve their performance objectives, they frequently need to be screeded over making them hard to audit. For comparison purposes the behaviour with respect to the performance criteria is given below:

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** When properly fitted and specified, particularly with respect to the limitations imposed by the properties of the pipe, the pipe wrap can satisfy the integrity requirement, although they are dependent upon the predictable behaviour of the associated construction. (☆☆☆☆)

- **Temperature rise (insulation).** They should not be any worse than pipe collars and possibly better due to the lack of any conductive metal casing. (☆☆☆☆)
- **Smoke resistance.** They will only provide good smoke resistance when fitted in a circular aperture with smooth sides and properly installed or when fully screeded over. (☆☆)
- **Contribution to fire growth/surface spread of flame.** Not applicable.
- **Deflection and differential movement.** Whilst the wrap is able to accommodate a certain amount of deflection excessive cyclic differential movement can cause the wrap to work loose unless it is screeded over. However, whilst the screeding helps to prevent the working loose of the wrap it then reduces the ability to accommodate deflection. (☆☆)
- **Interface with associated construction.** Whilst the wrap is flexible and can accommodate minor irregularities, it is too thin to accommodate irregular shaped holes or holes with sharp corners, unless sealed in place and is reliant on being screeded over to create the seal. The wrap generally has low adhesion characteristics. (☆☆)
- **Durability.** The wraps are difficult to audit to ensure that a complete wrap is installed (or even that a wrap has been fitted) when screeded over and difficult to ensure that they will remain in place if not screeded. (☆)

3.3 CABLE SEALING ASSEMBLIES

Cable sealing assemblies are pre-formed component systems consisting of a variety of resilient fire resisting blocks within a cage. The blocks can be replaced or removed to allow for the removal or the passage of additional cables. Such systems prevent the need for building work to take place when new cables are to be installed, making it easy to manage otherwise potential breaches in compartmentation/protection.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** These units, when properly specified, ensure compliance with the integrity requirements. (☆☆☆☆)
- **Temperature rise (insulation).** The ablative nature of the blocks normally ensure that excessive temperature rise is controlled. (☆☆☆☆)
- **Smoke resistance.** When blocks of the correct size are used to seal the appropriate diameters of cable the smoke resistance is good. (☆☆☆☆)
- **Contribution to fire growth/surface spread of flame.** Not applicable.
- **Deflection and differential movement.** Most modular cable sealing systems are able to accommodate movement of the service. (☆☆☆☆)
- **Interface with associated construction.** As a post-construction addition they need to be fitted as part of the building work and rendered in place. In a new build situation they are very easy to install but the components do require fixing into position as they do not have adequate resilience or self-adhesion to remain in place. (☆☆☆☆)

SUMMARY OF PERFORMANCE DATA

Table 1 below summarises the assessed relative abilities of the featured penetration seals to satisfy the identified performance requirements.

Table 1. Performance characteristics.

Requirements	Fire resistance (integrity)	Temperature rise (insulation)	Smoke resistance	Contribution to fire growth/surface spread of flame	Deflection and differential movement	Interface with associated construction	Durability
1. Small penetrations							
1.1 Mineral fibre fire stopping	☆☆☆☆	☆☆☆☆	☆☆☆	-	☆☆☆☆	☆☆☆	☆☆☆☆☆
1.2 Cementitious materials	☆☆☆☆	☆☆	☆☆☆☆	-	☆☆	☆☆☆☆	☆☆☆☆
1.3 Composite foam/intumescent gaskets	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆	-	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆
1.4 Proprietary mastics and sealants	☆☆☆☆	☆☆☆☆	☆☆☆☆☆	-	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆
2. Large penetrations							
2.1. Cementitious slabs	☆☆☆☆	☆☆☆	☆☆☆	☆☆☆☆☆	☆☆	☆☆☆☆☆	☆☆☆☆
2.2 Fire protection boards	☆☆☆	☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆	☆☆	☆☆☆☆
2.3 Perforated steel faced fire protection boards	☆☆☆	☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆	☆☆	☆☆☆☆☆
2.4 Uncoated mineral fibre slabs	☆☆☆☆☆	☆☆☆☆	☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆
2.5 Coated composite mineral fibre slabs	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆
2.6 Fire pillows	☆☆☆☆	☆☆☆☆☆	☆☆☆	-	☆☆☆	☆☆☆	☆☆
3. Pipe closing devices							
3.1 Metal cased pipe collars	☆☆☆☆☆	☆☆☆☆	☆☆☆	-	☆☆	☆☆☆☆	☆☆☆☆
3.2 Pipe wraps	☆☆☆	☆☆☆☆	☆☆	-	☆☆	☆☆	☆☆
3.3 Cable sealing assemblies	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆	-	☆☆☆☆☆	☆☆☆☆	☆☆☆☆

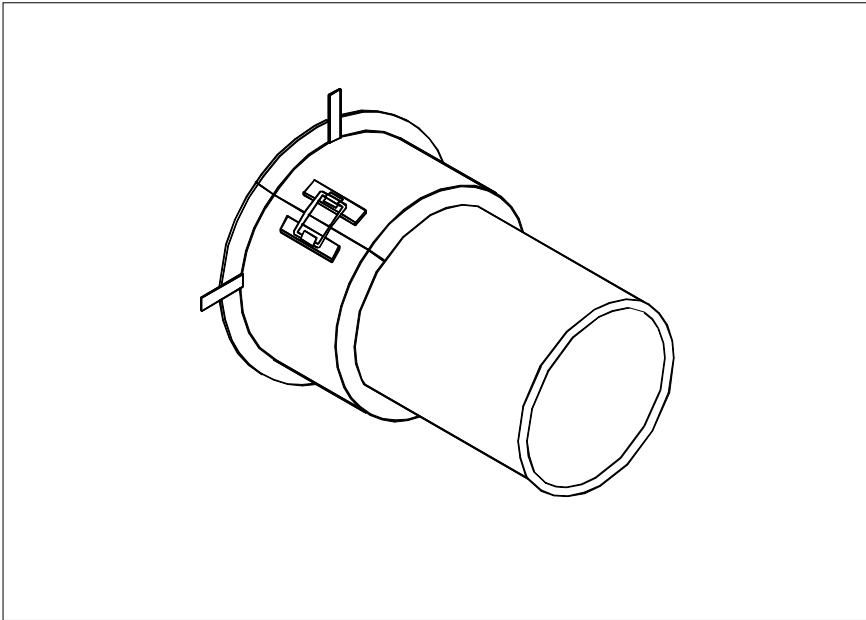


Figure 1. Intumescent pipe collar.

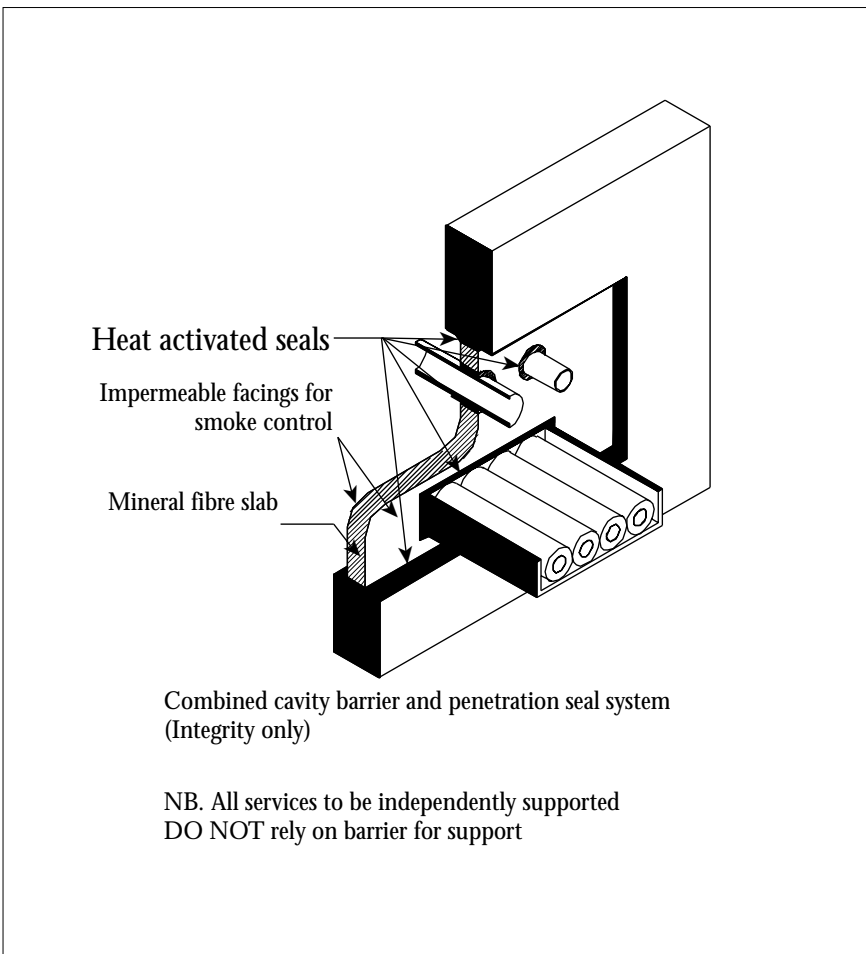
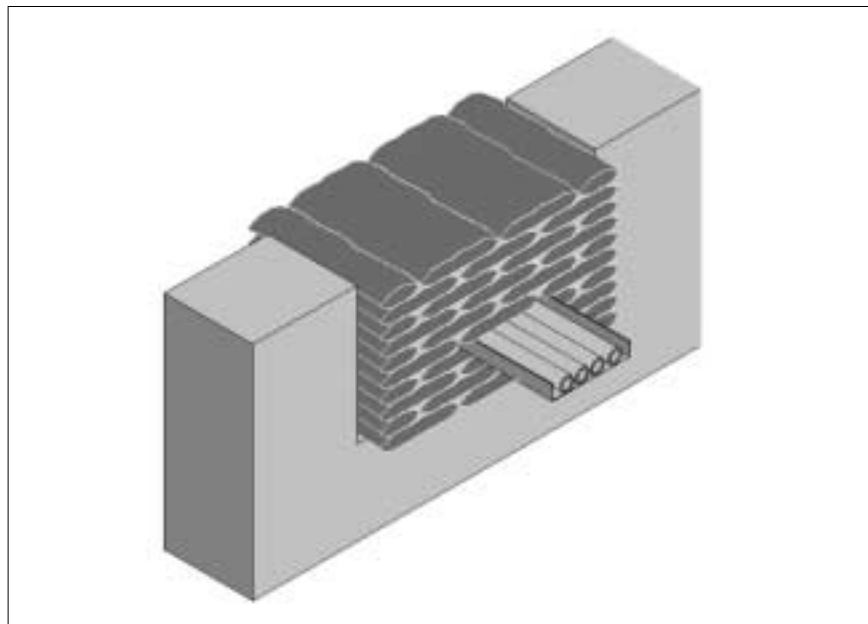


Figure 2. Intumescent bulkhead.

Figure 3. Intumescent pillows.



- **Durability.** The materials used are of proven durability and the unit is likely to remain in place. Management control will be required to ensure that the gland system is to be correctly used and that the new service is always properly sealed. (☆☆☆☆)

INSTALLATION

The installation of compartment floors with penetration seals should be executed and completed by a suitably qualified person to the required standard appropriate to the system used. It is advisable that where fire performance is required then an inspection by an independent body may be carried out on the completed installations.

OTHER SOURCES OF INFORMATION

Association of Specialist Fire Protection, Association House, 253 Ash Road, Aldershot, Hampshire GU12 4DD.

List of Approved Fire and Security Products and Services, The Loss Prevention Certification Board, Melrose Avenue, Borehamwood, Hertfordshire WD6 2BJ.

Intumescent Fire Seals Association (IFSA), 20 Park Street, Princes Risborough, Buckinghamshire HP27 9AH.

Sheet No: 6.7.2

6.7 Service sealing

Fire stopping and linear gap seals

Main application in respect to this *Design Guide*.

- Maintaining the fire resistance separation provided by compartment walls, floors and protected shafts when either a gap due to an imperfection of fit exists or where a functional gap has to be incorporated to accommodate a building design requirement.
- Maintaining the fire protection provided by protective corridors or protected stairways or cavity barriers when a gap exists as above.
- Used to create a barrier in small cavities to prevent fire and smoke spread.

There is significant confusion about the properties that a gap sealing system has to provide if the gap is to be sealed to maintain fire separation. In order to clarify the various functions and performance objectives the following definitions are included for clarity.

Fire Stopping. A seal provided to close an imperfection of fit or design tolerance between elements or components, excluding functional gaps, to restrict the passage of fire and smoke.

Linear gaps. A gap with a length of at least 10 times its width and where the gap width does not exceed 150mm. It may be functional or non-functional (see Figures 1 and 2).

Note: Gaps that do not comply with the above dimensional limitations shall be regarded as a penetration seal (6.7.1).

Functional linear gap. A gap of the above dimensions but which is installed in an element or building for a specific purpose, e.g. a movement joint, rather than an imperfection of fit.

Functional linear gap seal. A seal that accommodates the function that the gap has been incorporated for, e.g. expansion, and also maintains the fire resistance of the elements bounding the gap.

Non-functional linear gap seal. A seal that only has the purpose of maintaining the fire resistance of the elements bounding the gap, i.e. fire stopped.

This data sheet considers the relative performance (only in respect of fire) of a number of proprietary linear gap sealing systems, but is not intended to be comprehensive. When evaluating the potential performance of proprietary sealing systems that are not listed, the criteria or fire performance headings should be used by the specifier to establish their suitability.

BEFORE READING
THIS DATA SHEET
PLEASE REFER TO
THE
INTRODUCTION

IMPORTANT
THESE DATA SHEETS ARE ONLY INTENDED TO GIVE GENERIC INFORMATION.
DATA ON PROPRIETARY PRODUCTS MUST BE OBTAINED FROM THE MANUFACTURERS

FUNCTION OF FIRE STOPPING AND LINEAR GAP SEALS

In the case of functional linear gap seals the seal must accommodate the function whether that be to perform as an expansion gap, a movement gap, an acoustic or weather seal. This data sheet does not assess the relative merits of the different seal types to perform these various functions. The designer/specifier should however ensure that the performance criteria can be met.

To maintain the integrity of the wall/floor/barrier for the duration defined in Table 4.8 of the *Design Guide*, when either a functional or non-functional gap exists within or at the perimeter of the element.

To restrict the rise in temperature on the surface of the wall/floor or barrier at a point where gaps exist.

Restrict the passage of smoke through such gaps for the same duration as the integrity.

In the case of functional gaps, to withstand the in-service conditions.

Withstand the deflection and any differential movement between the two surfaces/edges forming the gap which is likely to be experienced both in use and during fire exposure whilst maintaining the requirements above.

Be capable of interfacing with the appropriate associated construction and remain in place.

Maintain the seal over the life time of the building, or for a shorter duration if allowed for in the fire safety management plan, in respect of the anticipated ambient conditions.

EVIDENCE OF FIRE PERFORMANCE

Evidence of performance shall comply with all of the following:

- **Fire resistance (integrity).** The ability of the seal to maintain integrity which shall be supported by test evidence generated in accordance with an ad-hoc test using the methodology of BS476: Part 22^{1h}, or to the CEN standard EN 1364, Part 1²⁶ with respect to the associated construction appropriate to its use and preferably supported by a Field of Application Report identifying any restrictions in use.
- **Temperature rise (insulation).** The sealing system should be able to maintain the unexposed face temperature below hazardous levels offering protection consistent with the surrounding construction. This performance should be supported by test/assessment evidence as for integrity.
- **Smoke resistance.** The seal should be impermeable to smoke and the method of installation shall be such that no visible gaps exist and if possible quantifiable leakage information should be available to justify any claims made by the manufacturer or installer. Preferably the wall/ceiling/floor with system installed shall have been tested to the methodology of BS476: Part 31^{1j} and demonstrated a leakage rate of not more than 10m³/m²/hr.
- **Deflection and differential movement.** The method of installation of the seal shall be able to accommodate any in-service deflection of the adjacent elements.

- **Compatibility with associated construction.** The seal shall be able to be easily formed or otherwise able to accommodate any irregularity in the aperture, particularly fire stopping, and have sufficient adhesion to retain itself in position.
- **Durability.** Evidence shall be available to show that the materials used in the construction of the seal are not going to be adversely affected by the ambient conditions and, if appropriate, abuse during the anticipated life of the seal.

GENERIC MATERIALS USED FOR FIRE STOPPING

Linear gaps have two distinct variations as identified at the beginning of this data sheet, namely functional linear gaps or non-functional linear gaps ('fire stopping'). A number of generic non-proprietary materials have traditionally been used to 'fire stop' accidental gaps and indeed some of these materials are recognised in building regulations. This data sheet considers the relative merits and de-merits of these materials.

For functional gaps proprietary seals need to be installed. Their primary function will be to satisfy the purpose for which they have been installed and fire separation will only be a secondary function.

The following products are covered in this data sheet:

1. Non-functional linear gap seals, 'fire stopping'
 - 1.1 Mineral fibre fire stopping
 - 1.2 Cementitious materials
2. Functional linear gap seals
 - 2.1 Intumescent mastics
 - 2.2 Non-intumescent mastics
 - 2.3 Composite foam/intumescent gaskets

1. NON-FUNCTIONAL LINEAR GAP SEALS, 'FIRE STOPPING'

This section considers the merits of the materials identified in regulations by generic description as being suitable for 'fire stopping' or the sealing of non-functional gaps. The materials described under the heading of sealing functional linear gaps are also suitable for fire stopping applications.

1.1 MINERAL FIBRE FIRE STOPPING

This section only considers the performance of 'stone' or rock fibre mineral wool as glass based mineral wool melts at low temperatures and is not suitable for fire stopping applications.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** When installed correctly, i.e. the void being fully filled and the fibre well compressed, high levels of integrity can be obtained. However, the material is vulnerable to inadequate installation and is therefore very installer dependent. The mineral wool can also become detached when subjected to cyclic differential movement between elements forming the gap. The material may also be prone to damage by vermin in concealed areas. (☆☆☆☆)

- **Temperature rise (insulation).** Mineral wool has good insulating properties when installed correctly and at the proper depth but as above, the temperature rise would be increased by poor installation. (☆☆☆☆)
- **Smoke resistance.** Mineral wool is not particularly impermeable unless capped off with a sealant and as such it will permit the leakage of smoke. When it gets hot the resins will break down and produce smoke. (☆☆☆)
- **Deflection and differential movement.** Mineral wool is able to accommodate movement because of its resilience and recovery, although in cyclic, differential movement situations it may creep and work loose. (☆☆☆☆)
- **Compatibility with associated construction.** Mineral wool, unless under high degrees of compression, has a low adhesion to the associated construction but is able to accommodate irregular apertures. It is more suited to sealing gaps in vertical elements than in horizontal elements due to its low adhesion. (☆☆☆☆)
- **Durability.** Mineral wool has excellent longevity properties. (☆☆☆☆☆☆)

1.2 CEMENTICIOUS MATERIALS

This section considers the use of cement mortar, gypsum based plasters and cement plaster vermiculite mixes.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Cementitious materials have excellent integrity performance when installed correctly and with sufficient depth. Differential movement between the associated constructions bounding the gap may lead to cracking. (☆☆☆☆)
- **Temperature rise (insulation).** Cementitious materials, with the exception of gypsum based products, are relatively conductive when heated and this can lead to the temperature rise criteria being exceeded. (☆☆)
- **Smoke resistance.** Cementitious materials are impermeable and unless cracked will have excellent smoke restricting properties. (☆☆☆☆)
- **Deflection and differential movement.** Being rigid in nature the materials are not able to accommodate differential movement between adjacent elements and may crumble away, although being strong in nature they may be able to resist failing until distortion is significant. (☆☆)
- **Compatibility with associated construction.** Cementitious material have a high adhesion (except possibly on smooth surfaces), but are unable to respond to erosion of the construction. (☆☆☆☆)
- **Durability.** Most cementitious materials would be considered durable, both to physical impact and chemical/moisture attack, albeit gypsum based products may be prone to degradation with respect to the latter. (☆☆☆☆)

2. FUNCTIONAL LINEAR GAPS

This section considers the performance of sealing systems and proprietary sealants which are able to seal linear gaps in order to maintain the fire resistance of the bounding elements and to accommodate the function for which they have been installed.

2.1 INTUMESCENT MASTICS

This section considers the performance of mastic sealants, with and without a backing strip, which take advantage of the benefits of intumescent materials to provide the fire performance.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** The principle of using an intumescent mastic sealant is that the mastic quantities are chosen such that the intumescent material is able to reduce the erosion of the mastic material in order to extend the duration for which the gap can be sealed. As such, as long as the mastic is manufactured and installed within the field of application generated by the test evidence, it has adequate integrity for the application. For wide gaps a suitable backing rod may be necessary and this should feature in the evidence of performance. (☆☆☆☆☆)
- **Temperature rise (insulation).** Subject to the depth of mastic being sufficient to maintain integrity for the required duration, these are generally able to satisfy the temperature rise requirements as the activated intumescent foam has good insulating properties. (☆☆☆☆☆)
- **Smoke resistance.** Subject to the mastic bead being run continuously, the smoke resistance is excellent. (☆☆☆☆☆)
- **Deflection and differential movement.** These products have reasonable compressibility and recovery with an ability to accept movement as covered by the physical properties of the mastic and if appropriate, the backing rod. (☆☆☆☆☆)
- **Compatibility with associated construction.** The product can normally be fitted easily to an irregular aperture and the 'stickiness' or self-adhesion properties normally ensure that it stays in place. (☆☆☆☆☆)
- **Durability.** Most forms of intumescent mastic are able to withstand normal environmental conditions. Ageing tests performed by the Intumescent Fire Seals Association (IFSA) have shown that in normal internal environments intumescent products show no significant degradation³⁷. (☆☆☆☆☆)

2.2 NON-INTUMESCENT MASTICS

There are a number of materials that are used as mastics and which claim to be fire resisting. A number of these are however only conventional mastics supported by a backing rod that is in itself fire resisting. When using these materials it is important to be assured that the backing rod material is that which has been tested with the mastic. It is often the case that if a fire resisting material is used for the backing it is unlikely to have the ability to provide the functional requirement for the seal. This section mainly addresses those materials that do not rely upon a special backing rod material.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** The non-intumescent mastic seals that are not too heavily reliant on the performance of the backing rod do not have an ability to react to a gap where the edges are being eroded away. However, if the mastic is installed in compliance with the assessment or field of application report generated from the test evidence then the integrity should be adequate. Where the sealant is heavily dependent upon the performance of the backing rod then the risk of a loss of integrity is greater. (☆☆☆)
- **Temperature rise (insulation).** Non-intumescent mastics are not able to provide as much insulation as intumescent mastics because of the lack of expansion. However, if the mastic is applied at a depth sufficient to maintain integrity it should be able to at least satisfy the maximum temperature rise criterion. (☆☆)
- **Smoke resistance.** Being a mastic material, if continuously applied they should provide an adequate seal to cold smoke but may produce smoke or break down and become permeable to smoke in the 'hot' condition, especially if the backing rod does not need to have any special fire properties. (☆☆☆)
- **Deflection and differential movement.** Mastics have a reasonable tolerance to differential movement in the cold state but unlike intumescent materials they have a poor tolerance to differential movement in the hot state. (☆☆)
- **Compatibility with associated construction.** Mastic can normally be fitted easily to an irregular aperture and the natural adhesion ensures that it remains in place in the cold state. It may not remain in place so easily when hot. (☆☆☆☆)
- **Durability.** Most forms of mastic materials are able to withstand normal environmental conditions. (☆☆☆☆☆)

2.3 COMPOSITE FOAM/INTUMESCENT GASKETS

The principle of these composite systems is that the intumescent quantities are chosen such that the intumescent material is able to replace the gap produced by the foam melting or burning as a result of fire exposure (see Figure 1). These products are generally flexible and a combination of intumescent and a carrying foam based material.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** As long as the product is manufactured and installed within the field of application generated by the test evidence, it has adequate integrity for the application. (☆☆☆☆☆)
- **Temperature rise (insulation).** Subject to the depth of seal being sufficient to maintain integrity these are able to satisfy the temperature rise requirements. (☆☆☆☆☆)
- **Smoke resistance.** Subject to the foam being of a closed cell type the smoke resistance is excellent. Closed cell foams are, however, harder to compress. Open cell foams will restrict smoke but not as well as closed cell. (☆☆☆☆☆)

- **Deflection and differential movement.** These products have an excellent compressibility and recovery with an outstanding ability to accept the design movement. (☆☆☆☆☆)
- **Compatibility with associated construction.** The product can normally be specified with sufficient depth of foam and thickness of intumescent to follow an irregular aperture and the degree of compression applied to the foam normally ensures that it stays in place. (☆☆☆☆☆)
- **Durability.** The foam and most forms of intumescent are able to withstand normal environmental conditions which are supported, in part, by ageing tests performed by the Intumescent Fire Seals Association, where the sodium silicate and graphite based materials normally used in such seals have been included in long term tests in excess of 10 years. (☆☆☆☆☆)

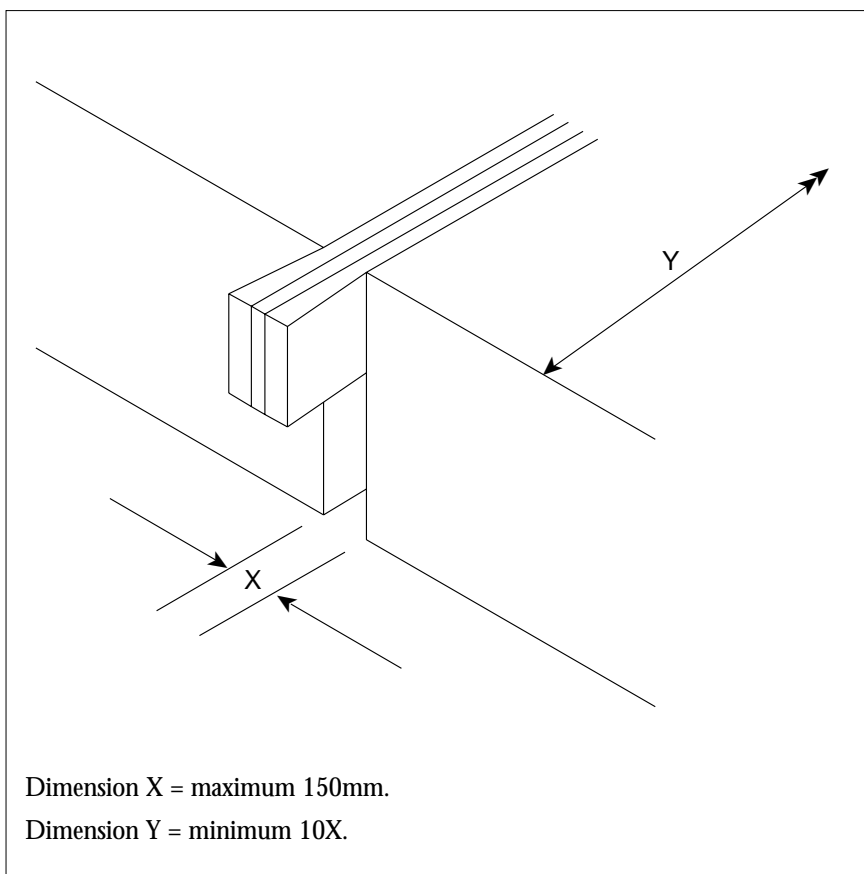


Figure 1. Composite foam/intumescent gaskets - horizontal joint.

Figure 2. Composite foam/intumescent gaskets - vertical joint.

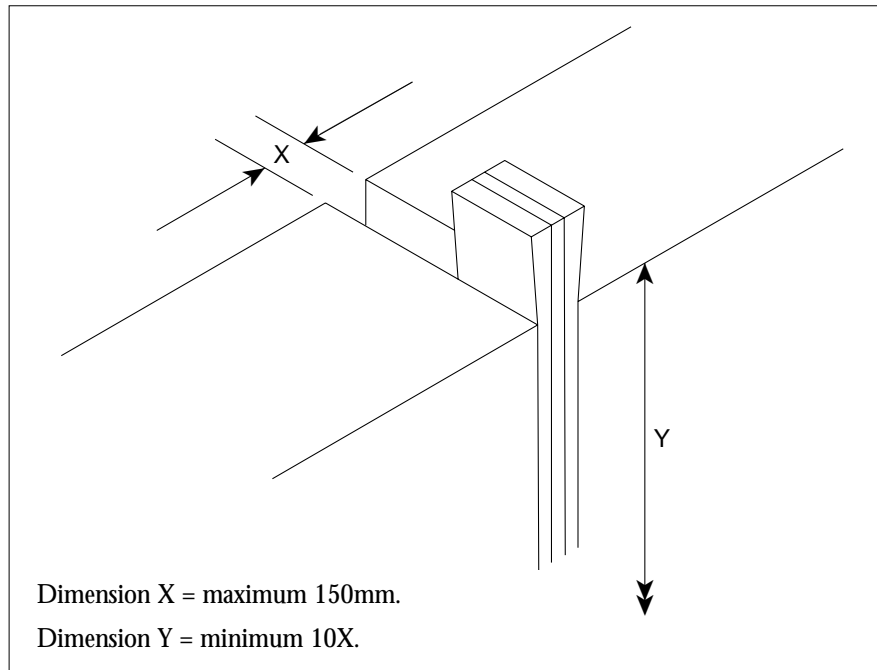


Table 1 below summarises the assessed relative abilities of the featured fire stopping and linear gap seals to satisfy the identified performance requirements.

Table1. Summary of performance data.

Requirements	Fire resistance (integrity)	Temperature rise (insulation)	Smoke resistance	Deflection and differential movement	Compatibility with associated construction	Durability
Fire stopping and linear gap seals						
1. Non-functional linear gap seals, 'fire stopping'						
1.1 Mineral fibre fire stopping	☆☆☆☆	☆☆☆☆	☆☆☆	☆☆☆☆	☆☆☆	☆☆☆☆☆
1.2 Cementitious materials	☆☆☆☆	☆☆	☆☆☆☆	☆☆	☆☆☆☆	☆☆☆☆
2. Functional linear gap seals						
2.1 Intumescent mastics	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆
2.2 Non-intumescent mastics	☆☆☆	☆☆	☆☆☆	☆☆	☆☆☆☆	☆☆☆☆☆
2.3 Composite foam/intumescent gasket	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆

INSTALLATION

The installation of fire stopping and linear gap seals should be executed by a suitably qualified person to the required standard for the appropriate system. It is advisable that where fire performance is required then an inspection by an independent body may be carried out on the completed work.

SOURCES FOR OTHER INFORMATION

Intumescent Fire Seals Association (IFSA), 20 Park Street, Princes Risborough, Buckinghamshire HP27 9AH.

Sheet No: 6.8.1

6.8 Fire resistant glazing

Fire resisting glass

Main application in respect to this *Design Guide*

- Maintaining the compartmentation when apertures are incorporated for the purposes of light or vision.
- Maintaining fire separation in walls and doors forming protected stairways and corridors when apertures are incorporated for the purposes of light or vision.
- Enclosing atria and light wells in commercial buildings when appropriate to the fire strategy used.

FUNCTION OF FIRE RESISTING GLASS

- To maintain the integrity of the compartment wall for the duration defined in the *Design Guide*, 2.4.3.
- To restrict the rise in temperature on the unexposed face to those levels required to prevent fire spread for the duration given in the *Design Guide*, 2.4.3. Normally this is for the same duration as the integrity requirement except where a clear zone policy is implemented (*Design Guide*, 4.3.3.3).
- To restrict the passage of smoke for the same duration as integrity and not generate significant volumes of smoke on the protected face.
- Not to be capable of spreading flame on the surface if used in significant areas.
- To withstand the deflection to be experienced in use, and during fire exposure, whilst maintaining the requirements above.
- To comply with appropriate safety requirements of BS 6206¹² if installed below 1.75m from floor and also of Approved Document N of the Building Regulations, England and Wales³¹.
- To be sufficiently robust in use and be of a construction or material adequate to maintain the separating performance for the life time of the building, and be readily replaceable in the event of an accident.

EVIDENCE OF FIRE PERFORMANCE

Fire resisting glasses that comply with *LPS 1158*; Issue 2²² can be used without restriction subject to them being installed in approved framing and glazing systems (Data sheet 6.8.2), in compliance with the conditions specified in the approval and the ability of the glasses to satisfy the appropriate integrity and insulation ratings for the application. Alternatively the evidence shall comply with all of the following;

BEFORE READING
THIS DATA SHEET
PLEASE REFER TO
THE
INTRODUCTION

IMPORTANT
THESE DATA
SHEETS ARE ONLY
INTENDED TO
GIVE GENERIC
INFORMATION.

DATA ON
PROPRIETARY
PRODUCTS MUST
BE OBTAINED
FROM THE
MANUFACTURERS

- **Fire resistance performance (integrity).** The ability of the glass to maintain integrity and keep the unexposed face temperature below hazardous levels shall be supported by test evidence generated in accordance with BS 476: Part 22^{1h} or EN 1364-1²⁶. The evidence shall be generated with respect to; the panes, the framing system, the glazing system and whether individual or multiple panes were tested and preferably this shall be incorporated in a field of application report identifying any restrictions in use.
- **Temperature rise (insulation).** The ability of the framing and glazing systems to resist the transfer of conducted heat to the unexposed surface to such an extent that excessive temperatures are not reached on this unexposed face. This ability shall be demonstrated and verified by test or assessment evidence in accordance with BS476: Part 22^{1h} or EN 1364-1²⁶.
- **Smoke resistance.** Monolithic glasses are generally assumed to be impermeable and hence have excellent resistance to smoke spread. Some methods of glazing may permit smoke leakage and the glazing system shall be seen to be impermeable (Data sheet 6.8.2) or the whole system should preferably have been tested to the methodology of BS 476: Part 31^{1j} and demonstrated a leakage rate of not more than 10m³/m²/hr. Some glasses are prone to producing significant volumes of smoke from the unexposed face during heating. These shall only be used when smoke removal is adequate.
- **Surface spread of flame.** The surface of the glass when tested including any laminating compound, shall have a surface spread of flame of Class 1 to BS 476: Part 7^{1d}, and be rated Class 0 as defined in England and Wales Building Regulations, Approved Document B²⁹; or other national regulations. Monolithic glass may be assumed to be Class 0 but evidence may need to be provided for laminated fire glasses.
- **Resistance to deflection.** The glass shall have been tested in a glazing frame that has a thermal response similar to that in which it is to be installed (ideally the same member size and material). That framing system must be compatible with the anticipated deflection of the wall into which it is built.
- **Safety rating/impact resistance.** The glass shall have been tested in accordance with BS 6206¹² and achieved a safety rating of class A or B.
- **Durability.** Evidence shall be available to show that the glass used in the glazed aperture is not going to be adversely affected by the ambient conditions and is robust enough in use to withstand anticipated impacts during the life of the building, unless the building management system is demonstrated as being able to replace any damaged glass almost immediately. If the glass achieves the Class A or B impact performance, as discussed in the preceding section, without breaking, it is suitable for use without restriction.

This data sheet considers in detail the following generic glass types:

1. Integral wired, soda/lime composition glasses
2. Non-integral wired, soda/lime composition laminated glasses

3. Unwired, monolithic float glasses of borosilicate composition
4. Unwired, edge controlled, toughened, clear, monolithic glasses of soda/lime composition
5. Unwired, edge controlled, toughened, surface coated monolithic glasses of soda/lime composition
6. Unwired, monolithic glasses of ceramic composition
7. Unwired, non-intumescent laminated glasses of soda/lime composition
8. Unwired, intumescent laminated glasses of soda/lime composition
9. Unwired, intumescent 'gel' filled glass units.

The ability of these glasses to meet the function is described below, assuming compatible glazing and framing systems.

1. INTEGRAL WIRED, SODA/LIME COMPOSITION GLASSES

Wires are physically inserted into the glass during the molten stage of glass manufacture. This has a major contribution to the fire performance characteristics when compared to non-integral wired products where wires are sandwiched between preformed glass panes (see Figure 1).

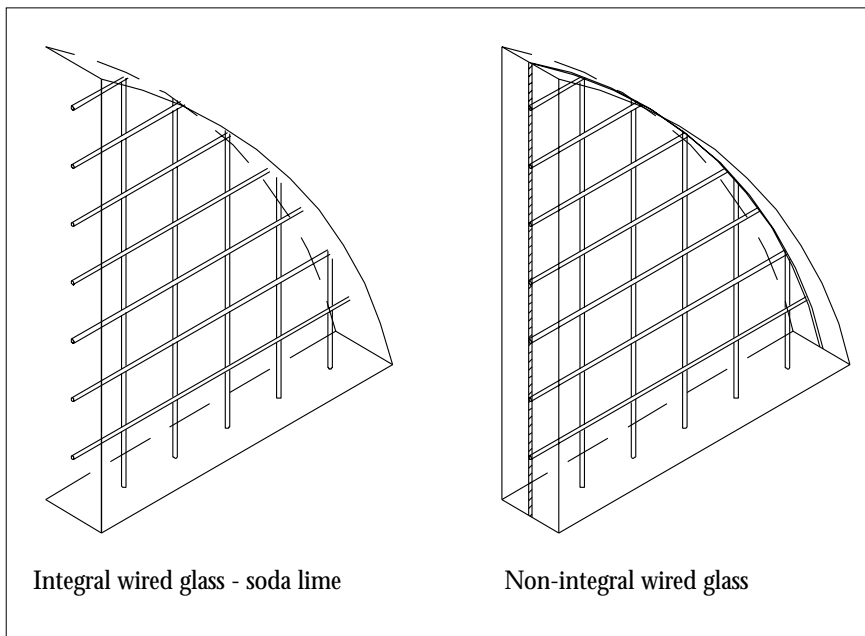


Figure 1. Typical non-insulating fire glasses.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** These glasses are able to provide a 30 minute integrity rating at large pane sizes and 60 minutes at moderate pane sizes and even larger durations in small sizes if an insulating or pressure producing glazing system is used. Larger pane sizes at 60 minutes or more may require the use of adhesives. The use of such products shall be identified on a permanent metal plate fixed adjacent to the glass to ensure correct glazing practice should it be replaced (☆☆☆).

- **Temperature rise (insulation).** The glass is unable to provide significant levels of insulation and may only be used in compartment walls when a clear zone policy is implemented, taking into account the anticipated level of radiation. The glass may be used for the protection of escape routes as permitted in Table 8 of BS 5588: Part 11^{7b} without restriction (☆).
- **Smoke resistance.** Impermeable and does not produce smoke. (☆☆☆☆☆).
- **Surface spread of flame.** Class 0 and non-combustible. (☆☆☆☆☆)
- **Deflection.** Able to withstand high levels of deflections (☆☆☆☆☆).
- **Safety rating.** The safety version, with thicker wire is available with a Class C rating whilst the ordinary wired glass is not considered to be a safety glass. (☆☆☆☆)
- **Durability.** The glass is inert and robust and resistant to impact. (☆☆☆☆☆)

2. NON-INTEGRAL, LAMINATED, WIRED, SODA/LIME COMPOSITION GLASSES

Sheets of Soda-lime glass sandwiching a wire mesh. The sheets of glass either side of the wire lattice are held together by a resin bonding material.

FIRE PERFORMANCE DATA

- **Fire resistance performance (integrity).** Not known to be capable of providing in excess 30 minutes integrity classification in anything but modest sized panes. Appropriate test and or assessment evidence should be sought for applications in excess of 60 minutes. (☆☆)
- **Temperature rise (insulation).** May be able to produce non-hazardous unexposed face temperatures for 15 minutes but generally only to be used with 'clear' zones. (☆☆).
- **Smoke resistance.** All glasses of this family of products will produce smoke from the unexposed face, many of them in excessive quantities and often toxic. (☆☆)
- **Surface spread of flame.** The spread of flame properties may be influenced by the interlayer and test evidence needs to be examined. (☆)
- **Deflection.** Not able to accept deflections. (☆)
- **Safety rating.** Class B to BS 6206¹². (☆☆☆☆☆)
- **Durability.** Evidence shall be sort from the manufacturer.

3. UNWIRED, MONOLITHIC FLOAT GLASSES OF BORO-SILICATE COMPOSITION

A clear glass manufactured by the float process but using a low expansion composition derived from glass ovenware. Originally manufactured by a drawing process (see Figure 1).

N.B. Not rated, compliance to be judged on any evidence available.

FIRE PERFORMANCE DATA

- **Fire resistance performance (integrity).** Borosilicate glass can achieve integrity ratings of 240 minutes. (☆☆☆☆☆)

- **Temperature rise (insulation).** As for integral wired glass. (☆)
- **Smoke resistance.** Impermeable and does not produce smoke. (☆☆☆☆☆)
- **Surface spread of flame.** Class 0 and non-combustible. (☆☆☆☆☆)
- **Deflection.** Strong and reasonably able to withstand high levels of deflection if properly glazed. (☆☆☆☆)
- **Safety.** Class A to BS 6206¹². (☆☆☆☆☆)
- **Durability.** The glass is inert and is resistant to impact damage except that generated by items with sharp edges, particularly at increased thicknesses of 8 or 10mm. Severe scratches can impair performance. (☆☆☆☆)

4. UNWIRED, EDGE CONTROLLED, TOUGHENED, MONOLITHIC GLASSES OF SODA/LIME COMPOSITION

Whilst being of a soda/lime composition with high rate of thermal expansion toughening, polishing the edges and severely restricting the edge cover to no more than 10mm prevents these glass types from cracking when heated.

FIRE PERFORMANCE DATA

- **Fire resistance performance (integrity).** The restrictive edge cover (a maximum of less than 10mm) prevents these glasses from achieving integrity ratings of more than 30 minutes in large panes without the use of adhesives. As with wired glass installations the use of adhesives shall be permanently identified by a metal plate fixed adjacent to the pane(s). (☆☆)
- **Temperature rise (insulation).** As for integral wired glass. (☆)
- **Smoke resistance.** As for integral wired glass. (☆☆☆☆☆)
- **Surface spread of flame.** As for integral wired glass. (☆☆☆☆☆)
- **Deflection.** Sensitive to high levels of deflections whilst cool, i.e. in the early stages of a fire, and requires a compatible glazing system. (☆☆☆☆)
- **Safety.** Class A to BS 6206¹². (☆☆☆☆☆)
- **Durability.** The glass is inert and being toughened is able to withstand impacts as long as they are not produced by an item with a sharp edge. Surface scratches can impair performance. (☆☆☆)

5. UNWIRED, EDGE CONTROLLED, TOUGHENED, SURFACE COATED MONOLITHIC GLASSES OF SODA/LIME COMPOSITION

This glass has similar characteristics to the glass described in 4 above, except the coating reflects some of the fire heat and is therefore more tolerant of thermal differentials allowing it to be installed with edge cover 40% greater (see Figure 1).

FIRE PERFORMANCE DATA

All of the performance statements given for non-coated edge controlled, toughened glass above apply except:

- **Fire resistance performance (integrity).** The edge cover restriction being increased by 40% over that for the non-coated glass allows the glass edge to be cooler and hence moderate sized panes should be able to achieve 60 minutes integrity up to 1.75m². With the use of adhesives they can be used to 3.5m². Large panes will, however need adhesives as well if it is to achieve 90 minute integrity. The use of adhesives shall be permanently identified by an adjacent metal plate as for integral wired glass. (☆☆☆)

6. UNWIRED, MONOLITHIC GLASSES OF CERAMIC COMPOSITION

These products are not truly 'glass' but being transparent they are accepted as such. Ceramic is a zero expansion product making it very tolerant of high temperature exposure. Only 5mm thick (see Figure 1).

FIRE PERFORMANCE DATA

- **Fire resistance performance (integrity).** Capable of achieving 240 minutes, or more, in any orientation. (☆☆☆☆☆)
- **Temperature rise (insulation)** As for integral wired glass (☆). Except when laminated to toughened or laminated glass for safety purposes where smoke is generated. (☆☆)
- **Smoke resistant.** As for integral wired glass. (☆☆☆☆☆)
- **Surface spread of flame.** As for integral wired glass. (☆☆☆☆☆)
- **Deflection.** Good resistance to deflection. (☆☆☆☆)
- **Safety.** Not a safety glass (no rating). If the product is laminated to safety glasses in which case it becomes Class A. (☆☆☆☆☆)
- **Durability.** Inert, but being only 5mm thick it is not as resistant to impact as other monolithic clear glasses. Unaffected by surface scratching. Impact resistance increased when laminated for safety. (☆☆☆☆)

7. UNWIRED, NON-INTUMESCENT, LAMINATED GLASSES OF SODA/LIME COMPOSITION

These are of the same basic construction as the non-integral wired glass, having only one interlayer, and have the same characteristics.

FIRE PERFORMANCE DATA

The performance is as for non-integral, laminated, wired, soda/lime composition glass above.

8. UNWIRED, INTUMESCENT LAMINATED GLASSES OF SODA/LIME COMPOSITION

These are generally constructed from 3mm thick float, soda/lime glasses laminated with interlayers containing clear intumescent which provides fire insulation and reduces radiation significantly. For external applications an additional layer of glass is laminated to the intumescent glass by an interlayer which provides ultra-violet (u/v) protection. The number of 'active' interlayers generally ranges from 1 to 5 depending upon the rating (see Figure 2).

FIRE PERFORMANCE DATA

- **Fire resistance performance (integrity).** These glasses can have integrity ratings of up to 120 minutes depending upon pane size and the number of layers. (☆☆☆☆)

- **Temperature rise (insulation).** The objective of these glasses is to restrict the temperature rise to below that which produces a hazard. Even after the normal limiting temperature rises associated with the insulation criteria has been reached they will continue to provide a barrier to radiation for a significant additional period, up to 100% for 30 minute glasses. (☆☆☆☆☆)
- **Smoke resistance.** Impermeable and non-smoke producing on unexposed face. (☆☆☆☆☆)
- **Surface spread of flame.** Class 0. (☆☆☆☆☆)
- **Deflection.** Normally tolerant of deflection. (☆☆☆☆☆)
- **Safety.** Class A to BS 6206. (☆☆☆☆☆)
- **Durability.** Edges of the glass must be protected from moisture which will make the product unsightly, albeit this may not significantly affect the fire performance. They are robust. (☆☆☆☆)

9. UNWIRED, INTUMESCENT 'GEL' FILLED GLASS UNITS

These glasses consist of 2 or 3 layers of 3mm thick float glass with a thick 'gel' interlayer containing clear intumescent compounds. When heated the 'gel' becomes an opaque insulating slab (see Figure 2).

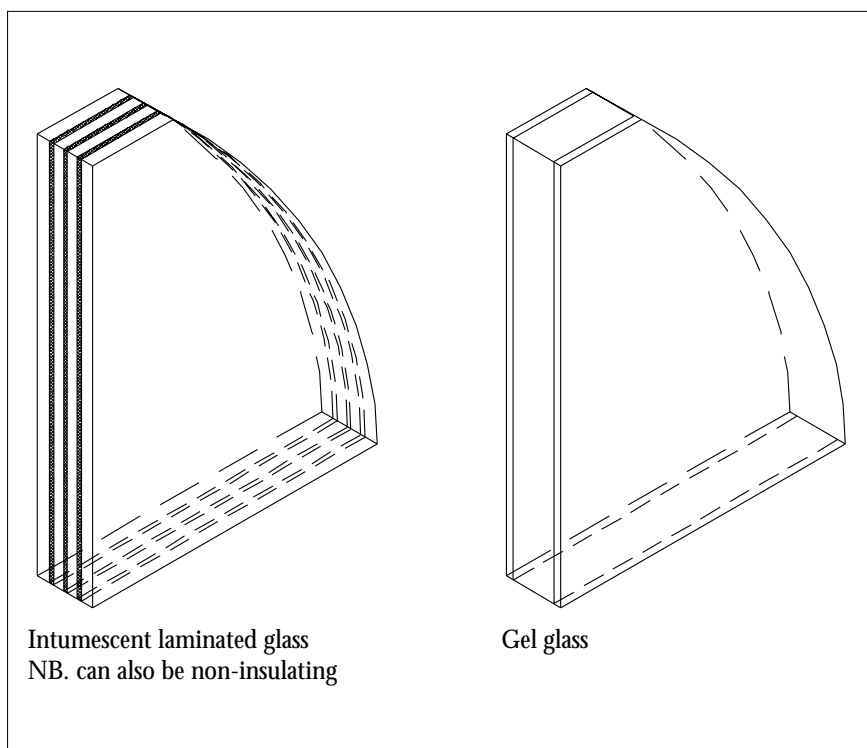


Figure 2. Typical insulating fire glasses.

FIRE PERFORMANCE DATA

- **Fire resistance performance (integrity).** These glasses are able to provide integrity ratings of up to 120 minutes depending upon thickness of 'gel', number of layers and area. (☆☆☆)
- **Temperature rise (insulation).** As for laminated intumescent glasses these glass types have been designed to restrict temperature rise to below that which produces a hazard. Thickness and weight limits their suitability for durations, above 90 minutes in large panes. (☆☆☆☆)
- **Smoke resistance.** Impermeable and not smoke producing on the unexposed face. (☆☆☆☆☆)
- **Surface spread of flame.** Class 0 for the surface glass but nothing known about the glass and gel interlayer. (☆☆☆☆☆)
- **Deflection.** Normally tolerant of deflection. (☆☆☆☆☆)
- **Safety.** Class A to BS 6206¹². (☆☆☆☆☆)
- **Durability.** Less prone to moisture affects than laminated glass and generally appears to be inert in use. Strong and impact resistant. (☆☆☆☆☆)

SPECIAL CONSIDERATIONS

There are a number of post-manufacturing features that may be used in conjunction with fire resisting glass:

- laminating additional glasses to increase vandal/crime resistance or change colour etc.;
- adding decorative features by etching, painting, the application of decals or markings;
- using as part of a double glazed unit.

These can all have a significant impact on the performance and only processes for which evidence of performance is available should be used. Problems that may be encountered are:

- Any additional interlayer may be combustible and cause flaming on the unexposed face, probably at an early stage, compromising integrity and possibly surface spread of flame and smoke production. Laminating with polycarbonate to increase impact resistance will compromise the integrity.
- Etching or sand blasting of the glass surface of monolithic unwired glass may induce stresses which will cause the glass to fail when heated. Decals or trim glued to the face of the glass may produce temperatures that can cause unwired glasses to fracture when heated.
- Double glazed units can build-up pressure between the panes during heating possibly resulting in the failure of one of them. This must not be the fire glass. Aluminium spacers melt-out in a fire and this may compromise integrity at the edges.

FRAMING AND GLAZING SYSTEMS

The selection of the framing and glazing system is often critical to the performance and the guidance contained within this data sheet assumes that

SUMMARY OF PERFORMANCE DATA

Table 1 below summarises the assessed relative abilities of the featured materials to satisfy the identified performance requirements.

Table 1. Summary of performance data.

Requirements	Fire resistance (integrity)	Temperature rise (insulation)	Smoke resistance	Surface spread of flame	Loading and deflection	Safety rating	Durability - impact resistance
Cavity barrier materials							
Integral wired, soda/lime composition glasses	☆☆☆	☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆
Non-integral laminated wired, soda/lime composition glasses	☆☆	☆☆	☆☆	☆	☆	☆☆☆☆☆	*
Unwired, monolithic float glass of boro-silicate composition	☆☆☆☆☆	☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆
Unwired, edge controlled, toughened, monolithic glass of soda/lime composition	☆☆	☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆
Unwired, edge controlled, toughened, surface coated monolithic glasses of soda/lime composition	☆☆☆	☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆
Unwired, monolithic glasses of ceramic composition	☆☆☆☆☆	☆ If laminated (☆☆)	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆
Unwired, non-intumescent laminated glasses of soda/lime composition	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆
Unwired, intumescent laminated glasses of soda/lime composition	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆
Unwired, intumescent 'gel' filled glass units.	☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆

* Evidence shall be sought from manufacturer

the system is either as tested, or is compatible. Information on framing and glazing systems relating to the compatibility with the glasses covered is to be found in Data sheet 6.8.2.

INSTALLATION

The installation of fire glass is important, particularly with edge controlled, monolithic unwired glass types. Glass should *always* be installed strictly in compliance with the manufacturers recommendations, using trained staff.

The edges of any monolithic unwired glass shall never be damaged nor stood on edge on hard, 'gritty' surfaces. Wood bearers, carpet or cloth should be used to stand the glass on. The maximum edge cover restrictions which apply to the edge controlled glasses shall *never* be exceeded on *any* edge. Suitable spacers shall be used to equalise the edge cover (Data sheet 6.8.2). The glass edge shall not be in contact with any metal fixing, e.g. screw or pin.

WARNING: When fire resisting glass is used in conjunction with sprinklers, and where the glass is adjacent to sprinkler heads, i.e. within 2.5m, to one side or below, the effect of the water spray needs to be considered on the integrity and smoke tightness of the system.

OTHER SOURCES OF INFORMATION

European Federation of Fire Separating Element Producers (EFFSEP)

Fire Resisting Glazing Advisory Service (FRGAS)

Intumescent Fire Seals Association (IFSA)

Note: the above can be contacted at:

20 Park Street, Princes Risborough, Buckinghamshire HP27 9AH

Glass and Glazing Federation (GGF), 44-48 Borough High Street, London, SE1 1XB.

List of Approved Fire and Security Products and Services, The Loss Prevention Certification Board, Melrose Avenue, Borehamwood, Hertfordshire WD6 2BJ.

Sheet No: 6.8.2

6.8 Fire resistant glazing

Fire resistant glazing systems and framing

Main application in respect to this *Design Guide*.

The performance of fire resisting glass is inextricably linked to the ability of the framing and glazing system to provide the conditions required by the glass to maximise its performance. *This data sheet needs to be read in conjunction with Data sheet 6.8.1; Fire resisting glass which identifies some of the critical characteristics of the fire resisting glasses that need to be reproduced by the framing and glazing system.* Fire resisting glazing systems are specified within the *Design Guide* for the following uses:

- Maintaining the compartmentation when apertures are incorporated for the purposes of light or vision.
- Maintaining fire separation in walls and doors forming protected stairways and corridors when apertures are incorporated for the purposes of light or vision.
- Enclosing atria and light wells in commercial buildings when appropriate to the fire strategy used.

FUNCTION OF FIRE RESISTING GLAZING SYSTEMS AND FRAMING

To provide the associated fire resisting glass with the support and edge conditions for the following:

- To maintain the integrity of the compartment wall for the duration defined in Table 2.2 of the *Design Guide*.
- To restrict the rise in temperature on the unexposed face to those levels required to prevent fire spread for the duration given in Table 2.2 of the *Design Guide*. The framing need not comply with the insulation criteria if the temperature rise due to the radiation emitted by the framing does not compromise the integrity requirement, i.e. where a clear zone policy is implemented.
- To resist the passage of smoke for the same duration as integrity and not generate significant smoke on the unexposed face.
- To withstand the deflections and any loading generated by the associated construction to which it is fixed.
- To be able to resist impact loads relevant to its use in the building, particularly, where appropriate, loading due to human forces.
- To be sufficiently robust in use and be of a construction or material adequate to maintain the fire separating performance for the life time of the building.

NOTE: Framing systems are exempt from any restriction on surface spread of flame.

BEFORE READING
THIS DATA SHEET
PLEASE REFER TO
THE
INTRODUCTION

IMPORTANT
THESE DATA SHEETS ARE ONLY INTENDED TO GIVE GENERIC INFORMATION.
DATA ON PROPRIETARY PRODUCTS MUST BE OBTAINED FROM THE MANUFACTURERS

EVIDENCE OF FIRE PERFORMANCE

Fire resisting glazing and framing systems that comply with LPS 1158: Issue 2²² can be used without restriction and subject to the appropriate fire resisting glass being installed in compliance with the conditions specified in the approval.

Alternatively the evidence shall comply with all of the following:

- **Fire resistance performance (integrity).** The ability of the framing and glazing systems to maintain integrity and, if appropriate, keep the unexposed face temperature below hazardous levels (only appropriate to insulated glasses in some applications) shall be supported by test evidence generated in accordance with BS 476: Part 22^{1h} or EN 1364: Part 1²⁶ or this evidence shall be generated with respect to; the glass type, the glazed area and the number of frames tested in the test construction and preferably this shall be incorporated in a field of application report identifying any restrictions in use.
- **Temperature rise (insulation).** The ability of the framing and glazing systems to resist the transfer of conducted heat to the unexposed surface to such an extent that excessive temperatures are not reached on this unexposed face. This ability shall be demonstrated and verified by test or assessment evidence in accordance with BS476: Part 22^{1h}, or EN 1364: Part 1²⁶.
- **Smoke resistance.** The framing system and glazing system shall effectively be impermeable and shall not produce significant volumes of smoke from the unexposed face during heating, or the whole system together with the glass shall have been evaluated with respect to BS 476: Part 31^{1j} and demonstrated a leakage rate of not more than 10m³/m²/hr. Glazing systems that incorporate solid strips of intumescent material are considered impermeable.
- **Deflection.** The method of installation shall be able to accommodate the deflections imposed by the associated constructions, above, below and to each side of the screen. Either fire resistance test evidence generated in similar forms of construction and/or design calculations may be required to substantiate this. (See Appendix 3D and the flow chart of decisions in Figures 3.18 (1)-(3) of the *Design Guide*.)
- **Impact resistance.** The framing system shall be adequately strong to resist anticipated impacts and preferably be rated at least as heavy duty in respect of BS 5234: Part 2⁴ Specification for Performance Requirements for Strength and Robustness Including Methods of Test and installed in accordance with Part 1 of that standard.

Where the construction is used in commercial buildings adjacent to high pedestrian use, e.g. staircases and atrium walls, then the construction will satisfy the requirements of BS 6180:1985¹¹ (Code of Practice for Barriers in and about Buildings) appropriate to the class of end user group for which the barrier is designed.

The glazing system should also comply with the recommendations of Approved Document M of the Building Regulations England and Wales³⁰.

- **Durability.** The framing systems shall be robust enough to last the lifetime of the building when subject to normal use and abuse. Evidence shall be available to show that the materials used in the glazing systems are not going to be adversely affected by the ambient conditions anticipated during the life of the glazed screen. Materials subject to LPC's analysis of the longevity of intumescent materials are deemed to meet this requirement.

FRAMING SYSTEMS

This section considers the following framing materials:

1. Timber
 - 1.1 Softwood
 - 1.2 Hardwood
2. Mineral boards/sections
3. Metal
 - 3.1 Aluminium
 - 3.2 Steel

The selection of glazing system is critical to maximising the performance with the selected glass. The fixing of the glazing beads is also important. Figure 1 shows typical fixings for timber based systems and Figures 2 and 3 show typical fixings for metal based systems. In all cases screws are preferred.

FRAMING MATERIALS

1.1 TIMBER - SOFTWOOD

Softwoods, in the context of this data sheet include all species where the charring rate is more than 0.5mm/min. This is normally, although not always, associated with densities less than 650kg/m³, when dry.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Generally restricted to 30 minutes when used with non-insulating fire glasses. Beads need to be angled as shown in Figure 4 and of at least 15mm glass edge depth. The bead profile and size will be a function of the level of performance required and of the glass being used and will normally limit integrity. May be suitable for 60 minute applications in large section sizes with moderate sized panes of insulating glass. (☆☆)
- **Temperature rise (insulation).** Excellent subject to duration restrictions given above. Has to burn through to produce hazardous conditions. (☆☆☆☆)
- **Smoke resistance.** Timber is impermeable and the methods of jointing are normally adequate to resist smoke penetration. Only small quantities of smoke will be given off on unexposed face with non-insulating glasses. (☆☆☆☆)
- **Deflection.** The section size can be increased to withstand deflections from adjacent construction and being inert, with a slight tendency to shrink it will not produce incompatible movement. (☆☆☆☆)

- **Impact resistance.** Framing member can be increased to resist impact and loads. (☆☆☆☆)
- **Durability.** Good, unless damp conditions prevail, i.e. partly exposed or fully exposed conditions. (☆☆☆☆)

1.2 TIMBER - HARDWOOD

Hardwoods, in the context of this data sheet includes all species where the charring rate is 0.5mm/min or better. This is normally, although not always, associated with densities in excess of 650kg/m³, when dry.

FIRE PERFORMANCE DATA

The performance of hardwood in respect of the identified requirements is similar to softwood, except for:

- **Fire resistance (integrity).** The slower charring rate allows hardwood to be used for 60 minute applications with non-insulating glass but bead profile and depth normally not less than 20mm is critical to the performance and a glazing system that incorporates a frame liner is invariably required (Figure 4). In large section sizes hardwood may be used for 90 minute integrity systems with insulating glass but evidence would have to be available. (☆☆☆)

2. MINERAL BOARDS/SECTIONS

This is a modern development where sections of mineral based compounds are either cast or machined to form framing members and/or glazing beads which may be veneered to look like timber.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Depending upon the size, composition and method of fixing together these systems may provide integrity ratings up to 120 minutes. (☆☆☆☆)
- **Temperature rise (insulation).** Generally good but depends upon the density, specific heat capacity and thermal conductivity. Whilst the conditions may be hotter than on the unexposed of the insulating glass they should not be hot enough to create a hazard. Any veneer may need to be flame retardant treated when used with non-insulating glass or for prolonged durations. (☆☆☆☆)
- **Smoke resistance.** Impermeable and generally non-smoke producing. (☆☆☆☆)
- **Deflection.** May need reinforcing to withstand large deflections from imposed loads although strong in compression when resisting vertical loads. (☆☆☆)
- **Impact.** Not strong with respect to impact. Reinforcement or large section sizes needed to meet the requirements. (☆☆☆)
- **Durability.** Generally inert but may be affected by moisture in partially exposed, or damp conditions. (☆☆☆☆)

3.1 METAL - ALUMINIUM

Aluminium is only normally used for framing glass in conjunction with steel stud partitioning systems and often only has a decorative role.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Low due to melting temperature. A maximum of 30 minutes and often this needs backing-up with steel or mineral/gypsum boards. (☆)
- **Temperature rise (insulation).** Aluminium is highly conductive. (☆)
- **Smoke Resistance.** Impermeable except for joints and non-smoke producing. Joints tend to be dry and could leak smoke. (☆☆☆)
- **Deflection.** Weak when hot and not able to resist deflection readily. (☆)
- **Impact.** All depends upon jointing and possible reinforcement with steel studs. (☆☆)
- **Durability.** Good durability. (☆☆☆☆☆☆)

3.2 METAL - STEEL

Steel sections form the majority of all high performance fire resistant glazed screens using a wide range of commercially available sections.

FIRE PERFORMANCE DATA

- **Fire resistance (integrity).** Suitable for integrity periods of up to four hours with suitable glass. (☆☆☆☆☆☆)
- **Temperature rise (insulation).** Steel is conductive and will not satisfy insulation for 30 minutes without protection. The sections are thin, however, and the radiation component of the total heat flux from the screen is low. Unless combustible materials are touching the exposed face the conditions are not very hazardous in the area in front of steel framed screens, solely as a result of the steel, i.e. when used with insulating glass. Fire protection board is applied to the faces of the sections to satisfy the insulation criteria for durations up to 120 minutes. (☆☆☆☆)
- **Smoke resistance.** Impermeable, normally welded joints and non-smoke producing, excellent (☆☆☆☆☆☆).
- **Deflection.** Strong, even when hot and normally able to withstand imposed deflections and loads. (☆☆☆☆☆☆)
- **Impact.** When properly jointed these are usually strong enough to meet all loading requirements but section sizes need to be adequately designed based upon tests or engineering calculations. (☆☆☆☆☆☆)
- **Durability.** Stable and inert when coated and in normal atmospheres. (☆☆☆☆☆☆)

Note: Steel does distort significantly when heated and the fixings need to be able to resist this. Also the glass and glazing system shall be selected in the knowledge of this behaviour.

GLAZING SYSTEMS COMPONENTS

This section considers the following glazing systems on a generic basis and identifies their compatibility with glasses and framing systems in Table 3 of this data sheet. In all cases LPCB approval or test evidence should be available to support the exact material used.

1. Intumescent glazing materials (I)
 - 1.1 Sealants (gunnable) (IS)
 - 1.2 Prefabricated strips
 - Low pressure (IPSL)
 - High pressure (IPSH)
 - 1.3 Channel sections (ICS)
2. Ceramic fibre tapes (CFT)
3. Closed cell elastomeric foam tapes (EFT)
4. All-in-one glazing systems (GS)

Because they only make a contribution to a limited range of the performance requirements, only those aspects critical to their performance are reviewed. Wired glass and monolithic unwired glasses rely on the glazing system to create either a 'cool' edge around the perimeter of the pane or pressure to the perimeter to resist 'slumping' (excluding ceramic glass). The ability of the materials, used in the glazing system, to provide this are considered. The impact of the glazing system/material on the critical edge condition of the glass is also considered.

1. INTUMESCENT GLAZING MATERIALS

These are normally, but not exclusively, used for timber framing where it is necessary because the beads and framing are consumed during fire attack.

1.1 INTUMESCENT SEALANTS

There are a wide range of formulations with high and low volumes of expansion and high and low levels of pressure generation. Ideally suited for timber applications where groove depth and gap width can vary. High expansion products must not be used with edge controlled monolithic glasses (Data sheet 6.8.1). High pressure products such as graphite compounds should not be used with pinned timber beads or clip-on metal beads nor in conjunction with intumescent glasses. High pressure products can help to clamp glass in position in metal systems. One hour timber systems normally require a line of impermeable strip material, ceramic fibre paper or intumescent around the aperture before fixing glass and beads.

FIRE PERFORMANCE DATA

- **Durability.** Good when formulated to resist moisture or have been the subject of ageing tests. (☆☆☆☆)

1.2 INTUMESCENT PREFABRICATED STRIPS

Like sealants these come in a range of expansions and a range of pressures. The identifications IPSH and IPSL in Table 3 of this data sheet denote high and low pressure formulations respectively. The limitations given for sealants above

apply to strips. High pressure forming strips such as sodium silicate or graphite based formulations help to 'clamp' glass into place and allow either longer durations or larger pane sizes with monolithic glasses. As with sealants, liners are invariably required with 60 minute timber systems.

FIRE PERFORMANCE DATA

- **Durability.** As for sealants but in addition all strips protected by plastic cases can be considered durable. Strip edges should be sealed when they are to be used in known moist applications. (☆☆☆☆)

1.3 INTUMESCENT CHANNEL SECTIONS

There are two primary types - elastomeric channels manufactured with rubber containing intumescent compounds and pvc 'U' - channels containing sodium silicate strips. These are both designed to provide 30 and 60 minutes integrity in timber based systems, albeit the elastomeric channels work well in metal glazing systems for 30 minute applications. Neither product produces high levels of expansion, and subject to meeting the maximum edge cover restrictions (Data sheet 6.8.1), they are compatible with most edge controlled glasses. Elastomeric gaskets can also be used with laminated intumescent glasses.

FIRE PERFORMANCE DATA

- **Durability.** Generally inert in use or protected. (☆☆☆☆)

2. CERAMIC FIBRE TAPES

These are not suitable for use in timber glazing systems where the glazing pocket becomes eroded by the fire. They are able to provide integrity ratings of up to 240 minutes used in conjunction with ceramic glass because they are able to be compressed when the beads are applied providing both a 'cool' edge and a clamping force. The degree of compression and width of tape are important factors. These can be used with insulated glasses but shall not be compressed as this may interfere with the glass expansion.

FIRE PERFORMANCE DATA

- **Durability.** Inert, excellent. (☆☆☆☆☆)

3. ELASTOMERIC CLOSED CELL FOAM TAPES

These are designed solely for use with insulating glasses which need room to expand and preferably in conjunction with timber or low integrity duration steel framing systems. They shall not be used with non-insulating glass.

FIRE PERFORMANCE DATA

- **Durability.** Depends upon manufacturer but assumed to be moderately durable. (☆☆☆☆)

4. ALL-IN-ONE GLAZING SYSTEMS

There is only currently one system, which consists of thick calcium silicate boards cut into strips and with a groove machined into the upper surface to accept the glass. The channels when used with 6mm thick wired and unwired monolithic non-insulating glasses can achieve up to 60 minutes integrity. They are designed solely for use in timber framing systems, particularly timber

doors. The bead section on the unexposed face is tolerant of radiation as it is non-combustible. Timber effect and veneer finished sections may be available however test evidence should be sought to support the effect such finishes have on possible premature ignition from radiation on the unexposed face. The typical loose fit means that neither a cool edge nor clamping can be achieved which will therefore limit the permissible pane sizes achievable.

FIRE PERFORMANCE DATA

- **Durability.** Good as calcium silicate is generally inert. The intumescent coating may be damaged by water and if wet the channel may suffer if subjected to frost. Only use in dry frost free environments. (☆☆☆)

SPECIAL CONSIDERATIONS

Double glazed units and any laminated fire glasses will require a special glazing system to compensate for the possible loss of the non-fire rated glass.

Because of the radiation and convection currents on the non-exposed face of timber framing systems the bead profile and the amount and nature of the expanded intumescent are vital to the performance. The expanded intumescent can provide a mask to restrict the radiation from falling onto the face of the unexposed face bead. Intumescent materials have different foam qualities and expansion rates and solutions are probably very material specific, particularly at 60 minute integrity ratings.

Figure 1. Typical fixings for timber based systems.

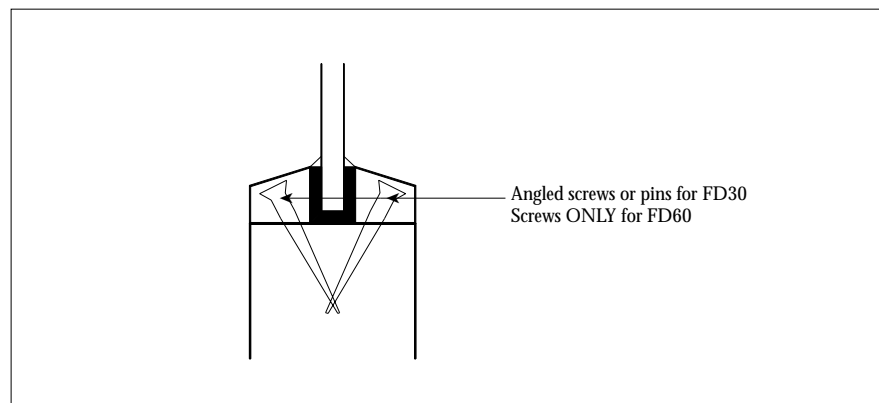


Figure 2. Typical fixing for metal based systems.

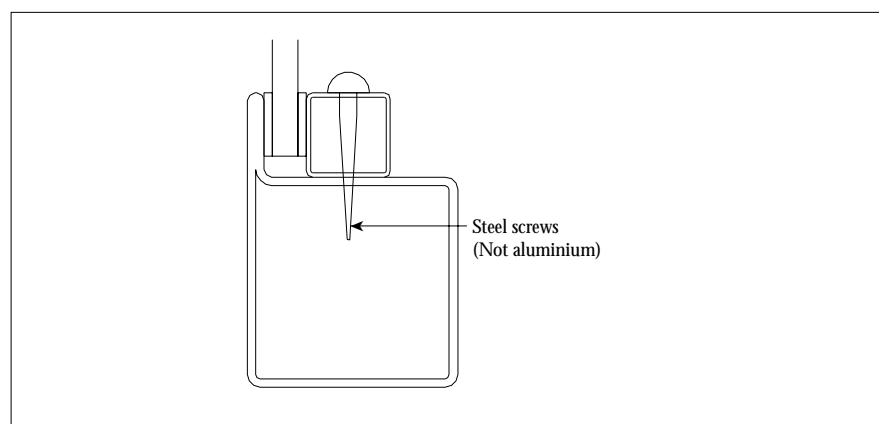


Figure 3. Typical fixing for metal based systems.

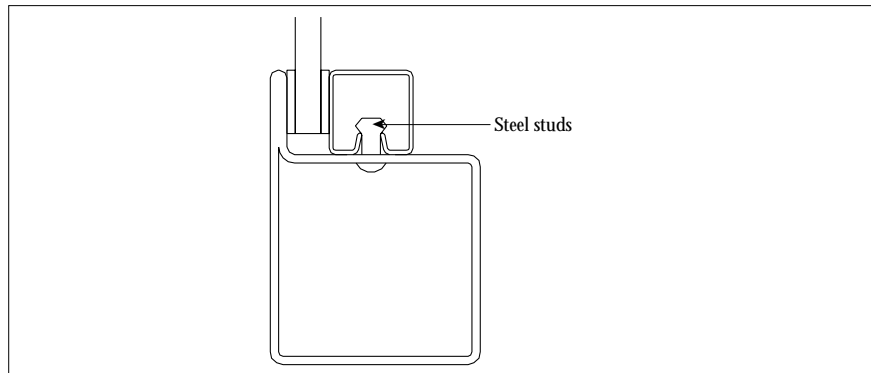
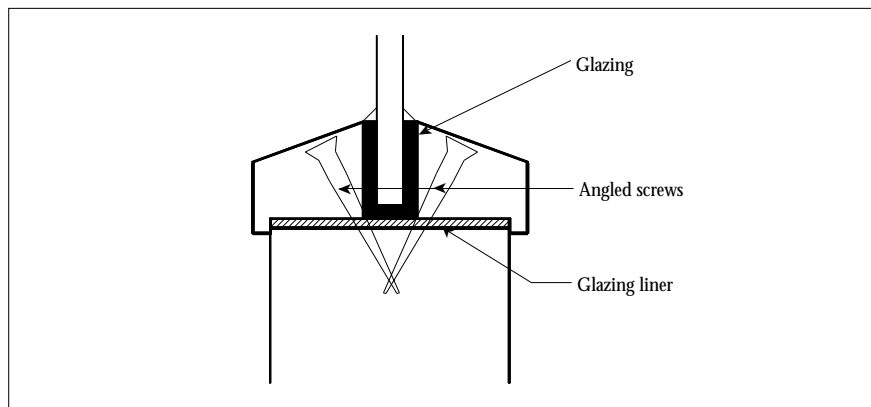


Figure 4. System with a glazing liner.



SUMMARY OF PERFORMANCE DATA

Table 1 - Summary of relative performance standards for generic types of framing systems.

Requirements	Fire resistance (integrity)	Temperature rise (insulation)	Smoke resistance	Deflection	Impact resistance	Durability
Framing material						
1.1 Timber - softwood	☆☆	☆☆☆☆	☆☆☆☆	☆☆☆☆	☆☆☆☆	☆☆☆☆
1.2 Timber - hardwood	☆☆☆	☆☆☆☆	☆☆☆☆	☆☆☆☆	☆☆☆☆	☆☆☆☆
2. Mineral board sections	☆☆☆☆	☆☆☆☆	☆☆☆☆☆	☆☆☆	☆☆☆	☆☆☆☆
3. Aluminium	☆	☆	☆☆☆	☆	☆☆	☆☆☆☆☆
4. Steel	☆☆☆☆☆	☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆	☆☆☆☆☆

Table 2 - Summary of relative durability of generic types of glazing system component materials

Requirements	Durability
Generic glazing system components	
1.1 Intumescent sealants	☆☆☆☆
1.2 Intumescent prefabricated strips (High & low pressure)	☆☆☆☆
1.3 Intumescent channel sections	☆☆☆☆
2. Ceramic fibre tapes	☆☆☆☆☆
3. Elastomeric closed cell foam tapes	☆☆☆☆
4. All-in-one glazing systems	☆☆☆

Table 3. Compatibility of glazing systems with glasses and materials.

Glass type	Integral wired	Non-integral wired	Borosilicate	Monolithic edge toughened	Monolithic edge controlled toughened coated	Ceramic	Laminated non-wired	Intumescent laminated	Intumescent gel filled
Framing material	1.1 Timber - softwood	IS	(3)	IS	(1)	IS	IPSH	IS	IS
		IPSL		IPSL	IPSH	IPSL		IPSL	IPSL
		IPSH		IPSH	ICS	ICS		IC	IC
		ICS		ICS	GS			EFT	EFT
		GS		GS					
1.2 Timber - hardwood	IS	(3)	IS	(1)	IS	IPSH	IS	IS	
	IPSL		IPSL	IPSH	IPSL		IPSL	IPSL	
	IPSH		IPSH	ICS	ICS		IC	EFT	
	ICS		ICS	GS			EFT	EFT	
	GS		GS						
2. Mineral board sections	IS	N/P(2)	(1)	(1)	IS	N/P(2)	IPSL	IPSL	
	IPSL		IPSL	IPSH	IPSH	IPSL		EFT	
	ICS		ICS	ICS	ICS	ICS	CFT	EFT	
				CFT	CFT			CFT?	
	IS	N/P(2)	IS	IPSH	IPSH	IPSH	N/P(2)	CFT	
	IPSH		IPSH	CFT	CFT	CFT			
3. Metal - aluminium	ICS		ICS						
	CFT		CFT	CFT	CFT	CFT		CFT	
	IPSH		IPSH	ICS	ICS			EFT?	
4. Metal - steel	CFT		CFT	CFT	CFT	CFT		CFT	
	IPSH		IPSH	ICS	ICS			EFT?	

Intumescent glazing materials (I)
 Prefabricated strips-high pressure (IPSH)
 Closed cell elastomeric foam tapes (EFT)

Sealants (gunnable) (IS)
 Channel sections (ICS)
 All-in-one glazing systems (GS)

Notes:
 (1) Only low expansion sealants and strips to be used as expansion of the product can create excessive thermal differentials.
 (2) N/P: Not proven in this combination.
 (3) The compatibility of the glass with the glazing system is complex and only the tested system should be used for each substrate and pane size, as determined from an examination of the appropriate primary test evidence.
WARNING: When fire resisting glass is used in conjunction with sprinklers, and where the glass is adjacent to sprinkler heads, i.e. within 2.5m, to one side or below, the effect of the water spray needs to be considered on the integrity and smoke tightness of the system.

The insulating, intumescent based glasses provide protected conditions on the exposed face and the bead shape is not so critical. The fixings on timber beads are again critical and should not be varied from the approved or tested conditions.

INSTALLATION

The installation of fire resisting glazed systems and framing should be executed and completed by a suitably qualified person to the required standard appropriate to the system used. It is advisable that where fire performance is required then an inspection by an independent body may be carried out on the completed work.

OTHER SOURCES OF INFORMATION

European Federation of Fire Separating Element Producers (EFFSEP)

Fire Resisting Glazing Advisory Service (FRGAS)

Intumescent Fire Seals Association (IFSA)

Note - the above can be contacted at: 20 Park Street, Princes Risborough, Buckinghamshire, HP27 9AH

Glass and Glazing Federation (GGF), 44-48 Borough High Street, London SE1 1XB.

List of Approved Fire and Security Products and Services, The Loss Prevention Certification Board, Melrose Avenue, Borehamwood, Hertfordshire WD6 2BJ.

Sheet No: 6.9.1

BEFORE READING
THIS DATA SHEET
PLEASE REFER TO
THE
INTRODUCTION

6.9 Protection of air distribution systems**Duct mounted fire resisting dampers**

Main application in respect to this *Design Guide*.

Maintenance of compartmentation when air distribution ducts pass through compartment walls and floors.

FUNCTION

- Maintenance of compartmentation when air distribution ducts pass through compartment walls and floors.
- To achieve the same fire resistance in terms of integrity as required for the compartment wall or floors as specified in Table 2.2 of the *Design Guide*.
- As far as possible, prevent the passage of smoke through the duct.
- To be able to close completely as soon as a fire condition is detected.
- To be able to achieve the above functions regardless of the type of construction of compartment wall or floor that the duct in which it is located passes.

EVIDENCE OF PERFORMANCE

To ensure that fire resisting dampers meet in full the fire performance requirements of this *Design Guide*, the building designer should only specify dampers that:

- have been tested to ISO 10294-1^{16a}
and
- have been approved by LPCB to LPS 1162²³ and listed in the *List of Approved Fire and Security Products and Services*¹⁹.

Care should be taken to ensure that the method of installing the damper into the wall or floor does not deviate from that tested unless covered by an independent assessment. Inappropriate detailing may reduce the fire resistance of the wall or floor or the performance of the fire damper itself.

CONTRIBUTION TO FIRE GROWTH

Dampers constructed from steel will not make any contribution to fire growth and therefore fully meet the requirements of Part 2.2 of this *Design Guide*. Dampers that use intumescent seals to prevent hot gas leakage may also be regarded as meeting the intent of this clause.

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FIRE RESISTANCE

The damper shall have fire resistance (in terms of integrity) as defined in Table 2.2 of this *Design Guide*. This is conditional on no combustible materials being closer than 500 mm from the duct. The designer should ensure that no combustible services should be closer than 500mm from the duct (see Part 4.7.1 of this *Design Guide*).

The *Design Guide* does not demand that fire resisting dampers are insulated as it is assumed that combustible materials will not be in direct contact with the duct surface.

RESISTANCE TO SMOKE

Provided the fire resistance test was carried out in accordance with ISO 10294-1^{16a}, which includes measurement of gas leakage as part of the integrity evaluation, the damper can be regarded as having at least reasonable resistance to the passage of smoke. Where improved resistance to smoke is required, then the damper shall not exceed the limits for the 'S' classification defined in ISO 10294-2^{16b} which is reproduced in part below. Dampers that have been classified as ES are particularly recommended where the risk assessment has identified the need to minimise the spread of smoke.

Fire test performance criteria for fire resisting dampers

(based on ISO 10294-2^{16b})

Classification of fire resisting dampers	Size to be tested	Leakage at ambient temperature m ³ /h.m ² Clause 8 of ISO 10294-1 ^{16a}	Fire test Clause 9 of ISO 10294-1 ^{16a}		
			Leakage limited m ³ /h.m ²	Temperature rise limit °C mean/max	Perimeter integrity
UNINSULATED DAMPERS					
E (integrity only)	Max	Not required	360*	Not required	GG/SF
ES (integrity and smoke leakage)	Max	200	200*	Not required	GG/SF
	Min	200	Not required	Not required	Not required
INSULATED DAMPERS					
EI (integrity and insulation)	Max	Not required	360*	140/180	CP/GG/SF
EIS (integrity, insulation and smoke leakage)	Max	200	200*	140/180	CP/GG/SF
	Min	200	Not required	Not required	Not required

E = Integrity (gas flow corrected to 20°C)

CP = Cotton gad

GG = Gap gauge

SF = Sustained flaming

I = Insulation

S = Leakage (gas leakage corrected to 20°C)

* Leakage limits only apply after five minutes from the start of the test.

This data sheet considers in detail the following types of fire dampers:

1. Curtain fire dampers
2. Multi-blade dampers (combined fire and smoke control dampers)

1. CURTAIN FIRE DAMPERS

Constructed from galvanised or stainless steel. Activated by a fusible link element set to trigger after the link reaches about 70°C. Available in size ranges to suit ducts 100mm to 1500mm width and height depending on manufacturer. Where larger size ducts are used, then multiple damper assemblies are required but such installations require specific approval from the appropriate authority in each case. Examples of multiple damper assemblies are shown in Figures 1 and 2.

Normally fitted into a wall or floor by an installation frame, as shown in Figure 3 and typically spigot joints are provided for connecting to the duct. Flanged connections are also available as an alternative to spigot connections.

FIRE PERFORMANCE DATA

Contribution to fire growth. Dampers constructed from steel will not make any contribution to fire growth and therefore fully meet the requirements of Part 2.2 of this *Design Guide*. (☆☆☆☆☆)

Fire resistance (integrity). This type of product can provide fire resistance up to 240 minutes in terms of integrity. Correct installation is vital to achieve this rating. After installation, the ability of the damper to close should in every case be verified by the installer. (☆☆☆☆☆)

Resistance to smoke. This type of damper is not normally intended to provide resistance to smoke. (☆☆)

Strength and impact resistance. These can be regarded as having adequate strength and resistance to impact during normal service conditions. (☆☆☆☆)

Durability. For the majority of building applications, product performance can be anticipated as remaining unchanged during the life-time of the building. However, when adverse environmental conditions are anticipated, such as for some industrial applications, the advice of the manufacturer shall be obtained. (☆☆☆☆)

2. MULTI-BLADE FIRE DAMPERS (COMBINED FIRE AND SMOKE CONTROL DAMPERS)

Constructed from galvanised or stainless steel. Activated by signal from a smoke detector with blades closing via an externally mounted motor and typically also fitted with a fusible link as a back-up. An example of a typical multi-blade fire damper is shown in Figure 4.

Normally fitted into a wall or floor by an installation frame, and typically spigot joints are provided for connecting to the duct. Flanged connections are also available as an alternative to spigot connections.

Available in size ranges to suit ducts 100mm to 1200mm width and 100mm to 1800mm height depending on manufacturer. Where larger size ducts are

used, then multiple damper assemblies are required, but such installations require specific approval from the appropriate authority in each case. Examples of multiple damper assemblies are shown in Figures 1 and 2.

FIRE PERFORMANCE DATA

Contribution to fire growth. Dampers constructed from steel will not make any contribution to fire growth and therefore fully meet the requirements of 2.2 of this *Design Guide*. Where such dampers incorporate intumescent seals to reduce hot gas leakage, they can still be regarded as meeting this requirement. (☆☆☆☆☆)

Fire resistance. This type of product can provide fire resistance typically 120 minutes in terms of integrity although 240 minutes is also possible. Correct installation is vital to achieve this rating. After installation, the ability of the damper to close should in every case be verified by the installer. (☆☆☆☆)

Resistance to smoke. This type of damper can be designed to provide resistance to smoke. Some products are designed with an interlocking detail between adjacent blades when in the closed position. Typically to satisfy the ES classification the use of intumescent seals will probably be incorporated.

(☆☆) ('E')

(☆☆☆☆) ('ES')

Strength and impact resistance. These can be regarded as having adequate strength and resistance to impact during normal service conditions. (☆☆☆☆)

Durability. For the majority of building applications, product performance, including dampers containing intumescent seals, can be anticipated as having adequate durability. However, when adverse environmental conditions are anticipated, such as for some industrial applications, the advice of the manufacturer shall be obtained. (☆☆☆☆)

SUMMARY OF PERFORMANCE DATA

Table 1 below summarises the assessed abilities of fire resisting dampers to satisfy the identified performance requirements.

Table 1 Summary of performance - fire resisting dampers

Type of fire damper	Contribution to fire growth	Fire resistance (integrity)	Smoke resistance	Strength and impact resistance	Durability
Curtain fire dampers	(☆☆☆☆☆)	(☆☆☆☆☆)	(☆☆)	(☆☆☆☆)	(☆☆☆☆)
Multi-blade dampers (combined fire and smoke dampers)	(☆☆☆☆☆)	(☆☆☆☆)	(☆☆) ('E') (☆☆☆☆) ('ES')	(☆☆☆☆)	(☆☆☆☆)

Figure 1. Elevation showing four curtain fire dampers in a multiple assembly.

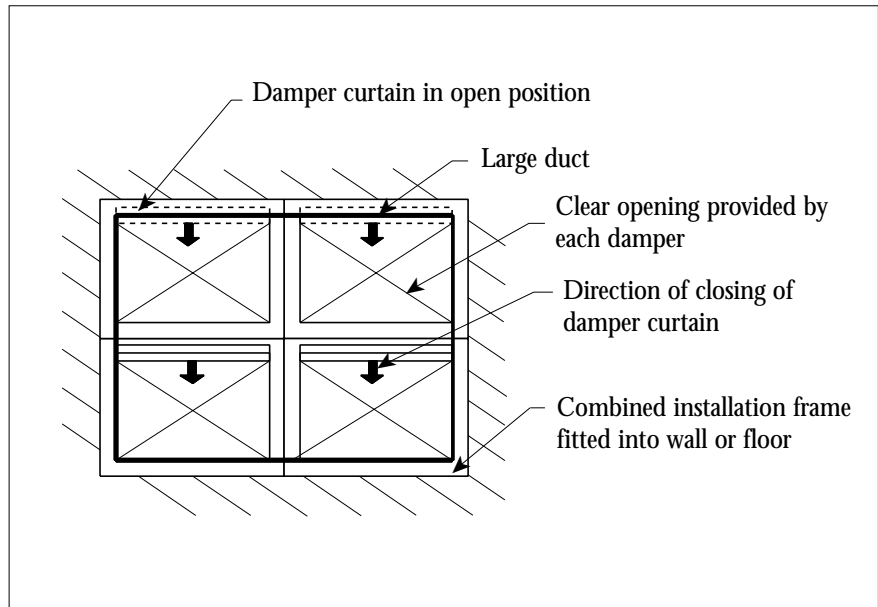
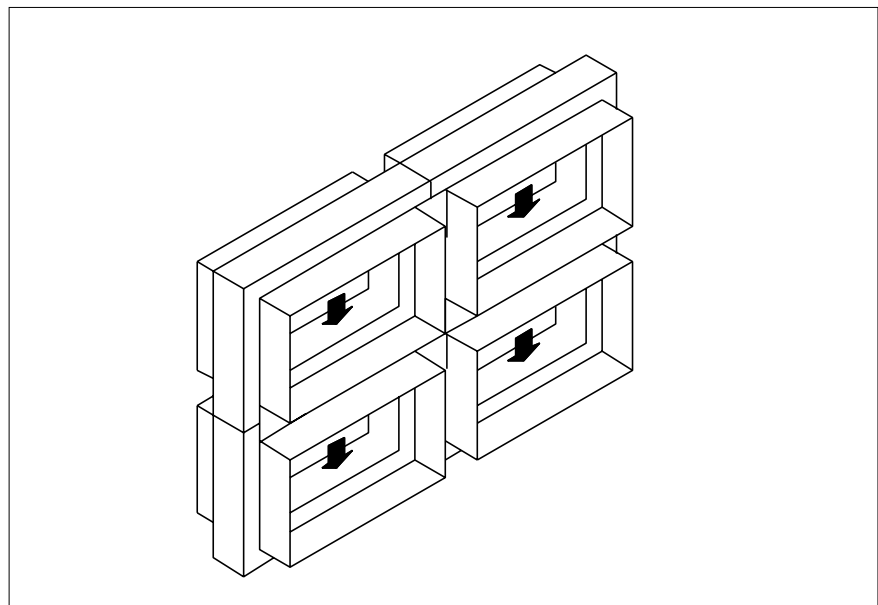


Figure 2. Isometric view of multiple damper assembly.



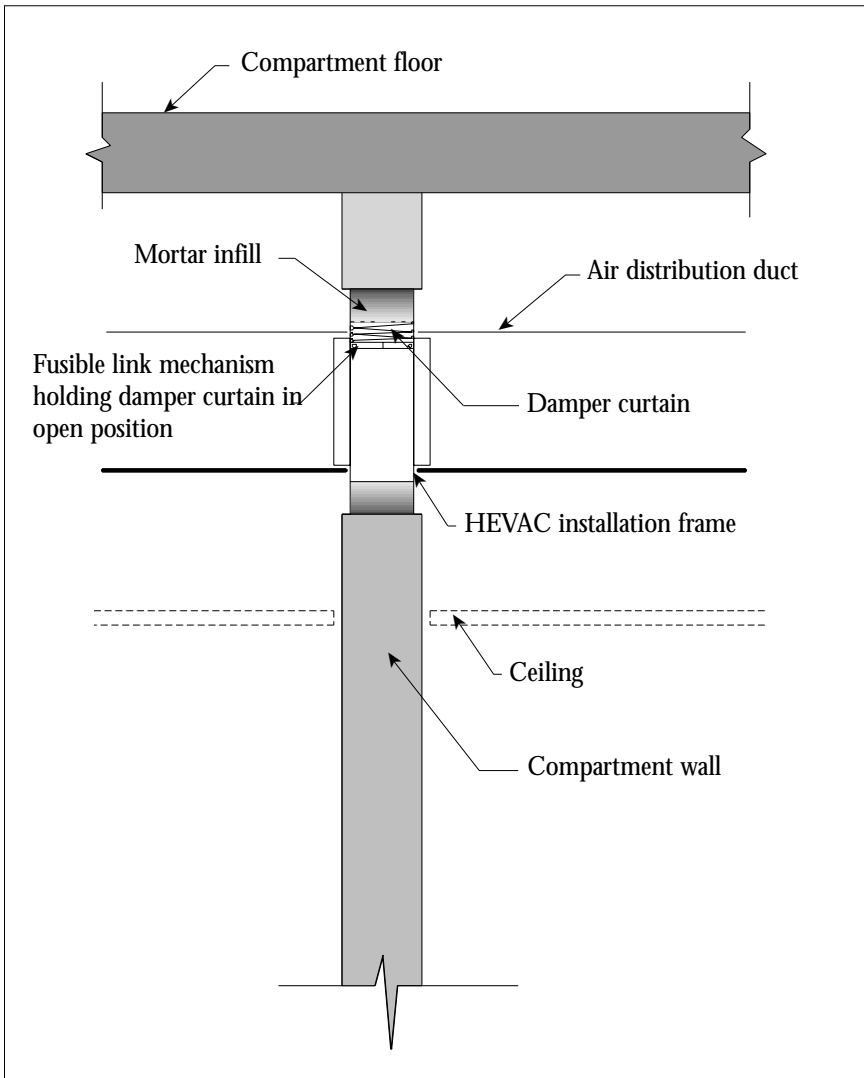
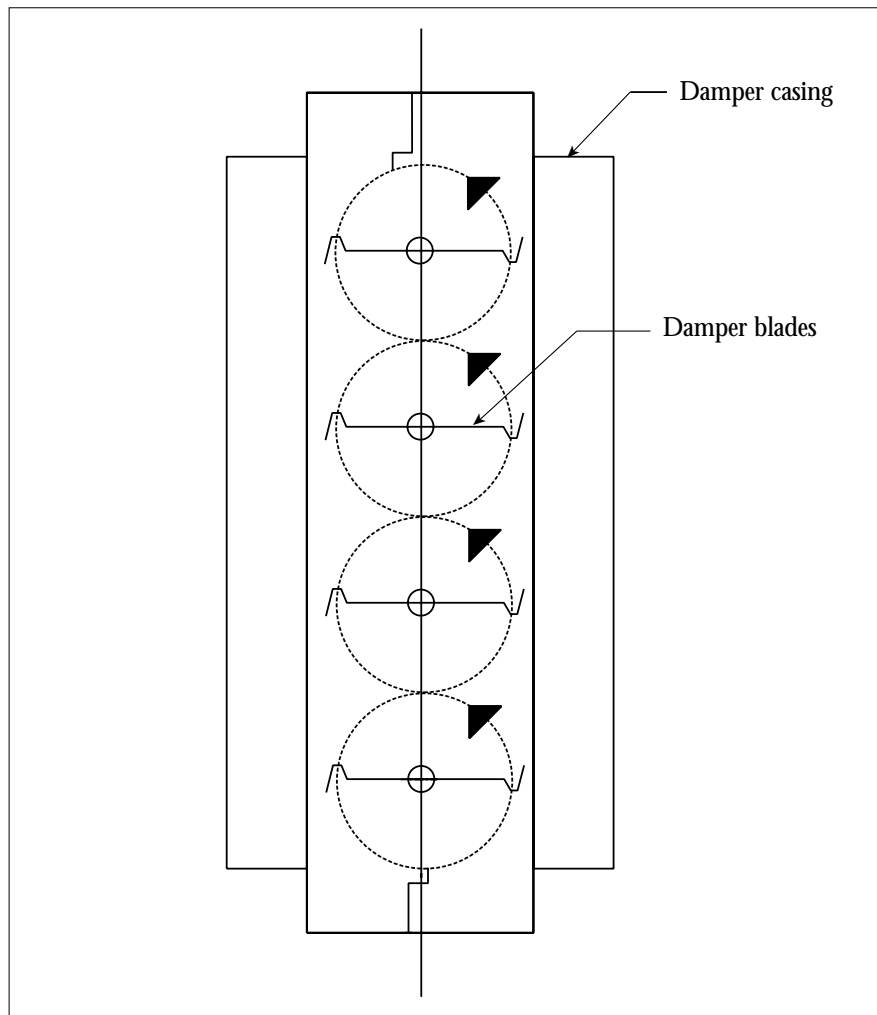


Figure 3. Curtain fire damper in a HEVAC frame installed into a compartment.

Figure 4. Typical multi-blade fire and smoke damper (with blades in open position).



SOURCES FOR FURTHER INFORMATION

HVCA, Heating and Ventilating Contractors Association, Esca House, 34 Palace Court, London W2 4JR.

HEVAC, Heating Ventilating and Air Conditioning Manufacturers Association, Sterling House, 6 Furlong Road, Bourne End, Bucks SL8 5DG.

List of Approved Fire and Security Products and Services, The Loss Prevention Certification Board, Melrose Avenue, Borehamwood, Hertfordshire WD6 2BJ.

Sheet No: 6.9.2

6.9 Protection of air distribution systems

Steel ducts protected by fire protection systems and self supporting duct systems constructed from fire protection boards

Main application in respect to this *Design Guide*.

Maintenance of compartmentation when air distribution ducts pass through compartment walls and floors.

FUNCTION

- Maintenance of compartmentation when air distribution ducts pass through compartment walls and floors where fire resisting dampers (see Data sheet 6.9.1) are not used or in situations where fire resisting ducts and dampers are used in a combined system.
- To achieve the same fire resistance in terms of integrity (and if required insulation) as required for the compartment wall or floors as specified in Table 2.2.
- To prevent, as far as possible, the passage of smoke through the duct into other compartments.
- To be able to achieve the above functions regardless of the type of construction of the compartment wall or floor that the duct passes through.

EVIDENCE OF PERFORMANCE

It is important that where fire resisting ducts pass through a compartment wall or floor, the method of fire stopping used around the duct where it passes through walls and floors has also been evaluated in the fire resisting duct test. This is because the deflections and loads applied during a fire from a duct system may be different from other services passing through walls and floors. This is due, at least in part, to the relative size of air distribution ducts compared to other service installation (cross-section and span) and larger levels of loading and deformation can be anticipated.

Some examples of the most common fire protection systems used for the fire protection of air distribution ducts are included in this data sheet.

- **Contribution to fire growth.** The types of fire protection systems normally used for the protection of ducts can be regarded as meeting the requirements of Part 2.2 of this *Design Guide*. Materials used are either non-combustible or of limited combustibility. However, the designer should establish in each case that the materials to be used meet this requirement.

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- **Fire resistance.** Currently, fire resisting ducts are tested to BS 476: Part 24^{1j}/ISO 6944^{28a} but a technically enhanced method has been developed, EN 1366-1, which measures leakage as part of the evaluation of integrity. The basic principle of both tests is similar, one duct specimen is exposed to an external fire (known as duct A, see Figure 1a) and a further specimen is exposed to an internal fire (duct B, see Figure 1b). Reduced levels of insulation may be anticipated with an internal fire and the designer should study the test data carefully. As well as criteria for integrity and insulation, an additional criteria is imposed regarding freedom of collapse. This is known as 'stability' and should not be confused with the same term that used to be applied to loadbearing elements.

With respect to internal fire, it is recognised that in a fully developed fire it is possible for the fire to gain access to inside the duct and any combustible material in contact with the outside of the duct could be ignited.

Where unprotected hangers/supports are used, restrictions on the maximum permissible stress in the hangers are imposed. Advice shall be obtained from the manufacturer on whether the supports to the ductwork need fire protection or not.

Some systems have restrictions in relation to the maximum cross-section of duct that they can be applied to and the advice from the manufacturer should be obtained.

- **Resistance to smoke.** The very nature of the design and construction of fire resisting ducts should minimise the passage of smoke. Once a classification system is established for fire resisting ducts tested to EN 1366-1^{28a} then it will be possible to specify ES and EIS systems where this parameter is important.

This data sheet considers in detail the following types of fire resisting ducts:

1. Vermiculite board
2. Calcium silicate boards
 - 2.1 Calcium silicate board with dry density 450-500kg/m³
 - 2.2 Calcium silicate board with dry density 640-650kg/m³
 - 2.3 Calcium silicate board with dry density 875-890kg/m³
3. Cement/steel composite board
4. Rock fibre mineral wool

1. VERMICULITE BOARD

Constructed from lightweight vermiculite boards, typically bonded and nailed to each other and to spacer battens. Vermiculite boards have a dry density of about 405kg/m³. Supplied in a range of thicknesses, 18mm to 80mm. May be used in conjunction with mineral wool insulation for higher levels of fire resistance. Can be supplied for both protection of steel ducts and in self supporting systems.

FIRE PERFORMANCE DATA

Contribution to fire growth. This material is non combustible and therefore fully meets the requirements of Part 2.2 of the *Design Guide*. (☆☆☆☆☆)

Fire resistance.

Fire outside the duct (Duct A)

System is able to provide from 30 minutes to 240 minutes in terms of stability, integrity and insulation. (☆☆☆☆☆)

Fire inside duct (Duct B)

System is able to provide from 30 minutes to 240 minutes in terms of stability, integrity and insulation. (☆☆☆☆☆)

Resistance to smoke. This material will not generate smoke. Because of the combined bonded and nailed system adopted, it can be anticipated that this system will prevent the passage of smoke leaking through the protection system. (☆☆☆☆☆)

Strength and impact resistance. Should have adequate resistance for most applications, but where mechanical impact is expected, an alternative system may have to be considered. (☆☆)

Durability. For the majority of building applications, product performance can be anticipated as remaining unchanged during the life-time of the building. However, when adverse environmental conditions are anticipated, such as for some industrial applications, the advice of the manufacturer shall be obtained. (☆☆☆☆☆)

2. CALCIUM SILICATE BOARDS

2.1 CALCIUM SILICATE BOARD WITH DRY DENSITY 450-500kg/m³

Calcium silicate boards reinforced with cellulose fibres and inorganic additives. Supplied in a range of thicknesses typically 20mm to 60mm. May be used in conjunction with mineral wool insulation for higher levels of fire resistance. Method of construction may vary from manufacturer to manufacturer.

Can be supplied for both protection of steel ducts and in self supporting systems.

FIRE PERFORMANCE DATA

Contribution to fire growth. This material is non combustible and therefore fully meets the requirements of Part 2.2 of the *Design Guide*. (☆☆☆☆☆)

Fire resistance

Fire outside the duct (Duct A)

System is able to provide 240 minutes in terms of stability, integrity and 120 minutes in terms of insulation. (☆☆☆☆☆)

Fire inside duct (Duct B)

System is able to provide 240 minutes in terms of stability and integrity and 30 minutes in terms of insulation. (☆☆☆☆)

Resistance to smoke. This material will not generate smoke. Because of the method of construction adopted, it can be anticipated that this system will prevent smoke leaking through the protection system. (☆☆☆☆☆)

Strength and impact resistance. Should have adequate resistance for most applications, and has higher mechanical strength than vermiculite boards but

where mechanical impact is expected, an alternative system may have to be considered. (☆☆☆)

Durability. For the majority of building applications, product performance can be anticipated as remaining unchanged during the life-time of the building. However, when adverse environmental conditions are anticipated, such as for some industrial applications, the advice of the manufacturer shall be obtained. (☆☆☆☆)

2.2 CALCIUM SILICATE BOARD WITH DRY DENSITY 640-650kg/m³

Calcium silicate boards reinforced with cellulose fibres and inorganic additives. Supplied in a range of thicknesses typically 12mm to 32mm. May be used in conjunction with mineral wool insulation for higher levels of fire resistance. Supplied for protecting steel ducts.

FIRE PERFORMANCE DATA

Contribution to fire growth. This material is non combustible and therefore fully meets the requirements of Part 2.2 of the *Design Guide*. (☆☆☆☆☆)

Fire resistance

Fire outside the duct (Duct A)

System is able to provide 120 and 240 minutes in terms of stability, integrity and insulation. (☆☆☆☆☆)

Fire inside duct (Duct B)

System is able to provide 120 minutes and 240 minutes in terms of stability, integrity and insulation. (☆☆☆☆☆)

Resistance to smoke. This material will not generate smoke. Because of the method of construction adopted, it can be anticipated that this system will prevent smoke leaking through the protection system. (☆☆☆☆)

Strength and impact resistance. Should have adequate resistance for most applications, and has higher mechanical strength than vermiculite boards but where mechanical impact is expected, an alternative system may have to be considered. (☆☆☆)

Durability. For the majority of building applications, product performance can be anticipated as remaining unchanged during the life-time of the building. However, when adverse environmental conditions are anticipated, such as for some industrial applications, the advice of the manufacturer shall be obtained. (☆☆☆☆)

2.3 CALCIUM SILICATE BOARD WITH DRY DENSITY 875-890kg/m³

Calcium silicate boards reinforced with cellulose fibres and inorganic additives. Supplied in a range of thicknesses typically 6mm to 25mm.

Can be supplied for protection of steel ducts and in some cases also as self supporting systems.

FIRE PERFORMANCE DATA

Contribution to fire growth. This material is non combustible and therefore fully meets the requirements of Part 2.2 of the *Design Guide*. (☆☆☆☆☆)

Fire resistance

Fire outside the duct (Duct A)

System is able to provide from 30 minutes to 120 minutes in terms of stability, integrity and insulation. 240 minutes systems are available for stability and integrity. (☆☆☆☆)

Fire inside duct (Duct B)

System is able to provide from 30 minutes to 120 minutes in terms of stability, integrity and insulation. 240 minutes systems are available for stability and integrity. (☆☆☆☆)

Resistance to smoke. This material will not generate smoke. Because of the method of construction adopted, it can be anticipated that this system will prevent smoke leaking through the protection system. (☆☆☆☆)

Strength and impact resistance. Should have adequate resistance for most applications, and has higher mechanical strength than vermiculite boards and some of the lower density calcium silicate boards. (☆☆☆☆)

Durability. For the majority of building applications, product performance can be anticipated as remaining unchanged during the life-time of the building. However, when adverse environmental conditions are anticipated, such as for some industrial applications, the advice of the manufacturer shall be obtained. (☆☆☆☆)

3. CEMENT/STEEL COMPOSITE BOARD

This material has a dry density of about 2300kg/m³ and is supplied in thicknesses of 6mm, 9.5mm and 13mm. Particularly applicable to applications where high resistance to impact is required. Some systems may be combined with other fire protection materials, particularly where higher levels of insulation are required.

Typical application is for self supporting duct applications.

FIRE PERFORMANCE DATA

Contribution to fire growth. This material is non combustible and therefore fully meets the requirements of Part 2.2 of the *Design Guide*. (☆☆☆☆)

Fire resistance

Fire outside the duct (Duct A)

Dependent on specification, with the addition of mineral wool or fire protection boards system is able to provide up to 240 minutes in terms of stability, integrity and insulation. (☆☆☆☆)

Fire inside duct (Duct B)

Dependent on specification, with the addition of mineral wool or fire protection boards system is able to provide up to 240 minutes in terms of stability, integrity and insulation. (☆☆☆☆)

Resistance to smoke. This material will not generate smoke. Because of the method of construction adopted, it can be anticipated that this system will prevent smoke leaking through the protection system. (☆☆☆☆)

Strength and impact resistance. Very robust and has excellent mechanical strength and should be used in applications where good resistance to mechanical impact is an essential requirement. (☆☆☆☆)

Durability. For the majority of building applications, product performance can be anticipated as remaining unchanged during the life-time of the building. However, when adverse environmental conditions are anticipated, such as for some industrial applications, the advice of the manufacturer shall be obtained. (☆☆☆☆☆)

4. ROCK FIBRE MINERAL WOOL

For this application, has a density of typically 165kg/m³. Range of thicknesses 25mm to 90mm. Some systems faced with aluminium foil. Joints may be glued with nails used in addition. Special sections available for circular ducts. Used for protection of steel ducts only.

FIRE PERFORMANCE DATA

Contribution to fire growth. This material has limited combustibility and will fully comply with the requirements of Part 2.2 of this *Design Guide*. (☆☆☆☆☆)

Fire resistance.

Fire outside the duct (Duct A)

Dependent on specification, will achieve up to 120 minutes fire resistance. (☆☆☆☆☆)

Fire inside duct (Duct B)

Dependent on specification, will achieve up to 120 minutes fire resistance. (☆☆☆☆☆)

Resistance to smoke. Any smoke generated from the resin contained in the mineral wool will be minimal. The steel duct in itself will restrict the passage of smoke. (☆☆☆☆)

Strength and impact resistance. Basic material is resilient and should have adequate resistance for applications where the risk of impact is minimal. (☆☆)

Durability. For the majority of building applications, product performance can be anticipated as remaining unchanged during the life-time of the building. However, when adverse environmental conditions are anticipated, such as for some industrial applications, the advice of the manufacturer shall be obtained. (☆☆☆☆☆)

Note: No other ventilation openings would be acceptable within the duct unless protected by a fire resisting damper (see Data sheet 6.9.1).

SOURCES FOR FURTHER INFORMATION

Association of Specialist Fire Protection, Association House, 253 Ash Road, Aldershot, Hampshire GU12 4DD.

List of Approved Fire and Security Products and Services, The Loss Prevention Certification Board, Melrose Avenue, Borehamwood, Hertfordshire Wd6 2BJ.

HVCA, Heating and Ventilating Contractors Association, Esca House, 34 Palace Court, London W2 4JR.

HEVAC, Heating Ventilating and Air Conditioning Manufacturers Association, Sterling House, 6 Furlong Road, Bourne End, Buckinghamshire SL8 5DG.

Table 1 below summarises the assessed abilities of fire resisting ducts to satisfy the identified performance requirements.

Table 1. Summary of performance data.

Type of fire protection to duct	Contribution to fire growth	Fire resistance (fire outside)	Fire resistance (fire inside)	Smoke resistance	Strength and impact resistance	Durability
Vermiculite boards	(☆☆☆☆☆)	(☆☆☆☆☆)	(☆☆☆☆☆)	(☆☆☆☆)	(☆☆)	(☆☆☆☆)
Calcium silicate board with dry density 450-500kg/m ³	(☆☆☆☆☆)	(☆☆☆☆)	(☆☆☆)	(☆☆☆☆)	(☆☆☆)	(☆☆☆☆)
Calcium silicate board with dry density 640-650kg/m ³	(☆☆☆☆☆)	(☆☆☆☆☆)	(☆☆☆☆☆)	(☆☆☆☆)	(☆☆☆)	(☆☆☆☆)
Calcium silicate board with dry density 875-890kg/m ³	(☆☆☆☆☆)	(☆☆☆☆)	(☆☆☆☆)	(☆☆☆☆)	(☆☆☆☆)	(☆☆☆☆)
Cement/steel composite board	(☆☆☆☆☆)	(☆☆☆☆☆)	(☆☆☆☆☆)	(☆☆☆☆)	(☆☆☆☆☆)	(☆☆☆☆)
Rock fibre mineral wool	(☆☆☆☆☆)	(☆☆☆☆)	(☆☆☆☆)	(☆☆☆)	(☆☆)	(☆☆☆☆)

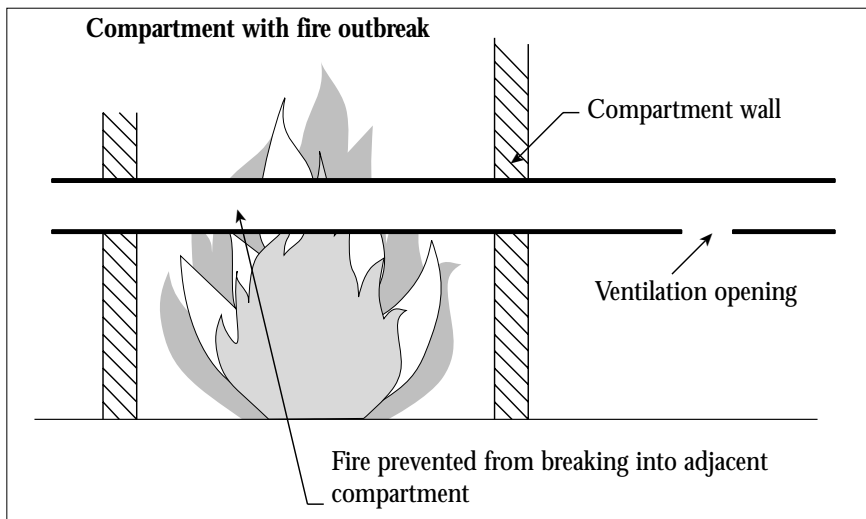


Figure 1a. Fire outside duct (Duct A).

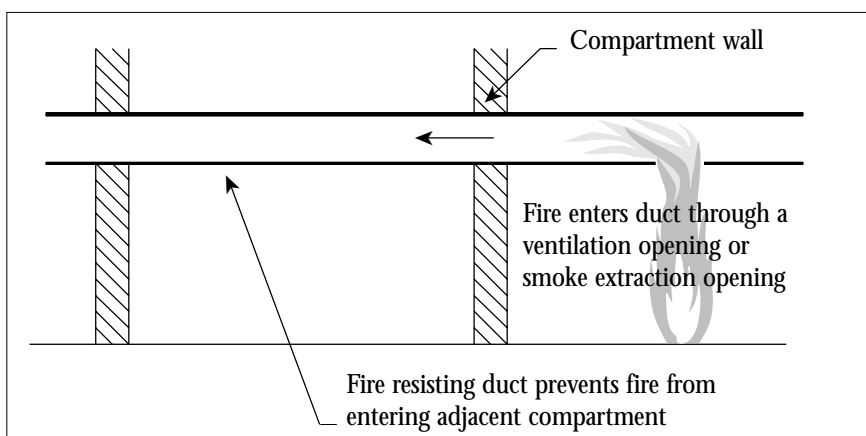


Figure 1b. Fire inside duct (Duct B).

Figure 2. Typical self-supporting duct (duct constructed from fire boards without using a conventional steel duct).

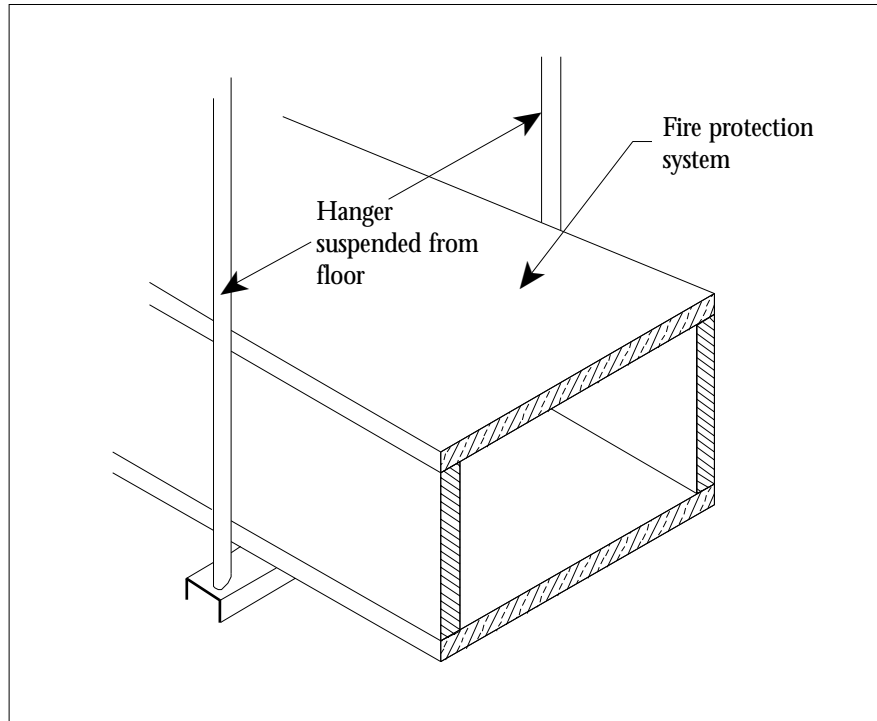
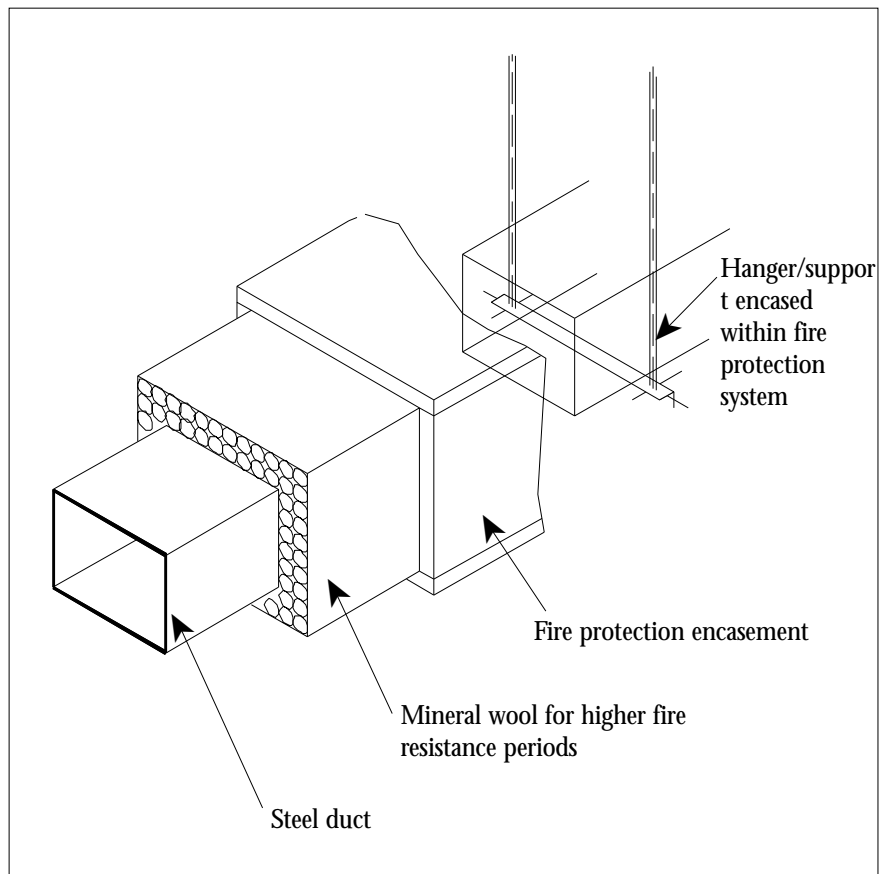


Figure 3. Typical fire protection system for steel ducts.



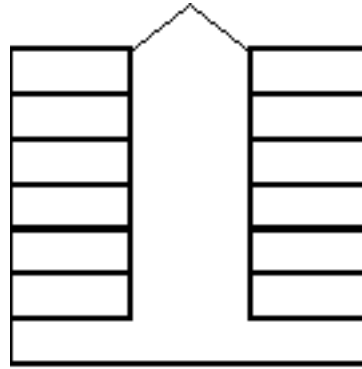
References

- 1 BS 476: *Fire tests on building materials and structures*, British Standards Institution;
- 1a BS 476: Part 3: 1975: *External Fire Exposure Roof Test*.
- 1b BS 476: Part 4: 1970 (1984): Non-combustibility test for materials.
- 1c BS 476: Part 6: 1989: *Method of test for fire propagation for products*.
- 1d BS 476: Part 7: 1997: *Method of test to determine the classification of the surface spread of flame of products*.
- 1e BS 476: Part 11: 1982 (1988): *Method for assessing the heat emission from building materials*.
- 1f BS 476: Part 20: 1987: *Method for determination of the fire resistance of elements of construction (general principles)*.
- 1g BS 476: Part 21: 1987: *Methods for determination of the fire resistance of loadbearing elements of construction*.
- 1h BS 476: Part 22: 1987: *Methods for determination of the fire resistance of non-loadbearing elements of construction*.
- 1i BS 476: Part 24: 1987: *Method for determination of the fire resistance of ventilation ducts*.
- 1j BS 476: Part 31: *Methods for measuring smoke penetration through doorsets and shutter assemblies*. Section 31.1: 1983: *Method of measurement under ambient temperature conditions*.
- 1k BS 476: Part 33: 1993: *Full scale room test for surface products* (also ISO 9705: 1993).
- 2 BS 1142: 1989: *Specification for fibre building boards*, British Standards Institution.
- 3 BS 3921: 1985 (1995): *Specification for clay bricks*, British Standards Institution.
- 4 BS 5234: *Partitions (including matching linings)*: Part 2: 1992: *Specification for performance requirements for strength and robustness including methods of test*, British Standards Institution.
- 5 BS 5268: *Structural use of timber*. Part 4: *Fire resistance of timber structures*, British Standards Institution.
- 5a BS 5268: Section 4.1 : 1978: *Recommendations for calculating fire resistance of timber members*.
- 5b BS 5268: Section 4.2 : 1989: *Recommendations for calculating fire resistance of timber stud walls and joisted floor constructions*.
- 6 BS 5427: *Code of practice for the use of profiled sheet for roof and wall cladding on buildings*. Part 1: 1996: *Design*, British Standards Institution.
- 7 BS 5588: *Fire precautions in the design, construction and use of buildings*, British Standards Institution.
- 7a BS 5588: Part 9: 1989: *Code of practice for ventilation and air conditioning ductwork*.
- 7b BS 5588: Part 11: 1997: *Code of practice for shops, offices, industrial storage and other similar buildings*.
- 8 BS 5628: *Code of practice for use of masonry*. Part 1: 1992: *Structural use of unreinforced masonry*, British Standards Institution.
- 9 BS 5950: *Structural use of steelwork in building*. Part 8: 1990: *Code of practice for fire resistant design*, British Standards Institution.
- 10 BS 6073: *Precast concrete masonry units*. Part 1: 1981: *Specification for precast concrete masonry units*, British Standards Institution.
- 11 BS 6180: 1995: *Code of practice for barriers in and about buildings*, British Standards Institution.
- 12 BS 6206: 1981 (1994): *Specification for impact performance requirements for flat safety glass and safety plastics for use in buildings*, British Standards Institution.
- 13 BS 8110: *Structural use of concrete*. Part 2: 1985: *Code of practice for special circumstances*, British Standards Institution.
- 14 BS 8200: 1985: *Code of practice for design of non-loadbearing external vertical enclosures of buildings*, British Standards Institution.
- 15 BS 8214: 1990: *Code of practice for fire door assemblies with non-metallic leaves*, British Standards Institution.
- 16 BS ISO 10294: *Fire-resistance tests. Fire dampers for air distribution systems*, British Standards Institution.
- 16a BS ISO 10294: Part 1: 1996: *Test method*.
- 16b BS ISO 10294: Part 2: *Classification, criteria and field of application of tests results* (not yet published).
- 17 DD 171: 1987: *Guide to specifying performance requirements for hinged or pivoted doors (including test methods)*, British Standards Institution.
- 18 DD ENV 1996: *Eurocode 6. Design of masonry structures*. Part 1: *General rules for buildings*. Part 1-2: 1997: *Structural fire design* (together with United Kingdom National Application Document), British Standards Institution.
- 19 *List of approved fire and security products and services - A specifiers' guide*, Loss Prevention Certification Board (LPCB), published annually.

- 20 LPS 1056: issue 5, November 1996: *Requirements and tests for fire doors, lift landing doors and shutters (including installation)*, Loss Prevention Certification Board.
- 21 LPS 1132: issue 3, October 1988: *LPC approval procedures for wall and floor penetration seals*, Loss Prevention Council.
- 22 LPS 1158: issue 2, October 1996: *Requirements and tests for fire resistant glazing systems*, Loss Prevention Council.
- 23 LPS 1162: issue 2, December 1990: *Requirements and tests for LPCB approval of fire dampers*, Loss Prevention Council.
- 24 LPS 1181: issue 2, March 1996: *Requirements and tests for LPCB approval of wall and ceiling lining products and composite cladding products*, Loss Prevention Council.
- 25 EN 1363-1, *Fire resistance tests, General requirements*, Comité Européen de Normalisation.
- 26 EN 1364-1, *Fire resistance tests on non-loadbearing elements in buildings, Walls*, Comité Européen de Normalisation.
- 27a EN 1365-1, *Fire resistance tests on loadbearing elements in buildings, Walls*, Comité Européen de Normalisation.
- 27b EN 1365-2, *Fire resistance tests on loadbearing elements in buildings, Floors*, Comité Européen de Normalisation.
- 27c EN 1365-3, *Fire resistance tests on loadbearing elements in buildings, Beams*, Comité Européen de Normalisation.
- 27d EN 1365-4, *Fire resistance tests on loadbearing elements in buildings, Columns*, Comité Européen de Normalisation.
- 28a EN 1366-1, *Fire resistance tests for service installations in buildings - Ducts*, Comité Européen de Normalisation.
- 28b EN 1366-2, *Fire resistance tests for service installations in buildings - Dampers*, Comité Européen de Normalisation.
- 28c prEN 1634-1, *Fire resistance tests for door and shutter assemblies - Fire door and shutter assemblies*, Comité Européen de Normalisation.
- 28d prEN 1634-3, *Fire resistance tests for door and shutter assemblies - Smoke control doors*, Comité Européen de Normalisation.
- 29 Approved Document B: *Fire Safety*, The Building Regulations 1991, Department of the Environment/Welsh Office, HMSO, 1991.
- 30 Approved Document M: *Access and facilities for disabled people*, The Building Regulations 1991, Department of the Environment/Welsh Office, HMSO, 1991.
- 31 Approved Document N: *Glazing - materials and protection*, The Building Regulations 1991, Department of the Environment/Welsh Office, HMSO, 1991.
- 32 *Fire Protection for structural steel in buildings*, 2nd edition (revised), Association of Specialist Fire Protection Contractors and Manufacturers Limited, The Steel Construction Institute and The Fire Test Study Group, 1992 (also Supplement to the 2nd edition (revised), 1994).
- 33 *The IFSA Code; Sealing apertures and service penetrations to maintain fire resistance*, Intumescent Fire Seals Association, 1999.
- 34 *The role of intumescent materials in the design and manufacture of timber based fire resisting doorsets*, Information Sheet No. 1, Intumescent Fire Seals Association, January 1997.
- 35 *The role of intumescent materials in timber and metal based fire resisting glazing systems*, Information Sheet No. 2, Intumescent Fire Seals Association, April 1993.
- 36 *Guide to the use of smoke seals in doorsets*, Information Sheet No. 3, Intumescent Fire Seals Association, January 1994.
- 37 *Ageing performance of intumescent seals*, Information Sheet No. 4, Intumescent Fire Seals Association, January 1997.
- 38 *The guide to the selection of smoke seals for doorsets*, Information Sheet No.5, Intumescent Fire Seals Association, February 1998.
- 39 ISO 6944: 1985: *Fire resistance tests - ventilation ducts*, International Standards Organisation.

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7 Special risks



7.1 Protection of buildings containing atria

7.1.1 INTRODUCTION

The purpose of this part of the *Design Guide* is to provide advice concerning adequate property protection in buildings containing atria. It does not deal with life safety aspects as regards which, reference should be made to BS 5588: Part 7: 1997. Where the provisions of the British Standard specify higher levels of protection such higher values will take precedence.

Atria, by their very nature and particularly where they are not enclosed, result in significantly increased property and business interruption values directly at risk from a fire (and the associated damage from smoke, heat and extinguishing water) starting either in the atria or associated floors.

The design of atria varies considerably, as does the complexity of the buildings in which they are located. As a consequence, it is not possible to provide specific guidance. Therefore, only general guidance is given and these recommendations are intended to be read in conjunction with other parts of this *Design Guide*. They should be seen as an amplification of BS 5588: Part 7: 1997, clause 6.2, Protection of property.

The guidance is applicable to all buildings containing atria regardless of the occupancy type.

This part of the *Design Guide* replaces LPC Recommendations for the fire protection of atrium buildings, RC 21, which is now withdrawn.

7.1.2 DEFINITIONS

7.1.2.1 Associated floor area

Any floor area in an atrium building not separated from the atrium by construction having a fire resistance equal to that required for the elements of the structure of the building.

7.1.2.2 Atrium (plural atria)

A space within a building, not necessarily vertically aligned, passing through one or more structural floors.

7.1.2.3 Atrium base

The plan area of the lowest floor level, bounded by lines projected down from the edge of floor slab immediately above the lowest floor level within the atrium.

7.1.2.4 High risk

Any part of a building that contains:

- a significant inception risk e.g. kitchens;
- areas where there may be highly combustible or flammable material;
- a considerable fire load e.g. stockrooms;
- serious business interruption consequences e.g. main frame computer installations or communication equipment rooms.

7.1.2.5 Permanent fire load

Any fixtures, goods or materials located at the base of the atrium that form an integral part of the day to day operation of the business.

7.1.2.6 Significant fire load

In the context of this part of the *Design Guide*, any fire load situated in the base of the atrium that:

- is outside the definition of a controlled fire load given in BS 5588: Part 7: 1997;
- would require the base of the atrium to be protected by sprinklers and/or upper floors protected by a fire resisting construction.

7.1.2.7 Smoke retarding construction

Construction that will adequately retard the passage of smoke. For property protection purposes reference should be made to Parts 3.1.2.3 and 4.2.6 of this *Design Guide* concerning 'Prevention of smoke spread' and 'Smoke control door assemblies' respectively. It shall be ensured that any glazing will remain intact even when wetted by the water discharged from sprinklers.

7.1.2.8 Temporary fire load

Display materials, maintenance equipment/operations etc. that may exist on the atrium base for a limited period of time.

7.1.3 RISK ASSESSMENT

In view of the diversity and complexity of atrium buildings, the importance of conducting an effective risk assessment of such buildings at the design stage cannot be over-estimated. This assessment should be carried out in accordance with the guidance in Part 1.3 of this *Design Guide* in which particular attention should be given to the risk and potential effects of fire spread via the atrium itself.

Only by completing this process will the specific risk factors emerge which will be fundamental in establishing the property protection solutions. For this reason, consultation with insurers at the earliest stage in the design process is considered to be vital.

7.1.4 GENERAL PRINCIPLES

The protection of atrium buildings should be governed by the outcome of the risk assessment and is likely to involve a combination of both active and passive protection measures:

- All materials used in the construction of the atrium shall comply with the requirements of Part 2.2 of this *Design Guide*;
- For the majority of buildings incorporating atria, the overall installation of sprinklers combined with a means of extracting smoke from the atria itself, will be the basis for the most effective solution;
- To prevent lateral spread of smoke into upper floors, the use of smoke retarding constructions should be considered;
- Enclosing all associated floor areas by fire resisting construction should always be considered;
- Ideally, no fire load (permanent or temporary*) should exist in the atrium base. Where a significant fire load cannot be avoided, the upper floors should be enclosed by a fire resisting construction. As an alternative, local sprinkler protection of the atrium base and the prevention of smoke spread laterally by use of smoke retarding construction may be considered;
- High risk locations should be compartmented in accordance with Appendix 3C (see 7.1.2.4 for definition).

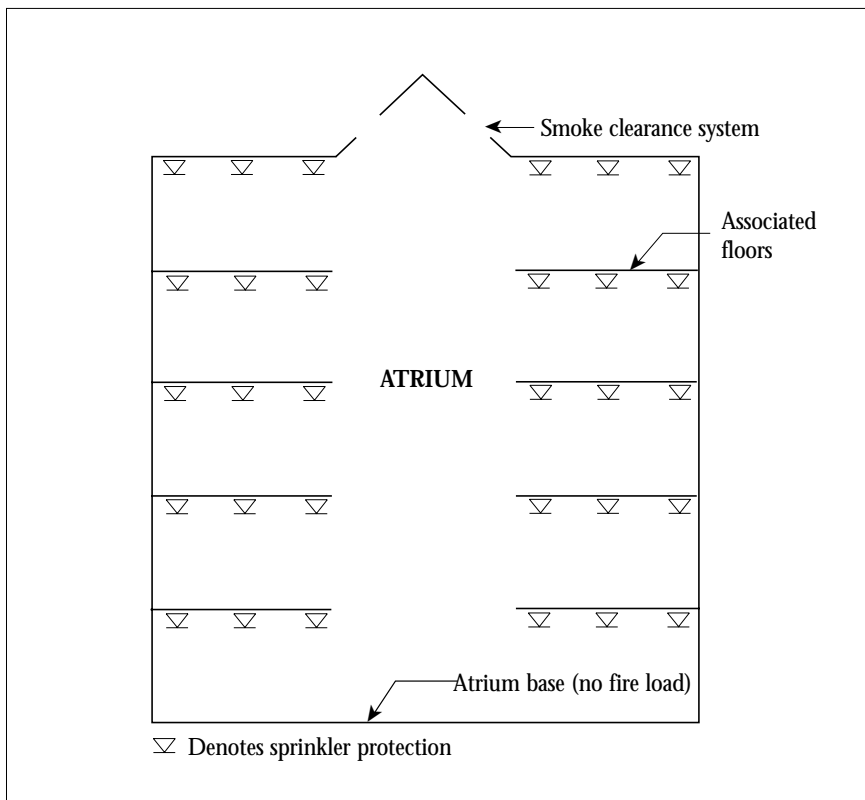


Figure 7.1 Minimum fire protection recommendations for buildings containing atria.

* Even if the intention is to use the atrium base as a sterile area (free of combustibles), a temporary fire load may exist during maintenance operations and this should be taken into account at the design stage.

Figure 7.2. Addition of smoke retarding construction to prevent lateral spread of smoke.

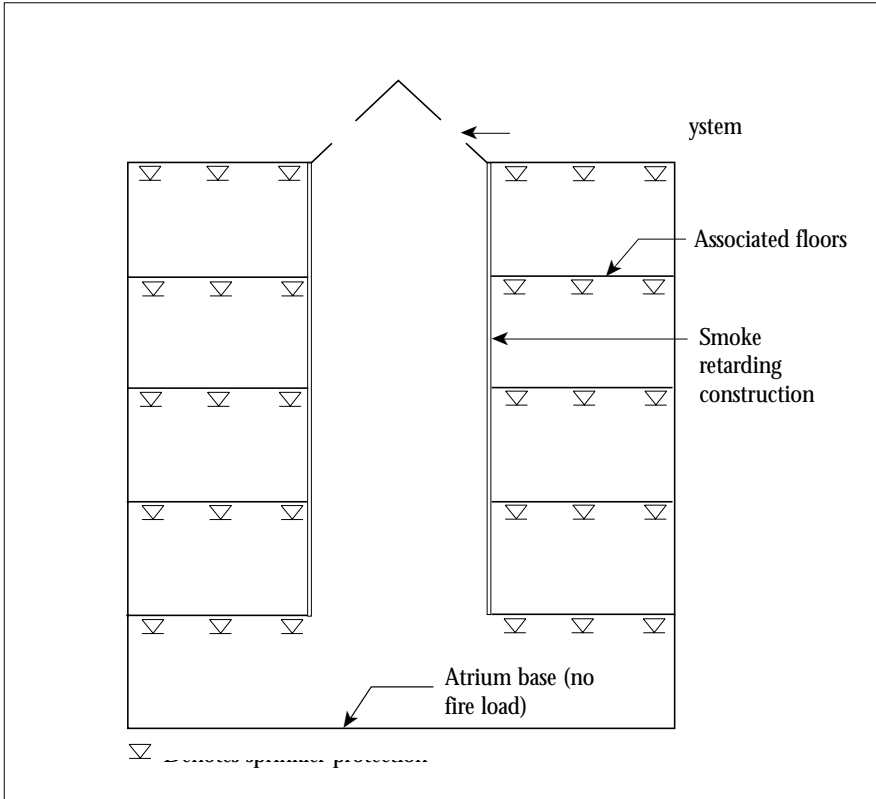
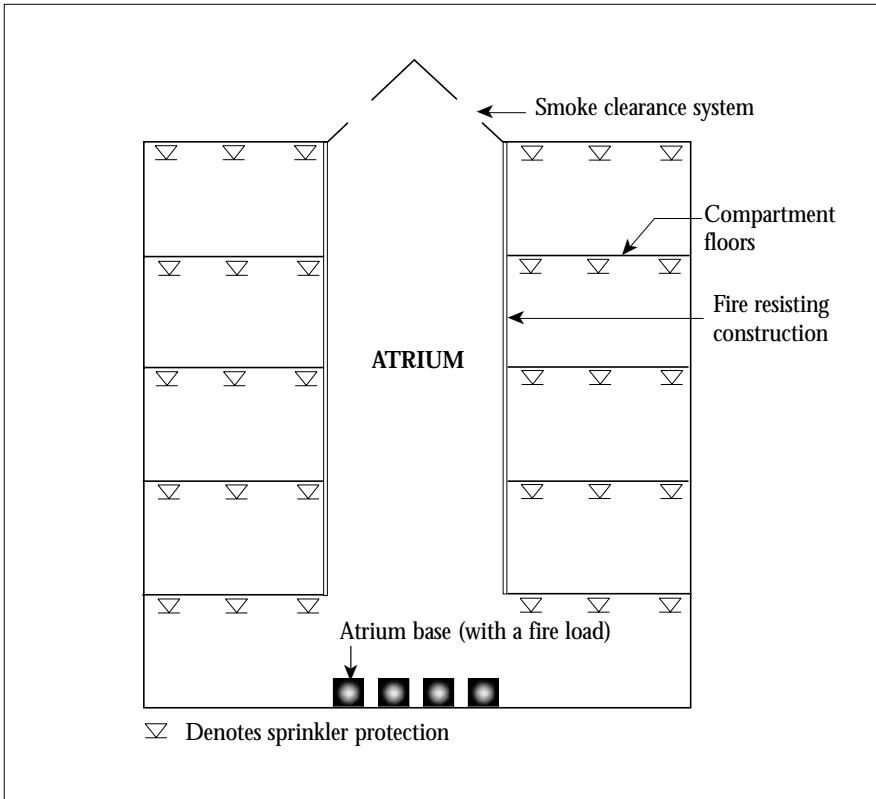


Figure 7.3. Upper floors separated from atrium by fire resisting construction.



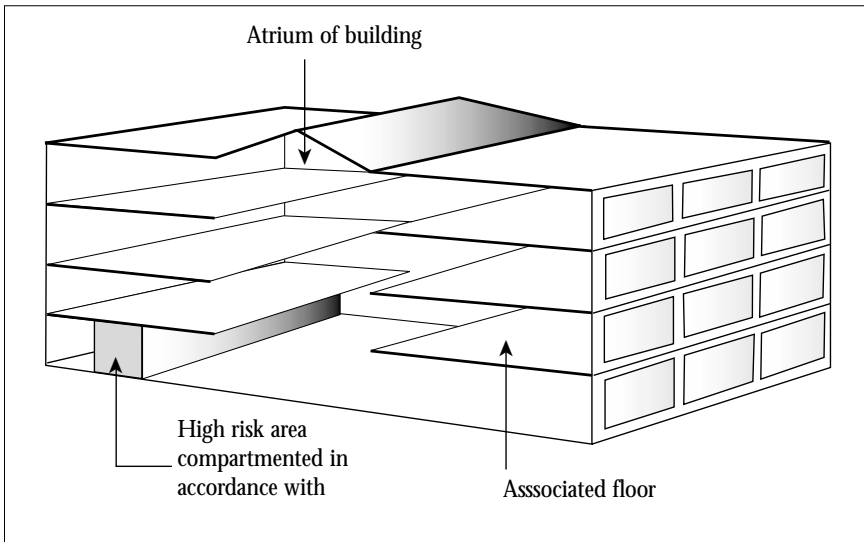


Figure 7.4.
Compartmentation of high risk locations.

7.1.5 REFERENCES

BS 5588: *Fire precautions in the design, construction and use of buildings*
Part 7: 1997: *Code of practice for the incorporation of atria into buildings.*

7.2 Food factories

7.2.1 SCOPE

This part of the *Design Guide* deals predominantly with recommendations for the passive fire protection of new food factory buildings (or major extensions) including storage areas within a food factory. However, the following storage areas are excluded:

1. Storage areas separated from factories by compartment walls complying with the fire resistance requirements specified in Table 2.2 of this *Design Guide*.
2. Stand alone refrigerated or temperature controlled storage buildings whether or not part of a food factory.
3. Individual cold stores (7.2.3.2) not exceeding 250m³ or in the aggregate 5% of the volume of a food factory building.

Notes: 1. The requirements for fire protection of buildings referred to in 2 above will very much depend on the outcome of a risk assessment, which will look closely at the potential for arson and also consider the size of the building.

2. It is preferred that the cold stores defined in exception 3 above should be constructed of materials referred to in 7.2.4.2.

3. This part of the *Design Guide* has been drafted on the basis that the food factory is a single-storey building. Multi-storey food factories should comply with the relevant recommendations of this *Design Guide* including those relating to vertical and horizontal compartmentation when required.

7.2.2 INTRODUCTION

Although the emphasis of fire safety management is to prevent a fire occurring, the *Design Guide* assumes that a fire may occur, either accidentally or maliciously. The overall objective is to contain the fire to the smallest possible area.

- To achieve the highest standards of fire protection commensurate with the best available insurance terms for the completed building, early and close consultation between the client, building designer and insurer is very strongly recommended. Early consultation will identify those recommendations which are most relevant to the protection of the building and assets of the business.
- It is important that the risk assessment principle referred to in 1.3 of this *Design Guide* is employed in both new buildings and in those existing buildings which are being extended.

Note: Information on upgrading existing food factories can be found in *LPC Code of Practice for Fire Protection in the Food and Drink Industry*.

- Food processing areas usually require a high overall standard of

insulation and it is frequently achieved by providing an insulated enclosure (7.2.3.1) within the building separate from the external fabric of the building.

- Reference should be made to the *RFIC Guide to the Management and Control of Fire Risks in Temperature Controlled Structures of the Refrigerated Food Industry*, and to other useful documents in support of fire safety management listed in 7.2.8.

7.2.3 DEFINITIONS

7.2.3.1 Insulated enclosure

For the purposes of this *Design Guide*, an enclosure, comprising walls and ceilings, normally but not exclusively constructed within a building, surrounding a food production or food storage area and designed to assist in maintaining strict control of temperature and facilitating the prevention of cross-contamination. Such enclosures are typically constructed from metal-faced insulated panels with food-safe surfaces and designed for regular cleaning to maintain a high standard of hygiene.

Note: Buildings where the external walls and roofs are constructed from insulated panels to meet the objectives given above are deemed to fall within this definition.

7.2.3.2 Cold store

An enclosure or stand alone building used to store frozen food products typically at temperatures of -25°C .

7.2.3.3 High risk area

In respect to this part of the *Design Guide*, any non-sprinklered area containing a significant fire inception risk arising from cooking or ancillary process and/or plant areas. Included are deep fat fryers, defrosting units and ovens. The decision on whether to consider an area as high risk is based on the overall risk assessment for the buildings. Storage, depending on the concentration of combustible materials, may need to be regarded as high risk.

7.2.3.4 Food safe panels

For purposes of this *Design Guide*, these typically are metal-faced panels, having a food-safe surface/jointing detail, and containing thermal insulation between the metal sheets. These panels should meet the specified fire performance levels given in this part of the *Design Guide* (see 7.2.7.2 and 7.2.7.3).

7.2.3.5 Refrigerated store

Any temperature-controlled enclosure or building (including cold stores defined in 7.2.3.2).

7.2.4 STRUCTURAL FIRE PROTECTION

7.2.4.1 Building fabric

This part of the *Design Guide* assumes that the building containing the insulated enclosure complies with the appropriate building regulations and the supporting documents to those regulations. In addition, the building

should comply with the recommendations given in the appropriate clauses of Parts 1-5 of this *Design Guide*.

7.2.4.2 Contribution to fire growth

The objective in relation to all elements of construction incorporated in food factory buildings is that any contribution to the growth and spread of fire, either internally or externally, should be minimal.

This is equally applicable to internal non-structural features such as linings, ceilings and partitioning systems, thereby reducing the overall potential for fire spread and growth (see 7.2.7.2).

The objective should be achieved by use of materials which meet the recommendations of 2.2 of this *Design Guide*.

7.2.5 COMPARTMENTATION - RECOMMENDED MAXIMUM FLOOR AREAS

The maximum floor area of a compartment (which may contain one or more insulated enclosures or non-insulated areas) shall be determined by the risk assessment but should not normally exceed the figures shown in Table 7.2.1.

Table 7.2.1 provides guidance on the maximum floor areas for any compartment. However, the following particular aspects will influence compartment size and/or the advisability for the installation of an LPC approved sprinkler installation:

- high fire load;
- high risk processes or storage;
- the need to limit the size of the financial loss including that resulting from the inability to trade.

The objective of compartmentation, as described in 7.2.6 and/or sprinkler protection, is to assist in limiting the potential fire cost both as regards direct damage to property and to the potential financial losses arising as a result of the company's inability to trade (business interruption)

Note: In addition the risk assessment will highlight any need for sub-division of the compartment. Guidance is given in 7.2.7 regarding the sub-division of compartments using suitable insulated panels.

Table 7.2.1

This table is based on Table 2.3 of this *Design Guide*, which should be consulted for further information.

Table 7.2.1. Guide to maximum recommended compartment floor areas in single-storey food factories.

OCCUPANCY TYPE	Floor area of any one compartment (m ²)	
	Not sprinklered	Sprinklered
Industrial	7000	14000
Storage	4000	8000

7.2.6 COMPARTMENTATION - RECOMMENDED FIRE RESISTANCE

Table 7.2.2 below, which is an extract of Table 2.2 of the *Design Guide*, details the recommended fire resistance needed between different occupancies or different occupancy types. For compartmentation of many food process buildings and all storage buildings the recommended fire resistance is 240

minutes, although in suitable circumstances this may be reduced to 120 minutes when sprinklers are installed. Storage, particularly for the food industry, includes packaging. The guidance given in Table 7.2.2 should be applied to separate process buildings from storage buildings as well as to reduce the size of individual compartments.

Table 7.2.2. Compartmentation - recommended fire resistance (for single-storey buildings).

OCCUPANCY TYPE	Minimum fire resistance (min)	
	Not sprinklered	Sprinklered
Industrial - Ordinary hazard groups I and II	120	90
Industrial - Ordinary hazard groups III and IIIs and High hazard process	240	120
Storage and other non-residential	240	120

Table 7.2.2

This table is based on Table 2.2 of this *Design Guide*, which should be consulted for further information.

Notes: 1. The appropriate recommendations of Parts 3, 4 and 5 of this *Design Guide* should also be complied with to ensure that compartmentation is effective.

2. For guidance on the sub-division of individual compartments reference should be made to Table 7.2.3.

7.2.7 RECOMMENDATIONS FOR INSULATED ENCLOSURES

7.2.7.1 Structural stability

The structural stability of the enclosure and any supporting structure shall in all cases be verified by a qualified structural engineer. This aspect is outside the scope of LPS 1208 (or LPS 1181-2).

7.2.7.2 Minimum requirements for insulated enclosures

The minimum requirement is that food safe panels and other components used in the construction of the insulated enclosure do not make a significant contribution to a developing fire. This may be achieved either by the use of non-combustible materials or adequately protected combustible materials. Food-safe panels that satisfy the requirements of the wall and ceiling lining test described in LPS 1181-2 for Grade B can be deemed to meet that requirement.

7.2.7.3 Additional recommendations for the insulated enclosure

Fire-resisting food-safe panels that satisfy the requirements of LPS 1208 and meet the levels of fire resistance specified in Table 7.2.3 are strongly recommended in the following circumstances:

- wall and ceiling panels forming the extent of the insulating enclosure;
- to enclose high risk areas;
- where a need has been identified in the risk assessment, to provide further sub-division to reduce potential property damage and financial loss (see 1.3 and 1.4).

The requirements and recommendations given in 7.2.7.2 and 7.2.7.3 are shown in Figs 7.5 and 7.6.

Table 7.2.3

Table 7.2.3. Fire resistance recommended for insulating wall and ceiling panels in the locations given in 7.2.7.3

APPLICATION	INTEGRITY	INSULATION
Normal risk*	30 minutes	30 minutes
High risk	60 minutes	60 minutes

* This will be deemed to be satisfied by any panel that has been approved by LPCB to Grade A of LPS 1181-2 and has been shown to be suitable for food factory applications.

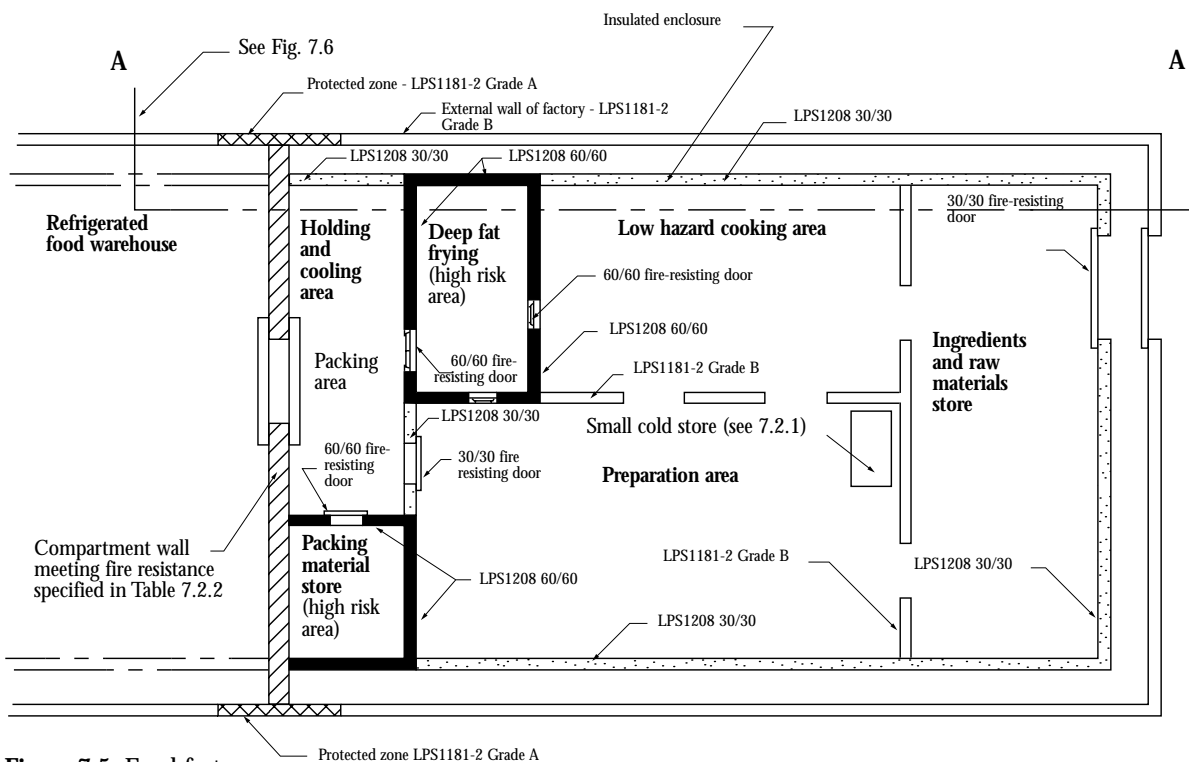


Figure 7.5. Food factory - An example of recommended fire resistances.

Notes: 1. External walls, unless required to by Part 5 of this *Design Guide* and any non-shaded internal walls are not required to have fire resistance. They should comply with 2.2 of this *Design Guide* (either be entirely non-combustible or meet the requirements of LPS 1181-2 Grade B).

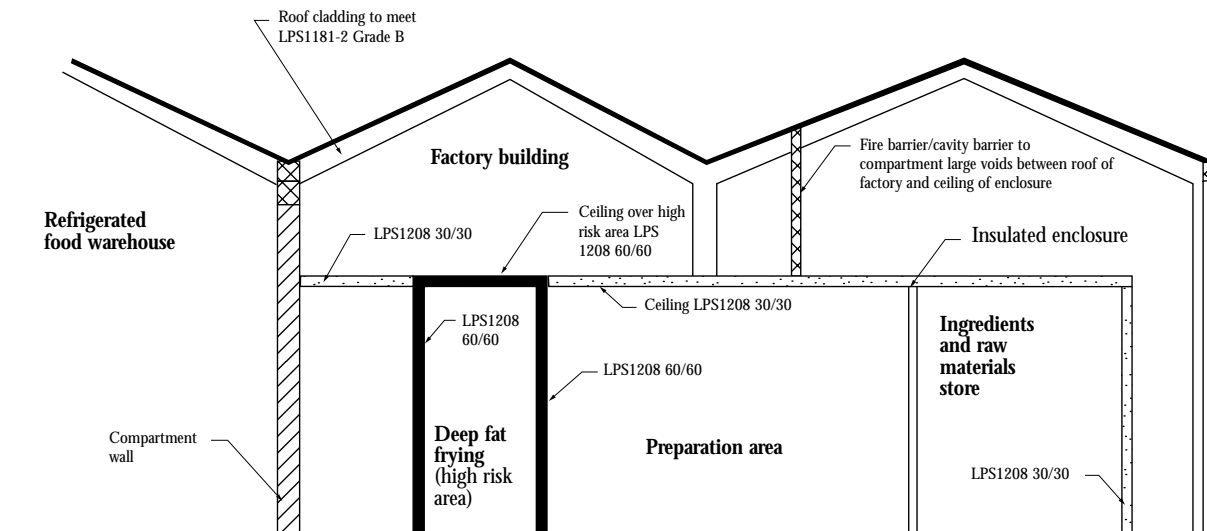
2. Shaded walls are those that are required to have fire resistance in accordance with the recommendations of 7.2.6 and 7.2.7. Ceilings separating the insulated enclosure from the rest of the building should also be fire resisting. (See Fig. 7.6.)

7.2.7.4 Other aspects

- Where any door, window or the passage of services pierces insulated enclosures, the advice given in Parts 4.1 - 4.4 of this *Design Guide* should be followed.
- It is important to recognise that such elements, i.e., doors, windows, services etc. may only have been tested in a conventional masonry or dry-lining construction and not in conjunction with a food-safe panel

construction. In such circumstances, further assessment and/or testing should be undertaken.

- The required fire resistance given in LPS 1208 shall be maintained when doors, windows and services are installed or pass through panels designated as requiring fire resistance (see 7.2.7.3).



- Where uninsulated doors or windows are fitted, it is important to maintain safe distances from combustible goods so as to prevent ignition from thermal radiation. Guidance is given in Parts 4.1 and 4.2.
- Large voids between the roof of the food factory building and the ceiling of the enclosure should as far as practical be compartmented by fire barriers/cavity barriers having fire resistance of not less than 30 minutes (see 2.4.2 (k), 4.1.3.5 and 4.5 of this *Design Guide*).
- The provision of active fire protection may also need to be considered, see 2.8 - 2.10 of this *Design Guide*.
- Materials used in the construction of the enclosure shall also satisfy any hygiene requirements specified by the food industry.
- Any electrical cables passing through an insulated cored panel shall be located inside conduits to prevent any potential degradation of the PVC insulation.
- The recommendations of 7.2.7.3 may be achieved by up-grading non-fire-resisting ceiling and wall panels with a system complying with LPS 1220 and also satisfying food hygiene requirements. This may be considered when end-use conditions restrict the choice of insulation. This method requires that fire stops should be provided at every third panel joint and these should meet the requirements for fire stops specified in LPS 1220. These are still recommended even when the enclosure is sprinkler protected.

Figure 7.6. Food factory - Elevation showing fire-resisting ceiling (Section A-A of Fig. 7.5).

(LPS 1220 defines the test and performance requirements for the up-grading of non-fire-resisting metal-faced insulated panels. This applies the same performance levels specified in LPS 1208.)

7.2.7.5 Active fire protection

- The risk assessment may lead to a recommendation for the installation of sprinklers.
- Where sprinklers are installed to protect food factories, particularly when the construction does not conform with the recommendations in this part of the *Design Guide*, care is required in locating the sprinkler heads to give maximum coverage of walls, ceilings and roof/ceiling and other voids.
- Where there are ceiling or roof voids, it may be necessary to upgrade the sprinkler water supply, to protect against the possibility of a premature collapse of the ceiling, leading to the simultaneous operation of the sprinkler heads above and below the ceiling.

7.2.8 REFERENCES

Loss Prevention Council

LPC Rules for automatic sprinkler installations, The Loss Prevention Council.

LPC Code of Practice for Fire Protection in the Food and Drink Industry, The Loss Prevention Council.

Loss Prevention Standards

LPS 1181, issue 2, *Requirements and tests for LPCB approval of wall and ceiling lining and composite cladding products*.

LPS 1208, *Fire performance requirements for metal-faced fire-resisting insulated panels*.

LPS 1220, *Test and performance requirements for passive fire protection systems used for upgrading insulated panels*.

Other guidance documents

Cold Storage and Distribution Federation, *The RFIC (Refrigerated Food Industry Confederation) Guide to the Management and Control of Fire Risks in Temperature Controlled Structures of the Refrigerated Food Industry*.

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8 Case studies

8.1 Introduction

8.1.1 The purpose of this part is to clarify the recommendations of this *Design Guide* by means of providing examples of typical industrial and commercial buildings.

8.1.2 Typical forms of construction (single storey portal frame, multi-storey frame) are shown on a whole building basis. Attention is drawn to issues of planning, structure, compartmentation and protection of services where *Design Guide* recommendations apply. The examples are not exhaustive but set out principles which can be applied to the majority of normal building projects.

8.1.3 The case studies will, as appropriate, allow for some flexibility in applying the recommendations given in the *Design Guide* based on the outcome of the risk assessment. The principles of the risk assessment in respect to property protection are outlined in 1.3 of this *Design Guide* and the case studies assume that this process has been followed.

8.0.4 References to the appropriate clauses in the *Design Guide* are given in brackets thus [].

8.2 Single storey industrial building

8.2.1 GENERAL

The construction is a steel portal frame (80m x 40m) with mono-pitch lean-to office block. The client is a plastics production manufacturer who owns the building but intends to let part of it to a haulage contractor (Tenant A) as a transit warehouse. The building will thus be divided along one of the portal frame gridlines into two occupancies. The larger of the two will be the plastics production facility for which a rough outline of operational flow is available. The decision has been taken not to install sprinklers in any area of the building.

8.2.2 SUMMARY INFORMATION

Occupancy	
Single	Multiple
	✓

Where a compartment wall divides buildings in different ownerships, the requirements of Table 2.2 and clause 3.2.2.1(i) should be met

Occupancy types covered in this case study							
2a/2b	3	4a	4b	5	6a	6b	7a
						✓	✓

Compartmentation between different occupancy types should have the fire resistance given in Table 2.2 of this *Design Guide*. Occupancy types are defined in Appendix 2A.

Location of building			
Large city/town	Small town	Rural	
✓			
Adjacent buildings or hazards			
Yes		No	
		✓	
Where there are adjacent buildings or hazards, the requirements of Part 5 of this <i>Design Guide</i> should be consulted.			
Anticipated speed of fire brigade response			
5 min	10 min	20 min	Over 20 min
✓			
Anticipated fire growth rate of principle contents*			
Slow	Medium	Fast	Ultra fast
			✓
Key:	Picture gallery	slow	
	Office	medium	
	Hotel	medium	
	Shop	fast	
	Factory/storage	ultra fast	
* Based on Table 10, BS DD 240:Part 1:1997			
Hazard group**			
Ordinary hazard Group I	Ordinary hazard Group II	Ordinary hazard Group III	Ordinary hazard Group IIIs
			✓
** For further information, please see BS 5306:Part 2:1990, Table 3, page 17			
Sprinkler protection			
Not sprinklered	Partially sprinklered	Fully sprinklered	
✓			

8.2.3 RECOMMENDATIONS

Numbers given below relate to the drawings Figure 8.1(a) and 8.1(b)

1. Contribution to Fire Growth [2.2] - All building materials including the roof and external wall claddings to be non-combustible/limited combustibility or LPCB approved to LPS 1181.
2. Fire Resistance Compartmentation [2.4] - Recommended fire resistance from Table 2.2 for industrial occupancy type 6b - manufacturing process involving plastics (240min).

3. Compartment Floor Areas [2.5] - Less than the maximum recommended from Table 2.3 for industrial occupancy type 6 (7000m²). However, further compartmentation may be required to isolate plant that is difficult to replace and storage of high calorific value (Appendix 3C) *and it is recommended to consult the insurer.*
4. Compartmentation [2.4] - In spite of being in the same ownership the wall divides separate occupancy types therefore Fire Resistance = 240min. Fire stopping between the top of the wall and the portal frame needs to be of equal fire resistance [2.4.2 (j) & 3.4.4 (b)]. The columns of the portal frame need to be fire resisting to prevent frame deformation causing collapse of the wall [3.2.1.1.1 (a)]. The wall cannot be moved away from the frame because of requirements for structural stability in the cold state. It is important that consideration be given at design stage to include a hot state collapse mechanism for the purlins on this grid line [3.2.1.1.1(b)(iv)].
5. Compartmentation - The dividing wall with glazed partitions separates different occupancies and therefore requires 240min fire resistance. However, for the purposes of this case study, it has been assumed that after undertaking the risk assessment, insurers have allowed relaxation to 120min [1.3.2]. (This may depend on the value and effect of loss of the office block as a result of fire in one of the other compartments.)
6. The bays bordered by the neighbouring frames to either side of the compartment wall define the protected zone for both roof and walls. Minimum requirement for the cladding is 30 minutes integrity and 15 minutes insulation (see also 10 and 11 below) [3.3.1.2].
7. The production area and offices are separate compartments by reason of occupancy type. There is however the risk of fire spread from the roof of the office to the wall of the production facility. The requirement for the wall lining is 30 min integrity and 15 min insulation [5.4.2.1] over the height above the mono-pitch.
8. Fire resisting steel roller shutters to be used as part of the internal compartmentation. Size within allowable limits [Table 4.2] and safe storage distance (Figs 4.1 and 4.2). The risk assessment has recommended that roller shutters in tandem be installed in the compartment wall dividing the packing department from the production area to reduce the risk of fire spread from radiation.
9. The wall between the office block and the production facility contains glazed panels. This feature is permitted [3.2.2.2.3] but the glazing must achieve 120 min fire resistance (see 5 above). Guidance on possible specifications given [4.3.3.2]. Size only limited by the manufacturer's advice.
10. The boundary fence while provided primarily in a security context will also reduce the risk of arson [5.6.1].
11. Skips or timber pallets are often situated as close to the building as possible for ease of disposal but this increases the risk of fire spread from an external source. Solutions are (a) Remove to a safer area or (b) Specify fire resisting external walls and suitable location of eaves venting to prevent flames from being channelled into the roof. Good housekeeping should ensure that as soon as the skip is filled it is removed.

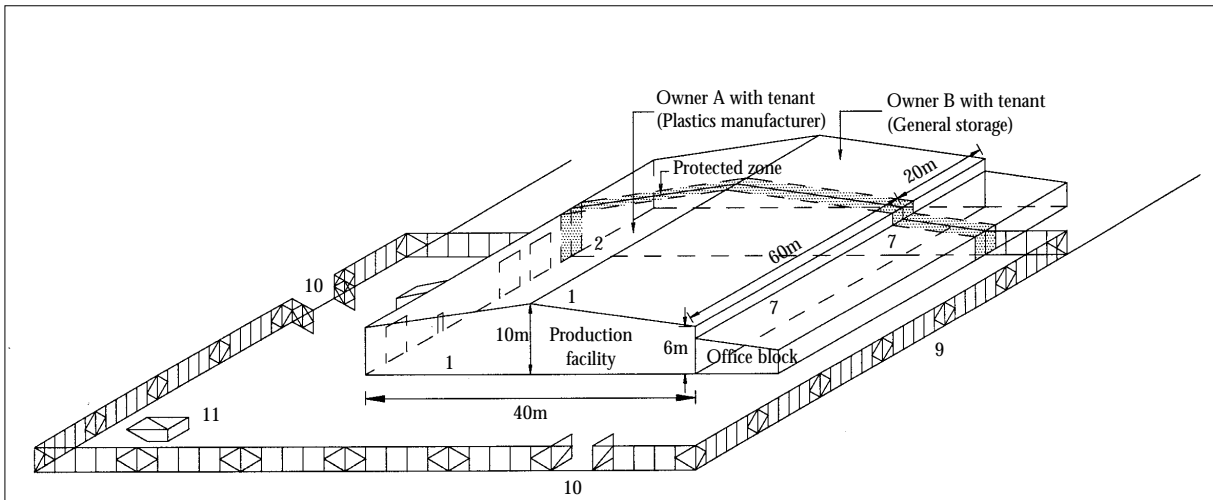


Figure 8.1(a). Isometric view of industrial building.

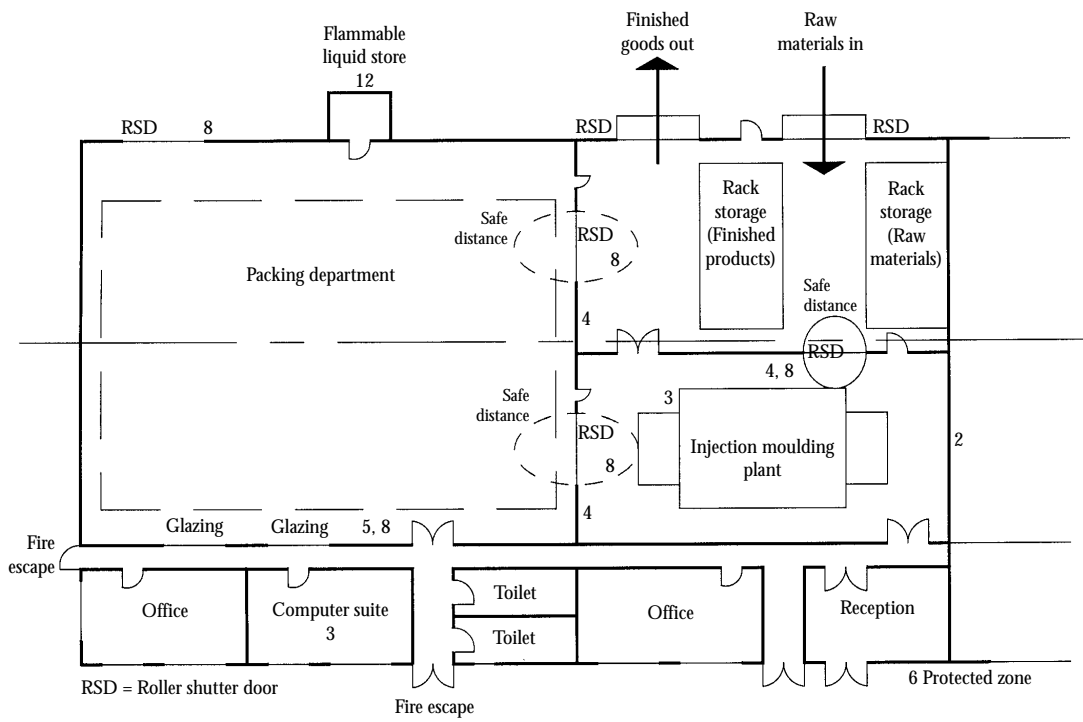


Figure 8.1(b). Planned view of production operation.

12. The flammable liquid store is an Appendix 3C (3) special risk. Table 3.1 recommends a minimum of 60 minutes compartmentation, which includes walls, roof and door. The alternative would be to locate the flammable liquid store remote from the main structure.

8.3 Multi-storey building

8.3.1 GENERAL

The construction is a steel framed, composite metal deck floored 14 storey building measuring approximately 41m x 14m in plan. Walls are supported of each floor level and are therefore non-loadbearing. The upper storeys are accessed by both lifts and stairwells. The developer has pre-let the ground floor as a retail outlet and the floors above as a hotel with conference facilities. The height of the building dictates (Approved Document B) that it is sprinklered for life safety purposes.

Figure 8.2(a) is a plan of the ground floor which is shared between the hotel reception and the retail outlet. Figures 8.2(b) and 8.2(c) respectively show plans of the 1st and 2nd floors displaying the use of open plan space for various occupancy types within the hotel. Figure 8.2(d) shows the floor plan of the residential section of the hotel which is repeated from the 3rd to the 12th floor. Figure 8.2(e) is a section through all floors contrived to illustrate as many possible routes for storey to storey fire spread as possible.

8.3.2 SUMMARY INFORMATION

Occupancy							
Single				Multiple			
✓							
Where a compartment wall divides buildings in different ownerships, the requirements of Table 2.2 and clause 3.2.2.1(i) should be met. Occupancy types are defined in Appendix 2A.							
Occupancy types covered in this case study							
2a/2b	3	4a	4b	5	6a	6b	7a
✓		✓					
Compartmentation between different occupancy types should have the fire resistance given in Table 2.2 of this <i>Design Guide</i>							
Location of building							
Large city/town			Small town		Rural		
✓							
Adjacent buildings or hazards							
Yes				No			
✓							

Where there are adjacent buildings or hazards, the requirements of Part 5 of this *Design Guide* should be consulted.

Anticipated speed of fire brigade response				
5 min	10 min	20 min	Over 20 min	
✓				

Anticipated fire growth rate of principle contents*				
Slow	Medium	Fast	Ultra fast	
	✓ (hotel)	✓ (retail)		

Key: Picture gallery slow
Office medium
Hotel medium
Shop fast
Factory/Storage ultra fast

* Based on Table 10, BS DD 240:Part 1:1997

Hazard group**				
Light hazard	Ordinary hazard Group I	Ordinary hazard Group II	Ordinary hazard Group III	Ordinary hazard Group IIIs
✓ (hotel)			✓ (retail)	

** For further information, please see BS 5306:Part 2:1990, Figure 3, page 16 and Table 3, page 17

Sprinkler protection		
Not sprinklered	Partially sprinklered	Fully sprinklered
		✓

8.3.3 RECOMMENDATIONS

- Contribution to Fire Growth [2.2] - All building materials including the roof to be non-combustible/limited combustibility, or LPCB approved to LPS 1181.
- Fire resistance of elements of structure (frame, walls and floors) differ depending on occupancy [Table 2.1] (residential type 2a/b and > 30m high =120min, shop and commercial type 3 sprinklered and > 30m high =120min).
- Compartmentation fire resistance [Table 2.2] is also occupancy dependent with special allowance for sprinklered buildings (residential type 2a/b and sprinklered = 90min, shop and commercial type 3 and sprinklered = 90min). Any sprinkler installation shall be in accordance with LPC *Rules for Automatic Sprinkler Installations* (incorporating BS 5306: Part 2).

At 7385m² the hotel is within the area limits for a single compartment [Table 2.3]. Compartmentation is required between the retail outlet and the hotel.

[3.2.1.2.4] specifically recommends that for multi-storey construction, limits for the fire resistance for structure are not less than that for compartmentation (in this case, 120min for the entire building).

- The stairwells must be compartmented because they provide both means of escape and a potential route for upward fire spread. Requirement is therefore for 120min fire resistance for both walls and doors. The doors shall additionally be able to prevent the passage of cold smoke and must be fitted with door closers. Floors should be cast into the stairwell to provide a smoke tight seal. Where gaps do exist they must be filled with 120min fire resisting fire stopping/linear gap seals [4.6].
- The lift shaft must be compartmented in the same way as the stairwell to prevent upward fire spread. Lift landing door [4.2.12.7] [4.2.13] fire resistance to be 50% that of the compartmentation subject to a minimum of 60min (*designers should note that if the door has only been fire tested from the landing side, then the door should have 120min fire resistance*).
- A service duct for all services runs the full height of the building. Specifiers can choose from three options to maintain compartmentation [3.2.3.3.1]:
 - (a) 50% fire resistance ducting and 50% fire resistance penetration seal at floor levels [Figure 3.13].
 - (b) 100% fire resistance ducting with no penetration seals [Figure 3.14].
 - (c) Non fire-resisting duct with 100% fire resistance penetration seal and additional sleeving to services at the change in floor level [Figure 3.15].
- The building contains an atrium and the architect's preference is for floors to be open to this space. This has implications for the fire load in the base of the atrium [7.1.2.5, 7.1.2.6, 7.1.2.8], boundaries to the atrium [7.1.4] and sprinkler protection for the associated floor areas [7.1.4].
- All doors comprising the boundaries of vertical shafts including those opening into the atria to be fire resisting [4.2.5].

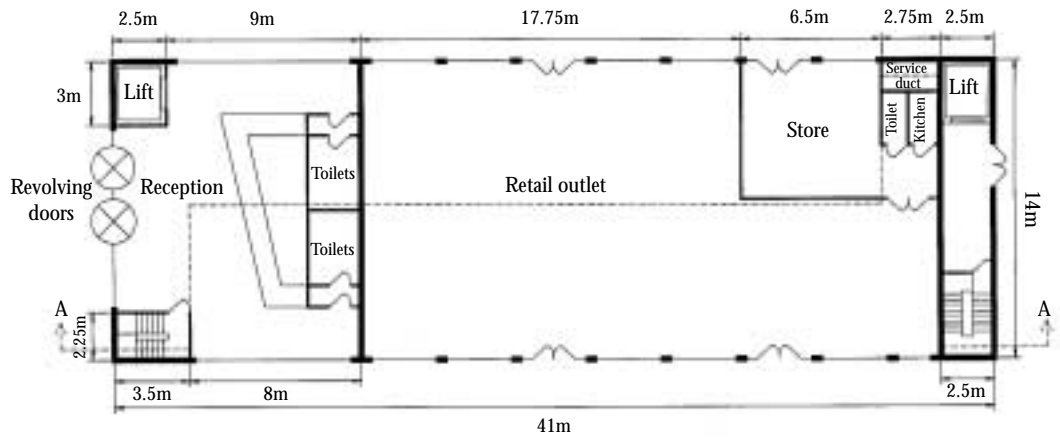


Figure 8.2(a). Floor plan (ground).

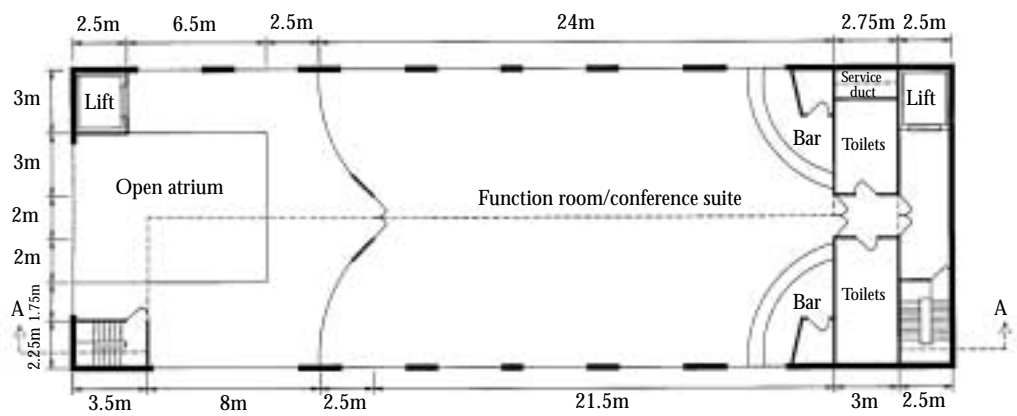


Figure 8.2(b). Floor plan (first).

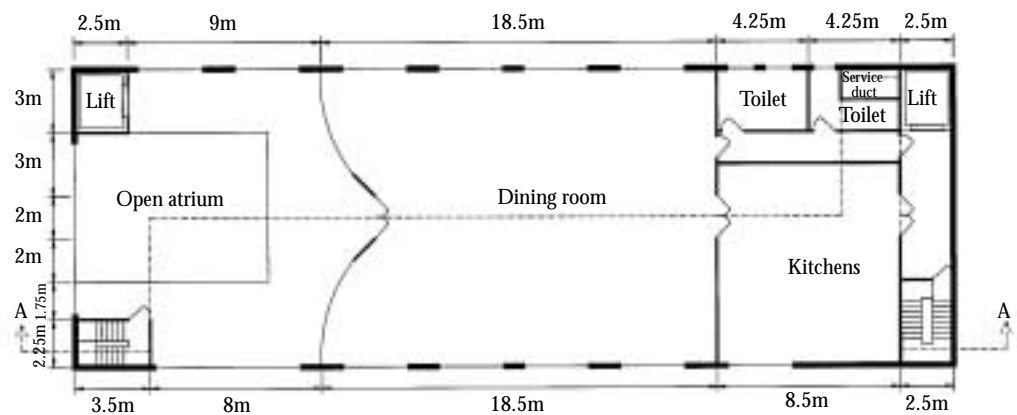


Figure 8.2(c). Floor plan (second).

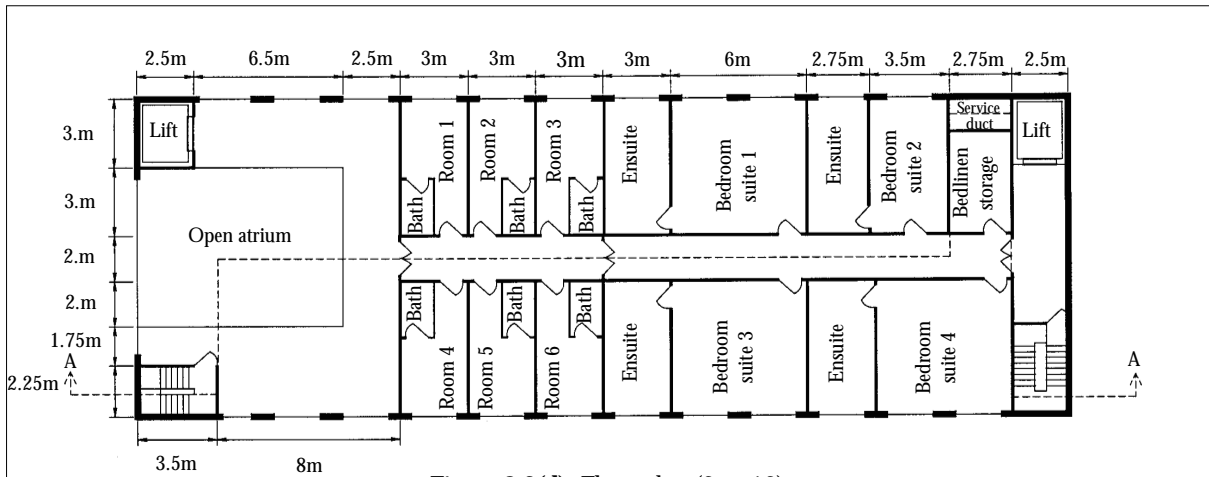


Figure 8.2(d). Floor plan (3 to 12).

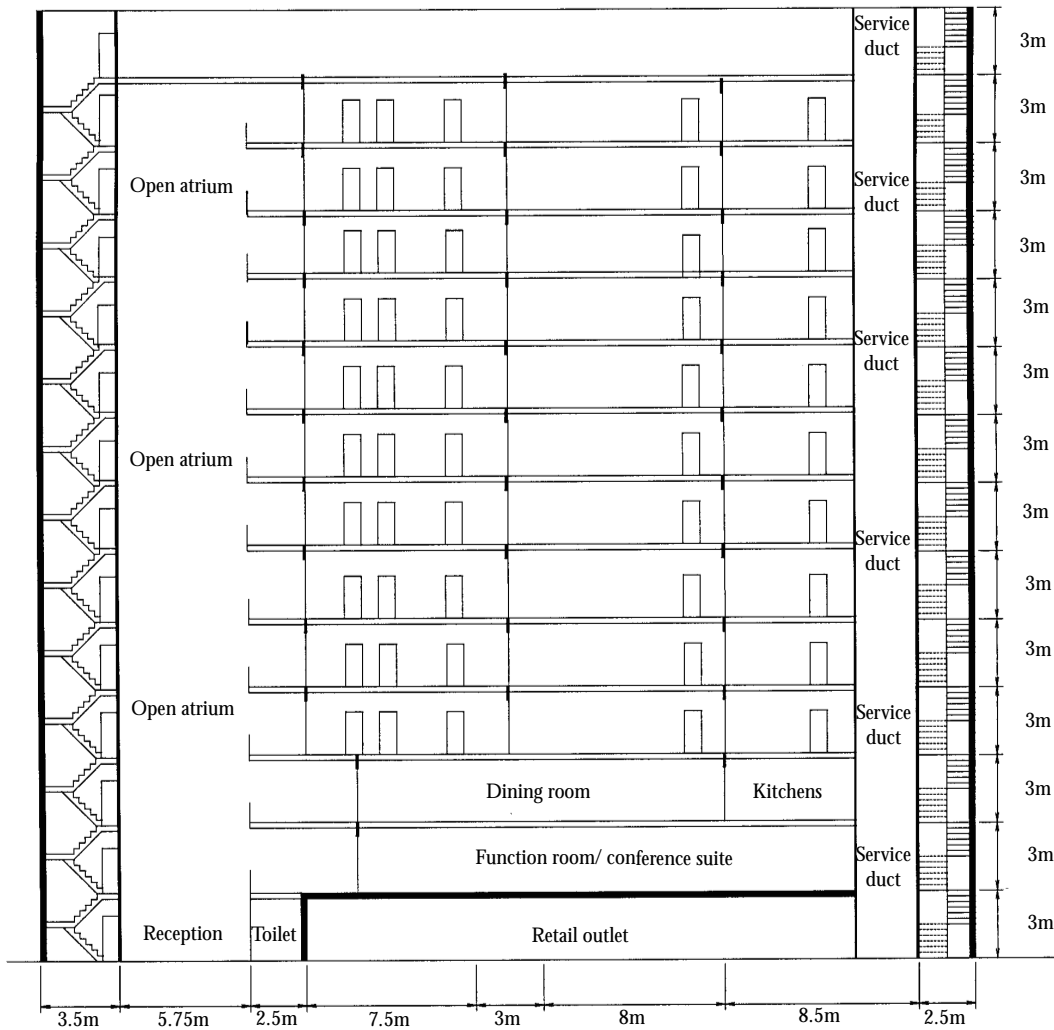


Figure 8.2(e). Sectional elevation A-A.

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