FPA Design guide

for the Fire Protection of Buildings

WAREHOUSES AND STORAGE BUILDINGS 1: DESIGN PRINCIPLES

FPA
Fire Protection Association

InFiReS

IMPORTANT NOTICE

This document is one of a number which go to make up the *FPA Design guide for the fire protection of buildings,* a development from the *LPC Design guide for the fire protection of buildings 2000*. That development is part of a programme of work being carried out by the Fire Protection Association under the sponsorship of the Insurers' Fire Research Strategy Funding Scheme (InFiReS). The scheme is operated by a group of insurance companies supporting a series of expert working groups developing and promulgating best practice for the protection of property and business from loss due to fire and other risks. The technical expertise for the *Design guide* is provided by the Technical Directorate of the FPA and experts from the insurance industry who form the InFiReS Passive Working Group.

The aim of the *FPA Design guide* is to provide loss prevention guidance for those who design, construct and equip industrial and commercial buildings. The *Design guide* documents continue a long tradition of providing authoritative guidance on loss prevention issues started by the Fire Offices' Committee of the British insurance industry over a hundred years ago and build upon earlier publications from the LPC and the Association of British Insurers.

FPA Design Guide: Essential Principles

The objectives of the Design Guide are to:

- reduce the likelihood of fire, either accidental or malicious;
- minimise the effect of fire on a business;
- protect the buildings within a business; and
- maintain the health and safety of those in and around the building (including firefighters).

This objective will be achieved by addressing essential principles to be followed in the design and construction of commercial and industrial premises.

The essential principles are:

Reaction in the event of fire:

1. The building shall be constructed in such a manner that if a fire starts, the extent of fire and smoke damage will be minimised and confined as close to the source of fire outbreak as is practical/feasible.
2. With the exception of joinery products, the building shall be constructed from building materials/products that will not make a significant contribution to the early stages of a fire or contribute to the spread of fire.
3. Suitable measures will be taken for the prevention of premature structural collapse and excessive deflection.
4. Consideration shall be given at the design stage to the potential damage from firefighting water and to ensuring, as far as practical, that the effect on the environment of the fire effluent will be minimised.

Workmanship:

5. As a minimum, all fire protection products shall be third-party certificated to an appropriate product or performance-based standard (attestation level 1 for CE marking).
6. All fire protection products/systems shall be installed by adequately trained specialist installers.

Response to fire:

7. The building shall be fitted with an appropriate automatic fire alarm system.
8. The fire protection systems shall be regularly maintained so that they are able to perform their intended function throughout the life of the building.

Fire prevention:

9. There shall be adequate provision to prevent an arson attack.
10. The building shall be so constructed that fire cannot spread into the premises from an adjoining building or other external fire source.

Fire safety management:

11. The building owner shall ensure an adequate standard of fire safety management throughout the life of the building.
12. Any fuel-burning appliance and services or electrical appliance and services shall be designed, constructed and installed in a manner that reduces their potential as an accidental source of ignition.

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FPA DESIGN GUIDE FOR THE FIRE PROTECTION OF BUILDINGS

WAREHOUSES AND STORAGE BUILDINGS 1: DESIGN PRINCIPLES

FPA Fire Protection Association

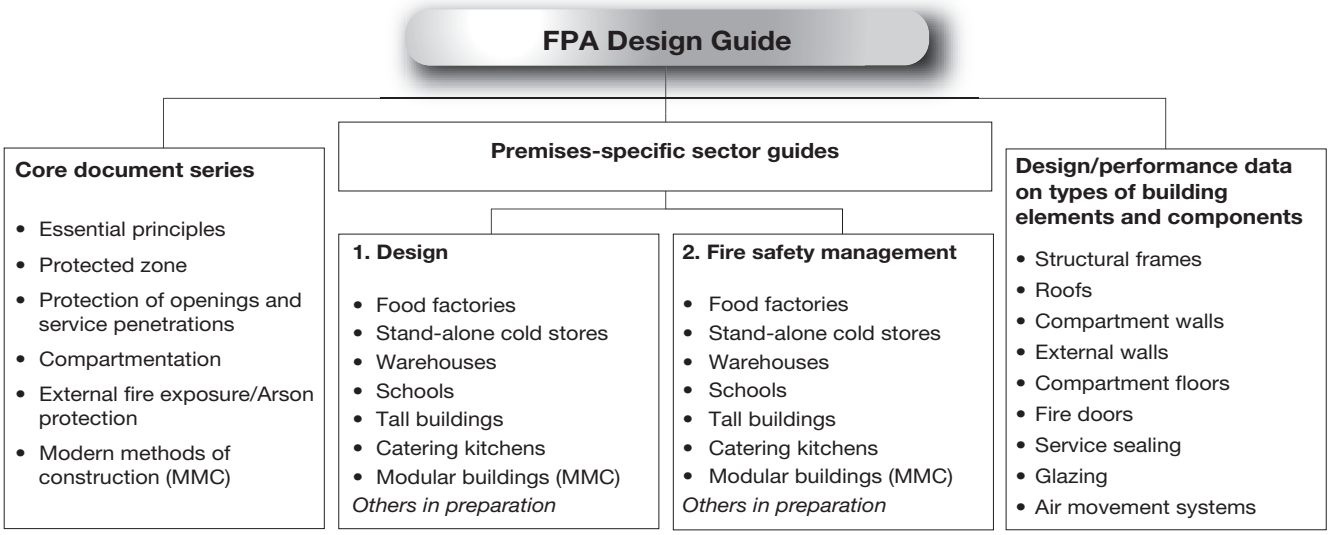
InFiReS

FPA Design Guide: the Fire Protection of Buildings

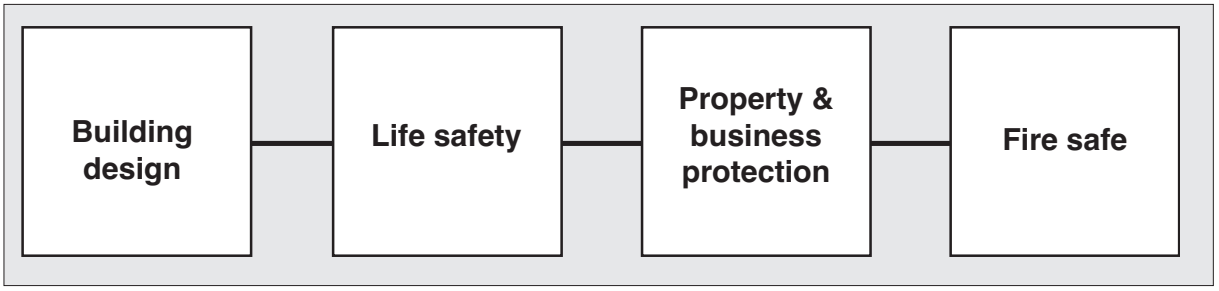
The FPA Design Guide is a series of publications which have been developed from predecessor documents and also cover new ground. The Design Guide informs architects and designers about the business risk management issues which relate to the fire protection of buildings, issues which supplement in very important ways the life safety requirements contained in the principal legislative controls. It will give designers a more complete view about designing fire-safe buildings.

The Design Guide has been recast in three main parts:

- core documents: a set of publications on fundamental design topics;
- premises-specific sector guides: for each type there will be a design guide and a document concerning fire safety management; and
- design/performance data on building products: the datasheets are accessible on *www.thefpa.co.uk/Resources/Design+Guide/.*



It is also proposed to produce a document which concentrates on technical data, definitions of terms and details of sources of reference and information, as commonly used for insurance underwriting purposes, to support the suite of Design Guide publications.



Basic fire safety design framework

Emphasis is placed on the importance of early consultation among architects, those who manage risks in industry and commerce, and insurers, and on the value of risk assessment in order to use the *Design Guide's* recommendations to best effect.

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Section 1
USE OF GUIDANCE

1.1 Sector Guides

1.1.1 Introduction

This document is one of a number which go to make up the *FPA Design Guide for the Fire Protection of Buildings,* a development from the *LPC Design Guide for the Fire Protection of Buildings 2000*. That development is part of a programme of work being carried out by the Fire Protection Association under the sponsorship of the Insurers' Fire Research Strategy Funding Scheme (InFiReS). The scheme is operated by a group of insurance companies supporting a series of expert working groups developing and promulgating best practice for the protection of property and business from loss due to fire and other risks. The technical expertise for the Design Guide is provided by the Technical Directorate of the FPA and experts from the insurance industry who form the InFiReS Passive Working Group.

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Lists of other publications on loss control are available at www.thefpa.co.uk and from the FPA at:

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Copies of publications can be purchased from the FPA at that address or by calling +44 (0)1608 812500 or emailing sales@thefpa.co.uk.

1.1.2 Essential Principles

National building regulations are intended to ensure that a reasonable standard of life safety is provided in case of fire. The protection of property, including the building itself, may require additional measures.

It is the objective of the *FPA Design Guide* to describe aspects of fire safety in buildings which will both reduce the risk of fire and make buildings better able to cope with the effect of fire in the event that it should break out. The aims are to:

- reduce the likelihood of fire, either accidental or malicious;
- minimise the effect of fire on a business;
- protect the buildings within a business; and
- maintain the health and safety of those in and around the building (including firefighters).

This objective will be achieved by following essential principles in the design and construction of commercial and industrial premises.

The essential principles are summarised as follows:

Reaction in the event of fire:

1. The building shall be constructed in such a manner that if a fire starts, the extent of fire and smoke damage will be minimised and confined as close to the source of fire outbreak as is practical/feasible.
2. With the exception of joinery products, the building shall be constructed from building materials/products that will not make a significant contribution to the early stages of a fire or contribute to the spread of fire.
3. Suitable measures will be taken for the prevention of premature structural collapse and excessive deflection.
4. Consideration shall be given at the design stage to the potential damage from firefighting water and to ensuring, as far as practical, that the effect on the environment of the fire effluent will be minimised.

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5. As a minimum, all fire protection products shall be third-party certificated to an appropriate product or performance-based standard (attestation level 1 for CE marking).
6. All fire protection products/systems shall be installed by adequately trained specialist installers.

Response to fire:

7. The building shall be fitted with an appropriate automatic fire alarm system.
8. The fire protection systems shall be regularly maintained so that they are able to perform their intended function throughout the life of the building.

Fire prevention:

9. There shall be adequate provision to prevent an arson attack.
10. The building shall be so constructed that fire cannot spread into the premises from an adjoining building or other external fire source.

Fire safety management:

11. The building owner shall ensure an adequate standard of fire safety management throughout the life of the building.
12. Any fuel-burning appliance and services or electrical appliance and services shall be designed, constructed and installed in a manner that reduces their potential as an accidental source of ignition.

1.1.3 Limitations

The *FPA Design Guide for the Fire Protection of Buildings* is made up of many documents, including a number of premises-specific Sector Guides. Each Sector Guide is in two parts: Part 1 covers the design principles for a particular type of premises and Part 2 is concerned with fire safety management.

This particular document is therefore concerned only with design principles for fire safety in warehouses and storage buildings and it does not address all of the essential principles in detail. It describes measures and makes recommendations which, if adopted, will assist in the design and construction of warehouse and storage buildings (or extensions thereto) which are less likely to catch fire. Should fire occur, however, the applied design principles will help minimise fire and smoke damage and thus minimise interruption to the business and day-to-day operation. However, fire safety management issues are dealt with in this Sector Guide to the extent that they must be taken into account at design stage in order to facilitate good fire safety management once the building is occupied.

In addition, this Sector Guide may also help in identifying ways to reduce fire risks in existing warehouses and storage buildings.

No specific guidance on life safety and means of escape is given in this document. For this, appropriate advice shall be obtained from the local fire authority and building control and reference made to the relevant parts of documents approved for the purpose of building regulations.

This Sector Guide is intended to provide guidance for some of the more common building situations. It is only a representative view of the many different facets of construction, and the designer should contact the insurer for further advice before construction details are finalised.

1.1.4 Fire safety engineering

The approach taken by documents approved for the purpose of building regulations is that life safety is delivered by a combination of methods. In general, these methods involve striking a balance between reasonable means of escape from fire, reasonable means to prevent fire spread, and reasonable measures to ensure structural stability in the early stages of fire.

By taking the alternative approach of fire engineering, it is possible to deliver adequate life safety by shifting the balance in favour of means of escape, and to reduce structural fire safety.

Such a shift in balance is not acceptable if this Sector Guide is to be complied with.

Fire engineering may be used as an alternative to this Sector Guide, but:

- an appropriate fire engineering standard must be followed in full. BS 7974 (ref. 1) is recommended, although CIBSE Guide E (ref. 2) is also acceptable;
- the essential principles must be achieved to the extent that they would be if this Sector Guide was followed in full;
- the fire engineering must be based on the following fire safety objectives, to protect and maintain:
  - the structure and fabric of the building;
  - the building contents;

  - the ongoing business viability; and
  - the corporate image;
- any design which incorporates fire engineering should be referred to the insurer.

1.1.5 The audience

This advice is addressed mainly to those professionals – architects, developers, surveyors, fire engineers and builders – who need help to understand and apply the principles of fire safety in the design and construction of buildings, by adherence to fundamental guidance given in the *FPA Design Guide for the Fire Protection of Buildings: Essential Principles* (ref. 3). It will also be of value to those who survey and assess the fire safety attributes of buildings on behalf of insurance companies.

It should also be of help to building owners and fire safety managers.

1.2 Warehouses and storage buildings

1.2.1 Scope

The advice contained in this Sector Guide is applicable to ambient temperature warehouses and storage buildings. It assumes that the building under consideration for design is a steel portal-framed warehouse, which may be:

- a storage building on a manufacturing site, either stand-alone or part of a larger industrial or commercial premises;
- a wholesale warehouse in which goods are stored awaiting distribution (including carriers'/transit warehouses);
- a bonded warehouse; or
- a warehouse for long-term storage.

The measures are applicable to both proposed new buildings and extensions and alterations to existing buildings.

1.2.2 Arrangement of sections

The essential principles mentioned above may be achieved by consideration of a range of issues. In this Sector Guide, these issues are grouped together and addressed in a way which closely follows the documents which support UK building regulations. The target audience will generally be familiar with documents approved for the purpose of building regulations, and arranging this Sector Guide in a similar way is intended to facilitate understanding, and to make it possible to compare and contrast building regulation guidance with the guidance set out here.

This Sector Guide addresses the following issues:

- reduction of internal fire spread – linings
- reduction of internal fire spread – structure
- resistance to external fire spread
- provision of warning and firefighting facilities
- access and facilities for the fire and rescue service
- design to facilitate fire safety management

1.2.3 Commentary

This document deals with the design principles for passive fire safety in warehouses. It describes measures and makes recommendations which, if adopted, will assist in the design and construction of warehouses (or extensions thereto) which are less likely to catch fire. Should fire occur, however, the applied design principles will help minimise fire and smoke damage and thus minimise business interruption.

It is stated in Paragraph 1.1.1 that the aim of the *FPA Design Guide* is to provide loss prevention guidance for those who design, construct and equip industrial and commercial buildings. This Sector Guide is intended to deliver that aim in relation to warehouses and storage buildings.

It is therefore not the intention here to describe management issues such as housekeeping, maintenance, or fire safety management.

Many major fires occur in warehouses and storage buildings every year. Following commercial demands for the provision of large distribution and logistical support centres for major retailers and multinational manufacturers, there has been a move towards the construction of very large warehouses in recent times. This has be a contributory factor in an increase in the financial cost of losses in warehouse fires.

With the growth of e-commerce and telephone shopping, this trend is likely to continue and many warehouse buildings have undivided floor areas of 2000m^2 and often exceed 20,000m^2. Such buildings may need to accommodate mezzanine floors and gallery levels, or have high-bay racking systems, some of which may also call for automated goods retrieval.

Modern facilities like this can be extremely complex in layout but thinly populated by warehouse staff, while at the same time containing high fire loads in terms of stored combustible goods and materials.

Given that background, it is important for designers and owners of warehouses to understand that the range and application of current building control and fire safety legislation is limited to the minimum provision to protect the health and safety of persons in and around buildings. Documents such as this Sector Guide aim for a higher general standard of fire prevention and protection in design terms, which will be based on the results of a risk assessment carried out before embarking on the design. Effective fire safety management will then be required once the building is operational. The prime objective is buildings that are better equipped to resist the incidence of fire, better able to cope with the effects of fire and smoke in the event that fire occurs, but also, better able to be managed in such a way that fire will not break out in the first place. An associated result will be buildings that are safer for people to work in and visit.

Section 2

REDUCTION OF INTERNAL FIRE SPREAD – LININGS

Principle 2:

'With the exception of joinery products, the building shall be constructed from building materials/products that will not make a significant contribution to the early stages of a fire or contribute to the spread of fire.'

2.1 Commentary

Although not generally representing a significant proportion of the fire load within a warehouse or storage building, wall and ceiling linings and the external fabric of a building can contribute significantly to the rapid growth and spread of fire. The choice of materials should therefore be carefully considered.

2.2 Classification of internal linings

In buildings without sprinklers, the provisions of Table 1 shall be followed.

In buildings fully sprinklered, the provisions of Table 1 may be considered too onerous. In such cases, standards outlined in documents approved for the purpose of building regulations should be followed.

2.3 Roof lights

Unlike windows, roof lights might be of a combustible material and could therefore contribute to internal fire spread.

Roof lights must therefore be considered in respect of internal fire spread. The provisions made for life safety purposes in documents approved for the purpose of building regulations must be followed.

Roof lights are also an issue for external fire spread and this is covered in Paragraph 4.6.

Table 1: Minimum classification of linings

Specified locations:	
Internal surfaces and linings	Euroclass B-s1, d0 of BS EN 13501 (ref. 4)* or Class 0 of BS 476-6 and 7 (ref. 5) (now Euroclass B) Test criteria**

* Under the European classifications, lining systems are classified in accordance with BS EN 13501-1: 2002, *Fire classification of construction products and building elements. Classification using data from reaction to fire tests.* Materials or products are classified as A1, A2, B, C, D, E or F, with A1 being the highest. There is also an 'additional classification' for smoke production (s1, s2 or s3) and falling flaming droplets and/or particles (d0, d1 or d2), with s1 being the highest requirement and lowest level of smoke production and d0 being the highest requirement corresponding to the occurrence of no falling flaming debris and/or droplets.

** In BS 476, smoke production and burning droplet formation is not assessed. Consequently Class 0 of BS 476- 6 and 7 is a lesser standard than Euroclass B-s1, d0 of BS EN 13501. If material is used which has only been testedto the British Standard, evidence should be provided to show that its smoke production and droplet formation is low or zero.

NOTE 1:
In UK Building Regulations, Euroclass B is the minimum standard in circulation spaces. Lower standards are acceptable on other locations. To satisfy this Sector Guide, lower standards are not acceptable in other locations.

NOTE 2:
Prior to 2002, minimum classifications of linings in documents approved for the purpose of Building Regulations were based on BS 476. In BS 476, smoke production and burning droplet formation is not assessed, so when Euroclasses were included in 2002, it was decided that to maintain equality between the existing British Standard requirements and the harmonised European Standards, no limit should be set for smoke production and/or flaming droplets/particles (s3, d2). This Sector Guide calls for a higher standard.

Section 3

REDUCTION OF INTERNAL FIRE SPREAD – STRUCTURE

Principle 1:

'The building shall be constructed in such a manner that if a fire starts, the extent of fire and smoke damage will be minimised and confined as close to the source of fire outbreak as is practical/feasible.'

Principle 2:

'With the exception of joinery products, the building shall be constructed from building materials/products that will not make a significant contribution to the early stages of a fire or contribute to the spread of fire.'

Principle 3:

'Suitable measures will be taken for the prevention of premature structural collapse and excessive deflection.'

Principle 5:

'As a minimum, all fire protection products shall be third-party certified to an appropriate product or performance-based standard (attestation level 1 for CE marking).'

Principle 6:

'All fire protection products/systems shall be installed by adequately trained specialist installers.'

3.1 Commentary

3.1.1 Fire resistance of structure

If fire is allowed to take hold within the structure of a building itself (rather than just the contents of the building), it becomes that much more difficult to extinguish. The fire and rescue service must cause damage in order to expose the fire, it takes longer to put the fire out, and more water must be used in the process. It is therefore essential that the structure of a building should use 'non combustible materials' or 'materials of limited combustibility' or products that have been shown not to contribute significantly to a developing fire.

3.1.2 Basic principles

In general, the larger the area and volume of a building:

- the greater is the risk to the property and the people within it in the event of fire;
- the more difficult is the task of finding and fighting the fire.

Warehouses can be complex areas, housing high-value goods and with few operational staff. They are a prime target for arsonists and vandals, as well as thieves who may want to cover their tracks by starting a fire. The stored goods

– and particularly their packaging – are often highly combustible, allowing fire to spread quickly. Thus it is essential to include, in the design of any warehouse, features which will help to control the spread of fire and smoke. The following topics are of importance:

- compartmentation;
- internal space separation;
- protection of openings;
- fire stopping;
- ducts/ducting;
- fire venting.

3.1.3 Risk assessment

In this section, guidance is given on:

- the provision of compartmentation;
- the area and volume of compartments;
- the provision of internal space separation – other than compartmentation;
- the protection of openings.

This guidance is complemented by other parts of the *FPA Design Guide* series. The advice in this section is intended for application specifically to warehouses, and permits a type of quantitative fire risk assessment to underpin its application.

Appendix B plots the steps in carrying out the assessment.

In order to provide for some flexibility in fire performance, the risk-based approach which is employed uses three degrees of risk: low, medium and high.

3.1.4 Planning essentials

The risk assessment process described in Appendix B Paragraph B.2 is a broad brush approach to risk. In specific cases, insurers will have their own views on issues such as the compartmentation of areas used for the storage of high value or high-risk goods.

It is therefore imperative that, from the outset – and in the interest of achieving a building design in which fire protection is a high priority – the most comprehensive possible consultation takes place. This must involve all interested parties, in particular architects, fire safety engineers involved with the project, the architects' clients, the building owners or occupiers, their fire safety managers, the insurers of the premises, and any risk managers called upon for advice.

3.2 Compartmentation

This is the principle of the subdivision of a building's volume into smaller, fire-resisting cells each likely to withstand and contain a fire occurring within it for a specified duration. This duration depends on a variety of factors, including the risks represented by and within particular compartments. The following table takes into account factors such as the potential risk of fire and financial exposure. The recommended compartment sizes are typically are less than those specified in documents supporting building regulations. The following is

intended only to give guidance on the size of compartments. Insurers should be consulted as soon as possible for advice. This may be based on financial exposure and the nature of the goods being stored and the adequacy of fire safety management.

Table 2: Maximum floor areas for specific applications in warehouses and storage buildings – subject to insurer's individual risk assessment (for single-story buildings). Multi-storey warehouses should always be regarded as high risk

Application (Roof height less than 10m [1])	Recommended floor areas (m^2) [2]		
	High risk	Medium risk	Low risk
Warehouse with high rack storage	2000	4000	8000
Storage building connected to factory/production area without high rack storage	4000	8000	10000
Areas containing hazardous processes, equipment or other critical areas, including quarantine areas	250	500	

Note 1: Warehouses with a ceiling height to eaves greater than 10m present a particular risk. Proposals for such buildings should be referred to the insurer for specific guidance on requirements.

Note 2: Recommended floor areas may be increased if a suitable automatic extinguishing system is provided. Whether or not an increase is allowable, and the amount of increase, will be subject to the insurer's individual risk assessment.

While it is often desirable for warehouses to be open plan, the benefits of providing fire-resisting compartmentation are high, and the provisions of Table 2 shall be followed.

All compartmentation shall be to the standard given in Appendix A Table A1.

3.2.1 Special forms of compartmentation

As well as preventing excessive damage caused by fire and smoke spread, in this Sector Guide compartmentation is used to limit the spread of fire to:

- protect valuable materials;
- reduce business interruption caused by fire.

Therefore, compartmentation over and above that required to comply with Table 2 may be required to achieve the following:

- to enclose areas of high fire inception risk;
- to enclose areas of high fire load;
- to enclose areas where high-value goods are stored;
- to separate functions within the building (for example, separating administration offices from storage areas).

Most compartment walls are allowed to contain suitably protected openings such as doors. However, insurers may use the term 'fire-break wall'. A fire-break wall shall be a totally imperforate compartment wall typically used to separate two buildings in different ownership, and will be required to provide high levels of fire resistance.

The provision of fire-break walls is subject to an insurer's individual risk assessment.

3.2.2 The protected zone

An integral part of any compartment wall which abuts an external wall is the *protected zone*. This relates to the sections of roof, external walls and supporting frame of a single-storey building adjacent to and within a specified distance on each side of a compartment wall.

Guidance on the provision and construction of the protected zone can be found in Section 4.

3.2.3 Provisions for care and maintenance of compartment walls

Where fire-resisting compartmentation is installed, the importance of designing to allow for 'hot state' movement (the tendency for a structure to deform under the effect of fire), as outlined in the *FPA Design Guide* core document on the subject of compartmentation (ref. 6), cannot be over-emphasised, since it will reduce the possibility of early failure of compartment walls.

Compartment walls shall be maintained in good condition. All fittings installed shall be able to maintain the prescribed level of fire resistance.

Where possible, barriers should be provided to reduce the risk of mechanical damage from fork-lifts and other lifting or transportation processes to any vulnerable wall linings or construction features such as doors and door frames.

3.3 Internal space separation

The internal space of a building may be separated by walls and ceilings other than for purposes of compartmentation (such as walls surrounding toilets, and walls separating offices).

Any walls and ceilings used to subdivide warehouses (other than compartment walls or ceilings) shall be constructed from materials of limited combustibility or better.

3.4 Protection of openings

Openings in compartment walls need to be protected in such a way as to offer resistance to fire (such as by approved fire doors and shutters). The degree of fire resistance provided by the opening shall be no less than that provided by the compartment wall.

Fire doors shall be fitted with door closer devices.

Most fire doors only provide integrity. They do not provide insulation.

3.4.1 Uninsulated doors

Uninsulated doors (fire doors which only provide integrity) can reduce the effectiveness of a fire-resisting (compartment) wall by aiding heat transfer in the event of a fire. For that reason, only approved (certificated) fire doors shall be used. In any event, the building must be designed so that combustible goods do not need to be stacked near an uninsulated door. Some guidance on safe distances is given in the *FPA Design Guide: The fire protection of buildings: Core document: Protection of openings and service penetrations from fire* (ref. 7).

Where such doors are used to protect openings in warehouse buildings, these are to be in tandem to reduce the effect of radiation. Where only single doors are fitted in an existing building, consideration should be given to changing these for a door on each side of the opening. Uninsulated doors shall be

approved to a standard such as LPS 1056 (ref. 8). Regular checks shall be made to ensure that the doors close properly, and such examinations shall be recorded and documented.

3.5 Fire stopping

Wall and ceiling cavities, and openings around service ducts, pipework and conduits, need to be fire-stopped where they pass across or penetrate compartment boundaries. The stopping shall extend for the full thickness of a compartment wall, and shall provide no less resistance to fire than the compartment wall.

3.6 Ducts/ducting

Air conditioning and other ducting needs to be fitted/protected with fire dampers (see below) where it passes through compartment boundaries, so as to control the spread of fire and smoke.

Fire-resisting ductwork will maintain compartmentation in situations where it is necessary for ducting to pass through compartment walls. Where fire-resisting dampers are not used, such ducts shall provide the same fire resistance in terms of integrity (and, if necessary, insulation) as the walls of a compartment.

Fire-resisting ducts are tested for compliance with the requirements of BS 476-24: *Fire tests on building materials and structures: Method for determination of the fire resistance of ventilation ducts* (ref. 5).

3.6.1 Kitchen extract ducting

Kitchen extract ducting presents a particular risk, and the provisions of the FPA's document RC44 *Recommendations for fire risk assessment of catering extract ventilation* (ref. 9) should be followed.

3.6.2 Fire dampers

Where a fire-resisting damper is provided in a duct, it should be designed to close completely as soon as a fire is detected. Its purpose is to maintain compartmentation where an air distribution duct passes through the wall of a compartment and to provide the same fire resistance as required for the wall.

3.7 Fire venting

Single-storey buildings and, to an extent, some multi-storey buildings, can be provided with a limited degree of fire protection by properly designed and installed roof venting. Such a system, by venting smoke and hot gases, can help limit the spread of fire and smoke and facilitate fire fighting. Where a sprinkler system is installed, the venting and sprinkler systems shall be designed to be mutually compatible. BS EN 12101-6: 2005 (ref. 10) gives guidance on the design, installation, testing and commissioning in new and existing buildings of systems intended to limit the spread of smoke by means of pressure differentials. In a warehouse or storage area, smoke ventilators may delay operation of automatic sprinklers and for that application smoke ventilators should be manually operated by fire fighters only.

3.8 Other features

The ability of a warehouse to perform its function can be impaired by the effect of fire on the building services, including electrical power and light supplies, equipment fuelled by gas and oil, and air conditioning systems.

Heating, lighting and power services can act as sources of fire, which is why service ducting and voids above suspended ceilings and the like need to be protected in order to limit their capacity to act as a pathway for fire spread.

3.8.1 Cavity barriers/fire curtains

Fire cavity barriers and/or fire curtains in the roof of a warehouse shall be regularly checked for any breach that will affect their performance under fire conditions.

If services are to pass through a cavity barrier, it shall have been proved by test that the barrier is suitable for the passage of services.

3.8.2 Roof spaces and roof void walkways

If a warehouse design includes the installation of plant in a roof space, it will inevitably be necessary to access that plant for maintenance.

In such cases, the design of the building must provide for safe access to the plant in such a way that damage will not be caused to any facilities provided for fire protection (for example, cavity barriers or the suspended ceiling).

3.8.3 Services

Where services' pipework or ducting passes through walls (especially walls containing combustible materials, such as foam-cored composite panels) it can introduce a fire spread hazard. Thus:

- as far as possible, service penetrations through walls containing combustible materials shall be avoided;
- if this is not possible, any gaps shall be adequately sealed to prevent fire attacking the core. These filled gaps shall be examined at regular intervals and, if defective, made good by a competent specialist contractor. Guidance from the system manufacturer's design/installation manual shall be followed;
- attaching items to walls shall be avoided as far as practical. Where this is not possible, care shall be taken to ensure that any combustible core is not left exposed or damaged.

Section 4
EXTERNAL FIRE SPREAD

Principle 5:
'As a minimum, all fire protection products shall be third-party certified to an appropriate product or performance-based standard (attestation level 1 for CE marking).'

Principle 6:
'All fire protection products/systems shall be installed by adequately trained specialist installers.'

Principle 9:
'There shall be adequate provision to prevent an arson attack.'

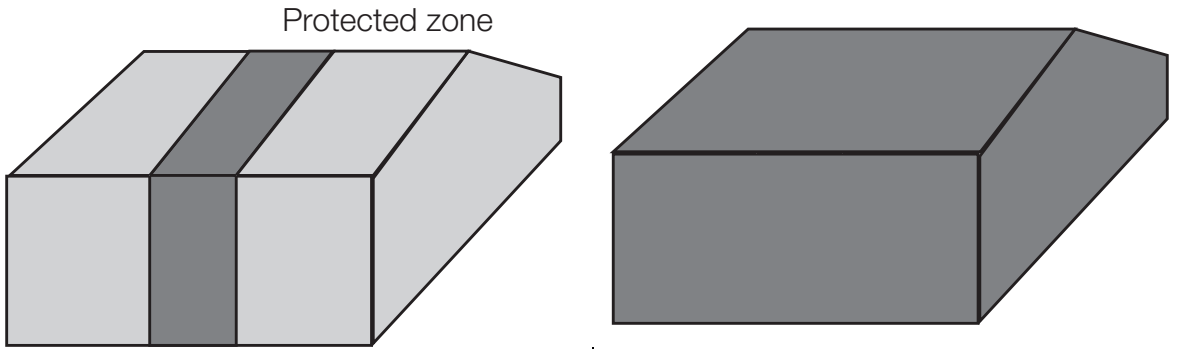
Principle 10:
'The building shall be so constructed that the fire cannot spread into the premises from an adjoining building or other external fire source.'

4.1 Commentary

The external walls of a warehouse or storage buildings are particularly vulnerable to an arson attack, and the provisions in this part of the sector guide take that into account.

4.2 External surfaces

The external surfaces of walls should meet the provisions in Figure 4.1.



a. Building where the provisions of Paragraph 7.4 have been met

b. All other buildings

Detailed guidance on the design and use of the protected zone on each side of a compartment wall can be found in the document *FPA Design Guide for the Fire Protection of Buildings: Protected Zone.*

KEY TO EXTERNAL WALL SURFACE CLASSIFICATION

Index (I) not more than 20 (National class) or class C-s3, d2 or better (European class). (The index I relates to tests specified in BS 476-6)

Class 0 (National Class) or class B-s3, d2 or better (European class)

Figure 4.1 Provisions for external surfaces of walls

4.3 External wall construction

It is an essential principle of this Design Guide that 'with the exception of joinery products', the building shall be constructed from building materials/products that will not make a significant contribution to the early stages of a fire or contribute to the spread of fire.

The essential principle described above will be achieved in respect of external fire spread if the objectives of Table 3 are met.

This table provides guidance on fire resistance recommended for external walls. The objective is to enable external walls to resist fire from an external arson attack or a fire arising from stored materials outside a building (such as pallets) being accidentally ignited.

4.3.1 Fire resistance of external walls/external fire exposure

Approved documents supporting national building regulations make few provisions relating to the resistance to fire penetration from an *external* fire. Where an external wall is more than 1m from a relevant boundary, there are usually *no provisions* relating to the resistance to fire penetration from an external fire.

To comply with national building regulations, most external walls only have to have a degree of resistance to fire penetration from an *internal* fire.

Doors and windows in an external wall are not counted as part of the wall itself. Rather, doors and windows are defined as an 'unprotected area', and do not need to provide *any* resistance to fire penetration from an *internal or external* fire.

The greater the distance an external wall is from a 'relevant boundary', the more of the 'wall' is allowed to be replaced with 'unprotected area'.

Consequently, in order to meet the essential principle that 'There shall be adequate provision to prevent an arson attack', national building regulations are often inadequate. To comply with this Design Guide, the fire resistance of an external wall will be considered satisfactory if:

- there are no 'unprotected openings' within the protected zone; and
- the wall is fire-resisting *from the outside* to the standard described in Table 3.

4.3.2 Unprotected openings

It is not considered necessary to describe any special provisions for 'unprotected openings' in this guide, as it is not common practice to put large areas of doors and windows into warehouses and storage buildings (other than at loading bays). If a design is proposed which does incorporate large 'unprotected openings', guidance should be obtained from the insurer. Such openings are not allowed in the protected zone, and shall be located no closer than 2.5m to any compartment wall (Figure 4.2).

Table 3: Specific provisions of test for fire resistance (Method of exposure – fire from outside)

Part of building	Minimum provisions when tested to the relevant part of BS 476-20 to 22 (minutes)	
	Integrity	Insulation
1. External walls		
a. Unsprinklered buildings		
(i) Within protected zone		
Low and medium risk	60	30
High risk	60	60
(ii) Not in the protected zone		
Low and medium risk	30	15
High risk	30	30
b. Sprinklered buildings		
(i) Within protected zone		
All risks	60	30
(ii) Not in the protected zone		
All risks	30*	15*
2. Roofs		
a. Unsprinklered buildings		
(i) Within protected zone		
Low and medium risk	30	15
High risk	30	30
(ii) Not in the protected zone		
All risks	✶	✶
b. Sprinklered buildings		
(i) Within protected zone		
All risks	30	15
(ii) Not in the protected zone		
All risks	✶	✶

NOTE 1: Constructions used for the external fabric of a warehouse will be able to be assessed against Table 3 on the basis of prior testing against the appropriate part of BS 476 (ref. 5), relevant European Standards and on the basis of historical evidence.

NOTE 2: Built-up cladding and sandwich panel systems may also be assessed against Table 3 on the basis of prior testing and approval against *LPS 1181-1: 2003: Part 1: Issue 1.1* (ref. 11). Elements that achieve grade EXT-B may be assumed to provide no integrity or insulation, but crucially make no significant contribution to fire growth during the developing stages of a fire. Where periods of integrity and insulation are specified in Table 3, appropriate elements of grade EXT-A should be used. (EXT-A15 or EXT-A30 or EXT-A60)

* EXT-B may be acceptable if there is adequate control against arson and pallets etc are at least 10m away from the external wall

** Table 3 is specifically concerned about fire exposure from the outside. Many materials, products and systems used in the construction of external fabric of buildings will only have been tested against fire exposure from the inside, (for example, LPS 1181-1 tests for reaction to an internal fire). Materials, products and systems which have only been tested against fire exposure on their internal face will be considered to comply with Table 3 only if they are symmetrical (internal and external faces and substrates the same). If the materials, products or systems are asymmetrical, it will be necessary to show separately that they comply with Table 3 against a fire on the external face.

✶ Fire resistance not required but roof cladding must be EXT-B.

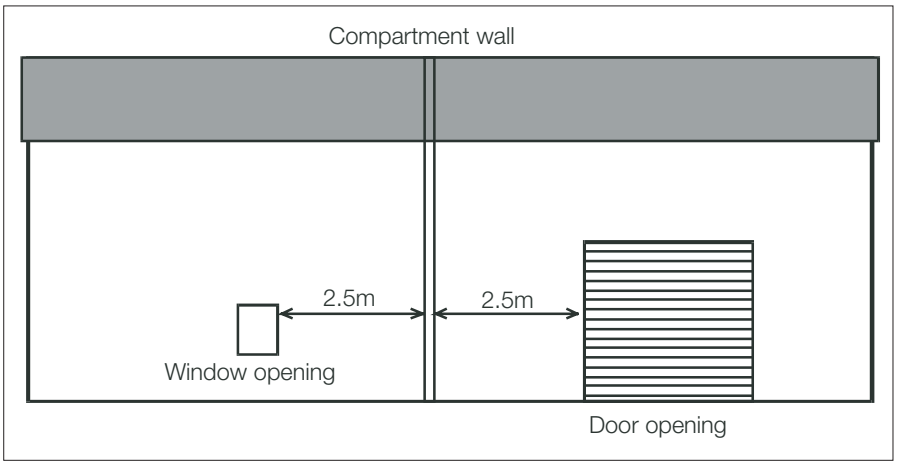


Figure 4.2: Minimum distance between unprotected openings and compartment wall

4.3.3 Fire attack at eaves

Many warehouse designs do not incorporate wide soffits. However, experience has shown that fire can penetrate through the eaves from an external fire and enter buildings easily. Wide soffits are particularly vulnerable as they tend to provide a reservoir for hot gases. Soffits with a provision for ventilation of a roof space can provide a ready passage for flame and hot gases.

Therefore, where wide soffits are part of the design:

- ventilation of roof spaces should be via roof vents rather than eaves vents;
- soffits and fascias should be non-combustible; and
- either:
  - the external wall should continue to the underside of the roof. Jointing detail between the top of the wall and the roof must prevent the passage of heat; or
  - the line of the external wall should be extended to the underside of the roof by way of a fire barrier.

4.4 Space separation

As a minimum, when constructing two or more buildings on a single site, space separation and the amount of unprotected area will be calculated using a method described in documents approved for the purpose of building regulations. This will be done assuming a notional boundary between the two buildings.

Dependent upon the specific risk, individual insurers may have stricter requirements than those described in documents approved for the purpose of building regulations. It is therefore important that guidance is obtained from the insurer, particularly in the case of large buildings, tall buildings, or buildings with high-value contents.

4.4.1 Provision for the storage of material

The use of a notional boundary – while ensuring as far as possible that the probability of fire spread from one building to another is minimised – fails to take into account the effect of any combustible materials, such as pallets, stored between buildings, or vehicles parked between buildings.

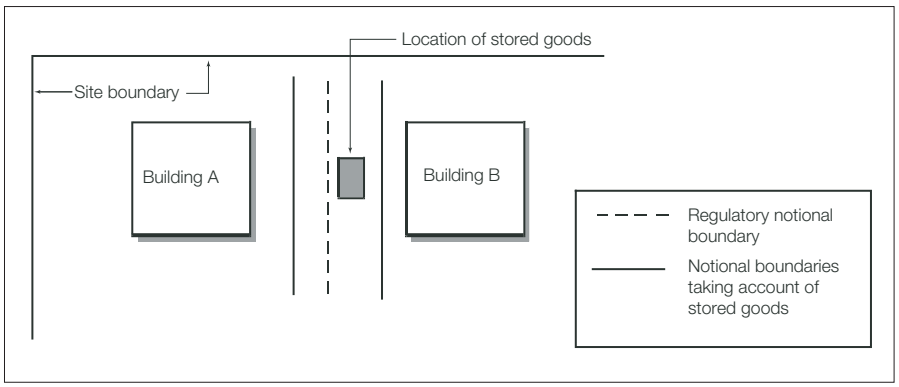


Figure 4.3: Combustible goods stored between building and notional boundary

Figure 4.3 illustrates the concern that insurers have when two buildings have combustible materials stored between the building and the notional boundary specified by regulators.

To protect the external walls of buildings from fires in stored goods or vehicles, the design of the building must be such that the occupier is able to comply with Paragraph 7.2.4 and Paragraph 7.3.1 of this document.

4.5 Roof coverings

Standards outlined in documents approved for the purpose of building regulations should be followed. In addition:

- there should be no 'unprotected openings' within the protected zone of the roof;
- roof coverings should be of non-combustible construction; and
- if sandwich panels or built-up cladding systems are used for roof coverings, LPS 1181 Grade EXT-A or B classifications will be acceptable (ref. 11).

4.6 Roof lights

The basic objective is to prevent possible fire spread across a compartment boundary via roof lights.

Purpose-made, low melting point roof lights may be used as part of a fire-engineered smoke control strategy based on suitable assumptions and calculations, but plastic roof lights should not be seen as a cheap method of providing smoke extraction. Thermoplastic roof lights should not be specified in a sprinkler-controlled building.

Roof lights that have been classified as EXT F.AA or EXT S.AA should be specified. However, these shall be no closer than 2.5m to any compartment wall, as shown in Figure 4.4.

If roof lights need to be located closer than 2.5m to any compartment wall, then fire-resisting roof lights shall be used and the roof light, together with its perimeter frame, shall have fire resistance of not less than 60 minutes integrity when tested to BS 476-20 (ref. 5).

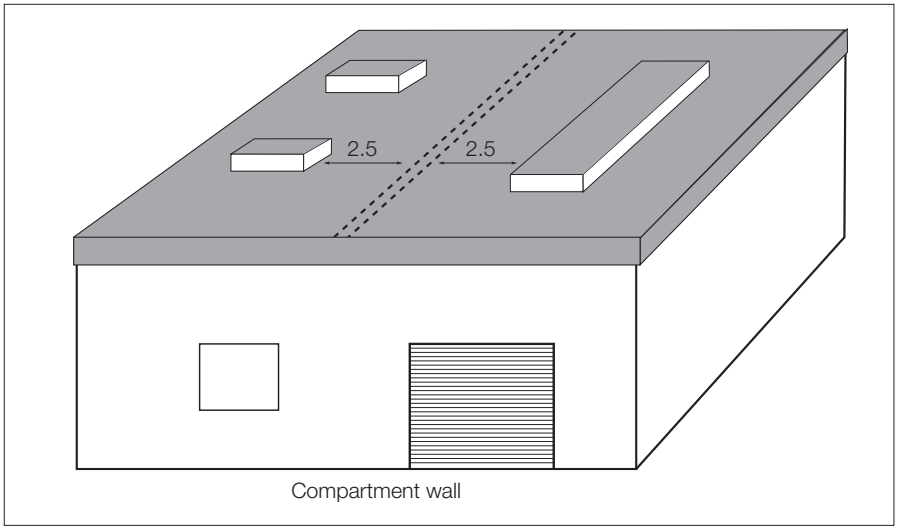


Figure 4.4: Location of roof lights from compartment wall

Section 5

MEANS OF WARNING AND FIREFIGHTING FACILITIES

Principle 4:
'Consideration should be given at the design stage regarding potential damage from firefighting water and to ensure as far as practical that the effect on the environment of the fire effluent will be minimised.'

Principle 5:
'As a minimum, all fire protection products shall be third-party certified to an appropriate product or performance-based standard (attestation level 1 for CE marking).'

Principle 6:
'All fire protection products/systems shall be installed by adequately trained specialist installers.'

Principle 7:
'The building shall be fitted with an appropriate automatic fire alarm system.'

5.1 Commentary

In the context of this Sector Guide, the purpose of a fire warning system is to alert either the occupants, or some other party, to a fire at the earliest possible opportunity, so that it can be extinguished before it causes any significant damage.

In unsprinklered buildings, a fire detection system should be provided which complies with BS 5839-1: 2002 (ref. 12) and conforms to design of Category P1/M (property risk protection). This class of system would provide detection throughout the building in addition to manual call points.

In buildings provided with sprinklers, a fire detection system should be provided which complies with BS 5839-1: 2002 (ref. 12) and conforms to design of Category P2/M (property risk protection). This class of system would provide early warning of fires in areas of high fire hazard level, or areas in which the risk to property or business continuity from fire is high.

A monitored remote connection to a central alarm receiving centre must be provided to enable swift attendance by the fire and rescue service outside normal working hours.

The purpose of a sprinkler system is to automatically control a fire in its early stages. This directly limits damage, and maintains the fire at a small enough size that it may be easily extinguished by the fire and rescue service.

A useful side effect of installing a sprinkler system is that because fire is controlled or even extinguished in its early stages, a minimum amount of water is used, reducing water damage and minimising polluting firefighting water

run-off. The risk of a sprinkler system causing water damage is considered minimal – a sprinkler system may control a fire with a little as 60 litres of water per minute.

NOTE: A single fire brigade main jet will deliver 2,250 litres of water per minute into a burning building.

5.2 Fire alarm systems

5.2.1 Introduction

One of the major factors in the extent and cost of warehouse fires is their late detection – often made by a neighbour, passer-by or even by activation of the intruder alarm caused by elements of the system being affected by the fire.

In order to have early detection of any fire occurring when the warehouse is unoccupied, it is necessary to have an automatic fire detection system.

Several other recommendations in this Sector Guide, such as door hold-open devices and fire dampers, may rely upon the provision of an automatic fire (smoke) detection system.

5.2.2 Choice of system

- In unsprinklered buildings, a fire detection system should be provided which complies with BS 5839-1: 2002 (ref. 12) and conforms to design of Category P1/M (automatic property risk protection with manual call points). This class of system would provide detection throughout the building in addition to manual call points.
- In buildings provided with sprinklers (see Paragraph 5.3), it may be acceptable for the standard for a fire detection system to be lower than P1/M. Individual insurers will make this decision on a case by case basis.
- A monitored remote connection to a central alarm receiving centre must be provided to enable swift attendance by the fire and rescue service outside normal working hours.
- The response of the local fire and rescue service to a call received from a central alarm receiving centre varies from authority to authority. The precise response of the particular authority should be identified and built into the fire safety management system: the provisions in buildings provided with sprinklers (as above) will apply in all cases.

Fire alarm systems must be installed by a third-party approved installer certified to install the specific product/system when an appropriate scheme is available (for example BAFE or LPCB to LPS 1014) (ref. 13).

A certificate of conformity must be issued for the installed system.

5.3 Sprinkler systems

5.3.1 Introduction

Automatic sprinkler systems provide the only means of both detecting and controlling fires in warehouses without human intervention. In unsprinklered warehouses, stored goods provide the ideal environment for the rapid development of fire once ignition has occurred.

Packaging materials and protective coverings on stored goods often constitute the immediately available fire load and means of fire propagation – consequently most stored goods have the potential to burn.

In warehouses, the seat of the fire may be inaccessible due to height or configuration of the stored goods. Consequently, by the time a fire is detected or seen by the warehouse staff, it may be too late for manual firefighting to be successful. Warehouse staff may be discouraged from attempting to tackle fires, on health and safety grounds, due to the potential speed of fire development. They may be advised to concentrate on the immediate evacuation of the warehouse and reporting the fire. The fire brigade's efforts will also initially be concentrated on the safe evacuation of people from the warehouse. Controlling the fire within a warehouse may be considered a secondary issue and may not be attempted on health and safety grounds. These considerations make automatic sprinkler protection of warehouses essential if a total loss is to be avoided should a fire occur.

5.3.2 Choice of system

Sprinkler systems should be designed and installed in accordance with the *LPC Rules for automatic sprinkler installations incorporating BS EN 12845* (ref. 14, 15), and it is essential that the work is undertaken by an appropriately qualified and certificated sprinkler installing company.

5.3.3 The essential principles of sprinkler protection

The essential principles of sprinkler protection are as follows:

- the building should be sprinklered throughout. There are allowable exceptions to this principle, but they are few, and if sprinkler protection is omitted there are specific separation requirements and other conditions to be fulfilled. In some instances other forms of active fire protection may be required to protect an unsprinklered compartment;
- a hazard assessment must be carried out at the design stage to determine the occupancy of the building for sprinkler protection purposes. The constructional details of the subject building and any neighbouring buildings must be considered in order to specify and design the sprinkler protection and identify appropriate separation requirements between compartments and adjoining or adjacent buildings;
- a knowledge of the contents of the building, including the nature of the stored goods and the storage systems to be used must be gained. The provision of sprinklers may be required within the racking or shelving systems;
- suppression sprinkler systems such as ESFR and EPEC may be an acceptable form of protection, providing the storage methods, storage heights, building heights, roof or ceiling slope and other features are compliant;
- the provision of appropriate water supplies is essential. Most warehouses will be classified as a High Hazard requiring a 'duplicate water supply', usually consisting of a water storage cistern of 90 minutes duration feeding two suction pumps, of which at least one will be diesel driven;

- sprinkler systems generate alarms when:
  - water flows into the installation;
  - a pump starts running;
  - a pump become inoperative or is isolated;
  - a normally open stop valve is closed.

  It is a requirement of the installation standard that alarms are transmitted to a permanently manned location, on or off the premises, or to a responsible person so that action can be taken;
- operational sprinkler systems require management and maintenance. Insurers may require:
  - maintenance to be undertaken by a suitably qualified and certificated company on a regular basis;
  - regular reviews of hazard and storage methods to be carried out;
  - non-compliances to be dealt with promptly; and
  - consultation with insurers and other stakeholders before disabling a sprinkler system for any reason, or carrying out any hot work procedure within the sprinkler-protected building.

5.4 Portable firefighting equipment

If a fire in a warehouse is large and growing, firefighters are unlikely to enter the building and attempt to extinguish the fire for reasons of health and safety. While they would enter the building to perform rescue, if lives are not at risk they are much more likely to allow the warehouse to burn, and simply protect surrounding risks with covering jets of water.

Sprinklers are likely to contain a fire to a sufficiently small size to enable firefighters to enter the building and attempt to extinguish the fire in relative safety.

However, relying completely on a sprinkler system and fire service intervention to deal with fires is not satisfactory. Even a sprinkler-controlled fire can result in much fire, smoke and water damage.

It is recommended that buildings are provided with suitable fire extinguishers and fixed hose reels so that suitably trained staff can deal with small fires in their incipient stages. The following conditions should be observed:

- no part of the building should be more than 30m from a portable fire extinguisher which is suitable for its adjacent risk;
- fixed hose reels should be provided so that all parts of the building can reached with a jet of water; and
- fixed hose reels should be no more than 30m in length.

5.5 Fire points

Fire safety equipment which is provided for use by staff should be grouped at ‘fire points’. The following may be located at a fire point:

- a fire alarm call point;
- a fire instruction notice; and
- fire extinguishers/a hose reel.

Fire points shall be visible and accessible. The location of fire points shall be clearly indicated from all parts of the building.

Section 6

ACCESS AND FACILITIES FOR THE FIRE AND RESCUE SERVICE – THE REQUIREMENTS

Principle 4:
'Consideration should be given at the design stage regarding potential damage from firefighting water and to ensure as far as practical that the effect on the environment of the fire effluent will be minimised.'

6.1 Commentary

Providing adequate access and facilities for the fire and rescue service will reduce the time delay between discovering a fire and firefighters being able to intervene. Consequently, providing a high standard of access and facilities for fire and rescue services reduces the amount of damage a fire can cause, and reduces the amount of water that will be used to fight a fire.

The provisions for fire and rescue service access and facilities contained within documents approved for the purpose of building regulations are generally sufficient for the aims of this Sector Guide. However, in high-risk buildings, and on sites where perimeter security is provided, some specific considerations have to be made at the design stage.

The fire brigade and insurance surveyors should have access to information on the construction materials used in the warehouse and details of the fire protection systems fitted.

6.2 Water supplies

The provisions of BS 5588-5: 2004 (ref. 16) should be followed with respect to the positioning of fire hydrants.

In addition, where the building in question is a high risk and is not provided with a sprinkler system:

- no part of the external fabric of the building should be more than 60m from a hydrant or less than 6m from a hydrant;
- if this condition cannot be met from hydrants on the street, then private hydrants shall be provided on the site, designed and installed in accordance with BS 5306-1 (ref. 17), ideally forming part of a ring main system.
    - generally a minimum flow rate of 1500 litres/min should be available at all times.
    - the precise water requirements should be evaluated in conjunction with the local fire and rescue service.

- where hydrants alone cannot provide adequate water supplies, the building should ideally be fitted with a sprinkler system. Alternatively, a suitable emergency water supply should be provided to the satisfaction of the local fire and rescue service.

6.3 Vehicle access

6.3.1 Access to the site

Perimeter security is an important aspect of arson reduction. However, badly planned perimeter security can be a hindrance to fire and rescue service vehicle access. Access for fire appliances must therefore be taken into consideration when planning perimeter security. It is advisable to involve the local fire and rescue service in this matter at the design stage.

6.3.2 Fire appliance movement on the site

In the following situations, the provisions for vehicle access contained within documents approved for the purpose of building regulations are sufficient:

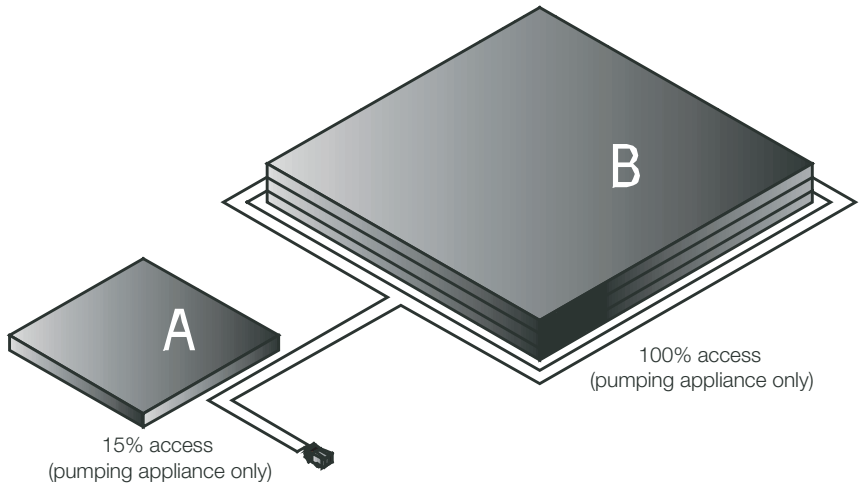
- low risk buildings;
- medium risk buildings;
- buildings provided with fire mains in accordance with an approved standard; and
- buildings provided with sprinklers.

In other situations, these provisions are generally not adequate to satisfy this Sector Guide, and Table 4 should be applied. Figure 6.1 graphically indicates typical provisions in a life safety standard.

Table 4: Fire and rescue service vehicle access to high risk buildings and buildings not fitted with fire mains or sprinklers

Total floor area of building (m^2)	Height of top storey	Provide vehicle access to	Type of appliance
< 2000	Single storey	25%	Pump
	Multi storey	25%	High rise
2000 to 8000	Single storey	75%	High rise
	Multi storey		
> 8000	Single storey	100%	High rise
	Multi storey		

NOTE: The principle being applied in this table is that fire appliance access needs to be to a high standard for buildings in this situation, and that high rise appliance access must be given a high priority to facilitate modern defensive firefighting techniques.



Building A: 2000m^2 total floor area, single storey
(Largest building which calls for 15% access for a pumping appliance)

Building B: 24,000m^2 total floor area, three storey (< 11m)
(Smallest building which calls for 100% access for a pumping appliance)

(Minimum standard taken from Approved Document B to the England and Wales Building Regulations(ref. 18))

Figure 6.1: Illustration of life safety requirements for fire and rescue service vehicle access to high-risk buildings and buildings not fitted with fire mains or sprinklers

Section 7
DESIGN TO FACILITATE FIRE SAFETY MANAGEMENT

Principle 5:
'As a minimum, all fire protection products shall be third-party certified to an appropriate product or performance-based standard (attestation level 1 for CE marking).'

Principle 6:
'All fire protection products/systems shall be installed by adequately trained specialist installers.'

Principle 8:
'The fire protection systems shall be regularly maintained so that they are able to perform their intended function throughout the life of the building.'

Principle 9:
'There shall be adequate provision to prevent an arson attack.'

Principle 11:
'The building owner shall ensure an adequate standard of fire safety management throughout the life of the building.'

Principle 12:
'Any fuel burning appliance and services or electrical appliance and services shall be designed, constructed and installed in a manner that reduces their potential as an accidental source of ignition.'

7.1 Design considerations

Fire prevention in a building is achieved through a combination of measures which include adherence to the passive fire safety recommendations in documents such as this Sector Guide, and also the installation of appropriate active fire safety systems and equipment.

Once a building is occupied, assessment, monitoring and maintenance of fire safety systems and management routines, including staff training, are very important and may well improve the risk before other measures are implemented. The process followed is a fire risk assessment (see Paragraph B3 Appendix B).

The ability of building management to continually assess, monitor and maintain fire safety systems and management routines can be greatly enhanced by considering fire safety management at the design stage. Such considerations require dialogue between the designer, the building operator and the insurer.

For example, one particular hazard in an existing warehouse that merits regular monitoring is the storage of hazardous materials, including flammable liquids and aerosol products. Storage methods and locations for such goods should be established at the outset, in consultation with the insurers.

Consequently, it is worthwhile describing some management topics here. (Reference may also be made to *Fire precautions in warehouses and distribution buildings* (ref. 19), *Recommendations for fire safety in warehouses* (ref. 20) and *The prevention and control of arson* (ref. 21).)

7.2 Ignition and fire spread hazards

On occupation, a fire risk assessment of the building must be undertaken, and any remedial measures identified as being necessary must be implemented. The requirement to carry out this task is placed upon the 'responsible person'.

However, the role of the responsible person can be made easier if the designer of the building has an understanding of the issues which will be examined in the risk assessment. This way, the designer can 'design out risk' at the planning stage, so that necessary remedial measures will be few and far between.

To this end, the designer should be familiar with the fire risk assessment issues described in Appendix B, and the design should specifically address the following issues where appropriate.

7.2.1 Nature of stored goods

A warehouse shall be designed to cope with any hazard presented by the goods likely to be stored. The designer needs to know what the potential hazard is, and whether or not there are likely to be products in storage which are combustible, flammable or highly flammable. The prospective owner or operator of the warehouse should be asked to clarify the likely nature of goods (including packaging) to be held within the building and to give advice, as necessary, concerning their hazards. Their guidance should also be sought concerning likely storage heights and type of racking. Special considerations apply where there is to be storage of goods which are hazardous by nature, for example, oxidising chemicals, flammable liquids and aerosol products. Reference shall be made to manufacturers' data sheets for guidance on storage and the insurers should also be consulted.

Security systems which are designed to deter the arsonist and generally protect the site and its buildings are even more necessary for warehouses in which high-value goods are stored.

7.2.2 Maintenance and inspection of equipment

All equipment, particularly that identified as a potential source of ignition or inception risk, needs to be regularly maintained by suitably qualified staff or by competent subcontractors, and a maintenance record shall be available for inspection by the insurer or regulatory body. The use of thermal imaging cameras to inspect machinery and equipment for overheating, as part of routine maintenance, can detect problems which other inspections might miss.

The designer should consider the need for inspection and maintenance and take this into account in the design.

7.2.3 Internal storage

The means of storage of goods in a warehouse will need to be appropriate to the nature of the goods being stored. The following measures should be applied:

- the design and provision of storage arrangements shall take fire safety into account by providing adequate access between aisles and limiting the width and height of stacks. (For the purposes of this

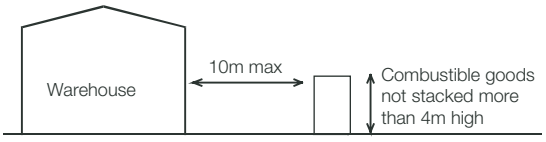
document, high rack storage is racking of 4m in height or more, a hazard which will need attention in the risk assessment);

- racking arrangements shall not obstruct fire doors or shutters. If there are in-rack sprinkler heads they shall not be obstructed by the stored goods;
- where goods may be stored temporarily on the floor, provision should be made in the design so that, in the course of stowage, they shall not obstruct escape routes, pedestrian walkways or fork-lift trucks' routes;
- if the warehouse is used for the storage of combustible or flammable goods, special storage precautions may need to be taken in respect of the hazards which the goods comprise.

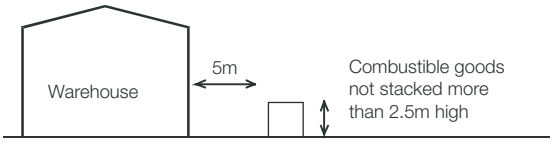
7.2.4 External storage

If it may be necessary for goods or other combustible materials that might present a risk to be stored in the open outside the warehouse, provision should be made so that they do not need to be – or cannot be – placed near to the surface of the external walls, under any eaves or portico, or near unprotected openings in walls. In particular, timber or plastic pallets should not be stacked closer than 10m from any external wall, nor within 2m of a perimeter fence. Stacks should not be higher than 4m (see Figure 7.1).

If it is not practicable to design a building to comply with Figure 7.1, the insurer may insist that any materials stored outside must be a distance of at least 1.5 times the stack height from an external wall.



(a) Ideal external storage arrangement of combustible goods



(b) Example of alternative arrangement where ideal solution is not feasible

Figure 7.1: Minimum safe distance for external storage of combustible goods

Fire brigade and insurance surveyors should have access to information on the construction materials used in the warehouse and details of fire protection systems fitted.

7.2.5. Packing operations and materials

Packing and unpacking operations use packaging material and will result in an accumulation of waste. These operations also involve the use of equipment which may depend on hot processes, such as shrink wrapping. Thus, the design of goods inwards and despatch preparation areas need particularly careful attention to ensure that the volumes of packaging materials, new or used, can be kept to an operational minimum.

See also Paragraph 3.2.1, *Special forms of compartmentation.*

7.2.6 Security matters

Security starts at the perimeter of the site. The design should therefore incorporate a perimeter fence, which can be maintained in good condition and have adequate, lockable gates or a staffed vehicle barrier.

NOTE: Walls are perceived as being a more formidable defence but fences can be more helpful because they do not screen buildings from passers-by.

Doors and windows shall be kept to a minimum in warehouse buildings, and shall be capable of being locked shut.

The provision of perimeter security fencing must take into account the needs of fire service access to the site outside of working hours.

Paragraph 7.4, *Arson prevention*, goes into more detail about security matters. Other guidance should be obtained from the insurer.

7.2.7 Electrical equipment and lighting

The following measures should be applied:

- electrical equipment located in the warehouse shall be installed, examined and tested by a competent person, as per the appropriate standard. Refer to Paragraph 7.2.2, *Maintenance and inspection of equipment*;
- portable appliances need to be inspected and/or tested at intervals dictated by the risk assessment, and at least once a year – if not more frequently. However, the need to test portable appliances can be reduced by designing fixed appliances into the building, such as water boilers and space heating equipment;
- fixed wiring systems shall be inspected/tested at five-yearly intervals unless significant changes in layout or premises alterations make it advisable to carry out interim maintenance;
- all fixed lighting shall be designed to meet the requirements of the user of the warehouse and with fire prevention in mind. It shall be installed by competent electricians in accordance with the manufacturers' operating and installing instructions. It shall be wired and fused independently from circuits providing power for other equipment;
- care shall be taken to ensure that goods can never be stored too close to luminaires and light bulbs, and particularly not too close to high-temperature lighting such as high-intensity discharge lamps and quartz halogen bulbs. More guidance is given in a set of FPA Recommendations (RC30, ref. 22);
- electrical cables passing through thermal insulants (such as foam-cored composite panels) shall be enclosed in an appropriate conduit to protect them against the effects of substances which might cause them harm. However, a risk assessment shall be undertaken to ensure that this does not increase the fire risk;
- fire prevention in computer facilities is the subject of a set of FPA Recommendations (RC3, ref. 23), in which there is an appraisal of different types of electronic equipment installations and the categories of risk into which they might fall, as well as advice about appropriate fire detection and extinguishing systems;

- all electrical installations must be installed in compliance with BS 7671: 2008: *Requirements for electrical installations. IEE Wiring Regulations. Sixteenth edition* (ref. 24).

7.2.8 Heating

Central heating systems are less likely to cause fires than portable or transportable heaters, the use of which shall be discouraged in warehouses. The following measures should be applied:

- heating systems shall be designed to meet the requirements of the user of the warehouse and shall be installed and regularly maintained with fire safety in mind;
- gas-fuelled heating systems in warehouses shall be installed in compliance with the technical provisions of the Gas Safety (Installation and Use) Regulations 1998 (ref. 25). Those Regulations do not apply to warehouses but represent good, basic advice;
- gas appliances and systems shall be installed by personnel from a company in membership of CORGI (Council for Registered Gas Installers);
- types of space heaters, an insurer's classification of their relative hazards, and recommendations for the conditions under which they might apply, are the subject of a set of LPC Recommendations, RC27 (ref. 26). Designers shall be encouraged to refer to that document;
- any central heating boiler shall be located in a separate fire-resisting compartment with a fire resistance of not less than 60 minutes;
- heating oil tanks shall be located within suitable bund walls. Ideally they should be outside the building, but in an area where they are not exposed to the risk of arson attack or vandalism.

7.2.9 Flues

Flue pipes from heating appliances require special precautionary measures. They shall be kept clear of combustible materials throughout their length, guarded where necessary, and shall take the most direct route to the outside.

Flues used to extract hot gases shall not pass through, in, or close to combustible materials/linings unless adequately protected to prevent the transmission of heat.

Flues shall be kept clear of combustible materials throughout their length.

Flue pipes shall take the most direct route to the outside and shall not pass through – or be contained within – floor or ceiling voids, or roof spaces where exposed combustible materials are present.

7.3 Vehicles

7.3.1 General

Delivery vehicles can constitute a fire hazard. Warehouses should therefore be designed so that petrol and diesel vehicles shall never need to be allowed inside.

Design provision needs to be made for delivery vehicles to come close to a warehouse, possibly incorporating loading platforms and dock levellers to permit unloading via fork-lift truck or similar means.

All vehicle parking areas shall be designed to be located well clear of the warehouse and, for reasons of security, visiting drivers shall not have free access to the building.

Experience suggests that this last requirement is particularly important in the case of parking areas for refrigerated vehicles.

7.3.2 Fork-lift trucks

In all situations where fork-lift trucks are to be employed, it is essential that, before designs are prepared, a thorough risk assessment is conducted to cover the nature and type of equipment to be used, the environment in which it will operate and the arrangements concerning, as appropriate:

- provision for the safe storage and use of fuels (diesel or LPG), including an area in the open air or with appropriate ventilation where LPG cylinders can be changed;
- a suitable storage location for LPG cylinders in accordance with FPA recommendations RC8 (ref. 27);
- facilities for battery recharging for electrically powered fork-lift trucks. Consideration shall always be given to locating such facilities under cover but outside the warehouse, preferably in their own fire-resisting, enclosed building. If this is not possible, they shall be located well away from any identified inception risks and combustible materials, and within a fire-resisting enclosure of not less than 60 minutes' fire resistance – or such other duration that shall be agreed with the property insurer;
- the need for entrances which are to be used by fork-lift trucks to be adequately protected with fire roller shutters.

If there is likely to be an explosive atmosphere in a warehouse, management will wish to acquire fork-lift trucks which have explosion protection systems and are designed for use in such atmospheres.

There is a range of recommended loss control measures related to the use of fork-lift trucks in *Recommendations for the use of fork-lift trucks* (ref. 28).

7.4 Arson prevention

A perception of the problems and potential occurrence of arson is vital, not only for the company fire safety manager, but also for the building designer. Both should be aware that, in industry and commerce, more than 50% of fires are started deliberately, some of them by members of the workforce.

The FPA's book *The Prevention and Control of Arson* (ref. 21) deals fully with the subject and includes a chapter called 'Designing against arson'. It is a major topic to be considered in the risk assessment, particularly if the location of the warehouse is an area where arson is common.

Those involved in the design and construction of warehouses need to be aware of the gravity of the problem and to bear in mind at least the following, so that a new warehouse will be better protected against the possibility of an arson attack:

- potential arsonists may be kept at bay by:
  - properly organised physical and electronic security measures, including perimeter fencing;

  - secure doors and windows;
  - an intruder alarm system;
  - monitored cctv;
- adequate security is of particular importance when the warehouse is located in a rural area when the fire brigade may take longer to respond than in towns and cities;
- warehouses may have accumulated quantities of delivery pallets (plastic and wooden) on the premises. These are favourite targets of the arsonist and provision shall be made for secure storage areas outdoors and not within 10m of the outer walls of the warehouse, plant or adjacent premises' buildings, or within 2m of the perimeter fence;
- waste materials are attractive to the arsonist and a code of practice for dealing with commercial and industrial waste is included in the FPA's book *Fire Safety and Waste Materials* (ref. 29);
- vegetation and undergrowth in the proximity of the warehouse, or alongside the perimeter fence, shall be pruned regularly so as not to provide a potential source of fuel or a place of concealment for arsonists, or to help intruders scale fences. The designer needs to consider this when planning landscaping.

7.5 General housekeeping

Management and staff need to work together to ensure that the principles of good housekeeping are applied in the interests of fire safety. Consideration of these issues by the building designer, and the incorporation of sympathetic design features, will make the job of management and staff much easier. The following measures should be taken:

- premises should be kept clean at all times;
- staff shall be encouraged to spot and report hazards, such as electrical equipment in dangerous condition, or any other premises or equipment shortcoming that could contribute to fire starting;
- combustible waste materials such as packaging shall be removed from the warehouse at the end of every working day, or more frequently if necessary;
- goods shall not be stored in aisles and other designated clear areas since they could hinder escape and interfere with firefighting operations;
- storage of combustible materials on loading docks and under external canopies shall be prohibited. Materials stored in such locations have been shown to provide arsonists with a ready and effective source of fuel;
- internal storage of idle pallets shall be kept to a minimum;
- burning of rubbish in the open shall be prohibited;
- it may be appropriate for the designer to provide external smoking areas or shelters for staff who wish to smoke. The location and construction of such shelters must be subject to a specific fire risk assessment; and the shelter must be:

- constructed of non-combustible materials;
- subject to the results of the risk assessment, sited away from hazardous materials, storage areas, and, where practicable, at least 10m away from any building or structure;
- provided with suitable metal ashtrays and a separate metal waste bin with a fitted lid.

In order to satisfy both legislation and fire protection to property, the shelter must not be sited near to:

- windows;
- ventilation intakes/extracts;
- entrances and exits from the premises;
- hazardous materials;
- waste storage containers (such as skips or bins).

It also must not be sited beneath a canopy or low slung eaves;

- as stored quantities of combustible materials (such as packaging materials) will also aid rapid fire spread in the event that fire breaks out, the design of the building must provide adequate storage for combustible materials in fire-resisting compartments separate from other parts. It should not be necessary, for example, to store packaging material in an area that is also used for the storage of finished goods.

APPENDICES

Appendix A

Fire resistance performance of materials and structures and guidance on compartment sizes

Fire safety guides which accompany national building regulations deal exclusively with life safety. Typically these guides call for durations of fire performance which increase with the height of the building; the reason being that a building must retain its structural stability and compartmentation must maintain its integrity for longer periods in tall buildings because they take longer to evacuate.

This Sector Guide is not targeted at life safety; it is concerned with property protection. In delivering adequate standards of property protection, the height of the building is only relevant if it is likely to adversely affect any possible fire and rescue service intervention which might mitigate fire damage.

As a result, the provisions for fire performance of elements of structure and compartmentation in this Sector Guide are not wholly based on the height of the building.

Table A1: Fire resistance levels for warehouse buildings

Application	Recommended fire resistance levels		
	High risk classification	Medium risk classification	Low risk classification
Compartment wall separating main storage area from factory production area	240EI	120 EI	90 EI
Compartment wall used to separate warehouse from office building	120EI	90EI	60EI
Compartment walls and ceilings used to enclose areas containing hazardous processes, equipment or other critical areas, including quarantine areas	240EI	120 EI	60EI

E = integrity; I = insulation

The required fire resistance (integrity) shall be maintained when doors, windows and services are installed in or pass through compartment walls.

Where uninsulated doors or windows are fitted, it is important to maintain combustible goods at safe distances from them so as to prevent ignition from thermal radiation. Guidance is given in reference 7.

Where a compartment wall meets the external cladding of the building, a section of the external wall and roof on each side of the compartment wall shall have fire resistance. This is known as the protected zone and it is the topic of a separate document in the *FPA Design Guide* (ref. 30). For basic guidance, the length of the protected zone on each side of a compartment wall built shall not be less than 2.5m. It can then be terminated at the next available structural member

Appendix B
Fire risk assessment

B.1 Introduction

Within this document, two types of fire risk assessment are considered:

- **Design fire risk assessment**

  The first type of risk assessment is a broad brush assessment of the overall exposure to fire risk.

  This assessment is based on:

  - type of goods being stored;
  - vulnerability to fire spread and disproportional damage;
  - standard of fire safety management;
  - possibility of arson attack.

  The function of this fire risk assessment is to categorise the building under consideration as either high, medium or low fire risk, and then to select appropriate levels of fire protection from this Guide.

- **Operational fire risk assessment**

  The second type of fire risk assessment considered is the detailed assessment of fire risk which must be carried out once the building is occupied.

  Although not strictly speaking a design issue, it is considered to be of value if the designer of the building has an insight into this process.

  If the designer of the building has an understanding of the issues associated with an operational fire risk assessment, he or she will be able to contribute to the ongoing management of fire risk by good design.

  An outline of the issues considered in an operational fire risk assessment is therefore reproduced in this Appendix to help the designer incorporate beneficial measures into the design.

Both types of fire risk assessment are considered in more detail below.

B.2 Design fire risk assessment

In this context, fire risk assessment is not a detailed assessment of the risk and consequences of fire breaking out. This Sector Guide takes a risk-based approach to the degree of fire safety required of a building, and the risk assessment here is intended to be a preliminary assessment of the degree of risk from fire to which the building and its contents will be exposed. This is used to help establish suitable fire performance levels. It should be noted that:

- it does not provide a definitive solution to the design problem;
- it is not intended to take the place of, or equate to, the kind of thorough risk assessment which a fire surveyor would undertake for an insurer. (For example, poor site security and a high incidence of arson attack in the locality may make a building an unattractive risk from an insurance viewpoint);

- moreover, it certainly does not take the place of the kind of comprehensive fire risk assessment which an employer may be required to make under existing fire legislation.

When planning a new warehouse building, or significant alterations to an existing structure, discussions should be held with the insurers at an early stage concerning the degree of fire protection required. While the probability of loss of life in such buildings is relatively low, insurance loss experience is that such buildings do require a very high level of fire protection to safeguard the business. A fire risk assessment is a key element in determining the potential risk posed by fire, and the degree of fire protection required to address that risk.

It is common for guides which consider life safety in fire to base their standards on the degree of risk to life. Consequently, higher standards of fire safety are usually called for in public buildings than they are in private buildings. Higher standards still are called for in sleeping risks. The taller a building is, the longer its structure must maintain stability in fire. This gives people the required time to escape.

In this Sector Guide, an equivalent approach is taken, except that here, standards are based on the degree of financial risk from fire.

The financial risk from fire is based on:

- the likelihood of fire occurring;
- the ability to control a fire should one start;
- the amount of damage (both direct and indirect) which could be caused.

It is therefore necessary to carry out an assessment of the likely fire risk and hazards so that they are properly understood before embarking on the design and construction of a building.

This risk assessment process is shown in Figure B1.

Using Table B1:

- consider each defined aspect and determine the risk category for that aspect;
- determine the appropriate points rating for each defined aspect;
- calculate the total number of points.

Using Table B2:

- determine the risk classification for the building.

The risk classification of the building then be used against this guide to determine various fire safety requirements, including:

- fire resistance performance requirements from Table A1;
- recommended maximum floor area from Table 2;
- specific provisions of test for external fire resistance from Table 3;
- fire service access arrangements from Section 6.

Figure B1: Risk-based approach to arrive at appropriate requirements for warehouses and storage buildings

Table B1: Fixed conditions. Risk matrix. Warehouses

ASPECT		High risk category	Medium risk category	Low risk category
Financial exposure		High financial exposure		Low financial exposure
	Points rating	50	30	20
Fire brigade response		Risk located in rural area with slow fire brigade response	Up to 20 minute response	Rapid response of fire brigade (up to 10 minutes) Automatic fire detection or 24 hour occupation
	Points rating	30	15	5
Water supplies		Poor provision of fire hydrants and no open water supply nearby	Good provision of fire hydrants and/or inexhaustible open water supply nearby	Discussed with fire service and agreed as being adequate and appropriate for risk
	Points rating	100	50	20
Type of goods being stored		High value goods High rack storage without in-rack sprinklers Highly volatile goods Hazardous processes and goods	High rack storage with in rack sprinkler protection	Low value goods Stored goods have low combustibility
	Points rating	100	50	30
Vulnerability to fire spread and disproportional damage		Poor standard of construction Inadequate fire protection Non-compartmented floor area in excess of 4000m^2	Fire resisting compartmentation and floorareas in accordance with this sector guide	Sprinklered building and fire resisting compartmentation in accordance with this sector guide
	Points rating	100	50	20
Standard of Fire Safety management		No evidence of a suitable standard of fire safety management	Adequate standard of fire safety management	Risks controlled by a well-documented fire safety management system
	Points rating	50	30	5
Possibility of arson attack		Poor site security Area has high incidence of arson attack	Some public access to external fabric but good standard of fire safety management	Secure site
	Points rating	50	15	5

Table B2: Risk classification based on total points from Table B4. Warehouses

High Risk classification	Medium Risk classification	Low Risk classification
241-480	126-240	105-125

Important note:

Tables B1 and B2 are only intended to provide a basis for establishing suitable fire performance levels. They are not intended to imply that they are necessarily equivalent or similar to an individual insurer's risk assessment.

It is imperative that full consultation between all interested parties is carried out, particularly between insurers, owners and their managers of warehouses, designers, fire safety engineers and risk managers.

B.3 Operational fire risk assessment

It is a legal requirement that fire risk assessments are carried out to meet the requirements of the Regulatory Reform (Fire Safety) Order.

The purpose of this Order is solely to protect the health and safety of those in and around the building. However, by driving down the risk to health and safety by reducing the risk of ignition and fire spread, the degree of property protection from fire is enhanced.

While the probability of loss of life in warehouse buildings is relatively low, insurance loss experience is that such buildings do require a very high level of fire protection to safeguard the business. Therefore, in addition to the fire risk assessment carried out under the Fire Safety Order, occupiers may go further and carry out a specific *property protection fire risk assessment.* This may be carried out by the occupier, either to satisfy their insurer, of simply for the sake of good asset management.

(The FPA publishes a guide to the subject of fire risk assessment, *Fire Risk Management in the Workplace* (ref. 31).)

Among the many considerations which are taken into account during a fire risk assessment are:

- the method of construction of the building and the building materials used;
- the fire hazards represented by the variety of equipment in the building, in particular its potential as possible sources of ignition;
- the fire load within the building and the potential of stored goods to ignite and burn quickly;
- the degree of compartmentation to limit the spread of fire, especially to and from high-risk areas;
- commercial pressures, in terms of optimum use of floor area, which dictate densely packed storage of goods, often on high racking;
- environmental issues;
- the financial exposure.

If these prime sources of hazard are understood by the designer, it is possible to proceed to design the building in the knowledge that the fire risk will be catered for.

This risk assessment process is shown in Figure B2.

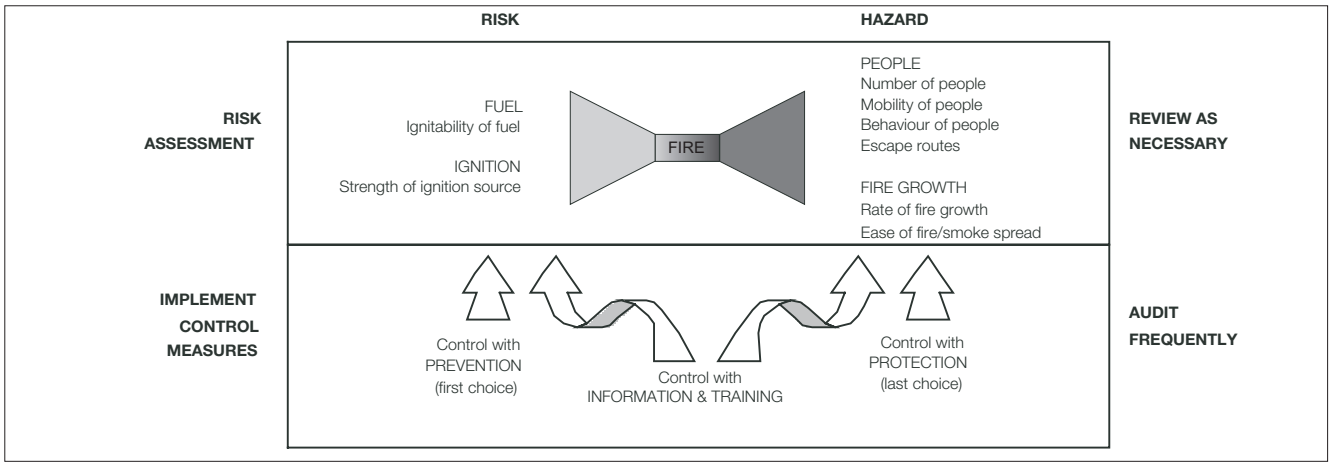


Figure B2: The operational risk assessment process

B3.1 Explanation of Figure B2

Step 1

Sources of ignition and sources of fuel must be identified. Consideration must be given to:

- the strength of the ignition source;
- the quantity and flammability of the fuel;
- the proximity of ignition sources to the fuel;
- the likelihood of ignition.

A combination of these factors results in an assessment of the risk (probability) of a fire starting.

Step 2

On the assumption that a fire may start, the next step in the process is to consider the effect of a fire:

- how quickly will the fire grow?;
- how quickly will it spread beyond the item first ignited?;
- how quickly will it spread beyond the room of origin?;
- how quickly will it spread beyond the compartment of origin?;
- how easily can people escape?;
- what will the financial consequences be?;
- how quickly can the business recover from the fire?

Once Step 2 is completed, the risk assessor has an idea of the amount of harm or damage that a fire could cause.

Step 3

By considering the probability of different fire scenarios, and the amount of harm or damage that each fire scenario could cause, the risk assessor can determine what appropriate control measures should be put in place.

The best control measures are always those which will reduce the risk of fire. This can be achieved by:

- reducing the number of ignition sources in the building;
- reducing the amount of fuel;
- physically separating potential fuel from potential ignition sources.

The second best control measures are those which assume that a fire will start, but which attempt to reduce the amount harm or damage which might be caused. This can be achieved by:

- providing early warning of fire;
- providing fixed firefighting equipment;
- providing facilities which will assist firefighters;
- providing a high degree of fire compartmentation.

Step 4

On a regular basis, the assessment of risk must be reviewed to identify any changes which have to be accommodated, and the control measures must be audited to ensure that they are fit for purpose.

B3.2 The role of the designer

Section 7 of this Sector Guide suggests several areas where the designer of the building can 'design out risk' at the planning stage, thus facilitating the risk assessment process.

In general terms, the designer can help in the first three steps of the process by measures such as:

- designing in as few ignition sources as possible;
- providing internal partitions which separate potential ignition sources from the rest of the building;
- designing storage so that combustible goods are remote from ignition sources;
- keeping fire compartments small;
- providing early warning of fire, and automatic fire suppression systems;
- specifying materials which are robust and/or easily repaired. This ensures that the fire safety measures remain fit for purpose;
- designing facilities which enable inspection, audit and testing to be carried out with the minimum of effort.

Early consultation between the designer, the building operator, and the insurer is strongly recommended to ensure that the design of the building facilitates good fire safety management.

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Appendix D
Definitions

For the purposes of this Sector Guide, the following definitions apply.

Protected zone

The sections of roof, external walls and supporting frame of a single-storey building adjacent to and within a specified distance on each side of a compartment wall.

Risk assessment

The appraisal of the fire risk in a building to meet the requirements of the Regulatory Reform (Fire Safety) Order and insurance considerations

Unprotected openings

Openings for windows or doors that do not have a fire resistance rating

Compartmentation

A means of sub-dividing a warehouse or storage building by fire-resisting walls meeting the performance requirements defined in Appendix A, Table A1

FPA Design guide

for the Fire Protection of Buildings

WAREHOUSES AND STORAGE BUILDINGS 1: DESIGN PRINCIPLES

FPA Fire Protection Association

InFiReS