A COMPREHENSIVE GUIDE TO FIRE SAFETY

COLIN S. TODD

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Business Information

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To my three children, Keith, Jayne and Fiona.

And to Karen for loving me against all odds.

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Introduction

Each year, despite the constant efforts of central government, fire and rescue services, fire insurance companies, professional fire advisers and a plethora of other interested bodies, around 500 people die in fires in the United Kingdom, while around 15,000 people are injured by fires. The majority (about 75–80 per cent) of these fatal and non-fatal casualties occur in dwellings, rather than places of work. The reasons for this include the enhanced risk of injury if fire occurs when people are asleep, the absence of legislative control over general fire precautions in most private dwellings and the absence of very old people, who are, statistically, at greater risk from fire than young people, from places of work. Nevertheless, in 2004 for example, 55 people died and 1,500 were injured in fires in non-domestic buildings. In addition, and often more memorably, people other than employees are sometimes involved in very serious fire incidents as they shop, travel, engage in recreational activities or reside in care homes. The need for fire precautions is, therefore, easily established in most buildings.

Fire also results in serious economic losses. The most obvious of these is direct damage to property. It is estimated that, in 2004, the value of property damaged by fire was £1.3 billion.[1] While this includes uninsured damage to property for which the owner would have received no recompense, it excludes the indirect or consequential losses suffered by industry and commerce due to the loss of profits following a major fire. Although consequential loss (or 'business interruption') can be insured, the effects of a serious fire on the future revenue earning of a business can be difficult to quantify. It is often claimed that a significant number of companies cease trading within a few years of a major fire. Undoubtedly, a large fire can result in loss of confidence by customers, long-term loss of business and ultimately loss of jobs. The value of lost business as a result of fires in 2004 was estimated to be £43 million.

The management of fire risk and the engineering of fire safety measures are now identified as disciplines in their own right. Undergraduate and postgraduate degrees are offered in fire safety management and fire engineering. Fire engineers can now become registered chartered engineers, incorporated engineers and engineering technicians through their own professional body, the Institution of Fire Engineers. Fire engineering is, however, a discipline that impinges on, and has traditionally drawn from, many other disciplines, including management science, building design, mechanical engineering, electrical engineering, chemical engineering, law, psychology, physics and chemistry. Fire-related legislation has recently undergone major change; knowledge of fire behaviour in complex buildings is advancing, and the facilities for formal education of practitioners in the field of fire safety are expanding, as is the codification of fire-engineering knowledge.

The purpose of this book is to provide a basic guide to this complex subject for the non-specialist, such as the facilities manager, the personnel manager, the health and safety manager, the building manager and others with responsibilities for fire safety in buildings. It is, however, hoped that it will also provide a basic reference for certain fire safety practitioners, such as company fire safety managers and officers in enforcing authorities/bodies when they first enter this field.

The approach adopted in this book is to divide the subject into a number of discrete components, each of which is considered separately. The breadth of the topics discussed is such that it is not possible to consider any one topic in a depth beyond that required by the generalist. However, guidance is given on sources of further information for the reader with an interest in specialist aspects of the subject.

The division of fire safety into independent topics is necessary in a textbook; it is not the manner in which fire safety should be approached in an actual building. For example, the absence of an automatic fire detection system in a relatively large building in which people sleep would result in a poor standard of fire safety. The absence of smoke-stop doors in the long and convoluted corridors of the same building would, in itself, be considered unacceptable, as would the absence of emergency lighting. However, the overall effect of these three deficiencies is much greater than the simple sum of the individual deficiencies; a fire during the night may develop, undetected, until the corridors are completely smoke logged, so that means of escape are impassable and, in any case, difficult to use because the normal lighting has failed due to fire damage to the cables of lighting circuits. Many fire disasters have arisen from an unfortunate combination of apparently independent defects, at least some of which are almost always related to management shortcomings, and any one of which, if rectified, would have ameliorated the situation in which those involved found themselves.

A corollary to the above assertion is that it is possible to design and engineer an integrated 'package' of fire precautions that enables one or more fire safety objectives to be achieved. This is the concept of 'fire engineering', which is already recognized by legislation and the manner in which it is enforced, but it is likely that, in the future, the scope for this approach will continue to expand (see Chapter 22). Already, it is well accepted that compliance with the goals set by building regulations can be achieved by a fire engineering approach, rather than solely by the rigid, prescriptive approach, albeit that, for most projects, the traditional approach will often suffice. On a more routine level, the fire risk assessments that legislation requires be carried out for existing buildings should not involve inflexible application of guidance; the action plan that emanates from the fire risk assessment should be proportionate to the risk.

Unfortunately, there is still much to be learned about the interrelationships between the many forms of fire precautions, and fire engineering is a matter for the specialist. Before departing from standard solutions, the reader is, therefore, advised to seek expert opinion and the views of enforcing authorities; the latter can still sometimes be rather conservative in approach. Indeed, before specifying any fire protection measure of any real complexity, cost or effect on overall fire safety, early consultation with all interested parties, particularly those charged with enforcement of legislation and insurance of the property, is strongly advocated.

Further reading

Fire Statistics, United Kingdom. Published annually by Communities and Local Government.

Reference

1. Source: *The Economic Cost of Fire: Estimates for 2004*. Published by the Office of the Deputy Prime Minister (now Communities and Local Government).

1

Fire safety legislation

Historical background

Historically, most fire safety legislation has arisen from specific fire disasters. For example, it is widely held that the Factories Act 1961 arose as a result of the fire at a mill in Keighley some five years before. Equally, it is said that the fire at Hendersons department store in Liverpool in 1960 gave rise to the fire safety requirements imposed by the Offices, Shops and Railway Premises Act 1963. Even the one time cornerstone of United Kingdom fire safety legislation, the Fire Precautions Act 1971, was said to be enacted as a result of 11 deaths in a fire at the Rose and Crown Hotel, Saffron Walden in 1969. In the 1980s, the Fire Safety and Safety of Places of Sport Act 1987 followed the fire at Bradford football stadium in 1985, while the Fire Precautions (Sub-surface Railway Stations) Regulations 1989 arose as a result of the fire at King's Cross underground station in 1987.

Sometimes, it is not new legislation that follows a disaster, but a significant change in requirements imposed under legislation. In England and Wales, the maximum compartment size specified for single-storey retail premises in guidance published in support of the Building Regulations in 2000 was influenced by the death of a female fire-fighter in a fire in retail premises. In Scotland, following a disastrous fire at a residential care home in 2004, the Building (Scotland) Regulations specified, for the first time, that residential care homes need to be protected by an automatic fire suppression installation.*

This approach to the legislative control of fire safety caused much fire safety legislation to be piecemeal and fragmented over many decades. It was only

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* In England and Wales, this is not mandatory if a sprinkler system is provided. However, certain design freedoms in residential care premises have, since 2007, been accepted under the guidance that supports the relevant building regulations; an example is that bedroom doors need not be self-closing.

in 2006, with the coming into force of the Regulatory Reform (Fire Safety) Order 2005 in England and Wales (and equivalent legislation in Scotland and, subsequently, Northern Ireland) that there has been major rationalization of a great swathe of fire safety legislation, somewhat akin to that achieved in the more general field of health and safety in 1974, when the Health and Safety at Work etc. Act was introduced.

One of the earliest attempts to consolidate fire safety legislation followed from the recommendations of the Holroyd Report in 1970. The report recommended that fire safety legislation should be divided into two main branches; one dealing with new buildings (and building works in the form of extending or materially altering an existing building), while the other deals with occupied premises. This is largely the current situation and remains the Government's intent for the long term future. In England and Wales, new buildings and major alterations to existing buildings are required to comply with the Building Regulations 2000. In Scotland, buildings must comply with the Building (Scotland) Regulations 2004 and, in Northern Ireland, with the Building Regulations (Northern Ireland) 2000. In England and Wales, on completion of the building work, fire precautions are controlled by the second 'branch' of legislation in the form of the Regulatory Reform (Fire Safety) Order 2005. (A similar situation exists in Scotland and Northern Ireland.) There is, however, a form of bridge (first introduced in 2007) between the two branches, in that the Building Regulations 2000 (as amended) require that, on completion of the building work, or on occupation of the building or extension (whichever is earlier), suitable fire safety information is passed on to the responsible person (as defined in the Regulatory Reform (Fire Safety) Order) to enable that person to operate and maintain the building or extension safely.

In England and Wales, the building regulations are the responsibility of Communities and Local Government (CLG), and they are enforced either by the building control officer (BCO) of the local authority or by a private sector approved inspector (AI). The BCO or AI consults with the fire and rescue authority concerning various fire precautions. In Scotland, the Building (Scotland) Regulations are produced by the Scottish Building Standards Agency, while in Northern Ireland the relevant government department is the Department of Finance and Personnel. In Scotland and Northern Ireland, there are no private sector building control bodies, such as approved inspectors; responsibility for enforcement of building regulations rests solely with local authorities.

Building Regulations 2000

The Building Regulations 2000 apply to virtually all new buildings, material alterations to existing buildings and material changes of use of buildings (as defined in the Regulations) in England and Wales. However, certain buildings are exempt from control, and these include the following:

- buildings to which the Explosives Acts 1957 and 1984 apply;
- buildings on sites for which a licence under the Nuclear Installations Act 1965 is required;
- ancient monuments;
- agricultural buildings and greenhouses of limited size, subject to separation from other buildings;
- temporary buildings;
- small detached buildings and detached buildings that would not normally be entered by people, subject to adequate separation from other buildings;
- certain other extremely small buildings with no sleeping accommodation.

Building control bodies do not have any power to apply the Regulations to Crown buildings. However, government policy is that Crown buildings should comply with the Regulations.

Building regulations contain no detailed technical requirements. Instead, they are cast in so-called 'functional form', containing only functional requirements that are, in effect, simply fundamental fire safety objectives.

In England and Wales, there are just five functional requirements relating to fire safety. These are set out in Part B of Schedule 1 to the Building Regulations 2000, and are generally referred to as Regulations B1, B2, B3, B4 and B5. The requirements of each Regulation are now discussed in turn.

Regulation B1

This requires that all buildings to which the Regulations apply are designed and constructed so that there are:

- adequate means of giving early warning of fire; and
- (other than in prisons) appropriate means of escape in case of fire from the building to a place of safety outside the building.

The means of escape must be such that they can be safely and effectively used at all material times.

Thus, the measures addressed may not be limited to structural measures; in many types of building, emergency escape lighting may be necessary (see Chapter 9). It should be noted that the requirement for early warning of fire, which was only introduced into the Regulations in 2000, brings fire detection and fire alarm systems within the scope of the Regulations; this includes material alterations to such systems, for which approval under the Regulations is necessary.

Regulation B2

B2 is concerned with measures to restrict the spread of fire over internal surfaces, such as walls and ceilings. The requirement is that materials used on walls and ceilings must be adequately resistant to spread of flame over their surfaces and, in some cases, that, if ignited, the rate of heat release will be reasonable in the circumstances.

It should be noted that Regulation B2 does not apply to floor coverings, and that an alteration to linings is not a material alteration for which approval under the Regulations is necessary.

Regulation B3

B3 is concerned with measures to limit the spread of fire within the building and to prevent structural collapse due to fire. It requires that:

- in the event of fire, the building will remain stable for a 'reasonable period';
- certain large buildings be subdivided into fire-resisting compartments and/or be provided with suitable automatic fire suppression systems;
- concealed spaces be limited to prevent hidden fire and smoke travel;
- party walls be fire resisting.

Regulation B4

B4 is concerned with the prevention of fire spread from one building to another. It requires that external walls provide adequate fire resistance, and that roofs be adequately resistant to spread of flame, to achieve this objective.

Regulation B5

B5 requires access to the building and other measures to assist the fire and rescue service, although, strictly, only measures to ensure safety of life. These measures comprise:

- suitable access to the building for fire appliances and fire-fighters;
- in certain buildings (particularly those of significant height above or depth below ground) measures to facilitate fire-fighting, such as fire-fighting stairs, lobbies and, in some cases, lifts, plus fire mains (see Chapter 16);
- measures for heat and smoke removal in basements.

A single publication produced by Communities and Local Government describes, in technical detail, the way in which the functional requirements of the five regulations can be satisfied. This publication, Approved Document B, defines, for example, periods of fire resistance according to the size and use of the building and makes reference to various British Standard tests.

However, the designer is not obliged to adopt the solutions described in the Approved Document, only to satisfy the functional requirements of the Regulations. The designer may develop a different solution, or wish to convince the building control officer or approved inspector that, in the circumstances, the 'conventional' solution in the Approved Document is unreasonable. Nevertheless, compliance with Approved Document B would tend to satisfy the Regulations. Equally, if an alternative approach is followed, it is necessary to demonstrate that the performance requirement is still satisfied.

Alternative approaches to the guidance contained in the approved document comprise:

- use of an alternative recognized guidance document for special occupancies (for example, the Approved Document itself recommends the use of other guidance documents in the case of hospitals, schools, enclosed shopping centres, assembly buildings and buildings containing one or more atria);

- use of a generally applicable guidance document, such as the relevant part of BS 5588;
- a 'fire engineering solution' (see Chapter 22).

The performance requirement does, of course, relate only to health and safety, and not to protection of property. Thus the fire resistance of, for example, many single-storey buildings in England and Wales may be quite short, and compartment sizes were at one time unlimited. This led to concern regarding the unconfined spread of fire through, and early collapse of, a number of large, uncompartmented, single-storey retail units when fire occurred. Accordingly, Approved Document B does now advocate, for example, limitation of compartment sizes in single-storey retail premises and single-storey warehouses. In contrast, no limit is advocated for other single-storey occupancies, but limits are imposed on maximum compartment sizes in all multi-storey buildings, other than offices and car parks for light vehicles.

Once a building is erected, ongoing control of fire safety is, in the case of nearly all buildings other than dwellings, effected in England and Wales by the Regulatory Reform (Fire Safety) Order 2005 (see p. 8). However, the Building Regulations control 'material alterations' to a building, i.e. any alteration that would adversely affect the fire safety of the existing building as controlled by Regulations B1, B3, B4 or B5. Thus if, for example, part of a fire-resisting enclosure, required by the Building Regulations at the time of construction, were completely removed by an occupier as part of an alteration, the occupier would be guilty of an offence, unless the alteration had been approved by local authority building control or by an approved inspector.

Building regulations in Scotland and Northern Ireland

Similar principles to those of the Building Regulations 2000 apply in both Scotland and Northern Ireland.

In Scotland, the Building (Scotland) Regulations 2004 are set out in functional form within Section 2 of Schedule 5 to the Regulations, but contain an additional major requirement, namely the provision of an automatic life-safety fire suppression system; this requirement applies, however, only to enclosed shopping centres, residential care buildings, sheltered housing and high-rise flats. On the other hand, the requirement to provide fire warning systems only applies to dwellings, residential buildings and enclosed shopping centres.

The Scottish regulations also require that design and construction of buildings be such that electrical installations do not become a source of fire. (In England and Wales, control over safety of electrical installations only exists in respect of domestic premises.)

The Regulations in Scotland are supported by two technical handbooks (one for domestic premises and one for non-domestic premises), the function of which is similar to that of Approved Document B in England and Wales.

In Northern Ireland, the Building Regulations (Northern Ireland) 2000 are virtually identical to the Building Regulations in England and Wales. The wording of the functional requirements within Regulations E2–E6 is similar to that in Regulations B1–B5 of the Building Regulations 2000 respectively.

The supporting guidance for the Building Regulations (Northern Ireland) can be found in Technical Booklet E, published by the Northern Ireland Department of Finance and Personnel. Its recommendations are very similar (but not absolutely identical) to those in Approved Document B.

Local acts

It would be incorrect to assume that, in designing a building, only the nationally applicable legislation discussed above applies. In some areas of England and Wales, local acts impose additional requirements for certain categories of premises, such as high buildings and large storage buildings.

Perhaps the most well-known local legislation is that contained in Section 20 of the London Building Acts (Amendment) Act 1939 [as amended by the Building (Inner London) Regulations 1985]. This legislation empowers London district surveyors to require special fire safety measures, such as sprinkler protection, in certain high buildings, or in large uncompartmented buildings used for manufacturing or warehousing, in inner London. Requirements of local acts are not generally concerned with means of escape for occupants, but with measures that will limit the extent of fire spread and assist the fire and rescue service. Since such measures are also incorporated in national building regulations, the need and justification for them to be addressed in local acts is not entirely logical. It is likely that, in the long term, fire safety provisions of local acts will be repealed as part of any further reshaping of fire legislation. It should, however, be noted that various local acts have now been amended by the Regulatory Reform (Fire Safety) Order 2005 to prevent overlap between the two branches of legislation.

Existing buildings in England And Wales: The Regulatory Reform (Fire Safety) Order 2005

Background

The Regulatory Reform (Fire Safety) Order 2005, which came into force on 1 October 2006, totally reshaped the structure of fire safety legislation in England and Wales. It repealed (or amended to delete requirements in respect of fire safety) virtually all legislation that had previously made specific requirements in respect of fire safety in occupied buildings in England and Wales. This repeal included the Fire Precautions Act 1971, which had previously required fire certificates, issued by the fire and rescue authority, for many common places of work in Great Britain; existing fire certificates ceased to have effect from the date that the Regulatory Reform (Fire Safety) Order (the 'Fire Safety Order') came into effect. The Fire Certificates (Special Premises) Regulations 1976, under which fire certificates were issued, for certain high-hazard sites and construction sites, by the Health and Safety Executive, were also repealed.

The repeals also included the Fire Precautions (Workplace) Regulations 1997 and those parts of the Management of Health and Safety at Work Regulations 1999 that made requirements of a managerial nature in respect of fire safety (other than in respect of fire safety within industrial processes, etc., which remain, in effect, part of general requirements of health and safety legislation). However, this now repealed legislation was originally brought into force to satisfy the requirements of two European directives, namely the Framework Directive and the Workplace Directive, both of which had been signed by the Council of Ministers in Brussels in 1989. In repealing the legislation under which these directives were implemented in Great Britain, it was still necessary for any new legislative regime to implement the requirements of the directives, which relate to health and safety (including safety from fire) of employees in workplaces.

For this reason, the requirements of the Fire Safety Order, in respect of fire precautions, adopted virtually the exact wording of the Fire Precautions (Workplace) Regulations, which itself had followed, almost exactly, the relevant wording of the European directives. The Fire Safety Order also adopted wording contained within the Management of Health and Safety at Work Regulations 1999, thereby applying relevant health and safety requirements within these regulations, which had also emanated from the European directives, more specifically to fire safety. While the reader need not be concerned with this background to the wording used in the Fire Safety Order, it may assist with an insight into the somewhat convoluted, and in some cases vague, wording of the Fire Safety Order; much of the wording is, in effect, second generation wording from the Framework Directive and the Workplace Directive.

The main purpose of the Fire Safety Order was not, however, to implement the European directives, as this had already been achieved. It is merely that, in reshaping fire safety legislation, it was necessary to maintain the requirements of the directives. The purpose of the Fire Safety Order, which was created using the powers granted by the Regulatory Reform Act 2001, was to consolidate and rationalize fire safety legislation, which had previously taken the form of a multitude of disparate legislative instruments, into a single legislative instrument.

Thus, the effect of the Fire Safety Order is to impose, in one order, an almost universal duty of fire safety care on almost all non-domestic premises. The rationalization and simplification of fire safety legislation had been the intention of the Government for many years, following government scrutiny in 1994, carried out in accordance with deregulation initiatives. The 'Independent scrutiny of fire safety legislation and enforcement' had concluded that fire safety legislation in England and Wales was, at the time, conflicting and confusing, to the extent that it imposed unnecessary burdens on businesses. The scrutiny recommended rationalization and simplification, and the Fire Safety Order was the Government's response to that recommendation.

At the time of writing, the coming into effect of the Fire Safety Order is quite recent. As yet, there is no relevant case law. The somewhat vague nature of the language used in much of the Fire Safety Order is such that, until there is case law, the boundaries of its scope and the manner in which certain requirements must be interpreted will be a matter for debate. While, to assist readers, the author has endeavoured to interpret, where necessary, certain aspects of the Order, ultimately only the Courts can determine matters of interpretation.

Scope of the Fire Safety Order

Because the Fire Safety Order effectively repealed all other legislation (or parts of legislation) under which fire precautions in existing buildings was primarily controlled (with the notable exception of the Fire Precautions (Sub-surface Railway Stations) Regulations), the scope of the Order is extremely broad. It should be noted, firstly, that that the requirements of the Order generally apply to ‘premises’. However, the term premises is somewhat all encompassing, since the definition of premises, given in Article 2 of the Order, includes ‘any place’, and, in particular, includes:

a) any workplace (so ensuring that obligations under the relevant European directives are satisfied);
b) any vehicle, vessel, aircraft or hovercraft;
c) any installation on land (including the foreshore and other land intermittently covered by water), and any other installation (whether floating, or resting on the seabed or the subsoil thereof), or resting on other land covered with water or the subsoil thereof); and
d) any tent or moveable structure.

Notwithstanding this very broad interpretation of premises, Article 6 of the Order then does apply some limitations to the application of the Order by excluding the following premises (but only those premises) from the application of the Order:

a) domestic premises;
b) offshore installations;
c) ships (in respect of normal shipboard activities carried out by the crew under the direction of the master; during work on the ship in, say, a dry dock, the ship would, therefore, fall within the scope);
d) fields, woods or other land of a forestry or agricultural undertaking, but which is not inside a building and is situated away from the undertaking’s main buildings;
e) aircraft, locomotives or rolling stock, trailers or semi-trailers used as a means of transport or a vehicle for which a licence is in force under the Vehicle Excise and Registration Act 1994 or a vehicle exempted from duty under that Act;
f) mines, other than buildings on the surface of the mine;
g) borehole sites.

With regard to domestic premises, these are defined as ‘premises occupied as a private dwelling (including any garden, yard, garage, outhouse, or other appurtenance of such premises which is not used in common by the occupants of more than one such dwelling’). The wording in parentheses is particularly important, since, by excluding, from the definition, common parts of blocks of flats and similar premises, such as houses in multiple occupation (see p. 42), such common parts fall within the scope of the Fire Safety Order. (The common parts of blocks of flats are, however, excluded from the equivalent legislation in Scotland and Northern Ireland.) It should also be noted that, by virtue of

Article 31 (10) of the Fire Safety Order, a prohibition notice (see p. 29) may be served on a house in multiple occupation (HMO), and this power is not limited to purely the common parts of the HMO.

The term ‘private dwelling’ is not defined in the Fire Safety Order. Clearly, however, its use must exclude from the scope of the Fire Safety Order the main residence of any single person or single household. Nevertheless, there remain certain ‘grey areas’, about which there cannot be absolute certainty without future case law.

Individual chalets on a holiday park are not considered to be excluded from the scope, nor, arguably, would caravans on a similar site, since these could probably not be regarded as private dwellings (unless in private ownership). They may in effect be regarded in totality as a fragmented hotel, and should no more be excluded than the individual guest bedrooms within a hotel.

At the other end of the spectrum, consider a cottage, owned by a single family and used only occasionally as their holiday home. If, for several weeks a year, they choose to rent it to third parties, does it cease to be a private dwelling? Arguably, not. At what stage does the single holiday cottage, from which the family earn some meagre income, if extended in the level of commercial gain, or if extended to two or more cottages used as an income for the family, become the commercial holiday park?

Similarly, within a hospital, the overnight residence of an on-call doctor clearly comes within the scope of the Fire Safety Order. The flat occupied by the caretaker in a block of flats as their main residence, and for which rent is paid, is, arguably, a private dwelling and outside the scope of the Fire Safety Order. The same argument might be applied to dwellings owned by a private school and occupied by staff as their sole or main residences. Would, however, this situation alter if the caretaker or the school staff paid no rent, are on-call outside their normal working hours, are constrained to be present within their dwellings at certain times and have facilities, such as CCTV monitors for the site, in their dwellings?

Whereas, on the one hand, it is accepted that the dwellings of homeworkers, who work for their employer from a room within their own, privately owned dwelling, are outside the scope of the Fire Safety Order (but may not be outside the scope of the Health and Safety at Work, etc. Act and statutory provisions under the Act), and it is also accepted that the presence of gas fitters, carers and visiting nursing staff does not make a dwelling into a workplace, could the hypothetical circumstances described for the caretaker and school staff, turn their dwellings into facilities provided for use in connection with a workplace, and hence part of a workplace, as defined in the Fire Safety Order?

In the case of most of the other premises to which the Fire Safety Order does not apply, other legislation continues to impose relevant requirements in respect of fire safety. For example, marine legislation deals with fire safety on ships, while public service vehicle licensing and taxi licensing generally deals with fire precautions in these forms of transport used by the public. (There may, however, be a form of 'loophole' in respect of, say, a bus used as both transport and sleeping accommodation for a travelling group of entertainers, since, even when it is parked on private land and used as sleeping accommodation, the licence for the vehicle is 'in force' (unless an application for a Statutory Off Road Notice [or SORN] had been made to suspend the licence)).

Similarly, the excluded offshore installations are those within the scope of the Offshore Installation and Pipeline Works (Management and Administration) Regulations 1995, to which other safety-related legislation applies. The excluded mines are those within the scope of the Mines and Quarries Act 1985 (which makes requirements in respect of fire precautions and measures to prevent explosions) and the excluded borehole sites are those within the scope of the Borehole Sites and Operations Regulations 1995, Schedule 2, which makes requirements in respect of fire precautions.

The fire safety duties imposed by Part 2 of the Fire Safety Order (see p.19) are imposed on Crown buildings. However, certain powers of enforcement and powers to serve notices do not apply to buildings occupied by the Crown, although some of these powers do apply to buildings owned by the Crown, but occupied by others.

Dutyholders and competent persons

The Fire Safety Order introduced various defined groups of persons (some of whom were previously the subject of either the Fire Precautions (Workplace) Regulations or the Management of Health and Safety at Work Regulations) with whom the Order concerns itself, namely the:

- responsible person;
- other persons having control of premises;
- competent persons to assist with evacuation;

- competent persons to use fire-fighting equipment;
- competent persons to assist the responsible person to undertake the 'preventive and protective measures'.

The responsible person

It is primarily the 'responsible person' on whom the Fire Safety Order imposes requirements and duties. Accordingly, it is important to consider, for every premises, who exactly constitutes the responsible person (or 'RP'). The answer to this can be found in Article 3 of the Fire Safety Order. For most premises with which readers will be involved, the definition will be relatively straightforward, since, in the case of a workplace, Article 3 defines the RP as 'the employer'. This will be the body corporate – the company or organization that employs people to work in the premises. It should be noted, however, that, in the case of prosecution for an offence under the Order, a director, manager, company secretary or similar officer of the company could be prosecuted as well as, or instead of, the body corporate if the offence had been committed with that person's consent, connivance, or as a result of their negligence.

The definition of workplace is very broad, although it excludes domestic premises. (Hence, domestic servants or homeworkers are not protected by the provisions of the Order.) By definition, under the Order, a workplace means any premises, or parts of premises, made available to one or more employees. This includes any place within premises to which an employee has access while at work. It also includes the means of access to or egress from the place of work (e.g. footpaths external to the building or common parts within premises in multiple occupation), other than public roads.

It is obvious from the above definitions, that, thus far, we have not considered premises occupied by persons who are self-employed, with no employees. These persons are not employers, and the premises do not fall within the definition of workplace. However, if the premises are not a workplace, Article 3 defines the RP as the person who has control of the premises (as occupier or otherwise) in connection with the carrying on of a trade, business or undertaking (for profit or not). This definition, again, is very broad in nature and effectively encompasses virtually all premises, other than single-family dwellings, that are not already captured within the definition of workplace, including non-domestic premises where self-employed people work, the premises of voluntary organizations with no employees, etc.

However, lest, for any premises other than dwellings, there be any difficulty in finding an RP, Article 3 has a further ‘catch all’ for situations in which the premises are not a workplace and the person in control of the premises does not have control in connection with the carrying on by that person of a trade, business or undertaking. In such circumstances, the RP is defined by Article 3 as the owner of the premises. In practice, it is very difficult indeed to imagine a situation in which this would arise, although the owner will often already be the RP by virtue of having control for the purposes of his/her business.

Other persons having control of premises

The RP is the primary dutyholder under the Order, and can never escape this duty (e.g. by delegating to others). However, in addition to (but never instead of) the RP, the requirements imposed on the RP in respect of fire safety and fire precautions are also imposed on every other person who has, to any extent, control of the premises, so far as the requirements relate to matters under this other person’s control.

Article 5(4) of the Order gives a further clue as to who such persons might be. This person includes any person who has, by virtue of a contract or tenancy, an obligation of any extent in relation to maintenance or repair of any premises (including anything in or on the premises), or an obligation in relation to the safety of the premises. The person is, however, only treated as this other person having control of premises to the extent that the above obligations extend.

In practice, the most obvious examples of this ‘other person’, on whom the Order imposes fire safety duties, are the owner and managing agents of industrial or commercial premises in multiple occupation. Under tenants’ leases or tenancy agreements, the owners (and by virtue of their contract with the owner, the managing agents) are normally responsible for maintenance, repair and safety of the common parts. Often these parties are also responsible for maintenance of a building-wide fire detection and fire alarm system and/or automatic sprinkler installation. Thus, it would appear that in these circumstances, they are responsible for the *adequacy* of fire precautions in the common parts and for the *adequacy* of the building-wide fire protection systems. Equally, the tenants (as RPs) would also be responsible for shortcomings in these fire precautions if they affected persons using their premises. (Duties in respect of premises in multiple occupation are discussed later in this chapter.)

It should also be noted that fire protection systems maintenance contractors may have duties of care under the Order, at least in respect of their maintenance work. They are, in effect, a person having control by virtue of a contract for maintenance of something (the relevant fire protection system) in the premises.

Competent persons to assist with evacuation

Article 15(1)(b) of the Fire Safety Order requires that the RP nominate a sufficient number of competent persons to implement the fire procedures, so far as they relate to evacuation of the relevant persons from the premises. (This Article is extracted from the Management of Health and Safety at Work Regulations, which makes the same general requirement in respect of persons to implement procedures for serious and imminent danger). In practice, therefore, there will, in most premises, be a need to nominate fire wardens (see Chapter 20).

Competence is defined in Article 15(3) as having sufficient training and experience or knowledge and other qualities to enable the person properly to implement the evacuation procedures. Thus, fire wardens need to be properly trained.

Competent persons to use fire-fighting equipment

Article 13(3) of the Fire Safety Order requires that the RP must, where necessary, take measures for fire-fighting in the premises, adapted to the nature of the activities carried out, the size of the undertaking and of the premises. It is also required that competent persons are nominated to implement these measures and to ensure that the number of persons, their training and the equipment available to them are adequate, taking into account the size of, and the specific hazards involved in, the premises.

Thus, for virtually all premises, in practical terms, there will be a need to determine who is to use the fire-fighting equipment (portable fire extinguishers and/or hose reels). This could simply reflect very common fire procedures, whereby whoever discovers a fire may tackle the fire with a fire extinguisher if safe to do so – it could then reasonably be argued that anyone who discovers a fire is 'nominated' to take fire-fighting measures. It would need then, to be ensured that all occupants of the premises were adequately trained to do so.

This Article does, however, afford flexibility to the RP. An adequate number of persons might only be a proportion of employees, who are nominated to use the fire-fighting equipment, while other employees, not so nominated, are instructed never to use the fire extinguishers. It should also be noted that the requirement hinges on the *necessity* to nominate people.

The requirement imposed by this Article in the Fire Safety Order is carried over from the now repealed Fire Precautions (Workplace) Regulations and extended to protect relevant persons; in the case of the Fire Precautions (Workplace) Regulations, the necessity was only for the purpose of safeguarding employees in the event of fire. Under those Regulations, some employers argued that it was *never* necessary, for example in a school, for anyone to use fire extinguishers in the event of fire in order to protect the teachers (as the employees).

This was, arguably, a very perverse interpretation of the legislation. All fires generally start as small fires. The concept of evacuating a building in the event of a small fire that could easily be extinguished with a fire extinguisher, while awaiting arrival of the fire and rescue service to what by then might be a serious fire, is now very outdated. Under the Fire Safety Order, it would seem to be expected that, in most buildings, there be, at least, an adequate number of persons able to use fire extinguishing appliances on a small fire. The RP would need, in the opinion of the author, to go to some lengths to demonstrate that such arrangements were not necessary, albeit that, say, in a single storey premises of just one or two rooms with only two or three occupants, this might be possible. Again, the definition of competence is defined in Article 15(3) as having sufficient training and experience or knowledge and other qualities to enable the person properly to implement the fire-fighting measures. Thus, anyone who is expected to use fire extinguishers and/or hose reels needs to be properly trained in the use of this equipment.

Competent persons to assist the responsible person

Article 18(1) of the Fire Safety Order requires that the RP must appoint one or more competent persons to assist the RP in undertaking the ‘preventive and protective measures’ (see p. 18). The only exception to this requirement relates to self-employed persons, or business partners, where, in either case, there is competence on the part of the self-employed person or one or more of the business partners. In simple terms, this means that every RP must have access to competent advice on compliance with the Fire Safety Order. Article

18(2) requires that the number of persons appointed, and the time available to them, are adequate.

Article 18(8) requires that, where RPs have competent persons in their employment, they must be appointed for this purpose in preference to any third party. Thus, where possible, in-house advice must be used, rather than, say, external consultants. It should be noted, however, that it is not necessarily this competent person who must carry out the fire risk assessments, although this may, or may not, be the case. For example, the in-house competent person might be the fire safety manager or health and safety manager of a large group. This person would then provide the competent assistance, subject to satisfying the definition of competent, namely having sufficient training and experience or knowledge and other qualities to render the assistance required. The in-house competent person then might arrange for others, such as consultants, to carry out the fire risk assessments, either because of the number of premises involved or because of the need for greater expertise in fire safety than that of the in-house competent person; competence is, in this connection, generally regarded to include recognition of a person's own limitations and a willingness to seek external advice when appropriate.

A small employer will, however, often need to rely on external advice. In such a case, Article 18(4) requires that the RP provides the external adviser with sufficient information, including information about dangerous substances or any factors that could affect people's safety. It is important, therefore, that the RP does not attempt simply to delegate all consideration of fire safety to a third party.

Relevant persons

The objective of the Order is primarily to protect *relevant persons* from fire. Relevant persons are any persons who are, or may be, lawfully on the premises. Thus, this would include employees, visitors, contractors, etc. and it includes the RPs themselves. It does not, however, include fire-fighters when they attend a fire or other emergency at the premises. (However, there is an obligation to maintain equipment provided for the safety of fire-fighters.)

Relevant persons also include anyone in the immediate vicinity of the premises who is at risk from a fire on the premises. As well as, perhaps, including passers-by, this could include those using common escape routes from a commercial building in multiple occupation, into which, say, a tenant's premises open.

Preventive and protective measures

What are the so-called preventive and protective measures with which the RP needs to receive assistance from a competent person? These are simply the measures that have been identified, by means of the fire risk assessment, as the 'general fire precautions' needed for compliance with the Order.

Duties of the RP regarding fire precautions

Having determined who is the RP for the premises, and considered the various other categories of person with whom the Order concerns itself, we need to now consider what exactly is expected of the RP in terms of fire precautions. The duties in this respect are set out in Article 8 of the Order.

Article 8(1) requires that the RP take such *general fire precautions* as will ensure, so far as is reasonably practicable, the safety of any employees of the RP. 'Reasonably practicable' does not simply mean that it is feasible to take a particular precaution; it is a less onerous burden than 'practicable'. The existence of the risk must be weighed against the cost, effort and difficulty of addressing the risk, although, in terms of cost, the size and financial status of the organization has no real relevance; it would be inequitable to expect one organization to remove or reduce risk to employees, while another did not remove or reduce an identical risk simply because it could not afford to do so.

Article 8(2) requires that, in relation to relevant persons who are not the RP's employees, the RP must take such general fire precautions as may reasonably be required in the circumstances of the case to ensure that the premises are safe.

The broad concept of fire precautions is discussed in Chapter 4. In the Order, *general fire precautions* are defined as:

1. measures to reduce the risk of fire on the premises and the risk of the spread of fire on the premises;
2. measures in relation to the means of escape from the premises;
3. measures for securing that, at all material times, the means of escape can be safely and effectively used;
4. measures in relation to the means for fighting fires on the premises;
5. measures in relation to the means for detecting fire on the premises and giving warning in case of fire on the premises; and

6. measures in relation to the arrangements for action to be taken in the event of fire on the premises, including:
   a) measures relating to the instruction and training of employees; and
   b) measures to mitigate the effects of the fire.

The precautions required under the Fire Safety Order do not, however, extend to process fire precautions, such as would be required by the Health and Safety at Work, etc. Act 1974, or legislation made under the powers of that Act. Thus, fire precautions associated with, for example, preventing fire or explosion in an industrial process remain within the scope of health and safety legislation and are enforced by the Health and Safety Executive. The same is true of precautions specific to the use and storage of dangerous substances, although the general fire precautions need to take account of such substances.

It should be noted that there is a subtle difference between the duty imposed by the Fire Safety Order in relation to employees and that imposed in relation to non-employees. The safety of the former is to be ensured (as far as is reasonably practicable) by the general fire precautions adopted. In the case of non-employees, the duty is only to ensure that the *premises* are safe. The difference might be considered to arise from the greater control employers have over the safety of their employees (e.g. by training, provision of information, etc.), whereas, in the case of, for example, the public, all that can be ensured is that the premises are safe for their use; their behaviour is less under the control of employers than that of employees.

Equally, the flavour of the entire Order is to impose a more onerous duty of care in respect of safety of employees, over and above the duty imposed in the case of non-employees, to ensure compliance with the European Directives, which are concerned primarily with employee safety and make employers unconditionally responsible for the safety of employees; the difference in wording might also be considered to arise from this philosophy. Moreover, the employees are likely to be nominated to carry out duties that assist in the safety of non-employees, thereby making the premises safe for the non-employees.

Fire safety duties

The *fire safety duties* imposed by the Fire Safety Order are contained in Part 2 of the Order. Articles 8–22 inclusive set out the measures, both physical and managerial, that the responsible person (and, hence, where relevant, also the person having control of the premises) must take. The duty to take *general fire precautions*, imposed by Article 8 of the Fire Safety Order, was discussed earlier in this chapter. In order to identify the general fire precautions that these dutyholders must take, a fire risk assessment must be carried out. The requirement to carry out this risk assessment is contained in Article 9, which also requires that the assessment be reviewed regularly. Article 9 also requires that the responsible person, as soon as practicable after the assessment is made or reviewed, records the significant findings, including the measures that have been, or will be, taken in order to comply with the Fire Safety Order, and records any group of persons identified as being especially at risk, if any of the following apply:

a) the RP employs five or more employees (anywhere within the organization and not merely within the premises concerned);
b) a licence under an enactment is in force;
c) an alterations notice (see p. 27) requiring that this information be recorded is in force.

Where a dangerous substance is, or is liable to be, present, the risk assessment must include consideration of various matters set out in Part 1 of Schedule 1 of the Fire Safety Order. No new work activity involving a dangerous substance may commence unless the risk assessment has been made and the measures required to satisfy the Order have been implemented. Dangerous substances are defined within the Order, but, basically, these are substances that are flammable, explosive or oxidizing, or that create a fire risk because of their properties.

If young persons (under 18) are to be employed, the fire risk assessment must take particular account of matters set out in Part 2 of Schedule 1 of the Order. The responsible person must not employ a young person unless he or she has, in relation to the risks to young persons, made or reviewed the fire risk assessment, taking account of these matters. Fire risk assessment is the subject of Chapter 5.

Where the responsible person implements any preventive and protective measures, they must do so on the basis of the '*principles of prevention*'. These principles are set out in Part 3 of Schedule 1 of the Fire Safety Order (but were, previously, applied to fire safety by the Management of Health and Safety at Work Regulations 1999). The principles of prevention are:

a) avoiding risks;
b) evaluating the risks that cannot be avoided;

c) combating the risks at source;
d) adapting to technical progress;
e) replacing the dangerous by the non-dangerous or less dangerous;
f) developing a coherent overall prevention policy, which covers technology, organization of work and the influence of factors relating to the working environment;
g) giving collective protective measures priority over individual protective measures;
h) giving appropriate instructions to employees.

This emphasizes the holistic approach of the Order to fire safety, necessitating both the prevention of fire and the protection of people from fire.

Means of escape

The term 'means of escape' is used within the definition of '*general fire precautions*', but does not appear explicitly in any of the articles within the Order. This is simply a result of the use of European terminology in the 'copying out' of the relevant European directives. However, Article 14 of the Fire Safety Order ('Emergency routes and exits') may effectively be summarized as a requirement for adequate means of escape.

Article 14(1) requires that 'where necessary in order to safeguard the safety of relevant persons, the responsible person must ensure that routes to emergency exits from premises and the exits themselves are kept clear at all times'. This is simply a requirement not to obstruct escape routes.

Article 14(2) specifies that the following requirements must be complied with in respect of premises where necessary (whether due to the features of the premises, the activity carried on there, any hazard present or any other relevant circumstances) in order to safeguard the safety of the relevant persons:

- emergency routes and exits must lead as directly as possible to a place of safety;
- in the event of danger, it must be possible for persons to evacuate the premises as quickly and as safely as possible;
- the number, distribution and dimensions of emergency routes and exits must be adequate having regard to the use, equipment and dimensions of the premises and the maximum number of persons who may be present there at any one time;
- emergency doors must open in the direction of escape;

- sliding or revolving doors must not be used for exits specifically intended as emergency exits;
- emergency doors must not be so locked or fastened that they cannot be easily and immediately opened by any person who may require to use them in an emergency.

However, none of these requirements in Article 14(2) should be regarded as prescriptive requirements of an absolute nature. It should be noted that all requirements are prefixed by the qualification that these measures must be implemented *where necessary*. Means of escape is discussed in more detail in Chapter 7. At this stage, it should be noted that the necessity for the measures is determined by the fire risk assessment.

Means for securing the means of escape

The *general fire precautions* include measures for securing that, at all material times, the means of escape can be safety and effectively used. More explicit requirements of the Fire Safety Order in this respect can be found in Articles 14(2)(g) and 14(2)(h). These require that:

- emergency routes and exits must be indicated by signs; and
- emergency routes and exits requiring illumination must be provided with emergency lightning of adequate intensity in the case of failure of their normal lighting.

Once again, these measures need only be implemented *where necessary* to ensure the safety of relevant persons from fire. Fire safety signs are discussed in Chapter 10 while emergency escape lighting is discussed in Chapter 9.

Fire-fighting and fire detection

The *general fire precautions* include measures in relation to the means for fighting fires on the premises and measures in relation to the means for detecting fire on the premises and giving warning in case of fire on the premises. Specific requirements in respect of these measures are set out in Article 13 of the Fire Safety Order.

Article 13(1) requires that *where necessary* (whether due to the features of the premises, the activity carried on there, any hazard present or any other relevant circumstances) in order to safeguard the safety of relevant persons, the responsible person must ensure that:

- the premises are, to the extent that it is appropriate, equipped with appropriate fire-fighting equipment and with fire detectors and alarms;
- any non-automatic fire-fighting equipment so provided is easily accessible, simple to use and indicated by signs.

In addition, the responsible person must, where necessary:

- take measures for fire-fighting in the premises, adapted to the nature of the activities carried on there, the size of the undertaking and of the premises concerned;
- nominate competent persons to implement those measures and ensure that the number of such persons, their training and the equipment available to them are adequate, taking into account the size of, and the specific hazards involved in, the premises concerned; and
- arrange any necessary contacts with external emergency services, particularly as regards fire-fighting, rescue work, first aid and emergency medical care.

Arrangements for fighting fire and nominating people to implement these measures were discussed earlier in this chapter. The requirement for necessary contacts with external emergency services should be interpreted as, at least, arrangements to summon the fire and rescue service in the event of fire. However, the wording might also reasonably be interpreted as making requirements in respect of arrangements to meet the fire and rescue service on arrival. In the case of more complex premises, and those with hazards of which fire-fighters need to be aware, the wording could reasonably be interpreted as requiring routine liaison with the fire and rescue service to make them familiar with the premises and enable them to pre-plan for any incident.

Managerial requirements of the Fire Safety Order

The Fire Safety Order contains many requirements in respect of managerial arrangements that must be in place. Some of these, such as arrangements for summoning the fire and rescue service and for assisting with evacuation, have already been discussed. In addition to these requirements, the Fire Safety Order makes requirements in respect of:

- the establishment of fire procedures;
- where necessary, carrying out fire drills;
- provision of information to employees and carrying out training of employees;

- provision of information to employers and the self-employed from outside undertakings;
- cooperation and coordination of the measures taken in premises in multiple occupation;
- maintenance of fire precautions, including measures required under other legislation for the safety of fire-fighters;
- recording of the fire safety arrangements where five or more employees are employed by the undertaking, or a licence is in force, or an alterations notice, requiring a record to be made of the arrangements, is in force. (This, in effect, requires some form of fire safety manual for the building.)

Fire-fighters' switches for luminous tube signs

The Fire Safety Order makes requirements for cut-off switches for high-voltage signs, such as can be found outside certain entertainment venues, etc. If a cut-off switch complies with BS 7671, it is deemed to comply with the requirements of the Order. Moreover, the requirements of the Fire Safety Order do not apply in the case of cinemas licensed under the Licensing Act 2003 or to apparatus that previously complied with the relevant requirements of the Local Government (Miscellaneous) Provisions Act 1982.

If it is proposed to install high-voltage lighting to which the Fire Safety Order applies, the responsible person must give notice to the fire and rescue authority not less than 42 days before the installation work begins, showing where the cut-off switch is to be placed and how it is to be coloured or marked. The purpose of this is to ensure that the switch is readily recognizable by, and accessible to, fire-fighters.

Dangerous substances

The Fire Safety Order makes various requirements in respect of dangerous substances. As already noted, dangerous substances need to be taken into account in the fire risk assessment. Article 16 of the Fire Safety Order imposes additional emergency measures in respect of dangerous substances, including provision of information, suitable warning and other communication systems, suitable warnings before any explosive conditions are reached and suitable escape facilities. Unless the quantity of each dangerous substance poses only a slight risk to relevant persons and the responsible person has taken appropriate measures to control the risk, the responsible person must provide information to the emergency services to enable them to prepare their own response; information must also be displayed at the premises, unless the results of the risk assessment make this unnecessary.

Many of the requirements of the Fire Safety Order in respect of dangerous substances overlap with requirements contained within the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR). These regulations are a statutory provision under the Health and Safety at Work, etc. Act and apply to workplaces. The purpose of DSEAR is to provide for the protection against the risk from fire, explosion and similar events arising from dangerous substances used, or present in, the workplace. Since a risk assessment is also required under DSEAR, employers should already have addressed most, or even all, of the requirements of the Fire Safety Order in respect of dangerous substances by complying with DSEAR. It should also be noted that the requirements of the Fire Safety Order in respect of dangerous substances are primarily intended to ensure that the general fire precautions (e.g. means of escape, fire warning, training) are appropriate. Special measures in relation to the use and storage of dangerous substances are more a matter for DSEAR.

General duties of employees at work

The Fire Safety Order requires that all employees must, while at work, take reasonable care for their own safety and the safety of relevant persons who may be affected by the acts or omissions of employees. It is also required that employees cooperate with employers to enable employers to comply with duties or requirements imposed under the Fire Safety Order. Employees are also required to inform their employer, or other employee with specific responsibility for the safety of employees, of any situation or shortcoming in protection measures that could affect the safety of the employee in question or that arises out of that employee's own activities.

Enforcement of the fire safety order

Enforcing authorities and their powers

The responsibility for the enforcement of the provisions of the Order and any future Regulations made under the Order will, for the majority of premises, rest with the local fire and rescue authority, who use officers of the fire and rescue service for the purpose.

However, the Health and Safety Executive (HSE) are the enforcing authority for nuclear installations that require a licence or permit under the Nuclear Installations Act 1965, and for similar premises used by the Crown. The HSE also enforce the Fire Safety Order in the case of ships in the course of construction, reconstruction, conversion or repair by persons other than the master and the crew. Enforcement of the Fire Safety Order on construction sites is also the responsibility of the HSE, unless the construction site is within premises occupied by persons other than the construction workers. The Defence Fire Service enforces the Fire Safety Order in premises occupied solely by the armed forces or visiting forces, etc. They also enforce the Order in premises on Defence sites, even if the premises are not occupied by the armed forces.

The local authority enforces the Fire Safety Order in sports grounds that need safety certificates under the Safety of Sports Grounds Act 1975 and in regulated stands to which the Fire Safety and Safety of Places of Sport Act 1987 applies. Inspectors appointed by CLG generally enforce the Fire Safety Order in buildings owned or occupied by the Crown, and in United Kingdom Atomic Energy Authority premises (but not those nuclear installations for which the Health and Safety Executive are the enforcing authority). Powers to issue various notices are, however, limited in the case of Crown buildings.

The fire and rescue authority carries out periodic inspections, using a risk-based inspection programme that prioritizes inspections of higher-risk premises. Guidance on the development of a risk-based inspection programme for fire and rescue authorities has been provided by central government.

In general, fire and rescue authorities prioritize inspections towards higher-risk premises, such as those providing sleeping accommodation, larger public entertainment premises and the larger, more complex, commercial and industrial premises. It should not, however, be assumed that, simply because the premises may be small or present little risk, the fire and rescue authority will not carry out an inspection.

Inspectors appointed under the Order have power to enter any premises (at any reasonable time), and make any such inquiry as may be necessary to ascertain whether there is compliance with the provisions of the Order and to identify the responsible person. They can also require the production of any relevant records, and have the power to inspect and take copies of such records. If the records are computerized, they can request extracts from these records.

The inspector can require any person having responsibilities in relation to the premises (whether or not the responsible person) to give the inspector such facilities and assistance as are necessary. The inspector also has the power to take samples to ascertain their fire resistance or flammability, and to subject any article or substance to any process or test.

Alterations notices

The enforcing authority may serve on the responsible person an 'alterations notice' if the authority is of the opinion that the premises:

- constitutes a serious risk to relevant persons; or
- may constitute such a risk if a change is made to them or the use to which the premises are put.

The alterations notice must specify the matters that, in their opinion, constitute or may constitute a serious risk.

The effect of such a notice means that the responsible person must, before making any changes that may result in a significant increase in risk, notify the enforcing authority of the proposed changes. These changes include a change to the premises, a change to the services, fittings or equipment in or on the premises, an increase in the dangerous substances that are present and a change to the use of the premises.

The alterations notice may also include additional requirements for the responsible person to:

- notify any other person, who has to any extent control of the premises, of the terms of the alterations notice;
- record the significant findings of the risk assessment and persons identified as being especially at risk;
- record the fire safety arrangements; and
- before making the changes, send the enforcing authority a copy of the risk assessment and a summary of changes proposed to the general fire precautions.

However, providing the responsible person notifies the enforcing authority prior to making the changes, there is nothing in the Order to prevent the changes going ahead. It would, however, be sensible to discuss and agree any changes with the enforcing authority prior to their implementation. In practice, alterations notices (which, in effect, continue a requirement previously applicable to premises certificated under the now repealed Fire Precautions Act) are likely to be quite uncommon.

Enforcement notices

If the enforcing authority is of the opinion that the responsible person, or any other person who has control of the premises, has failed to comply with any provisions of the Order, they may serve on that person an enforcement notice.

The enforcement notice must:

- state that the enforcing authority is of the opinion that the responsible person has failed to comply with the provisions of the Order;
- specify which provisions have not been complied with; and
- require that person to take steps to remedy the failure within a specified period (not being less than 28 days).

The notice may include directions as to the measures that the enforcing authority considers are necessary to remedy the failure and may be framed to provide a choice between different ways of remedying the contravention. The enforcing authority may withdraw or extend the period of the notice.

Before serving a notice that would oblige a person to make an alteration to the premises, the enforcing authority must consult other relevant bodies, such as the relevant local authority (building control), the enforcing authority for the Health and Safety at Work, etc. Act (e.g. HSE) and any other person whose consent to the alterations would be required. For example, if the notice required the responsible person to undertake building work, the enforcing authority would need to notify the building control authority before issuing the notice to ensure the works satisfy the requirements of the building regulations. If the building were subject to an initial notice by an approved inspector, the approved inspector must be notified.

Prohibition notices

If the enforcing authority is of the opinion that the use of the premises involves, or will involve, a risk to relevant persons (including risk arising from anything that affects means of escape), so serious, that the use of the premises ought to be prohibited or restricted, they may serve on the responsible person or other person a 'prohibition notice'.

Similar to requirements in respect of an enforcement notice, the prohibition notice must specify the matters that have created, or will create, the serious risk. The notice will direct that the use of all, or part of, the premises is prohibited or restricted until the matters specified in the notice have been remedied. The notice can be issued to take immediate effect, if the enforcing authority considers that the risk of serious personal injury is, or will be, imminent, or can be framed to take effect at some later specified period. As before, the notice may include directions as to measures that have to be taken to remedy the matters specified; as in the case of an enforcement notice, the directions may be so framed as to give a choice of remedies. The measures will only be those necessary to remedy the serious risk, and additional works may still be required to comply with the provisions of the Order.

It should be noted that, although a person can appeal against a prohibition notice, the appeal does not suspend the notice, as it does in the case of alterations or enforcement notices. Once issued, it would be an offence to contravene a prohibition notice until the notice is lifted, or amended, by the enforcing authority or the Courts.

Offences

The main offences under the Order relate to the requirements or prohibitions specified under fire safety duties and notices issued under the Order.

It is an offence for a responsible person, or any other person who has control of the premises, to:

- fail to comply with any requirement or prohibition imposed under Articles 8–22 (fire safety duties) and 38 (maintenance of measures provided for protection of fire-fighters), where that failure places one or more relevant persons at risk of death or serious injury in case of fire;

- fail to comply with any requirements imposed by an alterations notice, or enforcement notice;
- fail, without reasonable excuse, to ensure compliance with the requirements of the Order relating to luminous discharge tube signs (including failure to give notice).

In addition, it is an offence for any person to:

- fail to comply with the general duties of employees, where that failure places one or more relevant persons at risk of death or serious injury in case of fire;
- fail to comply with any prohibition or restriction imposed by a prohibition notice;
- make any false entries in a book, document or register or provide false information;
- intentionally obstruct an inspector or fail to comply with any requirements imposed by the inspector, without reasonable excuse;
- pretend, with intent to deceive, to be an inspector.

It should be noted that nothing in the Fire Safety Order operates so as to afford an employer a defence in any criminal proceedings for a contravention of those provisions by reason of any act or default of an employee or a person nominated under articles in the Order.

Where an offence is committed by a body corporate or is proved to have been committed with the consent or connivance of, or be attributable to any neglect on the part of any director, manager, secretary or other similar officer or any other person, they, as well as the body corporate, are guilty of that offence.

Defence

It is a defence for the person charged to prove that he took all reasonable precautions and exercised all due diligence to avoid the commission of such an offence. This defence is not available for a breach of the requirement to take general fire precautions for the safety of any of his employees, or of the requirement for elimination or reduction of risks from dangerous substances.

In any proceedings, it is for the accused to prove that it was not practicable or reasonably practicable to do more than was in fact done to satisfy the duty or requirement. This reverse burden of proof, although generally inconsistent with criminal law, is consistent with the burden of proof in the case of defences for prosecution under the Health and Safety at Work, etc. Act 1974, and there is case law to establish that it does not contravene human rights legislation.

Appeals

A person may appeal to the Magistrates' Court against the serving of an alterations notice, an enforcement notice, a prohibition notice or a notice issued with regard to fire-fighters' switches for a luminous tube sign. The appeal must be made within 21 days from the day on which the notice was served.

On appeal, the Court may either cancel or affirm the notice and, if it affirms the notice, it may do so in its original form or with such modifications as the Court may decide.

Where an appeal is made against an alterations notice or an enforcement notice, the bringing of the appeal has the effect of suspending the notice until the appeal is fully disposed of by the Courts or is withdrawn. An appeal against a prohibition notice does not have the effect of suspending the notice unless the Courts direct that this is the case.

A person aggrieved by an order made by a Magistrates' Court may appeal to the Crown Court.

Determination of disputes by the Secretary of State

Where there has been a breach of the Order, and there is disagreement with the enforcing authority on the measures necessary to remedy the failure, they can refer the dispute to determination by the Secretary of State (at the CLG), provided both parties (i.e. the enforcing authority and the responsible person or person having control of the premises) agree. This is similar to the arrangement whereby a determination can be sought from the CLG if a building control body fails to approve plans under the Building Regulations. The intent is that, normally, the determination route would only be followed prior to any formal enforcement action.

It should be noted, however, that this process can be adopted only in respect of the matters necessary to remedy the breach, but not to decide whether a breach has occurred. This limitation, which is in recognition of the fact that only a Court can determine whether there has been a breach of legislation, limits the value of the determination process, as most disagreements with an enforcing authority are likely to relate to whether or not there is compliance with requirements of the Order, such as those relating to means of escape.

It will, in such circumstances, tend to be the case that the responsible person believes means of escape are adequate (otherwise the responsible person would have taken action in all probability), whereas the enforcing authority does not believe they are adequate. It is less likely that there will be agreement, between the enforcing authority and the responsible person, that the Order has been breached, but disagreement on the means of rectifying the breach, although such circumstances will arise.

When the Secretary of State has made a determination, the enforcing authority may not take any enforcement action that would conflict with the determination. This does not, however, apply to issues or changes outside the scope of the determination.

Guidance on the fire safety order

Article 50 of the Fire Safety Order requires that the Secretary of State make guidance available to assist responsible persons in compliance with Articles 8–22 (and with any subsequent regulations made under the Order). There was a requirement for the guidance to be available before the Order came into force; this contributed to a delay in bringing the Order into force.

The CLG are responsible for this guidance. There are 12 separate guides, each dealing with a different type of premises, namely:

- offices and shops;
- factories and warehouses;
- sleeping accommodation;
- residential care premises;
- educational premises;
- small and medium places of assembly;
- large places of assembly;
- theatres, cinemas and similar premises;
- open air events and venues;
- health care premises;
- transport premises and facilities;
- animal premises and stables.

A further, supplementary guide provides guidance on means of escape for disabled people.

Each sector-specific guide begins with an almost identical section on the subject of 'fire safety risk assessment', with the remainder of the guide giving technical advice on the appropriate fire precautions for the type of premises in question. The guidance given is not intended as a rigid set of rules; it is the intention that it simply forms a 'benchmark' for flexible application of the principles set out. The guides are available for purchase from HMSO, but can be freely downloaded from the Internet.

Existing buildings in Scotland: The Fire (Scotland) Act 2005 and the Fire Safety (Scotland) Regulations 2006

Background

The current Scottish fire safety legislation came into force on 1 October 2006, the same time as the introduction of the Regulatory Reform (Fire Safety) Order in England and Wales. However, the Scottish legislation comprises both primary legislation, in the form of Part 3 of the Fire (Scotland) Act 2005, and secondary legislation, in the form of the Fire Safety (Scotland) Regulations 2006. Neither of these can be considered in isolation. (Since its introduction, the Fire (Scotland) Act has been subject to various amendments, including amendments to Part 3 of the Act. These were implemented by the Fire (Scotland) Act 2005 (Consequential Provisions and Modifications) Order 2005 and the Fire (Scotland) Act 2005 (Relevant Premises) Regulations 2005.)

The effect of the Scottish legislation, when it came into effect, was much the same as that of the Fire Safety Order in England and Wales, in that it replaced virtually all existing legislation under which fire safety was previously controlled in Scotland. This was achieved by means of the Fire (Scotland) Act 2005 (Consequential Modifications and Savings) Order 2006 and the Fire (Scotland) Act 2005 (Consequential Modifications and Savings) (No. 2) Order 2006. As in England and Wales, the principal legislation that was repealed or revoked was the Fire Precautions Act 1971, the Fire Precautions (Workplace) Regulations 1997 and the general fire safety provisions of the Management of Health and Safety at Work Regulations 1999. However, numerous other primary and secondary legislative instruments were also modified.

Thus, the relevant legislative regime in Scotland takes the same form as that in England and Wales; the thrust of the two legislative regimes is identical, and much of the information and commentary applicable to the Fire Safety Order in England and Wales applies to the Scottish legislation. However, within the detail of the two legislative regimes, significant differences can be found. Thus, the regimes in Scotland (and Northern Ireland) have appropriately been described by Professor A.R. Everton, Emeritus Professor of Fire Law at the University of Central Lancashire, as 'cousins' of the regime in England and Wales, rather than 'sisters'. As in England and Wales, the Scottish legislation was designed to ensure continuing compliance with the relevant European Directives on workplace health and safety. Many of the detailed requirements of the Directives are contained within the Fire Safety (Scotland) Regulations.

Scope of the Scottish fire safety legislation

The scope of the Scottish legislation is almost equivalent to that of the Fire Safety Order in England and Wales; it is certainly very broad. The legislation applies to '*relevant premises*', a term not used in the Fire Safety Order. The term '*premises*' has a similar definition to that in the Fire Safety Order, and in particular includes '*any place*'.

Relevant premises are then premises, other than specified exceptions, which are those to which, equally, the Fire Safety Order does not apply. These are specified in Section 78 of the Fire (Scotland) Act and comprise:

a) domestic premises;
b) mines and offshore installations;
c) ships in respect of normal shipboard activities of a ship's crew that are carried out solely by the crew under the direction of the master;
d) borehole sites to which the Borehole Sites and Operations Regulations 1995 apply;
e) agricultural or forestry land not in buildings and situated away from the undertaking's buildings.

With regard to domestic premises, these are defined as 'premises occupied as a private dwelling (including a stair, passage, garden, yard, outhouse or other appurtenance of such premises which is used in common by the occupants of more than one such dwelling)'. Various premises are specifically excluded from the definition of domestic premises by Section 78(5) of the Fire (Scotland) Act. These comprise houses in multiple occupation for which a licence under the Civic Government (Scotland) Act 1982 is required, plus various premises that would come within this category, but for there being a management control order under Section 74 of the Antisocial Behaviour, etc (Scotland) Act 2004. Section 78(5) also excludes, from the definition of domestic premises, care homes, school care accommodation, independent health care premises and secure accommodation, all as defined in the relevant section of the Regulation of Care (Scotland) Act 2001.

Two contrasts with the Fire Safety Order in England and Wales emanate from the above considerations. Firstly, the common parts of blocks of flats are excluded from the Scottish legislation, unless, of course, they are a workplace by virtue of the presence of a porter or concierge, for whom these may be a place of work. Secondly, the legislation applies to the whole of a licensed house in multiple occupation, rather than just the common parts. Otherwise, the perplexities created by the absence of a definition of private dwelling apply as much in Scotland as in England and Wales.

As in the case of the Fire Safety Order, the Scottish legislation generally applies to Crown buildings. However, some compliance, enforcement and offence provisions do not apply to the Defence estate, where the enforcing authority is the Defence Fire and Rescue Service. In England and Wales, a number of these restrictions in application apply to all Crown premises, rather than just the Defence estate, although the Fire (Scotland) Act does not provide enforcing authorities with right of entry to premises occupied by the Crown.

As in England and Wales, the legislation prevents the Crown from being criminally liable for a breach of the legislation. However, under the Scottish legislation, an enforcing authority can apply to the Court of Session to declare non-compliance by the Crown unlawful; there is no equivalent process under the Fire Safety Order in England and Wales.

Dutyholders and competent persons under Scottish legislation

Under the Scottish fire safety legislation, the 'responsible person', to whom the Fire Safety Order primarily applies, does not exist. The fire safety duties within Part 3 of the Fire (Scotland) Act are set out in Chapter 1 of Part 3. In terms of dutyholders, the situation is, in the opinion of the author, much clearer and more straightforward than in England and Wales (partly as a result of the absence of the term 'responsible person', which tends to cause confusion).

Section 53 of the Fire (Scotland) Act imposes requirements on employers in respect of the safety of their employees from fire, so explicitly satisfying the relevant European Directives. As in England and Wales, the requirement to ensure the safety of employees must be implemented '*as far as is reasonably practicable*'. Section 54 imposes requirements on any person who has control to any extent of relevant premises in respect of the safety of relevant persons from fire, but the duty relates only to the extent of their control.

The term '*Relevant Persons*' is defined as in the Fire Safety Order but, where both Sections 53 and 54 apply to an employer, the employees of the employer are not considered to be relevant persons for the purpose of Section 54. There is no need for them to be considered under Section 54, as their safety is already secured by Section 53. In most workplaces in single occupation, the person having control will, in fact, be the employer to whom Section 53 refers. However, the duty of the employer in respect of the safety of employees is somewhat absolute and unconditional, albeit that the duty is imposed so far as is reasonably practicable. In contrast, the duty imposed on persons having control of premises is imposed only to the extent of the control.

Where the person in control is not the owner of the premises, and is not carrying on an undertaking, fire safety duties are also imposed on the owner in addition to (but not instead of) the person having control of the premises. In addition, as in England and Wales, where, under a contract or tenancy agreement, a person has an obligation of any extent in relation to maintenance or repair of relevant premises, or anything in relevant premises, or in relation to safety from fire in the relevant premises, the duties imposed by Section 54 are also imposed on that person.

As in the case of the Fire Safety Order, the Scottish legislation requires nomination of competent persons to assist in implementing the fire procedures and nomination of persons, where necessary, to use fire-fighting equipment. A similar requirement exists in both legislative regimes for there to be a competent person to assist the employer to implement relevant measures or duties. Under the Scottish legislation, the person(s) must be 'nominated' by the person with duties under Section 53 or 54 of the Fire (Scotland) Act. The person must assist in undertaking the measures necessary to comply with the Chapter 1 duties. (Under the Fire Safety Order the person(s) must be 'appointed' to assist the responsible person in undertaking the preventive and protective measures. It is, perhaps, a moot point as to whether nomination and appointment are identical in weight.)

Relevant persons under Scottish legislation

The *relevant persons*, who are to be protected from fire under the Scottish legislation, are almost identical to the relevant persons to whom the Fire Safety

Order in England and Wales makes reference. Thus, they are any person, lawfully in the premises, plus any person who is, or may be, in the immediate vicinity of the premises and whose safety would be at risk in the event of fire in the premises. As in England and Wales, relevant persons do not include fire-fighters carrying out operational tasks.

Fire safety measures

The Fire Safety Order in England and Wales makes reference to 'preventive and protective' measures, a term lifted directly from the relevant European Directives. As noted earlier in this chapter, these measures comprise the general fire precautions identified by the fire risk assessment as necessary for compliance with the Order. It is 'general fire precautions', a term defined in the Fire Safety Order, that are to be taken to ensure the safety of employees and relevant persons who are not employees.

The terminology in the Scottish legislation is somewhat more straightforward. Firstly, the term 'preventive and protective' measures does not arise. Instead, the legislation makes reference to '*the Chapter 1 duties*' (i.e. the duties imposed by Chapter 1 of Part 3 of the Fire (Scotland) Act). The fundamental duty in Chapter 1, for principal dutyholders, is that contained in Sections 53 and 54 of the Fire (Scotland) Act, namely to take appropriate '*fire safety measures*'. Happily, for those operating premises across the whole of Great Britain, the definition of fire safety measures (other than in respect of editorial differences and inclusion of measures required under any regulations made by the Scottish Ministers) is identical to the definition of *general fire precautions*. Moreover, the '*principles of prevention*' described earlier in this chapter, which under the Fire Safety Order in England and Wales must form the basis for implementation of the preventive and protective measures, are identical (again, other than in respect of minor editorial differences) to the '*considerations*' that, under Section 55 of the Fire (Scotland) Act, must form the basis for the fire safety measures required by Sections 53 and 54 of that Act.

In order to determine the requisite fire safety measures, as in England and Wales, a risk assessment must be carried out by the relevant dutyholder (e.g. the employer); this requirement is contained in Section 53 of the Fire (Scotland) Act (in relation to identifying risks to employees from fire), and in Section 54 of the Act (in relation to identifying the risks to relevant persons from fire). The equivalent requirements of the Fire Safety Order in England and Wales, in respect of recording the significant findings of the fire risk assessment, and recording relevant persons especially at risk from fire, are incorporated within Regulations 8 and 9 of the Fire Safety (Scotland) Regulations. Similarly, the equivalent requirements of the Fire Safety Order in respect of the consideration of young persons and dangerous substances required in a fire risk assessment can be found in Regulations 5 and 6 of the Fire Safety (Scotland) Regulations respectively.

Specific fire safety measures required by the Fire Safety (Scotland) Regulations

Part III of the Fire Safety (Scotland) Regulations sets out specific requirements in respect of fire safety measures that are to be taken. Broadly, these are equivalent to the requirements in England and Wales under the Fire Safety Order, the common duty arising from the common source of much of the wording, namely the relevant European Directives.

Requirements in respect of means of escape, fire escape signage and emergency escape lighting are set out in Regulation 13, which is almost identical to Article 14 of the Fire Safety Order (see p. 22). Similarly, the requirements of Article 13 of the Fire Safety Order regarding fire-fighting and fire warning can be found in Regulation 12 of the Fire Safety (Scotland) Regulations. The Regulations also set out, in more or less identical wording, the managerial requirements of the Fire Safety Order in respect of matters such as fire procedures, fire drills, employee training, provision of information to employees and to third parties, cooperation and coordination between parties in premises in multiple occupation, maintenance of fire precautions and recording of fire safety arrangements.

The requirements of the Fire Safety Order in respect of fire-fighters' switches for luminous tube signs are not contained in the Scottish legislation. Instead, requirements for these, in respect of new signs, are imposed under the Building (Scotland) Regulations. However, equivalent requirements for maintenance of facilities, equipment and devices required for the safety of fire-fighters (including fire-fighters' switches) are contained in both the Fire Safety Order and the Fire Safety (Scotland) Regulations. In the latter Regulations, this duty extends to such measures within the common parts of blocks of flats (as it does under the Fire Safety Order), even though such common parts are, otherwise, outside the scope of the Scottish legislation. Equivalent requirements in respect of dangerous substances are also contained within both legislative regimes.

Duties of employees under Scottish legislation

As in the Fire Safety Order, duties are imposed on employees by the Scottish legislation in respect of fire safety. The duties in the Scottish Regulations are, however, dispersed, in that the equivalent wording of Article 23 of the Fire Safety Order comprises a combination of Section 56 of the Fire (Scotland) Act and Regulation 22 of the Fire Safety (Scotland) Regulations.

Enforcement of the Scottish legislation

Enforcement of the Scottish legislation takes a similar form to that applicable to the Fire Safety Order in England and Wales. Generally, the enforcement is carried out by officers of the fire and rescue service. However, the Health and Safety Executive (HSE) enforce the legislation in the same types of premises as they enforce the Fire Safety Order in England and Wales. Similarly, the Defence Fire and Rescue Service enforce both the Scottish legislation and the Fire Safety Order in the same circumstances (see p. 26), and the local authority is the enforcing authority for the same sports grounds, etc. in Scotland, as in England and Wales, and also for sports grounds that contain a regulated stand. In the case of non-defence Crown buildings, the responsibility for enforcement rests with the HM Chief Inspector of Fire and Rescue Authorities.

As in England and Wales, the enforcing authorities in Scotland are empowered to issue alterations notices, enforcement notices and prohibition notices. However, some compliance, enforcement and offence provisions are disapplied in respect of Defence premises, where the Defence Fire and Rescue Service are the enforcing authority.

Offences and defences under the Scottish legislation

The nature of the offences that can arise under the Scottish legislation is consistent with that under the Fire Safety Order in England and Wales. Thus, for example, it is an offence for a dutyholder to fail to carry out a duty imposed by the legislation if the failure puts a relevant person at risk of death or serious injury in the event of fire.

Defences, and limitations in respect of defences, for those against whom proceedings are issued, are much the same as exist within the Fire Safety Order. Thus, it is a defence if it can be proved that the dutyholder took all reasonable precautions and exercized all due diligence to avoid the commission of the offence. The burden of proof rests with the accused. However, this defence is not available to employers who have put employees at risk of serious injury or death in the event of fire, by failing to implement fire safety measures that would ensure, so far as is reasonably practicable, the safety of the employees, or by failing to eliminate or reduce the risks from dangerous substances.

In Scotland, the enforcing authority cannot institute a prosecution. Instead, proceedings are instituted by the Procurator Fiscal.

Appeals under Scottish legislation

In Scotland, as in England and Wales, an appeal to the Court may be lodged by any person on whom an alterations notice, enforcement notice or prohibition notice is served. In Scotland, the appeal is made to the Sheriff Court. The sheriff is empowered to take the same actions as the magistrates in England and Wales. Any appeal against the decision of the sheriff would be heard by either the sheriff principal or the Court of Session.

Determination of disputes in Scotland

As in England and Wales, there is, in Scotland, a route by which a dispute between a dutyholder and the enforcing authority can be determined, without the need to use an appeal to the Court. The intent is that the determination route would be followed prior to any formal enforcement action. The wording of the relevant section of the Fire (Scotland) Act is subtly different, however, from that in the Fire Safety Order. Under the Fire Safety Order, the relevant article applies only where the responsible person (or any other person) has failed to comply with any provision of the Order. The determination then relates only to disputes regarding the measures necessary for compliance.

In Scotland, Section 67 of the Fire (Scotland) Act permits the determination route to be followed where an enforcing authority considers that a person has failed to comply with any of the Chapter 1 duties, but the person and the enforcing authority cannot agree on the action that is required to be taken to comply with that duty. This would appear to enable the non-judicial determination route to be followed when the dutyholder disagrees that there is a non-compliance with the legislation.

In Scotland, the dispute is referred to the HM Chief Inspector of Fire and Rescue Authorities for determination, unless the latter is the relevant enforcing authority, in which case the dispute is referred to the Scottish Ministers for determination. The determination route can, in either case, only be used if both parties (the dutyholder and the enforcing authority) agree to use this process.

Guidance on the Scottish legislation

Although, unlike the situation in England and Wales, there is no statutory obligation for guidance to be produced on the legislation, the Scottish Executive produce a series of guides providing practical fire safety guidance in respect of different types of premises, namely:

- care homes;
- offices, shops and similar premises;
- sleeping accommodation;
- factories and storage premises;
- places of entertainment and assembly;
- hospitals;
- educational establishments;
- open air events;
- transport premises and facilities.

A further, supplementary guide also provides guidance on evacuation of disabled people from buildings.

Each sector-specific guide begins with an overview of the legislation, followed by an almost identical section on ‘fire safety risk assessment’, while the remainder of each guide deals with management of fire safety and the fire safety measures required by the legislation. A number of annexes in each guide set benchmark standards, based on the Technical Handbooks that support the Building (Scotland) Regulations, against which the fire safety measures in any premises can be compared.

Existing buildings in Northern Ireland: The Fire And Rescue Services (Northern Ireland) Order 2006 and the Fire Safety (Northern Ireland) Regulations

The system in Northern Ireland will, ultimately, mirror very closely the system in Scotland; the new legislative regime is intended to comprise both primary legislation, in the form of the Fire and Rescue Services (Northern Ireland) Order 2006, and secondary legislation, in the form of the Fire Safety (Northern Ireland) Regulations, which, at the time of writing, are in draft form and likely to come into force during 2008. Until that time, Part III of the Fire and Rescue Services (Northern Ireland) Order, which deals with fire safety, will not come into effect.

At the time of writing, it is uncertain whether the legislative regime in Northern Ireland will address dangerous substances in the same manner as the remainder of the United Kingdom. It is also uncertain whether separate guidance on the legislation, distinct from the guidance under the other UK legislative regimes, will be produced; it is possible that Northern Ireland might adopt guidance documents from the mainland, possibly with changes only to the references to the legislation itself.

Until the new legislation comes into force, the Fire Services (Northern Ireland) Order requires fire certificates for many common places of work and certain gaming and leisure premises. In addition, the Fire Precautions (Workplace) Regulations (Northern Ireland) 2001 remain in force. Under the Management of Health and Safety at Work Regulations (Northern Ireland) 2000, a risk assessment is required, to ensure employers comply with relevant health and safety legislation, and with the Fire Precautions (Workplace) Regulations (Northern Ireland).

Housing legislation

Housing legislation remains an area with which there is overlap with mainstream fire safety legislation. The reason for this is that fire safety legislation does not treat the majority of houses in multiple occupation ('HMOs') as domestic premises for the purpose of the exclusion that would otherwise apply under the legislation. Thus, in England and Wales, the Housing Act 2004 contains requirements for mandatory licensing of larger high-risk houses in multiple occupation and discretionary licensing of other houses in multiple occupation. Assessment of the conditions of residential premises within the scope of the Act, which is very broad and extends well beyond houses in multiple occupation, is carried out by means of the Housing, Health and Safety Rating System ('HHSRS').

The purpose of the HHSRS is to provide a means of assessing dwellings that reflects the risk from any hazard and allows a judgement to be made as to whether that risk, in the particular circumstances, is acceptable or not. A total of 29 hazards, which are arranged in four main groups, must be considered in carrying out the HHSRS. One of the four categories is protection against accidents, and it is within this category that the hazard of fire is addressed. The assessment contains a scoring system, by which the overall risk is assessed by the housing authority, who enforce this legislation.

Unfortunately, there is no recognized national guidance on the standards of fire safety that need to be adopted in assessing an HMO under the HHSRS. A number of local authorities, often working in partnership with neighbouring local authorities, do produce local guidance. For example, Decent and Safe Homes (DASH) East Midlands, a project funded by the Government Office of the East Midlands, produce a *Fire Safety Guide for Houses in Multiple Occupation (and Other Dwellings)*.*

Since the Regulatory Reform (Fire Safety) Order 2005 includes, within its scope, common parts of premises used by the occupants of more than one dwelling, the common parts of most houses in multiple occupation fall within the scope of the Fire Safety Order. However, the definition of a house in multiple occupation within the Housing Act 2004 is very broad and includes, for example, student shared houses. It is a moot point as to whether a student shared house has 'common parts' that would bring the property, or part of it, within the scope of Fire Safety Order. The general consensus appears to be that, generally, such properties are likely to be outside the scope of the Fire Safety Order.

In Scotland, as noted earlier, houses that require a licence under the Civic Government (Scotland) Act 1982 are included within the scope of fire safety legislation, as are other premises that would be subject to such licensing, other than for the fact that they are subject to a management control order under the Antisocial Behaviour, etc. (Scotland) Act 2004.

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* Available at http://www.eastmidlandsdash.org.uk/firesafety.asp.

In view of the circumstances outlined above, there is a need for liaison between housing authorities and fire and rescue authorities in relation to enforcement of legislation in respect of fire precautions in houses in multiple occupation.

Other legislation

The mainstream legislative regimes under which fire safety is controlled in existing buildings, when introduced, had the effect of repealing other fire safety legislation and amending most other legislation under which fire safety requirements could be imposed, to repeal the latter requirements. The only notable exception to this relates to the continuation of the Fire Precautions (Sub-surface Railway Stations) Regulations 1989. At the time of writing, these regulations are still in force, but it is likely that, in due course, they too will be revoked.

Under the Regulatory Reform (Fire Safety) Order (and equivalent legislation elsewhere in the UK), the Health and Safety at Work, etc. Act 1974, and regulations made under that Act, do not apply to premises to which the Fire Safety Order applies, insofar as the Act or the Regulations relate to matters, such as means of escape from fire, fire alarm systems, fire extinguishing appliances, etc., in relation to which requirements could be imposed by the Fire Safety Order. This prevents any form of dual enforcement in relation to general fire precautions.

However, this disapplication does not apply to situations in which the enforcing authority for fire safety legislation is also the enforcing authority for the Health and Safety at Work, etc. Act, such as for some construction sites, nor does the disapplication apply in the case of sites to which the Control of Major Accident Hazards Regulations 1999 (COMAH) apply. Thus, the COMAH Regulations make requirements in respect of fire precautions, in addition to the requirements of the relevant fire safety legislation.

A further avoidance of overlap relates to legislation that requires licensing or registration, such as applies in the case of premises licensed for the sale of alcohol: cinemas, theatres, gaming establishments, care premises, etc. Licences and registration conditions may not contain requirements in respect of fire safety provisions that can be addressed by the relevant fire safety legislation.

Civil liability

Civil liability for loss or injury as a result of fire can arise in certain circumstances. The increasing awareness of the potential for litigation is likely to ensure that claims against occupiers or owners of property involved in fire will continue to arise. Liability to visitors to the premises, for example, is established by the Occupiers' Liability Acts. In a particularly important case, a fire-fighter successfully sued a householder for his injuries, incurred while fighting a fire. The fire started due to the negligence of the householder while undertaking work in the premises.

With regard to fire spreading to neighbouring property, the Fires Prevention (Metropolis) Act 1774 provides that 'No action suit or process whatsoever shall be had, maintained or prosecuted against any person in whose house, chamber, stable, barn, or other building, or on whose estate any fire shall accidentally begin.'

It has, however, been shown quite clearly that if a fire starts or spreads due to negligence or the presence of dangerous substances, rather than *by accident*, then liability arises.

The Regulatory Reform (Fire Safety) Order (and the equivalent legislation in Scotland and Northern Ireland) also confers rights of action in civil proceedings by an employee for damage to the employee caused by breach of a duty imposed on an employer by the Order. This right is not conferred on persons who are not employees; this is one of several respects in which the Fire Safety Order provides protection to employees over and above that granted to non-employees (see p. 19). This right overrides any limitations to the extent that would otherwise apply under the Fires Prevention (Metropolis) Act. (In the case of non-employees, there are still, of course, the rights conferred by common law and the Occupiers' Liability Acts.)

Further reading

GREAT BRITAIN. Communities and Local Government. The Building Regulations 2000 Approved Document B (Fire Safety) 2006 Edition: Volume 1, *Dwelling houses*, ISBN 978 1 85946 261 4. Volume 2, *Buildings other than dwelling houses*. ISBN 978 1 85946 262 1. Both volumes published by NBS (part of RIBA Enterprises Ltd). London: HMSO.

GREAT BRITAIN. The Building (Scotland) Regulations 2004. Scottish Building Standards Agency, Domestic Handbook. ISBN 0114973342. Non-Domestic Handbook. ISBN 0114973350. Both titles. ISBN 0114973369. London: HMSO.

GREAT BRITAIN. The Building Regulations (Northern Ireland) 2000. Department for Finance and Personnel. Technical Booklet E: 2005, *Fire safety*. London: HMSO.

GREAT BRITAIN. The Regulatory Reform (Fire Safety) Order 2005 SI 2005/1541Guides 1-11). CLG Publications, http://www.firesafetyguides.communities.gov.uk.

GREAT BRITAIN. The Fire (Scotland) Act 2005, The Fire (Scotland) Act 2005 (Consequential Provisions and Modifications) Order 2005 and the Fire (Scotland) Act 2005 (Relevant Premises) Regulations 2005. London: HMSO.

GREAT BRITAIN. Fire (Scotland) Act 2005 (Consequential Modifications and Savings) Order 2006 and the Fire (Scotland) Act 2005 (Consequential Modifications and Savings) (No. 2) Order 2006. London: HMSO, http://www.infoscotland.com/firelaw.

GREAT BRITAIN. The Fire Safety (Scotland) Regulations 2006 SI 2006/456. London: HMSO.

GREAT BRITAIN. The Fire and Rescue Services (Northern Ireland) Order 2006 SI 2006/1254(N.I. 9) Fire Safety (Northern Ireland) Regulations. London: HMSO.

In England and Wales, Communities and Local Government produce 12 guides on the Regulatory Reform (Fire Safety) Order, each dealing with different types of premises. In Scotland, the Scottish Executive produces similar guides on the equivalent Scottish legislation. The guides are available on the CLG website: http://www.firesafetyguides.communities.gov.uk. Both Departments produce guidance on means of escape for, and evacuation of, disabled people. The Scottish guides are only available on the worldwide web (http://www.infoscotland.com/firelaw).

2

The nature of fire

Components of fire: the fire triangle

In terms of basic chemistry, fire is an exothermic (heat releasing) chemical reaction between a fuel and oxygen. A very simple model of fire is often represented in the form of the 'fire triangle' (see Figure 2.1), which shows the three components that are required in order for fire to occur:

1. heat (in the form of an ignition source);
2. fuel (the combustible material ignited);
3. oxygen (which makes up 21 per cent of air).

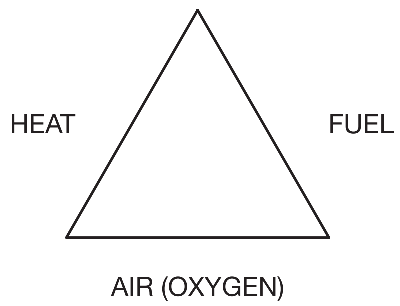


Figure 2.1 The fire triangle: removal of any component obviates the risk of fire

This model is actually something of an over simplification. It does not, for example, adequately explain the mechanism by which certain extinguishing agents extinguish flames or why flaming may cease when the oxygen level is still significant (8 per cent–12 per cent, depending on the temperature). However, it is a satisfactory explanation for the mechanism of most common agents; carbon dioxide, for example, extinguishes a fire by reducing the oxygen content (see p. 52).

The significance of this simple model, in terms of fire prevention, is that fire cannot occur if any one of the three components is removed. Of course, it is not normally possible to remove, or sufficiently reduce, the oxygen content of the atmosphere. However, by keeping doors and windows closed, it is possible for a fire to become starved of oxygen and self-extinguish as a result. This is particularly the case if the enclosure in which fire occurs is relatively small. (In special situations, it is also possible to create and maintain a permanent low oxygen concentration within a space to prevent the outbreak of fire.)

Complete removal of all fuel is equally impracticable although, as discussed in Chapter 6, measures such as removal of waste, security of flammable-liquids storage and the avoidance of unnecessary storage, all contribute to the prevention of fire. It is, therefore, necessary to avoid the introduction of the ever-present ignition sources to the ever-present fuel.

The combustion of solid materials

When solids and liquids are burning, what we see as flame is a gas-phase reaction between fuel *vapour* and oxygen. Part of the burning process involves the conversion of the 'fuel' into flammable vapour. For a liquid fuel, the flame is fed by simple evaporation from the surface of the liquid, but for solids the large molecules cannot 'evaporate' and have to undergo chemical degradation (pyrolysis), which produces smaller molecules that can evaporate from the surface.

For example, when a source of heat is applied to a piece of wood (see Figure 2.2), the chemical constituents of the wood (mainly cellulose) begin to break down, releasing vapours that comprise a complex mixture of flammable compounds. It is these vapours that then ignite and 'burn' to form a flame. The combustion of the vapours in the presence of oxygen releases heat, a significant proportion of which is transferred to the surface of the wood, so releasing more vapours to enter what is now a closed feedback loop (see Figure 2.3). The source of heat shown in Figure 2.3 is usually an external ignition source, but it should be noted in passing that some materials can self-heat resulting in 'spontaneous combustion'. A simple example is the case of discarded linseed oil-soaked rags left in a warm cupboard. An understanding of Figures 2.2 and 2.3 also leads to an explanation of the reason why solid materials burn more readily if they are subdivided into a finer form. A thin fuel (e.g. a sheet of paper) ignites more readily and burns more fiercely than a thick fuel (e.g. a book or thick plank of wood) because less heat is required to raise the temperature to the point at which fuel vapours are produced (i.e. 'the heat sink effect' is less).

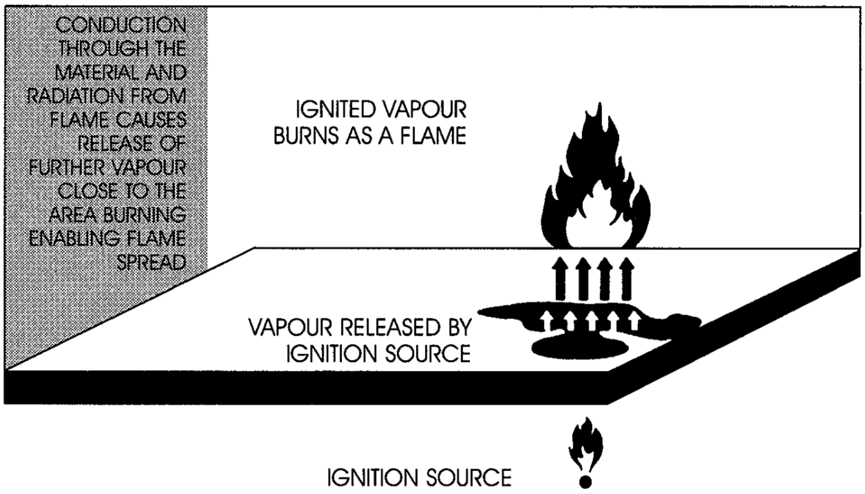


Figure 2.2 Combustion of a solid

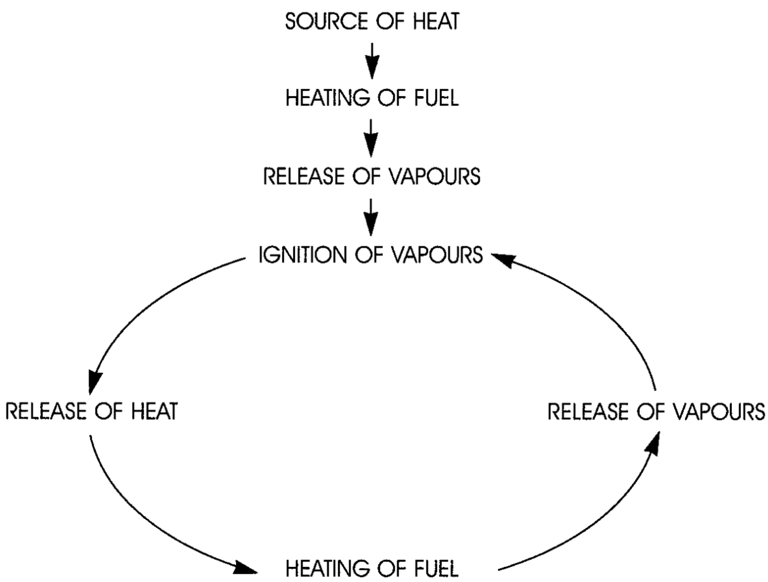


Figure 2.3 The feedback loop of fire

The combustion of flammable liquids

Some liquids, such as olive oil and cooking oil, behave in a similar manner to solids in that they require the application of a substantial amount of heat before they will ignite. Such liquids are called combustible. Their presence does not constitute a significantly greater hazard than the presence of combustible solids although they can be ignited very easily if absorbed on a wick (compare this with lighting a candle with a match). Other liquids, such as white spirit and paraffin, require much less heat in order to release sufficient vapour for ignition to occur. These liquids can be considered to be flammable and pose a greater hazard. Yet other liquids, such as petrol and ether, produce sufficient vapour, even below normal room temperature, to enable ignition of the vapour/air mixture by a small ignition source, such as a spark. Clearly, these liquids are particularly hazardous and require special precautions to ensure that the vapour is not permitted to come into contact with a source of ignition.

A useful measure of the hazard of any flammable liquid is its 'flashpoint'. This is the minimum temperature at which, in a specific test, the liquid gives off sufficient vapour to ignite on application of the ignition source specified in the test. Obviously, the higher the flashpoint of a liquid, the less hazardous it is. The flashpoint of many vegetable oils, for example, exceeds 200 ºC. At the other extreme, the flashpoint of petrol is typically –43 ºC.

The flashpoint of a flammable liquid, such as a solvent, will generally be marked on the container. Generally (under, for example, the Chemicals (Hazard Information and Packaging for Supply) Regulations), a liquid is considered to be flammable if its flashpoint is less than 55 ºC. Liquids with flashpoints below 21 ºC are defined as highly flammable. Liquids with flashpoints of less than 0 ºC and a boiling point of less than 35 ºC are known as extremely flammable. Special requirements apply to the method of storage and the ventilation of the workplace if flammable liquids are used, and quantities used in the workplace need to be limited.

Other, more subsidiary, measures of the hazard posed by a flammable liquid include the flammability limits of the vapour and the auto-ignition temperature. The flammability limits are the proportions (expressed as a percentage) in which the flammable vapour must be present in air for an explosion to occur on ignition of the vapour. Outside these limits, the vapour/air mixture is either too weak or too rich to ignite. For methane gas (the main constituent of natural gas), mixtures between 5 per cent and 15 per cent in air are flammable, but outside this range the mixture will not burn if an ignition source is introduced. (Note that in the headspace of a tank of petrol the concentration of fuel vapour is too rich to burn.) Clearly, wide flammability limits constitute a greater hazard than very narrow limits. Knowledge of the limits can be useful in determining the necessary amount of ventilation and the maximum acceptable concentration of vapour.

Auto-ignition temperature is quoted in the literature, but is of less significance. It is the temperature at which the liquid will ignite without the presence of an actual ignition source (such as occurs when a pan of cooking oil is left unattended on a source of heat) under strictly controlled test conditions. Normally, auto-ignition temperatures of flammable and highly flammable liquids are quite high (e.g. 200 ºC–600 ºC), but these refer to the onset of flaming. Some liquids, notably linseed oil and fish oils, at room temperature may undergo spontaneous heating leading to combustion when absorbed onto rags, etc., despite the fact that their flashpoints and auto-ignition temperatures may be high.

The combustion of flammable gases

In practice, there is little distinction between the combustion of flammable vapours arising from substances that are liquids at normal temperature and pressure, and the combustion of flammable substances that are gaseous at normal temperature and pressure. In the case of gases, of course, the question of flashpoint does not arise, and an indication of the hazard may be given by the flammability limits. As in the case of flammable liquids, auto-ignition temperature is of less significance and, again, tends to range between 200 ºC and 600 ºC for most common flammable gases.

In most commercial, and many industrial, premises, the presence of flammable gases, other than those used as a fuel for heating and cooking, will be uncommon. A possible exception arises during contractors' operations, when some activities such as cutting and welding may involve the use of acetylene or liquefied petroleum gas (LPG). The latter may also be used for temporary heating or as a fuel for tar boilers, etc. The main hazard associated with acetylene is the very wide flammability (or explosive) limits and the potentially unstable nature of the gas. The flammability limits of LPG are much narrower, but a particular hazard is its density, which is greater than that of air. The gas can, therefore, collect in low-lying areas, such as basements, pits and drains. Leakage from cylinders can then lie at low level until an ignition source causes it to ignite. Flame will then flash back to the cylinder, where the escaping gas will continue to burn.

The mechanism of extinguishment

In order to extinguish a fire, it is necessary to break the feedback loop shown in Figures 2.2 and 2.3. Thus, water (the most common extinguishing agent) extinguishes a fire primarily by cooling the fuel, so that it no longer releases sufficient vapour to enable combustion to be sustained. Foam applied to the surface of a burning liquid acts as a physical barrier, which prevents the release of vapour into the combustion zone above the surface of the liquid. More importantly, the barrier also reduces the effect of radiation from the flame onto the fuel surface. In addition, drainage of water from the foam can assist in cooling the surface of the hot liquid.

The action of carbon dioxide and other inert gases is straightforward. Inert gases reduce the oxygen concentration sufficiently to stop the combustion process. Thus, they directly remove one of the three components of the fire triangle, but require concentrations above 25 per cent to 30 per cent.

Before manufacture of halons ceased (see Chapter 14), this class of fire-extinguishing agents was particularly useful. The agents could extinguish fires at low concentrations (typically a few per cent concentration) because they extinguished fire by chemical means, interfering with the complex chemical reactions that occur in a flame. The mechanism by which the halocarbons that have replaced halons (see Chapter 14) extinguish fire is more complex. The extinguishing action is probably largely a physical effect (similar to the mechanism of carbon dioxide), with some minor action on the chemical reactions that occur in the flame.

The means by which dry powders extinguish fires is also very complex. However, it is probable that chemical inhibition is the major factor. Whatever the exact mechanism, the effect of dry powder, like that of the halocarbons, is rapid knockdown of flame.

Classification of fires

In order to consider the suitability of different extinguishing agents for different types of fire (see Chapter 13), fires are grouped into classes, according to the nature of the fuel. In the United Kingdom, the classification system used is defined in British Standard BS EN 2, which is, in fact, a European Standard. The classification system is as follows:

- *Class A fires* are those involving 'normal' (usually carbonaceous) solid materials, such as wood, textiles and paper, which form glowing embers when they burn.
- *Class B fires* are those involving liquids or liquefiable solids.
- *Class C fires* involve gases.
- *Class D fires* involve metals.
- *Class F fires* involving cooking media (vegetable or animal oils and fats) in cooking appliances.

Class C and D fires are not of major practical significance in most premises. In the case of Class C fires, the use of a fire extinguisher may be very undesirable since these fires often arise from a continuous leak of gas from, for example, a cylinder. Extinguishment of the flame may result in an explosion if no action is taken to prevent the leak from continuing. The correct action is to stop the flow of gas. Class D fires require special extinguishing agents.

The separate classification of cooking media in cooking appliances became necessary as a result of evidence that all extinguishing agents suitable for Class B fires are not necessarily effective on fires involving cooking oil. A specific British Standard (BS 7937) provides a specification for portable fire extinguishers for use on Class F fires.

In the UK, reference can sometimes be found to Class E fires, which are those involving electrical equipment. In practice, this classification is, however, not used, as the electrical equipment itself is not usually the major fuel, but merely the ignition source. If the power to the equipment is disconnected, the fire might self-extinguish, unless it has already involved other fuels. Such fuels will normally then constitute a Class A fire, on which an extinguisher suitable for use on such fires can be used. However, in the case of live electrical equipment, care must be taken not to use an extinguishing medium, such as water expelled from an extinguisher as a jet, which will conduct electricity and result in potential for electric shock.

The development and spread of fire

Once ignition of a fire in an enclosure has occurred, the subsequent development may be rapid. Mathematically, the development is often described as exponential; in simple terms, fire tends to double in size at regular intervals of perhaps only a matter of a few minutes. This rapidity of growth is beyond the common experience of most building occupants, as it contrasts sharply with the more commonly experienced, sedate behaviour of a fire in the open (e.g. a garden bonfire). This inability to anticipate the rate of development of a fire in a building has proved to be a major factor in certain multiple-fatality fires involving members of the public who failed to appreciate the need for immediate evacuation and died as a result. Examples include the fires at Woolworths, Manchester in 1979, the Stardust discotheque, Dublin in 1981 and the Bradford football stadium in 1985.

Fire develops by the transfer of heat from the burning zone by conduction, convection and radiation. Conduction can occur through a poorly insulating element of construction, such as a metal fire shutter. The most important means of fire spread within a building are, however, convection and radiation.

After the first item in the enclosure is ignited, hot gases rise vertically as a buoyant plume, into which air is entrained, so that the volume of smoke and gases increases with height. When the smoke reaches the ceiling, it spreads out in all directions and, ultimately, begins to form a rapidly deepening layer below the ceiling (see Figure 2.4). Thus, particularly in the case of a restricted space, such as a corridor, loss of visibility may be one of the earliest threats created by the fire. People are reluctant to use escape routes unless there is clear visibility for a number of metres ahead.

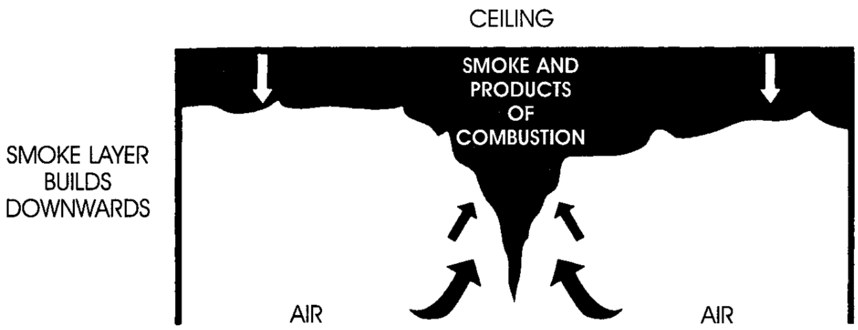


Figure 2.4 Build-up of smoke layer

As the plume containing smoke and hot gases rises, it cools. In a high space, such as an atrium space in a building, or in high buildings, such as tall warehouses or cathedrals, the plume may reach ambient temperature before it reaches the ceiling or roof. At that point, the smoke levels out, almost as though it had become trapped under an invisible ceiling. This phenomenon, known as 'stratification', can result in delay of operation of fire detectors and sprinkler heads, which are normally installed under the ceiling. Ultimately, as the fire grows, the heat output increases and the smoke and hot gases do reach the ceiling or roof. However, the fire will be larger at the point of operation of the fire detectors or sprinkler heads than if stratification had not occurred.

As the fire grows, the flames reach the ceiling and are deflected horizontally, radiating downwards over a large area of the enclosure (see Figure 2.5). When this thermal radiation becomes strong enough, flame will spread rapidly over combustible surfaces, and items over a relatively large area will reach a temperature at which they spontaneously burst into flames. In the case of a restricted enclosure, such as a cellular office with a low ceiling, this stage, known as 'flashover', may be reached quite quickly. After flashover, virtually all items in the room are alight, and survival of occupants within the room is impossible. The onset of flashover usually occurs when the temperature of the layer at the ceiling reaches 550 °C–600 °C.

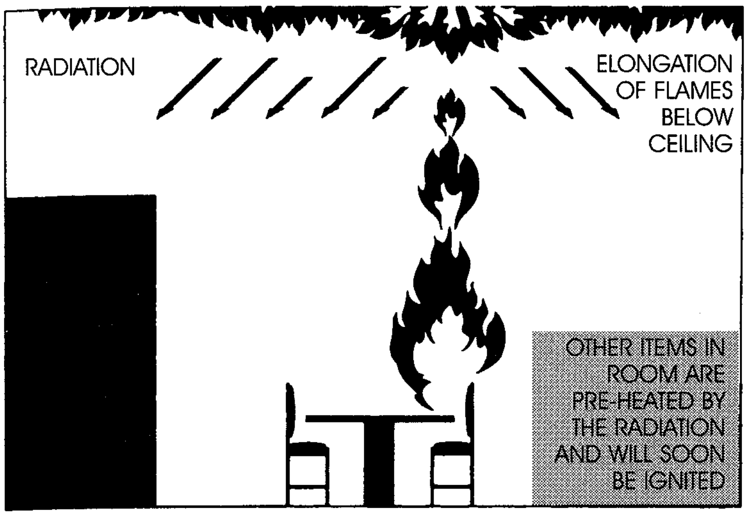
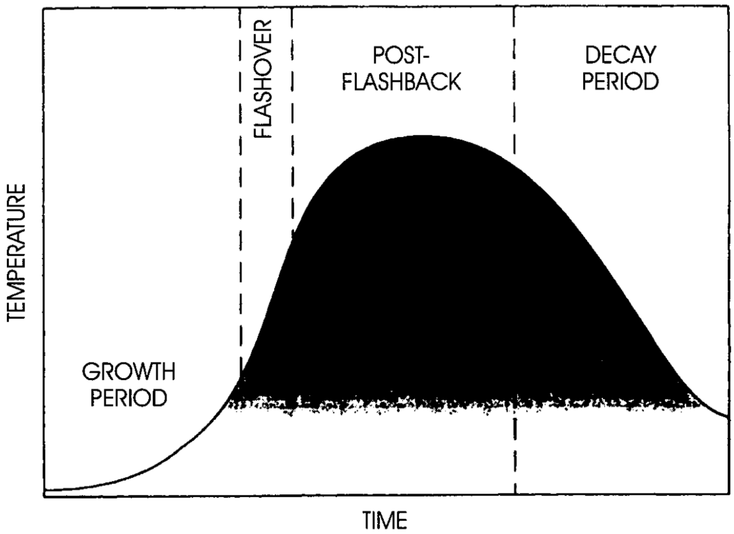


Figure 2.5 Onset of flashover

The progress of a fire in a building can be divided into three distinct phases (see Figure 2.6):

1. a growth period, during which the average temperature in the room of origin rises relatively slowly;
2. a post-flashover period, during which the temperature is very high (owing to the involvement of most combustible items in the enclosure);
3. a decay period that arises from the total consumption of most of the combustible materials, and continues until there remains no fuel for combustion.



Source: *After Introduction to Fire Dynamics*, D.D. Drysdale. © John Wiley & Sons Limited. Reproduced with permission.

Figure 2.6 Simple model of a fire in an enclosure

Escape from the compartment involved must be made well before flashover. There must, therefore, be adequate measures to ensure that rapid escape from a building is possible (see Chapter 7). During the post-flashover phase, the structure of the compartment is put under stress and structural fire precautions assume a greater significance (see Chapter 8). Before the building structure is seriously threatened, however, fire and smoke spread is often assisted by open doors, poorly stopped service penetrations and structural features, such as service shafts and risers, which, unless very effectively fire stopped, will allow the spread of smoke, and perhaps fire, from one floor to another by convection. Ventilation and air conditioning systems can also provide routes for spread of smoke, combustion products and fire.

Fire resistance

The most fundamental means of protecting escape routes and preventing fire spread comprises *fire-resisting construction*. The meaning of this term is rather self-evident, although the exact definition of the term 'fire resisting' is not always well understood by non-specialists. Fire resistance is defined in BS 4422 as the 'ability of an item to fulfil for a stated period of time the required fire stability and/or integrity and/or thermal insulation and/or other expected duty specified in a standard fire resistance test'.

Three points emerge from this definition.

1. fire resistance can only be defined in terms of a standard test;
2. the units of fire resistance are units of time;
3. fire resistance may relate to any one or all of at least three performance parameters.

In the United Kingdom, the standard test for fire resistance has traditionally been that described in BS 476-20. There is now, however, a harmonized European Standard, BS EN 1363-1, which will ultimately replace BS 476-20. In a fire resistance test, constructions such as walls, floors, ceilings, doorsets and glazing systems are subjected to the heat from a furnace in accordance with a time/temperature curve that is contained in BS 476-20 (see Figure 2.7). The curve is intended to simulate crudely the temperature/time profile experienced in a post-flashover fire.

Detailed test requirements for loadbearing elements of construction, including the criteria for pass or failure of the test specified in BS 476-20, are set out in BS 476-21. In the case of non-loadbearing elements of construction, the requirements are described in BS 476-22. These parts of BS 476 will gradually be replaced with a suite of European Standards. Loadbearing elements of construction may be tested for the three performance parameters defined in BS 4422, namely:

1. loadbearing capacity, i.e. the ability of the element to support its test load without excessive deformation;
2. integrity, i.e. the ability of the element to contain a fire without collapse or the development of holes or cracks through which flame could easily pass, and without sustained flaming on the side unexposed to the furnace;
3. insulation, i.e. the ability of the element to resist the passage of heat from the exposed to the unexposed face.

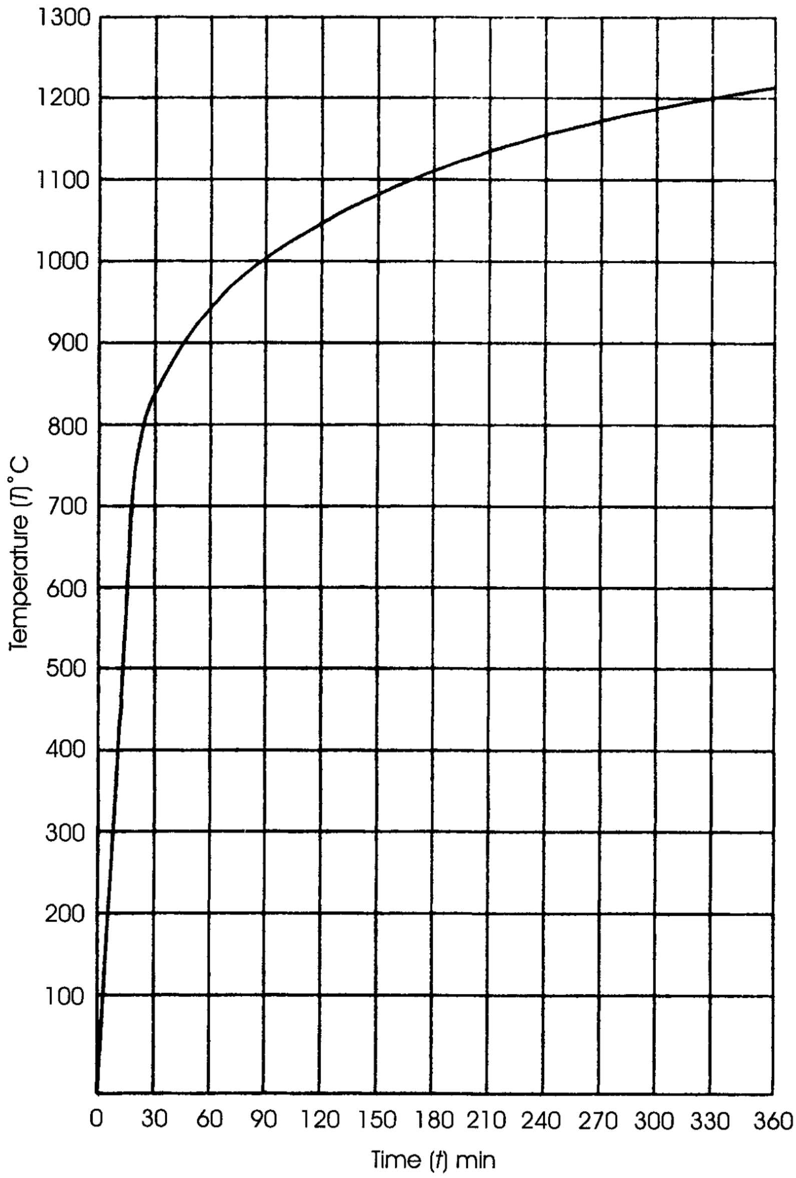


Figure 2.7 Time/temperature curve of BS 476-20

Non-loadbearing elements of construction are, of course, only tested for integrity and insulation.

The results of these tests only indicate the performance of the construction in units of time, based on a standard time/temperature curve. Other standards and regulations then indicate the performance required for elements of construction, such as doorsets, etc., according to the application. In practice, with the exception of cross-corridor smoke stop doors, the minimum period of fire resistance normally specified is 30 minutes; this is regarded as a norm for protection of escape routes. However, longer periods of fire resistance may be specified for various elements of construction, either in building regulations or by fire insurers. Requirements for means of escape and for structural fire protection are discussed in Chapters 7 and 8 respectively.

Further reading

Fire and hazardous substances. The Fire Protection Association Library of Fire Safety Volume 2. 1994. Fire Protection Association.

Wharry, D. M. and Hirst, R. *Fire Technology, Chemistry and Combustion*. (Third edition.) (Reprinted 1992.) The Institution of Fire Engineers.

3

The causes of fire

Many fires are the result of human failings, such as carelessness, malicious intent or simple incompetence in management. Even in the case of a fire started by faulty electrical wiring, greater attention to maintenance and safety might have prevented the incident. This rather philosophical approach does little, however, to reduce the incidence of fire; it is necessary to analyse statistics concerning sources of ignition in order to obtain information on which fire prevention may be based.

The following are useful sources of statistics concerning causes of fire:

a) United Kingdom fire statistics, which are published annually by Communities and Local Government (CLG); and
b) analyses of 'large fires', which are large financial losses for which insurance claims have been made; these analyses are produced by the Fire Protection Association (FPA).

The United Kingdom fire statistics are based on reports that fire and rescue services complete each time they attend a fire. The statistics can only be as accurate as the opinion of the officer in charge at each fire. (Some fires are, however, subject to investigation by specialist fire investigators within the fire and rescue services.) Moreover, the statistics give no insight into fires to which fire and rescue services are not summoned. Nevertheless, the statistics are the best information that is available and provide very useful information on fire risk. The FPA's 'large fire' analyses are based primarily on information provided by insurers concerning fires that result in a financial loss that exceeds a certain value – currently, at the time of writing, £100,000.

Figure 3.1 is based on the United Kingdom fire statistics for the year 2004. In practice, although there are noticeable trends over a number of years, the relative prevalence of each of the ignition sources defined does not vary greatly between one year and another. The statistics shown relate to all fires attended by fire and rescue services in the United Kingdom.

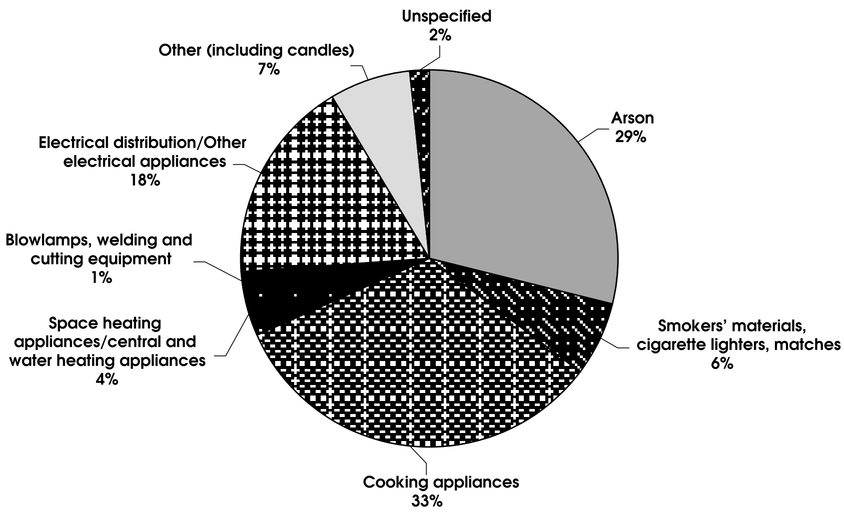


Figure 3.1 Causes of fire in the UK: 2004

The most significant points to emerge from the statistics are that most fires result from a very small number of causes, and, more specifically, that more than half of all fires are the result of arson, careless use or disposal of cigarettes and matches (including fires caused by children playing with matches) or electrical sources of ignition (including fires caused by electrical appliances and wiring).

The importance of these three sources of ignition in industrial and commercial premises is reinforced if fires in dwellings are removed from the statistics since, in the latter case, the most common cause of fire is cooking activities (see Figure 3.2). Figure 3.3 shows the sources of ignition of fires in non-domestic premises during 2004. Over two-thirds of these fires result from arson, electrical faults or careless use or disposal of smokers' materials.

The causes of fire vary from one type of occupancy to another. This is demonstrated by Figures 3.4–3.10, which respectively show the 2004 statistics on causes of fire in industrial premises, hotels and similar premises, schools, recreational and other cultural services, retail distribution, hospitals, and restaurants, cafes and public houses.

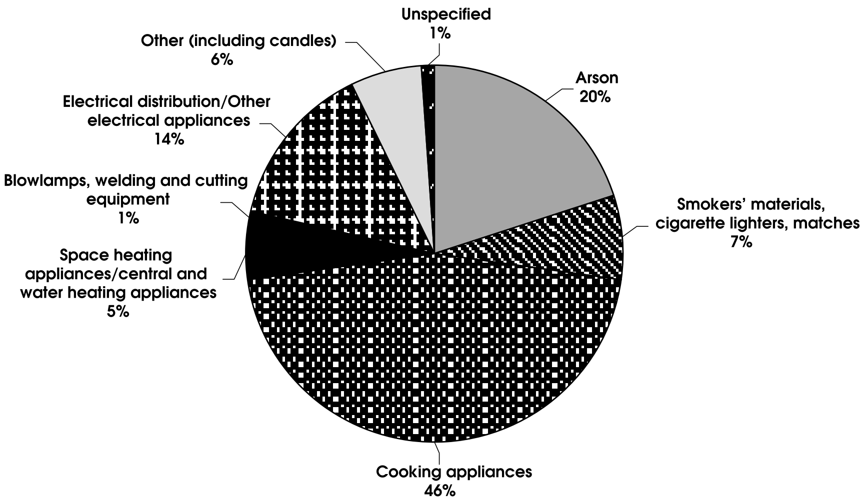


Figure 3.2 Causes of fire in dwellings: 2004

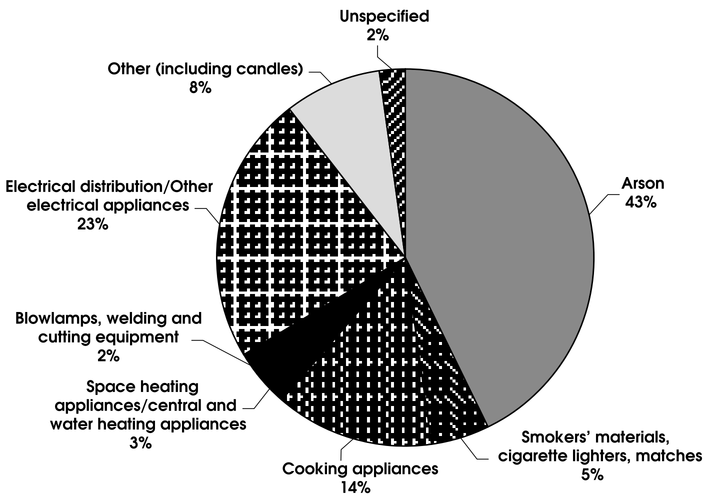


Figure 3.3 Causes of fire in non-domestic buildings: 2004

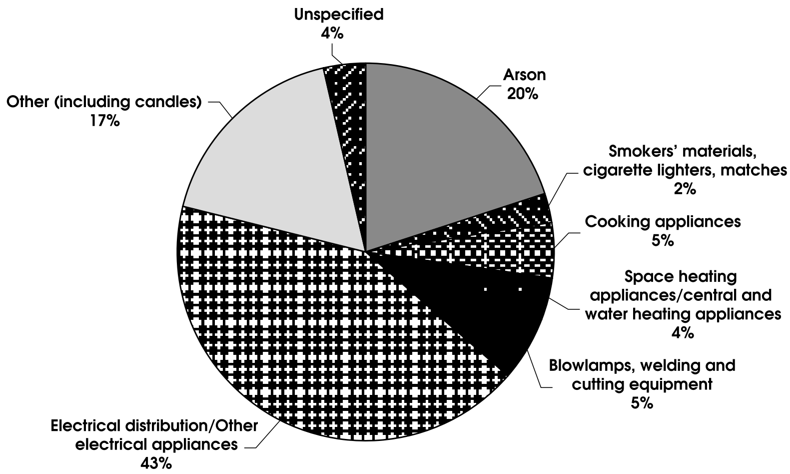


Figure 3.4 Causes of fire in industrial buildings: 2004

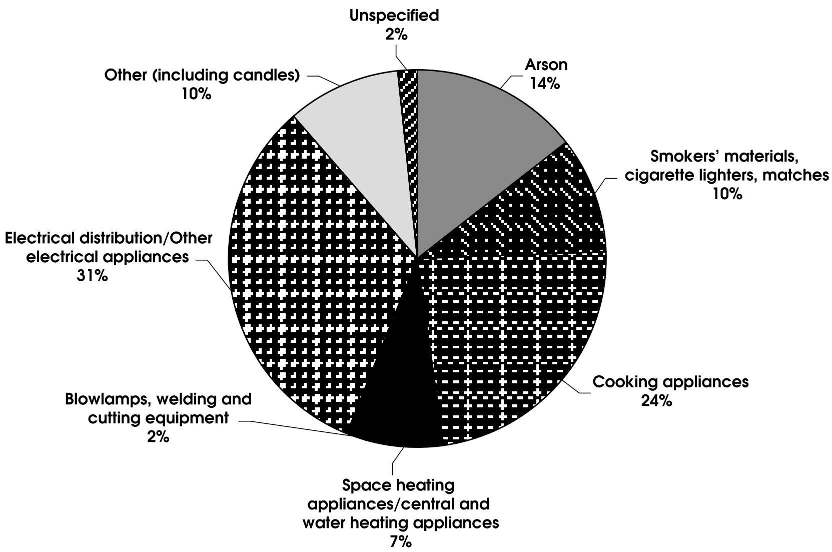


Figure 3.5 Causes of fire in hotels: 2004

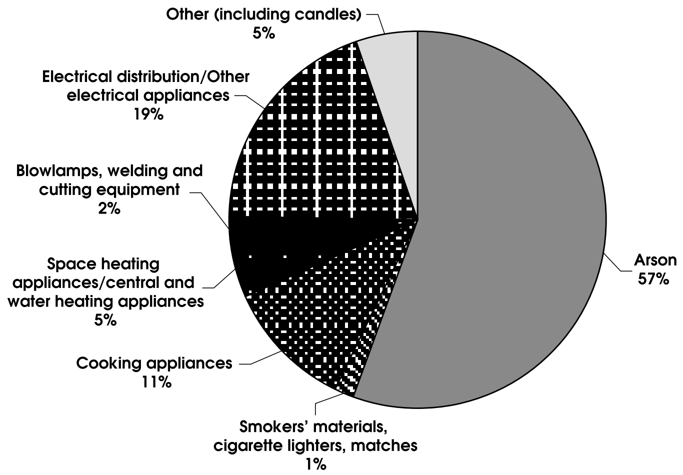


Figure 3.6 Causes of fire in schools: 2004

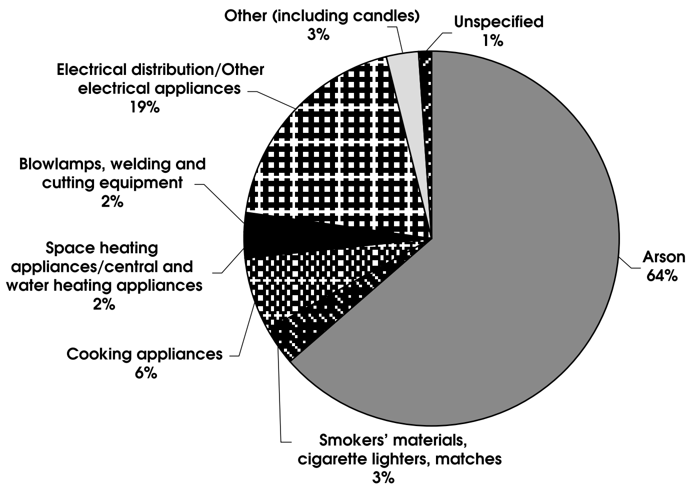


Figure 3.7 Causes of fire in recreational and other cultural services buildings: 2004

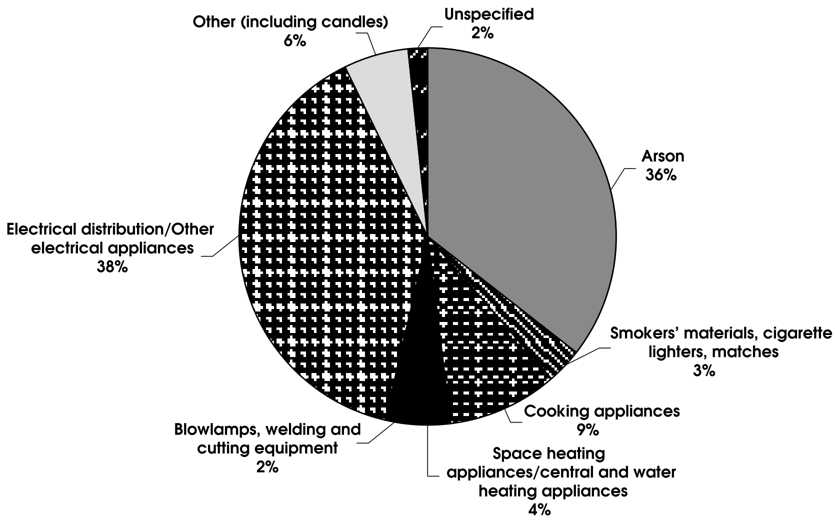


Figure 3.8 Causes of fire in retail premises: 2004

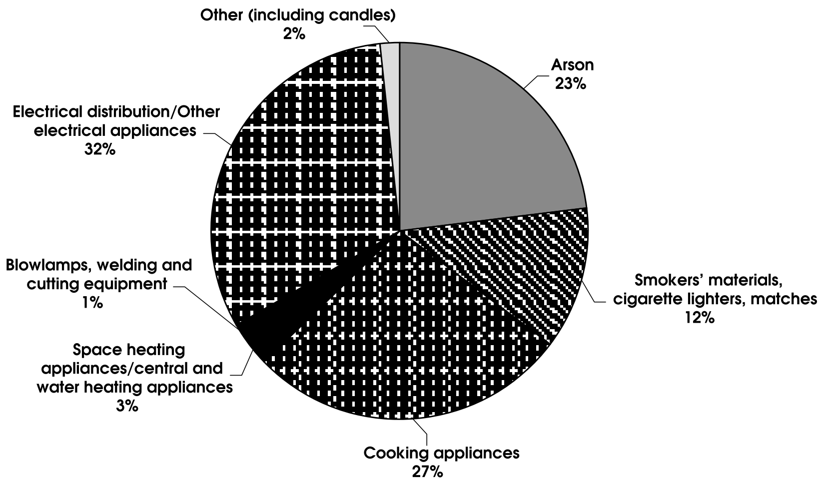


Figure 3.9 Causes of fire in hospitals: 2004

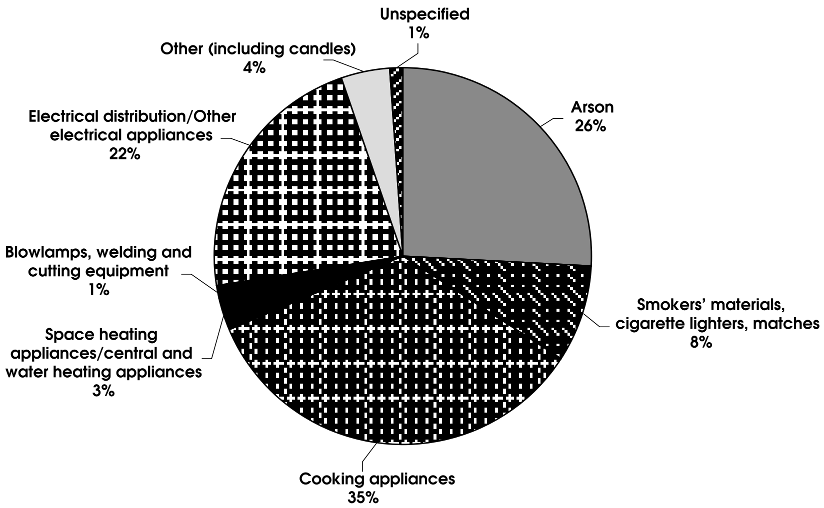


Figure 3.10 Causes of fire in restaurants, public houses, clubs, etc.: 2004

A number of points emerge from a study of these figures.

a) Arson is the most common single cause of fire in non-domestic premises. (In Scotland, the crime is called 'wilful fire raising', rather than arson.) Some types of premises, such as schools, are particularly prone to arson. Moreover, arson is a significant cause of fire in most of the premises to which members of the public are admitted. Arson is probably less common in industrial premises owing to stricter control over access.
b) Cutting, welding and blowlamps are a small, but very significant source of ignition. This highlights the significance of contractors' operations as a cause of fire.
c) In hotels, restaurants and hospitals, a significant number of fires involve cooking processes but, as a source of ignition, cooking appliances are less significant in other occupancies.
d) In industry, there are a large number of miscellaneous causes, often associated with the processes undertaken. The causes of fire therefore tend to be more diverse than fires in commercial establishments.
e) Heating appliances and installations cause only a small but consistent proportion of fires. Of these fires, space-heating appliances account for the majority; central heating and water heating installations result in far fewer fires.

Information drawn from the FPA large Fire Analysis for 2005 is shown in Figure 3.11. Again, the importance of the three main causes already described should be noted; arson, smokers' materials and electrical sources of ignition cause about 60 per cent of all large fires. Arson is the largest single known cause of major fires. The actual proportion of fires due to arson may be even higher due to the number of large fires for which a cause is never discovered.

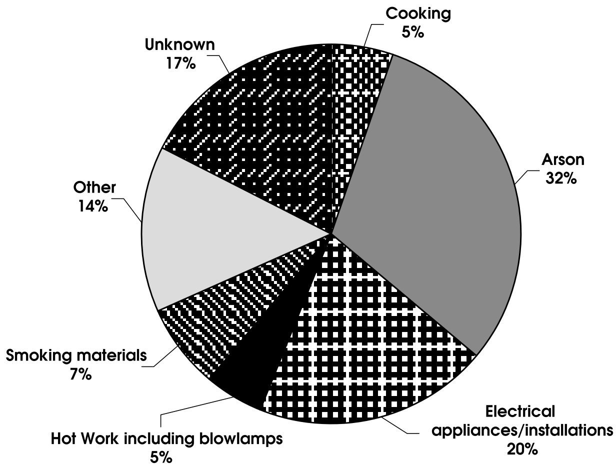


Figure 3.11 Large fire analysis 2005

In the case of office buildings, an FPA study indicated that 72 large fires occurred in the five years between 1994 and 1998. (This study has never been repeated, and there is no other ready source of data relating specifically to office fires.) In 26 of these fires (36 per cent), the cause was recorded as deliberate ignition. Other known sources of ignition were electrical appliances and equipment (22 per cent), cutting, welding and blowlamps (4 per cent), and smokers' materials (11 per cent). Although the number of fires caused by contractors' operations is not high, it is significant, and the average loss was high (around £300,000). Indeed, two of the largest claims in British insurance history both arose during the construction phase of large buildings.

A further study of fires in office buildings during 2004 was published by the FPA in 2006. During 2004, the FPA were made aware by insurers of 21 fires in office buildings in which the loss was in excess of £100,000. (It is likely, however, that there were more than this number of large fires.) Of these 21 fires, nine (43 per cent) were started deliberately, six (29 per cent) were electrical, one caused by smoking materials, four unknown, and one under investigation. The 21 fires incurred a total loss of £13.2 million and represented 5 per cent of the total number of fires in this period.

Companies with numerous locations should keep in-house records of all fire losses, including any very small fires that did not result in significant damage. Such records could allow the identification of hazards before a serious loss results.

Further reading

Fire Statistics United Kingdom. Communities and Local Government. London: HMSO.

4

The scope and nature of fire precautions

Earlier chapters of this book have described the common causes of fire and the threat that fire creates to people, property and the functioning of businesses. However, the remaining chapters, constituting the greater part of the book, are concerned with the response to the threat, in the form of fire precautions.

Fire precautions may be defined as measures taken to reduce the likelihood of ignition occurring and/or to mitigate the consequences should ignition occur.

The scope of fire precautions is very wide. It extends, for example, well beyond the measures required by traditional legislation that preceded the Regulatory Reform (Fire Safety) Order. There are two reasons for this. Firstly, prior to the Fire Safety Order, legislation was not generally concerned with the prevention of fire. The Health and Safety at Work Act, for example, did not permit positively unsafe situations for employees. Nevertheless, historically, most fire-specific legislation has generally been based on the assumption that a fire will occur, and required that people be protected against injury when it does. For example, if a fire occurred every day in a building, it might reasonably be argued that the fire precautions were inadequate, but there would not necessarily have been any breach of the Fire Precautions Act, which, between 1971 and 2006, was the cornerstone of fire safety legislation in Great Britain.

However, the Fire Safety Order, and its equivalent legislation in Scotland and Northern Ireland, represents a move towards a more holistic approach to fire safety; the measures required under this legislation must be based on a fire risk assessment, and probability of fire is an inherent component of fire risk (see Chapter 5).

Secondly, legislation is concerned primarily with the safety of life and not with the protection of property or protection of a company's ability to function. This has been very much emphasized in the legislation of recent times, particularly as a climate of deregulation began to prevail. Somewhat paradoxically, the measures required to protect life are often simpler, less extensive and usually less costly than those required to protect assets and earning capability, even though safety of life must always be the first priority. This is a natural consequence of the fact that, in most occupancies, people can be removed quite quickly from the hazards created by a fire, simply by evacuation of the building. (This is not, however, true of certain occupancies, such as hospitals.) The building, on the other hand, remains at risk until the fire is controlled and extinguished, as are many critical facilities, such as records, etc. within the building.

There is a natural distinction between fire precautions that are intended to prevent the occurrence of fire and those that afford a degree of protection if fire does occur. It is conventional to refer to these two types of fire precautions as fire prevention measures and fire protection measures respectively. Independent consideration of these two forms of fire precautions is consistent with the independent consideration of fire hazards and the consequences of fire in a fire risk assessment. Fire prevention eliminates or controls fire hazards, while fire protection measures limit the consequences if fire does occur.

Fire prevention

Fire prevention is defined in BS 4422[1] as measures to prevent the outbreak of a fire. Fire prevention measures are very diverse in nature and include procedures, as well as physical measures, to reduce the probability of the occurrence of fire. For example, fitting a residual current device to an electrical installation may reduce the chance of a fire of electrical origin. Procedures for routine inspection of the electrical installation may also lessen the fire hazard by early identification and rectification of faults.

Fire protection

Fire protection is defined in BS 4422 as measures taken in the design or equipment of buildings or other structures to reduce danger from fire. Fire protection measures, therefore, are also very diverse in nature, and range, for example, from a brick wall to a sophisticated fire detection and extinguishing installation. These measures may be intended to protect any of three exposures – namely people, property and business continuity.

In fact, most fire protection measures tend to be grouped into those required for protection of life and those required for protection against financial loss; it is the former measures that are generally required by legislation, while the latter measures may be a requirement or recommendation of fire insurers, or be installed on the advice of in-house advisers. It is normally quite clear whether the provision of any fire protection measure is primarily related to life safety or property protection. Emergency lighting, for example, may be an important life-safety measure as it can assist in the evacuation of people, but it does little or nothing to reduce directly the risk of property loss. Similarly, a gaseous extinguishing installation may be installed to extinguish any fire in a computer suite, but is certainly not required to protect the occupants, who must be evacuated before the system is discharged.

Although it is usually possible to identify whether the primary function of a fire protection measure is life safety or property protection, there is invariably some overlap between the two objectives. A sprinkler system, for example, installed for property protection (see Chapter 14) will contribute to the life safety of persons in the building, particularly in parts distant from the area of fire origin. Equally, sprinkler protection of a shopping complex is normally required under powers granted by legislation. It is one component of a fire engineering package (see Chapter 22) designed to ensure that safe evacuation is possible. It will, however, also make a major contribution to limitation of property damage in the event of fire. Fire-resisting doors installed to protect the enclosure of a stairway in order to provide a safe escape route for occupants (see Chapter 7) will also, at a later stage in the fire, assist in the prevention of smoke and fire damage on floors above and below the floor on which the fire is located.

A more subtle distinction exists between fire protection measures that are installed to protect property directly and those intended to protect a particularly critical function on which a business depends. Some simple examples may make this distinction clear. First, consider a computer that controls a production process upon which the revenue-earning capability of a manufacturing company depends. The computer may be highly protected against fire, perhaps by enclosure in a room with fire-resisting walls, automatic fire detection and an automatic extinguishing system. The computer itself, however, may not be of high value and may, in any case, be insured against fire damage. However, loss of the computer may result in significant downtime of the production process and cause financial losses well in excess of the value of the computer. A more extreme example is the case of a critical real-time computer facility that controls the operations at a larger number of locations. Fire damage to a few metres of communications cable, which may cost only a few pounds to replace, could result in huge losses to the organization due to loss of communications with all remote locations.

As a further example, consider a quality-control laboratory that contains specialist equipment that is used routinely to monitor the quality of products produced by a pharmaceuticals manufacturer. Again, loss of the laboratory may cause serious interruption to the manufacturing process.

It is thus clear that the purpose of fire protection measures can be divided into three categories; namely protection of life, protection of property or protection of business continuity. However, the actual nature of the measure is frequently subdivided into just two categories, namely active or passive.

1. *Active fire protection.* Active protection measures include mechanical and electrical equipment, such as fire detection, fire extinguishing and smoke-control systems. Such systems actively respond in some manner when fire occurs. For example, in the event of fire, power is supplied to alarm sounders, water is caused to flow through pipes or a smoke extract fan starts up – the system has responded to the fire.
2. *Passive fire protection.* Passive fire protection measures, by contrast, are those that need not change in any manner in order to perform their fire protection function; they are inherently protective in their normal, every-day condition. Such measures are primarily associated with containment of fires, but include good fire safety planning and design, adequate means of escape, compartmentation, structural fire protection and, to some extent, ventilation.

In practical terms, passive fire protection products are those that are mainly, but not solely, associated with building construction, linings or contents, and that have the objective of containing fire, or of limiting the extent or rate of fire spread and development. The term encompasses a wide range of product types that are not necessarily of even vaguely similar nature. They may be as diverse as a fire-resisting document storage cabinet, chemicals used to treat fabrics to improve their fire performance and paints used to reduce the rate of flame spread over timber linings, as well as the more traditional products, such as fire-resisting building materials.

Passive fire protection has traditionally been regarded as the fundamental, basic form of fire protection, often specified at a very early stage in the design of a building. Active fire protection systems are sometimes incorrectly regarded as 'add-on' elements. In fact, it may be necessary to design active systems, such as sprinklers, at quite an early stage in the design process. In more recent times, active and passive measures have become regarded as complementary measures that, together, form an integrated fire safety package.

Pre-planning

Fire protection measures, by definition, only have a bearing on fire safety after fire has occurred and, therefore, fire prevention has failed. It has already been noted in this chapter that, while fire prevention measures comprise both procedures and equipment, fire protection measures involve only equipment and materials. There is, however, a further group of fire precautions that are concerned with the procedures, both short term and long term, that follow an outbreak of fire. These precautions may be described simply as the emergency plan. The emergency plan addresses actions to be taken at the time of a fire, and planning for action after the fire.

Planning for actions in the event of fire includes the formulation of fire procedures (see Chapter 20) and the training of all occupants, including those with special duties in the event of fire. It also includes rehearsing the procedures by carrying out regular fire drills (see Chapter 21). Planning for action after a fire deals with the planning of salvage arrangements and the formulation of contingency plans for continuing the business. In the case of a hotel, for example, there might be a need to plan for accommodation of guests if the building cannot be reoccupied after the fire. In the case of a manufacturing company, it may be possible to formulate contingency plans for production to resume at another location.

Summary of the scope and nature of fire precautions

Fire precautions may, therefore, be divided into three groups:

1. Fire prevention measures
2. Fire protection measures
3. Emergency plans.

Many of the visible fire precautions in a building are fire protection measures. However, the 'software' of fire safety, such as procedures to prevent fire and pre-plans for action in the event of fire, are just as important as, or even more important than, the physical measures provided to prevent fire and protect against its consequences.

It is also important to note that the formulation of appropriate fire precautions in a building is a management duty (see Chapter 18). Fire precautions must not be an issue left to others, such as enforcing authorities or fire insurers, to impose on the organization.

References

1. BS 4422, *Fire vocabulary*.

5

Fire risk assessment

Background

Over the past decade or so, there has been a distinct move, particularly in implementation of fire safety legislation, towards 'risk-proportionate' fire precautions, rather than the more traditional 'prescriptive' approach, in which there was a more rigid application of codes of practice without full consideration of the fire risk. There has also been an acceptance of the fact that there is often more than one means by which a fire safety objective can be satisfied. Thus, for example, in the 1980s, building regulations in England and Wales were, for the first time, cast in functional form, in which the requirement was to satisfy a fire safety objective, rather than a prescriptive requirement (see Chapter 1). Guidance that supports the regulations makes it clear that variation of 'normal' fire precautions may be possible, taking into account fire hazard and fire risk.

However, the major 'step change' in recognition of, and indeed requirement for, the basing of fire precautions on fire risk assessment came as a result of the implementation of European Directives in the form of the Fire Precautions (Workplace) Regulations 1997 (see Chapter 1). In this respect, the Fire Precautions (Workplace) Regulations represented an insight into the shape of things to come. The need for a fire risk assessment to ensure compliance with these Regulations was carried forward into the Regulatory Reform (Fire Safety) Order,* in which a fire risk assessment is the foundation for the general fire precautions (see Chapter 1).

The use of risk assessment as a basis for formulation of safety measures is, of course, in accordance with modern practice in the more general field of health and safety. From 1993, this has been formalized within the Management of

* and equivalent legislation in Scotland and Northern Ireland.

Health and Safety at Work Regulations, which require that all employers carry out a suitable and sufficient assessment of the risks to the health and safety of employees at work, and of the risks to others arising from the employer's business. The Regulatory Reform (Fire Safety) Order* requires a risk assessment to identify the measures required to satisfy the Order. Thus, effectively, in the case of workplaces, there is a need for a fire risk assessment, as well as a health and safety assessment. In some ways, this represents a 'coming together' of fire safety and general health and safety, although the fire risk assessment would not normally form part of the general health and safety risk assessment; the two are normally entirely separate, except in the case of very small workplaces.

The requirement to carry out fire risk assessments has given rise to much perplexity and debate on the part of those charged with carrying out the task, even in the case of many fire safety practitioners. Yet, in fact, for those who understand the basic principles of fire safety, fire risk assessment should create no fears. For most premises, there is little mystique or complexity involved in undertaking and documenting a fire risk assessment. The process simply involves a formal, but logical and analytical, review of the fire hazards and fire risks, along with an examination of the fire precautions.

Terminology of fire risk assessment

Perhaps some of the confusion that can arise results from loose, inexact and sometimes conflicting use of terminology. In the paragraph above, the terms 'fire hazard' and 'fire risk' were introduced, and, before further consideration of the concept of fire risk assessment, it is necessary to consider carefully the exact meaning of the terms hazard and risk, both of which are used with a greater degree of exactitude in the field of health and safety. In the field of fire safety, they have, in the past, often been considered as either completely synonymous, or sufficiently so to enable them to be used interchangeably or, at best, with an ill-defined appreciation of the correct applications.

Given the assertions described above, and the closer relationship that might now be considered to exist between health and safety on the one hand, and fire safety on the other, it is appropriate to base the parlance of fire risk assessment on that adopted by health and safety practitioners. Guidance on the management of health and safety can be found in BS 8800, which also contains a useful annex on the subject of risk assessment.

* and equivalent legislation in Scotland and Northern Ireland.

In BS 8800, the following definitions are given:

- *hazard*: source or situation with a potential for harm in terms of death, ill health or injury, or a combination of these;
- *hazard identification*: process of recognizing that a hazard exists and defining its characteristics;
- *risk*: combination of the likelihood and consequence(s) of a specified hazardous event;
- *risk assessment*: process of identifying hazards and evaluating the risks to health and safety arising from these hazards taking account of the existing risk controls (or, in the case of a new activity, the proposed risk controls).

This clear distinction between hazard and risk is, as we shall see later in this chapter, of great value in any analytical approach to any aspect of safety, including fire safety.

It would then seem reasonable, by analogy, to regard a *fire hazard* as, quite simply, a source or situation with potential to result in a fire; an example would be defective electrical wiring, which could certainly be reasonably described, even in common parlance, as a fire hazard. If this definition were adopted, all potential ignition sources, such as smoking, arson, etc. would require to be considered as at least *potential* fire hazards.

On the other hand, not all fire hazards would, per se, be potential sources of *ignition*. A 'situation' could represent a failure to separate adequately combustible materials, which, in themselves, could not be regarded as a 'hazard', from potential sources of ignition, which, in themselves, could also not be regarded as a 'hazard'.

For example, a pile of waste cardboard would not, in every circumstance, be regarded as a fire hazard, nor would smoking cigarettes on the public highway. However, if the pile of waste cardboard were situated on the public highway, close to the windows of a building, a fire hazard is undoubtedly created; ignition by a carelessly discarded cigarette or match could start a fire that spreads into the building via the adjacent windows. Similarly, a rubbish bin located externally, but close to windows on the building's perimeter, might be regarded as a hazard, owing to the virtually all-pervasive potential for malicious ignition.

Within the field of fire safety, the term 'fire risk', in particular, has been subject to numerous varying and conflicting definitions. Until 2005, a definition for fire risk, made legitimate by a now superseded part of BS 4422, which is a glossary of fire terminology, was that it is the likelihood that fire will occur. This was inconsistent with the broader definition of risk used by health and safety practitioners, and given by BS 8800, in which likelihood of a hazardous event (such as a fire) is only one of the two components of risk. Moreover, without the second component, namely the consequences of the hazardous event (fire), the definition is quite unhelpful. It would imply that, for example, fire risk would be made tolerable in premises with wholly inadequate means of escape and fire warning, simply by reducing the likelihood that fire would occur. Equally, it would imply that, in industrial premises prone to small fires, the fire risk is high, which, in terms of safety of occupants, is not necessarily so; for example, there might be very good means of escape from fire, such that no occupant is ever more than a short distance from a fire exit.

Accordingly, the latest (2005) version of BS 4422 gives new definitions for the terms discussed thus far in this chapter, and these parallel much more closely definitions used within the health and safety profession. Thus, in BS 4422, the following definitions are given:

- *fire hazard*: potential for injury and/or damage from fire;
- *fire risk*: product of the probability of occurrence of a fire to be expected in a given technical operation or state, and the consequence or extent of damage to be expected on the occurrence of a fire;
- *fire risk assessment*: process of identification and evaluation of fire risk to people, property or the environment.

A similar approach to definition of these terms can be found in the relevant BSI publication on the subject of fire risk assessment, PAS 79, which was drafted by the author and which gives the following definitions:

- *fire hazard*: source or situation with potential to result in a fire (e.g. an ignition source or an accumulation of waste that could be subject to ignition);
- *fire hazard identification*: process of recognizing that a fire hazard exists and defining its characteristics;
- *fire risk*: combination of the likelihood and consequence(s) of fire;
- *fire risk assessment*: overall process of identifying fire hazards and evaluating the risks to health and safety arising from them, taking account of existing risk controls (or, in the case of a new activity, the proposed risk controls).

It should be noted that these definitions exactly parallel the definitions given in BS 8800.

Guidance published by the Scottish Executive on the Fire (Scotland) Act 2005, under which a 'fire safety risk assessment' is required (see Chapter 1), appears to support the definitions in BS 4422 and PAS 79. These guides are intended to be suitable for the lay user. Accordingly, they are less formal in their definitions of terminology, which are set out more in the form of discussion.

However, each of the Scottish Executive guides (relating to fire safety in different occupancies) advises, quite simply, that a (fire) hazard is a 'situation that can give rise to a fire'. They further advise that (fire) 'risk has two components: the likelihood that a fire may occur; and the potential for a fire to cause death or injury i.e. consequence'.

It did, for a time, seem, therefore, that, at last, the fire safety profession was beginning to achieve unanimity in its understanding of the concepts of fire hazard and fire risk. Alas, any such hopes were to be dashed by the publication, in England and Wales, of the 12 guides that support the Regulatory Reform (Fire Safety) Order. Each of these guides, published by Communities and Local Government (CLG), acknowledges that the terms 'hazard' and 'risk' are used throughout the guide, and they stress that '*it is important that you have a clear understanding of how these should be used*'.

Regrettably, this clarity of understanding is not promoted by the definitions given in each guide, namely that a hazard is '*anything that has the potential to cause harm*', while risk is '*the chance of that harm occurring*'. For within a few pages of the somewhat anomalous definition of risk, the guides recommend that steps within a 'fire safety risk assessment' include identifying people '*at risk*', evaluating the '*risk of a fire occurring*' and evaluating the '*risk to people from fire*'.

If the definition of risk given by the CLG is 'plugged into' these steps, they fail to make sense. Moreover, consider now a machine located in a single-storey factory with few occupants, and with no combustible material in close proximity to the machine. A fire on the machine may well cause harm to an operator, but the circumstances of this are likely to be such that the harm is very minor, albeit quite likely to occur. Is this high risk? The chance of very minor harm might be relatively high, but there might be little chance of any more significant harm. Under the CLG definition, this would, however, be high risk. Under the other definitions given above, it is suggested that this would not be the case. Clearly, fire risk must take into account the extent of harm, and this alone is missing from the definition in the CLG guides.

When the CLG definitions are 'plugged into' the defined steps, it might make sense to identify people 'at chance of harm occurring', or the 'chance of harm occurring to people from fire'. It is perplexing, however, to consider the 'chance of harm occurring of a fire occurring'. Clearly, the term likelihood of fire occurring is what is meant by the term 'risk of a fire occurring', and the use of the word risk, in this context, conflicts with the CLG's own definition of the word 'risk'. The term risk has been used both in the modern context and in the older context of likelihood of a fire occurring. Further tautology exists in the guides, which refer to the risk of hazards causing harm.

Perhaps the most confusing piece of guidance given in the CLG guides is that:

> *Having evaluated and addressed the risk of fire occurring and the risks to people (preventative measures) it is unlikely that you will have concluded that no risk remains of fire starting and presenting a risk to people in your premises.*

This very difficult piece of English is apt to confuse rather than clarify.

It is disappointing that, given the significance of fire risk assessment in the legislative regime, there is anomalous use of very term fire risk that is the fundamental matter for consideration. It can only be hoped that future standards and guidance can promote greater standardization of definitions.

In the meantime, a definition of fire risk that involves both the probability of fire and the consequences of fire (in the sense of likely extent of harm) is by far the most compelling. In terms of both assessing and managing fire risk, the separation of the two issues is essential. While the machine that regularly causes very small fires with no likelihood of significant harm to occupants does not create high fire risk, low probability of fire would not be likely to mitigate the effect of inadequate means of escape in a high-rise building. Similarly, as discussed later in this chapter, measures to reduce the probability of fire are very different from measures to mitigate the consequences of fire.

Fire risk assessment: the concept

A major component in fire risk assessment is, therefore, fire hazard identification, which, in simple terms, is the process of identifying circumstances that may result in a fire. The 'circumstances' may be 'soft' (i.e. related to management issues, such as poor maintenance) or ‘hard’, such as a portable heater in close proximity to combustible materials.

The response to fire hazards identified in the fire hazard identification is, of course, simply *fire prevention*, in the exact and literal sense of the term, as opposed to the older-fashioned and broader concept of fire prevention as practised by what used to be known as a ‘fire prevention officer’. In practice, in carrying out a fire risk assessment, fire hazard identification and investigation of fire prevention measures are likely to be carried out simultaneously as a single exercise.

The consequences of fire will be governed by many factors, both ‘soft’ and ‘hard’. The most significant factor that governs the outcome of a fire is the nature and content of *fire protection* measures, such as the means of escape, fire warning systems, automatic fire extinguishing systems, etc.

However, the characteristics of the occupants, such as their physical condition and their likely reaction to a fire alarm signal, are also extremely important. Impaired mobility is a major factor to consider, given the modern requirements for access to buildings for disabled people. The potential for temporary impairment by alcohol or drugs may also be important.

While the characteristics of occupants may be regarded as a given quantity for any building, the response of people to fire is a variable that can, and should, be improved by instruction, training and rehearsal in the form of fire drills (see Chapter 21). This cannot be overemphasized, as it is now widely recognized that human behaviour in fire is an important and legitimate aspect of the broad subject of fire safety engineering (see Chapter 22).

Accepting, then, the definition of fire risk offered in this chapter, what is involved in a fire risk assessment? The term ‘assessment’ has connotations of quantification, but true quantification of risk, in terms of quantified probabilities and complex event trees, is only relevant in the case of high-hazard industrial processes and similar situations, all of which are likely to be irrelevant for the typical reader of this book.

Some authors’ methods of fire risk assessment do involve pseudo-quantification, in the sense that the assessor ascribes a value, such as 1, 2 or 3, etc., to various factors, sometimes resulting in an overall numerical value for fire risk. However, the allocation of values is generally based on subjective judgement and, in truth, the terms low, medium, high, etc., could just as well be used for the factors concerned.

Moreover, the combination of the values allocated, by means of a formula, carries with it certain dangers. There is usually some form of weighting for different risk factors, which is, in effect, predetermined by subjective judgement on the part of the author of the scheme. This can sometimes lead to anomalous results, particularly if, for example, one risk (or protection) factor departs substantially from the norm; according to the weighting allocated to the factor, its unacceptable status may not be obvious from the overall value for fire risk. There is also a danger that an action plan concentrates on increasing the number of ‘safety points’ without proper consideration of the measures proposed. In simple ‘points schemes’ of this nature, it is also difficult to take into account the complex interactions between fire protection measures.

It is, in this connection, interesting to note that, in the health care sector, a method of fire risk assessment has been in place within the National Health Service for many years. However, the original method, based on a points scheme, was later replaced with a simpler method (now published by the Department of Health as HTM 05-03 Park K) that identified fire precautions that were individually inadequate and that offered scope for compensation by enhancement of other fire precautions.

For most commercial and industrial buildings, a relatively simple method of fire risk assessment is highly desirable. A wholly subjective, but knowledge-based, procedure is satisfactory. Thus, the author favours a methodology based on guidance given in the BSI publication PAS 79. The guidance in that publication is intended to parallel the guidance given in BS 8800 on occupational health and safety (OH & S) risk assessment.

Fire risk assessment: the process

BS 8800 recommends that risk assessment and control is achieved by:

- identifying hazards and making an estimate of the associated risk levels, on the basis of the existing or proposed risk controls;
- determining whether these risks are tolerable;
- determining whether further analysis is required to establish whether the risks are, or are not, tolerable;
- devising risk controls where these are found to be necessary.

It should be noted that BS 8800 makes reference to the concept of ‘tolerable risk’, recognizing that zero risk is unachievable. Tolerable risk is defined in BS 8800 as:

> *risk at a level that can be accepted provided risk controls are implemented to reduce risk as low as is reasonably practicable, i.e. reduced to the point where it can be shown that the costs (in terms of time, money and/or effort) of further risk reduction would be disproportionate to the further benefits.*

It should also be noted that, in this respect, there is consistency between health and safety principles and the requirements of fire safely legislation, which requires that the safety of employees be ensured as far as is reasonably practicable (see Chapter 1).

Thus the approach of BS 8800 can be adopted for a fire risk assessment, simply by prefixing the terms 'hazard' and 'risk' by the adjective *fire*. In the case of OH & S risk assessment, a methodology set out in Annex E of BS 8800 is intended to be used, amongst other things, in situations where hazards appear to pose a significant threat and it is uncertain whether existing or planned controls are adequate in principle or in practice. On the other hand, the full procedure described in BS 8800 is not regarded as necessary or cost-effective when it is quite clear that risks are trivial, or if previous assessment has shown that existing or planned controls conform to established legal requirements or standards and are appropriate.

Fire risk is rarely trivial, but in some circumstances, such as a small, single-storey, detached plant room, a lengthy fire risk assessment is usually inappropriate. It is also reasonable to consider that, after a full fire risk assessment has been carried out and fire risk is adequately controlled, reviews of the assessment need only be limited in depth.

OH & S risk assessment is commonly based on a single pro forma that is appropriate for the organization. In a similar way, a fire risk assessment should be based on a 'tailor-made' pro forma that takes into account, for example, the particular fire hazards associated with the activities in the building, and the factors, such as presence of the public for example, that might affect the outcome of a fire in the building.

Annex E of BS 8800 offers a simple prompt list for broad categories of hazard; fire and explosion is but one of the hazards in the list. In the case of very small premises, for which the fire risk assessment might well be incorporated within the OH & S risk assessment, this is a reasonable approach.

In practice, however, most premises arguably warrant a separate and more detailed fire risk assessment, which would begin with fire hazard identification, based on a prompt list of recognized fire hazards; these are, quite simply, the common sources of ignition, such as electrical installations and equipment, smoking, malicious ignition, cooking processes, heating equipment, etc. To these broad categories should be added any particular fire hazards associated with the company's activities, such as handling of flammable liquids, and any situations that could foreseeably result in a fire.

The hazard-identification process should give individual consideration to each hazard on the prompt list, along with the controls in place, so that some subjective view as to the likelihood of fire arising from the hazards can be reached. Often this process can involve two phases, which we might regard as 'policy' and 'practice'.

Consider, for example, the fire hazard associated with electrical equipment. The policy stage would include consideration of the company's arrangements for portable appliance testing, and for control over use, in the building, of employees' own personal electrical appliances. The practice stage comes when the premises are inspected and observations can be made as to whether there is evidence that there is adherence to the policy or whether, for example, portable appliance testing is overdue, any appliances are overlooked and whether employees contravene the policy on use of their own electrical appliances.

It would be possible to ascribe a likelihood, or subjective probability, to each hazard that is identified. Thus, for example, the likelihood of a fire caused by persons smoking may be judged to be low, while the probability of, say, a fire of electrical origin could (if, perhaps, there were old wiring) be high. It would, therefore, be possible to associate a 'fire risk' with each of the hazards or situations that are identified in the fire hazard assessment.

It could be argued that the consequences of a fire, once it occurs, are not dependent on the cause. This is, in fact, not entirely correct. If the hazard is the storage of easily ignited combustible materials within a means of escape stairway in which people are permitted to smoke, the risk (to occupants) is quite different from the risk associated with, say, defective wiring within a fire-resisting riser enclosure on the top floor.

Nevertheless, in the experience of the author, endeavours, certainly in the first stage of the risk assessment, to apportion a specific risk to each fire hazard tends to make the risk assessment unnecessarily complex, or at least unduly lengthy. Usually, it is sufficient, at the end of the hazard-identification stage, to define the overall level of fire hazard within the premises or part of the premises under consideration. This overall fire hazard may be regarded as the summation of the 'likelihoods' of fire resulting from each and every one of the fire hazards that has been identified; it is, therefore, simply a subjective statement of the probability of fire.

Obviously, probability of fire can vary greatly from one premises to another. Where only one premises is involved, or where a number of premises are to be assessed by one or even two competent fire safety specialists, several categories of fire hazard level may be appropriate.

However, if a significant number of premises are to be assessed by several specialists, or if the premises are to be assessed by a non-specialist, inconsistent or anomalous results are likely to occur from methods that involve too many categories. Under these circumstances, a simple system of categories, such as low, medium and high, can be sufficient. (This is consistent with the simple approach to risk assessment often adopted in a general health and safety risk assessment.)

The use of only three levels can provide a good degree of consistency amongst different assessors and is likely to provide sensible results by the non-specialist. There is already a natural tendency for people to classify many variables in their everyday life on the basis of three categories, such as: cold, normal and hot; small, medium and large, etc. A large number of observers would probably reach a consistent conclusion, after a car journey, as to whether the driver had driven slowly, at 'normal' speed or had driven fast. Consistency would, however, break down if they were asked whether the speed of the car had been very slow, slow, normal, fast or very fast, unless some very clear guidelines for the boundaries of the categories had been set in advance.

The probability of fire will depend on the nature of the premises, in the sense of the processes and activities carried out, the state of its electrical installation, etc. Account should be taken of the physical and procedural measures in place to prevent fire. It should be borne in mind that malicious ignition is a major cause of fire, particularly in premises to which the public are admitted in large numbers, such as places of entertainment (see Chapter 6); this may even preclude the probability of fire in such premises from being regarded as the lowest category.

The fire risk assessment process should then proceed to consider the consequences of fire. As already discussed, the consequences are independent of the probability of fire, albeit not entirely independent of the nature of the fire hazards that exist. In considering the consequences, due consideration should be given to both the potential extent of harm that may occur to occupants, as well as the likelihood that harm will occur.

The potential severity of harm that will occur in the event of fire, and the likelihood of harm, are governed by many common factors in most premises, such as:

- number of people at risk;
- the physical and psychological characteristics of the occupants;
- familiarity of occupants with the premises and the fire procedures;
- height of the building above ground;
- means of escape;
- measures that assist in escape;
- fire warning arrangements;
- means for containing and extinguishing fire;
- the standard of the emergency plan for action in the event of fire;
- the quality of staff training.

Thus, it is usually possible to classify the consequences into three categories, each of which may be thought of as a form of ‘average’ or most reasonably foreseeable consequences of a fire in the building. (For the mathematically inclined, they may be thought of as the subjective integration of a number of harm scenarios multiplied by the probability of each, with the product divided by the number of scenarios.)

When considering the potential consequences of a fire, account must be taken of the resources in place to respond to and control a fire once it occurs. Legal requirements and codes of practice should be considered in the assessment of the adequacy of these measures.

The risk is obviously greater when there are more people exposed to the fire. However, equally, serious risk can occur if, even only on a limited number of occasions, a small number of persons (even one) is unduly exposed to severe harm in the event of fire. An example could be one person working in a remote part of a building, with unsatisfactory means of escape and inadequate warning of a fire, or the occasional presence of disabled people without any adequate arrangements for their evacuation in the event of fire.

Having determined the likely consequences of fire, it is now necessary to combine the likelihood of fire with the consequences. If three categories are available for each, the fire risk may be determined from a 3 × 3 matrix, with, potentially, nine different risk categories. However, in practice, some of the combinations may be equivalent, and a system in which there are, perhaps, five risk categories is probably adequate.

Table 5.1 shows the 'risk-level estimator' contained in PAS 79. This matrix allocates five risk categories on the basis of three levels of likelihood of fire and three consequence levels. It therefore provides some scope for consistent assessment (a result of the assessor having to combine only one of three likelihoods and three consequence levels), while providing a useful breadth of risk categories. Action and timescale can then be related to risk.

Table 5.1 A simple risk-level estimator

Potential consequences of fire ⇨ / *Likelihood of fire* ⇩	*Slight harm*	*Moderate harm*	*Extreme harm*
Low	Trivial risk	Tolerable risk	Moderate risk
Medium	Tolerable risk	Moderate risk	Substantial risk
High	Moderate risk	Substantial risk	Intolerable risk

This process is often, in guidance documents, set out as a number of defined 'steps', in order to promote a structured approach. Government guidance documents on fire safety legislation advocate five steps, probably in order to maintain consistency with the five steps that the Health and Safety Executive have traditionally promoted in guidance on health and safety risk assessments.

In fact, the number of steps is irrelevant, and indeed BS 8800 defines eight steps in a risk assessment. Interestingly, the five defined steps promoted by the CLG in guidance produced in support of the Regulatory Reform (Fire Safety) Order are different from the five defined steps promoted by the Scottish Executive in equivalent guidance on the equivalent Scottish legislation. Moreover, in such guidance, certain of the 'steps' are actually several steps in practice, which presumably have been combined merely to limit the total number of steps to the traditional five. Also, in the guidance, the steps include, for example, training of staff, which is not so much a step within a fire risk assessment, but a measure that should already be in place and subject to consideration in the assessment process.

In PAS 79, nine distinct steps are defined and are each subject to detailed discussion and guidance. These nine steps are set out below.

1. Obtain relevant information about the building, the processes carried out in the building, the occupants of the building and any previous fires.
2. Identify the fire hazards and determine measures for their elimination or control.
3. Make a (subjective) assessment of the likelihood of fire.
4. Determine the physical fire protection measures, relevant to protection of people in the event of fire.
5. Determine relevant information about fire safety management.
6. Make a (subjective) assessment of the likely consequences to occupants in the event of fire.
7. Make an assessment of the fire risk and decide if the fire risk is tolerable.
8. Formulate an action plan.
9. Carry out a periodic review of the risk assessment.

The action plan

Having determined the level of fire risk, an action plan should be formulated to address any deficiencies and to reduce the risk to occupants from fire to as low as reasonably practicable. PAS 79 provides guidance on the suitable action and timescale for the five categories of risk (see Table 5.2).

Table 5.2 Action plan and timescale

Risk level	*Action and timescale*
Trivial	No action is required and no detailed records need be kept.
Tolerable	No major additional controls required. However, there might be a need for improvements that involve minor or limited cost.
Moderate	It is essential that efforts are made to reduce the risk. Risk reduction measures should be implemented within a defined time period. Where moderate risk is associated with consequences that constitute extreme harm, further assessment might be required to establish more precisely the likelihood of harm as a basis for determining the priority for improved control measures.
Substantial	Considerable resources might have to be allocated to reduce the risk. If the building is unoccupied, it should not be occupied until the risk has been reduced. If the building is occupied, urgent action should be taken.
Intolerable	Building (or relevant area) should not be occupied until the risk is reduced.

In the case of fire, it is likely that, even in premises in which the risk is defined as tolerable, there may be a need for some measures to be improved, usually at limited capital cost. The names ascribed to the five categories of fire risk developed by this approach should therefore not be taken too literally. Nevertheless the use of five different categories of fire risk, whatever they are called, is extremely useful in determining priorities and providing a comparison between different premises.

In formulating an action plan for situations in which the fire risk has been assessed as unacceptably high, an analytical approach to fire risk assessment should permit 'backtracking' to determine whether, in effect, the problem arises from inadequate fire prevention (i.e. inadequate control measures to prevent fire), inadequate fire protection (e.g. unsatisfactory means of escape or fire warning systems), inadequate managerial arrangements (such as fire procedures) or a combination of these.

The outcome should be an inventory of actions, in priority order, to devise, maintain or improve controls. Ideally, these should, where possible, eliminate hazards (e.g. by replacement of defective wiring). As recommended by PAS 79, a blend of technical and procedural controls is usually necessary.

The adequacy of the action plan must be tested, at least in the mind of the assessor, before implementation. The following questions are suggested by PAS 79 for use at this stage.

- Will the revised controls lead to tolerable fire risk levels?
- Are new hazards created?
- Have the most cost-effective solutions been chosen?
- What will occupants affected think about the need for, and practicality of, the revised fire precautions?
- Will the revised fire precautions be adopted and maintained in practice and not ignored in the face of, for example, normal use of, and operations in, the building?

All of these questions have a relevance to any fire safety action plan, the objective of which must, of course, be to address undue fire risk, but without the creation of new hazards. For example, it would be undesirable to improve fire precautions by installing additional fire doors to limit fire spread if these were actually found to be an impediment to means of escape. The resources adopted should be the most cost-effective available; often a single objective can be satisfied by quite a variety of measures.

The practicality of fire precautions and their acceptability to occupants are also essential. There is no point in installing self-closing fire doors if discussion with occupants would have revealed that they would be such an impediment to the work process that they would always be wedged in the open position. Equally, if this is clear from discussion with those in the workplace, the problem may be pre-empted by installing fire doors that are held open by door-release mechanisms (such as magnetic door holders), which hold the door in the open position, but release the door to close under the action of a self-closing device on operation of the fire alarm system.

Documentation of a fire risk assessment

Even in the case of those with traditional skills in the field of fire safety, some practitioners have difficulty in formulating a suitable document to record the findings of a fire risk assessment. In practice, there is no right or wrong way to record a fire risk assessment.

Clearly, the written fire risk assessment should record significant findings in respect of fire hazards, people at risk from fire, the likely consequences of fire and the controls that are in place. Since it is, after all, a risk assessment, it should not simply record facts, but should set out the assessor's opinion of the fire risk, in the form of a category, value or grade, along with sufficient information to demonstrate the basis for the opinion. When the fire risk assessment is required under legislation, it should explicitly address the matters that the relevant legislation requires be adequate in nature and extent. It should contain an action plan, possibly with defined priorities and/or timescales, along with confirmation that the action plan will be sufficient to maintain, or reduce, the level of fire risk, so that it is, or becomes, acceptable.

A framework for documentation of a fire risk assessment is suggested within the guidance given in PAS 79. Typically, many documented fire risk assessments will adopt a similar framework, and will comprise sections that provide information on:

- *the premises*: factors such as height, construction, etc., that have a bearing on fire risk;
- *the occupants*: relevant factors, such as number, nature, identification of those at special risk, etc.;
- *fire loss experience*: information on previous fires at the premises is of value on the basis that what has happened before could possibly happen again;

- *the fire hazards and measures for their elimination or control*: ignition sources and hazardous situations that could cause a fire, along with measures to mitigate the probability of fire;
- *fire protection measures*: consideration of all measures to protect occupants when fire occurs and evaluation of their adequacy;
- *management of fire safety*: review and assessment of procedures and policies;
- *the fire risk assessment*: subjective expression of the level of fire risk;
- *action plan*: proposed measures.

The risk assessment should be regarded by management as an inventory for action and the basis for ongoing control. It should not be regarded as an end in itself, completed in the belief that it is merely a bureaucratic imposition, as this will do little or nothing to ensure that the occupants are adequately protected against fire. This makes avoidance of unnecessary detail quite important. The fire risk assessment process should involve those responsible for management of the building, even though the assessment may be carried out by a third party, and a copy should always be studied by local management.

Periodic review of the fire risk assessment

The fire risk in any building may be subject to change, whether gradual or acute. Gradual change may occur, for example, as a result of the wear and tear on fire precautions such as fire resisting doors, changes in management, turnover of employees and minor changes in layout that, after a prolonged period and numerous changes, have a significant effect on means of escape. Acute changes may occur as a result of refurbishment, changes in processes carried out, introduction of disabled people, etc.

For this reason, legislation requires that the fire risk assessment should be reviewed regularly. It is also required that the fire risk assessment is reviewed if:

- there is reason to suspect that it is no longer valid (e.g. if a fire has occurred); or
- there has been a significant change in the matters to which it relates.

Once again, there is no right or wrong frequency for review of the fire risk assessment. This is a matter for local decision or group policy. In many premises, annual review might be reasonable unless the fire risk is regarded as very stable or is subject to frequent change. In practice, determining the appropriate frequency for review of a fire risk assessment is part of the process of carrying out the fire risk assessment. Accordingly, the date by which the fire risk assessment should be subject to review should be recorded within the documented fire risk assessment.

Review does not, of course, mean complete reassessment. However, equally, all aspects of the original risk assessment should be revisited to ensure that they have not been subject to change. This emphasizes the importance of adequate recording of the original fire risk assessment, so that the basis for its conclusions can be readily re-examined.

Further reading

BS 8800, *Occupational health and safety management systems — Guide*
BS 4422, *Fire vocabulary*
PAS 79, *Fire-risk assessment — Guidance and a recommended methodology*

Guidance on 'fire safety risk assessment' is given in the 12 guides produced by the CLG in support of the Regulatory Reform (Fire Safety) Order and similar guides produced by the Scottish Executive in support of the equivalent legislation in Scotland. (See 'further reading' in Chapter 1.)

6

Fire prevention

The importance of fire prevention

The prevention of fire, if successful, is more effective than merely minimizing the effects of fire. Strangely, however, fire prevention is often overlooked in favour of fire protection. Traditionally, in enforcing legislation, inspecting officers of local authority fire and rescue services (at one time called 'fire prevention officers') have spent most of their time dealing with fire protection measures. Yet fire prevention is often a matter of simple common sense and need not always involve sophisticated measures or high technology. Perhaps it is because many fire prevention measures are almost trivial, that they are sometimes regarded by managers and qualified engineers as unworthy of their time and attention. In contrast, the level of engineering and the capital expenditure associated with many fire protection measures make them of greater interest.

There is also a general impression that fires are inevitable, and that, therefore, only fire protection need receive attention. In this connection it is interesting to note the views of Mr Desmond Fennell QC in his report on the investigation into the fire at King's Cross underground station in 1987, which resulted in the loss of 31 lives. The report states that:

> *the management remained of the view that fires were inevitable on the oldest and most extensive underground system in the world. In my view they were fundamentally in error in their approach*

and

> *Dr. Ridley [then chairman and managing director of London Underground Limited] … saw London Underground's key task as to minimize the risk of fires becoming a danger to passengers by a better control procedure and by removing materials which posed the greatest*

> *fire hazard. In effect he was advocating fire precaution rather than fire prevention.*
>
> *It is my belief that this approach is seriously flawed because it fails to recognize the unpredictable nature of fire.*

It is common, however, particularly after a fire disaster, to concentrate on fire protection defects, rather than inadequacies in fire prevention. After the fire at Bradford football stadium in 1985, when 56 people died, there were suggestions that football stadia should be sprinklered. It may be argued, however, that this serious fire could have been avoided by better housekeeping, so that the rubbish underneath the flooring of the stand (the ignition of which led to the disastrous fire) was not present. Fire protection, therefore, only complements fire prevention; it must never be regarded as a substitute. Most fires are the result of a limited number of categories of ignition sources (see Chapter 3). If it were possible to eliminate fires that result from arson, smokers' materials and electrical sources of ignition, the number of fires that occur in the UK would be dramatically reduced. Concentration on the prevention of such fires therefore greatly diminishes the risk of fire in any premises. The remainder of this chapter deals with measures to combat these three sources of ignition, and other significant causes of fire.

It should be noted that the modern 'holistic' approach to fire safety arguably demands equal attention to fire prevention and fire protection. Given the modern concept and definition of 'risk', it is abundantly clear that a fire risk assessment, such as is required by the Regulatory Reform (Fire Safety) Order (see Chapter 1), requires consideration of fire hazards and their prevention as well as fire protection measures.

Prevention of specific causes of fire

Arson

Protection against arson (referred to in Scotland as wilful fire raising) involves measures that afford a high degree of security. While it is commonly believed that fire safety and security directly conflict because of the possible detrimental effects of security measures on means of escape (see Chapter 7), good security is itself a fire prevention measure. Excellent guidance on the security of buildings is given in BS 8220.[1] Common security measures that are relevant to prevention of arson include the following.

a) Secure boundaries to prevent intruders. In the case of a site, this involves the provision and maintenance of fences of adequate height and physical strength. For buildings, there is a need for all doors to be capable of being securely fastened against access from the outside. This includes fire exits, for which suitable exit devices, such as panic bars, should be provided on the inside of the door. Security of windows should also be addressed.
b) Access control, to ensure that only authorized personnel enter the premises, that they can only do so via supervised entry points and that they are properly identifiable. High-risk areas within any site should be the subject of additional control.
c) Security lighting, particularly in the case of open yards or large sites with open spaces between the perimeter fence and the buildings on site.
d) Intruder alarms, to ensure that occupants may be alerted and the police summoned (usually by an alarm receiving centre) if unauthorized access to the premises is gained. For a large site or building, CCTV monitoring might also be appropriate.
e) Periodic patrols, either by on-site security personnel or by a third-party guarding company.
f) Vigilance by staff, who should be aware of the need for security measures and be encouraged to challenge persons whom they consider may be unauthorized.

In assessing the risks, attention should not be paid exclusively to the large and dramatic fire – for example, in a computer room even the most minor occurrence can have potentially disastrous results.

In addition to these security measures, general good housekeeping contributes to the reduction of risk. Arsonists require fuel and are unlikely to bring this with them. Frequently, combustible waste and rubbish present a convenient fuel. These can be denied to an arsonist by their regular removal and proper disposal.

Combustible goods, timber pallets, rubbish bins or skips, etc., should not be stored close (e.g. within 6 m, or preferably 10 m for larger items such as skips) to a building. An arsonist could, without even having to enter the building, start a fire that ultimately destroys the building. In one fire, in which a supermarket was seriously damaged outside working hours, the item first ignited was simply a rubbish bin, located adjacent to an external wall under overhanging eaves. The fire spread into the building via the eaves and into an undivided roof void, through which it then spread. If combustible storage must remain in the open, it should be stored well away from any buildings.

Flammable liquids are very useful to an arsonist as accelerants. All flammable liquid stores should be kept secure. Only quantities sufficient for the working period should be allowed in the workplace, with any excess liquid being removed and replaced in the secure store at the end of the working day.

It has been assumed, so far, that a potential arsonist is always an outsider. While this will normally be the case, there is also a need for precautions against arson by employees or others, such as outside contractors, with a genuine need to be on the premises. Arson by disgruntled employees or ex-employees, for example, is a genuine threat. This is more difficult to control but highlights the need for proper vetting of employees and following up of references. It should also be ensured that facilities for access by an employee cease as soon as the employee leaves the service of the company.

Management should analyse, and remain aware of, the extent of the threat of arson to their company. This will vary from one organization to another, and depend on factors such as:

a) *The nature of the organization*. Large, faceless, establishment-type organizations may be seen as a more legitimate target than a small local family business. Schools are a particular target for vandals, who may set fire to the premises. In the past, maliciously started school fires were regarded as a threat to property, rather than life, as such fires almost invariably occurred at night. However, there is a worrying and growing trend for such fires to occur while schools are in use.
b) *The activities of the organization*. Potential target organizations are, for example, those associated with experiments on animals or trading in animal products, those with financial interests in, or major trading relations with, certain foreign countries whose policies are strongly opposed by radical pressure groups, etc., and those in some areas of the defence industry. Also, one can never discount arson as a means of industrial sabotage.
c) *The 'softness' of the target*. Certain types of premises are inherently more vulnerable than others. The bus-operating industry, for example, periodically suffers a major loss, invariably due to ignition of seats within parked vehicles. Bus garages are often difficult to secure because there is a need for regular access for vehicles until late at night, and it is common for large numbers of vehicles to be parked in such close proximity that fire can spread readily from one vehicle to another.
d) *Labour relations*. An organization with good industrial relations is likely, by definition, to have fewer disgruntled employees.
e) *Geographical location*. Premises in inner city areas are often at greater risk. More generally, there is a wide variation in the risk of arson in different

parts of the country. For example, a study of fires that occurred in 1997 showed that, in that year, 55 per cent of fires in Tyne and Wear were the result of deliberate ignition, whereas, in the Highland and Islands region of Scotland, the figure was 15 per cent.

f) *Admission of the public*. Public buildings, such as places of entertainment and retail premises, suffer much more from the problem of arson than buildings from which the public are excluded.

Liaison with the local police can assist in an awareness of the potential threat, and assist management in formulating an appropriate level of protection. The specialized nature of security will often require expert advice on the subject of both physical and electronic security measures. Advice should be sought from the crime prevention officer of the local police force and the company's insurers and insurance brokers. Advice may also be obtained from specialist consultants, who may be able to offer more in-depth guidance on certain matters.

Electrical faults

Much can be done to prevent fires of electrical origin without an in-depth knowledge of electrical engineering. Fires of electrical origin can be divided into three groups, according to whether they involve:

1. the fixed, permanent electrical installation in the building;
2. temporary wiring and leads to portable electrical appliances;
3. electrical appliances.

A modern electrical installation, installed and maintained in accordance with good practice, should not present a risk unless it is abused, inadequately modified or mechanically damaged. It is important, therefore, that all installation work, including the design of any new installation or modifications to an existing installation, conforms to the relevant edition of BS 7671[2] (equivalent to the Institution of Electrical Engineers Regulations for Electrical Installations – currently the 16th edition and commonly still known as the 'IEE Wiring Regulations'). Contrary to the implications of the title, BS 7671 has no statutory force, although, in Scotland, compliance will ensure that the requirements of the Building (Scotland) Regulations in respect of safety of electrical installations are satisfied.

Compliance with the Regulations (in the case of installations to which they apply) would be likely to prove that the relevant requirements of the Electricity at Work Regulations 1989[3] have been satisfied. Compliance with the Regulations is also deemed to satisfy the requirements of the Electricity Supply Regulations 1988,[4] which prohibit an electricity supply being provided to a consumer unless the installation is safe. The Wiring Regulations are primarily concerned with safety, particularly in respect of protection against fire and electric shock.

Electrical fires may be started by any of the following.

a) Overloading of cables by currents that the cables are not designed to carry; the cables then overheat, and the life of the insulation is shortened. This may occur because the current required by the appliances connected to the installation will, when the appliances operate normally, demand too much current. Abnormal conditions, such as an excessive mechanical load on a motor, or faults in equipment, can also be a cause of overload.
b) Short circuit of conductors due to, for example, mechanical damage to insulation; the vast currents that may then flow may be thought of as a very extreme case of overload, and the heat that results will cause combustible insulation to burn.
c) Leakage of current to earth, due to failure of the cable insulation.
d) Loose connections, which result in local overheating of components, cables or combustible materials.
e) Arcs and sparks that result from electrical faults.
f) Overheating due to bunching of several cables or the presence of thermal insulation; the cable insulation may then deteriorate and a fire can result.

An important part of the Wiring Regulations is devoted to avoidance of fires, using fuses or miniature circuit breakers to protect against the overcurrents that arise from overload or short circuit. The Regulations require that the currents at which these devices will isolate the circuit must be matched to the current-carrying capacity of cables. The maximum current that the Regulations permit a cable of a particular size to carry is related, in part, to the maximum temperature at which the insulation will be safe (although there are also constraints on voltage drop along the cable).

De-rating (i.e. reduction of the maximum permissible current that the cable may carry) is required where semi-enclosed (rewirable) fuses are used as protection against overcurrents; these devices are slower to operate than cartridge fuses or miniature circuit breakers. De-rating of cables is also required if the cables are surrounded by thermal insulation, because heat produced in the cable cannot be readily dissipated. It should also be noted that PVC insulated cables should not be laid in contact with polystyrene (sometimes used for thermal insulation) as the plasticizer will migrate from the PVC, causing the insulation to become brittle and a hazardous situation to result.

Electrical switchgear and distribution boards should be regarded as a potential source of ignition. Accordingly, combustible materials should be kept clear of such equipment. Small enclosures designed specifically to house electrical distribution equipment should not be used for storage, particularly of combustible materials. In large cupboards designed for storage, but housing electrical-distribution equipment, a clear space of at least 500 mm, but preferably 1 m, should be maintained between the equipment and storage or other combustible materials. Cupboards containing electrical-distribution equipment should not be used to store highly flammable liquids, flammable gases or aerosols.

Residual current devices

Fuses and miniature circuit breakers cannot protect against the leakage of very small currents between the cable conductors and earth. This may occur due to minor cable damage or the onset of failure of the cable insulation. Such small currents can cause local overheating and a fire. However, the circuit protection will only be tripped when sufficient current is drawn to cause adequate overcurrent. Nevertheless, it is possible to protect against small earth leakage currents by means of a residual current device (RCD). This device compares the current in the neutral and live conductors of a single-phase circuit; these currents should be the same under normal circumstances. Any 'out of balance' current represents leakage to earth. At a predetermined value of this current, the RCD isolates the supply automatically.

This type of protection is required for socket outlets that are intended to supply outdoor electrical appliances, and may be used more generally to provide a high standard of protection against electric shock and fire. Devices intended to protect against the risk of shock (the most common function of the RCD) are set to operate when a leakage current of 30 mA is detected. In some installations, an RCD can, however, lead to nuisance tripping due to the normal leakage through insulation and certain electrical equipment. A higher value of tripping current, such as 100 mA, may still be adequate to protect against the risk of fire, and will be less subject to nuisance tripping. Expert advice should be sought before selecting and installing an RCD in industrial and commercial premises, etc. Where RCDs are installed, regular testing of the devices is important.

Installation and maintenance

Electrical design, installation and maintenance work should only be carried out by competent, qualified persons. The National Inspection Council for Electrical Installation Contracting (NICEIC) publishes a roll of approved contractors, who undertake to carry out work in accordance with the Wiring Regulations, and their work is subject to periodic inspection by the NICEIC. In addition, in England and Wales, the Electrical Contractors' Association (ECA) operates a guarantee scheme for the work of their member companies, whereby work that does not comply with the safety requirements of the Wiring Regulations will be rectified. A similar scheme is operated by SELECT, the equivalent trade association in Scotland.

Maintenance, inspection and testing of electrical installations contribute to fire safety. Proper maintenance of electrical installations is a legal requirement, and it should be ensured that a designated person is responsible for the installation. There should be complete records of the installation, updated when modifications take place. It is unfortunate that some companies still fail to arrange for adequate periodic inspection and testing of electrical installations. Yet this is an excellent way of ensuring that the installation remains safe by early identification of, for example, poor insulation.

Temporary installations

Installations on a construction site, and temporary installations, present a greater risk than permanent fixed installations. The wiring of such installations is likely to be more exposed to mechanical damage, and would not be supported in the same manner as a permanent installation. Appliances are also more likely to be subject to abuse. Although the Wiring Regulations do not require the same degree of support for cables in temporary installations as may be found in a permanent installation, it is still required that there be no strain on joints or terminations. Temporary installations should be inspected and tested every three months. It is important that the cables used are suitable for the environment to which they are exposed.

Electrical appliances

Leads to portable appliances are more exposed to damage than fixed wiring. The electrical installation layouts of many office buildings are often not designed for the number of appliances that are now required in the modern office. As a result, it is common to find trailing leads and multiple adaptors in these buildings. Such practices should be avoided as far as possible. Long leads create even greater exposure to damage, and multi-way adaptors increase the potential for both overload and bad connections that may lead to overheating.

This should be taken into account during safety inspections. Where the practice is found to be prevalent, consideration should be given to the installation of additional socket outlets and the use of modern cable management techniques, including readily adaptable conduit systems. If adaptors must be used, the type that comprises a portable bank of sockets, connected to a lead with a plug on the end, should be used in preference to adaptors that plug straight into a socket outlet. If cable reel extensions are used for portable tools, no cable should remain on the reel while the tool is switched on. Otherwise, overheating of the cable may result.

In the course of safety inspections, all leads to portable appliances should be checked visually. It should be ensured that the connections to plugs are tight and that the cord grip makes good contact with the outer sheath of cables, which should not be stripped back to expose the insulation of the conductors. Cables that are damaged should be replaced rather than repaired; the safety of a lead to a portable appliance should not depend on a piece of insulating tape. Joints in the cable should be avoided. If the cable is not long enough, it should be replaced with a longer cable.

Electrical appliances are themselves associated with a significant number of fires of electrical origin. Faults in the equipment are not, however, the sole cause of such fires; incorrect use of electrical equipment is also an important factor. Many types of electrical equipment produce heat when operating normally, and must be kept well clear of readily combustible materials. Electric fires are an obvious example, but precautions are also required in the case of, for example, soldering irons and incandescent light fittings. Proper stands should be provided for soldering irons, and a neon indicator light should be fitted to all sockets that are used for such sources of black heat.

Most of the electrical energy that is fed into a tungsten filament lamp is actually converted into heat and not light. A clear space must, therefore, be maintained around light fittings. Although fluorescent fittings do not create a great deal of heat, faults in the associated control gear can lead to a fire; these should, therefore, be mounted on a non-combustible surface, and combustible materials should not encroach close to the fittings. Some equipment, such as motors, must be continuously ventilated to prevent a rise in temperature; ventilation must not be obstructed.

All electrical equipment should be kept clean, and not be permitted to come into contact with grease, oil, waste materials, etc. There should be a proper maintenance schedule for all items of electrical equipment. Employees should, generally, not be permitted to bring their own electrical appliances, such as heaters, radios, etc., into the premises. If the use of personal electrical appliances is permitted, they should first be checked for safety and compliance with relevant standards, and should be subject to the same maintenance as other electrical appliances in the building. All equipment should be switched off at the end of the working day unless its continued operation is essential. It is often recommended that equipment is also unplugged, but this is probably somewhat purist, and it could equally be argued that constant unplugging and plugging of electrical appliances causes wear on plugs and sockets, and, if plugs are not gripped carefully, strain on the cable terminations.

The practice of switching off appliances, however, applies even if the equipment itself is considered to be of low risk, as many appliances are. In areas such as workshops that contain a large amount of electrical test equipment, or rooms that contain numerous appliances, such as visual display units, a single local isolator should be provided so that all appliances can be simultaneously switched off. All equipment should be subject to a brief visual inspection during the course of any safety audits.

The standard of portable electrical appliances in industrial and commercial buildings has been enhanced by the portable appliance testing (PAT) programmes that are now generally in place to satisfy the safety requirements of the Electricity at Work Regulations 1989. Although the primary objective of portable appliance testing is protection against electric shock, even the simple visual inspection of leads and plugs makes a contribution to prevention of fire.

Smokers' materials

It has been common for many years for smoking to be prohibited in many places of work purely on health grounds. Now, smoking is prohibited, under legislation, in all public enclosed spaces, with few exceptions. (For example, in hotels and residential care premises, people may smoke in their own rooms. In day rooms in residential care premises, residents are often permitted to smoke, although staff and visitors are prohibited from doing so.)

Even before the legislative requirements to prohibit smoking in premises, prohibition of smoking in workplaces had grown in parallel with concern regarding potential liability for damage to health from 'passive smoking'. It had also been held by an industrial tribunal that a ban on smoking was not unfair since the right to smoke at work was not a fundamental right or indeed an implied term of the contract of employment.

Prohibition of smoking in workplaces is one factor contributing to the contrast between statistics on fires caused by smokers' materials in domestic dwellings and those in non-domestic buildings. In the 17 years from 1988 to 2005, the number of such domestic fires dropped significantly from 10,700 to 3,900. (These figures include fires caused by children playing with matches, which result in numerous domestic fires.) However, over the same period in non-domestic buildings, the number dropped much more dramatically from 7,200 fires in 1988 to just 1,700 fires in 2005. Although a change in the recording of fire statistics in 1994 did result in some fires being removed from this category and recorded, instead, as malicious, the downward trend over the 17 years is clear (see Figure 6.1).

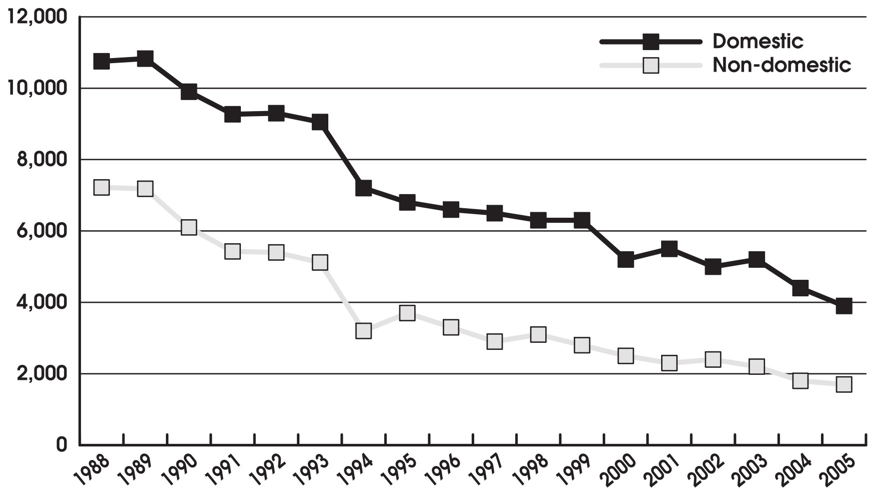


Figure 6.1 Number of fires caused by smokers' materials and matches in domestic and non-domestic buildings

Carelessly discarded cigarettes, cigars, pipe tobacco and matches are all capable of starting a fire, but cigarettes are a greater risk than cigars and pipes. Cigarette lighters are safer than matches, simply because no discarded materials are involved. Ignition of various solid combustible materials by smokers' materials is possible, although, other than in the case of a match that is burning, there is unlikely to be immediate flaming, but rather smouldering that can undergo a transition into flaming after some time. However, a cigarette can act as an immediate source of ignition for highly flammable vapours or gases.

It must be accepted, however, that some people find it very difficult to abstain from smoking for prolonged periods. Now that there is widespread prohibition of smoking in premises, there is a danger of surreptitious smoking, which is likely to occur in the worst possible locations, namely those that are out of sight and in which, therefore, a fire may develop without discovery. To avoid this, designated smoking areas, often in the open air, may be provided. To encourage compliance with prohibition of smoking in the premises, sometimes a form of shelter, akin to a bus shelter, is provided outside the building.

Heating

It will be recalled from Chapter 3 that central heating installations appear to cause fewer fires than local heating appliances. Fixed heating installations are safer than portable heaters, which should be avoided if at all possible. Electrical installations supplying electric heaters should comply with the Wiring Regulations and should he installed by competent persons. Gas appliances should be installed in accordance with the Gas Safety (Installation and Use) Regulations 1998,[5] which do not apply to factories but may be used as general guidance for installations in factories. The appliances should be installed by a contractor registered with the Confederation for the Registration of Gas Installers (CORGI). The Regulations require that, in places of work, all gas appliances, pipework and flues are maintained in a safe condition, in effect necessitating periodic inspection and testing, which should be in accordance with CORGI codes of practice. In residential premises, landlords must ensure that appliances and flues are checked annually.

Sensible use of heating appliances could do much to prevent fires. A clear space should be kept around all sources of heat, so that combustible materials cannot be ignited and there is free circulation of air. Adequate guards may be required to ensure this. There should be no combustible construction in close proximity to hot flue pipes. Local appliances should be fixed to a non-combustible surface. Any heating appliances in areas in which flammable liquids or gases may be present should be of a suitable type.

If portable heaters must be introduced for short-term heating problems, radiant heaters should be avoided. Heaters should be sited where they cannot be overturned or mechanically damaged, and be positioned on a non-combustible surface well clear of any combustible materials. All heating appliances should be subject to regular inspection and maintenance. Staff should not be permitted to bring their own heating appliances into the premises.

Cooking

Sensible use of cooking appliances is necessary if fire hazards are to be minimized. Appliances should never be left unsupervised, and staff should be properly trained in the use of the appliances and action in the event of fire. The kitchen should be kept clean, and build up of grease deposits should not be permitted. A clear space should be kept around each appliance and, in particular, between deep fat fryers and other appliances. There should be clearly labelled facilities to shut off power, fuel and air extraction in an emergency.

Electric appliances should be installed by a competent person, such as an NICEIC-approved contractor, in accordance with the Wiring Regulations. Gas appliances should be installed in accordance with the Gas Safety (Installation and Use) Regulations and BS 6173,[6] by a CORGI-registered installer. All appliances should be regularly inspected and maintained.

Grease filters, extract ductwork and grease traps should be subject to regular cleaning. Often, although filters are changed regularly, there is insufficient attention given to 'deep cleaning' of ductwork. A fire, for example, in a deep fat fryer can then spread throughout the ductwork, where there are thick layers of grease deposits. Guidance produced on behalf of the Association of British Insurers (ABI)[7] gives recommendations on the frequency at which deep cleaning should be carried out according to the number of hours of use of cooking equipment each day.

Deep fat fryers should be regarded as a particular hazard, as these are a common cause of cooking fires in non-domestic premises. As well as thermostats with a maximum setting of 205 °C, there should be a high temperature cut-out in case of thermostat failure. Grease traps should be fitted to any low-level ductwork. There should be a facility to shut down the lids of fryers in the event of a fat fire. The risk of a fire associated with deep fat fryers is such that consideration should be given to a fixed manual/automatic fire extinguishing system (see Chapter 14).

Contractors' operations

Carelessness by outside contractors is a common cause of fire, including many fires that result in serious financial loss. In Chapter 3, cutting, welding and use of blowlamps were identified as particular sources of ignition. Not all of these fires would have been caused by outside contractors. It has been estimated, however, that perhaps 20 per cent–25 per cent of all non-domestic fires result from 'ongoing work', such as refurbishment, repair and construction.

In 1990, a major fire occurred in part of the Broadgate development in London during the final stage of its construction programme. This fire, which, it has been suggested, resulted in one of the largest insurance claims in Europe for 10 years, is believed to have started in a subcontractor's office facility. A report on the fire by the Steel Construction Institute concluded that many more fires occur in temporary accommodation on building sites than is generally recognized and that comprehensive guidance on fire precaution measures, adopted during the construction phase, were required as a matter of urgency.

The range of hazards that contractors may, directly or indirectly, introduce to a building encompass most, if not all, of those discussed in this book so far. They include:

a) flammable liquids, such as adhesives, paints, thinners, timber preservatives;
b) flammable gases, such as acetylene and liquefied petroleum gases;
c) hot work, such as cutting, welding and use of blowlamps;
d) temporary electrical installations;
e) combustible materials, sometimes finely divided, e.g. sawdust and wood shavings;
f) careless disposal of smokers' materials by the workforce;
g) exposure to arson due to breaches in physical security;
h) burning of waste;
i) temporary heating appliances;
j) temporary lighting;
k) temporary buildings, partitions and screens of combustible construction;
l) tar boilers.

The hazards are exacerbated in buildings that are undergoing construction or major refurbishment, in which there may be incomplete floors and walls, inadequate fire stopping, incomplete means of escape and unserviceable fire alarm and sprinkler systems.

Fire safety requirements should form an integral part of the contract between a client and contractor. Ideally, a company should produce its own standard fire precautions for use in all contracts. Companies that have no such conditions may wish to cite *Standard Fire Precautions For Contractors Engaged On Crown Works*,[8] which is used within central government bodies and is available from HMSO. The Fire Protection Association publishes guidance in the form of *Fire Prevention on Construction Sites*.[9] In addition, an HSE publication, *Fire Safety in Construction Work*,[10] provides guidance, primarily on life safety, as opposed to property protection.

Contract conditions should cover matters such as:

a) *Waste removal*: all combustible wastes should be removed regularly to a safe place away from the building; burning of waste should take place at a safe distance from the building.
b) *Flammable liquids*: bulk stocks should be kept in a suitable secure location, outside the building. Quantities stored inside the building should be kept to a minimum and should be stored in metal lockers. Highly flammable liquids and petroleum spirits should be stored in accordance with the relevant regulations.
c) *Temporary partitions*: these should preferably be constructed of non-combustible materials or materials that have a low surface spread of flame (see Chapter 8).
d) *Gas cylinders*: these should be stored in a secure compound outside the building. Cylinders should be kept in the upright position at all times, and be removed from the building at the end of the working day. Liquefied petroleum gas (LPG) should not be introduced into basement areas.
e) *Hot work*: a permit-to-work should be required for all hot work, such as cutting, welding and the use of blowlamps. A sample of a permit that is available from the Fire Protection Association is reproduced in Figure 6.2. The permit is signed by an authorized person only after ensuring that the work cannot be carried out off site, that the proposed location is safe and that all suitable precautions have been implemented. The area should be checked again on completion of the work, and 30–60 minutes following completion. Areas in which work is to take place should be kept clear of combustible materials as far as possible. Remaining combustible materials should be protected with non-combustible screens or covers, and all holes

in the surrounding construction should be protected to prevent entry of sparks. If possible, two persons should be present at all times, at least one of whom should have training in first aid fire-fighting. Fire extinguishers or hose reels should be kept at hand. Flashback arrestors should be fitted to the cylinders of cutting and welding equipment.

f) *Tar boilers*: tar boilers should be kept away from combustible materials and never be left unattended. There should be a permit-to-work system for their use, and the area should be provided with ample fire extinguishing appliances. Tar boilers should not be used on roofs unless absolutely necessary.
g) *Workmen's huts*: these should be kept well away (e.g. at least 10 m) from buildings if possible, and an adequate clear space should be maintained between huts. Spaces beneath huts should be enclosed so that rubbish cannot accumulate below.
h) *Temporary electrical installations*: these should comply with the relevant requirements of the Wiring Regulations, and be inspected and tested every three months.
i) *Temporary lighting installations*: lamps designed for installation in the pendent position should not be installed in an upright position. All lamps should be kept well clear of any adjacent combustible materials.
j) *Temporary heaters*: these should be removed when not required. When present, they should be installed on non-combustible surfaces. General space heaters should preferably be fixed in position and kept clear of any combustible materials.
k) *Security*: it should be ensured that security is maintained during contractors' operations.
l) *Combustible materials and packaging*: these should be stored in a suitable location, preferably in a hut at least 10 m away from the building under construction/renovation.

The above precautions are not intended to be exhaustive, and, if formulating detailed contract conditions, the reader is advised to consult the guidance documents referred to above.

HOT WORK PERMIT

ISSUING COMPANY ______________________ PERMIT NO.______________

A PROPOSAL *(To be completed by the person responsible for carrying out the work)*

BUILDING ____

EXACT LOCATION OF PROPOSED WORK ______________________________

NATURE OF HOT WORK TO BE UNDERTAKEN ____________________________

The above location has been examined and the precautions listed on the reverse side of this form have been complied with as indicated.

SIGNED ______________________ NAME (BLOCK CAPITALS) ______________________

DATE ______________________ POSITION ______________________

CONTRACTOR (WHERE APPLICABLE) ______________________________

B AGREEMENT *(To be completed by the company fire officer or other nominated person)*

This Hot Work Permit is issued subject to the following conditions:

TIME OF ISSUE OF PERMIT ______________ TIME OF EXPIRY OF PERMIT * ______________

A FINAL FIRE CHECK OF THE WORK AREA SHALL BE MADE, NOT BEFORE ______________

ADDITIONAL CONDITIONS REQUIRED:- ______________________________

____

SIGNED ______________________ NAME (BLOCK CAPITALS) ______________________

DATE ______________________ POSITION ______________________

C FIRE WATCH *(To be completed by member of staff or contractor responsible for the work before returning this permit to the issuer)*

The work area and all adjacent areas to which sparks and heat might have spread (such as floors below and above, and areas on other sides of walls) have been inspected and found to be free of fire following completion of the work.

TIME INSPECTION COMPLETED ______________________ *(This must be at least 1 hour after work was completed)*

SIGNED ______________________ NAME (BLOCK CAPITALS) ______________________

DATE ______________________ POSITION ______________________

CONTRACTOR (WHERE APPLICABLE) ______________________________

* It is not desirable to issue permits for protracted periods. Fresh permits should be issued, for example, where work extends from morning to afternoon.

NB Where work is being carried out by a contractor, the issuer of the permit should ensure that the contractor has complied with the requirements prior to work being carried out, and should be satisfied that the area is free of fire when work is completed.

Figure 6.2a Typical hot-work permit (available from the Fire Protection Association)

HOT WORK PERMIT CHECK-LIST

CAN THIS JOB BE AVOIDED? IS THERE A SAFER WAY?

FIRE PROTECTION

(1) Where sprinklers are installed they are operative. ☐

(2) A trained person not directly involved with the work will provide a continuous fire watch during the period of hot work and for at least one hour after it ceases, in the work area and those adjoining areas to which sparks and heat may spread. ☐

(3) At least two suitable extinguishers or a hose reel are immediately available. Both the personnel undertaking the work and providing the fire watch are trained in their use. ☐

(4) Personnel involved with the work and providing the fire watch are familiar with the means of escape and method of raising the alarm/calling the fire brigade. ☐

PRECAUTIONS WITHIN 10 METRES (MINIMUM) OF THE WORK

(5) Combustible materials have been cleared from the area. Where materials cannot be removed, protection has been provided by non combustible or purpose made blankets, drapes or screens. ☐

(6) Flammable liquids have been removed from the area. ☐

(7) Floors have been swept clean. ☐

(8) Combustible floors have been covered with overlapping sheets of non-combustible material or wetted and liberally covered with sand. All openings and gaps (combustible floors or otherwise) are adequately covered. ☐

(9) Protection (non combustible or purpose made blankets, drapes or screens) has been provided for:

- Walls, partitions, and ceilings of combustible construction or surface finish ☐
- All holes and other openings in walls, partitions and ceilings through which sparks could pass. ☐

(10) Combustible materials have been moved away from the far side of walls or partitions where heat could be conducted, especially where these incorporate metal. ☐

(11) Enclosed equipment (tanks, containers, dust collectors etc) has been emptied and tested, or is known to be free of flammable concentrations of vapour or dust. ☐

EQUIPMENT

(12) Equipment for hot work has been checked and found in good repair. ☐

(13) Gas cylinders have been properly secured. ☐

(The person carrying out this check should tick the appropriate boxes.)

LPC

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Figure 6.2b Typical hot-work permit (available from the Fire Protection Association)

Industrial processes

The measures previously discussed would, if successful, contribute to the elimination of around 85% of all fires in non-domestic premises. However, in industrial premises, this figure drops to 60 per cent of all fires. The reason for this is that many industrial processes give rise to fire hazards. Many of these hazards are unique to individual industries, and can only be addressed in terms of specific process controls.

However, some hazards are common to a number of industrial operations. These include:

a) shrink wrapping;
b) battery charging;
c) paint spraying;
d) heat treatment;
e) drying;
f) use of flammable liquids and gases;
g) presence of combustible dusts.

Quite detailed fire prevention guides are available for such hazards. In addition, codes of safe practice are available for specific industries and commercial occupancies. The Fire Protection Association produces a large number of guidance documents, which are applicable to most of the common risks described and to some specific occupancies, such as offices and retail premises. Other useful guidance documents include those produced by the Health and Safety Executive and by industry trade associations. Consideration of industrial process hazards is outside the scope of this book. However, it should be borne in mind that basic good housekeeping can make a contribution to reducing the fire risk in even the most high-technology industries.

The contribution of furniture and furnishings to fire prevention

In approximately 8 per cent of non-domestic fires, the materials that ignite first comprise furniture and furnishings, floor coverings, blinds, upholstery, bedding and textiles. Although not a high percentage, it is similar to the number of fires in which flammable liquids and gases constitute the item ignited. Furthermore, it is comparable with the number of fires that involve ignition of the building structure and fittings – even though the fire performance of building elements is much more strictly controlled than that of furniture and furnishings.

There is, therefore, a good case for controlling the ignitability and flammability of furniture, furnishings, etc., particularly as legislative control is only exercised over these items in a very limited number of premises, such as places of entertainment. In the case of existing furniture and furnishings, it may be difficult to assess, or indeed modify, the fire performance. However, purchasing specifications for new goods should always include requirements on fire performance.

Domestic furniture flammability has received much attention in recent years because of its role in domestic fire deaths, and is controlled by the Furniture and Furnishings (Fire) (Safety) Regulations 1988, as amended. These impose requirements on the flammability of domestic furniture and beds. However, the Regulations do not apply to non-domestic furniture. There is a need, therefore, for the purchaser to specify appropriate requirements, see BS 7176[11] and BS 7177.[12]

BS 7176 and BS 7177 divide occupancies into four hazard classes – low, medium, high and very high. Ignition resistance performance is specified for each hazard class by reference to the tests contained in BS 5852[13] or, in the case of bedding, BS 6807.[14] Advice is contained in BS 7176 and BS 7177 on likely classifications of occupancies, such as offices, hotels, public buildings, hospitals, schools, etc. Factors to take into account in final classification of premises are also outlined. These include:

- whether or not people sleep in the premises;
- the level of occupancy;
- the presence of automatic fire protection systems;
- the presence of special hazards;
- the location of the hazard area;
- the effectiveness of staff control over evacuation;
- the ability of occupants to escape unaided.

If ignition resistance is imparted by chemical treatment, it is necessary to ensure that this is resistant to cleaning processes.

It is possible to specify fire performance characteristics for other items of furniture and furnishings by reference to various British Standard, and other, tests. However, in the case of tests for which results are not expressed as a simple pass/fail, there is less guidance on the level of performance that should be specified, than in the case of furniture and bedding. The appropriate standards to which reference should be made in purchasing specifications are as follows.

a) *Bedcovers and pillows*: BS EN ISO 12952 (all parts)[15] specify test methods for the ignitability of bedding items by a smouldering cigarette (1 and 2) and a small open flame (3 and 4). In addition, BS 7175[16] uses the ignition sources of BS 5852 to assess the ignitability of pillows, quilts, mattress cases and covers, sheets, pillowslips, blankets, bedspreads and quilt covers – individually and in combination.
b) *Curtain materials and blinds*: BS 5867-2.[17] This standard gives three sets of performance criteria by reference to tests specified in BS 5438.[18] The standard relates to the fabric from which curtains and blinds are made.
c) *Carpets*: Two tests exist: BS 4790[19] and BS 6307.[20] A further standard, BS 5287,[21] sets out the requirements for a carpet to be described as low radius of effects of ignition when tested in accordance with the hot metal nut method.

Excellent guidance on fire performance of furniture and furnishings for hospitals is contained in *Health Technical Memorandum* (HTM) 05-03 Part C (Firecode: textiles and furnishings), produced by the Department of Health. This guidance document recommends performance levels and safety measures for the complete range of furniture and furnishings that may be found in a hospital. The guidance can also be of assistance in other occupancies where high fire safety standards for furniture and furnishings are required.

Further reading

Fire prevention in any occupancy is largely related to the activities associated with the occupancy. Attention is, however, drawn to the publications of the Health and Safety Executive and those of the Fire Protection Association, the latter of which can be purchased as a several volume 'Library of Fire Safety'. Details of Fire Protection Association publications can be found at http://www.thefpa.co.uk. A number of industry trade associations also produce documents on safety.

References

1. BS 8220 (all parts), *Guide for security of buildings against crime*
2. BS 7671, *Requirements for electrical installations — IEE Wiring Regulations — Sixteenth edition*
3. GREAT BRITAIN. Electricity at Work Regulations 1989. London: HMSO.
4. GREAT BRITAIN. Electricity Supply Regulations 1988. London: HMSO.
5. GREAT BRITAIN. Gas Safety (Installation and Use) Regulations 1998. London: HMSO.
6. BS 6173, *Specification for installation of gas-fired catering appliances for use in all types of catering establishments (2nd and 3rd family gases)*

7. *Fire Risk Assessment*, Catering Extract Ventilation. Association of British Insurers. Published by BSRIA.
8. GREAT BRITAIN. Standard Fire Precautions for Contractors Engaged on Crown Works. London: HMSO.
9. *Fire Prevention on Construction Sites*. Fire Protection Association.
10. *Fire Safety in Construction Work*. Health and Safety Executive.
11. BS 7176, *Specification for resistance to ignition of upholstered furniture for non-domestic seating by testing composites*
12. BS 7177, *Specification for resistance to ignition of mattresses, divans and bed bases*
13. BS 5852, *Methods of test for assessment of the ignitability of upholstered seating by smouldering and flaming ignition sources*
14. BS 6807, *Methods of test for assessment of the ignitability of mattresses, upholstered divans and upholstered bed bases with flaming types of primary and secondary sources of ignition*
15. BS EN ISO 12952 (all parts), *Textiles – Burning behaviour of bedding items*
16. BS 7175, *Methods of test for the ignitability of bedcovers and pillows by smouldering and flaming ignition sources*
17. BS 5867-2, *Specification for fabrics for curtains and drapes — Flammability requirements*
18. BS 5438, *Methods of test for flammability of textile fabrics when subjected to a small igniting flame applied to the face or bottom edge of vertically oriented specimens*
19. BS 4790, *Method for determination of the effects of a small source of ignition on textile floor coverings (hot metal nut method)*
20. BS 6307, *Method for determination of the effects of a small source of ignition on textile floor coverings (methenamine tablet test)*
21. BS 5287, *Specification for assessment and labelling of textile floor coverings tested to BS 4790*

7

Means of escape

The term 'means of escape' is defined in many codes of practice as: *structural means whereby a safe route(s) is provided for persons to travel from any point in a building to a place of safety*. Means of escape is, therefore, the most fundamental of those fire precautions required for safety of life, and must be planned at an early stage in the design of a building. It should be noted from the definition that means of escape comprises structural measures; a lift, for example, could not be regarded as an adequate means of escape, at least for able-bodied people, even if the lift were designed for operation in the event of a fire. Similarly, lowering lines, folding ladders and chutes are not generally acceptable and do not, by definition, constitute adequate means of escape.

Normally, 'a place of safety' will be the open air beyond the building. It is not adequate for occupants to discharge from the building into an adjoining alleyway or small yard, from where there is no escape, and in which the occupants remain at risk.

Traditionally, the above definition sometimes ended with words that implied 'without outside assistance', although such words do not generally appear in the latest definitive fire safety codes. These words were intended to convey the meaning that rescue by the fire and rescue service should be discounted when planning means of escape from fire. This principle still applies, regardless of whether the words appear in the definition. Were it not to do so, the safety of occupants of a building would vary according to whether the building were located in an urban area or a remote rural location, and design principles would need to vary accordingly, which is not a logical situation.

There are at least three practical implications of the above principle. Firstly, escape onto flat roofs, or similar structures, from which there is no route to street level, other than rescue by ladder, does not constitute means of escape in the modern sense of the term, although many years ago it might have been accepted in some situations.

Secondly, windows do not constitute means of escape, except in very limited situations, such as may be acceptable under building regulations in the case of alternative means of escape from certain rooms in single- or two-storey dwellings and in small loft extensions to dwellings.

Thirdly, means of escape for disabled people should not rely on rescue of disabled occupants by the fire and rescue service, although, in this case, in a building of two or more storeys, primary means of escape may comprise a suitably designed evacuation lift, subject to the existence of alternative means of escape via stairways. Means of escape for disabled people is discussed later (see p. 143).

First principles of means of escape

The most fundamental principle of escape route design is that, ideally, people should be able to turn their back on a fire, and walk away from it towards safety wherever practicable (see Figure 7.1).

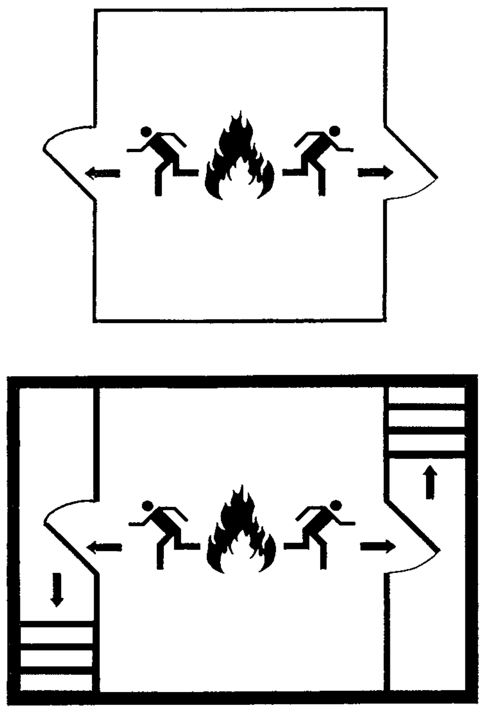


Figure 7.1 First principles of means of escape

It should be noted immediately that this will not be practicable in a small room, in a building with only one stairway, or within a corridor that is a 'dead end', or indeed in any other circumstances where dead ends exist (see Figure 7.2).

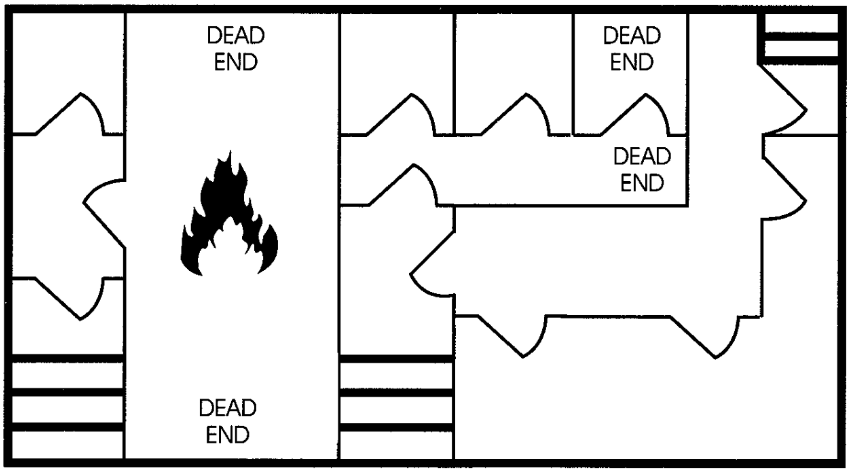
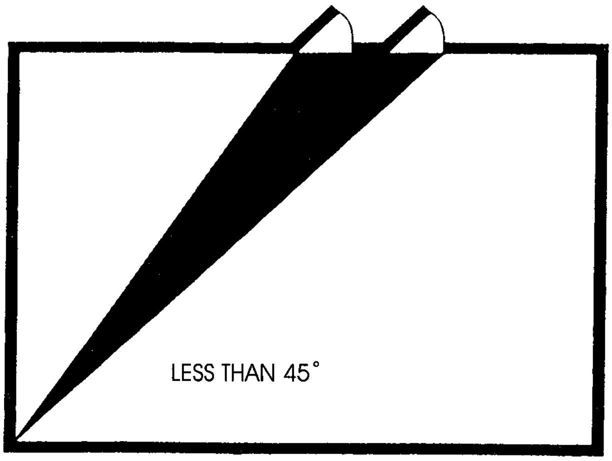


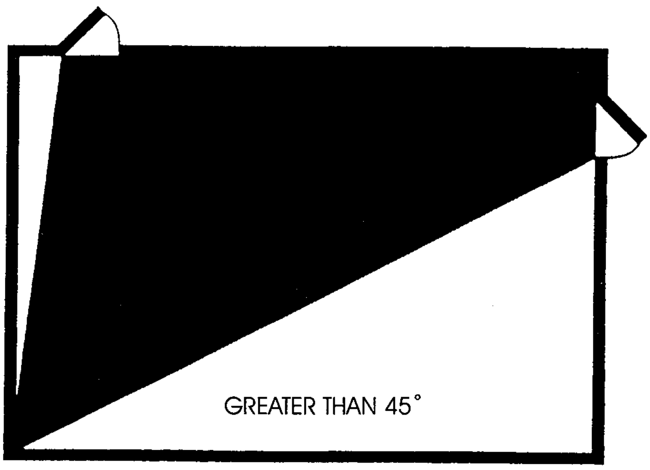
Figure 7.2 'Dead ends'
(these are only acceptable in certain circumstances and are subject to special requirements – see text)

Escape in only one direction should be avoided where practicable, but is acceptable in limited circumstances. However, to avoid the risk that a person's escape route may be cut off by the fire, an alternative escape route should generally be available. Alternative escape routes are generally defined as: 'Escape routes sufficiently separated by either direction and space, or by fire-resisting construction, to ensure that one is still available should the other be affected by fire.'

In a room or storey of a building, in which escape routes are not physically separated by fire-resisting construction, two exits are only considered to be sufficiently separated by direction to be alternatives if, from any point, the angle between the exits is at least 45° ('the 45° rule'). In order to understand the reason for this rule, consider Figure 7.3a). The exits are very close together and should be regarded as a single exit; common sense dictates that they cannot be regarded as alternatives, as one fire could easily prevent use of both exits. Clearly, the situation is much improved in Figure 7.3b), in which the separation between the exits is acceptable. If the two exits are moved closer together, there comes a point between the two extremes at which the safety of Figure 7.3b) is replaced by the hazard in Figure 7.3a). It is convention to regard this transition as the point at which the angle between the exits from any position is 45°.



a) Top TWO EXITS – BUT NOT ALTERNATIVES



b) Bottom TWO ALTERNATIVE EXITS

Figure 7.3 The 45° rule

Escape routes must ultimately lead to a place of safety – invariably open air outside the building. However, as it may be a considerable distance between, for example, the upper storeys of a multi-storey building and open air, it is normally necessary to first reach a place of relative safety, such as a protected stairway.

Escape routes should be obvious to all building occupants, and should not be tortuous or complicated. People will be more confident in using escape routes that are part of the normal circulation routes. For example, there may be a reluctance to use an escape route through an adjoining occupancy, even though this may satisfy the requirements of legislation.

There is also a tendency for people to leave a building by the same route that they entered it. Thus, alternative escape via, for example, stairways that are not in use as normal circulation routes may satisfy legislation, but they may not, in practice, be used to an adequate extent in the event of fire, particularly by those who are unfamiliar with the building and have not received adequate instruction.

Design codes

There are a number of very detailed codes of practice for the design of means of escape. Most fall into one of the following categories:

- British Standards in the BS 5588[1] series. Various parts of BS 5588 deal with different occupancies. Many common places of work, such as offices, shops, factories and warehouses, are addressed by Part 11, but other parts deal with dwellings (Part 1), places of assembly (Part 6), atrium buildings (Part 7), disabled people (Part 8) and shopping complexes (Part 10). These codes are primarily intended for new buildings and alterations or extensions to existing buildings.
- Guidance issued by the Government in support of fire safety legislation, such as the guides produced by Communities and Local Government (CLG) in support of the Regulatory Reform (Fire Safety) Order, and the equivalent guides produced by the Scottish Executive (see Chapter 1). These provide guidance on means of escape (and other fire precautions) in existing buildings to which this legislation applies.
- Guidance produced by CLG, the Scottish Executive and the Department of Finance and Personnel in Northern Ireland, in support of the building

regulations in England and Wales, Scotland and Northern Ireland, respectively. As in the case of BS 5588 codes of practice, this guidance is intended for new building work, including material alterations and extensions to existing buildings.

- Official guidance of a more specific nature, relating to particular occupancies, such as that produced by the Department of Health on design of means of escape (and other fire precautions) in hospitals as HTM 05-02, which is part of the Department's *Firecode* suite of documents, guidance on the design of fire precautions in schools, in the form of Building Bulletin 100, produced by the Department for Education and Skills, and guidance on fire precautions in residential care homes, produced in Northern Ireland by the Department of Health, Social Services and Public Safety as HTM 84. (A similar guidance document, entitled SHTM 84, is produced in Scotland by NHS Scotland, but no equivalent document exists in England and Wales.)

This may, at first, seem a daunting list of documents, all addressing the same technical issue, namely the design of means of escape from fire. However, on closer examination, it will be noted that many of the codes are specific to particular occupancies, thereby greatly reducing the potential ambiguity as to which code should be applied to any particular building. Moreover, there is a clear distinction between, for example, the British Standard codes along with the guidance that supports building regulations on the one hand, and the other CLG or Scottish Executive guidance documents on the other; the former apply to new building work and tend to be references used by designers and building control bodies, whereas the latter apply to existing buildings and are used by fire and rescue authorities (or other authorities enforcing the legislation in existing buildings), reflecting the two different branches of legislation (see Chapter 1).

Nevertheless, there is overlap, and hence inevitably conflict, between some codes, such as the guidance that supports building regulations and BS 5588-11,[2] albeit that either should be acceptable means of satisfying the fire safety objectives enshrined in legislation. Moreover, differences in guidance on fire precautions for different occupancies often reflect differences in the ideas and opinions of different sources, rather than differences that take into account true differences between the occupancies. Furthermore, a new building rapidly becomes an existing building; while the codes for new buildings tend to be more onerous than those for existing buildings, thus acknowledging that older building stock may not meet, or be expected to meet, the latest standards for new buildings, anomalies can result at the point of overlap. For example, this can occur in calculation of exit capacities (and hence the number of persons who can be safely accommodated) within places of public assembly, such as nightclubs.

Means of escape codes were, in the past, generally very prescriptive in nature. They set down relatively rigid recommendations, although, in theory at least, there should always have been flexibility in application; the extent to which flexibility was applied by enforcing authorities was variable. The latest codes, particularly those produced in support of the legislation that applies to existing buildings, generally stress the need for flexibility. Where, for example, figures are quoted for parameters, such as travel distance (see below), the guides stress that the figures are not intended to be hard and fast; to apply them rigidly would be contrary to the principles of fire risk assessment (see Chapter 5). Equally, there is still a tendency for some officers of enforcing authorities to treat guidance as quasi-rules.

In any case, however, alternative approaches to the use of prescriptive codes can be adopted. Means of escape can, instead, be designed on the basis of a fire engineering solution (see Chapter 22). A less sophisticated, but still advanced approach, somewhat between the two main alternatives of following a prescriptive code or adopting a fire engineering solution, is given in a BSI publication, DD 9999.[3] While this document, at the time of writing, has the status of a 'Draft for Development', it will, in the near future (probably in 2008), be converted into a full British Standard and be published as BS 9999. This document uses the principles of fire engineering to permit a more flexible and holistic approach to the design of fire precautions, such as means of escape, than adopted in prescriptive codes and guidance documents, taking all relevant factors, including management standards, into account.

It is the matter of means of escape that causes the greatest contention between owners or occupiers and the enforcing authorities. A particular complaint is the absence of consistency between the requirements of one fire and rescue authority and another, and even between those of one inspecting officer and another within the same authority. Equally, it can be argued that flexibility and consistency are, sometimes, mutually exclusive. The greater flexibility now permitted within codes and guidance documents might, therefore, result, for a time, in even greater inconsistency.

Much of the detail in codes is based on experience, tradition and arbitrary limits to specified parameters, such as travel distances (see below). However, this does not detract from the fact that the existing approach to means of escape works in practice, and possibly errs on the side of safety.

While it can be argued that arbitrary limits are meaningless, it can be equally argued that it is rare for anyone to die in non-domestic occupancies that comply with such limits. The issue is, therefore, perhaps less one of safety and more one of lack of flexibility for the building designer or user.

The sections that follow concentrate on the basic principles of means of escape and ignore the differences between the detailed recommendations of the various codes, except where these differences relate to fundamental principles. It is advisable, therefore, to consult the relevant code for more detailed guidance and seek the opinion of the enforcing authority or suitably qualified fire safety specialists.

Principal aspects of design

In planning means of escape, or assessing its adequacy in an existing building, there are three major elements to consider:

1. travel distances (or, alternatively, direct distances);
2. escape route and exit capacities;
3. the number of occupants for whom means of escape must be provided.

The requirements imposed on these parameters will have a major bearing on the configuration and number of stairways and exits.

Travel distance, direct distance and exit capacity

Travel distance may be defined as the maximum distance to be travelled from any point in a building to the nearest:

a) final exit (i.e. an exit to a place of safety, normally the open air); this will be the relevant definition on a ground or entrance level of a building;
b) door to a protected stairway (see page 132); this will apply on floors above and below ground or entrance level;
c) door to an external escape route (e.g. an alleyway, balcony, bridge, walkway, flat roof, etc.).

In effect, these definitions can often be combined; the travel distance, on any storey, is usually the maximum distance between any point on the storey and the nearest 'storey exit'.

Thus, travel distance is the maximum distance that a person would have to walk to reach a place of relative safety or to reach open air, measured along the actual route they would follow. Limitation of travel distance is a relatively simple, but crude, means for minimizing the exposure of people in the unprotected part of the escape route to the effects of fire. Although travel distances in codes and guidance documents should not be applied too rigidly, they should not generally be greatly exceeded, unless, as in the case of a fire engineering solution for example (see Chapter 22), there are compensating features.

At the design stage of a building, final internal layouts and furnishings will not normally be known. It is, therefore, not possible to measure travel distances, as the exact escape route along which people will travel may not be finalized, and may become convoluted by internal partitioning, furniture, etc. Thus, codes that apply to new work offer the alternative of measuring the direct distance. Direct distance is defined as: the shortest distance from any point within the floor area, measured within the external enclosures of the building, to the nearest storey exit, ignoring walls, partitions and fittings, other than the enclosing walls or partitions of protected stairways.

Direct distance is, therefore, a form of 'as the crow flies' straight line, between the furthest point in the accommodation and the storey exit. It is conventional, if direct distance must be used in the absence of fit-out information, to limit it to two-thirds of the limit that will, ultimately, be imposed on travel distance. This permits the distance that a person may, ultimately, travel from the furthest point to the point of protection to be increased by 50 per cent as a result of partitioning and furnishings.

However, it is important to note that direct distance and travel distance are not parameters that ever need, or should, be imposed simultaneously. It is travel distance that matters. Direct distance is simply a useful concept that can be used on a transient basis, until sufficient information is available to deal with travel distances. The corollary is that, if sufficient information is available to consider travel distance, direct distance has no relevance whatsoever. The distinction between travel distance and direct distance is shown in Figure 7.4.

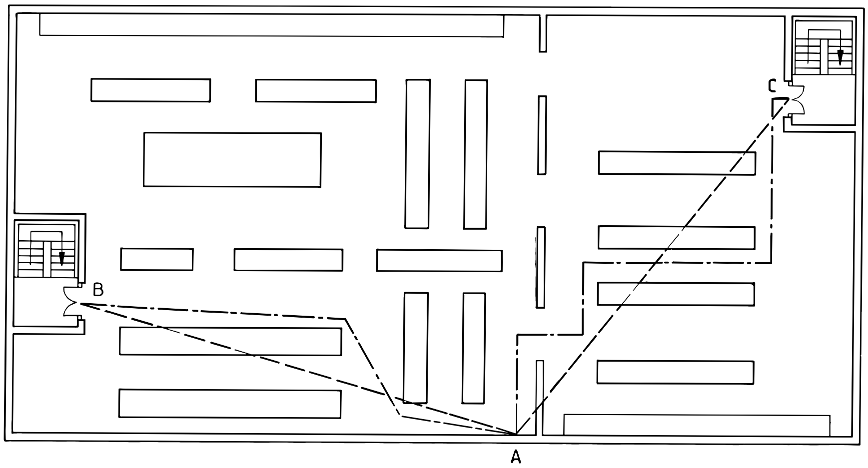


Figure 7.4 Travel distance and direct distance

The maximum permitted travel distance varies from one code to another. Within any one code, very different travel distances are normally specified according to whether there is escape in one direction only (i.e. a dead end), or alternative means of escape (escape is possible in more than one direction). In addition, different travel distances apply to areas in which the fire hazard varies from the normal hazard of the occupancy. Maximum travel distances recommended in the most popularly used codes for common places of work, such as offices, shops and factories, are shown in Table 7.1. For other occupancies, the relevant code should be consulted.

In practice, since the intent of limiting travel distance is to limit exposure of people to smoke, toxic gases and other effects of fire, it would be more appropriate to consider time, rather than distance. This is the approach adopted in a fire engineering solution. The use of time, rather than distance alone, is also inherent in the more advanced approach to means of escape incorporated in DD 9999. In a fire engineering solution, the time required for people to reach a place of relative safety after ignition of a fire, which depends only partly on the travel distance, is compared with the time available for escape following ignition.

Table 7.1 Travel distances for common places of work

Code	*Occupancy*	*Maximum travel distance (or direct distance) specified for:*	
		Escape in one direction	*Escape in more than one direction*
Approved Document B (under Building Regulations in England and Wales)	Institutional (e.g. care homes)	9 m	18 m
	Other residential (e.g. hotels, boarding houses, halls of residence, hostels)	In bedrooms: 9 m	18 m
		In bedroom corridors: 9 m	35 m
		Elsewhere:18 m	35 m
	Offices	18 m	45 m
	Shops, restaurants, public houses, etc.	18 m	45 m
	Places of assembly and recreation (e.g. dance halls, bingo halls, cinemas, sports centres, public libraries, airports and rail terminals)	Areas with seating in rows: 15 m	32 m
		Premises primarily for disabled people except schools: 9 m	18 m
		Elsewhere: 18 m	45 m
	Factories and warehouses	High risk: 12 m	25 m
		Normal risk: 25 m	45 m
	Places of special fire risk (e.g. oil-filled transformer and switchgear rooms, boiler rooms, fuel and flammable substances stores, generator rooms)	9 m special fire risk within the room	18 m, special fire risk within the room
	Plant rooms or roof-top plant	Distance within room: 9 m	35 m
		Escape route not in open air (overall distance) 18 m	45 m
		Escape route in open air (overall distance): 60 m	100 m

Code	*Occupancy*	*Maximum travel distance (or direct distance) specified for:*	
		Escape in one direction	*Escape in more than one direction*
BS 5588-11	Buildings other than industrial, storage and laboratory buildings (i.e. offices, shops)	18 m[A)] (12 m)	45 m[A)] (30 m)
	Ancillary accommodation (e.g. rooms containing hazards such as boilers, transformers, switchgear, fuel storage, generators)	High-hazard areas[A)] 12 m	25 m
		Other areas 25 m	45 m
	Industrial, storage buildings and laboratories	Low hazard[B)] 45 m (30 m)	60 m (40 m)
		Normal hazard[B)] 25 m (16 m)	45 m (30 m)
		High hazard[B)] 12 m (8 m)	25 m (16 m)
CLG guides that support the Regulatory Reform (Fire Safety) Order	Offices and shops	High risk 12 m	25 m
		Normal risk[C)] 18 m	45 m
		Low risk 25 m	60 m
	Factories and warehouses	High risk 12 m	25 m
		Normal risk 25 m	45 m
		Low risk 45 m	60 m
	For other types of premises, see the appropriate guide.		

A) Increased for certain small premises of no more than two storeys and no more than 280 m per floor (see BS 5588-11).
B) For definitions of low, normal and high hazard, see BS 5588-11.
C) For definitions of low, normal and high risk, see the relevant guide.

The time required for escape will depend on:

1. the time for detection of the fire (whether by people or automatic fire detectors);
2. the subsequent time for the alarm to be raised (which, if reliance is placed on people, rather than automatic fire detection, may be rather unpredictable and, possibly, relatively long);

3. the ‘pre-movement time’, during which people need to recognize the alarm signal as an instruction to evacuate and then respond appropriately; and
4. the time to reach a place of relatively safety.

It should be noted that it is only the last of these that is affected by travel distance. In practice, the time between ignition and final evacuation is often governed more by the time for detection and the time for response of occupants to the alarm signal.

The basic principles of fire engineering are discussed in Chapter 22. However, even in applying the flexibility that is intended in use of the limits on travel distance, recommended in codes and guidance documents, the more analytical approach previously discussed can be adopted on a subjective basis, such as in a fire risk assessment (see Chapter 5). Since a critical factor is the time between ignition and evacuation, longer travel distances than those specified might be appropriate, for example, if there is early warning of fire (whether by automatic fire detection or highly trained staff) and a high likelihood of immediate response by occupants (e.g. in a very disciplined environment populated only by well-trained occupants).

The time between ignition and evacuation has true relevance, however, only in relation to the time between ignition and a point at which conditions in escape routes are such as to create a significant hazard to life. This ‘available safe egress time’ will depend largely on the rate of fire growth and the protection afforded to escape routes (both active and passive). This can, again, be taken into account in application of flexibility in limitation of travel distance. Clearly, there is much more available time for escape (and, hence, longer travel distances can be accepted) in a warehouse that stocks only metal components stored in metal crates than in a warehouse with high rack storage of flammable liquids in cardboard cartons. Similarly, since, in the event of fire, the first danger to occupants is loss of visibility as a result of smoke, a building with a very high roof represents a safer condition than one with very low ceiling height, particularly if, in the former case, automatic vents open to release the smoke and contain it well above the heads of occupants as they escape (see Chapter 15).

Stairway and exit capacities

Limitation of travel distance alone does not ensure the adequacy of means of escape. In a crowded shop, for example, a single, narrow exit door might be insufficient to enable all occupants to escape quickly enough to be safe from any fire that develops – even though no occupant were further than the maximum specified travel distance from the exit. The number and width of exits and stairways, therefore, must be sufficient to enable sufficiently rapid evacuation.

The principles involved in calculating the required number and width of exits are based on a very simple model. It is traditionally assumed that the shoulder width of an adult is around 0.53 m. Therefore, any exit of this width, which is known as a unit of exit width, will only permit people to pass through in single file. It is further assumed that people passing through an exit in single file do so at the rate of 40 persons a minute. In practice, an exit of only 0.53 m width would be somewhat tight for occupants to pass through, and, therefore, a factor of safety is normally added to this figure; thus, most codes specify a minimum exit width of 750 mm (BS 5588-11 permits this to be reduced to 600 mm in certain, very limited, circumstances in which the exit caters for no more than 10 ambulant persons who are not members of the public.)

In principle, however, a unit of exit width is capable of discharging 40 persons a minute. Moreover, any exit that is less than two units of exit width can still only permit people to discharge in single file at this rate. When a width of two units is reached, the discharge capacity effectively doubles as people can, according to this simple model, pass through two at a time. Thus, in principle, an exit that is 1.06 m in width should be capable of discharging 80 persons a minute.

If the required evacuation time is then defined, it is possible to calculate the number of occupants that may be served by any exit. Based on experience and studies of major fires, an evacuation time of 2½ minutes is traditionally deemed to be required. (A contributing consideration in the evolution of this time is often held to be a fire at the Empire Palace Theatre, Edinburgh, in 1911, when an audience of 3,000 evacuated safely in around 2½ minutes – allegedly the time taken for the band to play the National Anthem during the evacuation!)* Thus, in theory, one unit of exit width is adequate for evacuation of 100 persons, while an exit of two units caters for 200 persons.

** This fire was interesting in a number of respects. The audience behaved in a calm, rational manner, and the subsequent investigation by the then British Fire Prevention Committee considered that their 'mental coolness, which avoided panic and confusion', was a matter for congratulation, as were the fire precautions. There was, thus, evidence* *as long ago as 1911 that, even in the event of a serious fire, people do not 'panic' (see Chapter 17).*

The fire also demonstrated the benefit of the safety curtain, used to separate the stage from the auditorium in a theatre. The fire occurred on the stage, but the corrugated iron curtain was dropped, albeit that it did not even fully descend to the floor, but stopped around 2' 6" from the floor, fouled by the normal drop curtain; 10 of those on the stage side died (as did a lion and a horse), and even they could have escaped safely had they endeavoured to do so at an early enough point in the fire development, while there were no casualties of any kind amongst the audience, even though, ultimately, the building was severely damaged in a relatively short time.

Even in 1911, the need to treat scenery and drapes in a theatre with fire retardant solutions was recognized. However, there was doubt as to whether the theatre company that were performing on that night had done so. A lesson was, however, learned about protection of stairways, as evidence given to the inquiry was that it would have been beneficial for a door to have been fitted between the stage and a stairway that led to dressing rooms, where three bodies were found, each of the deceased having suffered from smoke inhalation.

With regard to the matter of evacuation time, the evidence of witnesses was considered, by those producing codes of practice on means of escape years later, to be relevant. The stage manager gave evidence that about three minutes elapsed between noticing the fire and the need for him to leave the stage for his own safety. He offered the opinion that 'if all the people on the stage, whenever they saw there was any danger, had at once made for the available exits, I think that they could have got away quite easily'. (In fact, they delayed escape to assist others and, possibly, attempt to rescue the animals.) A scenic artist also gave evidence of a similar nature: 'Not more than two or three minutes elapsed from the time I noticed the fire until I escaped altogether; the place was then unbearable. There was plenty of time for anyone who was on the stage to get away.' A third witness spoke of hearing people trapped behind a door from the stage to the auditorium about two or three minutes after he first noticed the fire. And so, the foundation was laid for the 2½ minutes evacuation time of today!

Recommendations for exit widths and escape routes in most codes are based on the above model, although the figures in some codes have been rounded off or modified slightly, resulting in minor variations. The relationship between exit width and discharge capacity in the BS 5588 series of codes, and in official guidance that supports building regulations, is as shown in Table 7.2. It should be noted that, in the case of 220 persons and above, the figures in Table 7.2 are based on 5 mm per person.

Table 7.2 Exit and escape route capacities recommended in guidance on building regulations

Discharge capacity (number of persons)	*Exit width m*
60	0.75
110	0.85
220	1.1
240	1.2
260	1.3
280	1.4
300	1.5
320	1.6
340	1.7
360	1.8

In the case of places of assembly, the government guides that support the Regulatory Reform (Fire Safety) Order adopt a more traditional approach, based on a unit of exit width of 525 mm, and increases in exit width above two units are made in increments of 75 mm, which are deemed to cater for 15 people. The guides also suggest three different evacuation times, namely 2 minutes, 2½ minutes and 3 minutes, according to whether the premises are high risk, normal risk or low risk respectively; the risk category is determined by the rate of fire spread anticipated (or the likely time between detection and warning). These guides also adopt the traditional model more exactly than other guides, so that a single unit of width (750 mm) is adequate for 80, 100 or 120 people in high risk, normal risk and low risk premises respectively, while two units (1,050 mm) can provide escape for 160, 200 or 240 people.

In the case of stairways, the same principles apply, but the situation is complicated by the fact that allowance is made for the number of persons who can be accommodated within the stairway itself. For example, if a stairway serves only one floor, its capacity will be as outlined in Table 7.2. If it is now extended to a second floor, its capacity must be greater, constituting the original capacity plus the standing capacity between the original floor and the additional floor. Mathematically, this becomes quite complicated, but stairway capacities, based on an evacuation time of 2½ minutes, are tabulated in most relevant codes, and Table 7.3 shows the figures commonly used.

Table 7.3 Staircase capacities commonly recommended in means of escape codes

Discharge capacity (number of persons)									
No. of floors served	*Width of staircase (in millimetres)*								
	1000	*1100*	*1200*	*1300*	*1400*	*1500*	*1600*	*1700*	*1800*
1	150	220	240	260	280	300	320	340	360
2	190	260	285	310	335	360	385	410	435
3	230	300	330	360	390	420	450	480	510
4	270	340	375	410	445	480	515	550	585
5	310	380	420	460	500	540	580	620	660
6	350	420	465	510	555	600	645	690	735
7	390	460	510	560	610	660	710	760	810
8	430	500	555	610	665	720	775	830	885
9	470	540	600	660	720	780	840	900	960
10	510	580	645	710	775	840	905	970	1035

In the case of certain high buildings, such as offices, it may not be necessary to evacuate all floors of the building simultaneously. Provided stairways are approached by way of a protected corridor or lobby, and suitable fire alarm and public address systems are installed, it may be acceptable to evacuate only two floors at a time, subject to there being adequate fire resistance between each floor. In this case, the aggregate width of all stairways may be less than the dimensions recommended in Table 7.3. Guidance on such 'phased evacuation' and the relevant stairway capacities is contained in BS 5588-11 and guidance that supports national building regulations.

It was, traditionally, necessary to build a degree of redundancy into means of escape. Accordingly, in calculating the total exit and stairway capacity of a building, it was, in the past, always assumed that one exit/stairway might be inaccessible due to the fire. So that the total exit capacity would then remain adequate for the number of occupants, it was necessary to ensure that there would be adequate capacity when each exit or stairway was discounted in turn. This practice is still universal, when calculating storey exit widths. However, under modern codes and guidance documents, there is no need to discount one stairway provided the stairway is approached through a protected lobby (see page 133) on all floors (other than the topmost), or provided the stairway is protected against smoke entry by means of pressurization (see Chapter 15).

Floor space factors

It is often difficult to predict the number of persons who may, at any time, occupy a floor or area of a building. In restaurants with fixed seating, it is quite simple: all that is necessary is to count the number of seats. However, in many buildings, some assumption as to the likely maximum number of occupants must be made, particularly at the design stage of a new building, unless it is known that the area is designed to hold only a specific number of occupants.

Floor space factors are used for this purpose. A floor space factor is the area per person adopted for the purpose of calculating the occupant capacity of a room or storey. The number of occupants for whom provision must be made, in respect of the number and widths of exits, is obtained by dividing the area of the room or storey (in m^2) by the floor space factor (in m^2/person). Stairways, lifts and sanitary accommodation are excluded from the calculations.

Typical accepted floor space factors for common occupancies, given in Approved Document B, which supports the Building Regulations 2000 in England and Wales, are given in Table 7.4.

These figures are, however, sometimes varied by negotiation with the enforcing authority. This may arise because the occupancy does not 'fit' any of those in the relevant code, or because, for example, experience in a large chain of identical premises can provide a better basis for calculation. It should, however, be noted that floor space factors are simply a tool for determining the number of occupants for whom exit capacity must be provided. They are not intended as a limit to the number of occupants within a space; this is determined by the exit widths.

The term fire-resisting construction was discussed in Chapter 2. It refers to construction (walls, floors, ceilings, doors, etc.) that can resist attack by fire for a specified time. For protection of means of escape, a fire resistance of 30 minutes is usually specified. However, longer periods of fire resistance may be required for high-hazard areas, and may be required under building regulations to minimize fire spread as opposed to protecting escape routes.

(Further discussion of requirements for fire-resisting elements of construction may be found in Chapter 8.) Not all escape routes are required to be protected, although it is a common misconception that all corridors should be enclosed in fire-resisting construction.

Table 7.4 Typical floor space factors for common occupancies

Area	*Floor space factor m²/person*
Standing spectator areas, bar areas (within 2 m of serving point) and similar refreshment areas	0.3
Bar areas (without fixed seating), bingo halls, dance halls, general purpose assembly halls	0.5
Restaurants, lounges, bars (other than as above), dining rooms, staff rooms, meeting rooms	1.0
Most sales areas of shops, including department stores and supermarkets	2.0
Offices	6.0
Lightly occupied sales areas of shops, such as furniture and 'whitewear' departments, cash and carries, etc.	7.0
Warehouses	30.0

Protection of escape routes

In defining travel distance, the terms protected stairway and protected lobby were used. In referring to means of escape, the term protected has a particular meaning. An escape route (or part of an escape route), such as a corridor stairway or lobby, is protected only if it is enclosed (other than in the case of an external wall) by construction that is fire resisting.

The three stages of escape

Means of escape can be divided into three stages:

stage 1: travel within rooms;
stage 2: horizontal travel to a storey exit or a final exit;
stage 3: vertical travel within a stairway and thus to a final exit.

Stage 1: travel within rooms

For the first stage of assessing means of escape:

a) room contents should be so arranged that there is free passageway to exits;
b) begin measuring travel distance;
c) 'large' rooms (often defined as those accommodating 60 persons or more) usually require more than one exit, so that there is an alternative exit if the route to one is blocked by fire (note that the 45° rule applies);
d) flammability of wall and ceiling linings is normally restricted (see Chapter 8).

Special requirements apply in the case of 'inner rooms', defined as rooms from which escape is possible only by passing through another ('access') room. The purpose of these requirements is to ensure that the escape route for occupants of the inner room is not cut off by a fire in the access room before they can escape.

In the case of inner rooms:

1. there must be:
   a) a clear vision panel between the inner and access rooms, so that occupants of the inner room can see a fire in the access room; or
   b) a space between the top of the partitions between the inner and access rooms; or
   c) automatic smoke detection in the access room to give early warning of fire to occupants of the inner room;
2. there must be no inner rooms leading off other inner rooms (i.e. an inner room must not act as an access room for a further inner room);
3. the access room must not be an area of high fire hazard.

Where the traditional option of a vision panel is selected, it should be of sufficient size, and suitably located, to enable a fire in the access room to be observed at an early enough stage for escape to be possible; it should not merely be an inadequately sized token gesture. If automatic detection is provided in lieu of a vision panel, care should be taken in buildings with a 'staff alarm' arrangement to ensure that delays in providing a general evacuation signal do not apply to the warning given to the occupants of the inner room.

Stage 2: travel to a storey exit

Corridors with alternative means of escape

The appropriate measures for cellular accommodation in which there are corridors with alternative means of escape are as follows.

1. Each room should be fitted with a door that need not be fire resisting or self-closing, except in the case of protected corridors (see page 133) so that smoke movement, in the early stages of a fire, can be prevented by closing the door.
2. Except in the case of sleeping accommodation, or corridors that form common escape routes from different occupancies in premises in multiple occupation, the enclosing walls or partitions of the corridor need not generally be fire resisting or extend above false ceilings (i.e. a protected corridor is not necessary), but they should extend to any false ceiling to prevent smoke movement in the early stages of a fire.
3. Measurement of travel distance continues and a limitation of the total distance within stages 1 and 2 applies (see Table 7.1).
4. Codes frequently specify a minimum corridor width, which must be adequate for the number of occupants; a typical figure is 1.05 m.
5. Long corridors should be subdivided by doors to separate stairways (so that more than one stairway is unlikely to be affected by smoke) and to limit the maximum length of corridor that may become smoke logged. These doors are usually permitted to have a fire resistance that is less than 30 minutes, but must be resistant to the passage of smoke (see Chapter 8). The doors may normally be held open, providing they close automatically on operation of appropriately sited, automatic smoke detectors or operation of the building's fire alarm system. Guidance on the interface between electrically powered hold-open devices ('door-release units') and fire detection and fire alarm systems (including guidance on the location, siting and spacing of the appropriate smoke detectors) is given in BS 7273-4.[4] It is normal practice for such doors to be closed at night, but care must be taken to ensure that, if a central control is used for this purpose, sudden release of doors cannot cause injury to occupants, particularly those of a frail nature, such as those in residential care homes. (One local authority was successfully prosecuted under health and safety legislation for just such an incident, in which a frail, elderly person died subsequent to injury by a fire door released by use of a central control.) BS 7273-4 recommends that, where such controls are provided, a suitable warning sign (known as a 'knockdown cautionary' or 'KC' sign) is erected

adjacent to the control, unless an audible warning of impending release is given at the doors themselves (which is uncommon).
6. There should be adequate exit capacity for the number of occupants, assuming that one exit is not available.
7. The 45º rule applies.
8. Doors should preferably open in the direction of escape, and must do so if a significant number of persons (typically 60 or more in most codes) are involved. Exits from rooms or areas with potential for rapid fire development, such as laboratories and certain industrial process areas, and from rooms with gaseous extinguishing systems (see Chapter 14), should also open outwards.
9. The flammability of wall and ceiling linings in the corridors should be low (see Chapter 8).
10. Escape routes should not be obstructed in width or contain fire hazards.

Dead-end corridors

The requirements for other corridors apply to dead-end corridors, except that:

1. the corridor should always be a protected route, i.e. doors opening onto the corridor should be fire resisting, self-closing and resistant to the passage of smoke; enclosing walls or partitions should be fire resisting and should extend from slab to slab through any false ceiling or floor;
2. a very limited travel distance applies (see Table 7.1);
3. at the point at which alternative means of escape is reached, the alternatives should be separated from one another by fire-resisting self-closing doors that are resistant to the passage of smoke (see Figure 7.5);
4. it is particularly important that dead-end corridors contain no ignition sources, fire hazards or quantities of combustible materials.

Open-plan areas

The following requirements apply to open-plan areas:

1. a travel distance limitation applies (see Table 7.1);
2. there should be adequate exit capacity for the number of occupants, assuming one exit is not available;

3. the 45° rule applies ;
4. doors should preferably open in the direction of escape, and must do so if a significant number of persons (e.g. 60 or more) is involved or rapid fire growth is anticipated;
5. the flammability of wall and ceiling linings is usually restricted (see Chapter 8).

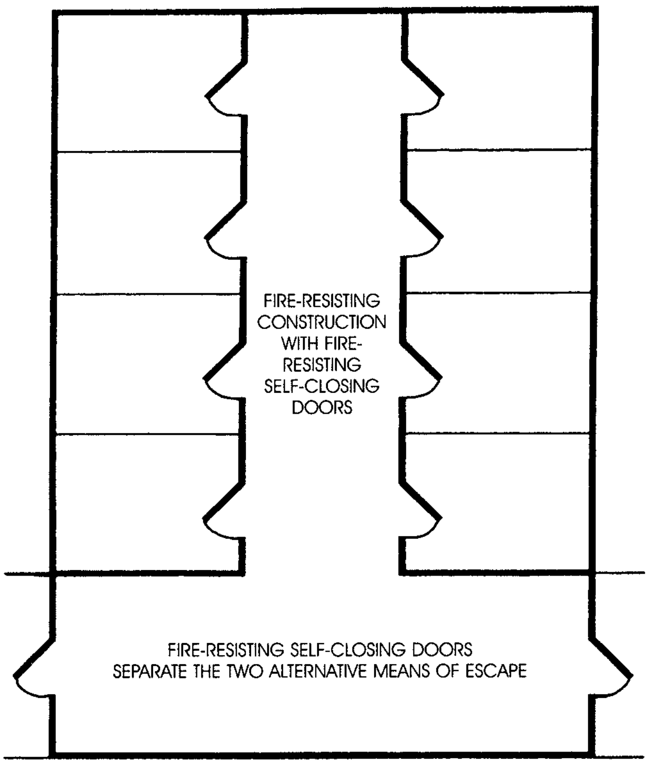


Figure 7.5 Requirements for dead ends

Stage 3: vertical travel down a stairway

For the third stage of assessing means of escape the following should be taken into account.

1. If the stairway is protected, it is a place of relative safety, and therefore there is no need for any limitations on travel distances within the stairway.

In this case, doors to the stairway must be fire resisting and self-closing. The ability of stairway doors to fit well in their frames, and to protect against the penetration of smoke, is also very important.

2. At one time, enforcing authorities did not permit stairway doors to be held open by units that release the doors automatically when fire is detected or the fire alarm system operates. This restriction has been relaxed considerably in recent years, on the basis that there are now suitable British Standards for the most commonly used release devices, and there is a code of practice (BS 7273-4) to address their interface with fire detection and fire alarm systems; there is also an acceptance that this arrangement is better than wedging the doors in the open position, which may happen in practice in some cases if automatic release units are not fitted.
3. In England and Wales, guidance that supports building regulations does not advocate any restrictions on the use of door-release units, nor do the guides that support the Regulatory Reform (Fire Safety) Order. However, the *Technical handbook for non-domestic buildings*, which supports the Building (Scotland) Regulations in Scotland recommends against the use of such units on stairway doors in buildings, or parts of buildings, in which there is only one protected stairway available for escape, in premises where people sleep and in the case of fire-fighting stairways. In Northern Ireland, compliance with the equivalent guidance restricts use of electrically powered hold-open devices on doors to fire-fighting stairways.
4. If the stairway is unprotected (such as an open stairway between two floors in a shop) it affords no degree of safety from a surrounding fire. Therefore if, in small premises, an unprotected stairway forms part of the means of escape (e.g. from the first floor of a small shop) the distance of travel down the stairway would, in effect, form part of the stage 2 travel distance. However, the presence of an unprotected stairway may not be acceptable at all in some premises. Even if an unprotected stairway does not form part of the means of escape, it is a route for vertical fire spread; it must therefore be ensured that the stairway is not detrimental to means of escape, and some codes limit the number of floors through which an unprotected ('accommodation') stairway that is part of the means of escape may pass.
5. If a building is served by only one stairway, obviously dead ends are created, and the travel distance limitation, in effect, restricts the floor area of such a building. In addition, codes restrict the number of storeys, or height of building, that may be served by only a single stairway. It is normal to provide protected lobbies between a single stairway and the accommodation on each floor, so that fire and smoke must pass through

two doors before they can affect the stairway; the same objective could, however, be achieved in cellular accommodation by means of a protected-corridor approach to the stairway.

6. Stairway capacity must be adequate for the number of occupants even if, in multi-stairway buildings, one stairway must be discounted on the assumption that it cannot be used due to the fire; discounting of stairways is, however, not always necessary.
7. It should not be necessary to pass through a stairway enclosure to reach an alternative escape route; nor should the only route from one part of the premises to another be through a stairway enclosure, as this will encourage the wedging of the stairway doors and increase wear and tear on these critical doors, unless automatic door-release units hold the doors open under normal circumstances.
8. Ideally, a stairway should lead directly to a final exit. Otherwise, there should be two exits from the stairway enclosure, each leading to final exits via routes that are separated from one another by fire-resisting construction. Alternatively, there should be a protected route to a final exit. Similarly, if there is more than one stairway without final exits within the actual protected enclosures of the stairways, the routes from each stairway should be separated.
9. The flammability of any wall and ceiling linings must be negligible (see Chapter 8).
10. The stairway enclosure should contain no fire hazards or combustible materials. It should be regarded as a totally sterile area. However, it is normally acceptable for a stairway to contain a small reception area of not more than 10 m^2, provided the stairway is not the only means of escape from any part of the building. (Some enforcing authorities also accept vending machines, provided they do not contain a heating element (e.g. for hot drinks).
11. External stairways are usually permissible, but should, in effect, be protected routes. Thus, doors opening onto the stairways should be fire resisting and self-closing, and windows in close proximity to the stairway should contain fire-resisting glazing in frames that are fixed shut (see Chapter 8).
12. Spiral stairways are only acceptable in certain circumstances, and for a limited number of persons. Vertical ladders are rarely acceptable unless, for example, they are the alternative means of escape from plant areas that are not normally occupied and are likely to be visited by no more than a very small number of persons.
13. Escape in an upward direction should generally be avoided (other than from below-ground areas), but a short distance of travel to, say, a roof

exit may be accepted in unusual circumstances, but not generally for members of the public. If exit across a flat roof is accepted, there are usually various special requirements. These include defined routes guarded with barriers, suitable roof construction, and the absence of any hazards, such as rooflights or ventilation outlets, through which fire could pass and cut off the means of escape.

14. Self-rescue devices, such as lowering lines, are not usually acceptable under any circumstances.

Final exits

Ultimately, all escape routes lead to a final exit from the premises. Common requirements for final exits are as follows:

a) the exits should be obvious and/or signposted;
b) the exits must open easily (security fittings for fire exits are discussed on p. 140);
c) revolving doors are normally required to have conventional exit doors sited adjacent to them;
d) in modern codes, wicket doors, goods delivery shutters, etc., are not normally acceptable as final exits, except, in some codes, in very restricted circumstances, where a very small number of persons are involved (e.g. no more than 10); these exits are virtually always regarded as unsuitable for members of the public under any circumstances;
e) on escape through a final exit, it must be possible to disperse from the building.

The interrelationship between means of escape and security

It is a commonly held belief that there is a direct conflict between requirements for security and those for means of escape. In a simplistic sense it is true that good security necessitates highly secure entrance and exit doors, whereas fire exits must be readily available for use in an emergency. However, in reality, this is a gross oversimplification, and potential conflicts between the two objectives can almost always be overcome without serious compromise of either life safety or security.

However, inadequate security equates to bad fire prevention; a high level of security actually contributes to fire safety, since arson is one of the most common causes of fire. In addition, while safety of life from fire must, in case of real conflict, virtually always override security requirements, the fire safety specialist must recognize that there can be situations in which overriding the security specialist's objectives can result in an overall increase in the risk to life. For example, in premises occupied by VIPs who are at risk from terrorists, and in banks and other premises in which the risk of armed robbery is high, no favour is done to the occupants by insisting that their safety from fire is so paramount that they must be exposed to the danger of being shot, blown up or kidnapped. Similar considerations may apply to hostels for young females or premises providing refuge from domestic violence. There is often a need, therefore, for the fire specialist to consult with any security specialist who is involved with the building, to appreciate the level of the security threat and the form of security precautions that are required.

As stated above, when such consultation does take place, an adequate solution can normally be formulated. In considering the problems that arise, the following points should be borne in mind:

1. Fire exits may be secured provided they can be opened readily from the inside in an emergency.
2. Arrangements that involve the use of a key, such as the provision of a key in a glass-fronted box adjacent to the exit door, are never regarded as acceptable. The key may be difficult to access or use if there is a crowd of people pressing against the exit door, or if visibility is reduced by smoke. In addition, those unfamiliar with the premises may believe the door is unopenable. One of the recommendations contained in the report of the committee of inquiry into the fire at Woolworths, Manchester, in 1979, which resulted in 10 deaths, was that the use of keys in glass-fronted boxes for doors on escape routes should not be allowed in the future.
3. The ideal form of fastening for a fire exit door is a panic lock or latch, which is released by pressure on a bar that runs across the full width of the door. Panic bars are not, however, the only acceptable form of release mechanism. They tend to be required where the exit may be used by large numbers of persons (sometimes defined as 60 or more), particularly if the persons are members of the public. In other areas, the only requirement is that the devices used are simple and easy to use by occupants, and are able to result in immediate release of any locking device. Panic bolts tend to secure a door at two points, but security specialists normally require an arrangement whereby the risk of manipulation from outside is minimized; this will usually entail securing the door to the frame at the hinged edge.

4. If the security of a fire exit door is a problem, consideration should be given to fitting an alarm device to the door so that a warning is given (locally and/or remotely) if the door is opened. This may, in complex buildings, be supplemented by CCTV monitoring.
5. Electronic locking of doors may sometimes be acceptable provided adequate safeguards are implemented. Locks must release automatically on operation of the building's fire alarm system (other than in some high-security applications, such as places of lawful detention). Guidance on interfacing electronic locks with a fire alarm system is given in BS 7273-4. In practice, compliance with BS 7273-4 will necessitate:
   a) fail safe locks that release the door on power failure;
   b) release of locks on operation of the fire alarm system;
   c) a local electrical override control by each door that, once operated, cannot be reset without replacement of a frangible element.

   A means for mechanically overriding the lock in an emergency is also sometimes provided. There is general preference for magnetically secured doors ('maglocks'), rather than solenoid-operated devices, in which there are moving parts and, often, springs. The latter devices are sensitive to poor installation, permitting the bolt to foul on the keep, and to a similar effect as a result of force created by people pressing against the door. Caution should also be exercized in interfacing the locks with a fire alarm system via another system, such as an access-control system, which may not fail safe and may not be designed to have the reliability of a life-safety system, such as a fire alarm system. BS 7273-4 tentatively suggests restrictions on the applications for such an arrangement.
6. It may be acceptable to some enforcing authorities for normal fastenings, such as panic locks and latches, to be supplemented by additional fastenings, such as padlocks and chains, during periods of non-occupation, provided there is a very reliable and formal procedure for removing these, as part of opening procedures before the public enter the premises. This arrangement may sometimes be found in theatres and cinemas.
7. Since windows should not form part of the means of escape (unless, in exceptional circumstances, a proper window exit is provided for a small number of persons), bars on windows should not affect the means of escape. Even so, following a fatal fire at James Watt Street, Glasgow, in 1968, enforcing authorities were advised to press for removal of bars in all cases where they are not strictly required for security purposes. Legislation does not, however, generally demand that windows are not barred. Nevertheless, bars on windows can impede fire-fighting operations, and may prevent rescue if the means of escape are, in very unusual circumstances, impossible for occupants to use. The report on

the Woolworths fire reiterates the advice that followed the James Watt Street fire in this respect. The potential effect of window bars on fire safety is also recognized in the various parts of BS 8220[5] (security of buildings against crime).

8. Badly fitted, or inappropriate, locks and latches can impair the fire resistance of doors (see Chapter 8). Very wide mortice locks should be avoided.
9. It may be undesirable for certain fire-resisting self-closing doors to be self-locking, e.g. the front doors of a flat; if, say, a lone parent were to leave the flat to seek the assistance of a neighbour in the event of fire, access to the children remaining in the flat may be prevented by the self-locked door.

Means of escape for disabled people

There is an increasing awareness in society that disabled people should be able as a right to enter and use modern buildings, whether to work, study and learn, be accommodated, or engage in leisure activities. Equally, once in the building, disabled people must be safe from fire. The right of access is now enshrined in legislation in the form of building regulations, which are further reinforced by the Disability Discrimination Act 1995, and the need for safe egress follows from this. It should be noted that disability can take many forms but, as this chapter is concerned only with means of escape, consideration of the requirements for disabled people relates primarily to non-ambulant people, particularly those in wheelchairs, although there is also a need to consider facilities for blind or partially sighted people, and for deaf or hard of hearing people; means of warning the latter group in the event of fire are discussed in Chapter 11.

Guidance on means of escape for disabled people is contained in BS 5588-8.[6] Guidance is also provided by the CLG and the Scottish Executive as part of the suites of guides produced in support of fire safety legislation (see Chapter 1). As in the case of other parts of BS 5588, the code is intended primarily for new buildings or buildings undergoing substantial refurbishment. However, an annex to the code considers the application of the code to existing buildings. It is recognized that, in the case of an existing building, compliance with the code is not always possible. Nevertheless, it is recommended that alternative ways of meeting the objectives of the code should be sought. (At the time of writing, it is planned that, probably during the currency of this book, the recommendations of BS 5588-8 will be incorporated within BS 9999.)

BS 5588-8 is concerned with structural measures to facilitate escape by non-ambulant persons in the event of fire. However, management procedures are an essential part of arrangements for escape by disabled people. Guidance on managerial arrangements, including techniques for assisting disabled people to evacuate a building, are given in BS 5588-12.[7] Procedures include special arrangements for assisting wheelchair-bound persons, or others with walking difficulties, along corridors or stairways, and for supervising the use of an evacuation lift if provided (see below).

Normally, nominated members of staff are made responsible for assisting in the evacuation of disabled people. A particular example of this is the 'buddy' scheme, whereby a nominated person is responsible for assisting a designated disabled person who works in the vicinity. The advantages of this arrangement are that the able-bodied person and the disabled person often work in the same department, can be made aware of each other's absence on any day, and can develop confidence in each other's ability to carry out rehearsed procedures in an emergency.

There is a need, however, to ensure that a deputy or deputies are nominated to take on the role when the nominated helper is absent, and that they are aware of their responsibilities when they arise. Perhaps a more serious disadvantage is that the freedom of the disabled persons may be restricted, as there may be no nominated helpers when they visit other parts of the building, which, in the event of a fire, might not be able to be accessed rapidly by the nominated helpers. There may, therefore, be a need to train a proportion of, or all, fire wardens (see Chapter 20) in evacuation of disabled people.

Ideally, helpers should be trained to carry wheelchair-bound disabled people in their own wheelchairs. However, the weight of the now commonly used motorized wheelchairs alone makes this impracticable in many cases. A more practical solution is to provide specially designed 'evacuation chairs' into which the disabled people are assisted by those helpers. The provision of these in large buildings is now quite common.

BS 5588-8 also introduces the concept of refuges. A refuge is defined as: 'An area that is enclosed with fire-resisting construction (other than any part that is an external wall of a building) and served directly by a safe route to a storey exit, evacuation lift or final exit, thus constituting a temporarily safe space for disabled persons to await assistance for their evacuation.'

In new buildings, refuges are normally required in order to satisfy the requirements imposed under building regulations.

It is a common misconception that the creation of refuges involves the provision of large, dedicated spaces that are enclosed in construction that will afford very long periods of fire resistance. The code makes it clear that this is not the case. A refuge is required to be of sufficient size only to accommodate a wheelchair and permit the wheelchair user to manoeuvre into the space without undue difficulty. The space required for the wheelchair is recommended to be at least 900 mm × 1,400 mm to allow space for manoeuvring. The code suggests that, in many buildings, such spaces will be formed as part of the design and construction process.

Examples of satisfactory refuges further clarify the simple nature of refuges. Common examples comprise an enclosure, such as a compartment, protected lobby, protected corridor or protected stairway, and spaces in the open air, such as balconies or flat roofs, that are remote from the fire and provided with means of escape. However, it is stressed that the creation of refuges should not obstruct the flow of able-bodied persons.

This is very important; arrangements for evacuation of disabled people must never impede the means of escape for able-bodied people. However, compliance with BS 5588-8 will often automatically result in buildings that offer enhanced means of escape for able-bodied people. One important corollary is that, if there are deficiencies in the means of escape for able-bodied people, the means of escape are likely to be particularly inadequate for disabled people. Nevertheless, if stairway landings, lobbies or corridors are of sufficiently generous size and suitably protected they can, in principle, constitute refuges for disabled people without any further modification.

The code recommends that a refuge should be provided for each protected stairway on each storey (and for any final exits that lead onto a flight of stairs) except for:

- storeys consisting exclusively of plant rooms;
- buildings in single occupancy comprising not more than a basement, ground and first storey with a floor area per storey of 280 m^2 or less.

However, in England and Wales, the guidance in Approved Document B incorporates only the first of the previous two exceptions.

Prolonged periods of fire resistance are not required for the enclosures of refuges. A period of at least 30 minutes is recommended by the code.

The code also describes the technical recommendations for evacuation lifts, which may be used by disabled people in the event of fire. A fire-fighting lift that is intended for use by the fire and rescue service, and that complies with the recommendations for such lifts, may be used as an alternative. In the case of evacuation lifts, the recommendations include enclosure of the lift well in fire-resisting construction, a recall-to-ground switch and, with minor exceptions, a secondary source of power supply, with cables that are separated from those of the primary supply. It should be noted that all requirements that apply to a fire-fighting lift may not be necessary in the case of an evacuation lift. The former will be used in the advanced stages of a fire and fire-fighting operations, when, for example, there may be a need for the reliable operation of the lift when substantial quantities of water are being used for fire-fighting. At the stage when an evacuation lift is in use, this is not the case.

It should be emphasized, however, that BS 5588-8 does not specifically recommend that evacuation lifts be provided in all buildings; the provision of an evacuation lift merely reduces, but does not eliminate, the need to arrange physical assistance for evacuation of disabled people by way of stairways. Even if an evacuation lift is provided, there is a risk that it may become defective or that it cannot be used for some reason. Accordingly, even in buildings with evacuation lifts and fire-fighting lifts, disabled people, having reached a refuge, must normally have access to a stairway.

Such is the difficulty in formulating evacuation strategies for the number of disabled people who now, happily, have access to most buildings, that consideration is sometimes given, subject to a careful risk assessment, to the use of standard passenger lifts (or even goods lifts) for their evacuation. Any such proposal should be regarded with the utmost caution, and it should not be regarded as simply a cheap ‘shortcut’ to preclude expenditure on suitable and reliable means for evacuating disabled people in the event of fire. However, there is a (sometimes reasonable) theory that use of a standard lift to evacuate disabled people from a tall building might involve less risk to disabled people than use of relatively unskilled helpers to carry disabled people down many flights of stairs.

For example, consider the case of a well-managed, well-compartmented building, with comprehensive automatic fire detection, incorporated within an addressable fire alarm system that accurately, and at an early stage in fire development, pinpoints the location of a fire at fire alarm indicating equipment monitored by well-trained staff in the building. If it can thus be ascertained that the incident involves a (probably quite small) fire within an enclosure in one fire compartment, it might be reasonable to consider whether a standard lift in another fire compartment, the operation of which could not be affected by the fire, could be used in the early stages of the fire, to evacuate disabled people. The possibility of using normal lifts for evacuation of disabled people is now acknowledged, for example, in the guides that support the Regulatory Reform (Fire Safety) Order, subject to an adequate fire risk assessment and development of a suitable fire safety strategy by a competent person.

There are, unfortunately, many common misconceptions regarding evacuation of mobility-impaired people. A failure to grasp the fundamental principles of means of escape for disabled people often results in arrangements that, however well intentioned they may be, are ill-conceived to an extent that they may even put disabled people at greater, rather than lesser, risk, or at least fail to provide the enhancement in their safety that was actually intended. Often employers invest considerable capital expenditure to facilitate evacuation of disabled people, but fail to appreciate that robust and reliable managerial arrangements are also vital.

The most common, and undoubtedly the most serious, misconception is that it is sufficient simply to provide refuges, without any proper consideration of the procedures that will be implemented once disabled people have, often without the need for assistance, reached the refuges. Perhaps the term ‘refuge’ wrongly imparts the impression of a space that can be safely occupied indefinitely. In Scotland, the term ‘temporary waiting space’ is now sometimes used to avoid this impression.

Frequently, building managers, and certainly many employees, believe that the concept of refuges is based on later rescue of the disabled people by the fire and rescue service. In the experience of the author, this misconception appears to be more prevalent within public-sector bodies than in private-sector organizations of equal size and status. Perhaps this results from a greater awareness of the principles of liability, and the potential for prosecution or litigation if adequate levels of safety are not provided for all occupants, which exists in the private sector.

Equally, the fact that the principles of disabled evacuation are inadequately understood by such responsible and competent employers is a measure of the need for better education of those responsible for the operation of buildings on this particular subject. Further evidence of this need arises from claims by some building managers and similar responsible persons that they have been advised by their local fire and rescue service to leave disabled people within refuges, for rescue by the fire and rescue service. This somewhat wreckless advice normally emanates from operational personnel within fire and rescue services, rather than trained fire safety officers, but, equally, if those dealing with fire as a means of employment cannot comprehend the principles of disabled evacuation, it is, perhaps, little wonder that less knowledgable members of the public have difficulty.

Yet, it is clearly demonstrable, even on common sense grounds, that no disabled evacuation policy should depend on the presence of the fire and rescue service to ensure the safe evacuation of disabled people. In the same way as, by definition, means of escape is commonly regarded as means by which people can escape to a place of safety beyond the building without external assistance, arrangements for means of escape for disabled people should surely comprise means by which disabled people can escape to a place of safety beyond the building without external assistance.

Moreover, if means of escape for disabled people relied entirely on the fire and rescue service, their potential safety, and hence arrangements required for their protection, would vary significantly between premises in, say, central London and premises in remote rural areas; in fact, the requirements for the design of facilities and arrangements for disabled evacuation are the same in both cases, since there should be managerial arrangements to facilitate the safe evacuation of disabled people. The need for arrangements that do not depend entirely on rescue by the fire and rescue service is made relatively clear by BS 5588-8, but there is a need for greater emphasis on this in published guidance.

A further misconception is that, where an evacuation lift is provided, disabled people can use this without any assistance. In fact, use of evacuation lifts needs to be properly controlled, organized and managed. Thus, it is necessary to designate evacuation lift operators, often drawn from any security staff employed to work in the building, who will, in a pre-planned manner, evacuate disabled people first from the floor of fire origin, and then from other floors according to pre-determined priorities.

For this arrangement to operate satisfactorily, there must, except in small buildings, normally be adequate means of communication between refuges and some central control point, a feature that, again, is often overlooked. The method of communication should afford two-way speech between refuges and the control point, so that disabled people are both able to announce their presence at the refuges and to receive reassurance regarding the dispatch of assistance. BS 5839-9[8] provides recommendations for the design, installation, commissioning and maintenance of 'emergency-voice communication systems', designed for this purpose; it also provides recommendations for the design of the equipment itself. BS 5839-9 also applies to fire telephone systems for use by the fire and rescue service during a fire. Accordingly, the specification is very high and the installations are relatively expensive. However, costs may well decrease as such systems become more common.

Another common mistake in the provision of facilities for the evacuation of disabled people is to provide special evacuation chairs, which are indeed very useful, but to provide a wholly inadequate number of chairs to take account of the size of the building, all potential locations of disabled people (which often comprise all areas of the entire building) and all potential locations of a fire. Thus, it is not uncommon to find the chairs located within the main stairway in a building, without the provision of any chairs whatsoever in alternative escape stairways. This effectively precludes use of these stairways by disabled people, so, in effect, creating for these occupants, long travel distances, dead ends and the potential for being trapped by a fire that precludes access to the main stairway. The use of all alternative stairways that are required for means of escape by able-bodied people must be taken into account in planning for evacuation of disabled people.

Blind and partially sighted people

Blind people can often manage to evacuate a building with which they are sufficiently familiar, with only minimal assistance. However, the design of lighting and emergency lighting should take the needs of partially sighted people into account, particularly in respect of the uniformity of lighting levels. In buildings designed to take account of a significant number of partially sighted people, higher emergency lighting illuminance levels than those recommended in BS 5266-1[9] might be appropriate. In addition, BS 5588-8 refers to measures that would assist visually impaired people to use stairways. These include colour contrasting of stair nosings and colour contrast between handrails and supporting walls.

Although many blind and partially sighted people have a remarkable ability to negotiate a building, in the event of fire they may have to use alternative means of escape with which they are not familiar. This should be taken into account in planning the evacuation of visually impaired people. They should be encouraged and assisted to use alternative means of escape in fire drills. Further assistance in wayfinding could be provided by use of directional sounders (see Chapter 9).

In considering the evacuation of able-bodied people, the importance of dispersal away from the building has been stressed. Clearly, the same principle should apply to disabled people. They should not be placed at risk by their inability to move far enough away from the building. Furthermore, the siting of evacuation assembly points should take disabled people into account, so that they are able to reach the assembly point and are not placed at risk by so doing.

Deaf and hard of hearing people

Hearing impairment does not necessarily mean that a person is completely insensitive to sound. Some deaf and hard of hearing people are able to perceive certain types of conventional audible alarm signals. Nevertheless, this will not always be the case, and it must be ensured that there are suitable physical measures and procedural arrangements to provide deaf and hard of hearing people with an adequate warning of fire.

The measures and arrangements made need, to some extent, to be tailor-made for the circumstances in which people work. For example, a deaf person working on a production line, along with a number of colleagues, may need no special provisions for warning of fire, other than simple, common sense, pre-planned procedures. In such circumstances, it is commonly the case that a group of employees take meal breaks, etc. together. All that is necessary may be an arrangement whereby specific colleagues of the deaf person are tasked to ensure that they are responsible for the deaf person's welfare by knowing at all times where the deaf person is, and ensuring they are warned when the fire alarm system operates.

Where a deaf or hard of hearing person spends a large part of their working time in a single location (e.g. a post room), where they may be alone at some times, consideration should be given to the provision of visual fire alarm signals within that area. This is very easy to arrange, simply by installing flashing beacons on existing fire alarm sounder circuits. This ensures that the circuits supplying the flashing beacons are protected against fire and monitored in the same way as any fire alarm circuit.

Where deaf or hard of hearing people must have total freedom to use an entire building and will at times be unaccompanied, the ideal solution is to provide vibrating pagers, linked to the fire alarm system. This is discussed in Chapter 11.

Checking the means of escape

The means of escape should be regularly checked (e.g. on a weekly basis) to ensure that they remain adequate. This should not be time-consuming, particularly if a logical approach is adopted by following the three stages of escape. An excellent job can often be done in this respect by patrolling security officers, once even very simple basic training is given to them. The use of simple checklists can be of assistance by acting as an *aide mémoire* for the non-specialist. Typical points to look for are listed below:

1. Rooms.
   a) Is there ready access to exits? (Large rooms may require access to more than one exit.)
   b) Are any vision panels required in inner rooms unobstructed?
2. Corridors.
   a) Are they free of storage/fire risks?
   b) If they are required to be protected, is the protection maintained?
   c) Are all cross-corridor doors:
      i. adequately self-closing (including those normally held open) but released automatically in the event of fire?
      ii. not wedged open?
      iii. of good fit?
      iv. undamaged?
3. Protected stairways.
   a) Is protection maintained?
   b) Are they free of storage and fire risks?
   c) Are all doors:
      i. adequately self-closing (including those normally held open) but released automatically in the event of fire?
      ii. not wedged open?
      iii. of good fit?
      iv. undamaged?
4. Final exits.
   a) Are they accessible?
   b) Do they open easily?
   c) Are they free of obstructions outside the premises?
   d) Can occupants disperse away from the building?

Periodically, a more thorough examination of means of escape should be carried out. It should then be ensured that, for example:

a) no unsuitable wall or ceiling linings have been erected;
b) fire stopping above false ceilings has not been breached ;
c) no changes to internal layout have materially affected the means of escape;
d) there is no route for smoke spread around cross-corridor doors.

Further reading

GREAT BRITAIN. Communities and Local Government. The Building Regulations 2000 Approved Document B (Fire Safety) 2006 Edition: Volume 1, *Dwelling houses*, ISBN 978 1 85946 261 4. Volume 2, *Buildings other than dwelling houses*. ISBN 978 1 85946 262 1. Both volumes published by NBS (part of RIBA Enterprises Ltd). London: HMSO.

GREAT BRITAIN. The Building (Scotland) Regulations 2004. Scottish Building Standards Agency, Domestic Handbook. ISBN 0114973342. Non-Domestic Handbook. ISBN 0114973350. Both titles. ISBN 0114973369. London: HMSO.

GREAT BRITAIN. The Building Regulations (Northern Ireland) 2000. Department for Finance and Personnel. Technical Booklet E: 2005, *Fire safety*. London: HMSO.

BS 5588-1, *Fire precautions in the design, construction and use of buildings — Part 1: Code of practice for residential buildings*

BS 5588-6, *Fire precautions in the design, construction and use of buildings — Part 6: Code of practice for places of assembly*

BS 5588-7, *Fire precautions in the design, construction and use of buildings — Part 7: Code of practice for the incorporation of atria in buildings*

BS 5588-8, *Fire precautions in the design, construction and use of buildings — Part 8: Code of practice for means of escape for disabled people*

BS 5588-10, *Fire precautions in the design, construction and use of buildings —Part 10: Code of practice for shopping complexes*

BS 5588-11, *Fire precautions in the design, construction and use of buildings —Part 11: Code of practice for shops, offices, industrial, storage and other similar buildings*

BS 5588-12, *Fire precautions in the design, construction and use of buildings — Part 12: Managing fire safety*

In England and Wales, Communities and Local Government produce 12 guides on the Regulatory Reform (Fire Safety) Order, which incorporate technical guidance on means of escape, each dealing with different types of premises. The guides are available from CLG Publications, but are also available on the CLG website: http://www.firesafetyguides.communities.gov.uk

In Scotland, the Scottish Executive produces similar guides on the equivalent Scottish legislation. The Scottish guides are only available on the website http://www.infoscotland.com/firelaw.

References

1. BS 5588, *Fire precautions in the design, construction and use of buildings*
2. BS 5588-11, *Fire precautions in the design, construction and use of buildings — Part 11: Code of practice for shops, offices, industrial, storage and other similar buildings*
3. DD 9999, *Code of practice for fire safety in the design, construction and use of buildings*
4. BS 7273-4, *Code of practice for the operation of fire protection measures — Actuation of release mechanisms for doors*
5. BS 8220 (all parts), *Guide for security of buildings against crime*
6. BS 5588-8, *Fire precautions in the design, construction and use of buildings — Part 8: Code of practice for means of escape for disabled people*
7. BS 5588-12, *Fire precautions in the design, construction and use of buildings — Part 12: Managing fire safety*
8. BS 5839-9, *Fire detection and alarm systems for buildings — Part 9: Code of practice for the design, installation, commissioning and maintenance of emergency voice communication systems*
9. BS 5266-1, *Emergency lighting — Part 1: Code of practice for the emergency lighting of premises*

8

Building construction

Structural fire protection is defined in BS 4422[1] as "features in a building's layout and/or construction which are intended to reduce the effects of a fire. Thus, structural fire protection involves the use of those passive fire protection products that are related to building construction" (see Chapter 4).

The hazards of fire that structural fire protection is intended to limit are broadly those controlled by building regulations (see Chapter 1), namely:

a) collapse of the building;
b) spread of fire within the building;
c) flame spread over the linings of walls and ceilings;
d) spread of fire beyond the building.

To these may be added the spread of smoke within the building. Depending on the objective, the extent to which it is necessary to control these hazards, particularly fire spread, may be well beyond that required in order to satisfy the building regulations or, indeed, any fire safety legislation. Protection of property or critical facilities often necessitates a higher standard. In order to discuss the principles, the sections below concentrate on the requirements of the Building Regulations 2000 (as amended) in England and Wales, but similar principles apply in Northern Ireland and, generally, in Scotland, under the relevant building regulations in these parts of the UK.

Structural stability: fire protection of the structure

Building regulations require that the building should be structurally stable for a sufficient time to secure the safety of people in and around the building and minimize the risk to fire-fighters, so that collapse does not occur in the early stage of a fire. In England and Wales, the relevant requirement in B3 of Schedule 1 to the Building Regulations 2000 states: 'the building shall be designed and constructed so that, in the event of fire, its stability will be maintained for a reasonable period'.

The effect of fire on the structural stability of a building is a very complex subject, involving a sound knowledge of structural engineering principles. However, one basic fire safety objective is perfectly clear: the probability of structural collapse (the inability of a loadbearing element of construction to continue to support its load) due to fire should be minimized.

In practice, elements of structure require a certain amount of fire resistance (see Chapter 2). For the purpose of Approved Document B, which supports the Building Regulations 2000, an element of structure may include any of the following:

1. a member forming part of the structural frame of a building, or any other beam or column;
2. a loadbearing wall or loadbearing part of a wall;
3. a floor;
4. a gallery (with some exceptions given in the Approved Document – see the following list);
5. an external wall;
6. a compartment wall (including a wall common to two or more buildings).

However, for the purpose of meeting the technical requirement, the following are excluded from the definition of elements of structure:

a) a structure that supports only a roof, unless:
    i. the roof performs the function of a floor, such as for parking vehicles or as a means of escape;
    ii. the structure is essential for the stability of an external wall that needs to have fire resistance;
b) lowest floor of the building;
c) a platform floor;
d) a loading gallery, fly gallery, stage grid, lighting bridge or any gallery provided for similar purposes or for maintenance and repair.

Tables in the approved document set out varying periods of fire resistance for elements of structure according to:

a) the use of the building (different requirements apply to each of the 11 'purpose groups', such as dwelling houses, flats, offices, shops, industrial buildings, etc. into which occupancies are divided);

b) the height of the building or depth of the lowest basement;
c) in some cases, whether the building is sprinklered.

Compliance with the building regulations in order to protect against structural collapse may be insufficient to provide an adequate standard of property protection. Fire insurers might well desire longer periods of fire resistance, since building collapse would greatly increase the financial loss. Premium discounts could apply where elements of structure are adequately protected, or additional premiums might apply in the case of buildings with the minimum fire resistance required under building regulations.

The Fire Protection Association publishes guidance entitled *Design Guide for the Fire Protection of Buildings* (see Further reading). This document has replaced an earlier recognized guide, published by the then Loss Prevention Council and that set out insurers' standards for the passive fire protection of buildings. The Insurers' Fire Research Strategy Funding Scheme (InFiReS) publishes, through the Fire Protection Association, *Categories of Building Construction for Fire or Property Insurance Surveys*. This guidance is intended for use by the British insurance industry, and it provides a common basis for the assessment and categorization of the relative fire risks of elements of building construction. Insurers should always be consulted at the design stage of a building to ensure that their requirements for passive protection can be taken into account by the designer, although clearly this is not possible in the case of a 'spec' building.

Protection against the spread of fire and smoke

Compartmentation by walls and floors

In the context of building regulations, compartmentation refers to the subdivision of a building by walls and/or floors for the purpose of limiting fire spread within the building. The building is divided into compartments, so as to contain a fire within the compartment of origin.

In England and Wales, the relevant performance requirement for compartmentation, expressed in B3 of Schedule 1 to the Building Regulations 2000, states: 'where reasonably necessary to inhibit the spread of fire within the building, measures shall be taken, to an extent appropriate to the size and intended use of the building, comprising either or both of the following:

a) sub-division of the building with fire-resisting construction;
b) installation of suitable automatic fire suppression systems.

Approved Document B refers to the fire-resisting walls and floors that are used to separate one fire compartment from another as 'compartment walls and floors'. The Approved Document specifies maximum compartment sizes for many purpose groups (but not offices or car parks for light vehicles and some single-storey buildings) in the form of maximum floor areas or, in the case of multi-storey storage buildings, maximum volumes. Maximum compartment sizes are doubled if the building is sprinklered, although no limit is imposed on the compartment size of a single-storey warehouse if it is sprinklered. In the case of industrial and storage buildings, the maximum compartment size is greatly reduced if the building is over 18 m in height.

Until 2000, in England and Wales, no requirements for compartmentation of single-storey buildings was imposed under the building regulations. Approved Document B did not specify any limitation of compartment sizes in single-storey buildings. This gave rise to concern, following a number of serious fires that totally destroyed large, single-storey retail premises, such as those often used for DIY stores and supermarkets. In many of these fires, there was rapid fire spread, followed by structural collapse within a relatively short time (sometimes less than 30 minutes) from the time of the call to the fire and rescue service.

Following strong lobbying from fire and rescue services, the then Department of Transport, Environment and Regions gave detailed consideration to this issue and accepted that limitation of compartment sizes in unsprinklered single-storey retail premises would be cost-effective, on a national basis, in terms of the potential for injuries saved, for occupiers and fire-fighters alike. This was reflected in the 2000 edition of Approved Document B, which, in effect, meant that sprinkler protection was, thereafter, normally required in single-storey shops greater than 2,000 m^2 in area (unless subdivided by compartment walls) similar to the situation that already existed under building regulations in Scotland. In 2007, Approved Document B introduced a limit (of 20,000 m^2) for the maximum compartment size of unsprinklered single-storey warehouses.

Compartment walls and floors need not (and generally cannot) be imperforate, as they are penetrated by service ducts and risers, stairways, lifts, escalators, etc. However, these penetrations should typically be enclosed in a protected shaft, of a construction that is of the same fire resistance as required for elements of structure. Doors in compartment walls or floors, and in the enclosing walls and floors of a protected shaft, are required to be fire resisting.

In England and Wales, certain local acts (see Chapter 1) also specify maximum compartment sizes for large storage buildings in order to prevent a major conflagration that would be beyond control by the fire and rescue service. Compartments beyond the sizes specified in these acts are permitted only if there are additional fire protection measures, such as sprinklers, automatic fire detectors and smoke ventilation. Now that the matter of compartmentation of warehouses is addressed in Approved Document B, there is, arguably, no need for these requirements in local acts, and the acts could probably be amended to remove such requirements in due course, albeit compartment sizes set by the local acts are normally much smaller.

There are other objectives that give rise to the need for a form of compartmentation. Technically, the enclosure of any space, such as a small room, within a building by fire-resisting construction constitutes compartmentation, even though the term 'compartmentation' is often reserved for the division of a building into the relatively large compartments required by building regulations.

Codes, such as those in the BS 5588 series, recommend that certain high-hazard areas within a building are enclosed in fire-resisting construction. The periods of fire resistance recommended by the BS 5588 codes vary from 30 minutes for kitchens, many workshops, low-voltage equipment rooms and small storage areas, to 60 minutes in the case of workshops where flammable liquids are stored or used, large storage areas and covered loading bays. In the case of boiler rooms, generator rooms, high-voltage transformer or switchgear rooms and refuse storage areas, the minimum fire resistance recommended is that required for elements of construction, but at least 60 minutes. In contrast, Approved Document B recommends only 30-minute enclosures for such 'places of special fire hazard'; these enclosures are not deemed to be constructed from compartment walls or floors. More generally, in premises where people sleep, such as houses in multiple occupation, hotels and boarding houses, etc., consideration of life safety may demand fire separation between individual occupancies and associated 'common areas'.

In order to limit property loss in the event of fire, fire insurers generally require that hazardous storage areas, such as those containing flammable liquids, hazardous processes (e.g. paint spraying) and fire risks (e.g. diesel generators and oil-filled transformers) be separated from surrounding accommodation by fire-resisting construction. Protection of property does not, however, only involve the creation of small compartments around special risks. Fire insurers also favour a broader form of compartmentation that is more akin to that required by building regulations. The purpose is to limit the insurer's (and client's) estimated maximum loss (EML). This is defined as the maximum loss that is likely to occur in the event of fire, assuming that fire protection arrangements are effective. Classic applications for such compartmentation include:

a) separation of a manufacturing process from the raw materials and finished goods storage areas (in the storage areas, the fire load is often high; although the fire inception hazard is normally lower than in the process area, the loss potential can be very great);
b) subdivision of large warehouses (again, although the fire inception hazard may not be high, the loss potential can be enormous);
c) separation of sprinklered parts of a building from unsprinklered parts;
d) separation of buildings that are likely to attract a high fire insurance premium from buildings that would be more favourably rated, e.g. separation of an office block from a factory area.

In order to protect the ability to function (i.e. prevent interruption to business) in the event of fire, it is often necessary to enclose a facility in fire-resisting construction to prevent the spread of fire into the facility. The most common example of this principle may be found in the construction of a data-processing installation within a building. The enclosing construction is normally fire resisting to prevent fire spread from surrounding accommodation. Periods of fire resistance recommended by BS 6266[2] range from 60 minutes to 240 minutes, according to the fire load of the adjacent accommodation. Facilities on which the data-processing equipment depends should, of course, be similarly protected.

Many organizations are now quite dependent on data-processing facilities, but there may be many other facilities that need to be protected in order to prevent interruption. These could include communications facilities, records, and patterns for a manufacturing process. In all such cases, the critical facility should be enclosed in fire-resisting construction.

Sealing and subdivision of concealed spaces

While it is important to protect against any form of unrestricted fire spread, concealed fire spread within cavities, such as roof spaces, floor voids and ceiling voids is a particular hazard. Concealed fire spread may permit fire to develop to an extent that it is a threat to life before evacuation takes place; it certainly increases the threat to property, and it may create difficulties for fire-fighting by the fire and rescue service. Past experience, such as fires in schools and residential care homes that were constructed with undivided roof spaces, has demonstrated the hazards of cavities. The fire at the Summerland leisure complex on the Isle of Man in 1973, which resulted in 50 deaths, also graphically provided a further example of the problem – in this case a void between an external combustible wall and internal linings.

Subsequently, in 1976, the building regulations in England and Wales introduced requirements for cavity barriers. The performance requirement of the current regulations in England and Wales is set out in B3 of Schedule 1 to the regulations, which states that: 'the building shall be designed and constructed so that the unseen spread of fire and smoke within concealed spaces in its structure and fabric is inhibited'.

Accordingly, depending upon occupancy type, Approved Document B suggests that concealed spaces should be sealed and divided by cavity barriers. A cavity barrier is simply construction, which may already be provided for another purpose (e.g. a 38 mm timber window surround) to seal or subdivide a cavity.

Doors

In terms of fire safety, doors may be required to perform any of the following functions, according to their location:

a) prevent the spread of fire;
b) prevent the spread of smoke, particularly smoke of a relatively low temperature;
c) both a) and b).

Doors, and their associated frames, that afford a fire resistance of anything from 30 minutes to 240 minutes are readily available. Those providing the shorter periods of fire resistance are normally of timber construction, while, for the longest periods of fire resistance, steel is normally used. Timber doors tend to be used throughout commercial premises, except in the case of high-hazard plant rooms and compartment walls of substantial fire resistance, where metal doors and shutters may be appropriate. Metal doors and shutters are also used in industrial premises to maintain the fire resistance of fire break walls and floors needed for compartmentation.

Modern timber fire-resisting doorsets incorporate an intumescent strip in either the door or the frame. This swells at temperatures of, typically, 150 ºC and seals the gap around the edge of the door, which is the point at which an 'integrity failure' (failure to resist the passage of flame and fire gases) most commonly occurs. It is unlikely that a door would achieve a fire resistance of 30 minutes unless an intumescent strip is fitted. Many manufacturers insert a colour-coded plug in the door edge to indicate the fire resistance and, if applicable, the need for an intumescent strip. Modern fire-resisting doors may not need to be 44 mm thick, nor need a 25 mm rebate, as was specified many years ago.

Older doors may not incorporate intumescent strips, and are thus unlikely to afford a fire resistance of 30 minutes if they were tested in accordance with modern test methods. In many applications, however, a fire risk assessment is likely to show that they need not be replaced unless the fit of the door in its frame is poor because, for example, the door has become warped. The final decision as to whether an existing fire-resisting door is acceptable will often lie with the relevant enforcing authority, who may be prepared to accept existing doors. Any new fire-resisting door should obviously comply with modern requirements.

A smoke seal should be fitted to doors that are required to provide a level of smoke control as well as fire resistance. This seal, which is similar to a draught seal, will substantially reduce the amount of smoke that can pass through the door before the temperature is high enough to cause an intumescent seal to operate.

Although intumescent seals and smoke seals are available as individual components, combined intumescent/smoke seals are commonly used, and are necessary for timber doors that are required to protect against the passage of both fire and smoke. This applies to all doors that protect means of escape, such as doors to a protected stairway and within protected corridors.

The degree of insulation afforded by some fire-resisting doors, particularly those of metal construction, may be minimal, and in the event of fire they can become extremely hot on the opposite side to the fire. The thermal radiation emitted from this unexposed face can be sufficient to ignite combustible materials, which should not, therefore, be placed in close proximity to an uninsulated door.

There may be applications in which insulated doors would be of benefit. For example, the fire-resisting door to a sensitive electronic equipment room should afford a good degree of insulation as, if there is a significant fire load in the surrounding accommodation, transmission of heat through the door could result in temperatures within the room that could cause damage to the equipment.

The ability to resist the passage of smoke may also be required for reasons other than life safety. For example, it is desirable for fire doors to rooms that contain sensitive electronic equipment to perform a smoke control function.

It is now conventional to specify fire doors by means of the letters 'FD' followed by the required integrity in minutes. Thus, a 30-minute fire-resisting door would be specified as FD 30. If the door is also required to fulfil a smoke control function, the suffix 'S' is added (e.g. 'FD 30S'). (In the case of doors tested in accordance with the relevant part of the European standard, BS EN 1634, rather than the British Standard, BS 476-22, the letter E is used, rather than FD, and the doors are classified as Sa where restricted smoke leakage is required; e.g. E30Sa, rather than FD 30S).

BS 5588-11[3] recommends the following performance for fire-resisting doors:

a) fire doors to protected stairways, lobbies etc.: FD 30S;
b) dead-end corridors: FD 20S;
c) ancillary accommodation, such as plant rooms: FD 30S-FD 60S (according to the nature of the accommodation);
d) lift shafts, enclosed in fire-resisting construction: FD 30;
e) service ducts, etc.: FD 30S;
f) cross-corridor fire doors: FD 20S;
g) fire doors to external fire escape stairways: FD 30.

This is similar, but not quite identical, to the guidance given in Approved Document B, which addresses the issue of fire spread as well as means of escape. For example, doors to service shafts may need a longer period of fire resistance for compliance with the approved document (as they need no less than half the fire resistance of the wall in which they are fitted), but they do not need resistance to the passage of 'cold' smoke.

In existing buildings, doors that were deemed to be fire resisting under previous test standards are usually accepted by enforcing authorities, provided the premises were brought into use when the test was current, or the door was manufactured when the test was current.

In order to serve its function, any fire door must be closed at the time of a fire. The doors should, therefore, be effectively self-closing or, in the case of, for example, doors to cupboards and service shafts, be kept locked shut.

Rising butt hinges are not generally acceptable as self-closing devices, but Approved Document B accepts these in the case of doors in cavity barriers. The self-closing device should be capable of closing the door from any angle and should be capable of overcoming the resistance of any latch on the door. (Self-closing devices with a 'snap action' in the final part of the travel of the door can be used to ensure compliance with the latter requirement.)

If doors are a major hindrance to the flow of people or goods, then, depending upon circumstances, they may be held open by either:

a) a fusible link (subject to certain conditions, see p. 164), which melts at a predetermined temperature and causes the door to close, usually under the action of a falling weight;
b) an electrically actuated automatic release mechanism that permits the door to close under the action of the self-closing device when smoke is detected by an automatic fire detection and alarm system.

Most commonly, the arrangements comprise a continuously energized electromagnet that holds the door open by means of a metal pad on the door; the electromagnet is then de-energized when the automatic fire detection and alarm system operates. In this case, it is important that the electromagnet and the self-closing device are in the same horizontal plane to prevent twisting forces that will warp the door. Where the door is critical for protection of means of escape, it is important that the doors close in the event of failures of the fire alarm system.

Other forms of door-release mechanisms also exist. For example, one type of release mechanism involves a plunger that holds the door by means of friction with the floor, but retraction of the plunger is triggered by the sound pressure level emitted by the fire alarm system. BS 7273-4 tentatively suggests restrictions on such acoustically linked release mechanisms in the most critical of applications, such as doors protecting the single stairway that may be available for means of escape from a building or part of a building, and stairways in premises in use as sleeping accommodation (e.g. hostels, hotels, residential care establishments, etc.). This is because, in the (unlikely) event of total failure of the fire alarm system, the doors would not automatically release in the event of fire. Government guides on the Regulatory Reform (Fire Safety) Order also suggest that self-contained devices not directly connected to the fire alarm system are unlikely to be suitable for use in doors protecting single stairways or other critical means of escape.

It should be noted that a fusible link will not operate sufficiently early to prevent the passage of large volumes of smoke. Accordingly, these are not suitable for doors that are required to protect escape routes or equipment and stock that is sensitive to smoke damage.

In certain premises, such as residential care homes, there is often a need for all doors in circulation spaces, and doors to bedrooms of residents, to be held open at all times, other than during the night, but to release automatically when the fire alarm system operates. This is because the doors are an impediment to free movement of infirm residents; in the case of bedroom doors, care considerations may also need bedroom doors to stand open during the night. This can best be achieved by the use of free-swing devices, which permit the door to swing freely anywhere between a predetermined position and the closed position, but which self-close the door on operation of the fire alarm system. Approved Document B advises that these are appropriate for bedroom doors in buildings in which self-closing doors could present an obstacle to residents.

Insurers generally require that fire-break doors are kept closed outside normal working hours. It is also conventional that all normally held-open fire-resisting doors are closed at night in premises where people sleep. This practice probably originated partly from problems with early electromagnetic-release devices, which sometimes failed to release the doors because of residual magnetism, owing to the permanent magnetizing of the devices. This is much less of a problem with modern devices, and the relevant product standards include a test to ensure that it is not likely to occur. If the closer and the hold-open devices are in different planes, closing the doors at night reduces the time for which the twisting forces can cause warping of the door; it also enables the problem to be identified if the doors fail to close. In practice, this does not tend to occur to a significant degree, particularly if, as they should be, the two devices are mounted in the same plane. Moreover, release mechanisms and correct operation of the doors should, in any case, be tested on a weekly basis. However, most enforcing authorities still advocate closing doors at night, possibly, in part, because of a slight mistrust of automatic systems at a time when the risk is highest, but the need for the doors to be held open is least.

Great care should be taken in the specification and fitting of hardware for fire-resisting doors. Inappropriate, or inappropriately fitted, ironmongery can severely impair the fire resistance of the door. It is necessary to ensure that the melting point of any metal used in the construction of a hinge for a fire-resisting door is at least 800 ºC. Steel hinges are ideal, but aluminium hinges and some types of brass hinge are unsuitable. All fire-resisting doors should typically be hung on at least three hinges, unless there is test evidence to indicate that a single pair of hinges may be used.

The fitting of locks, self-closing devices and other ironmongery may result in removal of sufficient wood from the door to reduce the fire resistance to an unacceptable degree. Over-mortising is one example, since the thickness of timber that remains may be totally inadequate. The use of intumescent materials can, however, help to minimize the effects of mortising. Useful guidance on maintaining the fire resistance of timber fire-resisting doorsets is contained in BS 8214.[4]

Fire doors are probably the greatest potential point of weakness in a fire-resisting barrier. It is, therefore, important that they are checked regularly to ensure that:

a) no doors are wedged open;
b) the doors are not damaged, and no voids or holes have been created by removal or change of hardware;
c) the self-closing devices close the door effectively, even in the case of latched doors;
d) hinges are not worn;
e) the doors remain of good fit (e.g. there are no gaps of more than around 4 mm between the door and frame or between the leaves of double doors);
f) intumescent seals and smoke seals are undamaged;
g) any automatic release mechanisms operate correctly;
h) no storage or rubbish will impede the effective closing of a door or shutter that is normally held open.

Glazing

Fire-resisting barriers, such as walls and doors, may be glazed, provided the glazing does not reduce the overall fire resistance of the barrier. Normal glass offers no resistance to fire as it shatters and falls out at an early stage. However, various types of fire-resisting glass and glazing systems are available – the most common and cheapest is fire-resisting Georgian wired glass.

In more recent years, a number of unwired glasses, capable of affording substantial periods of fire resistance if installed in suitable frames and channels, have become available. They tend to be much more expensive than traditional wired glasses, but have aesthetic advantages since they are virtually indistinguishable from normal glass. Georgian wired glass and some unwired glasses do not provide significant insulation. Accordingly, Approved Document B sets out the applications in which these products cannot be used in critical situations, such as the enclosure of a protected stairway in a single-stairway condition.

However, a number of proprietary glasses are also able to provide insulation. These glasses are generally laminated, with protective intumescent interlayers, which provide the insulation in the event of fire, or are sealed units that contain a heat-absorbing gel. These products are, therefore, relatively thick compared with uninsulated products, but are less restricted in their use within fire-resisting construction.

Protection against flame spread over linings

The materials used to line walls and ceilings in escape routes should be such that they are not able to spread fire rapidly across their surfaces and do not release any significant amounts of heat if involved in a fire. Less stringent requirements are usually applied to linings in rooms, particularly those of limited size.

In England and Wales, the performance requirement contained in B2 of Schedule 1 to the Building Regulations is that:

> *(1) To inhibit the spread of fire within the building, the internal linings shall:*
> > *(a) adequately resist the spread of flame over their surfaces;*
> > *(b) have, if ignited, a rate of heat release which is reasonable in the circumstances.*
>
> *(2) In this paragraph, 'internal linings' mean the materials lining any partition, wall, ceiling or other internal structure.*

Compliance with the performance requirement is related to the performance of linings when tested in accordance with the appropriate parts of BS 476. BS 476-7[5] permits materials to be grouped into four classes, according to the rate at which, in the test, flame travels over the surface of a specimen of the material. Class 1 constitutes the best performance, while class 4 is the worst. Approved Document B permits class 3 linings in very small rooms, but generally specifies class 1 linings in other rooms, although small areas of class 3 are acceptable. The approved document also specifies alternative performance in European classifications that are acceptable. The European classifications are described in BS EN 13501,[6] and are based on a combination of four European test standards.

In the case of circulation spaces, however, Approved Document B specifies an even higher provision for linings, namely class 0. Class 0 is a composite classification that only exists within the building regulations. A class 0 material is defined as one that achieves class 1 when tested in accordance with BS 476-7, but which, in addition, will not release heat at a significant rate when the material is burning. The method by which the heat-release limitation is specified in Approved Document B is complicated, and relates to further parts of BS 476. The intention is to ensure that, in circulation areas, the contribution of linings to fire growth is limited. Alternative European classifications are also given in the approved document.

Common class 0 materials include plasterboard and mineral fibre tiles, as well as inorganic, non-combustible materials, such as brickwork, blockwork, concrete, etc. Timber is generally a class 3 material. However, by means of treatment with fire retardant paints or intumescent coatings, the rating of timber can be improved to class 1 or even class 0.

Protection against fire spread beyond the building

Prevention of fire spread beyond the building of origin is probably one of the earliest objectives of building regulations, dating from the Middle Ages, following 'great fires' of not just London by many other cities in both England and Wales.

In England and Wales, there are two relevant performance requirements in B4 of Schedule 1 to the building regulations to protect against fire spread beyond the building:

1. the external walls of the building shall adequately resist the spread of fire over the walls and from one building to another, having regard to the height, use of and position of the building;
2. the roof of the building shall adequately resist the spread of fire over the roof and from one building to another, having regard to the use and position of the building.

The first requirement gives rise to the need for external walls in certain circumstances to be fire resisting and for the external surfaces of the walls to be limited in susceptibility to ignition and fire spread. Approved Document B contains a number of additional, more detailed recommendations for external walls, such as limits on the extent of openings and other 'unprotected areas', to limit fire spread between buildings by radiated heat. The approved document also sets out recommendations for separation between buildings.

The second requirement gives rise to quite detailed recommendations in Approved Document B, which relate to the performance of the roof construction in the tests contained in BS 476-3[7] or, for the purpose of the European classifications, BS EN 13501-5.[8] BS 476-3 tests the ability of the roof to resist penetration by fire when its external surface is exposed to radiation and flame. The time to ignition and the spread of flame are measured and roofs are classified by two letters, 'AA' being the designation for the best performance and 'DD' the worst. The approved document relates the designation of the roof to the maximum distance of the roof from any point on the building's boundary, the purpose being to obviate fire spread to the building by radiation or flying brands from another building.

Further reading

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References

1. BS 4422, *Fire vocabulary*
2. BS 6266, *Code of practice for fire protection for electronic equipment installations*

3. BS 5588-11, *Fire precautions in the design, construction and use of buildings — Part 11: Code of practice for shops, offices, industrial, storage and other similar buildings*
4. BS 8214, *Code of practice for fire door assemblies with non-metallic leaves*
5. BS 476-7, *Fire tests on building materials and structures — Part 7: Method of test to determine the classification of the surface spread of flame of products*
6. BS EN 13501, *Fire classification of construction products and building elements*
7. BS 476-3, *Fire tests on building materials and structures — Part 3: Classification and method of test for external fire exposure to roofs*
8. BS EN 13501-5, *Fire classification of construction products and building elements — Part 5: Classification using data from external fire exposure to roofs tests*

9

Emergency escape lighting

Types of emergency lighting

Emergency lighting is installed in a building to provide a degree of illumination when the normal lighting fails. The term includes:

a) emergency escape lighting, which provides illumination for the safety of people during evacuation (if necessary terminating a potentially dangerous process before doing so) when the supply to the normal lighting fails;
b) standby lighting, which is provided to enable normal activities to continue substantially unchanged when the supply to the normal lighting fails.

Most lighting failures arise from electrical faults or complete failure of the supply from the electricity supply authority. However, fire can also lead to a failure of all or part of the normal lighting, due to the effect of heat on the lighting circuits. Unless the cables are designed to be fire resisting, or are suitably protected against fire, the cable insulation can melt, resulting in a short circuit and isolation of the circuit by the appropriate protective device (fuse or miniature circuit breaker). The failure of the normal lighting can make use of escape routes very difficult.

Emergency escape lighting

Fire safety only necessitates the provision of emergency escape lighting. The term emergency lighting is commonly used to refer to what would more properly now be described as emergency escape lighting, and it is purely with emergency escape lighting that this chapter is concerned. If standby lighting is provided in a building, it may contribute to, or constitute, the emergency escape lighting, providing the standby lighting on escape routes complies with the requirements for emergency escape lighting.

Emergency escape lighting may be divided into three parts (see Figure 9.1). Escape route lighting is that part of the emergency escape lighting provided to ensure that the means of escape can be effectively identified and safely used when the premises are occupied. Open area lighting is provided where there are no defined escape routes (such as corridors), but escape takes place throughout, for example, an open-plan area. (In some countries, this is known as 'anti-panic lighting', as it is considered to be provided, in part, to avoid panic when the normal lighting fails.) High-risk task area lighting is that part of the emergency escape lighting that provides illumination for the safety of people involved in a potentially dangerous process or situation and to enable proper shut down procedures for the safety of the operator and other occupants of the premises; it is, arguably, as much, or more, within the remit of the health and safety practitioner as the fire safety practitioner.

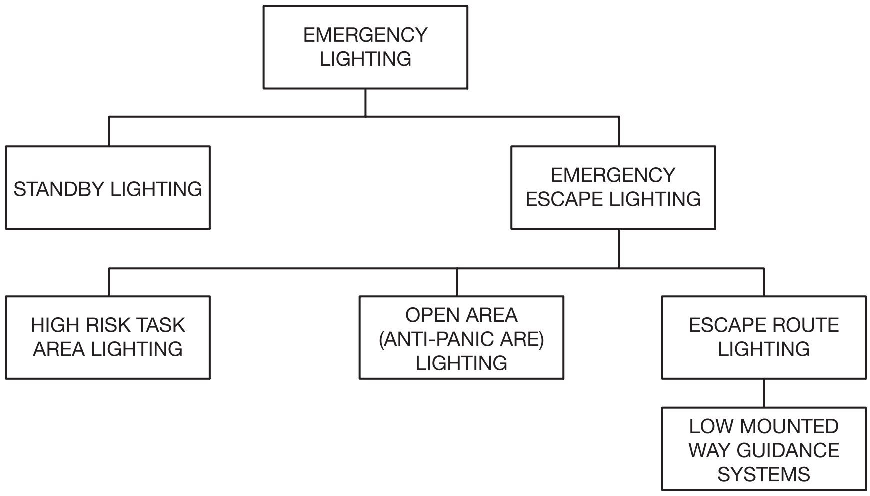

Figure 9.1 Emergency escape lighting

Need for emergency escape lighting

Emergency escape lighting is one of what have traditionally been described as the supporting provisions for means of escape, and may be required under the powers of most fire safety legislation, including building regulations and the Regulatory Reform (Fire Safety) Order in England and Wales (and equivalent legislation in Scotland and Northern Ireland).

In England and Wales, Approved Document B (see Chapter 1) advocates the provision of emergency escape lighting within:

- the common escape routes in residential buildings (other than two-storey flats);
- all escape routes and accommodation in assembly and recreation buildings (other than certain semi-open sports grandstands and similar accommodation, if used only during normal daylight hours);
- public escape routes in shops (other than small shops of three or fewer storeys);
- public escape routes in restaurants and bars;
- electricity generator rooms, emergency lighting switchrooms, etc.;
- toilet accommodation within a floor area of more than 8 m².

In offices, shops, factories, warehouses, car parks, etc., to satisfy Approved Document B, emergency escape lighting would also be necessary in:

- underground or windowless accommodation;
- centre core stairways;
- stairways serving floors above 18 m in height;
- internal corridors more than 30 m long;
- open-plan areas of more than 60 m².

This means that, for example, in England and Wales, compliance with Approved Document B would not necessitate emergency escape lighting in, say, a 17 m high building with no open-plan accommodation or corridors more than 30 m long, although the approved document does advocate that, in all buildings, normal lighting in escape stairways is supplied via a separate circuit from those supplying other areas; this avoids fire in the accommodation disabling lighting in stairways. In practice, regardless of the recommendations of Approved Document B, normally emergency escape lighting would be provided in such a building as a matter of good practice; indeed a fire risk assessment (see Chapter 5) might dictate the need for its provision. It should also be noted that guidance that supports the Building (Scotland) Regulations is somewhat more stringent in its recommendations for the situations in which emergency escape lighting is necessary.

Under the Regulatory Reform (Fire Safety) Order,* there is a need to provide measures for securing that, at all material times, the means of escape can

* and equivalent legislation in Scotland and Northern Ireland.

be safety and effectively used. In order to ensure that this is the case, the Order requires that, where necessary, emergency routes and exits requiring illumination must be provided with emergency (escape) lighting of adequate intensity in the case of failure of their normal lighting.

In premises where people sleep or the public assemble, emergency escape lighting is an essential component of the fire protection measures required for safety of occupants in the event of fire. In premises such as offices, factories and warehouses, emergency escape lighting should normally be provided if the premises are occupied during the hours of darkness, or if parts of the escape route are devoid of natural lighting.

More generally, the provision of emergency escape lighting should be regarded as good practice in most premises, regardless of whether it is specifically required by legislation. It is a matter that, at least, must be considered as part of the fire risk assessment required by fire safety legislation.

Design standards

The generally accepted design code for emergency escape lighting is BS 5266-1.[1] However, to avoid conflict with European Standards on the subject, which have been published as BS 5266-7 and BS 5266-8, BS 5266-1 does not now address all the relevant aspects of design of an emergency escape lighting installation. Instead, it is a base document, which is intended for use in conjunction with BS 5266-7 and BS 5266-8. Accordingly, to specify fully an emergency escape lighting installation, it is necessary to call for compliance with the recommendations of BS 5266-1, and with the requirements of BS 5266-7[2] and BS 5266-8.[3]

Choice of installation

There are three main types of emergency escape lighting installation:

a) self-contained luminaires;
b) central battery systems;
c) emergency generators.

Self-contained luminaires

Emergency escape lighting is most commonly provided by the installation of self-contained luminaires, particularly in smaller premises and those premises to which emergency escape lighting must be retrofitted. As the name implies, each luminaire is entirely independent and comprises a battery, charger, changeover device, inverter (for fluorescent fittings) and lamp(s) – all within a single housing (although the control gear may be separated from the actual lamp housing by up to 1 m). It is possible to convert normal mains luminaires into self-contained fittings by the addition of a conversion pack. This normally operates a small lamp within the main luminaire but, in the case of more sophisticated units, provides power to the existing lamp.

The self-contained luminaire is connected to the local lighting circuit. The battery therefore remains charged by the normal lighting circuit. Failure of the normal lighting circuit is detected automatically, and illumination is provided by the emergency lighting unit. BS 5266-7 requires that luminaires conform to a European product standard, BS EN 60598-2-22.[4]

Self-contained luminaires are simple to connect and relatively cheap and quick to install, making them ideal for retrofitting into a building that has no emergency escape lighting. They also provide a good degree of flexibility and can be adapted to suit changes in the layout of a building. The connection to the lighting circuit may comprise any suitable cable, such as the PVC insulated and sheathed cables that are commonly used for lighting circuits. It is important, however, that non-maintained fittings are connected to the normal lighting sub-circuit that serves the area in which they are installed; otherwise, a failure of the local lighting circuit will not be detected, and a fire that affects only this circuit will result in total loss of illumination.

A further advantage claimed for self-contained luminaires is that the batteries are maintenance free, since sealed cells are used. While it is true that maintenance of batteries is not required, many users fail to appreciate that the life of these batteries is finite, and may be no more than 4-5 years. There is a tendency for the units to be installed and forgotten, with the result that, on demand, the units either fail to operate, or provide illumination for only a limited duration.

Regular testing is therefore necessary, and this may become a burden if the building is large and the number of luminaires is great. The replacement of batteries may also result in significant costs, which may ultimately exceed the economy achieved at the installation stage. Battery life will be shortened further if the units are installed in areas where the ambient temperature is high; the reliability of the associated electronics will also be affected. Systems for automatic testing of self-contained emergency lighting installations are available, although their use is still not common. These can greatly reduce the routine maintenance burden that would otherwise be created in a large self-contained installation.

Central battery systems

A central battery system comprises a single-battery installation with associated charger. This provides a source of supply at a suitable voltage to all 'slave' emergency lighting luminaires, by means of a dedicated wiring system, thus forming a complete secondary lighting installation. BS 5266-7 requires that slave fittings conform to BS EN 60598-2-22. The batteries and control equipment are housed in a metal 'cubicle', or a dedicated battery room in the case of very large sites. In order to operate fluorescent fittings, a bulk inverter is required, or alternatively, an inverter must be fitted to each luminaire. In principle, when a bulk inverter is used, conventional 230 V luminaires can then be used as slave fittings.

Uninterruptible power supply (UPS) systems are, however, not always suitable for supplying emergency escape lighting, as they are not always able to start fittings under mains failure conditions (because of the surge that occurs on start-up of large fluorescent loads) or blow individual distribution fuses under overload. Care must be taken at the design stage if a UPS system is used.

Central battery systems are relatively expensive to install because of the long runs of wiring between the central point(s) and the luminaires. Further costs arise from the need to ensure that fire cannot cause loss of power to luminaires in the same way as it can affect normal lighting circuits. The wiring used must either be inherently fire resistant (e.g. mineral-insulated copper-sheathed or other proprietary fire-resisting cable), or be protected against fire by fire-resisting construction; metal or rigid PVC conduit does not, by itself, provide adequate fire protection for non-fire-resisting cables. Unless the protection is adequate, the entire emergency escape lighting installation may be vulnerable to complete failure.

Additional complexity and cost may arise from the need for sub-circuit monitoring. Unless the emergency escape lighting is illuminated at all times, monitoring relays in normal lighting sub-circuits will need to be installed, to ensure that failures are detected and the emergency escape lighting is switched on.

There are, however, certain advantages in the use of central battery installations, particularly in the case of large installations with many luminaires. If vented cells are used, relatively long battery life (e.g. 25 years) is possible. Although these batteries will require maintenance, battery testing is simplified by the presence of a single installation. Thus, central battery systems can be cost effective for large installations.

Emergency generators

The existence of an emergency generator may allow standby lighting to be provided, but it is not necessarily adequate for emergency escape lighting. The generator will only start on total power failure. This is not the most likely result of fire, which is more likely to affect only a limited number of circuits. Unless the generator supplies dedicated luminaires that are wired in fire-resisting cable, it is unlikely to be adequate for the provision of emergency escape lighting. Moreover, the testing regime needed for generator systems requires that the system is tested monthly for one hour with at least two-thirds of the load connected. Thereafter, the generator must be refuelled to be ready for an emergency. This is an onerous commitment, unless appropriate maintenance staff are available.

Mode of operation

There are three possible modes of operation of luminaires:

a) non-maintained – the luminaire operates only when the normal lighting fails;
b) maintained – the luminaire is illuminated at all times;
c) combined (maintained or non-maintained) – one lamp in the luminaire is energized from the emergency supply on failure of the normal supply; the other(s) is energized from the normal mains supply.

Illuminated exit signs are often of the maintained or combined maintained type. Maintained emergency escape lighting is normally provided in cinemas, theatres, concert halls, discotheques and other places of public entertainment.

Duration of emergency escape lighting

BS 5266-1 recommends an emergency escape lighting duration of 1 or 3 hours according to the occupancy. For premises in which people sleep and for recreational premises, such as cinemas, theatres, concert halls, exhibition halls, sports halls, public houses and restaurants 3 hours is recommended. In offices, shops and many factories, a period of 1 hour is usually acceptable. In practice, many users tend to install 3-hour units even where 1-hour units would, in theory, be acceptable. This has the benefit that the building need not be evacuated in the event of a total power failure that does not exceed 2 hours in duration and enables immediate reoccupation of buildings, while 1-hour systems should be recharged before the building is used again.

Siting of luminaires

A system of emergency escape lighting should provide illumination of the following:

a) escape routes and stairways;
b) exits (there may also be a need for external illumination unless public lighting is adequate);
c) changes in level or direction, and intersections of corridors;
d) fire equipment (manual call points, fire extinguishers, hose reels, etc.) and first aid posts;
e) fire safety signs (fire exit signs may be internally illuminated and form part of the emergency escape lighting installation);
f) large toilets (defined in BS 5266-1 as those greater than 8 m^2), but not toilets intended for use by only a single, able-bodied person or en suite toilets and bathrooms in hotel bedrooms;
g) plant rooms associated with normal and emergency escape lighting.

Although not strictly part of the emergency escape lighting system, it is also good practice to install emergency escape lighting, normally of the self-contained type, in lift cars. This is essential if lifts are used for evacuation of disabled people (see Chapter 7). Emergency escape lighting is also required in fire-fighting lifts (see Chapter 16).

In order to prevent obscuration by smoke, luminaires should be mounted relatively low; to prevent obscuration by persons, a minimum height of 2 m above floor level is recommended by BS 5266-7. Siting should also avoid excessive contrast along the escape route and prevent glare. These design considerations are particularly important if the building may be used by partially sighted people.

Level of illumination

In areas with defined escape routes, BS 5266-7 recommends that the illuminance at floor level on the centre line of the route should be at least 1 lux. In addition, for escape routes up to 2 m wide, the code recommends that 50 per cent of the width be lit to a minimum of 0.5 lux. Wider escape routes are treated as a number of 2 m wide strips. In open-plan areas with undefined escape routes, the code recommends a minimum level of 0.5 lux over the core area (i.e. ignoring areas less than 0.5 m from walls).

These levels of illuminance should be achieved under the most adverse circumstances, such as voltage reduction at the end of the designed duration, lamp ageing and dirty diffusers on luminaires. In addition, manufacturers' data on the luminaire spacings required to achieve this level ignore reflections from wall surfaces, etc. Therefore, under normal circumstances, higher levels of illumination invariably exist. Higher levels may also be appropriate in premises occupied by a significant number of partially sighted people.

Checking emergency escape lighting

Checking emergency escape lighting can prove difficult unless special test facilities are incorporated in the scheme. Central battery systems offer an advantage in that the mains supply can be isolated at a single point in order to test the central battery; checking luminaires then only involves a walk around the premises to ensure that all lamps are operational and that diffusers are clean.

Simple test facilities should always be incorporated in an emergency escape lighting scheme. The simplest form of test facility comprises a keyswitch that isolates the supply to a group of self-contained fittings. A timer can also be fitted to ensure that the supply is restored after a predetermined period. More sophisticated test facilities, such as hand-held, infrared remote controls that put a luminaire into test mode, are also available, as are completely automatic test facilities.

BS 5266-8 gives recommendations for routine inspection and testing of emergency lighting on a daily, monthly and annual basis as follows.

Daily inspection

Control equipment of central battery systems or generators should be checked daily to ensure that they indicate normal operation. This is normally achieved by ensuring a fault indicator or repeater is in an area that is normally occupied.

Monthly inspection

On a monthly basis, all luminaires and internally illuminated exit signs should be energized by simulating a mains failure to ensure that they operate correctly. Any generators should be tested in accordance with ISO 8528-12.

Annual inspection

All luminaires and internally illuminated exit signs should be tested for their full rated duration annually. Any generators should be tested in accordance with ISO 8528-12.

Care should be taken to ensure that full duration discharge testing is carried out at a time and in such a manner that risk to occupants is minimized. Ideally, this should be carried out at a time when the premises can be devoid of emergency escape lighting for 24 hours (the recharge time of the batteries). Obviously, this is not always possible (e.g. in buildings that are continuously occupied seven days a week). In the case of self-contained luminaires, risk can be reduced by testing only alternative luminaires on the occasion of each full discharge test, so that 50 per cent of the luminaires continue to function normally at the time of each test. This approach cannot be adopted in the case of central battery systems, but the stationary cells used can be discharged for two-thirds of capacity and an accurate evaluation of final capacity can be made using supplier's data.

Emergency wayfinding systems

In recent years, systems known as emergency wayfinding systems have been developed to assist people in using escape routes when power to normal lighting circuits has failed. BS 5266-2 and BS 5266-6 cover powered and unpowered systems, giving guidance on system design and components. Wayfinding systems can be valuable additions to conventional emergency escape lighting. These systems highlight the escape routes by means of tracks of light mounted at low level along the edges of the route and around exit doors. The tracks are likely to be visible when smoke is present. Considerable research on this subject has been carried out by the Building Research Establishment, who have carried out tests on the following systems:

- electroluminescent systems;
- miniature incandescent systems;
- light-emitting diode (LED) systems;
- photoluminescent systems.

The first three systems require a source of power, which is provided by batteries, whereas photoluminescent materials give off light after a previous period of exposure to artificial light. The Building Research Establishment has conducted research into the use of these systems for partially sighted people; their findings are that wayfinding systems can be very effective, but that photoluminescent wayfinding systems are too dim for visually impaired people.

Directional sounders

Directional sounders are, in effect, a special form of audible wayfinding system. Although their use is not common, they could be used to assist people in finding their way to fire exits. Research has shown directional sounders to be very effective in assisting people to follow correct escape routes in buildings, ships and aircraft. They are said to be particularly effective in doing so for blind and partially sighted people, or where vision is impaired by smoke. Equally, it might be argued that conditions in a building should rarely reach a situation in which people are trying to find exits in thick smoke that obscures the fire exits.

A directional sounder is a form of electronic sounder that produces a broadband sound, often referred to as ‘white noise’, that covers all or most of the audible frequency range of the human ear (20 Hz to 20 KHz). Broadband sound allows the human ear to locate the sounder much more easily than sound of restricted bandwidth emitted by conventional fire alarm sounders. By strategically locating a directional sounder (e.g. at an exit door from an area), people in the area are directed to that sounder, and therefore to that exit.

Because directional sounders have a wide sound bandwidth, their sound is not readily masked by the sound from conventional fire alarm sounders or bells. Both types of sounder can therefore operate simultaneously.

Many directional sounders produce bursts of sound, interspersed with periods of silence. Voice messages can be broadcast by the sounders in the 'gaps' between the sound bursts. Typical messages could be 'Exit here' or 'Stairs down here'. Where voice messages are used, they should not be broadcast at the same time as the directional sound signal. If there are several directional sounders along a route to, say, an exit, the pulse rate of the sound bursts from each sounder can be set to reflect its distance from the exit, with the sounder nearest to the exit having the highest pulse rate. This technique improves the effectiveness of the guidance offered by the directional sounders.

At present, there are no British, European or International standards or codes of practice for the design of directional sounder systems. However, a Publicly Available Specification (PAS 41[5]), published by BSI, sets out requirements for the sounders themselves.

Further reading

BS 5266-1, *Emergency lighting — Part 1: Code of practice for the emergency lighting of premises*

BS 5266-2, *Emergency lighting — Part 2: Code of practice for electrical low mounted way guidance systems for emergency use*

BS 5266-6, *Emergency lighting — Part 6: Code of practice for non-electrical low mounted way guidance systems for emergency use — Photoluminescent systems*

BS 5266-7 (BS EN 1838), *Lighting applications — Part 7: Emergency lighting*

BS 5266-8 (BS EN 50172), *Emergency escape lighting systems*

BS EN 60598-2-22, *Luminaires — Particular requirements — Part 2-22: Luminaires for emergency lighting*

Emergency Lighting (Technical Memorandum TMI2). Chartered Institute of Building Services Engineers.

Emergency wayfinding lighting systems. Paper IP1/93. Building Research Establishment.

Emergency wayfinding systems: their effectiveness in smoke. Paper IP10/97. Building Research Establishment.

Emergency lighting and wayfinding systems for visually impaired people. Paper IP9/97. Building Research Establishment.

Watts C J. *A guide to emergency lighting*. BIP 2081. BSI Business Information. ISBN 058047755X.

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1. BS 5266-1, *Emergency lighting — Part 1: Code of practice for the emergency lighting of premises*
2. BS 5266-7 (BS EN 1838), *Lighting applications — Part 7: Emergency lighting*
3. BS 5266-8 (BS EN 50172), *Emergency escape lighting systems*
4. BS EN 60598-2-22, *Luminaires — Particular requirements — Part 2-22: Luminaires for emergency lighting*
5. PAS 41, 2003, *Directional sounders — Requirements and tests*

10

Fire safety signs

There are five categories of fire safety sign:

1. safe condition;
2. mandatory;
3. fire equipment;
4. hazard;
5. prohibition.

General guidance on the shape, layout and colour of all fire safety signs (and other safety signs) is contained in BS 5499-1,[1] while specific graphic symbols are given in BS 5499-5.[2]

Signs that provide information on escape routes, fire exits or fire-fighting equipment are subject to the requirements of the Health and Safety (Safety Signs and Signals) Regulations 1996,* which impose requirements regarding the shape, colour and general appearance of such signs. These regulations implement an EU directive on safety signs at work, the purpose of which is to enable workers to move from one workplace to another without facing different signs. The fire exit pictogram (often described as the 'running man') contained in BS 5499-5 is slightly different from that contained in the Health and Safety (Safety Signs and Signals) Regulations. However, the BS 5499-5 pictogram is deemed to satisfy the regulations.

The Health and Safety (Safety Signs and Signals) Regulations do not specify where and when a sign must be provided. However, they do impose an overriding requirement that signs must be provided wherever a risk cannot be eliminated by other means. Thus, employers must base their provision of fire exit and fire extinguishing equipment (and other safety) signs on a

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* in Northern Ireland, the Health and Safety (Safety Signs and Signals) Regulations (Northern Ireland) 2006.

risk assessment. In practice, this will be undertaken as part of the fire risk assessment required by the Regulatory Reform (Fire Safety) Order.* The enforcing authority in respect of fire safety signs, under the Health and Safety (Safety Signs and Signals) Regulations, is the authority that enforces the fire safety legislation under which signs are required (see Chapter 1).

The Fire Safety Order* also requires that emergency routes and exits, and manual fire-fighting equipment, are indicated by signs wherever this is necessary to safeguard relevant persons in the event of fire. Again, compliance should be based on the fire risk assessment (see Chapter 5).

Many of the signs specified in BS 5499 take the form of graphic symbols, but these may be supplemented with 'supplementary' signs that bear words. However, to comply with BS 5499, supplementary signs can be used only with an accompanying graphic symbol. Accordingly, except where no suitable graphic symbol exists to convey the meaning required, signs complying with BS 5499 comprise a graphic symbol, with or without an accompanying worded sign. The graphic symbols specified are, in general, internationally agreed, so that they enable non-English speakers to understand the meaning of the sign.

Table 10.1 contains a description of the shape, colouring and format of the six categories of sign. The size of the sign's wording or symbols depends on the distance from which the sign will be viewed. BS 5499-10[3] contains guidance on letter size as a function of viewing distance.

Safe condition signs

The most important safe condition sign, and indeed arguably the most important of all fire safety signs, is that indicating a fire exit or the route to a fire exit. The internationally agreed symbol, traditionally specified for many years by BS 5499, is the 'running man' (see Figures 10.1 and 10.2). The figure is normally running to the right (Figure 10.1), except in the case of an escape route that changes direction to the left, in which case Figure 10.2 would be used in conjunction with an arrow. In the case of a change of direction to the right, an arrow would also be used in conjunction with Figure 10.1.

* and equivalent legislation in Scotland and Northern Ireland.

Table 10.1 Categories of fire safety sign

Category of sign	*Shape*	*Colours*
Safe condition	Square or oblong	White symbol or text on a green background
Mandatory	Circular	White symbol or text on a blue background
Fire equipment	Square or oblong	White symbol or text on a red background
Hazard	Triangular	Black symbol or text on a yellow background, surrounded by a black triangular band
Prohibition	Circular with cross band	Black symbol on a white background, inside a red circle with a red cross bar
Supplementary	Square or oblong	Black text on white background or the safety colour of the safety sign that is supplemented, with the text in the relevant contrasting colour

Figure 10.1 Running man: fire exit to right (green and white)

Figure 10.2 Running man: fire exit to left (green and white)

The Health and Safety (Safety Signs and Signals) Regulations require that all emergency escape signs incorporate a pictogram, along with an arrow in circumstances in which directional guidance is necessary. This requirement became retrospective in December 1998, and, since that time, it has been a breach of the Regulations to use a fire exit or similar sign without incorporating a pictogram. The Regulations specify the pictograms that should be used, although minor variations are acceptable (see Figure 10.3). Note that the 'running man' in the Regulations is slightly different from that specified in BS 5499-5. However, guidance produced by the Health and Safety Executive advises that the use of the latter 'running man' is acceptable under the Regulations. This is accepted by fire and rescue authorities.

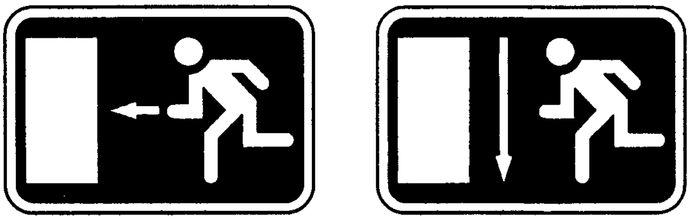

Figure 10.3 The Health and Safety (Safety Signs and Signals) Regulations 'running man'

It is conventional to indicate as 'fire exits' only those routes of travel that are not the normal exit routes from the building, which may be signposted as 'exits'. If an exit cannot be seen, or the escape route is not obvious, exit symbols should be supplemented with directional arrows. BS 5499-4[4] gives guidance on the selection and use of escape route signs conforming to BS 5499-1.

Graphic symbols should also be used to convey the following meanings, but these may, again, be supported by supplementary signs, worded as shown below:

a) 'slide to open';
b) 'break glass (or cover) in the event of fire'.

The remaining standard safe condition sign is that used to provide instructions for panic bolts or latches, and bears the words 'Push bar to open'. Other safe condition signs can be constructed by using the general safe condition sign (see Figure 10.4) in conjunction with an appropriately worded supplementary sign.

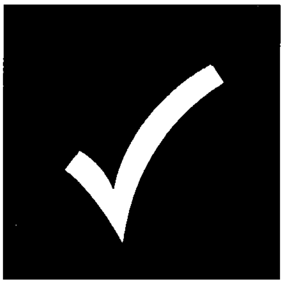

Figure 10.4 Safe condition sign (green and white)

Mandatory signs

The most common mandatory signs are those used on fire-resisting doors, each of which should bear the appropriate sign. Standard wordings for common mandatory signs follow. It should be noted that the Health and Safety (Safety Signs and Signals) Regulations do not apply to these signs:

a) 'Fire door keep shut' – used on a self-closing fire door (except an automatic fire door) when not in use, see Figure 10.5;
b) 'Fire action' – used as a heading for written fire instructions;
c) 'Fire door keep locked shut' – used on a fire door that is not self-closing and which must be kept locked when not in use;
d) 'Automatic fire door keep clear' – used on a fire door, or shutter that becomes self-closing in the event of fire;
e) 'Automatic fire door keep clear. Close at night';
f) 'Secure door open when premises are occupied' – used, for example, on a door or gate opening in the wrong direction for escape;
g) 'Remove security fastenings when premises are occupied';
h) 'Gangway keep clear';
i) 'Fire exit keep clear' – this sign is sometimes confused with the safe condition fire exit sign but should, typically, be used outside a fire exit door that may be obstructed.

Figure 10.5 Mandatory sign 'Fire door keep shut' (blue and white)

A general mandatory symbol (see Figure 10.6) can be used in conjunction with appropriate supplementary signs.

Figure 10.6 General mandatory sign (blue and white)

Fire equipment signs

Traditionally, for many years, BS 5499 has incorporated pictograms, which may be used with supplementary wording, to indicate the following meanings:

a) fire alarm call point;
b) fire telephone;
c) fire hose reel;
d) fire extinguisher.

The Health and Safety (Safety Signs and Signals) Regulations 1996 also specify pictograms, which may be used with directional arrows when appropriate, for each of these, other than the fire alarm call point. A graphical symbol for a fire alarm call point sign is given in BS 5499-5. In addition, the Regulations incorporate a pictogram for a ladder, see Figure 10.7.

Figure 10.7 Fire-fighting equipment signs (red and white) specified in the Health and Safety (Safety Signs and Signals) Regulations

The concept in the Regulations is that, where there is a need to identify the location of any of this equipment, such as fire extinguishers, the colour red must be used. Identification can be by means of the red pictogram, with or without supplementary wording, but may, instead, be achieved by colouring the background behind the equipment red, as is often the practice in factories and industrial premises. It is a common misconception that all fire alarm call points and fire extinguishers need to be indicated by signs. This is not the case. The need for signs should be determined by the fire risk assessment. Normally, there will be no need for a sign if the equipment is obvious, but signs are relevant if the equipment is hidden from view. Moreover, fire alarm call point signs do not fall within the scope of the Health and Safety (Safety Signs and Signals) Regulations.

Guidance on the Regulations, produced by the Health and Safety Executive, also advises that, if the equipment is predominantly red, there may be no need even for the coloured background. Since fire extinguishers manufactured in accordance with BS EN 3[5] are predominantly red (see Chapter 13), the use of these extinguishers may, in itself, constitute identification for the purposes of the Regulations, provided they are not hidden from view.

Standard notices, comprising a graphic symbol and words, are also described in BS 5499 to indicate the following:

a) the location of a foam inlet;
b) the location of a dry riser;
c) the location of a wet riser;
d) a switch for use by fire-fighters (e.g. to ground lifts);
e) the need to operate a valve (e.g. before running out a hose reel);
f) the location of plans of the premises for use by fire-fighters.

In each case, the sign comprises graphic flames (see Figure 10.8) in conjunction with appropriate wording.

Figure 10.8 Collection of fire-fighting equipment (red and white)

Hazard signs

A general hazard sign for use in conjunction with supplementary signs is shown in Figure 10.9. The most common supplementary sign is that indicating 'in case of fire avoid use of lift'. Standard graphic warning signs are contained in BS 5499-5 to indicate the following meanings, which may also be conveyed by a supplementary sign, worded as shown below:

a) 'Beware flammable material';
b) 'Beware oxidizing material';
c) 'Beware explosive material'.

Fire 10.9 General hazard sign (yellow and black)

All three of these signs come within the scope of the Health and Safety (Safety Signs and Signals) Regulations 1996, which also specify the pictograms that must be used to convey these meanings.

A further standard sign comprising the warning triangle and the words 'No escape' is used on doors, or in routes, that may appear to provide a means of escape but do not in fact do so.

Prohibition signs

The most common prohibition sign is the universally recognized 'No smoking' sign. BS 5499-5 contains graphic symbols to indicate that:

a) naked flames are prohibited;
b) water must not be used as an extinguishing agent.

Again, these signs come within the scope of the Health and Safety (Safety Signs and Signals) Regulations 1996, which also specify the pictograms that must be used to convey these meanings.

For other forms of prohibition, the general prohibition symbol (see Figure 10.10) may be used in conjunction with a supplementary sign.

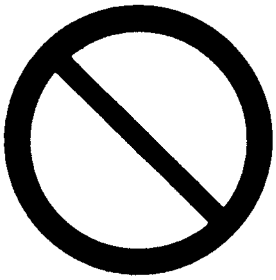

Figure 10.10 General prohibition sign (red and white)

Further reading

BS 5499-1, *Graphical symbols and signs — Part 1: Safety signs, including fire safety signs — Specification for geometric shapes, colours and layout*

BS 5499-5, *Graphical symbols and signs — Part 1: Safety signs, including fire safety signs — Signs with specific safety meanings*

GREAT BRITAIN. The Health and Safety (Safety Signs and Signals) Regulations 1996. Guidance on Regulations. Health and Safety Executive. ISBN 0717608700. London: HMSO.

Guide to Fire Safety Signs. Fourth edition. 2007. Fire Protection Association. ISBN 0902167871.

References

1. BS 5499-1, *Graphical symbols and signs — Part 1: Safety signs, including fire safety signs — Specification for geometric shapes, colours and layout*
2. BS 5499-5, *Graphical symbols and signs — Part 1: Safety signs, including fire safety signs — Signs with specific safety meanings*
3. BS 5499-10, *Safety signs, including fire safety signs — Part 1: Code of practice for the use of safety signs, including fire safety signs*
4. BS 5499-4, *Safety signs, including fire safety signs — Part 1: Code of practice for escape route signing*
5. BS EN 3, *Portable fire extinguishers*

11

Fire detection and fire alarm systems

The need for fire alarm systems and automatic fire detection

In all premises, there should be some means of giving a warning to all occupants in the event of fire. The Regulatory Reform (Fire Safety) Order* requires that, where necessary to protect relevant persons from fire, there must be a suitable fire detection and fire alarm system.

In a very small, single-storey building, means of giving warning might comprise manually operated mechanical devices, such as turn-handle rotary gongs. If the premises were small enough (e.g. many small shops), it might even be sufficient for persons to shout 'Fire!' in order for an adequate warning to be given. In practice, most buildings with which readers of this book will be concerned are likely to require an electrically operated fire alarm installation that will alert all occupants, indicate the location of the fire and, perhaps, automatically summon the fire and rescue service.

In the case of a manual system, the fire warning signal can be initiated only by the operation of a break-glass manual call point by occupants. With an automatic system, the warning can be initiated by strategically sited automatic fire detectors. In practice, any automatic fire alarm system is normally combined with a manual fire alarm system.

In premises in which people sleep, there will be a need for extensive provision of automatic fire detection. Such premises include hotels, hostels, residential care premises and houses in multiple occupation.

Automatic fire detection may also be used to provide compensation for deficiencies in other fire protection measures, particularly means of escape.

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* and equivalent legislation in Scotland and Northern Ireland.

There is some logic in this principle, since automatic fire detectors may alert occupants before they would otherwise become aware of a fire. The occupants may then begin to use the means of escape, before the shortcomings that exist cause the escape route to become impassable.

Fire insurers may also strongly encourage the installation of automatic fire detection in a building, in order to reduce the likely property damage in the event of a fire. In some premises, particularly those of an industrial nature, insurers may actually grant a small discount in fire insurance premiums if automatic fire detection is installed throughout the premises.

Design codes

In the United Kingdom, most fire alarm installations are designed in accordance with BS 5839-1.[1] If a fire alarm system is required by an enforcing authority or by fire insurers, they will normally require compliance with this code.

In the case of automatic fire detection systems installed in dwellings, including houses divided into individual flats or bedsits, and dwelling units within sheltered housing schemes, the appropriate design code is BS 5839-6.[2] However, since this code does not apply to commercial occupancies, it is not considered further in this book. There is, however, reference to this code of practice and associated guidance in the Further Reading section at the end of this chapter.

In the case of hospitals, guidance on the design of fire detection and fire alarm systems is published by the Department of Health in the form of HTM 05-03: Part B[3] (formerly entitled HTM 82[4]). This supplements BS 5839-1.

Categories of installation

BS 5839-1 defines eight categories of installation:

1. *category M systems* are, by definition, manual fire alarm systems and, therefore, incorporate no automatic fire detectors;
2. *category P1 systems* are intended for the protection of property, and incorporate automatic fire detection throughout all areas of the protected building;

3. *category P2 systems* are also installed for the protection of property, but incorporate automatic fire detection only in defined parts of the building;
4. *category L1 systems* are intended for the protection of life, and incorporate automatic fire detection throughout the protected building;
5. *category L2 systems* are also intended for the protection of life, but incorporate automatic fire detection only in defined parts of the building, which include those parts in which a category L3 system would require detectors to be installed, plus defined high-hazard areas and areas in which a fire would present a high risk to occupants;
6. *category L3 systems* are installed only for the protection of escape routes; the objective is to ensure that occupants evacuate before escape routes are impassable owing to the presence of fire, smoke or toxic gases. To satisfy the objective, detectors need to be installed in rooms or areas that open onto escape routes, as well as within the escape routes themselves;
7. *category L4 systems* comprise smoke detection within those parts of the escape routes forming the circulation areas and spaces, such as corridors and stairways; the purpose of a category L4 system is simply to enhance the safety of occupants by providing warning of fire within the escape routes; such a system would not, however, be sufficient to protect sleeping occupants; in premises in which people sleep, the minimum appropriate standard of protection is that provided by a category L3 system, but, in practice, a category L1 or L2 system is likely to be necessary;
8. *category L5 systems* are systems intended to satisfy a specific fire safety objective related to protection of life; these are 'tailor-made' systems, in which the areas protected by automatic fire detectors are carefully specified for the purpose of meeting the defined objective.

Category M systems are very common. They are usually sufficient to satisfy the requirements of legislation in common places of work in which no one sleeps. Categories L1, L2, L3 and L4, by definition, incorporate a manual (category M) system. In practice, categories P1, P2 and L5 usually also incorporate a category M system. However, exceptions do exist; for example, in a building that is protected throughout by a simple category M system, a category P2 system may be installed quite independently to protect a computer suite.

The distinction between property protection and life safety may, at first sight, seem somewhat academic; any system that satisfies one objective will, to a greater or lesser extent, satisfy the other. Certainly, it is true that a category P1 system and a category L1 system are almost identical. Nevertheless, subtle differences do exist. For example, unless the premises were occupied at all times, a category P1 system would need means for automatic transmission of fire signals to an alarm receiving centre, from where the fire and rescue service would be summoned. For most premises, this would not be necessary in the case of a category L1 system, as the primary objective is to evacuate the premises. Also, it is possible that a category P1 system might need larger batteries than a category L1 system, to cater for, say, a weekend, during which a fault in the mains supply might not be identified and repaired.

In view of the existence of eight different categories of fire detection and fire alarm system, it is meaningless for a specifier, enforcing authority or insurer simply to specify the provision of a system conforming to the British Standard. Any reference to BS 5839-1 needs to be accompanied by a reference to system category. Moreover, in the case of category P2, L2 and L5 systems, further information would need to be provided regarding the areas that are to be protected with automatic fire detection.

Components of an installation

A schematic of a typical fire alarm installation is shown in Figure 11.1. The basic components of an installation are as follows:

a) trigger devices/sensors – manual fire alarm call points and automatic fire detectors;
b) control and indicating equipment (with associated power supplies);
c) alarm devices – bells, electronic sounders, etc.;
d) wiring (but interconnection may instead be by radio signalling).

To these basic components, may be added optional extras, such as:

a) a transmitter that will transmit any alarm to a remote location ('alarm receiving centre', or 'ARC');
b) interfaces with other systems, such as air conditioning and ventilation plant, gaseous extinguishing installations, plant shutdown facilities, door release units, electronic locks, etc.

Manual call points

Manual call points are devices by which building occupants can raise the alarm of fire. They comprise a frangible element, such as a piece of glass, which breaks, or appears to break, on operation of the device. The operation of the device should require only a single action, which should be irreversible by the operator. (Where false alarms are likely to result from casual malicious operation, it may be acceptable to fit a hinged plastic cover over the face of the call point. In order to break the glass, it is then necessary to lift the cover.)

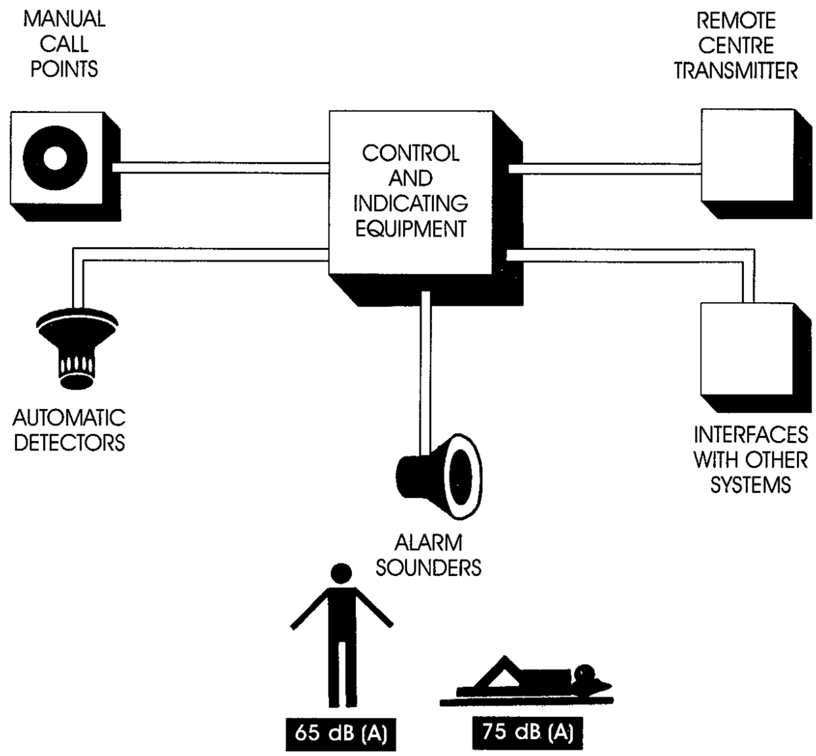

Figure 11.1 Schematic of typical fire alarm installation

BS 5839-1 recommends that manual call points should be sited at storey exits and at final exits. In practice, those at storey exits are normally installed within the accommodation on each floor, immediately adjacent to the storey exits to the staircases, but BS 5839-1 would permit manual call points to be sited on staircase landings (other than in buildings with phased evacuation).

No person should need to travel more than 45 m from any point in a building to reach the nearest manual call point. This figure is reduced to 25 m in buildings with a significant proportion of mobility-impaired occupants (such as certain residential care homes) and in buildings where rapid fire development is likely (such as where there is use, or processing, of highly flammable liquids or flammable gases). It is also good practice to site manual call points close to specific hazards, such as paint spray booths. In a building with phased evacuation (see Chapter 7), additional manual call points may be necessary to ensure that, in the event of fire, the correct area(s) are subject to the first phase of evacuation.

Automatic fire detectors

Automatic fire detectors normally respond to one or more of the four characteristic products of fire:

1. heat;
2. smoke;
3. flame;
4. combustion gases, such as carbon monoxide.

Heat or smoke may be sensed at either a single point within the volume of the protected space by a point detector, or along a defined line within the space by a line detector.

Line detectors may be integrating or non-integrating, according to whether they integrate the effect of the characteristic along a line. For example, integrating-type line heat detectors respond to a low-temperature increase over a long length, as well as a high-temperature increase at a point. The non-integrating type respond only to the effect of the phenomenon at a point (e.g. by detecting only a high-temperature increase at a point). Non-integrating line detectors can, therefore, be thought of as an infinite number of point detectors.

Heat detectors

Heat detectors may be divided into two categories:

1. fixed temperature devices, which behave rather like thermostats;
2. fixed temperature/rate of rise devices, which will respond to either a rapidly rising temperature or at a pre-determined fixed temperature.

Early point heat detectors were invariably electromechanical in nature (e.g. comprising bimetallic strips), but modern devices are normally either pneumatic or, more commonly, electronic (e.g. thermistor based) in nature.

Line-type heat detectors may be based on pneumatic or, more commonly, electrical principles. Non-integrating line heat detectors usually comprise a length of current-carrying cable, in which the insulation melts at a defined temperature, resulting in a short circuit. In integrating line heat detecting cables, the capacitance and/or resistance of the insulation changes with temperature.

Heat detectors may be used for general property protection, but will normally be much slower to operate than smoke detectors. Flames could be as much as one-third of the way to the ceiling before a heat detector will operate. As the ceiling height increases, the fire size at the point of detection increases dramatically. If the ceiling height is doubled, for example, the size of the fire at the point of detection is likely to increase by a factor of five to six. The response of heat detectors is too slow to be of use in escape routes or in areas such as electronic equipment rooms, where a small fire could cause a significant loss.

Heat detectors are necessary, however, in areas in which dust, fumes, etc., may preclude the use of smoke detectors (e.g. kitchens). They may also be used in areas in which a fire is likely to produce a high heat output rather than smoke (e.g. certain flammable liquids risks). Heat detectors may also be suitable for installation in rooms enclosed in fire-resisting construction, if the fire protection objective is simply to provide warning before the integrity of the construction is threatened.

A particular example of this is rooms adjoining escape routes where, to satisfy the life-safety objective, it may only be necessary to provide early warning before a fire-resisting door fails to hold back fire and smoke. Thus, it may be acceptable for heat detectors, rather than smoke detectors, to be installed in hotel bedrooms, provided it is accepted that the objective is only to provide a general warning before common escape routes are threatened, rather than to provide an early warning to occupants in the room of fire origin. In this case, the particular advantage of heat detectors over smoke detectors is their much higher immunity to false alarms.

Normally, any heat detectors used are of the fixed-temperature/rate of rise point type. However, fixed-temperature detectors should be used where sudden rises in ambient temperature may occur (e.g. near ovens or in laundry rooms). Line heat detectors tend to be used for special applications, where the geometry of the protected space is particularly conducive to their use (e.g. in cable tunnels and under escalators).

Smoke detectors

There are two types of point smoke detector, namely:

1. the ionization chamber smoke detector;
2. the optical scattering smoke detector.

Ionization chamber detectors contain a radioactive source, which ionizes the air within the chamber, so allowing a small current to pass between two electrodes. Smoke particles interfere with the ion transport and lead to ion–electron recombination, so reducing the current. The reduction in current is sensed as an alarm condition.

Optical detectors contain a light emitting diode and a receiver. The detection principle is usually based on light scattering – the effect of smoke is to scatter light from the transmitter towards the receiver. However, in principle, obscuration of light by smoke could be used, as in the case of beam detectors.

Line-type smoke detectors ('beam detectors') use a beam of light (often in the infrared part of the spectrum). A transmitter and receiver unit are mounted on opposing walls, which, typically, may be up to 100 m apart. In some systems, normally used for relatively small areas, the transmitter and receiver may be housed in a single unit, and the beam reflected off a relatively small passive reflector. Some types of beam detector are also designed to respond to thermal turbulence, which, in effect, makes these detectors combined heat and smoke detectors.

Smoke detectors are quite sensitive, which means that they are faster in response than heat detectors, but much more susceptible to false alarms. There is overlap in the range of particle sizes to which optical and ionization chamber detectors are sensitive; this means that either type is suitable for general applications. However, ionization chamber detectors are sensitive to the very small invisible particles that are produced in rapid flaming and clean burning fires; optical detectors are less sensitive to these small particles, but are more sensitive than ionization-chamber detectors to the larger particles that occur in the cooler products of slow smouldering or in smoke that has 'aged'. Optical detectors are more likely to produce false alarms from tobacco smoke and steam; ionization chamber detectors are more likely to give false alarms if installed in areas in which fumes from cooking processes, (e.g. burnt toast) may occur, such as spaces close to kitchens. Ionization chamber detectors may also give a false alarm if installed in high air flows.

There is a tendency to use smoke detectors for general property protection, except in areas where processes or environmental influences may cause false alarms. Smoke detectors are also generally used for life-safety applications. In escape routes, only optical detectors should be used, while either type of detector may be installed in other areas, subject to consideration of the likely type of fire and the potential causes of false alarms. In areas where the earliest possible warning of fire by point smoke detectors is important, such as rooms containing computer and other sensitive electronic equipment, an equal mix of optical and ionization chamber detectors is often used. In such applications, however, it is now common to supplement the 'normal' smoke detectors with very high sensitivity smoke detection systems, which are normally of the aspirating type, although not necessarily so.

Beam detectors may prove economical for protection of large, open areas, such as warehouses, provided that the transmitter and receiver can be firmly attached to solid construction, and that the beam will not be obscured by, for example, fork lift trucks. Beam detectors may also be useful in situations in which a ceiling-mounted detector may be unacceptable, e.g. historic buildings.

Aspirating smoke-detection systems

In aspirating smoke-detection systems, a pump or fan draws air samples from the protected space (through holes in small bore tubing or pipework within the protected space) to a central smoke detector. The detector used may be of the ionization chamber type, but normally works on optical principles and is normally extremely sensitive. A sensitivity of several hundred times that of normal smoke detectors is possible to achieve.

These systems are frequently used for the protection of computer, communications and sensitive electronic equipment rooms, in which it is quite common to use them for monitoring return air to air conditioning units. Very small amounts of particulate matter produced by even an extremely small smouldering incident can often be detected by this means, since these combustion products are carried by the return air to the sampling points in the pipework of the aspirating system. It is not uncommon for incidents such as the burning out of electronic components in equipment cabinets to be detected in this way, even though on initial inspection of the room there is no visible smoke. Aspirating systems are sometimes used within atrium spaces in buildings, where vertical runs of pipework can sample smoke from different levels, at any of which stratification might occur (see Chapter 2).

Aspirating systems are also sometimes installed in stately homes and similar buildings. Here the reason is not the high sensitivity normally associated with such systems, but the possibility of providing virtually 'invisible' protection; the pipework can be installed above ceilings, and small bore capillary tube is passed through small holes drilled in the ceilings.

Aspirating systems are also sometimes used in situations where access to point smoke detectors for maintenance would be difficult. An example is at high levels within an atrium space or in a high-level ceiling void.

Flame detectors

Flame detectors detect either the infrared or the ultraviolet radiation that is emitted from flame. Infrared detectors use a solid-state infrared sensor, while ultraviolet detectors are usually similar in principle to Geiger-Müller tubes. In the case of infrared detectors, in order to filter out extraneous sources of infrared radiation, the detectors will give an alarm only if the radiation has the characteristic 'flicker' frequency associated with fires.

Flame detectors are basically line-of-sight devices. It is necessary for them to be able to survey the entire protected area without obstruction. These detectors are expensive and the nature of their response makes them suitable mainly for special applications, such as flammable liquids plant. Ultraviolet detectors tend to be used outdoors, although solar blind infrared detectors are available. Infrared detectors can also be used for indoor applications, if the ceiling height is such that the products of combustion may not rise to operate heat or smoke detectors until the fire is very large, e.g. as in an atrium space or a cathedral.

Combustion gas detectors

Combustion gas detectors are a relatively recent development. They sense the gases produced by a fire. Normally, this would be carbon monoxide, but other gases may also be detected. In carbon monoxide fire detectors, the sensor itself takes the form of an electrochemical cell.

Carbon monoxide fire detectors should not be confused with the carbon monoxide gas detectors that are used to give a warning of carbon monoxide produced by, for example, a poorly ventilated gas burning appliance. The latter detectors would not operate at an early enough stage in a fire to give adequate warning to occupants.

Experience suggests that these detectors may provide effective detection of fire, with immunity to many of the phenomena, such as steam, dust, etc., that cause smoke detectors to give false alarms. However, as carbon monoxide is produced as a result of inefficient combustion, in which the supply of oxygen is the limiting factor in the rate of burning, these detectors, while sensitive to many forms of smouldering fire, are less effective in the event of, for example, a flaming fire with plentiful ventilation.

Control and indicating equipment

The control and indicating equipment (CIE) is the 'heart and brains' of a fire alarm installation. It provides power to the trigger devices and sounders, and it monitors the trigger devices and any interconnecting cable to trigger devices and sounders, etc. The power supplies are normally derived from the mains, but there must also be a standby supply in the form of batteries.

When a manual call point or automatic fire detector operates, the control and indicating equipment provides an indication of the area (or 'detection zone') of alarm origin. The indication may take the form of a set of lamps, or an illuminated mimic plan of the premises. Ancillary text information can also be displayed on a liquid crystal or vacuum fluorescent display, or on a visual display unit.

At the CIE, the alarm sounders can be silenced by authorized users, and the system can be reset after an alarm condition. Normally, there are also facilities to isolate groups of devices (or individual devices), and sometimes certain test facilities are incorporated.

The siting of the indicating equipment is important. It should generally be located so that it is readily available to the fire and rescue service as they enter the building. Repeater panels or mimics may be sited at several locations, so that the information is available at all strategic entrances to a complex building. It is also important that a zone plan is located adjacent to the CIE, so that those responding to alarm signals, particularly the fire and rescue service, can clearly identify the location of the fire.

Alarm devices

Alarm signals are most commonly given by bells or electronic sounders. The decision as to which type of device to use is largely a matter of taste. Either can be used in staged alarm systems, in which the 'evacuate' signal is given in the area immediately affected and an 'alert' signal (e.g. pulsing bells) is given in other areas. However, a single common sounder should be used throughout a building; it would not be acceptable to use two different forms of sounder as the means of giving warning of fire.

Whichever device is selected, the sound level produced at any point in a building should generally be not less than 65 dB(A), or less than 5 dB(A) above any background noise, whichever is greater. The figure of 65 dB(A) is reduced to a minimum of 60 dB(A) within stairwells and small rooms (of less than around 60 m^2). It is also acceptable for the sound pressure level to reduce to 60 dB(A) within limited areas (e.g. a small area within an open-plan space that is the most remote point from a sounder), provided the figure of 65 dB(A) is generally achieved.

If there are sleeping occupants, a sound level of 75 dB(A) should be provided at the bedhead, unless, as in the case of hospital wards, the alarm signal is not intended to rouse sleeping occupants. For hospitals, Department of Health guidance on fire detection and fire alarm systems recommends a sound pressure level of between 40 dB(A) and 55 dB(A) in patient-care areas. The lower sound pressure level is intended to ensure that the alarm signal is still audible to staff, while the maximum level of 55 dB(A) is intended to ensure that the alarm signal is not disruptive for ill patients.

The practicalities of achieving these sound pressure levels are such that the figure of 65 dB(A) is unlikely to be achieved at any point if there is more than one door between that point and the nearest sounder. The figure of 75 dB(A) is unlikely to be achieved at a bedhead unless there is a sounder within the bedroom itself. Accordingly, it is normal practice to install a fire alarm sounder in each bedroom within sleeping accommodation. Often, these sounders form part of the bases of the fire detectors.

In residential care establishments, consideration needs to be given to whether the fire alarm signal is intended to rouse residents from sleep. If this is the case (e.g. when it is expected that residents will evacuate themselves without the need for significant assistance from staff), a sound pressure level of 75 dB(A) at bedheads may well be appropriate. If, on the other hand, residents would need assistance with evacuation, BS 5839-1 effectively treats the premises as a non-sleeping occupancy, so that the 60–65dB(A) level would apply throughout. (Guidance in HTM 84,[5] and equivalent guidance in Scotland conflict with BS 5839-1 in this respect, recommending the much lower sound pressure levels that apply in hospitals. Alarm signals of this sound pressure level are, however, likely to be difficult for staff to hear in rooms in which televisions or radios are operated at relatively high volume.)

In areas with high noise levels, visual alarms, such as flashing beacons, may be necessary to supplement the alarm sounders. These may also be of value in areas in which deaf and hard of hearing people work, and are sometimes used in television or radio studios in which audible sounders must be isolated during live transmissions. Care needs to be taken to ensure that the flash rate is not sufficiently high to cause epileptic attacks for people with photosensitive epilepsy. Although the rates recommended by BS 5839-1 (30–130 flashes per minute) are unlikely to result in such a problem, in open areas in which, at any point, it is possible to see several flashing beacons, problems may occur unless the beacons are suitably synchronized.

In buildings in which deaf and hard of hearing people work, it is also possible to provide vibrating pagers, linked to the fire alarm system, so giving deaf and hard of hearing people total freedom to use the building safely. In sleeping accommodation for deaf people, a combination of flashing beacons and vibrating pads, the latter of which are located under pillows or mattresses, may be incorporated into the fire alarm system to rouse the occupants. A suitable specification for the performance of these pads is given in BS 5446-3;[6] although this standard is intended to apply to smoke alarm 'kits' for deaf and hard of hearing people in dwellings, there is no reason why a vibrating pad that is effective in rousing someone from sleep in a dwelling will not perform equally well in a hotel.

To assist blind people with wayfinding to fire exits, a system of directional sounders can be used. These are not fire alarm sounders, in that their purpose is not to give a warning of fire, but to direct people towards exits. Accordingly, they are discussed in Chapter 9.

Voice alarm systems

As an alternative to conventional alarm sounders, such as bells and electronic sounders, warning of fire may be given by a specially designed public address system, known as a voice alarm system (see Chapter 12). Such systems are commonly used to provide fire warnings in large assembly buildings, such as air and rail terminals, shopping complexes, large auditoria, etc., and in buildings with phased evacuation.

It is common experience that, when conventional fire warnings, using bells or electronic sounders, are given, there is often a significant delay before people begin to evacuate the building. This delay may even exceed the time taken to escape from the building once the decision to evacuate is eventually made. Research has shown that this delay can be substantially reduced if the warning of fire is given by voice messages, rather than conventional alarm sounders.

Wiring

Wiring to sounders, detectors and call points must be monitored by the control equipment, so that a fault warning is generated in the event of an open circuit or short circuit. It is still necessary to ensure that the cable type and/or protection is such that it is not susceptible to mechanical damage.

It is also essential to ensure that fire alarm circuits do not fail as a result of fire damage to cables. Thus, all fire alarm circuits (including the mains power supply circuit serving the control and indicating equipment) need to be wired in fire-resisting cables, such as mineral-insulated copper sheathed cable or one of the numerous proprietary 'soft skin' fire-resisting cables. BS 5839-1 refers to two levels of performance of fire-resisting cables, known as 'standard fire resistance' and 'enhanced fire resistance'. These terms are defined by reference to the tests specified in BS 8434-1[7] and BS 8434-2[8] respectively, and by reference to BS EN 50200.[9]

BS 5839-1 specifically recommends cables of enhanced fire resistance only for unsprinklered buildings:

- that are greater than 30 m in height; or
- where an evacuation occurs in four or more phases; or
- where the evacuation of areas remote from the fire might be unnecessary (e.g. hospitals and certain large industrial sites).

However, BS 5839-1 also acknowledges the possible need for cables of enhanced fire resistance in, for example, certain fire engineering solutions (see Chapter 22).

Radio-linked systems

It is possible to link components of a fire alarm system by radio, thereby obviating the need for wiring. Radio-linked systems are sometimes regarded as an attractive solution for buildings in which wiring would be detrimental to the aesthetics of the building, and can be used to provide temporary protection that is quick to install and adaptable. However, one disadvantage of these systems is that their trigger devices and sounders must be provided with local power. Normally, in the case of detectors and call points, this comprises an internal primary battery with a second reserve primary battery. Thus, there is a need to change batteries in all devices periodically. Alarm sounders could, in theory, be hard wired in the conventional manner, but are normally also triggered by radio, power again being supplied by internal batteries.

If a radio-linked system is contemplated, it is essential that installation takes place only after a comprehensive radio survey has been undertaken to ensure adequate signal strength throughout the installation and that no other radio transmissions are likely to interfere with the communication. Where the nature of the building construction or the size of the building could result in poor signal strength, radio repeater units can be used.

Types of fire detection and fire alarm system

There are, fundamentally, two basic types of fire detection and fire alarm system, which differ according to the method by which the detectors and call points communicate with the control and indicating equipment. The two types of system may be described as:

1. conventional (or non-addressable);
2. addressable.

In a fire situation, a non-addressable system will be unable to identify at the control and indicating equipment which of the devices on the particular circuit has operated – only an indication of detection zone can be given. In order to minimize the delay in locating the fire, BS 5839-1 imposes restrictions on the size of a detection zone.

In an addressable system, the signals from each device are individually identified at the control panel. In the event of a fire alarm signal, the exact identity (and location) of the initiating device can be shown at the control panel. Although detection zone indication is also given as a more coarse form of indication, this zoning is not associated with circuits, but is a software function of the system; i.e. 'addresses' are configured into detection zones by the system software.

Although the area of a detection zone remains limited by BS 5839-1, a single circuit can serve many zones, and it is usually possible to connect more devices on a single pair of conductors than would be possible in a non-addressable system.

There are three categories of addressable system, according to whether the detectors are:

1. two state;
2. multi-state;
3. analogue.

Two-state detectors are no different in principle from the two-state detectors in non-addressable systems, but, of course, they transmit their individual identity along with the fire signal. Two-state addressable systems are not common; most addressable systems are of the analogue type.

Analogue detectors contain no circuitry to make the decision as to whether or not there is a fire – they are merely sensors that continually transmit a signal level that corresponds to the instantaneous value of the phenomenon that they are measuring, e.g. heat, smoke or flame. The actual decision as to whether the signal level is representative of a fire is taken by the control and indicating equipment. In the simplest analogue systems, the control equipment indicates four states for any detector, e.g. normal, fault, pre-warning and fire.

The fault signal would be given when the signal level became very low, indicating a lack of sensitivity, while the pre-warning would be indicative of a signal level that had risen above the normal level but had not yet reached the fire threshold (see Figure 11.2). In many systems, the thresholds may be varied automatically to compensate for changes in the environment and pollution of smoke detectors. The decision as to whether the signal received at the control panel is representative of a fire may also be based on more sophisticated decision making, such as the rate of rise of the signal or mathematical analysis of other parameters of the signal.

Such is the processing power that can now be built into a small package that the application of fixed thresholds, and an element of signal processing, can be undertaken at each detector head, which then need transmit only specific conditions, such as the four states defined above. This is the manner in which a multi-state detector operates.

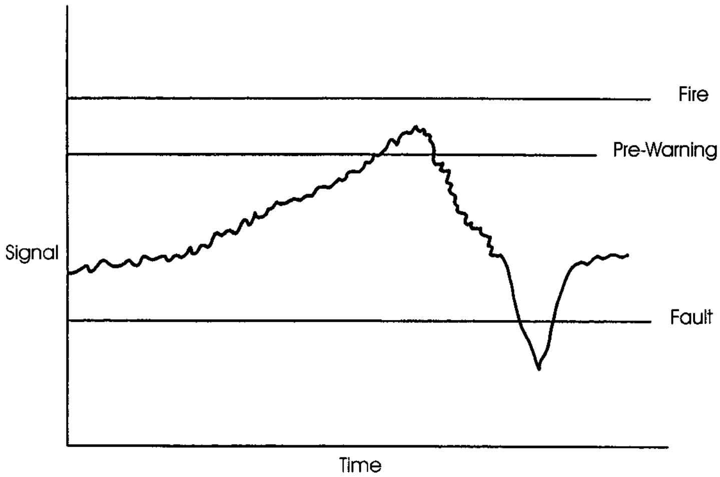

Figure 11.2 Representation of signal from an analogue detector

The function of the pre-warning state given by many analogue and multi-state systems is to obviate potential false alarms and enable early investigation of an incipient fire. Thus, pre-warning signals do not result in a general alarm, but merely give a warning at the control and indicating equipment.

Most analogue systems offer other advantages. They enable the facility to 'interrogate' each sensor at the control equipment to obtain an output of its present signal level. This can be of use to maintenance technicians in identification of sensors that need to be cleaned. It is also possible, in some systems, to vary the system performance, such as on a time-related basis, to enable higher sensitivity when the premises are unoccupied and false alarms are less likely to occur by such enhanced sensitivity.

A more recent development has been the launch of a number of so-called multi-sensor fire detection systems. These systems are usually like analogue systems in that decision making is carried out by software at the control and indicating equipment. However, each detector head incorporates more than one sensor and so is capable of detecting more than one characteristic of fire (e.g. heat and smoke).

By comparing the signals from the different sensors, it is possible to filter out certain false alarms (although, in some multi-sensor systems, the objective is primarily to offer a broader spectrum of fire detection). For example, whereas an optical detector close to a source of steam may cause false alarms, a multi-sensor detector, in which the signal from the optical sensor is compared with that from a heat and/or ionization chamber sensor, may be less likely to do so.

There is already some evidence that multi-sensor systems can significantly reduce false alarms in certain environments. In the long term, they are probably the future answer to false alarms. For this reason, BS 5839-1 recommends that multi-sensor systems with suitable measures to limit false alarms should be considered for systems that incorporate more than 1,000 fire detectors.

False alarms

False alarms remain a very significant problem for users of automatic fire detection systems, and they colour the judgement of building occupants regarding the effectiveness of these systems and the significance of an alarm condition. Around 95 per cent of calls to fire and rescue services as a result of fire alarm signals are false alarms. Most of these are 'unwanted alarms', in which the fire alarm system has performed as it is designed to perform (e.g. giving an alarm because of smoke from a bonfire entering the building), or as the technology naturally performs (e.g. responding to steam). However, the newer generation systems, particularly those of the analogue type should provide better immunity to unwanted alarms.

Common causes of false alarms (see BS 5839-1) are:

- fumes from cooking processes (including toasting of bread);
- steam (from bathrooms, shower rooms and industrial processes);
- tobacco smoke;
- dust (whether built up over a period of time or released from an industrial process);
- insects;
- aerosol spray (e.g. deodorants and cleaning fluids);
- high air velocities;
- smoke from sources other than a fire in the building (e.g. from an external bonfire);
- cutting, welding and similar 'hot work';
- processes that produce smoke or flame (e.g. flambéing of food);
- cosmetic smoke (e.g. in discotheques and theatres);
- incense;
- candles;

- electromagnetic interference;
- high humidity;
- water ingress;
- substantial fluctuation in temperature;
- accidental damage (particularly to manual call points);
- testing or maintenance of the system, without appropriate disablement of the system or warning to building occupants and/or an alarm-receiving centre;
- pressure surges on water mains serving automatic sprinkler systems that are interfaced with the fire alarm system.

BS 5839-1 offers benchmarks that assist in determining whether the number of false alarms from an automatic fire detection system should be regarded as 'acceptable'. In practice, the number of unwanted alarms that occur depends very much on the environment, but it is likely to be more or less proportional to the number of detectors installed, each of which is a potential source of a false alarm. Systems incorporating predominantly heat detectors, rather than smoke detectors, will produce far fewer false alarms.

BS 5839-1 suggests that, in a relatively benign environment, in which there is no tendency for dust, fumes or insects to occur, and in which there is a good standard of management, false alarm rates equal to, or less than, one false alarm per 100 detectors per annum are possible, even if the proportion of smoke detectors is very high. On industrial sites with shift working, it is suggested that a figure of one false alarm per 75 detectors per annum is probably a more realistic expectation. (This figure is now regarded as a form of target rate for false alarms in hospitals.) In general, false alarm rates of one false alarm per 50 detectors per annum should be readily achievable.

More specifically, BS 5839-1 recommends that, in systems that incorporate more than 40 detectors, the user should instigate an in-depth investigation by suitable specialists if, in any rolling period of 12 months, the false alarm rate exceeds one false alarm per 20 detectors per annum, or if three or more false alarms are initiated by any single manual call point or detector. In systems with 40 or less detectors, this in-depth investigation should be instigated if, in a rolling period of 12 months, three or more false alarms occur.

BS 5839-1 recognizes the importance of adequate servicing of fire alarm systems as a measure to limit false alarms. There is a need for the maintenance organization to work in partnership with the user in this respect. BS 5839-1 recommends that at least a preliminary investigation should be carried out as part of servicing if any of the following apply:

- the rate of false alarms over the previous 12 months has exceeded one false alarm per 25 detectors per annum;
- 11 or more false alarms have occurred since the time of the last service visit;
- two or more false alarms have arisen from a single manual call point or detector;
- any persistent cause of false alarms has been identified.

In the case of large buildings with many detectors, the potential disruption from false alarms may be unacceptable to the user, even if the rate of false alarms is as low as one per 100 detectors per annum; in a system with 5,000 detectors, this would equate to around one false alarm per week. In such cases, it is common to operate a 'staff alarm' arrangement. In such an arrangement, a signal from a single detector triggers an alarm at the fire alarm CIE. It may also trigger pagers or other restricted alarm devices to alert certain members of staff; there is, however, no general alarm signal in any area of the building. At this stage, the fire and rescue service is not normally summoned.

The purpose of a staff alarm is to enable an investigation before any general alarm is given, evacuation is initiated or the fire and rescue service is summoned. After a predetermined time delay, a general alarm is given unless those investigating confirm that there is no fire. A general alarm is usually given immediately on operation of any manual call point. Often, a general alarm is also given if two detectors operate during the investigation period; this is known as 'coincidence operation', but is sometimes (incorrectly) described as 'double knock'.

Transmission to the fire and rescue service

In general, automatic fire detection contributes to property protection only if it causes the fire and rescue service to be summoned. The system will be effective in reduction of loss only if it is continuously monitored at a manned location, from where the fire and rescue service can be summoned without delay.

In practice, there is often a need for signals to be transmitted automatically, without manual intervention by persons at the protected premises. For an automatic fire detection system to be recognized by insurers, automatic transmission to an alarm receiving centre (ARC) is usually a requirement, although this facility cannot normally be required under legislation; an exception, in this respect, can be found in the Building (Scotland) Regulations, which do require automatic transmission of fire alarm signals from systems in residential care homes and hospitals.

In hospitals, or premises with special evacuation problems, such as some residential care homes, the early and reliable summoning of the fire and rescue service when fire occurs is essential. Often, automatic transmission of fire alarm signals is provided in such premises as a 'back up' to the call that should be made by persons in the building.

The most common means for automatic transmission to an ARC normally comprise either:

a) digital communicators, which automatically dial up the ARC, using the public switched telephone network, and transmit a coded signal to a receiver at the ARC; or
b) British Telecom's RedCARE system, in which signals are transmitted over the subscriber's normal telephone line and are routed automatically to the alarm company's ARC.

It is important to ensure that there is a formal arrangement between the alarm company and the relevant fire and rescue service, whereby the alarm company has agreed a reliable means for passing calls on to the fire and rescue service. The Loss Prevention Certification Board operates a certification scheme for alarm company ARCs that monitor signals from fire alarm systems. Under the scheme, the published listing of each ARC shows the geographical areas of the country for which such arrangements, between the alarm company and the fire and rescue service, exist.

Interface of the fire alarm system with other systems

It is now common for there to be one or more interfaces between a fire alarm system and other systems or equipment, in order to satisfy the 'cause and effect' specified for the system. Thus, for example, when an alarm signal is given by the system, there is often a need for lifts to return to ground, heating, ventilation and air conditioning (HVAC) systems to change state, gas valves to close, fire doors to close, fire exit doors to unlock, powered sliding doors on means of escape to remain permanently open, smoke control systems to operate, etc.

No guidance on such interfaces is given in BS 5839-1, as that code of practice is concerned only with the primary function of a fire alarm system, namely to give warning in the event of fire. Often, there are codes of practice for the design of the other systems (e.g. gaseous extinguishing systems) or product standards for the other equipment (e.g. smoke extract fans). However, the interface between the two systems has, in the past, simply relied, in general, on sound engineering judgement.

Since 1990, a gradually expanding suite of codes of practice, which purely address the interface between a fire alarm system and other systems, has evolved in the form of the various parts of BS 7273. BS 7273-1,[10] which was first published in 1990 and has, since, been subject to two major revisions, deals with the interface with a total flooding gaseous fire extinguishing system (see Chapter 14). Thus, in specifying an automatically operated gaseous fire extinguishing system, it is appropriate to refer to three standards: BS 5839-1 for the fire detection system, the relevant part of BS ISO 14520 for the extinguishing system, and BS 7273-1 for the interface between the two systems.

BS 7273-2[11] addresses the interface with a mechanically operated local application or total flooding gaseous extinguishing system (see Chapter 14). Such systems are relatively uncommon. BS 7273-3[12] covers the interface with a pre-action sprinkler system (see Chapter 14).

BS 7273-4[13] has a much more widespread application than any of the other parts; it deals with the interface between a fire alarm system and door release units. The term 'door release units' includes devices designed to hold self-closing fire doors in the open position, but releasing them to close under the action of the self-closing device when the fire alarm system operates (see also Chapter 7). The use of hold-open devices in buildings is very common, and they assist the unimpeded use of buildings by mobility-impaired people. However, it is essential that, in the event of fire, the doors close correctly to protect means of escape. The main purpose of BS 7273-4, which was published in 2007, is to ensure the reliability of the interface between a fire alarm system and door release units.

BS 7273-4 also covers the interface between fire alarm systems and electronically locked doors. Again, the use of electronic locking of doors on means of escape is increasing (see also Chapter 7). Sometimes, these devices are actually necessary for the safety of building occupants (e.g. in banks or other buildings in which large sums of money are handled, in post-natal care units in hospitals, etc.). Electronic locking may also be necessary for the safety of the general public (e.g. in the case of exit doors in places of lawful detention, such as prisons and secure mental-health units).

However, serious risk to occupants can occur if electrically locked doors do not unlock in the event of fire. Incidents have occurred in which these locks have failed to release on operation of the fire alarm system in the building. This alone created an urgent need for BS 7273-4.

The final form of 'door release unit' to which BS 7273-4 refers is the equipment used to control powered sliding doors, such as those used at the main entrance of many retail premises and hotels. Under normal circumstances, these doors open as people approach the doors. However, in the event of fire (or power failure), the doors need to remain in the permanently open position.

Finally, BS 7273-5[14] provides recommendations for the interface with water mist fire suppression systems (see Chapter 14).

Checking fire alarm systems

BS 5839-1 recommends that the user carry out certain checks on a daily, weekly and monthly basis, as follows. This is in addition to the periodic servicing by a maintenance organization.

Daily

It should be ensured that the CIE is checked on a daily basis to ensure that there are no faults on the system.

Weekly

One manual call point should be operated on a weekly basis during normal working hours to test the system. A different manual call point should be operated each week, so that, over a period of time, all manual call points are tested in rotation. The sounders should not be permitted to operate for more than one minute. In premises in which some employees work only during hours when the system is not normally tested (e.g. permanent night-shift employees), a further test should be carried out at least once a month to ensure familiarity of employees with the fire alarm signal.

Monthly

If an automatic emergency generator forms part of the standby power supply, it should be operated, on a monthly basis, by simulation of mains failure and allowed to run on load for at least 1 hour. If vented batteries are used as a standby power supply (which is very uncommon), they should be checked, and, if necessary, electrolyte should be topped up. (A quarterly check of vented batteries should be carried out by a competent person.)

Periodically

The entire installation should be subject to periodic inspection and servicing by a competent person. Except in very large organizations with in-house expertise, this will normally involve a service visit by a specialist contractor, with whom there should be a standing contract for service visits and emergency maintenance. The interval between service visits should not exceed six months, but quarterly service contracts are quite common.

Routine safety inspections should ensure that access to manual call points is not obstructed. A clear space around detector heads should also be maintained so that the flow of smoke and hot gases to the heads is not obstructed. The siting of call points, detectors and sounders must remain appropriate following any changes to the layout or partitioning within the building.

Further reading

BS 5839-1, *Fire detection and fire alarm systems for buildings — Part 1: Code of practice for system design, installation, commissioning and maintenance*

BS 5839-6, *Fire detection and fire alarm systems for buildings — Part 6: Code of practice for the design, installation and maintenance of fire detection and fire alarm systems in dwellings*

Todd, Colin S. *The design, installation, commissioning and maintenance of fire detection and fire alarm systems*. A Guide to BS Code 5839-1. BSI. ISBN 058047626X.

Todd, Colin S. *The design of fire detection installations for dwellings*. A Guide to BS 5839-6: 2004. BSI. ISBN 0580440168

References

1. BS 5839-1, *Fire detection and fire alarm systems for buildings — Part 1: Code of practice for system design, installation, commissioning and maintenance*

2. BS 5839-6, *Fire detection and fire alarm systems for buildings — Part 6: Code of practice for the design, installation and maintenance of fire detection and fire alarm systems in dwellings*
3. Health Technical Memorandum HTM 05-03 Part B. Firecode: Fire Safety in the NHS. Health Technical Memorandum 05-03: Operational provisions. Part B: Fire detection and alarm systems.
4. Health Technical Memorandum HTM 82. Alarm and detection systems.
5. Health Technical Memorandum HTM 84. Fire safety in residential care premises.
6. BS 5446-3, *Fire detection and fire alarm devices for dwellings — Part 3: Specification for smoke alarm kits for deaf and hard of hearing people*
7. BS 8434-1, *Methods of test for assessment of the fire integrity of electric cables — Test for unprotected small cables for use in emergency circuits — BS EN 50200 with addition of water spray*
8. BS 8434-2, *Methods of test for assessment of the fire integrity of electric cables — Test for unprotected small cables for use in emergency circuits — BS EN 50200 with a 930°C flame and with water spray*
9. BS EN 50200, *Method of test for resistance to fire of unprotected small cables for use in emergency circuits*
10. BS 7273-1, *Code of practice for the operation of fire protection measures — Electrical actuation of gaseous total flooding extinguishing systems*
11. BS 7273-2, *Code of practice for the operation of fire protection measures — Mechanical actuation of gaseous total flooding and local application extinguishing systems*
12. BS 7273-3, *Code of practice for the operation of fire protection measures — Electrical actuation of pre-action sprinkler systems*
13. BS 7273-4, *Code of practice for the operation of fire protection measures — Actuation of release mechanisms for doors*
14. BS 7273-5, *Code of practice for the operation of fire protection measures — Electrical actuation of water mist systems*

12

Voice alarm systems

The quite common use of 'voice alarms' as a means of giving warning to occupants of a building when fire occurs is a relatively recent innovation, which has grown significantly in popularity since the 1990s. However, the principle of using public address systems (or 'sound distribution systems', as these systems are often now known) is not new. The use of public address systems of a relatively standard nature, as opposed to those specially designed for fire warning purposes, goes back to at least the 1960s. In some cases, the public address system was the primary means of giving warning, as well as serving as a conventional public address system, although, in other cases, public address systems were used to provide only supplementary information during the course of an evacuation initiated by conventional fire alarm sounders. There was, however, virtually no integration of the fire detection and fire alarm system in the building with the public address system.

The term 'voice alarm system' is now reserved for a sound distribution system that provides means for automatically broadcasting speech messages and/or warning signals, and that is designed to satisfy, or even possibly in some respects exceed, the standards adopted for conventional fire alarm systems. Thus, it is rarely possible, or acceptable, simply to convert an existing sound distribution system that was never designed for fire warning purposes into a voice alarm system that will satisfy current standards for such systems.

Two developments have led to a major increase in the use of voice alarm systems instead of conventional bells or electronic sounders as a means of giving warning of fire. The first is the common use of phased evacuation in tall office buildings. As discussed in Chapter 7, in such buildings, the use of phased evacuation precludes the need for the simultaneous evacuation of a large number of people on every occasion that the fire alarm system operates, and it enables the number and/or widths of staircases to be reduced. Generally, in a building with phased evacuation, occupants are evacuated in a controlled and phased manner, usually two floors at a time, normally starting with the floor of fire origin and the floor immediately above. On other floors, usually an 'alert signal' is given to warn people of the possible need for evacuation at a later stage and to reassure them that there is no need for them to evacuate until instructed to do so.

This latter reassurance is an important feature in a building with phased evacuation. If all occupants decided to evacuate simultaneously, the reduced number/widths of staircases would be such as to create overcrowding on the staircases and, at least, an unacceptably prolonged evacuation time. Voice messages are now generally regarded as essential in such buildings to ensure that occupants respond correctly, by evacuating those floors on which evacuation is required, but instructing people to remain on other floors until instructed to evacuate.

The second, and perhaps more important, factor in the promotion of voice alarm systems was the considerable research that took place on the subject of human behaviour in fire during the 1980s (see Chapter 17). Relevant aspects of this research relate to the motivation of occupants of a building to evacuate and to the concept of 'panic'. The research showed that people tend to react inappropriately to conventional fire warning signals. In some cases, they may not even be sure as to whether the warning signal that they hear represents a warning of fire or a warning of some other emergency. Even if they recognize the sound as that of a fire warning, there is a tendency to disbelieve the warning signal, on the assumption that it might be a test or false alarm. As a result of this uncertainty, there is often a reluctance on the part of building occupants to evacuate when the fire alarm system is operated, resulting in a 'response time' that can greatly exceed the time taken to evacuate the building, so constituting the major element of the time interval between outbreak of fire and total evacuation of a building.

With regard to the concept of 'panic', behavioural psychologists now believe that the conventional wisdom that people panic, in the sense of pursuing irrational actions, when fire occurs, has little foundation (see Chapter 17). Rather, the reactions that people, with hindsight, ascribe to panic are in fact borne out of an understandable desire for self-preservation, coupled with inadequate information on which to base their reactions.

Thus, both issues, namely reluctance to evacuate and the adoption of inappropriate procedures, can be addressed by providing occupants of a building with better information than the simple 'digital' on/intermittent/off information that can be provided by conventional fire alarm sounders. The research described above had major implications for fire management in large, complex buildings and buildings in which the public assemble in large numbers.

It is now the situation that voice alarm systems are the recognized norm in buildings where there is a need for:

- optimum control of large numbers of the public;
- sophisticated evacuation procedures;
- an enhanced motivation to evacuate.

Thus, it is now recognized practice to use a voice alarm system, rather than conventional bells or sounders, in the following categories of building:

- buildings with phased evacuation;
- major air and rail terminals;
- large public assembly buildings that incorporate auditoria, such as cinemas and theatres;
- shopping centres.

Design code of practice

Since at least 1972, fire alarm system design codes have addressed what was often described as the use of public address systems in lieu of conventional alarm sounders. The basic principles expounded in these codes were, in effect, that the sound distribution systems should satisfy many of the same principles adopted for fire alarm systems; this is clearly not only logical but essential. However, the limited guidance given proved inadequate, either in extent or, at least, in its adoption by installers. This led to contention in respect of many aspects of voice alarm system design and, as a result, systems installed in numerous complex buildings, such as shopping complexes, failed to meet even the most fundamental principles of fire alarm system design. It might even be said that people were so blinded by the elegance of the concept of voice alarm systems that they failed to take adequate care over the more mundane, but extremely important, engineering design of the systems.

The design of voice alarm systems was, however, put on a proper footing when a dedicated code of practice, BS 5839-8,[1] was published in 1998. The code addresses, in considerable detail, all aspects of voice alarm design, and considers not only those aspects for which there is an analogous requirement for fire alarm systems, but aspects of the audio system design that are unique to voice alarm systems.

In the case of sports stadia, guidance on voice alarm systems is also given in BS 7827.[2] There is also a more general European code of practice on the subject of sound systems for emergency purposes (BS EN 60849[3]).

Factors to consider in the design of a voice alarm system

As well as the traditional engineering issues that must be addressed in the design of a fire alarm system, such as fault monitoring and fire resistance of wiring, the use of a voice alarm system brings with it additional considerations that must be addressed at the outset of design or specification.

These include:

- the overall responsibility for the combined fire detection and voice alarm system;
- the nature and requirements for interconnections between the fire detection system and the voice alarm system;
- whether or not the system is to be used to broadcast other hazard warnings, such as bomb warnings;
- whether or not the system is to be used for paging and/or background music, etc.;
- prioritization of applications;
- a possible need for specialist consultants to address the acoustic design;
- the acoustic environment of the building, such as the reverberation time and background noise;
- the method of loudspeaker circuit monitoring for faults, which may be more complex than in the case of conventional sounder circuit monitoring;
- the possible need for ambient noise sensing and compensation, so that the sound output of a system is always higher than background noise;
- the required level of intelligibility;
- the need for, and number of, emergency microphones;
- the possible need for interfaces with other sound systems.

All of these issues are addressed in BS 5839-8.

Use of voice alarm systems for other purposes

It is perfectly acceptable, in the UK, to use a voice alarm system for purposes other than giving warnings of fire. (This practice is, however, normally regarded as unacceptable in North America.) Such other purposes may include giving warning of other hazards, such as bomb threats, and use of the system for conventional public address purposes, such as staff paging, background music, etc. It is, of course, vital that non-essential uses are overridden and 'locked out' when the system is required for fire alarm warnings.

The combined use of a voice alarm system for fire warnings and for routine public address functions can provide a significant element of economy in the provision of the voice alarm system. At the present time, a fire warning system that incorporates a voice alarm system, rather than conventional alarm sounders, is likely to be more expensive, but, if public address facilities are required in the building, clearly any cost penalty can be significantly reduced or eliminated. As a 'spin-off', the user obtains a public address system of much higher reliability, integrity and, often, intelligibility than would otherwise be the case.

Emergency microphones and message sources

The fire alarm messages in every voice alarm system should be pre-recorded. The message generators used for message storage and control must use only solid-state electronics, as storage media involving the use of moving parts, such as tapes, compact discs or hard disks, would not be sufficiently reliable.

In a simple building, the pre-recorded messages may be all that is necessary to provide an adequate facility for giving warning of fire; there may be no need for any microphones for transmission of real-time emergency messages. However, in complex buildings, including those where phased evacuation is used, emergency microphones are necessary as a means of ongoing control of evacuation by the building management or the fire and rescue service. It is usual for emergency microphones to have the highest priority of all inputs, so that they override pre-recorded emergency broadcast messages.

Intelligibility of messages

The sound pressure level of alarm messages should generally be at least as high as that required for conventional fire alarm signals. However, whereas, in the case of conventional fire alarm sounders, the only requirement is that the 'sound' produced by the sounder should be audible, in the case of a voice alarm system there is an additional requirement that the message broadcast should be intelligible.

Assuming that the quality of the sound system, including the loudspeakers, is such that distortion is not an issue, the two factors that are most likely to affect intelligibility are the reverberation time within the building and the ambient noise levels. In buildings with long reverberation times, resulting from a lack of sound-absorbing materials, so that echoes arise from the largely hard surfaces that exist, the late arriving echoes at the ear of listeners can make the direct sound from loudspeakers unintelligible. In buildings with long reverberation times, the involvement of an acoustic specialist in the system design is likely to be required.

Similarly, if the background noise is particularly loud, the sound generated by fire alarm sounders and the messages broadcast by a voice alarm system may be equally audible provided the sound pressure level that they generate is at least 5 dB or 6 dB above background noise. However, again, the messages broadcast by a voice alarm system may not be adequately intelligible. To achieve a satisfactory level of intelligibility, the ratio of speech signal level to background noise level should normally be at least 10 dB.

A further factor that can affect intelligibility is the presence of a solid element, such as a door or partition, between the listener and the nearest loudspeaker. Solid construction tends to act as a high frequency filter, which permits only the lower frequencies to pass. Unfortunately, the brain requires some of the information within the higher frequencies to decipher the message. In practice, this means that a voice alarm system is likely to require a loudspeaker in many rooms in which it would not be necessary to install a fire alarm sounder as part of a conventional fire alarm system.

There are various means by which intelligibility can be quantified, using sophisticated test equipment. These can be useful in the event of a dispute between an installer and the user or enforcing authority as to whether the system is adequately intelligible, provided that the required intelligibility level has been specified at the design stage.

In some buildings, the background noise is likely to be very variable. An example is an airport terminal, in which ambient noise levels may be very high during busy daytime periods, but the sound level at night is very low. In such cases, ambient noise sensing and compensation can be provided, so that background noise is sensed and the voice alarm broadcast levels are automatically adjusted as the background noise levels vary.

Checking voice alarm systems

For the purpose of routine testing, a voice alarm system should be thought of as part of the fire alarm system, and recommendations for testing of fire alarm systems can be applied (see Chapter 11). However, in addition, in the case of a voice alarm system, it should be ensured that:

- on a weekly basis, all microphones are checked for correct operation;
- over a period of not more than 13 weeks, all loudspeaker zones are checked for correct operation, including a subjective assessment of message intelligibility.

Further reading

BS 5839-8, *Fire detection and fire alarm systems for buildings — Part 8: Code of practice for the design, installation, commissioning and maintenance of voice alarm systems*

Mason, D F and Todd, C S. *The design of voice alarm installations for warning of fire*. A guide to BS 5839-8. Paramount Publishing. ISBN 0862131685.

BS 7827, *Code of practice for designing, specifying, maintaining and operating emergency sound systems at sports venues*

BS EN 60849, *Sound systems for emergency purposes*

References

1. BS 5839-8, *Fire detection and fire alarm systems for buildings — Part 8: Code of practice for the design, installation, commissioning and maintenance of voice alarm systems*
2. BS 7827, *Code of practice for designing, specifying, maintaining and operating emergency sound systems at sports venues*
3. BS EN 60849, *Sound systems for emergency purposes*

13

Fire extinguishing appliances

Fire extinguishing appliances in buildings may comprise any of the following:

a) portable fire extinguishers;
b) trolley-mounted fire extinguishers;
c) fire blankets;
d) hydraulic hose reels.

Trolley-mounted extinguishers are used only for special applications, where there may be a need for trained occupants to tackle a very large fire, such as one involving a large quantity of flammable liquids. They are, therefore, not considered further.

Need for fire extinguishing appliances

The Regulatory Reform (Fire Safety) Order* (see Chapter 1) requires that fire extinguishing equipment is provided where this is necessary to safeguard relevant persons in the event of fire. Similar requirements may be imposed in houses in multiple occupation, under the powers of the Housing Act 2004.*

In theory, in most buildings, either portable fire extinguishers or hose reels may be provided. In practice, it might be appropriate to consider hose reels as supplementary to portable extinguishers, rather than as a direct alternative. Extinguishers offer the advantage that they can be used on a fire very quickly, while hose reels may take longer to run out. However, hose reels provide an unlimited supply of extinguishing agent, and thus enable a much greater degree of 'first aid' fire-fighting. Equally, for this very reason, some fire and

* and equivalent legislation in Scotland and Northern Ireland.

rescue services are not greatly in favour of hose reels; they take the view that the unlimited duration of supply may encourage occupants to remain in the building for a longer period than desirable. Also, if hose is taken through a fire door, it will prevent full closure of the door, possibly permitting spread of smoke and fire, particularly if the hose is not removed as occupants then evacuate.

Fire insurers will normally require that non-domestic buildings are provided with fire extinguishing appliances. Although there can be no requirement for occupants of a building to tackle a fire purely to save property, in practice, there can be no doubt that fire extinguishing appliances make a significant contribution to limitation of property damage, as well as, arguably, contributing to safety of occupants, particularly in premises in which people sleep and premises with special evacuation difficulties, such as hospitals and residential care homes.

The benefits of fire extinguishing appliances are not always apparent from published fire statistics, as these normally relate only to fires to which the fire and rescue service were summoned. However, a survey carried out by the Fire Extinguishing Trades Association (now part of the Fire Industry Association) indicated that, in 1990, member companies (involved in the manufacture and servicing of fire extinguishing appliances) received reports of 927 fires in which fire extinguishing appliances were used. Of these, 75 per cent were not even reported to the fire and rescue service, but were extinguished by occupants of the building (albeit that the fire and rescue service should always be summoned immediately in the event of fire). A number of those reported to the fire and rescue service were also extinguished before the arrival of the fire and rescue service. Only 11 per cent of the reported fires were in fact extinguished by the fire and rescue service.

In 2002, this survey was repeated, in conjunction with Eurofeu (the European trade association for companies engaged in the manufacturer, installation and maintenance of fire extinguishing equipment). The findings were similar; in that survey, it was found that 83 per cent of reported fires were extinguished using portable appliances and that 78 per cent of fires were not reported to fire and rescue services. Fire extinguishing appliances have, therefore, an important role to play in the fire protection of any building.

Portable fire extinguishers

Media

Most portable fire extinguishers contain one of the four recognized extinguishing agents, namely:

a) water;
b) foam;
c) powder;
d) carbon dioxide.

Other agents used in portable fire extinguishers are mainly intended for special applications.

Water

Water is the most common extinguishing agent, and is suitable for use on class A fires (see Chapter 2), which involve 'normal' combustibles, such as wood, paper, textiles, etc. Water is not suitable for class B fires (involving flammable liquids, etc.), nor for discharge onto live electrical equipment. Water extinguishes fire by cooling the fuel, into which the discharge from a portable extinguisher can normally penetrate reasonably well.

The most common size of extinguisher contains 9 litres of water, which usually provides a discharge for around 1 minute. The throw of the discharged water is approximately 6 m. The discharge results either from release of permanently stored pressure (in which case the extinguisher bears a pressure gauge), or from the generation of pressure, on operation of the appliance, due to the release of gas from an internal, pre-sealed gas cartridge.

Water extinguishers are relatively heavy (a full 9 litre extinguisher typically weighs around 13 kg) and some staff may find them difficult to carry. Extinguishers of smaller capacity, and hence lighter weight, can be obtained and may, particularly if they contain an additive, such as a wetting agent, obtain the same fire rating as a 9 litre water extinguisher. These extinguishers, which are typically of 6 litres capacity, can be useful in premises with a predominance of female staff, but it should be noted that the discharge time of extinguishers smaller than this may be quite short, raising the question of whether these smaller extinguishers are truly as effective in untrained hands, even though they have the same fire rating.

Foam

Two types of foam may be found in portable extinguishers:

1. fluoroprotein foam;
2. aqueous film-forming foam (AFFF).

Fluoroprotein foam is intended for use on class B fires, while AFFF, which is much more common, may be used on class A or class B fires. Foam extinguishes flammable liquids fires by smothering – the foam creates a barrier between the liquid surface and the surrounding air. AFFF extinguishes class A fires in much the same manner as water, but the reduced surface tension created by the additive aids the wetting of the fuel surface.

The size and weight of foam extinguishers are similar to those of water extinguishers, although AFFF extinguishers containing 6 litres of extinguishing medium are readily available. The efficiency of the latter appliances is such that they can achieve the same class A rating (see below) as a 9 litre water extinguisher. As in the case of water extinguishers, the appliances may be either of the stored pressure or gas cartridge type.

Foam is not particularly effective on running flammable liquid fires, nor should it be used on fires involving live electrical equipment. Certain AFFF spray extinguishers are incapable of conducting an electric current down the actual discharge from the extinguisher, but the dampened surfaces on which the operators may then stand could pose a danger to operators if they came into contact with live electrical equipment.

Powder

Depending on the extinguishing medium used, powder extinguishers may be suitable for both class A and class B fires, or only for class B fires. Most powder extinguishers are of the 'multi-purpose' type and can be used on both class A and class B fires. Extinguishers usually contain several kilograms of agent, and the mechanism of expulsion may, again, be stored pressure or gas cartridge. The gross weight of the extinguisher is usually less than that of a water or foam extinguisher (typically 5 kg –10 kg), and the range of the discharge is around 5 m. The means by which powder extinguishes fire is very complex (see Chapter 2), but involves chemical inhibition and the imposition of a thermal load.

Powder provides very rapid knockdown of flame, and the performance ratings achieved for both class A and class B fires are quite high. Powders are also quite effective on running flammable liquid fires. A disadvantage of powder, however, is that it has no cooling effect and cannot readily prevent re-ignition of a fire that continues to smoulder after the extinguisher is discharged; in contrast, foam, for example, would tend to prevent transition from smouldering to flaming. Powder may be used on live electrical equipment, but may cause significant damage to electronic and electromechanical equipment.

Carbon dioxide

Carbon dioxide extinguishes fire by displacing oxygen and imposing a thermal load on the flames. Most portable extinguishers contain either 2 kg or 5 kg of the agent, but, as the gas is stored as a liquid under high pressure, the cylinder itself is heavy and the typical gross weights of extinguishers are in the region of 5 kg to 12 kg. The extinguishing performance is, however, significantly less than that of other extinguishers of similar weight, and CO_2 extinguishers are provided mainly for use on fires involving electrical equipment. In office areas, it is common to provide CO_2 extinguishers, in conjunction with water or AFFF extinguishers, purely for use on electrical equipment.

Carbon dioxide extinguishers should not be discharged into confined spaces, as the gas is both an asphyxiant and toxic. In the quantities used in portable extinguishers, however, there is no significant danger from using carbon dioxide in normal areas of commercial and industrial buildings.

Carbon dioxide extinguishers are not particularly 'user-friendly', in that their weight is high in relation to their extinguishing capability and they generate a significant amount of noise when they are operated. Also, the discharge horn, unless made from a thermally insulating material, becomes very cold during the discharge and, if gripped tightly for long periods, mild frostbite can result. It is essential that staff are aware of the noise that will be created and the correct method of holding the extinguisher. It is necessary to approach quite closely to a fire, as the typical effective discharge distance is only around 1 m.

Other agents

In the past, halon 1211 (bromochlorodifluoromethane) was commonly used in fire extinguishers. These extinguishers typically contained only a few kilograms of gas and were, therefore, both small and light. Halon was a useful agent, as it could be used on live electrical equipment, and, unlike carbon dioxide, was very effective on class A fires. It was also effective on fires involving flammable liquids.

Unfortunately, halons deplete the ozone layer, and manufacture has now ceased in most countries in the world, including member states of the EU, North America and other countries that are signatories to the 'Montreal Protocol', an international agreement on the phasing out of ozone depleting substances. All halon extinguishers should now have been removed from premises, but they are still permitted for some 'critical uses', such as on board aircraft, where the extinguisher is necessary to protect life and there are no suitable alternatives.

Although research on, and development of, halon replacements has been extensive, such replacements are used mainly in fixed systems (see Chapter 14), rather than portable extinguishers, for which there is no significant demand by users for halon replacements.

Other agents used in portable fire extinguishers are mainly used only for specific applications. One relatively recent development has been the introduction of extinguishers intended purely for class F fires (involving cooking oils and fats). In commercial kitchens, the quantity of cooking oil in a deep fat fryer is normally too great for use of a fire blanket to be appropriate. Although foam is effective in creating a blanket over burning oil, the high auto-ignition temperature of the oil (see Chapter 2) is such that significant heat remains in the liquid, resulting in the potential for early destruction of the foam blanket. Indeed, once ignition has occurred, the auto-ignition temperature of vegetable oil, after subsequent extinguishment, is reduced, making constant re-ignition more likely unless there has been substantial cooling of the bulk of the liquid. Also, the relatively fast discharge from CO_2 and foam extinguishers can cause splashing of the liquid.

The agents used in class F extinguishers are normally saponification agents, which effectively convert the flammable oil into a soap. The rate of discharge of the agent is relatively slow to prevent splashing of the liquid and possible fire spread. It is now quite common to find these extinguishers provided in large commercial kitchens. Consideration and performance requirements for these extinguishers are given in BS 7937[1] under which extinguishers are given a class F rating, according to the size of fire that they can extinguish.

It is also possible to obtain special extinguishing agents for class D fires (involving combustible metals). Since this is a very specialized application, it is not considered further.

Relevant standards

The manufacturing standard for portable fire extinguishers is BS EN 3.[2] Extinguishers manufactured in accordance with this European standard must be predominantly red in colour. Not more than 10 per cent of the area of the extinguisher body may be colour coded to indicate the contents of the extinguisher. In the UK, a further standard, BS 7863,[3] specifies that between 3 per cent and 5 per cent of the extinguisher body should be colour coded for this purpose, using the traditional colours for each agent, as follows:

- *water*: red;
- *foam*: pale cream;
- *powder*: blue;
- *carbon dioxide*: black.

Unfortunately, different manufacturers use a different method of displaying the relevant colour.

Until the introduction of the European Standard, most fire extinguishers were manufactured in accordance with BS 5423, which was withdrawn in 1997. Under this standard, either the entire extinguisher body could be colour coded to indicate the contents (so, for example, the carbon dioxide extinguishers were entirely black), or the protocol now adopted under the European standard could be used. Most manufacturers adopted the former arrangement, resulting in the familiar colours of extinguishers, to which most users were accustomed.

After 1997, there was potential for substantial confusion on the part of occupants, until such time as the new colour coding was widely understood. The situation was somewhat exacerbated by the fact that it will be some years before all BS 5423 extinguishers are replaced with BS EN 3/BS 7863 appliances. In the meantime, there will, inevitably, be a mix of the two systems of colour-coded extinguishers within (a rapidly decreasing number of) buildings.

There is, of course, no legal or other obligation for users to provide extinguishers conforming to BS EN 3; it is a product standard, directed primarily at manufacturers of extinguishers. While manufacturers will not be able to receive certification (such as Kitemarking by BSI) for their products unless the products comply with BS EN 3, the requirements of this standard are not imposed on users. Indeed, some manufacturers have for many years, and still do, produce fire extinguishers in special, non-standard finishes, such as stainless steel.

British Approvals for Fire Equipment (BAFE) publish a list of extinguishers that have been independently tested in accordance with BS EN 3, and that are manufactured in accordance with a satisfactory quality assurance scheme. Specification of such independently certificated extinguishers provides an assurance of product quality and reliability. In addition, the Loss Prevention Certification Board (LPCB) publish a list of fire extinguishers that have been independently tested to BS EN 3 or other standards.

Siting of extinguishers

Guidance on siting of portable fire extinguishers is given in BS 5306-8.[4] Extinguishers should be sited in conspicuous locations on escape routes, such as at storey exits and in corridors, and should normally be wall mounted on brackets. If wall mounting is not feasible, they can be placed within specially designed floor stands, but they should never be left free standing on floors. No person should need to travel further than 30 m to reach the nearest extinguisher.

It may also be advisable to provide additional extinguishers of a suitable type in close proximity to particular hazards. For example, a CO_2 extinguisher is normally provided in the vicinity of any large photocopying machine. However, it is not necessary to 'flood' an area with CO_2 extinguishers simply on account of the use of normal office equipment, such as VDUs, etc. It is usually sufficient to provide such extinguishers at the normal fire points at storey exits, with perhaps one or two additional CO_2 extinguishers within large open-plan office areas.

Extinguishers complying with BS EN 3 are marked with a rating to indicate the maximum size of test fire that the extinguishers have been shown to extinguish, when used by a skilled operator. These class A and class B ratings may be used to determine the number of extinguishers required in an area. BS 5306-8 recommends that the aggregate class A rating of extinguishers in an area should comprise 0.065 × floor area in square metres. Since, for example, a 9 litre water extinguisher normally achieves a 13A rating, each 9 litre water extinguisher may be considered to be sufficient for a floor area of 200 m^2. However, the aggregate rating of all extinguishers on a storey should generally not be less than 26A, except in the case of buildings in single occupancy with an upper floor of less than 100 m², where a 13A rating on each floor would suffice. In a large building it may, in some cases, be reasonable to reduce the number of class A rated extinguishers if the building is also provided with hose reels.

Fire blankets

Fire blankets are normally made from coated fibreglass, and are contained in wall-mounted housings. They are used for extinguishing fires in people's clothing, and can be used to smother a fire involving burning food (e.g. chip pan fires).

Their main application is, therefore, in kitchens, but fire blankets may also be found in some laboratories or areas in which people handle highly flammable liquids.

Hose reels

Hose reels comprise a reel of rubber hose that is normally 30 m in length and is permanently connected to a water supply. The relevant design code, BS 5306-1,[5] provides recommendations for the flow rates and flow range of hose reels by reference to BS EN 671-1[6] and BS EN 671-2.[7]

In many buildings, the water is supplied from the building's water mains, but, in higher buildings, there is a need to provide a tank and pumps as a source of supply. A tank of at least 1,125 litres is typically provided as BS 5306-1 recommends that the duration of the supply should be 45 minutes. Duplicate electric pumps, which are readily available as a package, should be used.

Normally it is necessary for the user to open a valve before running out the hose. However, some hose reels have automatic valves, which provide a supply after a short, predetermined length of hose has been run out. While these have the advantage that the user need not remember to open the valve, which, if not properly maintained, can become stiff to operate, automatic valves involve additional complexity and have been known to fail when required.

Staff training

Whatever extinguishing equipment is installed in a building, all (or a defined proportion of) members of staff should be properly instructed and trained in its use (except in the case of fire blankets that are only likely to be used by particular occupants, such as kitchen staff). The need for staff to be trained is often regarded as a contentious point, and is not considered reasonable or desirable by some organizations. This view is often based on the practical problems of instructing a large number of employees, or a fear that staff may be injured if they are encouraged to fight fires.

In the opinion of the author, it is vital that all (or, at least most) staff are given suitable instruction in the use of fire extinguishers. This view is based on the following considerations.

a) The Regulatory Reform (Fire Safety) Order* requires that, where necessary, premises must be provided with appropriate fire-fighting equipment, and that measures must be taken for fire-fighting, with competent and adequately trained persons to implement the measures (see also Chapter 1).
b) Most premises are provided with extinguishers. These will not normally be used by the fire and rescue service, and they can only, therefore, be intended for use by persons on the premises. The provision of extinguishers, without training in their use, could be regarded as a risk to occupants unless they are given suitable instruction in the use of extinguishers. Regardless of whether occupants may be instructed not to fight fires, given that extinguishers are actually available to occupants, there is a likelihood that they would be used. It is contrary to the principles of health and safety to provide safety equipment without instruction in its use; liability may arise if an employee were injured as a result of using a fire extinguisher without suitable knowledge or understanding of the means of operation or the limited circumstances in which it should be used.
c) Statistics make it clear that fire extinguishing appliances make a valuable contribution to the defences against fire loss (see p. 226).

However, the qualification that people be nominated and trained *where necessary* would appear to support the policy, adopted in some companies, that only selected members of staff, trained to a high standard, are permitted to tackle a fire.

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* and equivalent legislation in Scotland and Northern Ireland.

Checking fire extinguishing appliances

All extinguishing appliances should be inspected and maintained annually by specialists in accordance with the recommendations of BS 5306-3.[8] However, users should ensure on a much more regular basis (such as every month) that:

a) access to hose reels and extinguishers is unobstructed;
b) manual hose reel valves are in the off position (except in the case of automatic reels) and are free from leaks;
c) all hose is neatly wound on the reel;
d) hose reel nozzles are not blocked;
e) both hose reel pumps, if provided, operate correctly;
f) all fire extinguishers are in their correct position, are undamaged, and are mounted on brackets (this is particularly important in premises in which there is potential for tampering with extinguishers, such as student hostels, colleges, shopping centres, etc.);
g) the gauges of stored pressure extinguishers indicate normal pressure;
h) any seals on hose reel valves or extinguisher release controls are in place;
i) labels attached to the appliances indicate that maintenance has been undertaken within the last 12 months.

Further reading

BS 5306-8, *Fire extinguishing installations and equipment on premises — Selection and installation of portable fire extinguishers — Part 8: Code of practice*
BS 5306-1, *Code of practice for fire extinguishing installations and equipment on premises — Part 1: Hose reels and foam inlets*

References

1. BS 7937, *Specification for portable fire extinguishers for use on cooking oil fires (class F)*
2. BS EN 3, *Portable fire extinguishers*
   Part 1. Description, duration of operation, Class A and B fire test.
   Part 2. Tightness, dielectric test, tamping test, special provisions.
   Part 3. Construction, resistance to pressure, mechanical tests.
   Part 4. Charges, minimum required fire.
   Part 5. Specification and supplementary tests.
   Part 6. Provisions for the attestation of conformity of portable fire extinguishers in accordance with EN 3 Part 1 to Part 5.

3. BS 7863, *Recommendations for colour coding to indicate the extinguishing media contained in portable fire extinguishers*
4. BS 5306-8, *Fire extinguishing installations and equipment on premises — Selection and installation of portable fire extinguishers — Part 8: Code of practice*
5. BS 5306-1, *Code of practice for fire extinguishing installations and equipment on premises — Part 1: Hose reels and foam inlets*
6. BS EN 671-1, *Fixed firefighting systems — Hose systems — Part 1: Hose reels with semi-rigid hose*
7. BS EN 671-2, *Fixed firefighting systems — Hose systems — Part 2: Hose systems with lay-flat hose*
8. BS 5306-3, *Fire extinguishing installations and equipment on premises — Part 3: Maintenance of portable fire extinguishers — Code of practice*

14

Fixed fire-fighting systems

Types of fixed fire-fighting system

A fixed fire-fighting or control system is a system that is permanently installed in a building, or on an item of plant, for the purpose of controlling, suppressing or extinguishing fires, by either automatic or manual discharge of a fire extinguishing medium.

Traditionally, the main systems to which this chapter refers were described as fixed fire extinguishing systems. However, in many of these systems, the main objective is 'control' or 'suppression' of a fire, rather than total extinguishment, which may be regarded as something of a 'bonus'. The three terms, control, suppression and extinguishment may be defined as follows:

- *fire extinguishment*: a sharp reduction in heat-release rate leading to complete elimination of any flaming or smouldering fire;
- *fire suppression*: a steady reduction in the heat-release rate resulting in a lower controlled level of burning;
- *fire control*: limitation of fire growth and protection of structure (by cooling of the objects, fire gases and/or by pre-wetting adjacent combustibles).

Fixed fire-fighting systems tend to be classified according to the extinguishing agent, i.e. water-based or aqueous systems, and non-aqueous systems. However, as far as applications are concerned, this division is much too crude and there is a need to consider either the actual agent, or its physical nature and the form in which it is discharged. Thus, water-based systems may be divided into the types and subcategories shown in Table 14.1, while non-aqueous systems may be divided into the types and subcategories shown in Table 14.2. The main applications for each system, in terms of the type of fire for which the systems are normally used, is also shown.

Table 14.1 Types of water-based fixed extinguishing system

Type of system	*Major subcategories*	*Main applications*
Sprinkler	–	Class A fires in buildings
Drencher		Prevention of fire spread between buildings
Water spray	High velocity	Extinguishment of class B fires involving liquids with high flashpoints (66 ºC and above)
	Medium velocity	Control or extinguishment of class B fires involving liquids with low flashpoints (below 66 ºC) and water miscible liquids (also protection of plant against radiation from an adjacent fire)
Fine water spay ('water mist')	–	Control/extinguishment of class A and B fires
Foam	Low expansion	Class B fires
	Medium expansion	Class B fires
	High expansion	Class A fires

Table 14.2 Types of non-aqueous fixed extinguishing system

Type of system	*Major subcategories*	*Main applications*
Gaseous	Local application	Protection of a localized class A or class B risk within a larger volume
	Total flooding	Protection against class A or class B fires throughout the entire volume of a protected space
Powder	Local application	Localized class B risks
	Total flooding	Protection against class B fires throughout the entire volume of a protected space

Automatic sprinkler systems

Sprinklers are undoubtedly the most important and most generally applicable type of fixed fire-fighting system. They are normally used for general protection throughout a building, and are commonly found in industrial and commercial premises, such as factories, warehouses and offices. In such premises, they are normally used to protect property by detecting and controlling a fire, so as to limit the fire size until the fire is extinguished by the fire and rescue service, although, in many cases, the system is likely to extinguish the fire.

There is, however, a more recent recognition of sprinklers as a life-safety measure although, in the United Kingdom, sprinklers have traditionally been used mainly to protect premises where the risk to life is relatively low. It is often argued that, on a worldwide basis, loss of life in premises that are sprinklered is very rare indeed. Perhaps the classic life-safety application for which sprinklers are recognized is covered shopping complexes, in which an important role of the sprinklers is to limit fire development to a size with which smoke-control systems can cope (see Chapter 15).

The need for sprinklers

Sprinklers may be required under building regulations in order to increase the permitted compartment sizes in many types of premises (see Chapter 8). In addition, certain local legislation, such as Section 20 of the London Building Acts (Amendment) Act, empowers local authorities to require sprinklers in certain high buildings and in large warehouses or factories.

In any high building in which phased evacuation is used (see Chapter 7), sprinkler protection of the building is, in practice, an important measure to ensure that the fire development is controlled.

Fire insurers are very much in favour of sprinklers, particularly in industrial buildings, such as factories and warehouses. Where sprinklers are installed throughout a building, or a fire separated part of a building of this class, substantial fire insurance premium discounts can apply, provided the installation conforms to the Loss Prevention Council (LPC) *Rules for Automatic Sprinkler Installations*, and the equipment used is of a type approved by the Loss Prevention Certification Board (LPCB). In large, high-risk buildings, some insurers may actually require sprinkler protection as a condition of insurance.

There has been a substantial growth in the use of sprinkler installations in dwellings and other forms of residential accommodation over the past few years. As noted in Chapter 1, building regulations in Scotland actually require automatic fire suppression systems in any new (or extended) residential care homes, sheltered housing accommodation and flats in blocks greater than 18 m in height. In England and Wales, compliance with the guidance that supports the Building Regulations in the form of Approved Document B necessitates sprinkler protection in blocks of flats (and non-residential buildings) exceeding 30 m in height. Normally, fire suppression systems in dwellings and residential accommodation take the form of a sprinkler installation, although, in some cases, water mist suppression systems might be considered (see p. 252).

It is now not uncommon for fire suppression systems to be considered as a compensatory feature for departure of other fire precautions from prescriptive codes of practice, such as Approved Document B under the Building Regulations 2000 in England and Wales. The scope for alternative solutions incorporating sprinkler protection is recognized within the approved document, which, itself, offers various design freedoms if sprinklers are installed.

For example, in a house with a floor at, or greater than, 7.5 m above ground level, Approved Document B provides the option of providing sprinkler protection instead of an alternative escape route from floors situated 7.5 m or more above ground level, so enabling the entire property to be served by a single protected stairway. A similar approach is accepted in a multi-storey flat with the entrance above ground floor level. Certain other design freedoms are offered by Approved Document B if sprinkler protection is provided. For example, in residential care homes, bedroom doors need not be self-closing if the building is sprinklered, and limits on the number of residents within a single sub-compartment do not apply.

Design codes for sprinkler systems

The basic design code in the United Kingdom was traditionally BS 5306-2,[1] and, where a sprinkler system has been required for non-domestic premises under legislation, it was generally to this code of practice that enforcing authorities referred. BS 5306-2 was based on an earlier set of 'rules', originally published by the Fire Offices' Committee (see Chapter 23) for use by insurers. Traditionally, the vast majority of installations in the United Kingdom were designed in accordance with these rules.

The LPC *Rules for Automatic Sprinkler Installations* are now published by the Fire Protection Association (FPA), but, for some years, these have simply comprised BS 5306-2, supplemented by a number of 'Technical Bulletins'. The technical bulletins augmented BS 5306-2 to satisfy insurers' requirements on issues that were outside the scope of the British Standard, and to make use of new developments resulting from research or service experience. Thus, the LPC

Rules represent insurers' requirements for sprinkler installations. However, even if an installation is not required by insurers, or acknowledged by the insurer in premium rating, many installations are designed in accordance with the LPC Rules (i.e. taking account of the guidance in the technical bulletins). BS 5306-2 has been superseded by the European Standard BS EN 12845.[2] (However, it remains current but obsolescent. It is, therefore, frozen in time and will not be subject to further revision or amendment.) Now, the LPC rules will incorporate BS EN 12845 in conjunction with the relevant technical bulletins, plus a supplement that provides further guidance on interpretation of BS EN 12845.

Sprinkler systems in the United Kingdom are sometimes designed in accordance with American codes if, for example, the building is owned by an American company, or if the company is insured by an American fire insurer. Under these circumstances, the American code used would normally be National Fire Protection Association (NFPA) Standard 13. In some circumstances, additional requirements of the American-based Factory Mutual insurers may also apply.

In the case of residential and domestic occupancies, the relevant design code is BS 9251.[3] This code of practice is much less onerous than BS 5306-2 and BS EN 12845. For example, discharge densities, capacity of water supplies and recommendations for reliability of water supplies are significantly less onerous. BS 9251 applies to domestic properties, such as houses, flats, maisonettes and transportable homes. It also applies to residential occupancies that include residential homes, boarding houses and houses in multiple occupation, subject to a limitation that the building does not exceed 20 m in height.

Components of a sprinkler installation

A schematic of a typical wet pipe sprinkler installation is shown in Figure 14.1. The basic components of an installation are as follows:

a) a water supply;
b) a main valve set;
c) a network of pipes;
d) a number of sprinkler heads.

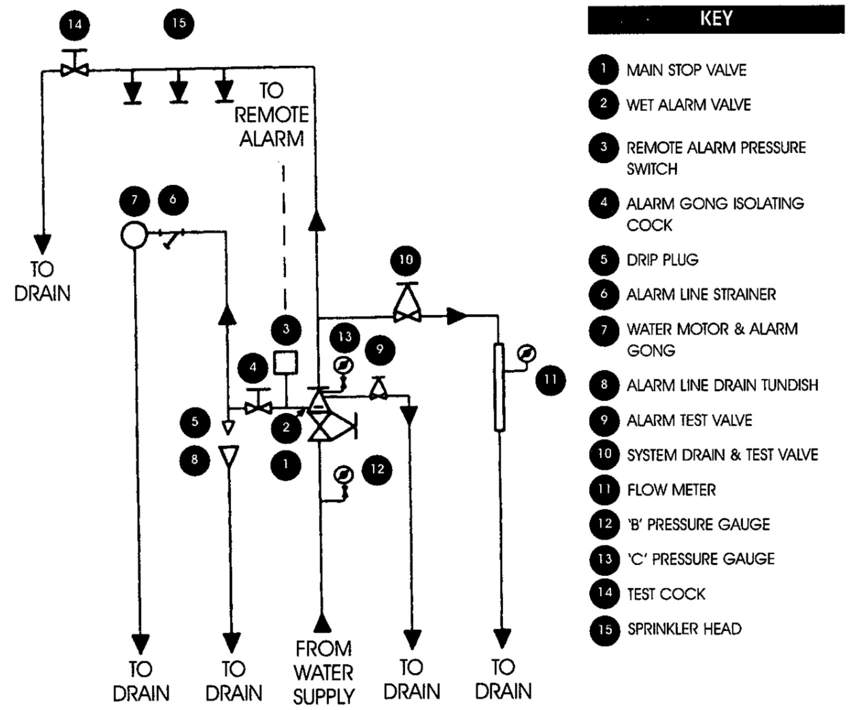

Figure 14.1 Wet pipe sprinkler system

Principles of sprinkler operation

Each sprinkler head is a combined heat detector and discharge valve. When the temperature of the detecting element is sufficiently high, the valve opens, permitting water to be discharged. Each head operates entirely independently of every other head (except in 'deluge systems' protecting special risks, where a group of 'open' heads operate simultaneously when a single valve opens on operation of a single sprinkler head on an associated air or 'pilot' line, or a group of sealed heads is actuated electrically). Many fires are controlled or extinguished by the operation of only a few heads. The common view that all heads throughout a large area operate simultaneously is totally incorrect.

The sprinkler pipework is normally permanently charged with water, which is, therefore, available as soon as the first sprinkler head opens. Thus, such installations are permanently 'wet'. However, in unheated warehouses (other than those classified as high hazard) for example, an 'alternate' installation is sometimes used. In these systems, the pipework remains charged with water during the summer months, but is drained and charged with air, becoming 'dry', during the winter months. A special type of alternate valve set is required, permitting water to enter the installation pipework when the air pressure is lowered by the operation of the sprinkler head(s). In special circumstances, such as cold stores, a permanently dry installation may be required.

The main valve set comprises an installation stop valve and an alarm valve. When a sprinkler head opens and water flows into the installation, the alarm valve permits a small amount of water to flow down small bore pipework that terminates in a water driven gong, normally located outside the building, to provide a warning. A pressure switch may be fitted to this pipework, enabling the sprinkler system to connect with, for example, a fire alarm system. Therefore, the fire alarm system may also operate when a sprinkler head opens. Alternatively, flow switches may be fitted to installation pipework in order to achieve the same result or to provide more accurate information as to the location of the fire. For example, in shopping complexes, each sprinkler installation may serve numerous shops; a pressure switch in the alarm line pipework indicates that the installation is discharging water, while a flow switch in the pipework to each shop confirms the shop in which sprinkler discharge is occurring.

In a 'pre-action' installation, dry pipework is charged with water when an automatic fire detector operates. The system may additionally operate as a conventional dry installation, in that the pipework will become charged with water even if the detection system fails to operate. The system can also, more commonly, be configured so that the pipework would become charged with water *only* if a fire detector operates. The pre-action valve set required is expensive, and the interface with an automatic fire detection installation reduces the inherent reliability of a wet sprinkler installation. Such systems are only used for special applications in which there is concern over water damage as a result of accidental damage to sprinkler heads, or, less commonly, there is a need to speed up the operation of a dry system. Where a pre-action sprinkler system is to be used, recommendations on the interface with the fire detection and alarm system are given in BS 7273-3.[4]

Sprinkler installation design principles

For the purpose of installation design, occupancies are divided into the following three hazard categories according to the nature of the activities and combustible materials that might be expected:

1. light hazard;
2. ordinary hazard;
3. high hazard.

The higher the hazard category, the greater the size and rate of development of fire that may be anticipated. Accordingly, a different density of water discharge is required for each of the three hazard categories. Density of discharge is expressed in a similar manner to rainfall, namely in units of millimetres per minute. Since only a limited number of heads should be required to open in order to control any fire in the premises, each hazard category has a different assumed maximum area of operation (AMAO).

Light hazard installations are uncommon. They are used in non-industrial occupancies, in which the amount of combustible material is low and the building is subdivided into spaces of limited size by fire-resisting construction. In principle, the classification could apply to many areas of hospitals and hotels (which are, in fact, only rarely sprinklered in any case), museums and some offices. There is very little flexibility for changes to the building if a light hazard installation is installed. If, for example, an area containing a number of small, fire-resisting cellular offices were made open plan, there could be a need to upgrade the installation to ordinary hazard. In the most hydraulically unfavourable part of the installation, the minimum design density in a light-hazard installation must be 2.25 mm/minute, with an AMAO of 84 m^2.

Ordinary and high-hazard occupancies are further divided within BS EN 12845 into subcategories. In the case of the ordinary-hazard subcategories (ordinary-hazard Groups I, II, III and IV), the minimum design density in the most hydraulically unfavourable area of the installation is the same (5mm/minute), but the AMAO ranges from 72 m^2 to 360 m^2 respectively.

Ordinary-hazard occupancies are normally industrial and commercial premises in which there is unlikely to be rapid fire development owing to the nature and method of storage of the fire load. Many office buildings (excluding high-rise buildings) could be classed as ordinary-hazard group I, provided there are no major storage areas. A typical light metalworking factory might be classed as ordinary hazard group II, a department store would be regarded as ordinary-hazard group III, while a theatre would be classed as group IV. Typical examples of ordinary-hazard occupancies and their groupings are given in BS EN 12845, but the classification of occupancies is probably as much an art as a science, and different insurance companies may differ in their opinion on the classification of a risk. Early consultation with the insurers at the design stage of any sprinkler installation is therefore vital.

High-hazard occupancies are those in which the process, or the nature, amount, and type, of storage are such that there is a more significant challenge to the sprinkler installation. High-hazard risks are divided into:

a) process hazards;
b) high-piled storage hazards;
c) potable spirit storage hazards;
d) oil and flammable liquid hazards (which, in practice, would normally require special protection).

There are four types of process hazard, for which the densities vary from 7.5 mm/minute to 12.5 mm/minute, according to the nature of the hazard. For three of the types of process hazard, the AMAO remains the same, and only the minimum density of discharge varies. For the fourth type, which is rare but includes firework manufacturing, BS EN 12845 recommends that each building be provided with complete 'deluge' protection. This comprises open heads that will result in discharge of water over the entire area, on actuation of the installation.

High-piled storage, high-hazard occupancies are commonly warehouses. The definition of high piled varies according to how the commodity is stored and the nature of the stored materials. (Goods are classified into four categories, according to the fire challenge they present.) The minimum design density and AMAO are related to the storage height. For example, free-standing flat paper would only be regarded as a high-hazard risk if the storage height exceeded 4 m; below this height ordinary-hazard group III would apply. At the other extreme, rolls of free-standing foam rubber would require high-hazard protection if stacked more than 1.2 m in height. In the case of some categories and heights of high-hazard racked storage, protection by ceiling mounted sprinklers alone is not regarded as sufficient; intermediate sprinklers within the storage racks may be required.

The classification of the occupancy (and the definition of the required design density and AMAO) is the first step in the specification and design of a sprinkler installation, as it will determine the nature of the water supply and the size of the pipework. As the design density and AMAO increase, a greater flow rate must be capable of being provided by the water supply. If the supply is a water authority main, it must be capable of reliably providing the required pressure and rate of flow. If it cannot do so, as will normally be the case in respect of high-hazard risks or high buildings, then a tank(s) and pump(s) must be provided. Again, the minimum required flow rate will determine the rating of the pump(s). In addition, since the system must be capable of supplying water for a minimum specified time, the hazard classification and rating of the pumps will determine the capacity of the tank(s).

For sufficient water to flow at a sufficient rate to the most remote area, the diameter of the pipework must be adequate. In general, therefore, the hazard category will have a major effect on pipe sizes and, hence, the cost of the installation. There are two methods of designing the pipework. Either, schedules of pipe sizes in BS EN 12845 may be used, or the entire installation may be hydraulically calculated (normally by means of a computer program) to ensure that the design requirements are satisfied. The latter method offers greater flexibility in initial design, can result in a more cost-effective installation, and its use is quite widespread. This method can, however, restrict future changes to the system. In the case of high-piled storage with in-rack sprinklers, hydraulic calculation is essential.

Water supplies for sprinkler systems

Water supplies for sprinkler installations normally comprise either a connection to a water authority main, or a pump(s) and tank(s) supplied from a water authority main. However, other sources of supply, including a gravity tank, a pressure tank, an elevated private reservoir and even a river or canal can, in principle, be used, although some limitations are imposed by BS EN 12845.

BS EN 12845 describes three forms of water supply:

1. a single supply, such as a single town main, or single pump drawing from a tank;
2. a superior supply, such as a town main that is fed from both ends, or duplicate pumps drawing from a tank;
3. duplicate supplies, such as two independent town mains, or duplicate pumps and duplicate tanks fed from a potable water supply.

Whenever practicable, superior or duplicate supplies should be provided. Single supplies are not, in any case, acceptable for high-hazard risks.

Insurers classify water supplies as grade I, grade II and grade III. The lower the grade of water supply, the lower any premium discount that may apply. The three grades of supply are defined in a technical bulletin in the LPC rules, summarized as follows.

1. A Grade I supply is either a duplicate supply or a superior supply (but the total number of heads, and the number in any fire compartment, is limited if a superior supply is used);
2. A Grade II supply is a superior water supply in which the limitations imposed under the definition of grade I are not satisfied;
3. A Grade Ill supply is effectively a single supply, comprising a town main or a single automatic pump and tank(s).

Pumps for sprinkler systems may be either electrically driven or diesel driven. The pumps are commonly duplicated to provide either a superior or a duplicate water supply; a common arrangement is to install one diesel and one electric pump. Two electric pumps may be used, but each must then be powered from independent power supplies, or can be driven from the same supply, provided there is automatic changeover to a completely independent supply if this supply fails.

Sprinkler heads

Sprinkler heads operate on one of two principles.

1. Fusible link sprinklers, which open when heat from a fire melts a soldered link that normally holds the valve closed.
2. Glass bulb sprinklers, in which a liquid-filled glass bulb holds the valve closed. Heat from a fire causes the liquid to expand, thus exerting pressure on the glass bulb, which fractures and releases the valve.

Either type of head is generally acceptable.

Most conventional sprinklers can be mounted in either the pendent or upright position. Water is discharged onto a plate and is deflected in an upward and downward direction to provide ceiling wetting as well as discharge onto the fire in similar amounts. In the case of 'spray heads', the discharge is predominantly downwards.

Where it is undesirable for sprinkler heads to protrude significantly below a ceiling, flush, recessed or concealed sprinklers may be considered. Flush heads are mounted so that part of the head is actually above the plane of the ceiling, but the heat sensing element remains below the ceiling. In the case of recessed heads, all or part of the sensing element is also above the ceiling. A concealed sprinkler is actually a type of recessed sprinkler with a cover plate that falls away when the head is exposed to fire. None of these sprinklers may, however, be installed for protection of high-hazard risks.

Special sidewall pattern sprinklers may also be used in certain applications, other than high-hazard risks. These, as the name implies, are mounted in the plane of a wall, and throw water in an outward direction. They may be used, for example, in corridors or relatively small rooms in lieu of normal ceiling sprinklers.

Sprinkler heads are manufactured with a range of standard operating temperatures. Normally, the heads used in the United Kingdom operate when they reach a temperature of 68 ºC. The liquid in the glass bulbs of these heads is coloured red to indicate the temperature of operation. The yoke arm of standard 74 ºC fusible link heads is uncoloured. Sprinklers that operate at other temperatures are coded by colouring of the liquid in glass bulbs, or the yoke arms of fusible link heads, to indicate the temperature of operation.

When fire occurs, there is a significant difference between the temperature of a head and the surrounding air temperature. This is because it takes some time for the mass of the sprinkler head to become heated by the hot gases rising from the fire. Thus, two different designs of head may actually open at different times in a fire, despite being rated at the same temperature of operation. In order to reduce the delay in operation of heads in certain residential applications or high-piled storage risks, a number of 'quick response' heads with low thermal inertia are produced. It is sometimes suggested that the design fire size for smoke control systems might be reduced on the basis of the use of these heads (see Chapter 15).

A particular category of quick response head is used in so called ESFR (early suppression fast response) sprinkler systems. These systems were developed by the Factory Mutual insurers in the USA to protect, with ceiling sprinklers, storage risks that would normally require sprinklers within the storage racks as well as ceiling sprinklers. The systems are now recognized by insurers for use in the UK. However, great care in the design of such systems is necessary, as the systems are less 'forgiving' of adverse building features that affect sprinkler efficiency than conventional ceiling/in-rack sprinkler installations.

Location of sprinkler heads

Normally, if sprinkler protection is installed in a building, the entire building is covered. Partial protection of a building is unusual and should be avoided, as the sprinklers in a protected area may not be able to cope with a fire that spreads from an unprotected area. Thus, if a small office is constructed in a sprinklered warehouse, for example, it must also be sprinklered.

Sprinklers should obviously be omitted from areas in which water discharge would create a serious hazard, such as in industrial areas containing molten metal. Sprinklers may also be omitted from certain electrical switchgear or transformer rooms, rooms containing oil or other flammable liquids, toilets and some stairways. However, in each case, the unprotected area must be separated from the protected area by construction that is adequately fire resisting – normally 120 minutes fire resistance is required.

If a building that is sprinklered communicates directly with an unsprinklered building, it is important that the fire cannot spread from the unprotected building to the protected one. Separating walls with a fire resistance of 120–240 minutes are recommended by BS EN 12845, according to circumstances.

Sprinkler installation performance

The reliability of sprinkler systems to control or extinguish fire is now proven beyond doubt. Around 95 per cent to 98 per cent of fires that are large enough to result in sprinkler operation are controlled or extinguished by the sprinklers. Of the few per cent of sprinkler failures, many are the result of human error, such as closed stop valves, a change in hazard category without modification of the installation, improper storage practices or lack of maintenance.

The reliability of sprinkler systems against false discharge is also very high. Sprinkler leakage is rare and tends to result from mechanical damage, such as impact by fork lift trucks, freezing of pipework, or excessive temperature and corrosion in aggressive industrial environments. In the benign environment of an office building, the probability of sprinkler leakage is particularly low, and conventional wet systems are sometimes even used to protect computer suites, although concern over the possibility of water damage sometimes results in the use of pre-action systems for such applications.

Checking sprinkler systems

BS EN 12845 makes the following recommendations for daily and weekly inspection and test routines.

Daily

Any unmonitored means of relaying fire signals to the fire and rescue service (see Chapter 11) are checked daily.

Weekly

The following are checked weekly:

a) pressure gauge readings;
b) the water motor alarm and any equipment for relaying signals to the fire and rescue service;
c) pumps, e.g. fuel levels, oil levels; and various tests (described in BS EN 12845) should be undertaken;
d) vented batteries;
e) monitoring arrangements on stop valves of life-safety systems;
f) heating systems provided to prevent freezing in the system.

These recommendations are amplified by a technical bulletin in the LPC Rules.

Quarterly

There should normally be a contract with a specialist sprinkler maintenance contractor for quarterly servicing and maintenance of the installation, unless qualified persons are available in the organization to undertake this work. In the course of routine safety inspections of a sprinklered building, it should be ensured that:

a) all pipework is undamaged and that heads and pipework are free from leaks;
b) stop valves are secured in the open position;
c) goods are not stacked close to sprinkler heads;
d) no unprotected areas have been created;
e) there has been no change in the risk that would change the hazard classification;
f) sprinkler heads have not been painted.

Drencher systems

The purpose of a drencher system is to prevent the spread of fire from a closely adjacent building to the protected building. The drencher system discharges water externally over windows and other wall openings that may permit entry of fire to the building.

The heads may be sealed and operate in the same manner as sprinkler heads, forming an extension to the existing sprinkler installation. Alternatively, the heads may be open and are then actuated either manually or automatically by a separate detection system.

Water spray systems

High and medium-velocity water spray systems are used where there is a fire risk due to the presence of flammable liquids. As well as automatic operation, manual control over the discharge is possible in some installations.

High-velocity spray systems are used to extinguish fires in non water-miscible liquids that have relatively high flashpoints (66 ºC and above). The high-velocity spray nozzles produce large water droplets (1.5–2.5 mm diameter) that are able to penetrate the updraught from the fire and cool the liquid until it is extinguished. These systems operate in a 'deluge', in that a small group of open nozzles discharge simultaneously over the risk area. Typical applications for high-velocity spray systems include the protection of oil-filled transformers, diesel generators and oil-fired boilers.

Medium-velocity spray systems are used for risks involving water-miscible flammable liquids or low flashpoint (less than 66 ºC) non-water-miscible liquids. The spray heads ('sprayers') produce fine droplets (less than 0.4 mm diameter), which are able to extinguish the fire by diluting the liquid and therefore raising the flashpoint of the mixture. For liquids with low flashpoints, this method is more difficult, but a measure of control is possible.

If a sufficiently fine spray is produced, heat can be extracted from the flames and the fire can be controlled. This principle is used for low flashpoint non-water-miscible liquids but, again, control rather than extinguishment may be all that can be achieved.

Medium-velocity spray heads are normally open and can be operated in the same manner as high-velocity spray nozzles. Medium-velocity spray can also be used to cool exposed structural steelwork in the event of a fire in a flammable liquids plant, or to cool flammable liquid or gas storage tanks that may be threatened by an adjacent fire. Applications for medium-velocity spray systems are normally restricted to flammable liquids plants. They may also be used to protect, for example, an oil-fired boiler installation that burns fuel with a lower flashpoint than would be appropriate for a high-velocity spray system.

There is no British Standard for water spray systems, but tentative rules, produced by the then Fire Offices' Committee in 1979, remain in use as a guidance document. The American NFPA Standard 15 can also be used.

Water mist systems

Water droplets produced by conventional sprinkler heads and water spray nozzles need momentum to penetrate the plume of hot gases from the fire. As a result, relatively large droplet sizes are used. However, much smaller droplets, if applied to the flame reaction zone, can give rise to substantially more efficient extinguishment. In recent years, and largely because of the demise of halon gaseous extinguishing agents on environmental grounds, the use of fine water sprays, now described as 'water mist' (with small droplet diameters of typically 10-500 microns) has attracted a great deal of interest. The systems result in control, suppression or extinguishment of a fire by removal of heat and displacement of oxygen from the flame reaction zone.

Water mist systems have now become an established alternative to gaseous systems in certain applications. As the water acts as a gas-phase extinguishant, these systems often use only a relatively small amount of water and have proved capable of extinguishing very large flammable liquid fires.

Early use of water mist suppression systems, and associated research and development, centred mainly around protection of machinery spaces on ships, where the systems were used as replacement for halon gaseous fire extinguishing systems. In this respect, their effectiveness in suppression of large, flaming, high-heat output fires appears to be well proven.

The expansion in the use of water mist systems for land-based applications also related, initially, to similar fire hazards, such as local-application systems for protection of gas turbines, etc. However, the use of water mist systems has also expanded into the use of 'total compartment' or 'volume protection' systems as halon replacements for protection of entire enclosures (both in land-based and marine applications), such as a specific room within a building or vessel (e.g. a computer or electronic equipment room in a building), in which the likelihood of a high-heat output, flaming fire is much less; a slowly developing or even smouldering fire is a more realistic scenario. The performance of water mist systems for control or suppression of such low-heat output fires is less well proven, and it is often suggested that the performance can be detrimentally affected by large compartment volume and shielding of a fire by obstacles within the enclosure.

A more recent innovation has been the use of water mist systems for domestic and residential applications, where the space, weight and possible absence of a connection to a water supply has proved attractive. The systems have sometimes been accepted by enforcing authorities as compensation for reduction in other fire protection measures, such as means of escape, or to provide enhanced protection for occupants at high risk from fire.

An independent guide on water mist systems for residential buildings, published by the Building Research Establishment in 2006[5] concluded that:

- Information about the overall effectiveness of these systems for residential life-safety applications is not well established.
- Water mist systems are an emerging technology for life-safety building applications on land, and have been successfully applied to protect assets (e.g. electronic equipment and machinery spaces).
- There are, currently, no British or European Standards for components or systems.
- Other standards for water mist systems are not directly applicable to UK building applications. Expert interpretation and further work is required. The sources of further information on which to base expert interpretation are limited.
- Issues relating to the equivalence of performance of water mist systems compared to other active and passive fire protection measures have not been investigated.
- Aspects such as reliability, real fires history and long-term maintenance are largely unknown or unproven.
- There is, however, anecdotal evidence of activation of water mist systems in residential premises, and the systems were reported to be effective; in some cases, the life of the occupant of the dwelling was probably saved by the system.

The BRE guide contains a checklist for enforcing authorities to assist them in coming to a judgement on the suitability of a water mist system for specific residential building applications. There is likely to be a growth in the use of these systems for domestic and residential applications over the next few years. In the meantime, until there are suitable standards and codes of practice for this application, the caveats in the BRE guide should be noted.

System design and technology varies considerably. Some water mist systems use a single fluid (the water, often at high pressure), whereas others of the dual fluid type use air or nitrogen to 'atomize' the water at the nozzle. Droplet size, velocity and distribution all vary between different manufacturers' systems, and specialist design and engineering of these systems is crucial to their performance. Systems can be supplied from cylinders, and a connection to a water main is not always necessary. For more prolonged duration, a format more akin to a sprinkler system, with tanks, pumps and connection to a water supply, can be adopted.

As yet, there are no full British Standards for water mist systems. It has, in the past, been necessary to rely on the manufacturers for the design of systems, or to rely on American standards, such as NFPA 750.[6] (For shipboard protection, International Maritime Organization (IMO) standards exist.) NFPA 750 does not specifically cover residential applications. European and International Standards are in the course of preparation at the time of writing, although these will not specifically address use of water mist systems for domestic or residential applications. Water mist standards have, however, now been developed within BSI as Drafts for Development; one of these (DD 8458) addresses domestic and residential applications, while another (DD 8489) addresses commercial and industrial water mist systems. Part 1 of each of these Drafts for Development deals with design and installation, while Part 2 sets out component requirements and test methods. Also, a code of practice for the interface between fire detection systems and water mist systems has been published as BS 7273-5[7] (see also Chapter 11).

Foam systems

Foam is created by the mixture of water, air and a suitable foaming agent. Low and medium expansion foam systems are used primarily for special risk areas where quantities of flammable liquids are used or stored. It is unusual to find foam systems in general commercial and industrial buildings except, perhaps, in an oil-fired boiler room.

High expansion foam systems are intended to fill the entire volume of a protected area with foam and can be used to protect class A risks, particularly if they are inaccessible for conventional fire-fighting. Such systems have, very occasionally, been used to protect the underfloor areas of computer suites, although the suitability of the medium for this application is open to debate. Most foam systems must be tailor-made for the risk. However, BS 5306-6[8] provides further information on their design.

Two particular forms of foam, aqueous filmforming foam (AFFF) and filmforming fluoroprotein foam (FFFP), can be discharged from a sprinkler installation in order to provide more effective protection in, for example, a warehouse in which there is a large inventory of relatively low flashpoint flammable liquids. The sprinkler system is designed largely as a conventional installation with facilities for inducing the AFFF or FFFP liquid into the water supply.

Gaseous systems

Applications for gaseous systems

Gaseous extinguishing systems are normally used for protection of specific areas of a building, in which other extinguishing media, such as water, would be less suitable. The majority of gaseous systems are used in computer suites, rooms containing electrical plant, such as transformers or switchgear, and rooms housing sensitive electronic equipment or archive storage.

Gaseous extinguishing systems offer a number of advantages:

a) the agents are clean and leave no residues, thereby minimizing the degree of interruption to business following discharge;
b) the agents are non-conducting, making them suitable for use on live electrical equipment;
c) the agents can penetrate relatively enclosed spaces within the protected volume;
d) if operated by a suitable automatic fire detection system, the response of the extinguishing system can be fast;
e) gaseous extinguishing systems are suitable for use on both class A and class B fires, although extinguishment of a deep-seated smouldering class A fire is difficult and may involve special system design considerations;
f) operation of the system can normally be controlled manually or automatically.

The need for gaseous systems

There is generally no legislation that requires gaseous extinguishing systems to be installed in a normal industrial or commercial building. However, if, for example, sprinklers are installed in a building due to the requirements of legislation, it is often accepted that sprinkler heads may be omitted from rooms that have electrical or electronic equipment if, instead, a gaseous extinguishing system is installed in such areas.

Fire insurers normally seek the installation of a fixed fire-fighting installation in areas in which the contents are of high value, or where a fire could result in serious financial losses. Examples are areas housing computer equipment and electronic process control equipment. Although sprinkler protection of computer rooms may be acceptable to many insurers, the use of a gaseous system provides better protection of the equipment and leads to less interruption in the event of fire. A formal scale of premium discounts does not, however, apply to gaseous systems.

Gaseous extinguishing agents

Until the early 1990s, the gases most commonly used in fixed extinguishing systems were:

a) carbon dioxide;
b) halon 1211 (also known as bromochlorodifluoromethane or BCF);
c) halon 1301 (also known as bromotrifluoromethane or BTM).

For many years, halon 1301 in particular predominated for total flooding applications, such as computer suites. This was largely because of the very low toxicity of the agent. Exposure to CO_2 in the concentrations used in fire extinguishing by automatic systems is lethal, and stringent safeguards are necessary to avoid exposure of occupants. This has tended to limit the use of CO_2 in total flooding systems to areas, such as transformer rooms, that are visited infrequently and, only then, by trained persons. Nevertheless, CO_2 was, and still is, the agent most frequently used for local application systems (i.e. those where the gas is discharged onto a localized risk, such as a machine, within a larger volume).

Unfortunately, halons, like CFCs, were found to contribute to the depletion of the Earth's ozone layer. As a consequence, environmental controls that have been introduced have now resulted in a move to more environmentally friendly gaseous agents. Under European legislation, it was required that all existing halon installations be decommissioned by 31 December 2003, other than in the case of certain defined 'critical uses', such as military and aerospace applications. The Channel Tunnel and associated installations and rolling stock are also a critical use for which the use of halon is permitted.

When halon was first phased out, the only readily available form of gaseous extinguishing system was a CO_2 system, which is just as suitable for extinguishment of fire. Nevertheless, the safety aspects of CO_2 systems cause great concern amongst potential users, many of whom are unprepared to use such systems, at least in the case of normally occupied areas. Even so, it should be stressed that the Health and Safety Executive are unlikely to oppose the installation of a CO_2 system that is installed in accordance with the appropriate safety features. If, however, a system is installed, great care must be taken to ensure that no hazards to personnel arise from the leakage of gas into other areas, or the collection of the gas in low areas, such as lift pits. Great caution must be exercised after any discharge of a CO_2 system to ensure that all areas of the building are free of CO_2 before reoccupation. This should include any areas, remote from the area of discharge, into which CO_2 might have leaked by HVAC systems, the dampers within which are unlikely to be gas tight.

Fortunately, numerous alternatives to halon 1301 for use in fixed extinguishing systems for total flooding applications have emerged in recent years. These are also clean, gaseous agents, but they do not have the same detrimental impact on the ozone layer. Two categories of these new agents have emerged:

1. halocarbons;
2. inert gases.

Halocarbon agents, although similar chemically to halon, rely more on cooling the flames than on interfering with the chemical process that takes place in the flames – the highly efficient mechanism that is characteristic of the way halon works and resulted in design concentrations as low as 5 per cent volume/volume. Accordingly, none of these agents is as efficient as halon 1301 in terms of extinguishing capability, and, as a result, more agent (and more storage containers) are usually required. The agents include hydrofluorocarbons, such as HFC 227ea (CF_3CHFCF_3, probably the most commonly used halocarbon), and a fluorinated ketone FK-5-1-12 ($CF_3CF_2C(O)CF(CF_3)_2$, known commercially as Novec 1230). A number of other halocarbons can be used, but their use in the UK is uncommon.

The inert gas agents extinguish flames entirely by physical means; put simply, they reduce the oxygen concentration to a point at which combustion cannot be sustained. As with CO_2, which is also an inert gas, this requires much higher concentrations than for halon 1301 or the halocarbon agents. However, the new inert gas agents are much safer than CO_2, and the depleted oxygen levels that result from their use still support life.

There are four inert gas agents in common use. These are designated IG-541 (a mixture of 52 per cent nitrogen, 40 per cent argon and 8 per cent CO_2), IG-55 (50 per cent argon and 50 per cent nitrogen), IG-01 (an agent comprising 100 per cent argon) and IG-100 (comprising 100 per cent nitrogen).

There are a number of differences between the inert gases and the halocarbons, which will influence the choice of agent. These include the following.

1. Unlike the halocarbons, the inert gas agents cannot be stored as liquefied gases; they must therefore be stored at high pressure (typically 200 bar and 300 bar) with the result that considerably more containers are usually required.
2. Although not ozone depleting, halocarbon agents often have long atmospheric lifetimes and can contribute to global warming; inert gas agents have naturally occurring constituents.
3. Significant overpressures are created when the relatively high concentrations of inert gases are discharged into rooms. This can often result in the need for special pressure relief vents to be installed, although this may also be necessary in the case of a well-sealed enclosure into which halocarbons are discharged.
4. Like halon 1301, halocarbon agents are broken down by flames and hot surfaces. The resultant decomposition products are acidic and can cause corrosion if not removed quickly. Under these circumstances, dedicated mechanical extraction systems are considered essential. Although inert gas agents do not produce acidic breakdown products, mechanical extract is still desirable in order to remove smoke and soot deposits distributed around the room by the force of the discharge.
5. To prevent reignition, the extinguishing gas must be held for a period of time after the discharge. Good sealing of the enclosure is usually necessary to prevent leakage of the extinguishing agent. However, with inert gas agents, the density of the gas/air mixture produced after a discharge is close to that of air. As a result, leakage is slower, and the extinguishing gas can usually be held for longer periods.

As stated earlier, exposure to CO_2 must be avoided, and stringent safety measures must be present. While exposure to other fire extinguishing gases should also be avoided, their low toxicity is such that systems can still be maintained in the automatic mode of operation while people are present in the protected room. Audible warning of an impending gas discharge must, however, be provided, and there must be a time delay before gas is released to allow people to escape first. Controls to allow occupants to delay manually the discharge while others make their escape are also desirable.

Design codes for gaseous systems

With the exception of CO_2 systems, for which the relevant design code is BS 5306-4,[9] a suite of design codes for both halocarbons and inert gases is published as 15 parts of BS ISO 14520,[10] each part (other than Part 1, which gives general requirements) dealing with a different gas.

Components of an installation

A typical gaseous extinguishing system comprises:

- an agent storage facility;
- means of automatic fire detection (associated with a means for initiating gas discharge);
- manual release controls;
- a network of pipes and discharge nozzles (see Figure 14.2);
- means for switching the installation from the automatic/manual mode of operation to the manual-only mode;
- means for total isolation of the system.

The gas storage facility usually comprises a central bank of storage cylinders, normally sited outside the protected area (although, largely for engineering considerations, containers are sometimes distributed throughout the protected area). In very large CO_2 installations, the gas may instead be stored at lower pressure in a refrigerated tank.

The automatic fire detection arrangement may comprise a separate self-contained automatic fire detection system (see Chapter 11); BS 7273-1[11] gives advice on the interface between the fire detection and gaseous fire extinguishing systems.

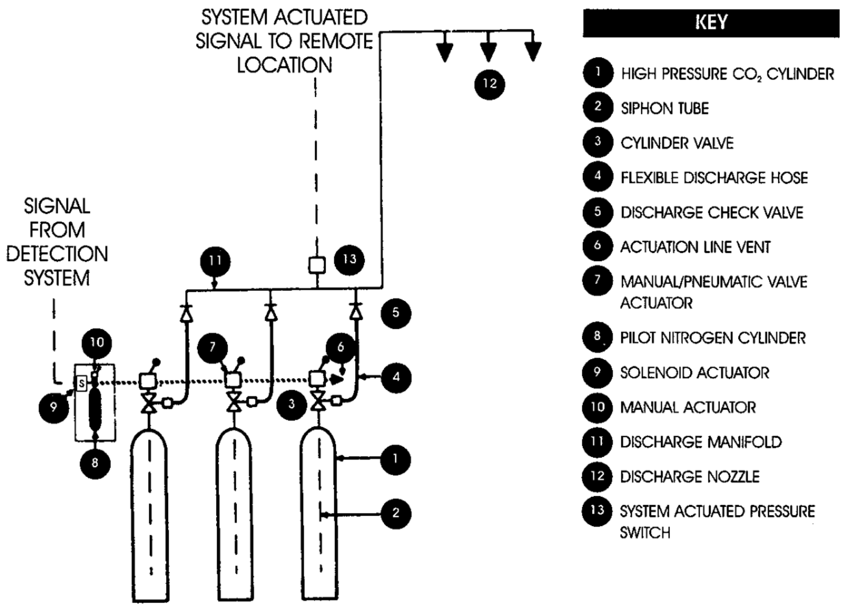

Figure 14.2 Automatic carbon dioxide system

Simple mechanical means of detection and automatic release of gas are also possible, and are sometimes used in small CO_2 installations. In this case, the method of detection usually comprises, for example, one or more fusible links located in the protected area. These links are attached to a wire under tension. When a fusible link melts in a fire, the tension on the wire is released, and this permits a weight to fall, actuating the mechanical discharge release control as it does so. BS 7273-2[12] deals specifically with such mechanically actuated gaseous extinguishing installations.

In electrically actuated systems, the manual discharge control normally comprises a 'two action' device (e.g. lift flap/break glass) that opens or closes an electrical circuit. In mechanically actuated systems, a mechanical pull handle is normally provided. In either case, these devices are normally situated outside the exits from the protected area. In the case of an electrically operated system, a three-way illuminated status display unit, indicating whether the system is in the automatic/manual mode or manual-only mode of operation, and providing a warning if gas has been discharged, should also be located at each entrance to the protected area.

Wet chemical systems

Wet chemical systems are commonly used for protection of deep fat fryers, both relatively small scale (e.g. in hotel kitchens) and large scale (e.g. industrial applications for food production). They use similar saponification agents to those used in class F fire extinguishers (see Chapter 13). There are two recognized standards for these systems, namely the American standard, UL 300[13] and the Loss Prevention Certification Board standard, LPS 1223.[14] Insurers now often require such systems in certain premises as a condition of insurance.

Powder systems

In principle, powder systems are suitable for total flooding or local application in areas that contain either class A or class B risks. In practice, powder systems are rare, and their use is mainly in local application for class B risks. However, special localized class A risks, such as textile machines, have been successfully protected by powder systems for many years. Also, powder systems have been used for other class B risks, including road tanker filling bays. Guidance on the design of powder systems is contained in BS 5306-7.[15]

Aerosol systems

These systems discharge micron-sized particles, together with gases and water vapour to form an aerosol, all of which are generated by electrical ignition of a solid within the system container. The aerosol acts as an extinguishing agent by a combination of physical and chemical effects, emanating from the nature of the particulate matter, which comprises, for example, potassium carbonate, which is one chemical used in powder fire extinguishers (see Chapter 13) and extinguishing systems. Their use is not common, but they could, in principle, be used for local application of plant or machinery, or for total compartment protection of small rooms. European Standards for system components and installation design are in preparation at the time of writing.

Oxygen reduction systems

These systems are not actually fire suppression systems. They reduce the likelihood of ignition and development of fire. The oxygen concentration in the protected space is reduced by a continuous supply of nitrogen into the space. It is claimed by suppliers that the space can still be occupied by people, the oxygen concentration being somewhat similar to that at high altitude, provided they have no medical condition that would preclude this. Since the oxygen concentration is permanently reduced, it would not be appropriate for people to work continuously for long periods in the protected space. Procedures, similar to those used for monitoring of people working in confined spaces, are appropriate. These systems are rare, and there are no standards for them at the present time. However, they may have certain potential applications for protection of, for example, unmanned storage vaults.

Further reading

BS 5306-0, *Fire extinguishing installations and equipment on premises — Part 0: Guide for the selection of installed systems and other fire equipment*
BS 5306-2, *Fire extinguishing installations and equipment on premises — Part 2: Specification for sprinkler systems*
BS 5306-4, *Fire extinguishing installations and equipment on premises — Specification for carbon dioxide systems*
BS 5306-6, *Fire extinguishing installations and equipment on premises — Foam systems — Section 6.1 Specification for low expansion foam systems*
BS 5306-6, *Fire extinguishing installations and equipment on premises — Foam systems — Section 6.2 Specification for medium and high expansion foam systems*
LPC Rules for automatic sprinkler installations. Fire Protection Association.
BS EN 12845, *Fixed firefighting systems — Automatic sprinkler systems — Design, installation and maintenance*
Fire suppression in buildings using water mist, fog or similar systems. Building Research Establishment.
Williams Dr C and Jackman Dr L. *An independent guide on water mist systems for residential buildings*. Building Research Establishment.
BS ISO 14520 (all parts), *Gaseous fire-extinguishing systems — Physical properties and system design*
DD 8458, *Water mist fire suppression systems for residential and domestic occupancies*
DD 8489, *Fixed fire protection systems — Commercial and industrial watermist systems*

References

1. BS 5306-2, *Fire extinguishing installations and equipment on premises — Part 2: Specification for sprinkler systems*
2. BS EN 12845, *Fixed firefighting systems — Automatic sprinkler systems — Design, installation and maintenance*
3. BS 9251, *Sprinkler systems for residential and domestic occupancies — Code of practice*

4. BS 7273-3, *Code of practice for the operation of fire protection measures — Electrical actuation of pre-action sprinkler systems*
5. Williams Dr C and Jackman Dr L. *An independent guide on water mist systems for residential buildings*. Building Research Establishment.
6. NFPA 750, *Standard on Water Mist Fire Protection Systems*. National Fire Protection Association
7. BS 7273-5, *Code of practice for the operation of fire protection measures — Electrical actuation of water mist systems*
8. BS 5306-6, *Fire extinguishing installations and equipment on premises — Foam systems — Section 6.1 Specification for low expansion foam systems*
   BS 5306-6, *Fire extinguishing installations and equipment on premises — Foam systems — Section 6.2 Specification for medium and high expansion foam systems*
9. BS 5306-4, *Fire extinguishing installations and equipment on premises — Specification for carbon dioxide systems*
10. BS ISO 14520 (all parts), *Gaseous fire-extinguishing systems — Physical properties and system design*
11. BS 7273-1, *Code of practice for the operation of fire protection measures — Electrical actuation of gaseous total flooding extinguishing systems*
12. BS 7273-2, *Code of practice for the operation of fire protection measures — Mechanical actuation of gaseous total flooding and local application extinguishing systems*
13. UL 300, *Fire Extinguishing Systems for Protection of Restaurant Cooking Areas*
14. LPS 1223, *Requirements and testing procedures for the LPCB certification and listing of fixed fire extinguishing installations for catering equipment*
15. BS 5306-7, *Fire extinguishing installations and equipment on premises — Specification for powder systems*

15

Smoke control

The threat from smoke

The need for measures to control smoke generated by a fire arises from the serious threat that smoke alone can create to people, property and the operation of many businesses. More people die from the inhalation of smoke and toxic gases than from direct burns. The toxic gases produced by most fires include carbon monoxide, the inhalation of which is a common cause of deaths in fires. Indeed, even when other toxic gases are present, such as hydrogen cyanide, the presence of carbon monoxide is likely to remain the main cause of death, although there can be synergistic effects in the combination of multiple toxic gases and elevated temperature.

Before the inhalation of smoke becomes lethal, it can create severe irritation to the respiratory system. In non-lethal concentrations, carbon monoxide will affect a person's ability to concentrate properly. One of the earliest dangers that smoke creates, however, is loss of visibility. It has been shown that people are unwilling to attempt to move through smoke which may be present in a corridor, unless the visibility is adequate, even though passage through the smoke may be possible without serious injury. Loss of visibility may, therefore, cause people to be trapped by fire and, as a result, suffer injury or death at a later stage. Visibility in smoke is also affected by the physiological response of the eye to the gaseous products of combustion, which result in the production of tears in sufficient amounts to cause blurring of vision.

Smoke also creates great difficulties for fire-fighters. Although the use of breathing apparatus can make entry into a smoke-filled building possible, poor visibility can lead to injury to fire-fighters, who are unable to see hazards within the smoke-filled area. Locating the seat of the fire is also difficult in smoke-filled conditions, and thus smoke constitutes an obstacle to the fire and rescue service in limiting the extent of fire and water damage, and in effecting search and rescue.

Smoke and acidic combustion products can result in damage to the building surfaces. These need to be cleaned very quickly after the fire is controlled in order to avoid deleterious effects on the surfaces of a building; this can be particularly important in the case of buildings of architectural and heritage significance. Smoke damage (as opposed to direct fire damage) may also contribute a very significant proportion of the damage to the contents of a building, particularly in, for example, a food warehouse, or if the contents of a building include sensitive electronic equipment. In any building, however, smoke from a fire is likely to require, at the very least, cleaning of surfaces and contents, and may ultimately lead to the onset of long-term corrosion of metalwork. In the case of smoke damage to a critical facility, such as a computer suite, the effects of smoke can lead to substantial business interruption while the affected equipment is either cleaned or replaced.

The spread of smoke

In the very early stages of a fire, substantial spread of smoke beyond the room of origin may occur simply due to an open door. As the fire develops and pressures are created by the expanding gases, the fit of any closed doors in their frames becomes important – smoke will tend to flow through any gaps owing to the pressure differential that is created across the door. Unstopped service penetrations in the barriers that enclose the room are also an important route for smoke spread. Once smoke spreads beyond the room of origin, it will flow unimpeded along corridors, up staircases and service ducts or shafts until, ultimately, a large part of the building may become smoke logged, unless checked by suitable construction or smoke management systems.

The spread of smoke from a fire can be controlled to a lesser or greater extent by various measures. Some measures are simple, straightforward and incorporated in most buildings as a basic design feature, while others are more sophisticated. Whatever the measures provided, their purpose and mode of operation must be understood by the person who is responsible for the building, and it must be ensured that maintenance of the facilities is adequate.

The nature of smoke control measures

The choice of smoke control measures may depend on their objectives, for example:

a) protecting the means of escape;
b) assisting the fire and rescue service;
c) limiting damage to the building and its contents.

Smoke control can be achieved by one of two methods. Either the smoke produced by a fire can be contained within the area of fire origin, or the smoke can be ventilated. Smoke control measures of both types may be regarded as either fundamental (i.e. incorporated into most building designs) or special (i.e. more sophisticated, and necessary only in certain applications). Although the subdivision of measures in this way is somewhat arbitrary, examples of fundamental and special means of providing smoke containment or smoke ventilation are shown in Table 15.1.

Smoke containment by physical barriers

Physical barriers, such as walls and partitions, are the simplest means of containing smoke. If all partitions that enclose a corridor extend to at least the level of any false ceiling, smoke movement can be prevented in the early stages of a fire. As the fire progresses, there is a need for the barriers to be fire resisting, in order to continue their smoke-control function. There is also a need for penetrations in barriers (e.g. for the passage of services) to be fire stopped to prevent leakage of smoke through the gaps around the services. In addition, the fire-resisting walls need to make contact with the underside of the structure above any suspended ceiling.

A tightly fitting door will assist in the limitation of smoke spread in the very early stages of a fire. As the fire develops, the pressure difference across the door may result in smoke passing through gaps around the door; such gaps should be minimized. Typically, gaps should be no more than 3 mm–4 mm. All doors that are specifically intended to resist the passage of smoke should be fitted with smoke seals (see Chapter 8). If the door's smoke-control function is to continue for any significant length of time, the door and seal must be fire resisting (i.e. combined intumescent seals and smoke seals are necessary).

Table 15.1 Examples of smoke-control measures

	Examples of smoke containment measures		*Examples of smoke ventilation measures*	
Objective	*Fundamental*	*Special*	*Fundamental*	*Special*
Protection of means of escape	Well-fitting solid doors with smoke seals and a reasonable degree of fire resistance Fire-resisting enclosures for 'protected' routes Fire stopping of penetrations in barriers that enclose escape routes Lobbies in certain circumstances	Pressurization of escape routes		Natural ventilation or mechanical smoke extraction facilities
Assistance for the fire and rescue service	Lobbies for fire-fighting staircases	Pressurization of fire-fighting staircases	Openable vents	Natural ventilation or mechanical smoke extraction
Damage limitation	Fire-resisting barriers and fire-resisting doors with smoke seals Lobbies in certain circumstances Fire stopping of fire-resisting barriers			Natural ventilation or mechanical smoke extraction facilities

As some smoke will inevitably leak around a door, two doors between the fire and the area that is to be protected will enhance the level of protection. This is sometimes known as the principle of 'two-door separation', but is often referred to as 'lobbying', as the two doors usually form a lobby between accommodation and an escape or fire-fighting staircase (see Chapter 16). Two-door separation can be achieved, however, by enclosing a corridor that approaches the staircase in fire-resisting construction. In some cases, ventilation of the lobby is necessary to afford additional, effective protection.

Smoke containment by pressurization

The presence of physical barriers may not offer a sufficiently high degree of protection. Examples are buildings in which the number of staircases is insufficient, or buildings where the fire-fighting staircase cannot be naturally ventilated or extends deep below ground level. In these cases, pressurization may be a suitable measure.

Pressurization involves the injection of air into escape routes (staircases or corridors) in order to increase the pressure in the escape routes, compared with that in the adjacent accommodation. The result is that this excess pressure opposes and overcomes that created by the fire, permitting a constant flow of air from the escape route into the accommodation, instead of a flow of smoke from the accommodation into the escape route. Doors through which the air is to flow should not be fitted with smoke seals, and the protected room should have an air relief vent(s), so that the pressurizing air is allowed to escape easily. This technique is now well recognized and has been found to operate successfully both in tests and in actual fires. Guidance on the design of pressurization systems is contained in BS 5588-4.[1]

Smoke ventilation

It is normal practice to provide smoke-ventilation facilities within the accommodation and staircases in a building, by means of openable windows. For most staircases, a suitably sized vent at the top of the staircase is accepted as an alternative. In fire-fighting staircases, ventilation at the top, and either means for providing ventilation at each storey (by openable windows), or at a final exit to open air (by means of the door(s)), are normally required unless the staircase is pressurized. The ventilation is controlled by fire-fighters. The lobbies to these staircases should also be provided with ventilation facilities. Where ventilation of staircases or lobbies cannot be provided direct to open air, ventilation may, instead, be via smoke shafts.

It should be stressed that the ventilation described in these cases is not to aid means of escape, but is intended to be of assistance to the fire and rescue service at a stage following evacuation. The objective of the ventilation is either to maintain a smoke-free access route for the fire and rescue service, or to purge the building of smoke after the fire has been extinguished.

In large volume, single-storey warehouse buildings and similar premises, the provision of smoke ventilation may be useful as an aid to the fire and rescue service, by keeping the base of the smoke layer at a sufficient height, so maintaining a reasonable degree of visibility at head height and below. In England and Wales, such facilities may be required under certain local acts (see Chapter 1). Ventilation facilities normally comprise vents that open automatically when a fusible link melts. However, the smoke vents can be of a type that operates either by a smoke detection system or by manual controls. Powered smoke extraction fans may be provided as an alternative, but require reliable power supplies, fireprotected wiring, and fans that can withstand high temperatures. However, powered extraction is much less susceptible than natural ventilation to external wind pressures.

Natural ventilation or powered extraction of smoke may be found in other applications. Perhaps the most important of these is the case of covered shopping centres, in which a form of smoke ventilation, often involving powered extraction, is invariably required to maintain a smoke free area at head height and below in the mall during the evacuation of the centre. Similar principles can be applied to large, single-storey retail 'superstores', in which the footprint of the building is so large that normal travel distances (see Chapter 7) cannot be achieved.

Atrium buildings are another example in which natural ventilation or powered extraction may be required. Alternatively, pressurization or depressurization of the atrium space may be used in some circumstances. In this case, however, the atrium space itself will not necessarily form part of the means of escape, and the facilities may be provided primarily for smoke removal from the atrium as a means of assistance to the fire and rescue service and to prevent undue alarm on the part of occupants. Guidance on smoke control (and other fire protection measures) in atrium buildings is given in BS 5588-7.[2]

In many applications that involve smoke ventilation, the objectives of the smoke-control system (such as maintaining clear escape routes) may not be satisfied unless the fire size is reliably controlled. This is normally achieved by the provision of sprinkler protection, which has a very high proven reliability in control of fire. This permits a maximum foreseeable fire size to be defined, enabling the required rate of smoke extraction to be calculated. The size of fire used in calculations is sometimes reduced if fast response sprinklers are used (see Chapter 14), although this relaxation is not necessarily universally accepted.

The combination of smoke control and sprinkler protection to satisfy a fire safety objective is a classic form of 'fire engineering' solution (see Chapter 22).

Further reading

Building Research Establishment. BRE Digest 260. *Smoke control in buildings: design principles*.

References

1. BS 5588-4, *Fire precautions in the design, construction and use of buildings — Code of practice for smoke control using pressure differential*
2. BS 5588-7, *Fire precautions in the design, construction and use of buildings — Part 7: Code of practice for the incorporation of atria in buildings*

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Fire and rescue service facilities

Fire and rescue service facilities may be provided to assist fire-fighters in tackling a fire and, if necessary, effecting rescues. In some cases, the facilities in question are required by legislation, such as building regulations or local acts (see Chapter 1). Liaison with the fire and rescue service concerning any facilities provided for their benefit is clearly wise, and, in England and Wales, the Fire and Rescue Services Act 2004* requires fire authorities to give advice on such matters on request.

It is also important to make local fire and rescue service crews familiar with the building and any special facilities, so that the fire and rescue service can perform as efficiently as possible in the event that they are summoned to a fire in the premises. Again, fire and rescue services are required by the Fire and Rescue Services Act 2004* to make themselves aware of information concerning property in their area, the available water supplies, the means of access, etc. Normally, fire and rescue services do this by means of 'familiarization' visits to the premises (often known in England and Wales as 7(2)(d) visits, after the clause of the Fire and Rescue Services Act that makes them necessary).

Facilities that may be provided to assist the fire and rescue service include:

a) access arrangements, including fire-fighting staircases and lifts;
b) dry or wet rising mains and foam inlets;
c) private water supplies;
d) smoke ventilation and plant shutdown facilities;
e) relevant information for use at the time of a fire, including floor layout plans, services controls, etc.;
f) special communications facilities;

* and equivalent legislation in Scotland and Northern Ireland.

g) fire-fighters' emergency switches in circuits supplying exterior electrical installations, or interior discharge lighting installations, if, in either case, the installations operate at a voltage exceeding low voltage.

Access for fire appliances

At the design stage of a new building, it is important to ensure that there will be adequate access arrangements to enable fire appliances to approach the building. Access requirements are imposed under building regulations.

Conditions imposed for access by the fire and rescue service are concerned with the practicalities of fire-fighting. Different requirements apply according to whether or not the building is fitted with rising mains. Private roadways and access gates to sites should be designed to take into account the need for access by fire appliances. Guidance on detailed requirements for access can be found in the guidance documents that support building regulations (e.g. in England and Wales, Approved Document B[1]).

Access for fire-fighters

The most important design requirement regarding access for fire-fighters is that relating to staircases and lifts. It is generally accepted that, for efficient fire-fighting in a high building or a building with deep basements, there must be a number of smoke-free staircases, known as fire-fighting staircases. Between each landing of a fire-fighting staircase and the accommodation, a fire-fighting lobby must be provided, which forms a 'forward command' for fire-fighting actions by the fire and rescue service. In order to enable fire-fighters to transport hose and equipment to the higher floors of the building, there should also be one or more fire-fighting lifts, which will continue to operate reliably during the course of the fire.

The staircase, lobby and lift are enclosed within a fire-resisting envelope, normally described as a fire-fighting shaft. The fire-fighting shaft also contains dry or wet rising mains. A fire-fighting shaft, without a lift or rising main, may also be of assistance to the fire and rescue service in a building that is not particularly high but is large in area, thereby making fire-fighting from outside the building more difficult.

A fire-fighting staircase is normally a staircase that is in everyday use by occupants of the building, and forms part of the means of escape. It is, however, afforded special protection to ensure that it remains smoke free during a fire. Not every protected staircase in a building need necessarily form a fire-fighting staircase.

A fire-fighting lift will normally be a conventional passenger lift (but not a goods lift) that is of sufficient size to carry fire and rescue service equipment, that can be grounded quickly in the event of fire and brought under the control of the operator in the lift, and that has power supplies that can maintain the operation of the lift during the fire.

Recommendations for fire-fighting shafts are contained in BS 5588-5.[2] (Slightly different guidance is given in the official guidance documents that support building regulations.) The code recommends that:

1. Fire-fighting shafts, each incorporating a fire-fighting staircase, a fire-fighting lift and a fire-fighting lobby with a rising (or falling) main should be provided in all buildings, or parts of buildings, exceeding 18 m in height or 10 m depth below ground.
2. If a shop, factory or storage building exceeds 7.5 m in height, with a floor area of any above ground storey exceeding 900 m², a fire-fighting shaft should be provided. In this case, however, the shaft need only contain a fire-fighting stairway, fire-fighting lobby and rising main, but not a fire-fighting lift; the same recommendation applies to all buildings if there are two or more basement levels, each with a floor area exceeding 900 m².
3. In buildings with a height of 11 m or more (in which, therefore, there will be one or more storeys above the height of ladders carried on most modern fire appliances), there should be an escape stair with an (unventilated) lobby and a fire main to assist the fire and rescue service with fire-fighting operations.

Where fire-fighting shafts are provided, there should be one fire-fighting shaft for every 900 m². The distance from the furthest point in a storey to the door of the nearest fire-fighting shaft, measured along the route that hose would follow, should not exceed 60 m; where a fire-fighting shaft is required in a tall building (or for deep basements), all upper floors (or basement floors in the case of deep basements) should be served. However, if the building is sprinklered, the number of fire-fighting shafts may be limited to two, provided the relevant hose distances are satisfied.

The importance of ensuring the integrity of the power supplies to a fire-fighting lift cannot be overemphasized. BS 5588-5 contains recommendations on operation of the lift-control system, but refers to BS EN 81-72[3] for guidance on engineering of the lift installation. An important aspect of design is security of the power supplies. There should be:

a) an alternative power supply to cater for failure of the normal supply;
b) protection against fire for cables providing power to the lift;
c) means for ensuring that the cables of the primary supply and the alternative supply cannot both be affected by a single fire.

The lift installation must have a switch at the fire and rescue service access level (to cause the lift to be returned to the fire and rescue service access level, after which it can only be controlled from within the lift car). There must also be a means of communication between the lift car, the fire and rescue service access level and the lift machine room.

Arrangements for access to any large building or site should be discussed with the enforcing authority so that access can be suitably pre-planned. Such liaison also ensures that any potential conflicts between security and the need for access by the fire and rescue service in the event of fire can be overcome. In a large building, there may be many more fire exits than normal access doors. For security reasons, many of the fire exits may be openable only from the inside. In the event of a need for access via such doors (for example, to provide an additional approach by which the fire may be attacked) they can often be forced open by the fire and rescue service. However, valuable time can be saved if the doors are fitted with locks that are readily opened from the outside by means of keys held on the premises.

Rising and falling mains

In high buildings, it would be time consuming and difficult to run a hose from a hydrant in the street to the higher floors of the building. The same difficulty applies in the case of very deep basements and buildings to which access by a fire appliance is not possible. In these circumstances, fire mains are provided. A dry fire main comprises an inlet, located externally, to which the fire and rescue service connects a line of hose from the nearest hydrant, and outlets, known as landing valves, on each floor of the building. The fire and rescue service takes lengths of hose into the building, and connects them to the landing valves, thereby obtaining a source of water for fire-fighting without the need to run hose from the street to the seat of the fire.

Dry fire mains that serve the upper floors of buildings are known as dry rising mains, while those serving the lower floors of a building with deep basements are known as dry falling mains. In very high buildings, the rising mains are permanently charged with water, supplied by pumps in the building. These mains are known as wet rising mains.

The landing valves of the fire mains are located in the fire-fighting lobbies. However, in residential accommodation, it is acceptable to regard the protected corridors as fire-fighting lobbies.

Detailed guidance on the design of dry and wet fire mains is contained in BS 9990.[4] Where mains are required, dry rising mains are recommended by the code, except in the case of buildings where there are floors exceeding 50 m above fire-fighting access level, for which wet rising mains are recommended. A dry rising main is normally 100 mm in diameter. Wet rising mains should be capable of supplying two fire-fighting jets for a period of at least 45 minutes when the total water demand is 1,500 litres/minute. A town main will not normally be adequate to satisfy this criterion, and the water supply normally comprises duplicate pumps drawing from a tank of at least 45,000 litres capacity, which is filled from a town main. Domestic water tanks are not suitable for this purpose, unless it can be ensured that the above quantity will always remain and cannot be used to meet the needs of the domestic supply.

Rising mains should be inspected by competent persons every six months. Every year, dry rising mains should be charged with water to check for leaks.

Foam inlets

Foam inlets enable the fire and rescue service to inject foam into areas at or below ground level in which there is a risk of an oil fire. Examples are oil-fired boiler rooms, oil storage tank rooms and transformer chambers. A system of fixed piping is installed, with outlets in the risk area, and an inlet(s), for use by the fire and rescue service, externally on a wall of the building. Guidance on foam inlets is contained in BS 5306-1.[5]

Private water supplies

If the hose reels on pumping appliances (supplied from water tanks carried on the appliances) are not sufficient to control a fire, lines of hose are usually set into public fire hydrants on water authority mains. These are capable of supplying water at a much higher rate than the hose reels. On a large private site, such as a major factory or a country mansion, however, the nearest public hydrant may be some distance away. In this case, there may be a need for the occupier of the site to provide private water supplies for use by the fire and rescue service.

Private water supplies normally comprise hydrants on the site's private underground water mains. The hydrants are normally sited adjacent to roadways, and should preferably be fed from a ring main, enabling the hydrant to be fed in two directions. Guidance on private fire hydrants is contained in BS 9990, which recommends that such hydrants should not be sited further than 90 m from an entry to a building served, nor should they be closer than 6 m from the building. The maximum distance between hydrants should not be greater than 90 m, and the water supply should, ideally, be capable of supplying 1,500 litres/minute. The locations of private hydrants should be marked by suitable signs, and should be inspected and tested every year to ensure that they remain adequate for use by the fire and rescue service.

Where suitable water mains are not available, static and natural sources of water supply may be considered. In practice, the fire and rescue service may have pre-planned the use of sources such as a river, canal, lake, etc., but liaison with the fire and rescue service may lead to measures, such as sumps and hard standing for portable pumps, which may assist the fire and rescue service's operational use of these supplies. If on consultation with the fire and rescue service it is revealed that a shortfall of water may nevertheless exist, consideration may be given to the provision of a dedicated emergency water supply, such as a strategically sited water tank of suitable capacity.

Smoke control facilities

In order to remove smoke, the fire and rescue service may need to open windows in the building. Any windows or vents that the fire and rescue service may require to open should be fitted with simple lever handles. A proportion of windows in sealed, air conditioned buildings should be fitted with locks that can be opened with a square-ended key. If the windows or vents are not accessible, they should be provided with a remote-control facility that is suitably marked and located at a position agreed with the fire and rescue service. Further information on smoke control facilities is given in Chapter 15.

In modern buildings with complex air conditioning systems, there should be facilities that enable the fire and rescue service to shut down or modify the air flows. Any such facilities, and any special facilities for smoke ventilation or extraction, should be discussed with the fire and rescue service at the design stage. In addition, local fire crews should be made familiar with the location and operation of the facilities.

Information for the fire and rescue service

In the case of a large building or site, it may be of great assistance to the fire and rescue service if they are provided with information on the building, its layout, any hazardous storage, and the locations of service controls, sprinkler stop valves, etc. Much of this information can be provided in the form of plans drawn up in consultation with the fire and rescue service, to be used at the time of a fire. The plans may then be kept in a suitably labelled container within, for example, the entrance hallway of a building or at a reception desk. This does not, however, obviate the need for a responsible person to meet and assist the fire and rescue service on their arrival (see Chapter 20). Where there are complex basement areas, it can be of assistance to the fire and rescue service for basement plans to be displayed in the building. The provision of signs to indicate the presence of potentially hazardous materials is also advisable, and may be required under legislation.

Communications facilities

Although the fire and rescue service has portable radios available for use in buildings, in large, complex buildings and in areas in which radio transmission could prove difficult, a dedicated communications system can be of benefit. Consideration should, therefore, be given in these cases, to the provision of facilities, such as dedicated telephones, between fire-fighting lobbies, and a suitable control point at the fire and rescue service access level. Two-way speech communications installed for use by fire and rescue service should comply with the recommendations of BS 5839-9.[6] Since these facilities are required to operate during a fire, the cable used should be such as to ensure that failure during the course of a fire is unlikely. This necessitates the use of cables of so-called ‘enhanced fire resistance’, conforming to the requirements of BS 8434-2,[7] as opposed to many of the much more common proprietary fire-resisting cables of ‘standard’ fire resistance.

Fire-fighters' emergency switches

The IEE Wiring Regulations (BS 7671)[8] require that a 'fireman's switch' be provided in the low-voltage circuit supplying:

a) exterior electrical installations operating at a voltage exceeding low voltage;
b) interior discharge lighting installations operating at a voltage exceeding low voltage.

In England and Wales, the provision of these 'fire-fighters' switches' (as they are now called) is required by the Regulatory Reform (Fire Safety) Order (see Chapter 1). In Scotland, the switches are required under the powers of the Building (Scotland) Regulations.

References

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2. BS 5588-5, *Fire precautions in the design, construction and use of buildings — Part 5: Access and facilities for firefighting*
3. BS EN 81-72, *Safety rules for the construction and installation of lifts — Particular applications for passenger and goods passenger lifts — Part 72: Firefighters lifts*
4. BS 9990, *Code of practice for non-automatic firefighting systems in buildings*
5. BS 5306-1, *Code of practice for fire extinguishing installations and equipment on premises — Part 1: Hose reels and foam inlets*
6. BS 5839-9, *Fire detection and alarm systems for buildings — Part 9: Code of practice for the design, installation, commissioning and maintenance of emergency voice communication systems*
7. BS 8434-2, *Methods of test for assessment of the fire integrity of electric cables – Test for unprotected small cables for use in emergency circuits — BS EN 50200 with a 930°C flame and with water spray*
8. BS 7671, *Requirements for electrical installations — IEE Wiring Regulations — Sixteenth edition*

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Human behaviour in fire

The previous chapters of this book have been concerned with the physical fire precautions in buildings. They have largely, certainly in the case of chapters dealing with fire protection measures, involved matters associated with the behaviour of fire in buildings, and with the reaction of buildings and fire protection equipment to fire.

There is now a discontinuity, in that the following chapters are concerned with 'soft' fire precautions in the form of management issues and matters associated with the behaviour of people in fire. It is, therefore, at this stage, appropriate to consider the very important issue of human behaviour in fire.

Physical fire precautions are, of course, very important. Indeed, to many people, fire safety is synonymous with measures such as fire exits, fire alarm systems, etc. Yet, very often, when fire occurs, unless there is one, or possibly several, significant defects in the most fundamental physical fire precautions, the outcome, at least in terms of the evacuation of occupants and the harm that they suffer, may be determined to a large extent by the manner in which people respond to the emergency.

Physical fire precautions have constantly evolved and improved over many years, in response to lessons learned from past fires and as a result of advances in technology. Thus, serious, multiple fatality fires are probably less likely in current times than, perhaps, at any time since the industrial revolution and the new fire risks that it brought.

Lessons about the way people behave in fire have taken longer to learn. Thus, when the now relatively rare serious, multiple fatality fire does occur in a non-domestic occupancy, it is almost certain that (other than in the case of, for example, an explosion) the behaviour of occupants will have had, at least, a bearing on the outcome and, in some cases, may have actually led to the outcome. Yet, even today, the organization that may find no difficulty in accepting that a five or six figure sum may need to be spent on a new escape-lighting installation will often be reluctant to spend a three of four figure sum on quite simple staff training that would ensure that, when fire occurs, efficient evacuation takes place before there is any real likelihood of widespread failure of lighting circuits.

It should, of course, be recognized that the design of some fire precautions has been developed to take account of the uncertainty and basic lack of confidence that exists regarding appropriate response by occupants. Sometimes, very specific lessons have led to fire precautions that are more 'forgiving' of human error or omission.

For example, BS 5839-1[1] recommends that all fire alarm control panels are provided with a 'clearly labelled facility for starting the fire alarm sounders'. This recommendation emanated from a fatal hotel fire, in the course of which a member of staff silenced the fire alarm sounders before appreciating that there was indeed a serious fire; thereafter, the alarms were not restarted because there was no obvious way of doing so, even though all that was required was to operate the 'reset' switch on the control panel.

Similarly, when the disastrous fire occurred at King's Cross Underground Station, the manual sprinkler system under the escalator, below which the fire started, was not operated. Subsequently, the Fire Precautions (Sub-surface Railway Stations) Regulations 1989 required that escalators in underground stations be protected by an *automatic* fire extinguishing system.

Other lessons about human behaviour have taken much longer to learn, perhaps because they were regarded as somewhat more esoteric than the more tangible lessons about engineering design. The Summerland fire on the Isle of Man in 1973, in which 50 people died, led to an acknowledgement of the additional dimension introduced when members of family groups are separated to pursue different activities within the same building.

The natural reaction of parents, when fire occurs in such a building, is to find their children, rather than escape. Yet it was 1990 (after another serious fire in a place of entertainment, albeit involving other factors) before the implications of this problem were translated into positive, practical guidance on measures that should be incorporated in places of entertainment that contain separate accommodation for children.

Much of the early thinking on human behaviour in fires resulted from research in this now well recognized, specialist aspect of fire safety, commissioned by the Building Research Establishment (BRE) on behalf of the then Department of Environment during the 1980s. Perhaps the most major departure from previous conventional wisdom arose from a model of human behaviour developed by the Fire Research Unit at the University of Surrey during the early 1980s.

Prior to this work, perceived wisdom was that, when people are involved in a fire, they generally 'panic', in the sense of acting irrationally and adopting procedures that, at least with the benefit of hindsight, were totally inappropriate.

Such was the strength of this apparently fundamental tenet that it formed the foundation of many fire procedures and evacuation strategies, and to some extent it continues to do so in some occupancies today. Thus, for example, in some premises to which the public resort, there remains a reluctance to provide a general widespread warning to people that there is a fire, or at least to use the word 'fire' in evacuation messages.

Research in the United Kingdom, supported by the findings of research in North America, led to an entirely different model, which is so fundamental that it has major practical implications for:

- education and training;
- fire evacuation strategies;
- organizational emergency structures;
- the nature of fire warning systems;
- the design of means of escape.

This model characterizes early behaviour of people in fires as frequently reasonable and sensible, given the ambiguity of the circumstances in the minds of the occupants, while truly irrational behaviour is rarely found to occur. The tendency is for people to have insufficient information during the early, critical stages of the fire to understand exactly what is occurring, or what is likely to occur in the immediate future, thus precluding adequate decision making.

This is summarized well in a description of human actions in serious fires, which was based on early psychological research on this fascinating area of fire safety and is reproduced in a well respected standard text on human behaviour in fires:[2]

> *The confusions and ambiguities of the early stages are apparent, with the subsequent search for further information. This is followed by fire-fighting or flight, depending on the particular circumstances. The part played by the existing communication pattern within the organization in either helping or hindering coping with the fire is also clear in all incidents. Escape then appears to take place directly in relation to*

normal modes of entry and exit from the building. In this, smoke plays a role of hindering egress but not necessarily preventing it, some people moving long distances through quite dense smoke. Furthermore, sensible actions are frequently found whereas irrational nonadaptive responses are never recorded. Where fires lead to loss of life there is frequently not only slow response to early cues, but also administrative confusion in terms of who should take what actions.

The latter sentence of this quotation has relevance to virtually all notable fire disasters in recent times, including those that occurred prior to the assertion that it contains, such as the following cases:

- Summerland Leisure Complex, Isle of Man 1973;
- Woolworths, Manchester 1979;

but also those that subsequently occurred, such as:

- Stardust Discotheque, Dublin 1981;
- Bradford Football Stadium, 1985;
- King's Cross Underground Station, London 1987.

Arguably, these fires simply represent the 'tip of the iceberg' and the unfortunate experience that, in a vast number of other cases that never came to light, there is delay in reaction, confusion and wholly inappropriate conferring between occupants when a fire occurs or the fire alarm system in a building is operated.

While, as a discipline, the field of human behaviour in fire is still relatively young, and the research has been of a quite fundamental and academic nature, already many practical implications have been clearly formulated and, in a number of cases, incorporated within codes of practice, including DD 9999[3] and PD 7974-6.[4] A discussion of the most significant of these follows.

Response to fire alarms

Formal research and common experience both show that people tend to disregard fire alarm signals.

The reasons for this may be any one or more of the following:

- an assumption that the signal is a false alarm;
- the assumption that the fire alarm system is being tested;

- a desire not to appear 'silly' by evacuating in response to what may well be a false alarm, while others continue to carry out normal activities;
- a commitment to other activities, such as work, enjoying entertainment, eating a meal;
- an uncertainty as to whether the alarm signal is, in fact, a warning of fire or some other warning.

Thus it may be said, in summary, that occupants of a building are generally unconvinced as to the 'truth' of a fire warning and generally feel the need to seek further information before reacting. Methods by which people attempt to obtain further information include conferring with colleagues and telephoning those who might be expected to be in possession of further information, such as a switchboard operator, security control room, etc. Junior members of staff may be inclined to seek advice from someone more senior, prior to taking appropriate action.

The practical implications of these findings relate to:

- fire procedures;
- staff training;
- information provided to visitors to a building;
- testing of fire alarm systems;
- minimizing the occurrence of false alarms;
- use of voice alarm systems.

It is essential that fire procedures stress the importance of immediate evacuation when the fire alarm sounds, since there is no doubt that delays, for whatever reason, have a major bearing on the safety of occupants. The written procedures should stress that it is not acceptable to finish existing activities prior to evacuation (see Chapter 20.)

Adequate training of staff is absolutely essential (see Chapter 21.) The importance of immediate evacuation needs to be constantly stressed to staff on a regular basis. In buildings to which the public are admitted in large numbers, it is essential that staff are trained to expect a reluctance of the public to evacuate if they are involved in other activities.

Visitors to a building should be aware of the nature of fire alarm signals, particularly if they could be unaccompanied at any time. This information can be provided verbally on their reception to the building, or in the form of short written instructions, perhaps handed to them at reception or printed on a visitor's pass.

Weekly fire alarm tests (see Chapter 11) present an opportunity to demonstrate the fire alarm signals to occupants of the building. Tests should, therefore, be carried out during normal working hours. In buildings with two-stage alarms (see Chapter 11), both the alert and evacuate signals should be operated on the occasion of each test, so that staff are familiar with both signals. If the building is provided with a public address system (regardless of whether this is used to give fire warnings), the meaning of both types of alarm signal can be broadcast to occupants.

The importance of this came to light in one building with which the author was involved; some occupants incorrectly believed that the continuous evacuation signal should be interpreted purely as a test, while the intermittent alert signal should be interpreted as an instruction to evacuate. This arose simply because, during each weekly test, the evacuation signal was sounded, while the alert signal was never sounded, giving rise to the erroneous conclusion on the part of some occupants that, if they ever heard the intermittent signal, this would indicate the 'real thing'.

On the other hand, too frequent testing of fire alarm systems, or multiple tests each week, can result in complacency by occupants. Accordingly, BS 5839-1 recommends that, during the weekly test, the total time for which alarm sounders operate should not exceed 60 seconds.

Occupants' response to alarm signals may be determined in part by the rate at which false alarms occur. Research has shown that, in this respect, response is governed less by the rate of false alarms (e.g. number per annum) than the time since the last false alarm occurred. This is largely something of truism. If there were 10 false alarms per annum, but the last one occurred three months ago, a new alarm signal is much more likely to be treated as a genuine fire than would be the case if there were only one false alarm per annum but it occurred 10 minutes ago.

In an ideal world, occupants would never hear the fire alarm sound unless they had been pre-warned that a test was about to take place or, alternatively, there was a genuine fire. Such an ideal situation is rarely, if ever, possible to achieve, but, equally, action should be taken in respect of frequent false alarms, as these will, ultimately, prejudice the safety of occupants, who will become reluctant to evacuate when the fire alarm sounds. If frequent false alarms really cannot be avoided (perhaps because of the sheer number of fire detectors in the building), consideration should be given to the use of silent, first stage 'staff alarms' and/or 'time-related systems' (see Chapter 11). The disadvantage of any delay that may occur in such a system when a real fire occurs may be outweighed by the advantage of much more appropriate action when the fire alarm does ultimately sound.

Caution should, however, be exercised in the use of staff alarms, or investigation arrangements, in which evacuation or summoning of the fire and rescue service is delayed. There can be a tendency for building management to draft what are, effectively, false alarm procedures, rather than fire procedures; the procedures will be ideal provided every fire alarm signal is a false alarm, but may be wholly inappropriate in the event of a real fire.

There is also a worrying trend for certain fire and rescue services to encourage management to investigate fire alarm signals, prior to summoning the fire and rescue service. This has arisen from the burden that false alarms create for fire and rescue services, particularly in rural areas in which retained fire-fighters are called from their normal place of work to attend false alarms. Such arrangements need careful consideration, as they are dependent on good management and an adequate number of staff; these procedures may not be appropriate during the night in certain premises in which people sleep (e.g. small hotels), or in which the early attendance of the fire and rescue service may be critical to safety of occupants (e.g. hospitals and residential care homes).

It is now well accepted that many of the problems associated with incorrect response of people to fire alarm signals can, to a large extent, be solved by the use of voice alarm systems (see Chapter 12). Such systems are now regarded as the norm for, at least, large public assembly buildings. It should, nevertheless, be borne in mind that the lack of credibility associated with conventional alarm sounders, such as bells, will, ultimately, apply equally to voice alarm messages if frequent false alarms occur.

Understanding of fire development

Most people's experience of fire is almost entirely limited to controlled, 'beneficial' fires, such as the open fire in a grate or a garden bonfire. The only accidental fire that is likely to be within the experience of anything other than a small minority of people is a chip or fat pan fire, which is usually quite simple to control and does not often spread beyond the cooker. It is, therefore, little wonder that they are ill prepared for an uncontrolled fire within a building; their expectation is that this fire will behave in a similar manner to the only other fires that they have experienced.

Unfortunately, the mechanism of fire spread in the uncontrolled fire is quite different from that in any other fires that people are likely to have experienced. The fire in the grate does not spread at all, unless the chimney catches fire or a spark ignites materials such as furnishings or carpets. The fat pan is readily extinguished by turning off the source of heat or using a simple, commonly available means, such as a damp tea towel.

However, the fire that, perhaps, misleads people most, with regard to what they should expect from a fire in a building, is the garden bonfire. It is common experience that the garden bonfire presents no threat to people or objects in quite close proximity to the fire. The convective heat output of the fire can be quite high, but people can remain close to the bonfire for an almost indefinite period of time. The bonfire tends to spread only by direct flame contact with surrounding items. As discussed in Chapter 2, the mechanism of spread of a fire within an enclosure is totally different. When the flames reach the ceiling, they bend over and elongate, so that, very soon, the entire ceiling becomes somewhat akin to a very powerful radiant panel that ignites all of the room contents almost simultaneously, resulting in 'flashover'.

The perception of people that an uncontrolled fire within a building will behave in a similar manner to a garden bonfire results in behaviour that, with the benefit of hindsight, may appear irrational or even stupid. In fact, the behaviour is borne of a simple lack of information about the likely future development of the fire and thus an inability to make a correct judgement as to the actions to take. Thus, in these early critical stages of the fire, the likely reaction of people may be:

- continuation of their current activities;
- remaining in place to observe what appears to be an interesting and unusual event;
- conferring with others as to what action should be taken.

One or more of these reactions has been a major factor in the outcome of most fire disasters in modern times. However, the rarity of fire disasters is not an implication that such inappropriate behaviour is, in any way, uncommon. The same behaviour occurs in many, or perhaps even most, small fires; it is merely fortuitous, probably as a result of the high standard of fire safety that we now expect in the design of buildings, that more serious injury to occupants does not occur. This implies that care must be taken in fire engineering solutions (see Chapter 22) not to rely too heavily on correct response by occupants, or on perfect standards of management, otherwise building designs could become too unforgiving of human error or misjudgement.

The continuation of normal activities is a particularly well-recognized problem in the case of buildings to which the public resort, such as leisure premises and shops. Thus, for example, in the early stages of the tragic fire at Bradford Football Stadium in 1985, many spectators continued to watch a game of football in the full knowledge that there was a fire in the stand; police officers and others needed to force people to leave against their will.

This has also been the common experience in the case of multiple-fatality fires in retail premises. Particular problems appear to arise in the case of restaurant areas, in which people have already committed themselves to the purchase and consumption of food.

Fires and Human behaviour (Ed: Canter)[2] contains quotations from statements by those involved in a number of historically important serious fires, including those reproduced below from statements made by those involved in a fire at Hendersons Department Store in Liverpool in 1960. This fire is generally held to have led to the fire precautions subsequently required by the Offices, Shops and Railway Premises Act 1963.

> A customer: *'…as soon as I entered the restaurant I noticed smoke hanging about but nothing very much and it didn't appear to be causing any concern; I had started to eat a sandwich…'*
>
> A waitress in the restaurant, who had told a customer that the premises were on fire and would she please leave quickly: *'…she started banging the floor with her stick. She said "I want to see the manager." I said, "You can't see him. He's rather occupied at the moment." She said, "This is disgusting!" The customer still wouldn't leave. She went over to the cash desk and more thick smoke entered the restaurant.'*

Not only does fire sometimes fail to impart a feeling of danger to people, it would seem that sometimes people exhibit avoidance behaviour or denial of the circumstances. There may be fear of being seen to overreact to what appears to be a minor incident. This has occurred in fires in shops, in which people actually walked past a fire to proceed with their shopping. Although there is a tendency for people to turn back in smoke-filled conditions, in which escape might actually be possible, unless they have visibility of around 3 m ahead, equally smoke itself does not seem to create the feeling of danger that it should. Thus, following the bombing of the World Trade Centre in 1993, people entered smoke-filled staircases. Analysis of this incident has suggested that the toxicity of smoke was not appreciated.

While fire safety specialists and behavioural psychologists learn from incidents like these, understandably the public do not. Thus, there has been a virtual ‘rerun’ of the problems of public response encountered at Hendersons in the course of subsequent department store fires. In the fire at Woolworths in Manchester in 1979, which resulted in 10 deaths, customers in the Woolworths restaurant wanted to either finish their meals or pay for their meals before evacuating. These circumstances were well disseminated throughout, at least, fire safety circles, and indeed attracted some media attention over subsequent years in popular science programmes on television, several of which focused on the findings of research on human behaviour in fire.

However, once again, when a serious fire occurred at a Littlewoods department store in Chesterfield in 1993, reluctance of customers in the restaurant to evacuate when requested to do so presented problems for staff, even when smoke was descending close to head height. It appears that the public did not seem to realize the serious nature of the fire until the ceiling began to collapse. The fire resulted in two deaths, 80 injuries and the need for rescue of many customers who were trapped on the first floor, on which the restaurant was located.

Recognition of these problems has led to modification to guidance that supports building regulations. In England and Wales, from the year 2000, Approved Document B, which supports the building regulations, has advocated that, where a storey of a building contains an area for the consumption of food and/or drink by customers, not less than two escape routes should be provided from that area, one of which should lead directly to a storey exit without entering any area of high fire hazard, such as a kitchen.

When the fire reaches such proportions that it diverts attention from normal activities, which are then abandoned, the failure to perceive the urgency of the situation often then results in the fire itself forming a focal point of interest for the public. The apparent perception is that, since it is safe to stand around a garden bonfire, there is no urgent need to leave a building in which there is an uncontrolled fire of similar proportions to the garden bonfire. Thus, for example, in the case of the fire at Bradford Football Stadium and the Stardust Discotheque fire in Dublin in 1981, where 48 people died, there was a tendency, once the entertainment had been suspended, for people to delay evacuation and watch the fire.

A feeling of the need to confer with colleagues or others emanates, once again, from a basic lack of information. Fire is an extremely unusual, completely unexpected and horrendous event in anyone’s life. For those at work, unusual and potentially serious events, encountered in the course of one's work, are a matter to refer to more senior staff. This is exactly what some employees do if fire occurs in the workplace; they refer the matter to their superiors, in one case with which the author is familiar, taking a lift to a higher floor level to seek out a more senior person to whom a fire in the staff restaurant kitchen could be reported.

The implications of these findings for the practical operation of buildings relates, once again, to:

- training of staff;
- the use of voice alarm systems.

In addition to ensuring that staff are properly instructed in the procedures to follow when they hear the fire alarm system, which has already been discussed, there is a need for people to understand the reasons that there should be no delay in taking action if they discover, or become aware of, a fire. This can be achieved in an interesting, graphic and attention-catching way by use of video material that demonstrates the speed of fire growth. One useful video is the so-called 'front room fire' video produced by the Building Research Establishment, which demonstrates the speed at which a fire can develop in a dwelling, using a full-scale 'mock up' of a living room. Another video that is sometimes used incorporates footage of the fire at the Bradford Football Stadium. Other commercially available videos demonstrate fire development and the lead-up to flashover.

The use of voice alarm systems to provide further information has already been discussed. As already noted, this can obviate any perception of a need to confer with others before taking appropriate action to evacuate.

The concept of panic

The findings from research and analysis of behaviour in real fires show that people do not panic, in the sense that the word would be used by a behavioural psychologist. In fact, people appear to think quite clearly in a fire emergency, but simply have inadequate information on which to base a decision. The shortage of information may relate to a general lack of understanding of the behaviour of fire and the way they should react, or a more short-term lack of understanding as to what is actually going on in the premises at the time in question. Lack of good judgement, on the basis of inadequate understanding does not, however, constitute panic.

The general lack of understanding can, once again, be addressed by training. The lack of short-term information can, as already stressed, be addressed by the use of voice alarm systems.

However, a reliance on training alone to ensure the safety of occupants may not always be adequate. To be effective, training must be given regularly, as people will readily forget information that they may never have any need to use. Therefore, it has been concluded that there is a need to provide 'fire intelligence' at the time of a fire. This may comprise pre-recorded or real time information that assists users in evacuating the building, supplemented by adequate signage and wayfinding information. The overall conclusion is that, if people are provided with information, there can be some dependence on them to use it fruitfully and sensibly.

Even those involved in the disastrous and terrifying terrorist attack on the World Trade Centre on 11 September 2001 seemed to exhibit little panic. There are many anecdotes of rational behaviour and, indeed, care for others by survivors, as has often been found in other disastrous events, such as aircraft crashes, in which chaotic, irrational behaviour seems rarely to have occurred.

This has a bearing on the traditional wisdom that the public should not be informed about a fire in the building, at least in the early stages. A commonly held view in the past was that, in places of public entertainment, the word 'fire' should not be used as it would lead to panic. Even today, some codes advocate against the provision of general fire alarm sounders, although it would be accepted that a voice alarm system could be used. While the latter system is certainly to be advocated in such circumstances, the reason that bells and alarm sounders are unsatisfactory is not so much that they will create 'panic', as that they will not provide adequate information; common experience is that, far from suffering panic when alarm bells sound, people tend simply to ignore them.

Both the academic research and the findings of inquiries into fire disasters appear to be in accord that there should be no fear about informing people that there is a fire, albeit that this should be supplemented with additional information. In this connection, the Stardust Discotheque fire is, perhaps, a classic case from which lessons on this matter should be learned.

The Tribunal of Inquiry into the Stardust fire concluded that:

> *The fact remains that the course adopted by those patrons who moved rapidly in the direction of the nearest exits was entirely rational:*

> *the confusion and disorder which ensued was the almost inevitable consequence of the inadequate or obstructed nature of the exits, the filling of the ballroom with black smoke and the failure of the lights, and not of the 'panic' referred to by so many of the witnesses.*

The disc jockey at Stardust fearing that people were about to panic, made an announcement urging people to stay calm and walk to the exits. The tribunal, however, stated that no blame was attached to the disc jockey for these actions because:

> *… it had been part of conventional wisdom that … a major objective should be the avoidance of 'panic'. However, … it is clear from what happened at Stardust that had more individual members of the crowd 'panicked' in the sense of running or walking rapidly towards exits, lives might have been saved and injuries avoided. Had the management and staff of the building injected a note of urgency into the evacuation as soon as the fire was observed, specifically by the broadcasting from the stage of an urgent appeal to people to leave the building immediately that result might have been achieved.*

This is amplified by the late Professor D J Rasbash who, in a paper on Stardust, wrote:

> *The lesson that stands out is that if the threat is not obvious, one should not be too concerned about causing 'panic' in injecting the appropriate degree of urgency into escape instructions, particularly if people are reluctant to move or even, as in this case, remain to take an unhealthy interest in what is going on.*

The role of those in charge

Research has shown that occupants of a building expect to be guided, in the event of an emergency, by those perceived to be in responsible charge. Shoppers and hotel guests expect to be guided by staff on what to do. Generally, staff accept this responsibility. Similarly, patients in a hospital and residents in a care home expect to be guided by staff.

Given this finding, and the tendency already discussed for people to contact those to whom they report on work issues for guidance when there is a fire, this behaviour should be anticipated, particularly in the instruction and training given to those in responsible charge.

The use of familiar escape routes

In their normal use of a building, occupants may rarely have the need, or perhaps even the opportunity, to use all the alternative means of escape. Under the stress imposed on them in a fire, their natural reaction will be to use the normal means of access and egress to the building for means of escape. This may involve travelling much longer than is necessary to reach a place of safety, possibly ignoring, or even passing, alternative escape routes that are not in normal use.

This information has implications for:

- staff training;
- the way in which fire drills are conducted;
- the design of buildings.

In staff training, it must be stressed that all designated fire exits should be used, thereby minimizing the evacuation time and the potential extent of exposure of people to the fire prior to reaching a place of relative safety.

When fire drills are carried out (see Chapter 21), benefit can be obtained from simulating obstruction of the main egress route, such as the main staircase in the building. This forces people to use alternative means of escape, and enables an evaluation of the likely evacuation time, when one escape route is unavailable, to be determined.

If doors are secured by panic bars, Redlam bolts, etc., or if they are fitted with security alarm devices, following the drill it should be confirmed that all security devices have been operated and that alarm signals have been given from all alarmed doors.

Although legislation would be satisfied in a building in which the required staircase or exit capacity comprises just one main staircase or exit, with a number of alternative staircases or exits that are excluded from normal use by the provision of security devices and alarm systems, this may not constitute best possible practice in the design of the building. It is much better for as many of the exit routes as possible to form part of the normal circulation and exit routes within the building.

Further reading

Canter, D (Ed) *Fires and Human Behaviour*. 2nd Edition. David Fulton Publishers Limited. ISBN 1853461393.

PD 7974-6, *Application of fire safety engineering principles to the design of buildings — Part 6: Human factors: Life safety strategies — Occupant evacuation, behaviour and condition*

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1. BS 5839-1, *Fire detection and fire alarm systems for buildings — Part 1: Code of practice for system design, installation, commissioning and maintenance*
2. Canter, D (Ed) *Fires and Human Behaviour*. 2nd Edition. David Fulton Publishers Limited. ISBN 1853461393.
3. DD 9999, *Code of practice for fire safety in the design, construction and use of buildings*
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Management of fire safety

Fire safety cannot be passively managed, nor can it simply be left for third parties, such as enforcing authorities or insurers, to impose at the time of periodic surveys. Equally, as we have seen in Chapter 17, the provision of fire protection equipment does not by itself lead to adequate fire safety standards. Fire safety must be monitored, controlled and actively managed.

The monitoring and control of fire safety is indisputably a management responsibility. It should not be regarded as an 'add on' duty, needing only concentrated attention on an infrequent basis. Fire safety should be an integral part of day-to-day management, emanating from the highest level of management. Too often, fire safety measures originate from lower-level management, who struggle to compete for the attention of more senior management, with the result that, if improvements are not actually positively blocked, they remain in prolonged abeyance.

What is involved in the management of fire safety? Management aspects of fire safety percolate through virtually every chapter of this book, from ensuring that proposed changes to the means of escape are approved by the building control body, (see Chapter 1), to arranging for training of staff in fire safety matters and carrying out fire drills (see Chapter 21).

If fire safety were a priority throughout the management activities of every company, there would be little need to highlight the subject of management in a book on fire safety. Such a world does not, of course, exist. Experience shows that a major contributing factor to multiple death fires in modern industrial or commercial buildings is, in the broadest sense, inadequate management of fire safety – rather than inadequate building design or failure of fire protection equipment.

In the previous chapter, we examined the role of human behaviour in fires involving multiple fatalities. The incorrect reaction by people, particularly staff, may be regarded as simply an important component of a broader failure to manage fire safety. Countless committees of inquiry into fire disasters have determined that management deficiencies played at least a significant role in the outcome of the fire, if not the major role. Examples include the following disasters:

Summerland leisure complex, Isle of Man, where 50 people died in a fire in 1973. Criticisms made included:

a) no overall duty in respect of fire safety;
b) no staff training in fire safety;
c) long delay in summoning the fire brigade;
d) no organized methodical evacuation;
e) locked fire exits;
f) misguided actions by staff;
g) delay in operating the fire alarm system.

Stardust Discotheque, Dublin, where 48 people died in a fire in 1981. Criticisms made included:

a) no emergency evacuation plan;
b) employees not allocated specific duties in the event of fire;
c) staff as confused as patrons during the fire;
d) exits were locked or gave the impression of being locked;
e) delay in summoning the fire brigade;
f) actions of staff uncoordinated and inadequate;
g) failure to operate the fire alarm system.

It remains the case in many organizations that the responsibility for fire safety is, as in the case of Summerland, unclear or undefined. As a result, there is a lack of coordination of fire safety matters. While some aspects of fire safety probably receive proper attention, some may ‘fall between two stools’ because they do not neatly fall into the category of building management, operations management or building maintenance. Committees of inquiry and criminal or civil courts of law tend to find much less difficulty in determining responsibility after a serious fire has occurred or when serious deficiencies in fire safety come to light. There appears to be a positive trend towards placing responsibility squarely on the shoulders of management. In his report on the King’s Cross Fire in 1987, Mr Desmond Fennell QC found that: ‘London Transport at its highest level may not have given as high a priority to passenger safety in stations as it should have done.’

The part of the Fennell report devoted to the management of safety found that no one person was charged with overall responsibility for safety. However, it is not only disasters that lead to the retrospective imposition of responsibility for fire safety. In one criminal case, the assistant manager of a London bookshop received a suspended prison sentence (and hence a criminal record) for deficiencies in the shop's fire safety, even though no fire or injury had occurred. The conviction was subsequently overturned on appeal, but this was because the court decided that the defendant did not, in effect, have the power to deal with the problem that his job title might otherwise have suggested. More generally, in the broad field of health and safety, it is now accepted that conviction of the directors of a company for corporate manslaughter is a real possibility if one or more deaths occur as a result of dereliction of management's duty towards safety.

A defined responsibility for fire safety, or at least its effective control, is, therefore, an important basis for the management of fire safety in any organization. In a large organization, operational control of fire safety may be delegated to a professional fire safety manager, who may also manage safety and/or security. In a smaller organization, operational control may lie with a director, personnel manager, chief engineer, etc. The actual position probably matters little, provided there is an adequate budget for fire safety measures, and the manager responsible:

a) is aware of his or her responsibilities;
b) is given authority to exert influence over all aspects of fire safety;
c) is allocated adequate time to devote to fire safety;
d) has adequate knowledge or ready access to specialist advice;
e) has support from senior management to develop and implement policies.

The formulation of clear fire safety policies is fundamental to the management of fire safety. Such policies must be based on an understanding that the risk from fire is a *pure* risk (i.e. can only result in loss), as opposed to a *speculative* risk (which can result in profit or loss). Policies on fire safety must be tailor-made for the needs of the organization and the potential for loss that it faces.

The simplest possible policy is that the company should comply only with the minimum fire safety requirements set by legislation. Such requirements will relate primarily to life safety. The risk of property damage, and often business interruption, is then managed by the purchase of insurance. While such a policy appears to be relatively simple, its strict implementation may be much more complex. There is a vast difference in the amount of time and effort devoted to fire safety by an organization that considers compliance with legislation to involve merely carrying out a fire risk assessment, and the much greater time and effort devoted by an organization in which the fire risk assessment is just one tool on which ongoing management of fire safety is founded.

In more informed organizations, the fire hazards will have been correctly identified, and the consequences of fire will be well understood. This will often lead to clearly defined policies regarding protection of assets and critical facilities, which supplement the basic requirements of legislation for protection of life. Thus, a group may decide that the potential for fire loss in their large retail buildings is such that all such buildings in the group should be sprinklered. Such a decision may have been taken in conjunction with the group's insurance advisers, who would be in a position to provide guidance on the 'payback' in terms of fire insurance premiums. At a more detailed level, the critical nature of the group's data-processing installations may require the gas-extinguishing systems to be set to automatic at all times – requiring special safeguards for the areas' occupants (see Chapter 14).

However, just as management of a company's finances does not end with the formulation of accounting and investment policies, management of fire safety does not end with the formulation of policy. It must be ongoing and routine. Unfortunately, good (and bad) fire safety management is probably easier to recognize than describe, given the diversity of the activities involved. Happily, there is now a single British Standard devoted purely to managing fire safety, BS 5588-12,[1] to which the manager can turn for definitive advice, and this code of practice consolidates the information and guidance that was previously dispersed throughout many different codes and standards. In addition, excellent, straightforward and simple guidance documents, which do not require substantial amounts of reading time, are produced by the Fire Protection Association (FPA). In particular, attention is drawn to the FPA Library of Fire Safety, which comprises a number of easy to read and highly practical volumes.

In assessing the standard of fire safety management in an organization, attention should focus on:

a) in every building, a defined responsibility for fire safety;
b) a properly documented and periodically reviewed fire risk assessment (see Chapter 5);
c) a documented fire safety manual, setting out the measures in place for prevention of fire, protection of occupants from fire and arrangements

for management of fire safety; guidance on the contents of a fire safety manual is given in BS 5588-12;

d) arrangements for assistance (whether in-house or external) in compliance with fire safety legislation and fire protection policies;
e) suitable and well-documented fire procedures, including arrangements for evacuation of disabled people (see Chapter 20);
f) training of staff in fire matters, with additional training for those with special responsibilities (see Chapter 21);
g) appointment of fire wardens if appropriate (see Chapter 20);
h) properly conducted fire drills (see Chapter 21);
i) regular in-house fire safety inspections (see Chapter 19);
j) contracts or other formal arrangements for inspection, testing and maintenance of fire protection equipment (see Chapter 19);
k) proper inspection, testing and maintenance of plant and equipment, including electrical installations (see Chapter 6);
l) close control over the activities of outside contractors (see Chapter 6);
m) proper procedures during hazardous activities such as hot work (see Chapter 6);
n) regular liaison with the operational personnel of the local fire and rescue service, and pre-planning for assisting the fire and rescue service in the event of fire (see Chapter 16);
o) liaison with the enforcing authorities, such as the building control body, when 'material' changes are proposed (see Chapter 1);
p) records of inspections, tests and maintenance of fire protection equipment, training of staff, fire drills, etc.;
q) policies concerning smoking (see Chapter 6);
r) good standards of fire prevention, including security against arson (see Chapter 6);
s) good standards of housekeeping;
t) recognition and control of dangerous substances;
u) contingency plans for fire or other emergency;
v) monitoring of fire loss experience, including all small fires.

Housekeeping standards are particularly relevant to fire safety. Housekeeping relates to the tidiness, order and general conditions within the building. Untidily strewn packaging materials that obstruct an exit route obviously constitute bad housekeeping, but of equal importance is attention to detail, e.g. the arrangements for storage and disposal of waste.

Comment and opinion on housekeeping form an important part of reports produced by the loss-control surveyors of insurance companies (see Chapter 23).

The surveyor's views on housekeeping provide the insurance underwriter with an indication of the management standards (which may also appear as a particular item in the report). The standard of management is considered to be significant in the assessment of the level of risk. In fact, particularly good housekeeping, or particularly bad housekeeping, may actually influence the insurance premium charged.

Housekeeping standards are important as they affect most aspects of fire safety, in particular fire prevention. Chapter 6 described hazards such as rubbish stored close to buildings, trailing leads to electrical appliances, storage close to light fittings, the build up of grease deposits in kitchens, etc., all of which increase the probability that a fire will occur.

Bad housekeeping can also affect the manner in which fire develops. If a fire starts in a neatly stacked pile of timber pallets, around which there is a clear space, the fire may be spotted and extinguished before it can spread. If the same pallets were strewn around in an untidy heap with adjacent rubbish, it is likely that the fire would spread over a larger area and involve further combustible materials.

Bad housekeeping may also impede the effectiveness of the fire protection measures that would otherwise limit the injury and damage caused by fire. For example, the efficiency of escape routes and exits, fire exit signs and emergency lighting will be threatened if they are obstructed or obscured.

Rapid access to fire equipment, such as manual call points, extinguishers and hose reels may also be prevented by bad housekeeping. Even if access is not positively prevented, if it takes longer to raise the alarm or reach an extinguisher, the fire will be larger before occupants can escape or extinguishers can be used.

The effectiveness of automatic fire protection systems may also be impaired by bad housekeeping. The presence of storage in very close proximity to smoke detectors can result in a delay in detection, as the free passage of smoke to the detectors is blocked. Materials stored too close to sprinkler heads can impair both the efficiency of detection and the effectiveness of the water discharge.

Finally, bad housekeeping may cause difficulties for the fire and rescue service. Badly stacked goods, once alight, may present a hazard to fire-fighters. The presence of clear aisles, however, may make fire and rescue service operations less difficult when the premises are smoke filled. Moreover, access for fire and rescue service appliances may be made difficult by poor external storage practices.

Further reading

BS 5588-12, *Fire precautions in the design, construction and use of buildings — Part 12: Managing fire safety*

Fire Risk Management in the Workplace. Library of Fire Safety. Volume 5. Fire Protection Association

Essentials of Fire Safety Management. Fire Protection Association.

References

1. BS 5588-12, *Fire precautions in the design, construction and use of buildings — Part 12: Managing fire safety*

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Inspection, testing and maintenance

Once fire protection measures have been provided in a building, they must not then be ignored. The Regulatory Reform (Fire Safety) Order* requires that fire protection equipment and systems provided for the safety of relevant persons must be subject to suitable maintenance and repair. Fire insurance policies may also incorporate warranties concerning the maintenance of systems, such as sprinklers; failure to do so could threaten the validity of the insurance in the event of fire. Moreover, there is a vast amount of recognized guidance on this subject: it may be relatively simple to prove liability in civil law for injury or third-party losses suffered as a result of failures of fire protection measures due to a lack of maintenance.

Formal inspections should be a part of a company's approach to safety. However, a general awareness on the part of all employees, particularly supervisors, engineers and managers, can ensure that, as the building occupants go about their day-to-day activities, new fire hazards are identified and addressed, while deficiencies in fire protection are recognized, reported and rectified.

Formal self-inspection procedures will vary in frequency and nature, according to the nature of the premises. The most thorough fire safety inspections, in which every room of the building is inspected, may be incorporated in more wide-ranging health and safety inspections. Less detailed inspections, where housekeeping and fire prevention standards are checked and means of escape are inspected, should be carried out on a more frequent basis. The use of checklists can help to ensure that nothing is missed in the course of inspections. These should be tailor-made for the premises. Matters relevant

* and equivalent legislation in Scotland and Northern Ireland.

to fire prevention, in particular, may vary between one building and another. It is, however, important to ensure that any checklist is used simply as an *aide-mémoire*. The slavish following of a checklist can stifle proper thought regarding problems that may affect fire safety but which do not appear on the checklist. Relatively routine issues can often be checked quite effectively by patrolling security officers.

Routine and formal inspections of any building frequently lead to identification of requirements for the maintenance of passive fire protection measures. Common examples are new service penetrations that have not been properly fire stopped, self-closing devices that require adjustment in order to close fire-resisting doors firmly shut in their frames, and gaps around fire-resisting doors through which smoke could spread.

In the case of active systems, visual inspection is necessary but not sufficient, and specific test routines are necessary to ensure that the systems will operate on demand. It is essential, therefore, that fire alarm systems, emergency escape lighting installations, sprinkler water gongs, etc., are tested frequently. Active systems and equipment also require periodic inspection, testing, servicing and maintenance by persons with technical knowledge. This will normally require contracts with specialist contractors for periodic visits. In large organizations, there may be suitably trained and experienced persons within the organization. It is essential in this case, that the in-house persons possess the same skills and qualifications as a typical specialist contractor and that servicing and maintenance routines comply with published codes of practice and recognized trade practices.

Reference has been made in previous chapters to specific items that should be checked, and the requirements for servicing and maintaining equipment. Typical frequencies at which certain inspections, tests and maintenance work should be undertaken are listed below. However, in the case of a specific building, the frequencies at which the work shown below should be undertaken should take into account:

a) the nature of the building and the risk from fire;
b) the recommendations of equipment manufacturers and suppliers;
c) relevant British Standards and other recognized codes of good practice;
d) any requirements or recommendations of the fire and rescue authority or other enforcing authority;
e) any requirements or recommendations of the company's fire insurers.

It should be noted that the periods shown below are the minimum common standard; where a monthly check is recommended, more stringent tests may be required less frequently, e.g. annually.

Daily

The following checks should be made daily:

- fire alarm control and indicating equipment and the log book;
- control panels of any emergency escape lighting central batteries or generators, and the log book;
- ensure that, if applicable, any fastenings are removed from fire exits (prior to general occupation of the building), and that escape routes are unobstructed;
- check any unmonitored connections by which alarm signals from sprinkler systems are relayed to an alarm-receiving centre.

Weekly

The following checks should be made weekly:

- escape routes, final exit doors and general housekeeping;
- test fire alarm systems (see Chapter 11);
- correct operation of all door-release mechanisms;
- inspect sprinkler installations and other fire-fighting systems; test sprinkler systems (see Chapter 14);
- actuate smoke-control systems provided to support means of escape;
- test switches for evacuation and fire-fighting lifts.

Monthly

The following checks should be made monthly:

- emergency escape lighting (see Chapter 9);
- fire safety signs are in place and visible;
- all fire extinguishers are in position, undamaged, accessible, etc. (see Chapter 13);

- hose reels (see Chapter 13);
- test generators, and inspect vented batteries, that provide standby power for fire alarm systems;
- simulate a failure of the primary power supply to evacuation lifts or fire-fighting lifts.

Quarterly

The following checks should be made quarterly:

- maintenance of sprinkler systems;
- test all smoke-control systems (including those provided to enable smoke clearance by the fire and rescue service).

Six monthly

The following checks should be made every six months:

- maintenance of fire alarm systems (quarterly maintenance is, however, quite common);
- maintenance of all door-release arrangements;
- maintenance of gaseous extinguishing installations;
- inspection of fire mains.

Annually

The following checks should be made annually:

- maintenance of fire extinguishing appliances;
- inspection and test of lighting protection systems;
- maintenance and full discharge test of emergency escape lighting installations;
- testing of spring-operated fire dampers (other fire dampers should be tested at least every two years);
- maintenance of private fire hydrants.

Periodically

Inspection and test of the fixed electrical installation, portable electrical appliances, gas installations, boiler plant, etc. should be carried out periodically by a suitably qualified person.

Records should be kept of all inspections, tests, defects, rectification work and routine maintenance necessary to demonstrate due diligence in, for example, any legal action, such as prosecution under fire safety legislation. In the case of, for example, inspections and tests of sprinkler installations, the completion of a record card may be a requirement of the fire insurer. Detailed records should, in any event, be kept in a log book, regardless of whether there is a specific requirement to do so. The existence of such records may provide evidence for defence against prosecution or civil action, in the event of allegations that an occupier has neglected to maintain fire protection measures in proper working order.

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Fire procedures

It was established in Chapter 17 that a significant factor in multiple-fatality fires in non-domestic premises is the incorrect response of building occupants. The behaviour of occupants is sometimes a more important cause of multiple deaths than failures in building design or fire protection equipment. This is particularly true of buildings that satisfy current legislative requirements, especially if no people sleep in the building. These facts underline the need for pre-planned fire procedures and for training of building occupants in the procedures. Staff training is discussed in Chapter 21 of this book; the subject of fire procedures is considered in this chapter.

In most buildings, fire procedures need not be complicated, and, indeed, must not be permitted to become so. The services of a specialist will not normally be required to write the fire procedures for the building. However, it is not possible to define an exact procedure that will apply to every building. Shutting down equipment may be part of the fire procedures in an industrial site, whereas, in most office buildings, such actions are less likely to be necessary. It should also be noted that the fire procedures must addresss arrangements for evacuation of disabled people, with appropriate assistance rendered by other occupants of the building. In the case of disabled staff who normally work in the building, this will involve preparation of personal emergency evacuation plans ('PEEPs').

Most fire procedures are written for three groups of occupants:

a) the person(s) who discovers the fire;
b) those who hear the fire alarm but have no special duties in the event of fire;
c) those with special duties to perform when a warning of fire is given.

Action on discovery of a fire

The simplest fire procedures are those to which the mnemonic RIP applies:

- raise the alarm;
- inform the fire and rescue service;
- put the fire out if it is safe to do so; otherwise evacuate.

In fire procedure notices, these three actions are normally set out in a theoretical chronological order, as though there were only one occupant of the building. This is also the manner in which they are considered here. However, in practice, all three measures need to be implemented simultaneously or as quickly as possible. If there are several occupants in the area of the fire, one person should tackle the fire immediately if it is safe to do so, while a colleague raises the alarm and ensures that the fire and rescue service are summoned.

Raising the alarm

The first action should be to warn all occupants of the danger, to avoid any delay in evacuating the building. It should be the recognized right of any person to operate the fire alarm system if they suspect, or know, that there is a fire in the building. Fire procedures based on informing a manager, telephoning a switchboard operator, security officer, fire warden, etc., if a fire occurs are inherently dangerous and divorced from the reality of both fire behaviour and human behaviour. Concerns that the alarm might be raised in the event of only a 'small' fire are unlikely to be considered with great sympathy if or when a 'large' fire develops.

In some buildings, it may be unnecessary to evacuate the entire building when a fire is discovered and the alarm system is operated. However, the fire alarm system should normally be configured in such a manner that any person who operates a manual call point receives confirmation (normally by operation of the alarm sounders in the area) that the signal has been received at the fire alarm control equipment. Even in buildings with two-stage alarms, in which an ' alert' signal, rather than an evacuation signal is given in some areas, an immediate evacuation signal should be given in the area in which the manual call point is operated. The arrangement, sometimes found in older fire alarm systems, where, on operation of a manual call point, the whole building (including the area in which the call point is located) is given an 'alert' signal, but no one in the area of the fire actually evacuates, is no longer acceptable.

At the very least, operation of a manual call point should normally lead to evacuation of those in the area (e.g. floor of the building) in which the call point is situated. If, exceptionally, this is not the case (e.g. in certain public entertainment buildings with 'staff alarms' that permit staff to prepare for evacuation of the public), on operation of a manual call point, there should be confirmation to the operator that an alarm signal has been generated (e.g. by illumination of a red-light emitting diode on the face of the call point).

In some buildings, after operating a manual call point, it may be required that further information is given, by telephone or in person, to a responsible person at a continuously manned location, such as a reception desk or switchboard. The need for this procedure may arise because of the complexity of the building and the need for key staff to be made aware of the circumstances as soon as possible. The use of the telephone is not, however, an acceptable means of actually raising the alarm, and should only be used to give further details after the alarm is sounding.

Informing the fire and rescue service

It is vital to ensure that the fire and rescue service is summoned immediately to every outbreak of fire, however small it may be. Operation of a manual call point should, therefore, be regarded as synonymous with the existence of a fire. (As discussed in Chapter 11, this may or may not also be true of operation of an automatic fire detector.) As discussed in Chapter 2, fire growth can be very rapid in its early stages, and even a short delay in summoning the fire and rescue service may put lives at risk and result in additional loss of property. A delay in summoning the fire and rescue service is a common factor of most fire disasters, such as the Summerland leisure centre fire, the fire at Woolworth's, Manchester, the Stardust discotheque fire in Dublin, and the fire at King's Cross underground station. Action must, therefore, be taken to summon the fire and rescue service as soon as the fire alarm system is actuated (unless it has been agreed that an investigation of alarm signals from smoke detectors is to be adopted).

Responsibility for summoning the fire and rescue service in the event of fire must be pre-planned. It is desirable that the responsibility is placed on a person other than the person(s) who actually discovers the fire. For example, the procedure may be that, on hearing the fire alarm, the switchboard operator will summon the fire and rescue service before evacuating the building. Care must then be taken to ensure that a situation cannot arise whereby, as a result of a failure of the fire alarm system, the alarm is sounding, the person who discovers the fire assumes that the fire and rescue service will be summoned, but the switchboard operator is unaware of the alarm signal.

The person who is responsible for summoning the fire and rescue service should be in a position to monitor closely the main fire alarm panel. It can then be assumed that, when an alarm is raised and alarm sounders operate, the signal will be displayed on the main fire alarm panel, and the person who monitors the panel will summon the fire and rescue service. Problems can arise, however, if the switchboard operator merely monitors a repeat indicator panel, situated in a separate part of the site from the main control panel. A failure in the link to the repeat indicator panel could result in a major delay in the summoning of the fire and rescue service. The fire procedure should then be that, after raising the alarm, someone contacts the switchboard operator from a place of safety to ensure that the fire and rescue service has been summoned.

The alarm signal may be relayed to an alarm company alarm receiving centre (ARC), from where the fire and rescue service will be summoned as soon as the signal is received. Although this should ensure that the fire and rescue service will be summoned quickly when the alarm system is operated (and some account may then be taken of this in fire procedures), a connection to an ARC never obviates the need for an emergency call to the fire and rescue service from the premises, if occupied. The link to the ARC can fail and incorrect procedures can occur at the ARC. It is not unknown for incorrect procedures at the central station to result in a long delay or failure in summoning of the fire and rescue service.

In buildings that have no suitable and continuously manned location at which the fire alarm control panel is monitored, the responsibility for summoning the fire and rescue service should still be pre-planned. For example, it may be the duty of a manager or supervisor, but it should be ensured that the duty is not delegated to a named individual (who may not always be present). In smaller premises, or those in which it is not practicable to delegate the duty for summoning the fire and rescue service, it may be necessary to place the responsibility for summoning the fire and rescue service on the person who discovers the fire. In this case, the duty should be made clear in the written fire procedures. Even in buildings with switchboard operators or reception desks, it may be necessary to resort to less formal, but clearly documented, procedures for summoning the fire and rescue service outside normal working hours.

Although immediate summoning of the fire and rescue service has been stressed, occupants should not place themselves at risk to make the call.

It may be necessary to retreat to a safe area of the building or to another building. However, procedures should never require the use of a telephone on a higher floor level than the fire, from which escape might prove difficult (except in the case of basements).

Extinguishing the fire

Procedures must not require persons to attempt to extinguish a fire, but should, in most premises, suggest that extinguishing action may be taken if it is safe to do so. The use of extinguishing appliances by occupants is a rather contentious subject (see Chapter 13) but, in practice, it is entirely unrealistic to have a procedure whereby even the smallest fire is left to burn for, perhaps, 10 minutes or more, pending the arrival of the fire and rescue service. Extinguishing action should, however, generally be implemented only in tandem with raising the alarm and summoning the fire and rescue service, and should be implemented only by persons who have received appropriate instruction in the use of the extinguishing appliances.

Action on hearing the fire alarm

The correct action on hearing the fire alarm sound depends on whether an alert signal or an evacuation signal is being given. In buildings with single-stage evacuation arrangements, only the evacuation signal will ever occur. In buildings with phased evacuation arrangements, an evacuation signal will be given in the area of the fire, and an alert signal will be given in other areas.

On hearing an alert signal, occupants should prepare for a possible evacuation. The form of preparation will vary from one building to another. In some buildings, equipment might be shut down during the alert stage. It is also wise to begin evacuation of disabled people at the alert stage.

The evacuation signal must be regarded as an instruction to occupants to evacuate immediately. There must be no delays while belongings are collected, an item on the agenda of a meeting is finished, telephone calls are finished, or meals in a restaurant are paid for or eaten. Procedures for dealing with occupants, including members of the public, who are reluctant to evacuate, must be considered. Any equipment that might itself create a fire hazard if left unattended should be switched off. As occupants make their escape, all doors should be closed, particularly those designated as fire doors. If it is possible to close windows quickly, this may also be appropriate, but is less essential.

All occupants, on evacuation, should report to a predetermined assembly point. Re-entry of the building should be strictly prohibited until the fire and rescue service officer in charge declares that it is safe to do so. In particular, the silencing of the fire alarm should never be regarded as an indication that it is safe to re-enter the building; the signal may have been silenced deliberately because it is known that the building is evacuated, or the fire may have damaged the alarm system, causing it to stop sounding.

Special duties

Summoning the fire and rescue service

The summoning of the fire and rescue service may be the responsibility of a designated post (but not named individual), such as a switchboard operator. In this case, a special procedure should be formulated for the person in question. Although this may seem trivial, as the procedure will normally be a matter of dialling 999, asking for the fire and rescue service and requesting its attendance at the premises, some of the detail of these simple actions benefits from pre-planning.

The procedure should include the exact manner in which the address of the premises should be given to the fire and rescue service. This will avoid any confusion or error in communication by, for example, using local terminology to a centralized fire control operator who receives fire calls from an entire county or even an entire region of the country.

As fire controls are centralized, the area served by any control room is very large. Local descriptions of premises, such as 'Ashmores' or 'the bakers in the High Street' may mean nothing to a fire control operator many miles away. Fire and rescue service controls are computerized, and presentation of an address in a manner that the computer can recognize enables efficient response by the fire and rescue service. In case of doubt, the relevant fire and rescue service can advise on the manner in which an address should be presented. The information should include:

a) the name of the company;
b) the correct postal address, including the area or district and the town;
c) the telephone number;
d) brief circumstances, such as automatic fire alarm actuating, fire in canteen, etc.;

e) in the case of complex buildings or sites, the appropriate entrance that the fire and rescue service should use.

Fire wardens

In larger buildings, or those in which a roll call after evacuation is ineffective due to a varying occupancy or the presence of members of the public, designated fire wardens and nominated deputies should be appointed for each area of the building. In the event of fire, the fire wardens should be responsible for ensuring that their areas are evacuated. They should then evacuate and report that their area (including any toilets) is clear to the person in charge at the assembly point.

It should be stressed that no one in a building should delay their evacuation pending instructions from a fire warden. The absence of fire wardens should have no effect on the evacuation, but could affect the reliability and value of information that is available to the fire and rescue service. A well-conducted evacuation should enable the fire and rescue service to turn its attention to fire-fighting, rather than searching for non-existent occupants.

If a fire warden scheme is operated, provisions must be made for fire wardens to be present at all times. Normally, fire wardens are named persons, but there must be sufficient wardens and deputies to cater for absences. The problem of absences can be avoided by incorporating the duties of fire warden with a designated post, such as shift supervisor, which it is known must always be filled. This, however, suffers from the possible disadvantage that an individual post holder may not be interested in the duties of fire warden, have inadequate time or desire to attend fire wardens' training sessions, and generally be reluctant to take the duty seriously.

Accounting for occupants

A responsible person(s) should be designated to account for occupants at the evacuation assembly point(s). If a roll call is considered to be a feasible pre-planned procedure, this person must obviously have available a list of occupants who should be present at the time of the evacuation. Otherwise, there should be arrangements for fire wardens to report to the person in charge of the assembly point(s) that their areas have been evacuated. Information regarding the status of the evacuation, and any person for whom it is impossible to account, should be given to the fire and rescue service on its arrival.

Reception of the fire and rescue service

An appropriate person should be made responsible for meeting the fire and rescue service on arrival and liaising with the officer in charge. A critical early action is to inform the officer in charge regarding the status of the evacuation. The person should also be familiar with the building and be in a position to advise regarding the location of any information packs for the fire and rescue service, the layout of the building, fire protection measures, building services and their controls, etc. This may require the availability of other persons, such as the building services engineer, who can provide specialist information if it is needed by the fire and rescue service.

Security officers

Security officers may be given special duties to perform in the event of fire. In a building with particular security risks, these duties may relate to their primary duty of maintaining security. However, security personnel may be required to perform other duties, such as:

- grounding lifts to ensure that they are not used to evacuate (except in the case of disabled people who may use special evacuation lifts (see Chapter 7));
- acting as lift operators for any evacuation lifts;
- preventing persons from entering the building, until a general reoccupation is permitted;
- coordinating salvage work;
- providing advice to the fire and rescue service concerning the building.

Senior management

A senior manager should be in overall charge until the fire and rescue service arrives. It should be understood that, on arrival, the fire and rescue service will take charge. However, the manager should be in a position to make decisions regarding alternative accommodation for building occupants, notification or call out of other managers or specialist employees, implementation of contingency plans, etc.

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Staff training and fire drills

Staff training and fire drills are clearly related but are not synonymous. Yet it is a common misconception that a company's training obligations are satisfied by carrying out periodic fire drills. Fire drills are both necessary and useful, but they do not educate employees in all matters with which they should be familiar.

However, training of staff in fire safety matters remains a contentious issue, with many companies taking the view that it is not reasonably practicable to provide training for all employees. This view has probably never been fully tested in court, but the fact that certain companies take the matter of fire training very seriously, and are able to train a large number of employees, adequately demonstrates the feasibility of providing proper training for all employees.

Prosecutions relating to fire safety training in isolation appear to be relatively rare, although failure to provide staff training is sometimes a matter for which companies are prosecuted, along with a host of other offences, when enforcing authorities decide to act because of an organization's gross failure to comply with the law.

Legal requirement for training

The Regulatory Reform (Fire Safety) Order* requires that employees must be given adequate fire instruction on induction and, as appropriate, periodically thereafter. The Order also requires that all employees are given information regarding fire procedures, the arrangements for fire-fighting, and the general fire precautions required to satisfy the Order.

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* and equivalent legislation in Scotland and Northern Ireland.

Method of training

Initial training should be given as part of any induction course for new employees. If this is not within a very short time of joining the company, new employees should be given basic instruction concerning escape routes, fire procedures, fire alarm signals, etc. on the day they begin work in the building. At the very least, they should initially be given a tour of all escape routes, including any alternative routes that do not form part of the normal access routes. If employees do not attend a formal induction course, they should be given detailed instruction on fire matters as soon as possible after joining the company. Instruction should be based on written material, which is given to the employee, but should normally, in addition, comprise verbal instruction. The only possible alternative might comprise computer-based learning packages, which can incorporate tests to evaluate leaning outcomes. Standard fire instruction leaflets are not adequate; the instructions should be tailor-made for the building in question.

Instruction should be given to all persons who work in the building. This includes permanent shift workers (e.g. night shift security staff), part-time staff, cleaners, etc. Special training is necessary for those with particular duties, such as fire wardens. After initial training on joining the organization, employees should receive refresher training once or twice a year.

Some organizations consider fire training to be impracticable, as they believe employees need to be sent off on an external course. Such courses may be one method for training those with special duties, but are not normally necessary for all building occupants. After the initial induction training, which may be part of an induction course or merely a briefing from someone with adequate knowledge, short sessions can be held periodically by the company fire officer, safety officer or other suitably knowledgeable person. Various external organizations, including consultants and some fire and rescue services, can also provide such training on the premises.

Periodic refresher training should not be time-consuming. In some companies, it may involve no more than a 30-minute session. These training sessions should not merely reiterate the standard fire instructions for the building. The objective should be to raise the awareness of employees by attracting their attention and providing material that is of interest. Videos can be of assistance, and numerous useful videos dealing with different aspects of fire safety can be purchased or hired. Refresher training also offers an opportunity to discuss any fire problems that have arisen in the company, or causes of false alarms that have occurred. Interest can also be generated by imparting guidance on domestic fire safety matters for the employees' own benefit.

Content of training sessions

The following matters should be covered in all training sessions. To these, should be added other matters that are more specific to the premises, such as particular fire prevention practices, smoking policies, and fire precautions relevant to particular equipment or processes.

Means of escape

All employees must be made familiar with all means of escape from the building in which they work. It is particularly important that they are made aware of escape routes that are different from the normal entrances and exits. Employees should also be shown how to operate any exit devices, such as panic bars and override devices fitted to doors with electronic locking.

Action in the event of fire

All employees should be instructed in the actions to take in the event of fire. This should include any special duties, such as those allocated to fire wardens. Procedures for evacuation of disabled people should also be outlined.

Means of raising the alarm

All employees must be familiar with the means of raising the alarm, which normally involves the operation of a manual call point. There is some variation between one type of call point and another – particularly older types, in which the glass breaks into fragments, and modern types in which it does not. The exact method of operating the type of call point that is present in the building should, therefore, be demonstrated. A member of staff should be given the opportunity to operate a call point on each occasion that a fire drill is held. Employees should also be reminded of the locations of manual call points.

Means of summoning the fire and rescue service

The need for the fire and rescue service to be summoned to all fires should be stressed in training sessions. The 999 emergency call procedure should be explained. Many people do not realize that the first person they will speak to is the public telecommunications organization's operator, who will only wish to know which emergency service is required. People commonly forget that they are not talking to the fire and rescue service at this stage, and begin to describe the circumstances of the fire. If the duty of summoning the fire and rescue service is associated with a specific post, such as a receptionist, consideration might occasionally be given to permitting a 999 call to be made, by prior arrangement with the fire and rescue service, at the time of a fire drill.

Action on hearing the fire alarm

One of the most important points to stress during training sessions is that occupants must evacuate as soon as the evacuation signal is given. People are always reluctant to do so; they tend to assume that the signal is the result of a false alarm and do not wish to appear foolish by evacuating when, perhaps, others are not doing so. This reluctance can be helped by making it clear that management will support an evacuation even if a false alarm has occurred, and by using visual aids that demonstrate the speed with which fire can develop. It is necessary to create an appreciation of the risk that fire presents to life.

If evacuation times are to be minimized, it must be stressed to employees that all means of escape should be used, including those that are not part of the normal access routes and which require the use of exit devices. It should also be emphasized that lifts must not be used, except in the case of lifts specifically designated for evacuation of disabled people.

Location and use of fire extinguishing appliances

All employees must know the location of the nearest fire extinguishing appliances to their normal working location and the general layout of appliances in the building. This can prevent undue delay in tackling a small fire that might otherwise grow to untenable proportions, while people search for a fire extinguisher.

Employees must understand the colour coding of portable extinguishers, and the types of fire for which the extinguishers provided in the building are suitable. If the building contains a mixture of extinguisher colour-coding protocols (see Chapter 13), it is important that this situation is addressed. The method of operation of extinguishers and hose reels should also be demonstrated. Ideally, selected members of staff should be permitted to discharge extinguishers onto fires so that they obtain an appreciation of the extinguisher's capability. This may not always be possible without transporting employees to a separate location. However, this more in-depth training should be considered for security officers, fire wardens and those responsible for giving instruction to others.

If use on fires is not possible, staff could be permitted to discharge extinguishers in, for example, an open yard or loading bay, merely to reinforce the method of operation and particular problems, such as the noise of discharge and the chilling of the horn of CO_2 extinguishers. Where any type of extinguisher cannot actually be discharged in training sessions, a sample of the extinguisher should be shown to employees, its method of operation should be described, and a film of an actual discharge should be shown.

General fire precautions

Occupants of a building often negate the fire precautions in the building simply because they do not understand the function of smoke-stop or fire-resisting doors, which they wedge open, or the need to keep escape routes clear of combustible materials. It is important that they are not only instructed on these mandatory measures but also on the reasons for them. In some buildings, there may be special precautions to take because of hazardous activities or dangerous substances and, again, it is vital that staff are aware of the appropriate precautions.

Fire drills

Fire drills are a useful means of reinforcing evacuation procedures, monitoring their effectiveness and ensuring competency of staff with designated duties. The Regulatory Reform (Fire Safety) Order* requires fire drills to be carried out, where necessary.

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* and equivalent legislation in Scotland and Northern Ireland.

Fire drills are not always taken seriously by employees or managers, and are seen as an unnecessary interruption to business. This is unfortunate as a properly conducted drill can highlight problems, such as the failure of occupants to use all fire exits, resulting in an inordinately long evacuation time.

The evacuation time, defined as the time between the operation of the fire alarm system and the evacuation of the last person from the building, should always be measured and recorded. In premises with more than one staircase or fire exit, the use of one staircase or exit should be prohibited, so that occupants are forced to use alternative routes. The design of buildings is such that acceptable evacuation times should still be physically possible. The drill should begin by permitting an employee to operate a manual call point. All occupants, including senior management and disabled people, should participate in the drill. Exemptions should be rare and should only be given in very exceptional circumstances, to persons on whose presence a critical continuous operation absolutely depends. A record of such exemptions should be kept, so that, if possible, the same persons are not exempted from two consecutive drills.

A debrief should always be held soon after each drill. This provides an opportunity for management to review the outcomes, fire wardens to report problems, such as any unwillingness to evacuate by specific groups, difficulties in hearing the alarm system, etc. Fire drill outcomes should be minuted at company health and safety meetings.

22

Fire safety engineering

The concept of fire safety engineering (sometimes known simply as 'fire engineering') is not new; it has been studied and practised for three or more decades. In the UK, the first higher-education course in the subject, leading to an MSc qualification, was inaugurated as long ago as 1974, when the late Professor D J Rasbash was appointed, at the University of Edinburgh, as the first professor of fire safety engineering in this country.

The acceptance of fire safety engineering as a fundamental approach to the design of fire precautions in buildings, and acceptance of so-called 'fire engineering solutions' as a means of satisfying fire safety objectives, is, however, more recent. Reference to fire safety engineering found its way into the guidance that supports the Building Regulations in England and Wales as recently as 1991. In that year, the new Approved Document B under the Regulations, which took effect in 1992, while not attempting to define fire safety engineering, acknowledged for the first time that:

> *A fire safety engineering approach that takes into account the total fire safety package can provide an alternative approach to fire safety. It may be the only viable way to achieve a satisfactory standard of fire safety in some large and complex buildings.*

Since then, there has been an almost exponential growth in the number of practitioners of fire safety engineering and in the number of buildings that are designed, in terms of their fire precautions, on the principles of fire safety engineering. To assist the reader who may, with increasing likelihood, need a basic understanding of the principles of fire safety engineering, this chapter sets out a simple outline of the concepts involved. It should, however, be noted that, in the context of this book, a distinction is drawn between what are, in the opinion of the author, two quite different concepts, namely fire engineering, as a broad engineering discipline, and fire safety engineering design of (usually complex) buildings, the latter of which incorporates so-called 'fire engineering solutions'.

Fire engineering – the discipline

Let us consider first the broad engineering discipline, known as fire engineering, which is not, in fact, the main subject of this chapter. A desire by the fire safety profession in the UK to have their subject recognized as a valid, distinct engineering discipline goes back to, at least, 1918. In that year, the Institution of Fire Engineers (IFE) was founded with the following objective:

> *To promote, encourage and improve the science and practice of fire extinction, fire prevention and fire engineering and all operations and expedients connected therewith, and to give an impulse to ideas likely to be useful in connection with or in relation to such science and practice to the members of the Institution and to the community at large.*

The founders' proposal to set up an institution incorporated the aim:

> '*…that we establish an Institute to be known as "The Institution of Fire Engineers" on similar lines to the "Institute (sic) of Civil Engineers" or "Electrical Engineers" and other kindred bodies*'.

It was to be 80 years before this aim was achieved. In the first few decades of the Institution, which now has branches throughout the UK and many other parts of the world, the membership was drawn mainly from fire brigades, albeit that its doors were open to all in the 'fire' profession. The Institution set, and continues to set, its own examinations, and is, more generally, very active as a professional body in its assistance to members in their continuing professional development.

During the 1970s and 1980s, other professional bodies representing fire engineers, particularly those working in fields other than local authority fire brigades, were formed, notably the Institute of Fire Safety (IFS). The achievement of professional recognition of fire engineers actually arose from a joint approach by the IFS and the IFE to the Engineering Council, which led to the formation of an Engineering Council Division (ECD) of the IFE and the subsequent transfer of IFS members into the new IFE Engineering Council Division. This consolidation and rationalization led to the IFE becoming the recognized professional body for fire engineers in the UK.

The IFE achieved recognition as a 'nominated body' by the Engineering Council in 1997, from which date it can be asserted that fire engineering has been recognized as a legitimate and separate branch of engineering, just as the founding fathers of the IFE intended. The Institution, through its Engineering Council Division, can now award the qualification Chartered

Engineer (C Eng), Incorporated Engineer (I Eng) and Engineering Technician (Eng Tech) to suitably qualified and experienced practitioners in the field of fire engineering.

In parallel with these developments, numerous higher education courses and qualifications have been developed by universities and colleges. Thus, it is now possible to obtain HNC, B Eng, MSc and PhD qualifications in fire engineering, and indeed, BSc degrees in associated fields, such as fire safety management.

What, in the context of the professional body, is fire engineering? The description of the activities of the membership, proposed at the time of foundation of the IFE in 1918, remains reasonably appropriate as a definition of fire engineering (other than the tautology associated with the inclusion of the term fire engineering with that description). Thus, in simple terms, the fire engineer is someone who practises engineering, in some form or other, for the purpose of preventing fire, protecting people and/or property against the effects of fire, or extinguishing fire.

A more comprehensive definition of fire engineering developed by the IFE, in response to a requirement from the Engineering Council to do so is:

> *The application of scientific and engineering principles, rules (codes), and expert judgement, based on an understanding of the phenomena and effects of fire and of the reaction and behaviour of people to fire, to protect people, property and the environment from the destructive effects of fire.*

On this basis, this entire book has actually been devoted to the subject of fire engineering, albeit at a level that is intended for the non-specialist!

Fire safety engineering design of buildings

In addressing the design of fire precautions for any building, it may be considered that two, quite distinct approaches are possible, namely:

- the 'prescriptive' approach;
- the 'fire safety engineering' approach.

The prescriptive approach may be recognized by two distinct features:

- design is based on reasonably rigid adherence to recognized codes of practice, standards and guidance documents (the 'prescriptions');

- as a first approximation, each component of fire safety, such as the means of escape, the fire warning system, etc., is considered in isolation of all other components, so far as prescribing its design.

The prescriptive approach is that traditionally adopted from the very earliest days of fire safety legislation. Thus, when, in 1189, it was decreed that houses in the City of London were to be built of stone, that thatched roofs were not permitted and that party walls were to be of a minimum height and thickness, this was a prescriptive approach to the achievement of a specific fire safety objective, namely prevention of fire spread beyond the building of origin; this remains an objective of building regulations today.

Building regulations remained entirely prescriptive in their approach to fire safety (and other matters that they control) until relatively recently. In England and Wales, the change came in 1985, when the regulations were cast in so-called 'functional form', setting out only a number of simple fire safety objectives, described in their totality on a mere one and quarter pages of A4 (see Chapter 1). What had previously been regulations became simply the guidance contained in the then current version of Approved Document B, which set out a form of model solution as to how the objectives may be satisfied.

The prescriptive approach was also traditionally adopted by fire insurers in achieving their objective of protecting property; technical bodies that advised the fire insurance industry produced 'rules' of a rigid nature. Although some aspects of fire protection continue, as far as insurers are concerned, to be governed by such rules, the more recent codes of practice used by insurers cater for greater flexibility. Moreover, the approach adopted by the insurers themselves is now much more flexible.

In some respects, there is much to commend in a prescriptive approach to fire safety, such as;

- the 'rules' are easy to learn, straightforward to apply and facilitate a degree of consistency;
- enforcing authorities, and many designers, users, etc., continue to gain 'comfort' from a traditional approach that involves little 'risk', either in terms of liability for an inadequate degree of safety or in terms of the potential for harm to occupants of the building;
- the 'rules' are proven, in the sense that deaths in 'code-compliant' buildings, other than dwellings, are uncommon; indeed, the codes of practice have evolved in the light of experience gained from past disasters;

- the knowledge base, education and training required for practitioners of a prescriptive approach is substantially less than that required for those who wish to adopt an alternative approach; thus, traditionally, a fire officer or insurance surveyor, with limited technical training and no engineering qualification, could ensure that an adequate level of safety was achieved by following a prescriptive code.

The approach adopted to fire safety in this book has been almost entirely prescriptive in nature. Each component of the fire safety 'package' has been examined independently, with only minimal consideration of the interactions between components. Figures quoted for parameters, such as travel distance, exit widths etc., have been extracted from prescriptive codes. There are numerous reasons for this:

- the overwhelming majority of buildings are still designed purely on the basis of prescriptive codes;
- most 'building work', in the sense of modifications to existing buildings, follows the prescription of codes of practice;
- the alternative 'fire safety engineering' approach is a specialist subject, that is generally outside the scope of this book and its intended readership.

It should also be stressed that prescriptive approaches frequently involve qualified fire engineers. Indeed, many qualified and recognized fire engineers may only be involved, in practice, with work that is largely, or even solely, prescriptive in nature.

Over the past two decades or so, there has been consistent criticism of the prescriptive approach by exponents of the alternative 'fire safety engineering' approach. The basis for this has been that:

- the limitations imposed by prescriptive codes are often arbitrary, with no basis in engineering or science; an example is the travel distances used in design of means of escape (see Chapter 7), which are, in effect, merely arbitrary requirements for the distribution of exits;
- although many of these limitations are intended to be flexible, in the past there has been a tendency to impose them in a much too rigid manner, resulting in unnecessary expenditure and disruption to implement token fire precautions;
- building designs, particularly of an innovative nature, are unnecessarily constrained, precluding architecturally interesting space utilization;
- fundamental problems of fire safety are not always addressed.

Governments have been persuaded by these arguments, and it was this that led directly to the fundamental change in approach of building regulations, discussed earlier in this chapter. Now, under building regulations, the designer is offered, in effect, the 'best of both worlds'. They may follow the prescriptive codes or standards that support the regulations, such as, in England and Wales, Approved Document B. Alternatively, they may, albeit less commonly, adopt an alternative approach, provided the underlying 'functional requirements' in the regulations themselves are satisfied. An alternative approach is to adopt a 'fire engineering solution'. The use of this approach is not restricted to compliance with building regulations. It may be adopted in compliance with legislation that applies to existing occupied buildings, when, for example, shortcomings in existing fire precautions are identified by a fire risk assessment.

In following this train of discussion, we find that the meaning of 'fire engineering solution' suddenly becomes obvious, even in the absence of a rigorous definition. Fire engineering solutions simply involve achievement of one or more fire safety objectives, such as the functional requirements contained in legislation, without following a prescriptive code of practice. Thus, for example, adequate means of escape may be provided, albeit that the travel distances specified in prescriptive codes are significantly exceeded.

In the fire safety engineering approach, it may be considered that all the issues considered independently in the earlier chapters of this book are applied as an integrated package of measures, rather than as a number of wholly independent measures.

Even in a fire safety engineering approach, it is rarely the case that prescription is simply set aside in its entirety. In the simple, but perhaps one of the most common, applications for fire safety engineering described above, namely a solution in which travel distances exceed those normally prescribed, it may be the case that all other aspects of design comply in full with the normal prescriptive code.

Application of fire safety engineering principles to a specific departure from prescriptive codes, such as 'excess' travel distance, is often described as a 'fire engineering solution'.

Fire safety engineering is, therefore, generally characterized by:

- departure from prescription;
- a 'first principles' approach to fire safety;

- integration of different fire precautions, often incorporating smoke control, to achieve a defined fire safety objective;
- calculation of one or more parameters.

A truly first principles approach to fire safety is by no means simple. It involves prediction of:

- the probability of fire;
- the development of fire;
- the spread of fire, smoke and toxic gases;
- the performance of fire protection measures;
- human reaction;
- evacuation times.

Such is the complexity of, at least, the phenomenon of fire, that there are gaps in available knowledge. However, BS 7974,[1] supported by a number of published documents, produced by BSI as various parts of PD 7974,[2-9] codifies current knowledge and practice.

BS 7974 defines fire safety engineering as 'application of scientific and engineering principles to the protection of people, property and environment from fire'. It provides a framework for an engineering approach to the achievement of fire safety in buildings, and is intended to enable a fire safety 'package' to be assessed. The associated published documents contain guidance and information on how to undertake detailed analysis of specific aspects of fire safety engineering in buildings. PD 7974-0 is a guide to the design framework and fire safety engineering procedures. Further parts of PD 7974 address the following issues:

PD 7974-1	Initiation and development of fire within the enclosure of origin.
PD 7974-2	Spread of smoke and toxic gases within and beyond the enclosure of origin.
PD 7974-3	Structural response and fire spread beyond the enclosure of origin.
PD 7974-4	Detection of fire and activation of fire protection systems.
PD 7974-5	Fire and rescue service intervention.
PD 7974-6	Evacuation.
PD 7974-7	Probabilistic fire risk assessment.

Much of BS 7974 and the associated PDs are concerned with calculation, offering equations that can be used to predict the relevant parameters in the likely fire scenario. The nature and use of such equations are extremely complex and outside the scope of this book. However, the principles of fire safety engineering described in BS 7974 are so fundamentally simple and compelling to make them almost basic truisms.

Ultimately, the safety of occupants is a time-related issue. We have a situation in which fire is growing with time, but opposing this phenomenon is whatever extinguishing action is taken, whether by automatic systems, or people using portable fire extinguishing appliances. In parallel with this scenario, people ultimately become aware that there is a fire and evacuate the premises.

This very simple analysis underpins the principles of fire safety engineering described in BS 7974. The principles are succinctly described in the form of 'time lines', which compare the progress of fire development with the progress of evacuation.

Figure 22.1 shows the time line comparison contained in BS 7974. In terms of fire development, smoke spread, etc., the critical factor is the available safe egress time (ASET), the calculated time that is available between ignition of a fire and the time at which conditions in the building, or specified areas of the building, are such that people become incapacitated; after ignition of a fire, the ASET is, therefore, the time at which conditions become untenable. The fundamental truism, in respect of life safety, is that the escape time, defined as the interval between ignition and the time at which all occupants are able to reach a place safety, must be shorter than the ASET. The time calculated (e.g. in PD 7974-6) is often described as the RSET (required safe egress time).

Calculation of the ASET involves prediction of fire growth, smoke and toxic gas production, and of the reaction of the building and its fire protection systems. As already discussed, this is complex, but simple models of fire growth do exist and can be used.

The escape time can be subdivided into a number of components. Occupants cannot begin to evacuate until they are aware that there is a fire. Thus, the first component is the detection time, defined as the interval between ignition and the detection of combustion, whether by an automatic system or simply by people in the vicinity of the fire.

There will be a delay between the detection of the fire and the sounding of the alarm. If fire is detected by automatic means, this may be extremely short, but it is still finite; product standards for fire detection systems permit this period to be as long as 10 s. If fire is detected by people, the time between detection and the sounding of the fire alarm system is likely to be not only longer but more variable, as there is a reluctance of people to operate a fire alarm system even when they are aware that there is a fire in the building. Moreover, they may delay operating the fire alarm system to perform other tasks.

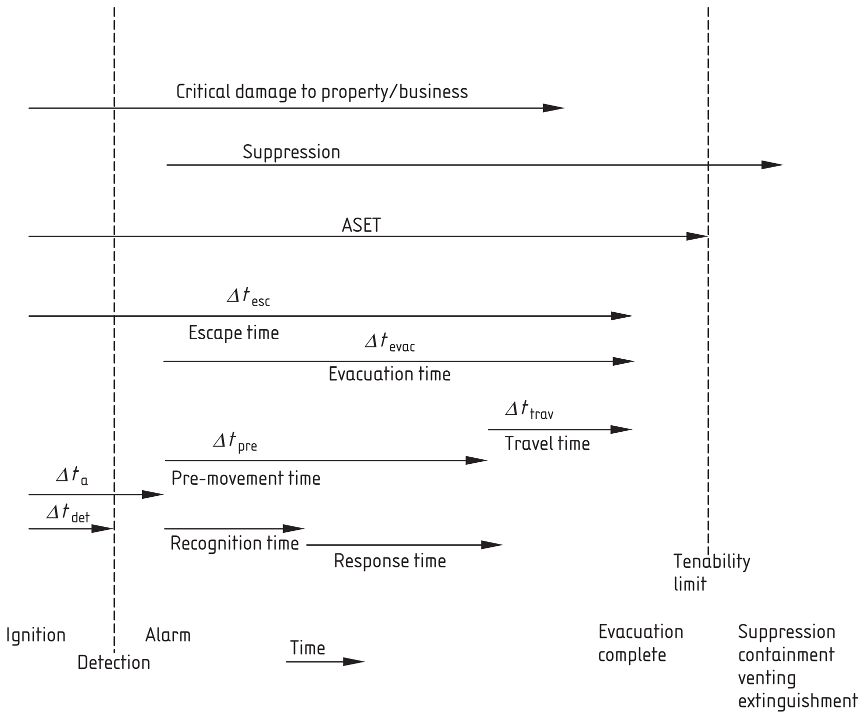

Figure 22.1 Example of time line comparison between fire development and evacuation/damage to property

After occupants hear the fire alarm system operate, or indeed see a fire, there is a defined 'recognition time', during which occupants continue with the activities in which they are already engaged, such as working, shopping, eating a meal, etc. (see Chapter 17). In well-managed buildings, such as theatres, and buildings in which there has been a good standard of fire training (see Chapter 21), the recognition period may be quite short. In other cases, the recognition time may be as long as several minutes.

After occupants recognize that there is a need for a response to the fire or fire alarm signal, there is a further 'response time' before people begin to move directly to an exit. Again, this response period may vary from a few seconds to many minutes, during which people may investigate, stop machinery, secure cash tills, gather together members of their family, etc.

The summation of recognition time and response time is known as 'pre-movement time', defined as the interval between the time at which a warning of fire is given and the time at which the first move is made towards an exit. Pre-movement time may actually be the most significant component of escape time, but, in a prescriptive code, no allowance, or, at least, variation is incorporated for this parameter. PD 7974-6 gives typical pre-movement times for the first few and last few occupants.

At the end of the pre-movement time, there is a 'travel time', which is simply the time needed, once movement towards an exit has begun, for all the occupants of a specified part of the building to reach a place of safety.

Normally, fire safety engineering is applied to large, complex buildings, to which the application of prescriptive codes may present difficulties. Equally, the same principles can be applied to quite simple buildings. In order to demonstrate the practical application of fire safety engineering principles, an example of their application to what is virtually the most simple building possible follows.

It is increasingly common for large, single-storey, shed-type retail buildings to be constructed on the outskirts of major towns and cities in the UK. Often, the basic 'footprint' of these buildings is large, dimensions of 100 m by 100 m being not uncommon. The layout of such buildings is often such that a person standing in the centre of the building is some considerable distance from the nearest exit. Moreover, the constant interruption of perimeter shelving to provide a substantial number of fire exits may be regarded as contrary to merchandising policy.

Thus, the travel distance of 45 m specified in commonly used codes of practice on means of escape (see Chapter 7) quite simply cannot be applied. Nevertheless, legislation demands, that, of course, there must be adequate means of escape in case of fire.

It is quite common for fire safety engineering principles to be used to demonstrate an 'equivalence' between recognized prescriptive codes and a proposed fire engineering solution, rather than to approach the problem from a genuinely first principles direction. In the case of the example described, it is the principle of equivalence that is often demonstrated by fire safety engineering.

Basically, the problem presented by the building design is that, in some areas of the store, people are, perhaps, 20 m further from the nearest fire exit than a prescriptive code would advocate. In a genuinely first principles approach, one would endeavour to predict the overall escape time and the ASET in order to determine whether an adequate degree of safety could be achieved. However, a much simpler approach is to assume that compliance with a prescriptive code would achieve an adequate degree of safety (which could not be refuted by an enforcing authority) and to concentrate solely on the matter of the 20 m 'excess' in travel distance.

Firstly, this travel distance would be converted to units of time. For example, it might be calculated that the effect was an increase in travel time of, say, 20–30 seconds. To 'redress the balance', and achieve equivalence with the prescriptive code, it would be possible to either:

- increase the ASET by 20 s–30 s;
- or reduce the other components in the overall RSET time by 20 s–30 s.

To increase the ASET, a smoke-control system might be installed (see Chapter 15). The effect of this system would be to maintain the smoke layer well above the heads of the escaping occupants for at least an additional 20 s–30 s (and probably considerably more) beyond the time at which the smoke layer would become a threat to occupants in a building that complied with the prescriptive code but that had no smoke control system. In order for the smoke control system to operate at an early enough stage, there would be need for an automatic fire detection system. Moreover, the smoke control system would be designed on the assumption that the fire size would not exceed a specified level, otherwise the system design could be uneconomical and impracticable. The assumption in respect of fire size would probably only be valid if the building were provided with an automatic sprinkler system to limit the size of the fire. Thus, we have an integrated package of measures, namely smoke control, automatic fire detection and sprinkler protection interacting synergistically to support yet another fire protection measure, namely means of escape; this is very characteristic of a fire engineering solution.

However, a completely alternative approach could be adopted. Normally, prescriptive codes would not dictate that the building be provided with automatic fire detection. The provision of smoke detection might, therefore, be considered as a possible means of reducing the overall escape time. The significance of automatic fire detection would, in practice, be greater in cellular spaces, in which there is likely to be a delay in detection by people. In a large, heavily populated, open-plan building, particularly one with a high ceiling, people are likely to be aware of a fire before it is detected automatically. Thus, in terms of detection times, the provision of automatic fire detection might, while the building is occupied, be little more than a token gesture. However, it could be argued that automatic fire detection would provide a more reliable and earlier form of fire warning, given that people might delay operating the fire alarm system.

As already noted, pre-movement time can be very significantly affected by the form of fire warning system. As discussed in Chapter 12, a voice alarm system can greatly reduce the pre-movement time by initiating a much more rapid response on the part of occupants. It is quite probable that the use of a voice alarm system alone would more than compensate for the increased travel time. The reduction in pre-movement time that is likely to arise from the use of a voice alarm system, instead of conventional alarm sounders, can be taken into account in a fire engineering solution.

This discussion has concentrated on hardware issues. It should, however, be noted that 'soft' issues also have a bearing and may well be taken into account in fire safety engineering. For example, sound procedures that are regularly rehearsed and in which staff have been well trained might also be taken into account.

The above example serves, perhaps, to support the earlier assertion that the principles of fire safety engineering are compellingly simple. However, while much of the logic expounded above was couched in terms of what may be 'argued', in an actual fire safety engineering approach subjective argument is often not sufficient, and there is a need for calculation, which is significantly less simple. Nevertheless, just as there are qualified fire engineers whose work rarely, if ever, necessitates the use of fire engineering solutions, there are specialist fire engineers whose work only involves such engineered solutions and who would not normally be involved in straightforward prescriptive solutions.

As we proceed in the new millennium, it is fitting that one of the last chapters of this book should be concerned with the subject of fire engineering as a newly accepted engineering discipline, and fire safety engineering as a rapidly developing approach to designing buildings in which people are safe to live, work, await transport and engage in leisure activities. Those who regard these disciplines as entirely new might, however, pause to reflect on the gratitude we owe to those who believed in these principles so steadfastly a quarter of a century or more ago. In my own case, I acknowledge, with much gratitude, the learning process to which I was exposed as a member of the first intake to the first higher-education course in fire engineering, in the UK, which was inaugurated at the Department of Fire Safety Engineering at Edinburgh University, and the teaching I received from the late Professor D J Rasbash and his colleagues in the Department, Dr E W Marchant and Dr (now Professor) D D Drysdale.

References

1. BS 7974-1, *Application of fire safety engineering principles to the design of buildings — Part 1:* Code of practice
2. PD 7974-0, *Application of fire safety engineering principles to the design of buildings — Guide to design framework and fire safety engineering procedures*
3. PD 7974-1, *Application of fire safety engineering principles to the design of buildings — Initiation and development of fire within the enclosure of origin*
4. PD 7974-2, *Application of fire safety engineering principles to the design of buildings — Spread of smoke and toxic gases within and beyond the enclosure of origin*
5. PD 7974-3, *Application of fire safety engineering principles to the design of buildings — Structural response and fire spread beyond the enclosure of origin*
6. PD 7974-4, *Application of fire safety engineering principles to the design of buildings — Detection of fire and activation of fire protection systems*
7. PD 7974-5, *Application of fire safety engineering principles to the design of buildings — Fire Service Intervention*
8. PD 7974-6, *Application of fire safety engineering principles to the design of buildings — Human factors: Life safety strategies — Occupant evacuation, behaviour and condition*
9. PD 7974-7, *Application of fire safety engineering principles to the design of buildings — Probabilistic risk assessment*

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Property protection and the role of the insurer

Limitations of legislation

Chapter 5 discussed the fire risk assessments that legislation requires for protection of life. Protection of life is the *sole* objective of national fire safety legislation, as government policy is that any requirements for fire precautions, imposed under fire safety legislation, should only be those necessary to protect life. Government policy is that, for example, measures required to protect property are a private matter for the building owner or occupier to consider, often in conjunction with the fire insurer.

Thus, for example, the Regulatory Reform (Fire Safety) Order requires means for warning occupants of the building in the event of fire, means by which the occupants can then escape safely and measures to assist in the use of these escape routes. The Order does, of course, require means for fighting fire, but only where necessary. Normally, such measures are limited to manual fire extinguishing appliances, such as portable fire extinguishers and/or hose reels, but even this simple equipment clearly contributes to limitation of property damage and is, therefore, also required by fire insurers.

Also, in complex buildings, automatic sprinkler systems, which, until recent years were considered as a property-protection measure, can be taken into account in the fire risk assessment, particularly if they were required under building regulations, often as part of a fire engineering solution. Moreover, fire resisting doorsets used to protect escape routes clearly limit fire spread and consequent property damage, while a fire alarm system can result in early attendance of the fire and rescue service (again, contributing to property protection), particularly if the system incorporates automatic fire detection and there are arrangements (possibly automatic) for summoning the fire and rescue service as soon as the system operates.

However, any benefits to property protection, ensuing from measures required under legislation to protect life, are purely fortuitous, regardless of the legislation involved. The measures required by the Fire Safety Order are simply those necessary to safeguard relevant persons in the event of fire. Similarly, building regulations are intended to ensure that a reasonable standard of life safety is provided in case of fire. Protection of property, including the building itself, may require additional measures, and insurers often seek their own higher standards before they accept the insurance risk.

In England and Wales, under the (now repealed) Fire Precautions Act, the veracity of this limitation in requirements imposed under fire safety legislation to those strictly necessary to protect life was tested in the landmark, high-profile case of City Logistics Limited v Northamptonshire County Fire Officer. This litigation centred around a large, high-bay warehouse situated in Northampton and occupied by City Logistics. Under the Fire Precautions Act, the fire and rescue authority issued a statutory notice, requiring sprinkler protection of the warehouse as a prerequisite for issue of a fire certificate. In the Magistrates' Court, it was held that this was a reasonable requirement. However, in the Crown Court, the judge took the view that the Fire Precautions Act was concerned with personal safety, not the safety of property. The judge considered that the City Logistics policy to evacuate the building and call the fire and rescue service in the event of fire, rather than fight a fire, was adequate to protect the occupants of the building and that to require sprinklers was to require measures for protection of property. Accordingly, the judge found in favour of City Logistics.

The fire and rescue authority appealed to the High Court, who held that the purpose of the Fire Precautions Act was not confined to the protection of occupants. The High Court judge considered that there were powers under the Act to require measures to protect fire-fighters, limit economic loss and limit potential damage to the environment from fire. Finally, however, in the Court of Appeal, the judges found for City Logistics. Having heard evidence from the Secretary of State regarding the original intent of the Fire Precautions Act, the judges took the view that the purpose of the Fire Precautions Act was to ensure safe escape for occupants of a building. In this connection, their view was that measures for fighting fire could only be legitimately required as a prerequisite for certification where the means for fighting fire were reasonably necessary to facilitate escape.

Fire safety objectives

In carrying out a fire risk assessment for any building, it is necessary to first determine clearly and unambiguously the objective(s) of the fire risk assessment. In practice, any one or more of three broad objectives may pertain, namely:

- protection of life (and hence compliance with legislation); this is, by far, the most common reason for carrying out a fire risk assessment;
- protection of property;
- protection against business interruption.

Protection of life can be considered as the foundation for all fire precautions, on which further fire precautions may be built to satisfy either, or both, of the other objectives. Even so, an occupier, owner or insurer may seek an assessment to determine the fire precautions necessary to satisfy purely the objective of property protection and/or protection against business interruption in the event of fire; these are perfectly legitimate objectives, which, in practice, are sometimes considered in complete isolation of measures required to protect life.

It is sometimes assumed that, as fire precautions intended to protect life are the most fundamental of those fire precautions now specified in buildings, these measures are also those with the longest standing history. In fact, this is far from the case. Indeed, in the context of the history of building design, means of escape are a relatively modern feature of design. Many of the earliest fire precautions incorporated within buildings were specified with the intent of limiting financial loss suffered by insurers. Certainly, what would now be regarded as a form of fire risk assessment was carried out by insurers to assess the risk to property, long before the term *fire risk assessment* was ever invented.

The forerunner of the IEE Regulations for Electrical Installations was actually the rules of the Phoenix Assurance Co. for electrical installations. Even the earliest requirements imposed under legislation that we would now describe as building regulations were intended to prevent large-scale conflagrations that could cause widespread damage to property in urban conurbations, rather than to ensure that the occupants of any particular building could escape safely from fire.

The role of insurance

The earliest form of insurance was the marine insurance provided to merchants in the 13th and 14th centuries. Merchants met in Lombard Street in the City of London to effect what would now be regarded as marine insurance policies.

In 1680, Edward Lloyd opened a coffee house in the City, which was frequented by shipowners, merchants and sea captains. Sale of ships by auction took place there, and the coffee house grew as a place for marine insurance to be transacted. This was the origin of the now world-famous Lloyd's, which is not an insurance company, but is merely a marketplace where underwriters in the form of Lloyd's Syndicates transact their business to this day.

The Great Fire of London in 1666 drew attention to the absence of any coordinated method of fighting fires and the need for some form of fire insurance. The first fire insurer, The Fire Office, was established in 1680. During the latter part of the 17th century and the early 18th century, the scope for fire insurance grew, and a number of other insurers or 'Fire Offices' was established.

The Industrial Revolution greatly expanded the need for fire insurance and, it could be argued, led to the earliest form of fire risk assessment, whereby insured properties, commonly referred to as '*risks*' were classified according to fire risk, for the purpose of setting rates for insurance. In the 18th century, the system of classification was very simple, in that premises were divided into three categories, namely 'common risks', 'hazardous risks' and 'extra hazardous risks'. However, as the simple processes of early manufacturing industries became much more complex, this was reflected in quite complex rating systems, known as '*tariffs*'. A tariff was, in effect, a form of quantitative fire risk assessment to enable the insurance premium charged to be commensurate with the level of fire risk.

The early fire insurers also set up their own fire brigades. 'Fire marks' were fixed to buildings to indicate or 'mark' them as being insured by a particular company. Generally, on arrival, one of these privately owned fire brigades would only deal with a fire if the building were marked as being insured by their company. The earliest attempt to form the different offices' fire brigades into one coherent fire brigade probably occurred in London, when, in 1832, all the London fire offices formed one fire brigade.

Other forms of cooperation between fire offices gradually grew. It became clear that, for example, there were advantages to offices if they were to pool loss experience and classify risks on a common basis, with agreed insurance rates. It could be said that this was a form of consistent property fire risk assessment. In Scotland, the way for this cooperation was led when meetings of Scottish Fire Office Managers began in 1829. In England, cooperation tended to grow on a piecemeal basis, usually following disastrous losses in particular forms of premises, such as warehouses, wharves and cotton mills, following which there would be cooperation in the rates that would apply to such premises.

The first UK-wide association of insurers was formed in 1860, and adopted a formal constitution in 1868 when the association became known as the Fire Offices' Committee (FOC).

The future development of the FOC was profoundly affected by the Tooley Street fire in London in 1861. The fire involved wharves and warehouses between Tooley Street and the River Thames and involved the Fire Offices in an aggregate loss of over £1 million. The Offices immediately increased the rates charged for wharves and warehouses, and, probably for the first time, they adopted a principle that still exists within insurance rating today. The rating system for wharves and warehouses was designed so as penalize bad features of construction and to encourage, by favourable rates, forms of construction that would perform better in fire, so mitigating the risk to property from fire.

From this principle, developed a multitude of 'tariffs' for different industries. The tariffs were a quite complicated method of formulating a rate for any factory or mill. The tariff began with a basic rate, according to the insurers' experience of losses in that industry. Loadings were then added to the basic rate for undesirable aspects of fire risk, such as poor construction, while discounts would apply for good features of construction and for fire protection measures, such as fire extinguishers, automatic fire detection systems and automatic sprinkler systems; the discounts offered for sprinkler protection were particularly high. Finally, the tariffs were dynamic, in that an adjustment was made according to the recent loss experience of the industry in question.

The fundamental *raison d'être* of the FOC was, therefore, the development and updating of tariffs. In the 20th century, until the demise of the FOC, most insurance companies were members of the FOC; those insurance companies that formed the FOC were known as the 'tariff insurance companies'.

Insurers also formed Salvage Corps in London, Liverpool and Glasgow. Their role was to reduce loss and damage caused by fires, to help mitigate the effects of fire and fire-fighting, and to salvage property affected by fire. Each salvage corps operated in cooperation with the local authority fire service, and had salvage tenders, very similar in appearance to local authority fire service appliances, that would attend fires. However, the salvage tenders carried heavy duty salvage equipment, rather than fire-fighting equipment. Personnel wore kit similar to that worn by fire-fighters.

The Salvage Corps in Liverpool was created from an earlier body with the same objective, which had been formed in 1845 by fire offices transacting fire insurance in Liverpool. The formation of that body, the 'Liverpool Committee of the London, Liverpool and other Fire Offices' had resulted from a disastrous fire that destroyed several acres of warehouses in Liverpool in 1842. In 1892, it was reconstituted as the Liverpool Salvage Association in accordance with rules and regulations drawn up by the FOC. After further name changes, in 1893 it became the Fire Salvage Association of Liverpool Ltd.

Members of the FOC formed the Salvage Corps in Glasgow in 1873. The Glasgow Salvage Corps Committee that operated it amalgamated with an existing insurance rating committee in 1876 to form the Glasgow Rate and Salvage Association. The London Salvage Corps was formed in 1865. Each of the three Salvage Corps continued in operation, funded by insurers, until they were disbanded in 1984, when their work was absorbed by the relevant local authority fire services.

The FOC became world-famous for its excellence in technical activities, rather than its insurance rating activities per se. In order to promote protection of property against fire loss, and to support the tariffs, the FOC developed rules and recommendations for fire protection measures in specific industries, for specific processes that were known to constitute a fire hazard (e.g. paint spraying), for the construction of buildings and for the installation of various fire protection systems (such as automatic sprinkler systems and automatic fire detection systems).

The rules for construction and for installation of various fire protection systems were necessary to support the discounts within the tariffs that were applicable if these rules were followed. However, this alone was insufficient. There was also a need to ensure that the actual equipment installed was of good quality. Accordingly, the FOC were extremely active in writing rules for, testing and approving fire protection products, such as fire extinguishers, fire doors and shutters, fire detection systems, components of automatic sprinkler systems, etc. Many of the British Standards in common use today, including BS 5306-2[1] and BS 5839-1,[2] are based on original FOC rules for design of fire protection installations and for the performance of products, such as fire detectors and sprinkler heads.

It follows from the above that the codes and standards produced by the FOC, for use by the insurance industry, were purely concerned with protection of property, and not with protection of life. Therefore, for example, an FOC-approved automatic fire detection and fire alarm installation required only two bells on the entire system, as the purpose of the system was not to alert occupants but to summon the fire and rescue service, by means of automatic transmission to a fire and rescue service control room (in the early days) or an alarm receiving centre; the purpose of one of these bells, which had to be located externally, was simply to bring the fire and rescue service to the correct entrance, where they would find the fire alarm control panel. Moreover, as the system was not intended to protect life, the system did not need to incorporate any manual call points. Similarly, in testing fire-resisting doors and shutters, while much longer periods of fire resistance were required than would be necessary to protect escape routes, the doors and shutters did not need any particular resistance to the passage of smoke.

The tariff insurance arrangements promulgated by the FOC included an agreement by members not to charge less than a minimum rate for certain risks (at least, without the agreement of other member companies) and an arrangement whereby, where a large risk was 'co-insured' by a number of different insurers, a minimum of 65 per cent of the values at risk should be underwritten by tariff companies. In 1972, the report of the Monopolies Commission on the supply of fire insurance regarded these arrangements as a form of restrictive practice, as a result of which the Monopolies Commission recommended that the tariff system should be abolished. The technical arm of the FOC became the Loss Prevention Council and its subsidiary approval and certification body, the Loss Prevention Certification Board (LPCB), which was self-financing and not related purely to the needs of fire insurers. The LPCB is now part of the Building Research Establishment (BRE).

As a result of the abolition of the tariff insurance arrangements, there is, today, much greater competition between fire insurers and much less pooling of statistical information on fire losses. This has, inevitably, led to a situation in which commercial considerations often preclude the fire insurer from imposing requirements for fire protection measures that, arguably, could reasonably be imposed by a prudent underwriter. Insurers are sometimes less 'bullish' about making requirements for measures, since they are aware that the insured company might well seek an alternative insurer with less stringent requirements.

However, there remains some cooperation between insurers (and insurance brokers) for the purpose of technical development. This is conducted primarily through the Insurers' Fire Research Strategy Funding Scheme (InFIReS). InFIReS' stated role is to conduct research and perform representation on behalf of a group of UK insurers into mitigation measures from fire and security risks. InFIReS publishes guidance and recommendations for insurers through the Fire Protection Association (FPA).

The extent to which the insurance market is capable of 'driving' the level of fire protection measures in buildings that they insure varies, in an almost cyclical way, with insurance market conditions. A market climate in which insurers feel able to demand stringent fire precautions, or impose premium penalties for poorer fire precautions, is generally referred to as a 'hard' insurance market, the corollary being described as a 'soft' insurance market. Traditionally, a soft insurance market has pertained in times of high interest rates, as the insurer seeks to obtain as much business, and hence premium, as possible (with less regard to the standard of fire protection), in order to invest the premium at the high rates of interest available.

Sometimes, the requirements imposed by fire insurers are actually 'driven' not by the insurers themselves, but by the reinsurers. Reinsurance comes into play when the potential loss is too great for the insurer to bear solely on their own account. The insurer then reinsures all or part of the risk with other insurers, some of which transact reinsurance business only. Thus, reinsurance is a form of protection, akin to insurance itself, which insurance companies and underwriters arrange 'behind the scenes' to protect themselves against major losses. The reinsurance might apply to a specific insured building, or may apply across the underwriter's portfolio of business.

In terms of measures to restrict loss, the reinsurer is usually not interested in measures that will prevent, or protect against, fires involving limited financial loss. Reinsurance can be regarded as a form of catastrophe cover, and accordingly the reinsurer is primarily concerned in preventing a catastrophic loss that would involve the reinsurer in making a significant payment to the insurer. Thus, while the insurer might express significant interest in, for example, smoking policies on a site and other measures to prevent fire occurring, the reinsurer is often more concerned with the provision of sprinkler protection and substantial water supplies for fire-fighting, as it is these measures that will prevent the catastrophic loss against which the reinsurer is providing cover.

The importance of the reinsurer in the level of fire precautions demanded by insurers became particularly clear after the disastrous events at the World Trade Centre in New York on 11 September 2001. The huge financial loss made a major impact on insurance markets around the world, including the Lloyd's market in London, which provided a substantial element of the insurance cover. Ultimately, however, much of the financial loss rested with the reinsurance market. The result was an increase in reinsurance premiums, a reduction in capacity within the reinsurance market and much more stringent demands by reinsurers for measures to protect against catastrophic losses, to be imposed by insurers. Insurers, themselves, also suffered, and the result was a major hardening of the insurance market, with insurers feeling able to demand fire protection measures as a condition of insurance, when, previously, the measures might have merely had the status of recommendations. It was probably 2004 before market conditions softened somewhat.

The loss control surveyor

Most large insurers employ specialists who were, traditionally, known as 'fire surveyors', but are, in more modern parlance, more commonly described as loss control surveyors or loss control engineers (albeit that the practitioners may or may not be qualified engineers). The role of the loss control surveyor is to act as the eyes and ears of the underwriter, providing information on which the underwriter can base the insurance premium charged, while making recommendations as to the 'loss control' measures that should either be required of the insured business as a condition of insurance, or should be recommended to the company, in order to prevent, or protect against, fire. The loss control surveyor is, therefore, effectively carrying out a property fire risk assessment.

Another role of the loss control surveyor is to provide the underwriter with 'maximum loss estimates'. Different insurance companies use different terminology and definitions for these, but common terms are estimated maximum loss (EML), maximum probable loss (MPL) and maximum foreseeable loss (MFL). These are the maximum financial losses that are likely to be suffered, and it is important that the underwriter has an estimate of such figures, partly so that adequate reinsurance can be put in place. Often, two levels of maximum loss are estimated, namely the loss that is likely to occur if all fire protection measures operate correctly, and the loss that could occur if fire protection measures are impaired.

There is often a misconception that the loss control surveyor will have given at least some attention to measures required to protect life, which is normally not the case, as they may only have a marginal bearing on the property fire risk assessment. It is often also cynically expressed that the insurer and the loss control surveyor are, somehow, lacking in compassion about life safety. The true situation is much simpler. In the same way as legislation precludes imposition of requirements regarding property protection, the property insurer would consider that protection of life is a matter for legislation, with which the insurer has no contractual or legitimate right to interfere.

Moreover, the insurer's loss control specialists would normally have no formal training in the requirements of fire safety legislation or the principles of means of escape, nor does the loss control surveyor require any knowledge on means of escape and similar fire precautions in order to do his job properly. Thus, although we began this chapter with an assertion that measures required to protect life often contribute to protection of property, this is, to a large extent, purely fortuitous, while the measures required by the insurer to protect property may enhance life safety but are not specified by the insurer for this purpose.

Nevertheless, the role of the loss control surveyor is a valuable one, and, traditionally, he undoubtedly took more interest in *prevention* of fire than enforcing fire safety legislation. Whereas, under traditional fire safety legislation, including building regulations and the Fire Precautions Act, the measures required were fire protection measures, which only had bearing once fire occurred, the fire insurer was just as concerned to prevent *any* fire occurring, as in providing measures to protect against loss once fire occurred. It could be argued that there was something of a coming together between the approach of the enforcing authority and the fire insurer as a result of the Fire Precautions (Workplace) Regulations in 1997. As a result of the fire risk assessments that employers were, for the first time, required to undertake, there arose, in effect, a legislative requirement (arguably for the first time) to consider fire hazards and their prevention, much as would be necessary in a property fire risk assessment.

Even so, fire and rescue authorities sometimes assume that the fire insurer will consider it vital that the fire risk assessment required by legislation is carried out and will have a major interest in its contents. Since the purpose of this fire risk assessment is primarily to ensure the safety of occupants in the event of fire, this is not necessarily the case. However, there is a growing interest, on the part of insurers, in the legislatively required fire risk assessments, as it is recognized that they are likely to contribute to a reduction in fire losses.

Liability insurance

To the extent that an insurer is greatly concerned regarding the legislatively required fire risk assessment, it is likely that the concern will be on the part of the employers' liability insurer or the public liability insurer. Employers' liability insurance began with the passing of the Employers' Liability Act 1880. Before this legislation was enacted, a person injured at work could hardly ever succeed in a lawsuit to make his employer pay damages, as the employer could put forward various legal defences. The 1880 Act removed some of these defences in certain classes of employment. Hence, there arose a demand for insurance.

Today, the Employers' Liability (Compulsory Insurance) Regulations 1998 require every employer to have in place insurance, with an indemnity limit of at least £5 million, for compensation awarded to employees for injury or death as a result of the negligence of the employer. Thus, inadequate precautions to protect employees in the event of fire, is as much (or more) a matter for the employers' liability insurer than the property insurer. Similarly, public liability insurance, which grew in parallel with employers' liability insurance, provides cover to property owners for their liability for accidents caused by defects in their buildings, and the public liability insurer should have an interest in shortcomings in fire precautions that might result in injury to a member of the public (or fire-fighter) in the event of fire.

Protection of life vs protection of property: differences in approach

It has been asserted in this chapter that measures intended to protect life are often effective, at least to some degree, in protection of property, and vice versa. However, there may be subtly different requirements in respect of the design of many fire protection measures, according to whether their role is protection of life or protection of property. Moreover, adequacy for one objective does not necessarily imply adequacy for another objective. The following are simple examples.

- Construction provided to protect escape routes will protect against fire spread, and hence property loss, but not necessarily to a sufficient degree. A fire resistance of 30 minutes is normally considered adequate for protection of escape routes, but would be regarded as barely adequate by a fire insurer, who would often consider 60 minutes as the minimum requirement for property protection, with significantly longer periods deemed necessary in certain circumstances. On the other hand, two-hour fire-resisting shutters, favoured by insurers for compartmentation (e.g. of large warehouses), are not normally suitable for protecting escape routes, as the fusible link used to close the shutter would be too slow to operate; moreover the shutters do not necessarily protect against the passage of smoke.
- While portable fire extinguishers are usually required by legislation and by insurers, many fire and rescue authorities do not favour the provision of hose reels, as they encourage people to remain in a building for longer than desirable. However, hose reels can make a major contribution towards property protection, particularly in the hands of a skilled fire team.
- A manual fire alarm system might be sufficient to satisfy legislation, but would not be considered of any significance by a fire insurer, who would consider that an automatic fire detection system was essential for the system to be of any value in property protection.
- For design of fire detection and fire alarm systems, the system must be ascribed a category; category L systems are automatic fire detection systems intended for protection of life, whereas category P systems are automatic fire detection systems intended for protection of property, and there are subtle differences in the design parameters for the two categories of system.
- Automatic transmission of fire signals from fire detection systems (and sprinkler systems) to the fire and rescue service is unlikely to be necessary for protection of life (other than in certain premises, such as hospitals and residential care homes), but is virtually a prerequisite for protection of property.
- The speed of operation of sprinkler heads traditionally used for protection of property may be inadequate in sprinkler systems intended for protection of life.
- Sprinkler systems intended for protection of life are generally required to have additional design features (such as duplicate alarm valves).
- As discussed in Chapter 8, insurers often adopt a different approach to compartmentation from that appropriate under building regulations.
- Various forms of fixed fire suppression systems, other than sprinklers and water mist systems, are often deemed necessary for protection of property, but such systems are rarely required for protection of life.

- Insurers often attach much greater importance than an enforcing authority to housekeeping and general management standards, although this is changing as audits by fire and rescue authorities take significant account of management standards.
- Security of a site and the proximity of combustible materials to the perimeter of the building is often more important in property protection than in protection of life.
- Fire and rescue service attendance times, availability of water supplies, flow rates from hydrants and capacities of static water sources all have a greater bearing on property protection than on life safety.

Protection against business interruption

Protection of business against interruption and additional costs as a result of fire is a much more modern concept than either protection of life or protection of property. Indeed, 'consequential loss' insurance was only introduced on its present basis around 1900. This class of insurance, which is now more commonly referred to as 'business interruption' insurance and is not included in a traditional fire insurance policy, covers the loss of anticipated profits during the period that the business cannot function fully, the standing charges that continue to apply even though the business is disrupted (e.g. rent, salaries, etc.) and additional expenses incurred in minimizing the loss of turnover (e.g. renting alternative premises). The business interruption insurer might be a quite different insurer from that providing insurance against property damage.

The major growth in the use of data processing in the 1960s and 1970s brought the potential for consequential loss into close focus. The risks associated with interruption to business as a result of fire had long been recognized, and it has, for a long time, been claimed that a significant proportion of businesses cease trading within a short time of a major fire. However, the complete dependence of industrial, commercial and financial giants on data processing by the 1970s, often without robust contingency plans for recovery of operations in the event of fire, was of almost frightening proportions.

In parallel with this, during the 1960s and 1970s, the UK was becoming less and less of a great industrial nation. Prior to this, the potential for interruption to the business of a large industrial conglomerate was often limited by the number of locations at which a product could be produced. As capacity for production began greatly to exceed demand, the potential for consequential loss declined even further to the extent that, in the event of loss of one production facility, the company might gladly accept the payout of the property insurer and find no need to even rebuild the sometimes redundant facility.

Gradually, however, British industry became much leaner, with production of certain product lines restricted to a single location. At specific locations, there could be frequent 'bottlenecks', comprising a single facility or process, the loss of which might prevent completion of production of the output of many production lines and even multiple locations.

The onward growth of the ubiquitous microprocessor, and the miniaturization of electronics, also led to situations in which all control of production in a major factory could depend on the availability of control equipment that could be housed in a relatively small space, no longer needing a special environment and capable of being housed in a small corner of the factory floor. As reverting to any form of manual control of the production processes became less and less possible, companies found themselves in the position that a relatively small fire involving an electronic control cabinet could result in huge consequential loss.

In more recent times, the 'just in time' policies of modern industry also bring new vulnerabilities to consequential loss in the event of fire. Rather than companies holding huge buffer stocks in large warehouses that form the interface between production and retail to consumers, many companies now operate on a much more direct chain between production and supply, with products being delivered 'just in time', rather than being delivered from a major stockholding in large warehouses.

By the early 1970s, the FOC had produced recommendations for protection of the major computer halls that were much more prevalent then than now. These recommendations were the foundation for what, ultimately, became BS 6266.[3] The latest version of BS 6266 recognizes that vulnerability to major business interruption can arise not just from data-processing facilities, but from a wide range of electronic facilities, including those associated with telecommunications, Internet servers, mobile telephone base stations, call centres, etc. The scope of the current version of BS 6266 therefore encompasses all electronic equipment installations, particularly those that are critical to the functioning of a business.

In the case of electronic equipment, the likelihood of fire in a modern installation is very low, but the high levels of fire protection often specified for such installations are the result of the huge consequential loss that can result if a fire does occur. Moreover, a fire protection strategy that addresses only the hazard of fire within the installation itself is severely flawed, as, frequently, fires that affect critical electronic installations originate outside the room containing the installation and spread into the installation; this dictates a need for fire-resisting construction around the installation itself and, often, fire detection or extinguishing systems in surrounding areas of the building, which might, on the face of it, house only relatively mundane office accommodation for which, otherwise, high levels of protection would not be warranted. Moreover, attention needs to be given to ancillary facilities, such as electrical switchrooms, air conditioning plant rooms, communication rooms, telecommunications and power cables, etc., on which the functioning of the critical facility depends.

Measures to protect a business against business interruption in the event of fire cannot be formulated purely by inspecting the building and its facilities. The fire protection strategy, in this case, needs to be founded on a form of business continuity fire risk assessment. This necessitates a thorough understanding of the business, a knowledge of its contingency plans for recovery in the event of loss of facilities, and an analysis of 'vulnerable' areas and operations, on which the functioning of the business depends.

In a manufacturing environment, the analysis will involve discussions with production personnel, as well as, possibly, the company's financial and marketing specialists. For example, it may be wholly inappropriate to spend large sums of money on fire protection to safeguard the production of a product that operates at a loss and that the manufacturer might gladly withdraw from the market.

In considering the potential for consequential loss, it may also be relevant to take account of marketing issues, such as product differentiation. For example, if the consumer perceives one manufacturer's blackcurrant drink to be wholly different from competitors' products, such as supermarket brand names, removal of the drink from retailers' shelves for one week will have no lasting effect; the manufacturer will lose the profit on one week's sales, but the consumer, having bought an alternative product for that week, will switch back to their preferred product as soon as it becomes available again. On the other hand, if the consumer perceives that all blackcurrant drinks are equivalent, having switched to an alternative product, there is no particular reason to switch back, and a permanent loss of market share can result.

It is clear from the above considerations that a visual inspection of a building or facility is of no assistance in determining the appropriate fire protection strategy to avoid business interruption. A major data-processing facility may, visually, appear to present a complex and important risk, housing tens of millions of pounds worth of equipment. However, it could be the case that the facility operates 'back to back' with a parallel facility in another location, which, at a moment's notice, can seamlessly take over the first facility's role. On the other hand, a small basement plantroom, housing equipment worth only a few thousand pounds, might attract little attention in a fire safety audit that is directed towards life safety or property protection, but the entire operations of an organization might depend entirely on the functioning of the equipment.

It should not be assumed that these considerations apply only to industrial organizations with a tangible product, financial institutions, etc. For example, in the case of a hospital, service delivery (i.e. treatment of patients) may depend heavily on patient records, ancillary facilities, such as MRI scanners, the availability of operating theatres, etc. For premises such as hotels and residential care premises, consideration has to be given to how residents would be housed in the event of a major fire; in this case, the potential for consequential loss might be best minimized by contingency plans (e.g. a mutual arrangement with another hotel or residential care premises), rather than additional fire precautions. Similarly, in service industries, such as those operating call centres, resilience in business can best be achieved by facilities to route calls to another call centre in the business, but, where this is not possible, very high standards of fire protection might be warranted, particularly in unoccupied supporting facilities, such as telecoms rooms.

Protection of the environment

Finally, there is now a greater awareness of the potentially damaging effects of fire on the environment, and it is likely that even more attention will be given to the need to protect the environment against the effects of fire in the future. The obvious implications in this respect relate to run off water from fire-fighting operations, which can find its way into the nation's waterways. If the fire involves environmentally harmful materials, toxic chemicals, etc., the implications for the environment are obvious. The environmentally harmful materials can include the materials used in building construction, such as asbestos cement roofs. An extreme case would, for example, be an organization that handles radioactive materials, which, if released into the environment as a result of fire, could cause widespread and long-term harm.

On a more general level, it is beginning to be argued that any large fire is harmful to the environment. This gives rise to the question as to whether the concept of the 'sacrificial building', such as a massive, unsprinklered warehouse, should even be permitted. The risk to life may be minimal, the owner of the building may be prepared to sacrifice it in the event of fire, rather than fit expensive fire protection installations, and it could be that alternative warehousing space could be obtained and rented without major consequential loss to the company. It is sometimes argued that risk to fire-fighters can be obviated by simply permitting the building to burn down, once it is known that all occupants have escaped safely. This then begs the question as to whether society is prepared to accept the occurrence of such fires and the potential harm they cause to the environment.

References

1. BS 5306-2, *Fire extinguishing installations and equipment on premises — Part 2: Specification for sprinkler systems*
2. BS 5839-1, *Fire detection and fire alarm systems for buildings — Part 1: Code of practice for system design, installation, commissioning and maintenance*
3. BS 6266, *Code of practice for fire protection for electronic equipment installations*

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Community fire safety

The focus of this book, thus far, has related to fire safety in non-domestic premises; this is entirely appropriate as the intended readership comprises those with responsibility for fire safety in such premises, such as health and safety practitioners, facilities managers, designers, building surveyors and those charged with enforcing fire safety legislation. In general, the professional work of the majority of the readership will not be principally concerned with fire safety in single-family dwellings. However, equally, the intent of this book is to provide a broad insight into all aspects of fire safety, and into all means, both physical and strategic, by which loss of life, injury, damage to property and interruption to business, as a result of fire, can be prevented or mitigated. It would therefore be inappropriate to ignore the importance of community fire safety in the furtherance of these objectives.

What is community fire safety?

There is no universally agreed definition of the term community fire safety (CFS), but CFS activities are generally understood to comprise proactive efforts to reduce the incidence and impact of fire through education, information and publicity. The main focus of CFS is to secure the safety of the population from fire, with particular emphasis on fire safety in dwellings. Equally, although, initially, CFS related primarily to domestic fire safety, the term is now often considered to encompass advice and assistance to the business community. The need for this broad concept of CFS is established by the Fire and Rescue Services Act 2004,* which imposes requirements in respect of CFS activities on fire and rescue authorities.

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* In Scotland, the Fire (Scotland) Act 2005; in Northern Ireland, the Fire Services (Northern Ireland) Order 2006.

Background to community fire safety

In the Introduction to this book, it was observed that 75–80 per cent of deaths and injuries from fire occur in dwellings. Yet, other than in the case of houses in multiple occupation (HMOs), traditionally there has been no ongoing legislative control over fire safety in dwellings, once constructed in accordance with building regulations. (This has changed more recently, as, in England and Wales, the Housing Act 2006 now permits action to be taken by housing authorities in the event of risk to occupants of single-family dwellings, as well as risk to occupants of HMOs. Even so, it would still be rare for any fire precautions to be imposed on an existing single-family dwelling under the powers of legislation.) In any case, legislation is something of a 'blunt instrument' to use to influence fire safety in single-family dwellings, particularly those occupied by the owners of the property. Nevertheless, if there is a desire to reduce deaths and injuries from fire, more needs to be done to assist and educate the public. In contrast, business is more capable of looking after itself in terms of fire safety, and this is acknowledged in the philosophical underpinning of the new generation of fire safety legislation (see Chapter 1).

Until the 1990s, the role of the fire and rescue service was traditionally one of intervention, in the sense of dealing with fires once they occurred. Although most fire and rescue services provided some form of fire safety education, there was no statutory duty for them to undertake this work. As a result, it only attracted limited resources and was not regarded by most fire and rescue services as an integral function of a fire and rescue service. Indeed, for a long time there was a great deal of scepticism about whether the fire and rescue service should be involved in educating the public, and whether doing so could actually make a difference.

Against this background, by the late 1990s, casualties from fires in dwellings had risen by 50 per cent over a 10-year period. Although 79 per cent of homes had smoke alarms, they were present in only 25 per cent of the dwellings that actually suffered a fire, and these raised the alarm in only 40 per cent of cases. This mirrored experience in the United States, where it had been found that those most in need of smoke alarms, in terms of likelihood of fire and risk of death or serious injury from fire, were those least likely to possess smoke alarms.

The Audit Commission report, *In the Line of Fire*,[1] published in 1995, recommended that greater priority should be given to fire prevention work, but arguably the major turning point in the development of CFS as a central focus of the fire and rescue service was the publication in 1997 of the *Safe as Houses*[2] report. This report, produced by the Community Fire Safety Task Force appointed by the Home Secretary, concluded that the majority of dwelling fires were preventable, as they resulted primarily from a lack of care or inappropriate behaviour on the part of the householder. It was argued that householders needed, therefore, only to take fairly simple measures to prevent fires occurring.

The establishment of the National Community Fire Safety Centre (NCFSC) in 1998 was a central recommendation of the *Safe as Houses* report. This led to a significant increase in the budgetary resources assigned to CFS, and helped to initiate a major programme of cultural and operational change in the fire and rescue service, in which a main objective became fire prevention. At that time, the CFS activities of fire and rescue services were not, however, underpinned by the requirements of legislation.

A great deal has changed since the publication of *Safe as Houses*. The Fire and Rescue Services Act 2004* has placed a statutory duty on the fire and rescue service to promote fire safety. In England and Wales, the Government's *Fire and Rescue Service National Framework*,[3] published in 2004, set out the Government's expectations of fire and rescue services. The Integrated Risk Management Plans (IRMPs), which fire and rescue authorities have been required to produce, heralded a new approach. In this respect, there have been great cultural and operational changes within fire and rescue services, and CFS is now accepted as a core activity of the fire and rescue service.

National Smoke Alarm Campaign

One of the most successful Community Fire Safety initiatives over the last 20 years has been the National Smoke Alarm Campaign, which began in 1987. The campaign owed its origins to two factors. First of all, technology and bulk manufacture made smoke alarms an affordable safety product. Secondly, the Government acknowledged the benefit of smoke alarms in 1988, when it published the first version of *Smoke Alarms for the Home*,[4] for the first time positively advocating the retrospective installation of smoke alarms in dwellings by householders.

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* and equivalent legislation in Scotland and Northern Ireland.

Government commitment to the installation of smoke alarms in dwellings was based on sound statistical evidence, which showed that, in the event of fire, the likelihood of a fatality was significantly reduced if the fire were first detected by a smoke alarm. (Current statistics suggest a reduction by a factor of between two and three.) A pilot campaign was launched in the north-east of England in 1988, which led to a doubling in smoke alarm ownership in that area. As a result of that success, the Government decided to embark on a major long-term campaign to increase smoke alarm ownership by 1994.

The initial campaigns saw a significant increase in ownership across the general public, but, despite this, paradoxically, ownership remained low amongst high-risk groups, particularly the elderly and those on low incomes. To address this, in England, the Government launched a four-year, £25m capital grant programme in 2004 to increase smoke alarm ownership, particularly amongst these vulnerable groups. The *Home Fire Risk Checks* initiative aims to target 1.23m vulnerable homes and provide them with long-life, battery-operated smoke alarms and other specialist devices, such as smoke alarm kits for deaf and hard of hearing people. (A British Standard for these kits, BS 5446-3, was published by BSI in 2005.) Fire and rescue services are also able to use this funding to purchase and install fire suppression systems in high-risk households. In England, the Government has reinforced this initiative through media and publicity campaigns under the 'Fire Kills'* banner.

Education in schools

Schools have traditionally been an area in which the fire and rescue service has devoted people and educational resources. There is evidence that this long-term investment is successful, but it is often difficult to secure time for schools to devote to safety education in a busy curriculum. This is despite the widely acknowledged and disproportionate number of childhood injuries and, indeed, the fire safety concerns for school buildings themselves.

Fire is one of the leading causes of accidental injury and death amongst children. Although, as with all domestic fire deaths, the number of children who die each year in domestic fires shows a continuing downward trend, in 2005, 30 children under the age of 16 still died, and over 1,200 were injured, in fires in dwellings. There is, therefore, justification for further effort to drive down the numbers still further.

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* http://www.firekills.gov.uk

Wide inequalities in the rates of accidental injury among children also exist. Evidence from the Institute of Child Health suggests that children from lower socio-economic groups are 16 times more likely to be killed in house fires than children from higher socio-economic groups.

Fire safety education, as a life skill for children is vital, not only because of the life-long messages and skills that can be absorbed, but also because schoolchildren can influence fire-safe behaviour in the home. This can have a significant impact on adults of all ages, including older members of the family, who may be at greater risk.

In 2006, the National Community Fire Safety Centre produced a comprehensive fire safety education programme designed to increase fire-safe behaviour amongst primary and secondary schoolchildren by increasing their awareness of the risks from fire and appropriate behaviour in the event of fire. Although the original intent of the programme related purely to the reduction of fire deaths in dwellings, the final programme was extended to include reduction of hoax calls and arson. The programme, which is intended to be delivered primarily by teachers with support of local fire and rescue services, is available to download from the Fire kills website.*

Central Government initiatives on education have been mirrored by initiatives within individual fire and rescue services. For example, Northumberland Fire and Rescue Schools Education Programme is an initiative originally funded by a Local Public Service Agreement. The aims were, and still are, to influence the attitudes and behaviour of children and young people, particularly towards deliberate and preventable fires. The initial project ran for three years, with a target of 32 per cent reduction in both deliberate fires and hoax calls. The target figure for deliberate fires was 1,515, with an actual figure of 1,315 achieved. The target figure for hoax calls was 178, with an actual figure of 134 achieved.

Home Fire Risk Check

Virtually all fire and rescue services offered free home fire risk checks, even before an initiative in England and Wales by the then Office of the Deputy Prime Minister (ODPM) in 2004 gave formal guidance on programmes for this work, under their Home Fire Risk Check Initiative. The Initiative did,

* http://www.firekills.gov.uk/education/index.htm

however, expand this work by means of a four-year grant, with particular emphasis on free installation of long-life, battery-operated smoke alarms and, in some cases, fire suppression systems.

Home fire risk checks are a means for involving local operational fire crews in CFS. Fire-fighters visit homes and, using simple questionnaires, identify hazards, and give advice to householders on fire prevention, escape plans, etc. as well as, of course, advising on fire detection, with installation of smoke alarms where necessary.

Evidence for success of Community Fire Safety

From the early days of CFS, it was quickly established that, in areas of the country where fire and rescue services actively promoted community fire safety, there were significant reductions in the number of fires and casualties from fire. For example, in Scotland, Lothian and Borders Fire and Rescue Service reduced deaths by two-thirds as a result of targeted efforts in the worst areas of their region. West Midlands Fire and Rescue Service, over a six-year period, achieved a reduction in annual fire deaths from 50 to less than 20. In Avon, the average number of annual fire fatalities was halved over a 10-year period, while, in Northern Ireland, deaths were reduced from 27 down to 8 within 10 years.

However, perhaps the greatest evidence for the success of CFS can be found in national fire statistics. In most years since the publication of *Smoke Alarms for the Home* in 1988, domestic (and, hence, total) annual deaths from fire have decreased from the previous year. Ultimately, 2004 was something of a milestone, in that the total number of deaths from fire in that year (508) was the lowest for 45 years, something of a huge success story that, sadly, attracted little publicity, as good news is regarded as much less newsworthy than bad news. In the case of dwellings, the 375 fire deaths that occurred in 2004 was the lowest ever since domestic fire deaths were first recorded separately from deaths in non-domestic premises in 1960.

At the time of publication of this book, the latest full year for which fire statistics are available is 2005. The total number of fire deaths in that year (491) was the lowest recorded since 1959. Although, in 2005, domestic fire deaths remained at the 2004 level (376 deaths), provisional figures for the year ending 31 March 2006 suggest a further drop in domestic fire deaths in that 12-month period, from 373 to 334 deaths.

Other CFS activities

CFS is generally associated with the main initiatives described above, such as the well-publicized smoke alarm campaigns, home fire safety checks and education in schools, plus, in more recent years, provision of fire suppression systems in extreme cases. However, government funding for CFS, in conjunction with innovative lateral thinking by fire and rescue services, has enabled many imaginative initiatives by fire and rescue services, often involving very specific actions to safeguard particular high-risk families or individuals.

Specific actions have included measures as diverse as provision of fire retardant bedding for bed-bound smokers, replacement of old upholstered furniture with more ignition-resistant furniture, provision of fireguards and exchange or removal of dangerous portable heaters.

Inter-agency cooperation with local councils in many areas has resulted in actions to address fly-tipping, removal of rubbish and removal of abandoned cars, all of which would, otherwise, increase the potential for malicious ignition.

Sometimes, CFS activities extend into voluntary work outside the main scope of a fire and rescue service's CFS activities. For example, in Merseyside, the Fire Support Network is the voluntary arm of the fire and rescue service. Their work can be unusual and innovative. For example, the Fire Support Network has provided an elderly high-risk resident with a dog trained to respond to the sound of a smoke alarm. The dog is trained to shut the door of the occupant's room, place a cloth against the bottom of the door and initiate communications with a control centre. Another initiative by the Network involves cleaning ovens of vulnerable residents in the Wirral, where at least two oven fires were occurring each week.

CFS in Wales, Scotland and Northern Ireland

Many of the references to the development of CFS in this chapter, such as those relating to the formulation of government CFS policies, the work of the NCFSC, etc. strictly relate specifically to England and, in many cases, Wales. With regard to Wales more specifically, Action Firebrake is a charitable organization working in partnership with the Welsh Assembly and the three Welsh fire and rescue services. The key objective of Action Firebrake is to reduce the number of deaths and injuries through fire-related incidents in Wales by public education, promotional activity and research.

Parallel work to that carried out in England and Wales in respect of CFS has been carried out in Scotland and Northern Ireland, where legislation and policies concerning fire and rescue services are devolved to the Scottish Parliament and the Northern Ireland Assembly; the relevant government departments are the Scottish Executive and, in Northern Ireland, the Department of Health, Social Services and Public Safety, both of which have actively encouraged CFS activities by fire and rescue services.

For example, the Scottish Executive funds and operates a television, radio and press campaign related to domestic fire safety called '*Don't give fire a home*'. The Executive also operates a website* that includes information and resources aimed at providing advice to children aged 4–14 years old.

In Northern Ireland, there is only one fire and rescue service. CFS initiatives are promoted through the Community Development Directorate. These initiatives have been very successful. For example, 98 percent of households in Northern Ireland now have at least one smoke alarm. The Community Development Directorate have a defined policy with key targets and priorities in line with those elsewhere in the UK, including measurable reductions in dwelling fires, accidental fire deaths, deliberate property fires and hoax calls.

Future of Community Fire Safety

Since its creation, CFS has been an enormous success story. In England, the strategic lead of the NCFSC helped considerably in making proactive fire safety and fire prevention work a core activity of the fire and rescue service. Similarly, the work of the Centre has played a key role in helping the fire and rescue service in its endeavours to deliver the Government's target to reduce accidental fire deaths in the home by 20 per cent from the 2001/2 baseline figure by 2010. As already noted, there has been a steady downward trend in fire deaths over the past decade, and the target is almost certainly realizable.

It might, however, be said that the NCFSC was a victim of its own success, as, sadly, after nine years of proven track record in furthering the Government's objectives of reducing fire deaths and injuries, in 2007 the Government announced the closure of the NCFSC. The rationale behind this is that the NCFSC had '*successfully discharged most of its functions…*' and '*much of*

* http://www.infoscotland.co.uk/blazeaware

the NCFSC work is regarded as mainstream activities by Fire and Rescue Services'. This might, arguably, have created a modicum of uncertainty for the future. Nevertheless, there can be little doubt that, both in theory and on the basis of experience, the future for reduction, and certainly the control, of domestic fire deaths and injuries rests with community fire safety.

Further reading

Safe as Houses. The report of the Community Fire Safety Task Force. Communities and Local Government. ISBN 185893569.

BS 5446-3, *Fire detection and fire alarm devices for dwellings — Part 3: Specification for smoke alarm kits for deaf and hard of hearing people*

References

1. *In the Line of Fire — Value for Money in the Fire Service: The National Picture Audit Commission*. February 2005. ISBN 118864041.
2. *Safe as Houses*. The report of the Community Fire Safety Task Force. Communities and Local Government. ISBN 185893569.
3. *The Fire and Rescue Service National Framework 2004/2005*. Communities and Local Government. Product Code 04FHSD01271.
4. *Smoke Alarms for the Home*. Communities and Local Government. Product Code. FS015ALLLOGO.

A COMPREHENSIVE GUIDE TO FIRE SAFETY

This easy-to-read publication is virtually unique in the breadth with which it tackles the allied subjects of fire prevention and fire safety management. Previously published as *Fire Precautions: A guide for management*, this book has been thoroughly revised and updated to incorporate explanations and guidance relating to the Regulatory Reform (Fire Safety) Order and related legislation in Scotland and Northern Ireland.

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