The BS 9999 Handbook

Effective fire safety in the design, management and use of buildings

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About the authors

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Michael Green is a chartered engineer, a partner of Buro Happold, and was responsible for the early development of their fire safety engineering consultancy team, FEDRA, with an involvement on fire safety since 1979. In addition to major international sports, cultural, transportation and commercial projects, he has made many contributions to the fire safety profession. This includes development of an approach to the appraisal of existing sports grounds, published by the IStructE in 1991 after the tragic fire at the Bradford North Stand. Subsequently he chaired the production of two further guides: An Introduction to the Fire Safety Engineering of Structures (2003) and An Advanced Guide on the Fire Safety Engineering of Structures (2007). He was also the author of the smoke and ventilation section of the CIBSE Guide E (1997). An early involvement with the development of BS 9999 from 1998, when work first began on this standard, has enabled an ongoing contribution to the BSI committee.

Michael continues to be a strong advocate of research and its application in the design and operation of buildings. He has strong links with many universities internationally and is a director of Vulcan Solutions, a joint venture company with Sheffield University.

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Foreword

The publication of BS 9999 was a major milestone in the development of British Standards relating to fire safety in buildings and, in consequence, took a long time to come to fruition. Following the issue of Part 11 of BS 5588 in 1997, a review established a need for a full review of the whole BS 5588 series which had grown over a period of years and which in themselves were developments from Codes of Practice developed in the late 1940s.

The review identified a number of problems with the existing documentation and a need for common national guidance which would be used by regulators, designers, users, and enforcers was identified. Work started in early 1998 and in June 2001 BS 9999-2 was issued as a Draft for Public Comment. A decision by regulators to reform existing fire safety legislation in UK necessitated a change of direction which resulted in the document being issued as a BS DD (Draft for Development) coupled with a new Part 12 to BS 5588 using the ‘Managing Fire Safety’ material from BS 9999-2. Resulting from further changes in legislation and issued Government Guidance, these stages were not finally completed until mid 2005.

In late 2006, work to turn the DD into a BS commenced; this included integration of BS 5588 Parts 5 and 12. Resulting from 2006/7 research on fire-fighter physiology and fire service practice, amendments were needed to the text from BS 5588-5 on incorporation into BS 9999 and the fully revised text for BS 9999 was issued as a Draft for Public Comment (DPC) in January 2008 and as a final document in October 2008.

BS 9999 is one of the most important guidance documents dealing with fire safety in buildings and, as stated in the document, its principal purpose is ‘to provide Guidance which gives a more transparent and flexible approach to fire safety design through the use of a structured approach to risk-based design where designers can take account of varying physical and human factors’. Although the guidance is based on fire safety engineering principles, it is not a guide to fire safety engineering.

I believe the document does exactly what was intended when the work started over 10 years ago and since its publication in 2008, BS 9999 has been used extensively and there have been numerous seminars and courses covering its scope and application. The publication of this book provides additional help and
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guidance to those using the Standard and to those who have previously had doubts about using it. The text of the book has been carefully structured, covering all aspects of BS 9999 and includes some useful worked examples.

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Introduction

BS 9999 and consequently this guide are intended for use by designers, fire engineers, fire and rescue services and fire safety managers. However, they are also clearly of value to regulators, enforcers, operators/end users/clients, insurers and contractors. The standard is designed as a holistic guide to bring together the key areas of fire safety:

- design for means of warning and escape;
- fire resistance performance to protect means of escape and provide structural stability;
- the provision of access and facilities for fire fighting;
- fire safety management.

BS 9999 contains a number of important changes from the guidance in the BS 5588 series, particularly in the approach for design of means of escape and construction. It also introduces the concept of the risk profile. It brings forward guidance from BS 5588-5 and BS 5588-12 and has taken into account the input from a major public consultation process. When compared with the various national guidance documents and other British Standards, some fire protection measures have been increased and others have been reduced to better reflect the risks that are more clearly identified by relating to both the characteristics of occupants and the potential for fire development in a more integrated way. This applies to means of escape, fire resistance and fire-fighting provisions.

The recommendations specifically relating to fire-fighting have been updated to take into account the findings of the Building Disaster Assessment group (www.communities.gov.uk/fire/researchandstatistics/fireresearch/buildingdisasterassessment/).

In the UK, technical guidance on fire safety is provided at three different levels. This permits a design approach to be adopted that corresponds to the complexity of the building and to the degree of flexibility required. The three levels are as follows.

- General approach. This level is applicable to a majority of building work undertaken within the UK. Fire precautions designed into the building usually follow the guidance in various national prescriptive documents (e.g. Approved Document B) published to support legislative requirements.
Introduction

- **Advanced approach.** This is the level for which BS 9999 is provided. Guidance provided gives a more transparent and flexible approach through use of a structured process to risk-based design to account for different fire and human factors. Much of the guidance in BS 9999 is based on fire safety engineering principles, although it is not intended as a guide to fire safety engineering.

- **Fire safety engineering.** This is the level for which BS 7974 is provided. This level provides an alternative approach to fire safety and can be the only practical way to achieve a satisfactory standard of fire safety in some large and complex buildings.

An early decision by the client and the design team on the most effective and efficient approach is recommended so that the needs of the project are best served. There might be circumstances in which it is necessary to use one publication to supplement another, but care needs to be taken when using a ‘pick-and-mix’ approach as it is essential to ensure that an integrated approach is used in any one building. Clear justification is necessary if this approach is adopted.

The method of procurement of a building and the time at which a future operator/end user can be identified is subject to a number of variables that cannot easily be prescribed. It is therefore particularly important that fire safety information, risk assessments and other relevant data throughout the whole design, procurement and the operation of a building are made available by those responsible at the different stages.

As per the standard, this guide does not cover the design of individual dwelling houses, flats or maisonettes. For guidance on the fire safety design of these types of premises refer to BS 5588-1.¹

**Use of this handbook**

This handbook, like BS 9999, takes the form of guidance and recommendations. It should not be quoted as if it were a specification, and particular care should be taken to ensure that claims of compliance are not misleading.

¹BS 5588-1 is due to be replaced by BS 9991 in late 2010.
The primary purpose of this handbook is to provide a ‘pocket’ guide to the use of BS 9999 that is easy to use and draws together the key areas of fire safety design that require consideration during the early development of design concepts. The handbook provides an aid to the understanding and use of BS 9999 and is not intended to be a substitute for the standard. The most commonly used data, tables, figures and a ‘Key Points’ list at the beginning of each chapter provide a quick and effective overview of the measures that may be necessary. In addition, a methodology is presented to help the user find the best approach to deploy the flexible design recommendations introduced by BS 9999.

Although it is a prescriptive guide, BS 9999 has a relationship with fire safety engineering, and the opportunity for adopting such an approach has been identified in a number of places throughout this handbook. The use of the guidance involves limited calculation and engineering but does require knowledge of fire safety in order to best judge the most appropriate package of fire protection measures, management and training. It does allow for the trade-off of one fire protection measure against another within a limited framework beyond which a fire safety engineering approach would be required.
1. General

Principles

The recommendations given in the British Standard are general, and all fire protection measures, procedures, etc., need to take into account the particular circumstances of the individual building or complex concerned. The same recommendations generally apply to both existing and new buildings, but existing buildings, especially historic buildings, often pose problems that are unlikely to arise in new buildings and, therefore, require further consideration by adopting a flexible approach in the risk assessment process.

Although it is a prescriptive guide, BS 9999 provides a higher level of flexibility than many prescriptive standards. It supports the concept of achieving the best balance between an adequate performance and reasonable value. This has been possible because the original basis of the recommendations gave recognition to many of the engineering principles embodied in BS 7974. Where relevant and useful, a brief background is provided in each of the chapters.

The guidance is straightforward to use for routine and typical buildings, but the inbuilt flexibility will also support a sustainable reuse of our built environment. The following areas are an essential contribution:

- The identification of alternative flexible solutions to support the preservation and the extended use of historic buildings, balancing the requirements of modern construction standards and the need to be sensitive with historic structures and finishes, is required.
- The logical approach that is embodied in the code enables a relatively simple risk assessment to appraise a change of use by addressing the fundamentals that affect the outcomes: the fire load and the occupancy characteristics. This will increase the overall ability of the design community to identify alternative solutions that are good value, sustainable and safe.
- The design of a new building to be adaptable for reuse at some future time is a new challenge, which if successful will significantly enhance the life of our building stock. The flexibility contained within BS 9999 allows designers to plan for alternative future uses without the addition of a disproportionate cost premium. The same flexibility equally allows alternative interpretations when appraising an existing building for alternative uses.
General

No one building or operator/end user/client is exactly the same as another, so a code of practice, such as BS 9999, can provide only a framework for the designer and the operator/end user/client to make an informed judgement on the most appropriate package of fire protection measures to meet both the requirements of the designer and the objectives of the building operator/end user/client. Fire precautions in all premises, however old, need to be seen as a whole, a package aimed at achieving an acceptable standard of fire safety.

BS 9999 applies straightforwardly where premises have a single main use and are contained in a single, separate building. However, complications might arise where a building comprises two or more different main uses. In such cases, it is important to consider the effect of one risk on another. A fire in a shop or unattended office could have serious consequences on, for example, a residential or hotel use in the same building. Similarly, a high fire risk in one part of a building could seriously affect other areas in another part of that building. A worked example in Chapter 15 provides an illustration of how to approach different risk profiles within a single building.

Spread of fire and smoke

A common basis for designing fire safety measures lies in the identification of the possible causes and sources of fire, and the evaluation of the development and spread through a building.

The fact that outbreak of fire is more likely to occur in furnishings, decorations, finished goods, raw materials, chemicals, equipment, electrical services, process plant, or service plant in a building has been taken into account in the development of the standard. Initially, a fire creates a hazard only in the part of the building in which it starts, and it is unlikely to involve a large area in the first instance, although it can subsequently spread to other parts of the building, and vertical shafts such as lifts and service risers are a particular risk. Fire is less likely to spread if passages, corridors, lobbies or stairways, intended for access or means of escape, are kept clear of combustible materials. As the fire grows, flames increase in height, reach the ceiling and are deflected horizontally, radiating heat downwards and accelerating fire growth. If the ceiling is combustible, it can ignite and add to the volume of flame and speed of fire growth. If the space has insufficient openings to provide a continuing air supply, the burning rate diminishes as it draws on increasingly vitiated air, but the gases generated are then extremely toxic.
The impact of fire on people

A fire occurring anywhere within a compartment of a building has to be regarded as presenting a hazard to all occupants within that compartment, even though the hazard may seem small in the initial stages. When a fire occurs in an enclosed space, hot smoke-laden toxic gases rise to form a layer, which at first has a tendency to flow under the ceiling and then deepens to fill the whole space. Smoke is likely to be the first sign that there is a fire. For higher and larger spaces, it takes longer for the space to fill with smoke, and so there is more time for escape, and therefore longer travel distances and smaller stairs are possible. Higher fire growth rates reduce the time available.

When smoke descends down to head height it causes difficulty in breathing and impairs visibility, which interferes with the efforts of occupants to find their way towards the exits. Smoke can cause intoxication, disorientation, incapacity, unconsciousness and, in the worst-case scenario, fatalities.

These considerations are particularly important when dealing with large numbers of people, who might be unfamiliar with their surroundings, and vary widely in age and degree of mobility. Also, when people are unfamiliar with their surroundings they might initially go in the wrong direction or they might not take the most direct path and, therefore, the average speed of travel to an exit could be slower than a typical average walking speed.

To facilitate escape it is therefore necessary:

- to ensure that protected escape routes are provided and that they are adequately safeguarded against the ingress of smoke;
- to limit the time people have to travel before they reach a protected route or final exit;
- to consider reverse flows that might occur as a result of a particular exit route being unavailable;
- to plan evacuation for disabled people in an integrated manner.

A means of smoke ventilation might be necessary to assist the fire and rescue service and, if operated automatically, can also assist escape from the building.

After the outbreak of fire there might only be a short time during which the actions necessary for ensuring the safety of occupants can be carried out. This time will be sufficient only if all provisions for the safety of people from fire are planned and managed so as to be effective when the occasion arises.
Historic buildings

Many historic buildings are listed, and permitted alterations are limited without the agreement of the appropriate authorities. The advice of consultative bodies, such as English Heritage, should be sought in the early stages of design. The appropriate authorities sometimes agree to limited modifications to improve life safety where, in turn, there will be added long-term protection and preservation of the original building fabric. Issues relating to historic buildings include:

- the preservation of the ambience and important features of the building, such as timber linings to accommodation stairs and slender cast iron structure, both of which can sometimes conflict with the desired fire safety but can be accommodated with suitable compensating features;
- the existing construction of the building, including hidden features such as cavities through which fire could spread and the fire performance of walls, partitions and floors;
- the interrelationship between life safety and measures to protect property/contents;
- the fire performance of the building structure. Although modern construction standards seldom apply to historic buildings, action to improve the level of fire and life safety might be necessary on the basis of change of use or due to the need to reduce the fire risk and potential for loss of the building and its contents.

In assessing the fire safety management needs of an existing building that is being modified, it is essential to have a full understanding of the existing structure (Appraisal of Existing Structures, 3rd edition, IStructE) and any fire safety provisions incorporated. Any change in use of the premises that could affect the fire risk profile (e.g. increased fire load and process risks, introducing the public, changes to sleeping risk, seasonal changes) should be considered. Also the legislation and guidance introduced since the premises were originally constructed or last altered, or since their fire safety was last assessed, should be reviewed.

In both new construction and upgrading existing buildings, the fire precautions are interrelated and weaknesses in some areas can be compensated for by strengths in others. BS 9999 provides a level of flexibility that allows the fire protection measures and the risks to be assessed to enable reasonable practical solutions to be designed.
**Property and business continuity protection**

The guidance and recommendations in BS 9999 are primarily concerned with the protection of life. The provision of fire safety systems for life safety does not necessarily give adequate protection to property or to the continuity of the business carried out in the building.

Smoke and fire spread are major causes of property damage and losses that include:

- property: contents, fabric and building services;
- business: loss of trade, loss of operational continuity, loss of records.

The objectives are first to reduce the chance of fire starting and second in the event of fire starting to reduce the consequences of that fire. Because many of the features necessary for life safety are common, the risk assessment for property and business continuity protection could be an extension to other risk assessments carried out for life safety. The following are the primary means of achieving the objectives:

- the first barrier to property and business loss is the level of fire prevention management in the building. This is to ensure that ignition hazards are eliminated or controlled, that operations in the building are carried out appropriately and that combustible loads are subject to control and good housekeeping.
- smoke management (mechanical, natural, pressurization) to prevent damage from heat and corrosive chemicals in the smoke;
- compartmentation and structural fire protection to reduce spread of fire between spaces. The complete involvement of the whole fire compartment is an extreme-event scenario. Adequate detailing of cavity barriers, fire-stopping doors, shutters, fire resistance, etc. is important to maintain the performance of the compartment walls and floors.
- fire-fighting facilities, including consideration of speed of response and the tactics for external and internal fire-fighting;
- external fire spread and building separation. For most buildings it is expected that these provisions for life safety will also be adequate for property protection. However, for some buildings and uses the provision may need to be more stringent. Consideration should be given to buildings having highly glazed façades.
- automatic suppression systems to reduce fire severity such as sprinklers, etc.
General

The consequences of fire on property and business loss can be highlighted to the owner, occupier, operator/end user/client, tenant, designers and insurers and can involve discussions on the acceptable level of risk.

Any changes in the design added for the purpose of property protection should be discussed with the relevant authorities to ensure that there is no adverse impact on life safety. If a conflict exists between the provisions for life safety and property protection that cannot be resolved, then life safety takes priority.

The risk assessment could range from a simple statement outlining the potential property and business losses that are acceptable to business managers and their insurers, through to a rigorous quantified analysis of probabilities and consequences of fire. Whatever method is used, the aims of the risk assessment should be understood by all concerned.

The insurance industry has produced various guides that are directed at property protection (including FPA guide Essential Principles and guidance published by the Arson Control Forum, Arson Prevention Bureau and Zurich Municipal). Arson and vandalism are addressed by guidance produced by the Arson Control Forum and the Arson Prevention Bureau.

Many insurers use the LPC Design Guide for the Fire Protection of Buildings as a basis for providing guidance to the building designer on what they require.

BS 9999 is the first significant design standard that embeds the quality of the management into the design process. Many fire losses are due wholly or in part to failures in management so it makes good sense to draw attention to the management needs. It will also be increasingly important for the insurance industry to build the quality of the management into their methodology to help reduce losses. However, trade-off for enhanced management, enabling reductions in the built provision, is not allowed in the standard.

Reference should be made to Annex A of BS 9999 for additional considerations for property and business continuity protection.

Means of escape for disabled people

Means of escape for disabled people, and the associated fire safety strategy, should be considered as an integral part of the design process, and not as a separate issue. Where a building is designed and managed inclusively to provide
access for all users, the facilities provided should, where appropriate, be used to improve egress arrangements.

Fire safety for disabled people is included within the standard; this includes consideration of all disabilities and is not restricted to guidance for assisting wheelchair users. Specific guidance on means of escape for disabled people is given in BS 9999: Clauses 17.7 and 18.8; general guidance on fire safety procedures for people at particular risk is given in BS 9999: Clause 44.3; and measures to aid the evacuation of disabled people are described in BS 9999: Clause 46.

Disabled people can be at particular risk in the event of a fire and need appropriate protection facilities. These might include relevant provisions for those requiring assistance, such as:

- appropriate means for giving warning in the event of fire;
- management planning;
- appropriate fire instructions in alternative formats;
- appropriate wayfinding systems;
- evacuation lifts or protected refuge areas and devices for taking people down or up stairs.

Special management procedures might be required when it is reasonably foreseeable that the proportion of disabled users in a building will be relatively high or where the use of the premises is likely to result in groups of wheelchair users being present (e.g. some types of sporting, entertainment, transport or public assembly building).

**The full circle of fire safety**

The concept of the full circle of fire safety is inherent within a comprehensive whole-life approach to fire safety. However BS 9999 is exceptional in that it incorporates an explicit connection between the use, the design and the operation. Historically, the management for fire safety has not been a significant part of the design process, and this is currently still the case in many countries.

The full circle of fire safety requires effective connectivity between the client brief, design, operational fire strategy and ultimately whether the actual operational approach meets with the client intentions and the full circle.
It is likely that simple buildings complying with the recommendations of the standard will only necessitate consideration of a selection of the sub-components of the circle of fire safety. However, complex buildings, particularly where a fire engineering approach is adopted, will probably necessitate the adoption of the majority of sub-components identified in Figure 1.