PUBLICLY AVAILABLE SPECIFICATION

PAS 911:2007

Fire strategies

– guidance and framework for their formulation

KINGFELL
PROTECTING TOMORROW

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Foreword

This Publicly Available Specification (PAS) was prepared by The British Standards Institution (BSI) in association with Kingfell plc, a multi-disciplinary company specializing in fire, risk and crisis control. It is intended to provide guidance for the preparation and/or review of a fire strategy. The PAS does not provide detailed recommendations or specifications with respect to the application or specification of fire safety and fire protection, as this information is normally covered in national codes and standards. Instead, it provides the user with one methodology to take the national guidance and utilize it within a framework; the purpose being to ensure that the final strategy follows a consistent style and covers the main issues. To assist with the formulation of the strategy, a number of "tools" or "models" are provided to assist with the analytical phases of strategy preparation. These are largely based upon original concepts developed by Kingfell since 1996.

The PAS is prepared in a format to allow use outside the jurisdiction of British Standards. National code information is provided in shaded regions to allow differentiation from the main text (see example below). These regions can be substituted by other national code references. Alternatively, the given references can be used where no other national code exists.

> This is an example of how National code guidance is provided in this document.

This document does not, and is not intended to, cover material already available in established British Standards or other National codes. These documents are referred to where appropriate.

Acknowledgment is given to the following persons and organizations that have been involved in the development of this PAS:

- BC Publications
- Building Research Establishment
- David Smith, Fire Engineering Consultant
- Fire Protection Association
- The Institute of Fire Prevention Officers
- The London Fire and Emergency Planning Authority (LFEPA)
- London Underground
- Network Rail
- Ove Arup
- Palace of Westminster

This PAS will be reviewed at intervals not exceeding two years and any amendments arising from the review will be published in an amended PAS and publicized in *Update Standards*.

This document is not to be regarded as a British Standard. It will be withdrawn upon publication of its contents in, or as, a British Standard.

This publication does not purport to include all necessary provisions of a contract. Users are responsible for its correct application.

Compliance with this PAS does not in itself confer immunity from legal obligations.

1) Further information on Kingfell Plc can be obtained at www.kingfell.com

Introduction

Notwithstanding the specific requirements of legislation, it is increasingly recognized that there is a need to ensure that proper and effective precautions have been taken to ensure that the potential threat of fire is, as far as possible, minimized and that any fire incident is properly, and promptly, dealt with. Within the UK, and elsewhere, fire safety legislation has historically been produced in a piecemeal fashion, usually as a result of an actual fire incident. Furthermore, fire safety and protection standardization has become a complex issue with a large number of British, European and International Standards covering various specific areas of the subject. Combine this with special requirements of bodies such as the Insurers, and this could lead to a general "fuzziness" in the specification and implementation of the various parts that make up the fire safety and protection arrangements being put into place. As a result these can be confused, ineffective and unnecessarily costly.

In view of this, it is recognized that, prior to undertaking new build projects, making alterations to a building, preparing fire system designs, or specifying fire prevention and management practices, an overriding document setting out the base requirements would greatly assist in the focus of subsequent, more detailed specifications, reducing the need to go back to first principles when a new aspect of the fire safety and protection provisions is foreseen. The document is often referred to as a fire strategy, although other names such as fire policy or fire plan are also used.

Fire strategies are prepared in a variety of formats and levels of detail. This could be due to the "in-house" style of fire consultants or the preferred methodology of the client. The end product may be highly satisfactory although comparison between two strategies for the same building, prepared by two different organizations, and their relative merits, may be difficult to judge. Similarly, when a building representative requests two or more organizations to tender for the preparation of a fire strategy, they may not be totally assured that the end product of any of the bidding organizations will be comparable in terms of work input and output.

With the introduction in the UK of the Regulatory Reform (Fire Safety) Order 2005 for England and Wales, The Fire (Scotland) Act 2005 and forthcoming similar legislation for Northern Ireland there is increased reliance on the specification of fire precautions following the undertaking of a fire risk assessment. Although risk assessments leading to specification for the management of fire safety and of active and passive fire protection may be sufficient in many cases, more complex environments may require consideration of other factors. The fire strategy may be informed by a pre-existing fire risk assessment but will also incorporate other considerations.

This PAS has been prepared to provide a degree of uniformity in the preparation of fire strategies. It does not provide specific requirements for fire precautions, management or system specifications as these are normally well covered by national standards or codes. Instead, it provides one recommended process:

1 **Determination of the design basis; A prescriptive or performance based approach?**
2 **Seven input themes with possible considerations. These themes are:**
   - Management and system audit;
   - Mandatory framework;
   - Objectives setting;
   - Risk and hazard assessment;
   - Building characteristics;
   - Occupant characteristics;
   - Practical issues.
3 **Strategy formulation.**
4 **Six output sub-strategies with key headings. The sub-strategies are:**
   - Fire policy statement;
   - Fire safety (management) strategy;
   - Evacuation strategy;
   - Fire and smoke control strategy;
   - Fire fighting strategy;
   - Fire protection strategy.
5 **Finalizing the fire strategy.**

The document also introduces a number of assessment "tools". These are diagrams to assist with the formulization process and are not normally intended for presentation in the final strategy document. These are based upon concepts first devised by Kingfell in 1996 and in subsequent years. The concept of using tools in a strategy analysis process derives from the successful use of "business tools or models" as part of the development of business strategies.

The preparation of a fire strategy can require more time, resource and cost at the front end of a project for which no prior fire strategy is available, however it can add benefits to the project if completed at the correct stage.

When preparing the fire strategy, it may also be worthwhile to review how the strategy fits with other disaster and crisis management strategies. For instance, requirements for a security strategy may impact on the effectiveness of the fire strategy. Similarly, some of the development associated with the fire strategy could be useful when implementing other crisis management and disaster management solutions. The requirements for evacuation in the event of fire, for instance, may be different when managing other incidents such as terrorist alerts.

This Publicly Available Specification is prepared to provide guidance in preparing a fire strategy that will encompass many of the key considerations and will lead to a document that is consistent in format and has the necessary level of detail to enable subsequent designs for the fire systems and for the setting up of procedure for management of fire safety to be prepared in a complementary manner.

A number of standards documents, including DD 9999 have been referenced throughout this PAS. At the time of publication DD 9999 was a draft for development and it was in the process of being converted to a full British Standard. Upon completion it will replace the BS 5588 series of British Standards.

1 Scope

This Publicly Available Specification (PAS) provides guidance to the formulation of a fire strategy encompassing a set of principles governing the subsequent specification, design and implementation of fire safety and protection systems and of the management of fire safety procedures. The guidance is designed to allow consideration of all factors associated with a fire strategy including life safety, property protection, environmental factors and business continuity.

It is written to cover the preparation of fire strategies for existing and new buildings. It should not be assumed that this is the only method although this guidance has been reviewed by a number of bodies and persons within the UK fire industry.

2 Normative references

The following referenced documents are indispensable for the application of this PAS. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest publication referred to applies.

PAS 79: 2007, *Fire risk assessment – Guidance and a recommended methodology*

DD 9999:2005, *Code of practice for fire safety in the design, construction and use of buildings*

BS 476 (all parts), *Fire tests on building materials and structures*

BS 5588-8:1999, *Fire precautions in the design, construction and use of buildings. Code of practice for means of escape for disabled people*

BS 5588-12: 2004, *Fire precautions in the design, construction and use of buildings: Managing fire safety*

BS 5839-1:2002, *Fire detection and alarm systems for buildings – Part 1: Code of practice for system design, installation, commissioning and maintenance*

BS 7974: 2001, *Application of fire safety engineering principles to the design of buildings. Code of practice*

BS 25999-1:2006, *Business continuity management. Code of practice*

NOTE *DD9999, BS 5588-8 and BS5588-12 will be replaced by BS 9999 in 2008.*

3 Terms and definitions

For the purposes of this PAS the following terms and definitions apply.

3.1 available safe escape time (ASET)

calculated time available between the ignition of a fire and the time at which the conditions for escape become untenable to the occupants

3.2 building

premises that is the subject of the fire strategy

NOTE *This could also refer to a group of buildings, and specialist building types such as railway stations, airports, manufacturing and processing plants, etc.*

3.3 cavity barrier

construction provided to close a concealed space against penetration of smoke or flame, or provided to restrict the movement of smoke or flame within such a space

3.4 compartmentation

sub-division of a building by fire-resisting walls and/or floors for the purpose of limiting fire spread within the building

3.5 competent person

person with sufficient training and experience or knowledge and other qualities, and with access to the requisite tools, equipment and information to enable them to carry out a defined task properly

3.6 concealed space or cavity

space enclosed by elements of a building (including a suspended ceiling) or contained within an element, but not a room, cupboard, circulation space, protected shaft or space within a flue, chute, duct, pipe or conduit

3.7 dead end

place from which escape is possible in one direction only, or in directions less than 45° apart that are not separated by fire-resisting construction

3.8 disabled people

people with a physical, sensory or other impairment which affects their mobility or their use of buildings

3.9 escape route

route forming part of the means of escape from any point in a building to a final exit

3.10 final exit

termination of a designated escape route from which there is direct access to a place of ultimate safety

3.11 fire damper

mobile closure or intumescent device within a duct, which is operated automatically and is designed to prevent the passage of fire and which, together with its frame, is capable of satisfying for a stated period of time the same fire resistance criterion for integrity as the element of the building construction through which the duct passes

3.12 fire door

door or shutter provided for the passage of persons, air or objects which, together with its frame and furniture as installed in a building, is intended (when closed) to resist the passage of fire and/or gaseous products of combustion, and is capable of meeting specified performance criteria to those ends

3.13 fire protection measures

design features, systems, equipment or structural measures taken within a building to reduce danger to people and property if fire occurs

NOTE *Examples of such features include means of detecting, extinguishing or containing fires.*

3.14 fire resistance

ability of an item to fulfil for a stated period of time the required load-bearing capacity and/or integrity and/or thermal insulation, and/or other expected duty specified in a standard fire resistance test

3.15 fire risk assessment

overall process of identifying hazards and evaluating the risks to people and/or property arising from them, taking account of existing risk controls and/or proposed risk controls

3.16 fire safety engineering

application of scientific and engineering principles to the protection of people, property and the environment from fire

3.17 fire safety policy

documented strategy that sets the standards of fire safety that an organization is committed to maintaining

NOTE *For example, the starting point of a fire safety policy is expected to be that the organization complies with all legislative requirements in respect of fire safety.*

3.18 fire stopping

Seal provided to close an imperfection of fit or design tolerance between elements, components or constructions of a building, or any joint, so as to restrict the passage of fire or heat or smoke through the imperfection or joint

3.19 fire system health check

independent verification of fire protection systems to test and investigate if they are arranged and perform as intended

3.20 flow rate

number of persons passing a point over a period of time on a path of a specific width

3.21 management of fire safety

tasks carried out by a defined individual or individuals with appropriate powers and resources to ensure that the fire safety systems, passive, active and procedural, within the building are working properly at all times

3.22 means of escape

structural means whereby a safe route in the event of fire is provided for persons to travel from any point in a building to a place of safety (without external assistance)

3.23 national codes

rules, standards and regulations pertaining to the relevant country in which the strategy is to be prepared

3.24 non-combustible

not capable of undergoing combustion under specific conditions

3.25 phased evacuation

system of evacuation in which different parts of the building are evacuated in a controlled sequence of phases, those parts of the building expected to be at greatest risk being evacuated first

3.26 place of relative safety

place in which there is no immediate danger, but in which there could be future danger, from the effects of a fire

3.27 place of ultimate safety

place in which there is no immediate or future danger from fire

3.28 pre-movement time

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

3.29 protected route

route designated for use as an escape route which is protected from the remainder of the building by fire resisting construction and which leads to a place of ultimate safety

3.30 risk profile

means of categorizing the risks for a range of building types or occupancies based on the building parameters, internal processes, occupancy profile and the potential rate of fire growth

3.31 smoke control

measures to control the spread or movement of smoke and fire gases within a building in order to protect the structure, the contents, the means of escape, or to assist fire-fighting operations

3.32 smoke damper

mechanical device which, when closed, prevents smoke passing through an aperture within a duct or structure

3.33 travel distance

actual distance a person needs to travel from any point within a building to the nearest storey or final exit, having regard to the layout of walls, partitions and fittings

3.34 travel time

time needed once movement has begun, for all of the occupants of a specified part of a building to reach a place of relative safety or a place of ultimate safety

4 Understanding the purpose of the fire strategy

4.1 General

Prior to preparing the strategy, it is important that those involved fully appreciate and understand the purpose of the strategy. The main benefits of a fire strategy are:

a) To prompt a full and thorough consideration of the fire safety requirements of the premises in question and of its occupants;

b) To widen the consideration of fire precautions with respect to broader objectives that may include life safety, property protection, business protection and environmental considerations;

c) To assist in the review of fire system design criteria prior to the preparation of the designs;

d) To ensure that fire protection system designs support the strategy;

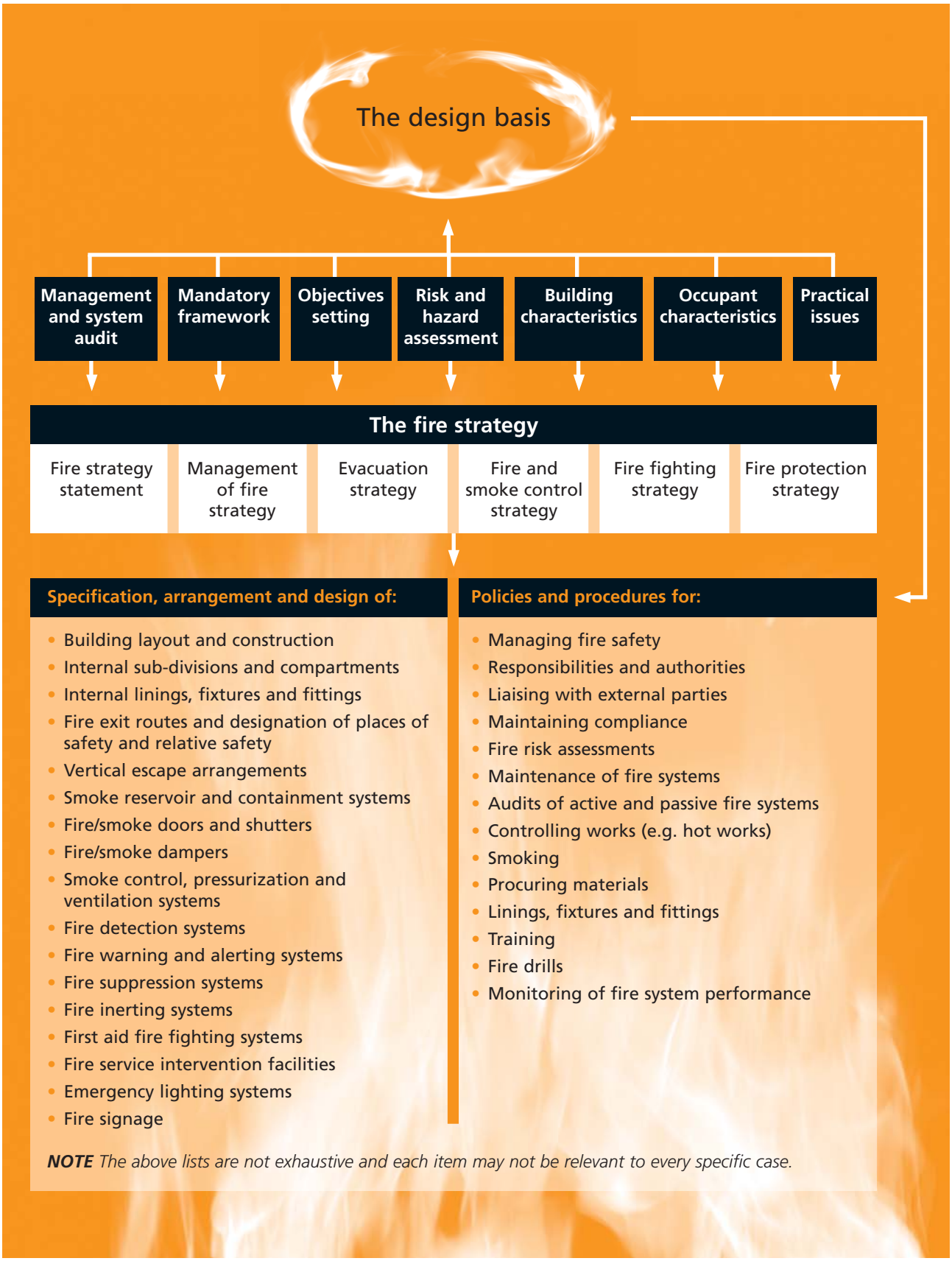
e) To provide a framework for all future fire safety and protection works;

f) To provide a framework for integrating fire protection measures in multi occupancy or associated premises.

4.2 Formulating the fire strategy – inputs and outputs

In order to provide a comprehensive and future proof strategy, there are seven key inputs given for analysis to ensure that all salient factors have been considered. All inputs and outputs are illustrated in Figure 1. These inputs should be assessed separately and then collectively to guide the development of the strategy. These inputs will also help determine the design basis to be used for subsequent specification and designs of fire safety and fire protection systems. The design basis is covered in Clause 5. The fire strategy inputs are covered in Clause 6. The fire strategy outputs are covered in Clause 8.

Figure 1 – Fire strategy inputs and outputs (© Kingfell)



4.3 Competency to prepare the fire strategy

It is vital that those entrusted to prepare a fire strategy have the necessary levels of competence to undertake the task professionally and thoroughly. The level of competency required will be commensurate with the expected complexity of the building to be assessed, but the person, or team should have the following credentials:

a) A good understanding of fire related aspects of premises and their function;

b) An appropriate knowledge of fire legislation and the requirements of other enforcing bodies;

c) Appropriate qualifications, training and / or experience in fire safety and fire protection issues;

d) Knowledge of relevant national codes and past experience of their application.

One way of validating competency is to ensure that those preparing the strategy or those approving the strategy are members of a relevant professional body at an appropriate level.

For more detailed studies, the competent person or company may need to demonstrate ability to undertake complex fire modelling or evacuation analysis.

4.4 Involvement in the fire strategy

Prior to formulating the strategy, a panel should be set up to guide the persons tasked with its preparation. All persons that have an interest or may be directly affected by the fire strategy should be represented at the panel. Those involved may include;-

a) the person(s) preparing the strategy;

b) persons representing the fire safety interests of the building or organization;

c) persons representing other building or organization interests affected by the fire strategy (e.g. human resources, heritage issues, facilities management, etc);

d) relevant regulatory authorities;

e) insurers;

f) architects / building engineers;

g) fire systems engineers.

The panel should meet at key stages of the strategy development. These stages may include:

a) planning meeting(s);

b) meeting(s) to consider specific issues, such as objectives setting, risk assessments, building issues, etc;

c) technical meetings to consider aspects such as system technologies, construction methods, etc;

d) review meetings at key milestones to review work stages.

NOTE 1 *Recommended key milestone meetings are given in Figure 7.*

All interested parties may not be required to be at all meetings although it is recommended that they do attend the initial and milestone meetings.

The meetings should normally be chaired by those preparing the strategy as they should have the relevant knowledge and experience to ensure all factors have been appropriately considered.

NOTE 2 *Where a fire safety engineering design basis is used in accordance with BS 7974, some of the above meetings may be supplemented by the Qualitative Design Review meetings and panels covered in that Standard.*

4.5 Agreeing the scope of the strategy

Before commencing with the analysis, all persons involved with the strategy should agree the scope of the strategy. Key to this process will be:

a) to agree what is to be specifically included and excluded from the fire strategy.

b) to agree the parameters that will be used as acceptance criteria. This could vary between projects but could be simply to meet with a basic level of fire precautions required by fire safety legislation or to cater for specific issues raised by internal or external parties. This criteria may be subject to amendment as a result of initial investigation, particularly as a result of assessing the objectives for the building. In such cases, amendments should be mutually agreed by all interested parties.

c) to agree what assumptions may be made at the outset of the strategy. Similarly, a process may be required to accept and approve subsequent assumptions made throughout the stages of strategy preparation.

d) the strategy may need to consider issues relating to the construction phases, especially where buildings may be part occupied.

5 Determining the design basis

5.1 General considerations

At an early stage in the development, there will be a need to consider the most appropriate design basis for the fire strategy and subsequent fire safety and protection designs. There are three possible methods;-

a) A prescriptive approach using existing codes and standards.

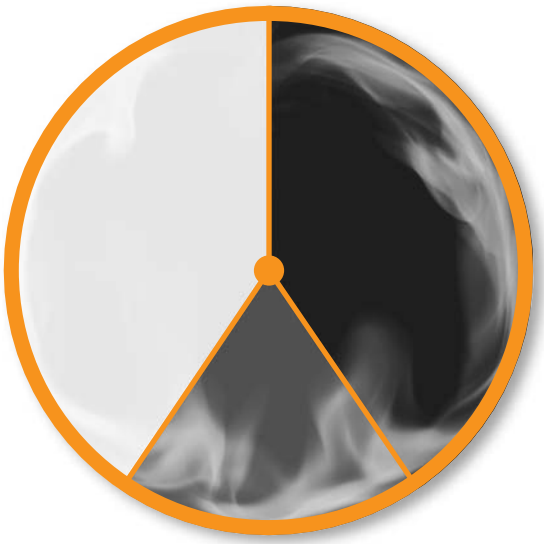
b) A performance based approach applying measures based on the assessed requirements for the building and/or business covered by the fire strategy.

c) A "hybrid" approach using a combination of performance based and prescriptive guidance.

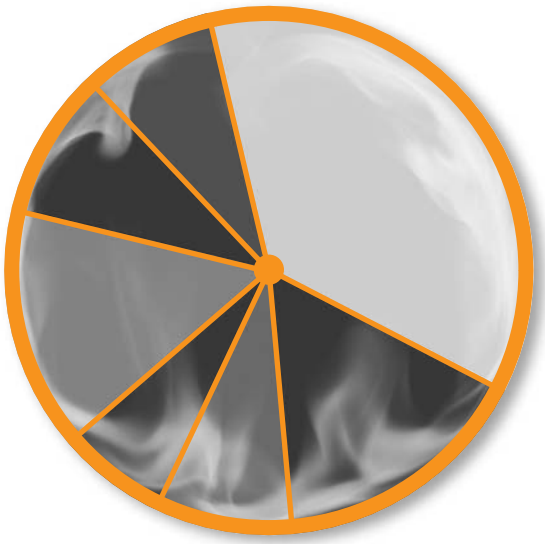
A simple way of illustrating the key differences is shown in Figure 2. Prescriptive rules, theoretically, tend to be "black and white", i.e. the guidance is followed or not followed. However, as in the majority of cases, there will be aspects that cannot be made to comply exactly with the standards and are thus the "greyed" area. A thorough prescriptive based solution may describe these aspects as variations or deviations from the national code. A performance based approach will not lead to any obvious single answer. Instead, a solution may be more or less effective, i.e. there will be degrees of grey with no single correct approach.

Figure 2 – Analogy of prescriptive vs. performance based solutions (© Kingfell)

The prescriptive solution



The performance based solution



The choice should be based on an initial assessment of the inputs given in Figure 1. A prescriptive approach may be most appropriate for "standard" building design where specific requirements can be applied with minimal variation. A performance based approach may be most appropriate for innovative or unusual buildings where "standard" requirements cannot be easily applied.

There are certain advantages to using the prescriptive approach. This approach ensures that the requirements are:

a) straightforward to use and apply;

b) based upon past experience and research by others;

c) provides a consistent approach and output;

d) easier to assess and audit by other parties.

There are certain disadvantages to using the prescriptive approach. The requirements may:

a) be inflexible to the actual needs of the building in question;

b) not necessarily lead to an optimum solution;

c) fall behind current design and assessment practices.

There are certain advantages to using the performance based approach. This approach ensures that the requirements:

a) can be tailored to the specific needs of the building;

b) allow for innovation;

c) force a holistic approach; to consider all aspects that may impact on the building and its occupants;

d) can lead to more cost effective and more appropriate designs.

There are certain disadvantages to using the performance based approach. The requirements may:

a) require a more thorough and detailed assessment by suitably qualified persons which could initially result in higher fees and a longer design programme;

b) result in the output being more difficult for external parties to assess.

5.2 Prescriptive based design criteria

A prescriptive approach will make use of existing codes and standards. This may be found in the majority of national standards and specifications. Prescriptive standards provide the criteria to which designs and other fire parameters should adhere to. They may define, in numerical terms, how fire precautions and fire protection systems should be designed.

The overriding documents that can be used as a basis of a prescriptive based fire strategy are the applicable local or national building regulations. This legislation typically includes the following functional requirements:

Means of escape in case of fire:

- Means of escape provisions for different purpose groups and building types
- Design for horizontal and vertical escape
- Special requirements for dwelling houses

Internal fire spread (linings):

- The design and application of provisions
- Variations and special provisions
- A section on thermo-plastic materials

Internal fire spread (structure):

- Structural load-bearing elements
- Fire compartmentation
- Concealed spaces (cavities)
- Protection of openings and fire stopping
- Special provisions

External fire spread:

- Construction of external walls
- Space separation
- Roof coverings

Access and facilities for the fire and rescue service:

- Fire mains
- Vehicle access
- Personnel access
- Areas requiring special consideration

These section headings could be used as the basis for a fire strategy.

Each section refers to more detailed standards covering specific areas, many of which are published British Standards. These include the **BS 476** series for elements of construction and the **BS 5839** series for fire detection and alarm systems.

An alternative document that could be used for the assessment of new and existing buildings is **DD 9999**. This covers all aspects of fire safety in a manner similar to the existing **BS 5588** series.

A fire strategy adopting a prescriptive approach could follow each of the sections albeit other factors should be included, such as the management of fire safety and the overriding fire safety policy as identified in Figure 1.

5.3 Performance based design criteria

A performance based approach can make use of a variety of information from research papers to prescriptive standards. This will allow a "back to basics" approach to the design of building parameters. There will be no absolute rules guiding the specification of fire measures, but performance requirements as set out by the assessment of objectives for the fire strategy and by the results of risk assessments and hazard analysis should be met.

The current UK basis appropriate for a performance based solution is BS 7974: Application of fire safety engineering principles to the design of buildings. This document provides the appropriate framework for preparing a fire safety engineered design, and is supported by a series of British Standard Published Documents:

PD 7974-0: *Guide to the design framework and fire safety engineering procedures;*

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 service intervention;*

PD 7974-6: *Evacuation;*

PD 7974-7: *Probabilistic fire risk assessment.*

The document describes a process from the quantitative design review through to completed design solution encompassing active and passive fire protection. Following the process will cover many of the aspects appropriate to the preparation of a fire strategy.

The current edition of the Building Regulations incorporates a degree of performance assessment and could be relevant to some forms of assessment.

5.4 Hybrid design criteria

A hybrid design process may take aspects of a performance based approach and combine this with prescriptive rules. It should be noted that many performance based approaches will call up prescriptive standards for specific aspects such as for fire protection systems. A hybrid design may also be used where some parts of a building require specialized consideration and a performance based approach is appropriate, whilst other areas are more uniform and a prescriptive approach would be satisfactory.

The reasons for using the hybrid approach should be given in the strategy and clearly state which areas are performance based and which are code based together with detailed explanations for using this approach.

6 Fire strategy inputs

6.1 General

A fire strategy can only be effective and complete if all determining factors have been properly considered. These are the factors that should be thoroughly investigated by a combination of research of relevant data and records, by liaising with key personnel to derive relevant information and by undertaking on-site surveys. In some cases, the determining factors may be limited, possibly because previous assessments have been undertaken and can be used to support the strategy, or the scope of assessment has been limited to consideration of specific aspects only. The complexity of the building or the design basis chosen could also influence the extent of input analysis. It is recommended that the extent of assessment is agreed at the initial planning meetings.

When following a purely prescriptive approach and/or when the meeting of base level legislation is the sole objective, detailed analysis using all seven inputs may not be seen to be justified. Nevertheless, the information gained from such analysis could lead to a more effective, robust and complete strategy, Figure 1 provides the main inputs to the strategy. Each of these inputs is considered below.

6.2 Management and system audit

> ***NOTE*** *Recommendations for management of fire safety are covered in* ***BS 5588*** *Part 12.*

6.2.1 Management audit

Prior to preparing a new fire strategy, a thorough investigation into the existing management of the fire safety regime should be undertaken. This will be more appropriate for existing buildings but the exercise should be carried out in all cases, as new build projects may have been subject to previous examination. Key information will include:

Existing fire policy statements: This will detail the corporate approach to fire safety matters in relation to life safety, property and asset protection, environmental issues and business continuity.

Existing responsibilities and authorities for fire safety: This information is vital in ensuring that the fire strategy takes into account those who are the major stakeholders in its implementation and maintenance. Key personnel should be involved with the preparation of the strategy or should at least be consulted at key milestones.

Previous fire strategies, plans and specifications: Any prior fire strategies or other plans and specifications covering fire safety and protection should be examined. There may be information within such documents which will guide the preparation of the new fire strategy.

In-house codes and standards: As with any regulatory requirements, the fire strategy should follow specific codes or standards relevant to the premises. If, for any reason, the codes or standards are deemed inappropriate, there should be evidence as to why the strategy cannot follow them.

Existing requirements of external parties: Although, any requirements of external parties are examined in **6.3**, there should be a review of all prior requirements. There may have been modifications over time that could reveal useful information.

Existing fire prevention methodologies and procedures: There may be a number of controls instituted over the years that may have been implemented because of specific issues or as a result of continuous improvement. Each of these processes should be examined as part of the assessment. Specific issues may include:

a) controls on works (hot works, sub-contactors movements etc.);
b) no smoking enforcement;
c) requirements for fabrics and furnishings;
d) control of projects on-site;
e) fire and safety audits;
f) training programmes and records.

Policies for disabled persons: The accessibility policy for the premises will inform the nature of the disabilities that will need to be considered when formulating a fire strategy for that premises.

Notes of fire safety meetings: Notes of relevant fire safety related meetings can reveal if any previous requirements or enforcements have been considered. The minutes may also show aspects of the building and its occupancy that may not be apparent and may save much time in subsequent investigation.

Records of fire investigations: Reports of investigations of any fire occurrence may establish where any part of the fire strategy was inadequate. Equally it may highlight particularly successful aspects, including the actions of people. Results should be used to provide feedback to the preparation of the new fire strategy.

Records of incidents, false alarms etc.: Such information

can help highlight existing problems that can be tackled by the strategy. Records of incidents can highlight the results of actual events including the response time of the fire service, the manner in which the incident was dealt with and the performance of fire protection systems. For instance, an ongoing false alarm record in a specific part of the building may not just indicate that the wrong type of fire detection is being used but that the management process may be deficient in ensuring action is taken.

6.2.2 System audit and "fire system health check"

For fire systems, an audit should be undertaken of the existing systems, including fire detection systems, alarm and warning systems, fire suppression systems, fire fighting systems, passive protection systems (including fire doors and smoke dampers), smoke control systems and fire suppression systems.

Information should be obtainable from system handover documentation (such as Operation and Maintenance Manuals) and from the fire system maintenance companies. The purpose of the audit is to identify the existing design criteria, confirm these criteria are still appropriate and acceptable, and that the system arrangements still meet with these design criteria. A review of cause and effect programmes in particular, can illustrate how the systems have been mutually designed to meet specific objectives.

Where it is judged that the information is incomplete or inconclusive, it may be advisable to undertake a fire system "health check". Ideally, this is an impartial assessment undertaken by a third party fire system engineering company not connected with the maintenance company or with the manufacturers of existing or proposed equipment. The system health check could include:

a) Detailed review of the system arrangement against design criteria;
b) A check of the operation of control and indicating equipment;
c) A sample check of field devices;
d) A test of system interfaces and mutual operation;
e) A review and test of the cause and effect programming.

6.3 Mandatory framework

In the context of the fire strategy, the mandatory framework is key to achieving compliance with external requirements, whether legal and regulatory or by organizations with authority or control over fire safety for the premises.

Legislation: The strategy should take into account all relevant fire safety legislation concerned with fire safety. Where the strategy may vary from the national regulations, then it should state where and why the variation is made.

Insurers: They may impose special conditions on their Insured, particularly relating to property protection and business continuity.

> The Association of British Insurers may provide additional guidance as to what may be required for the protection of property. Similarly, the Fire Protection Association and the Loss Prevention Certification Board publishes rules and recommendations specific to property protection.

Special Groups: There may be specific requirements or limitations imposed on the strategy by special groups who may have an interest in the safety of the building and its occupants.

Within the UK, special groups may include English Heritage, Historic Scotland, Historic Ireland and the National Trust for Heritage Buildings, the HMRI for Station Premises, HSE etc.

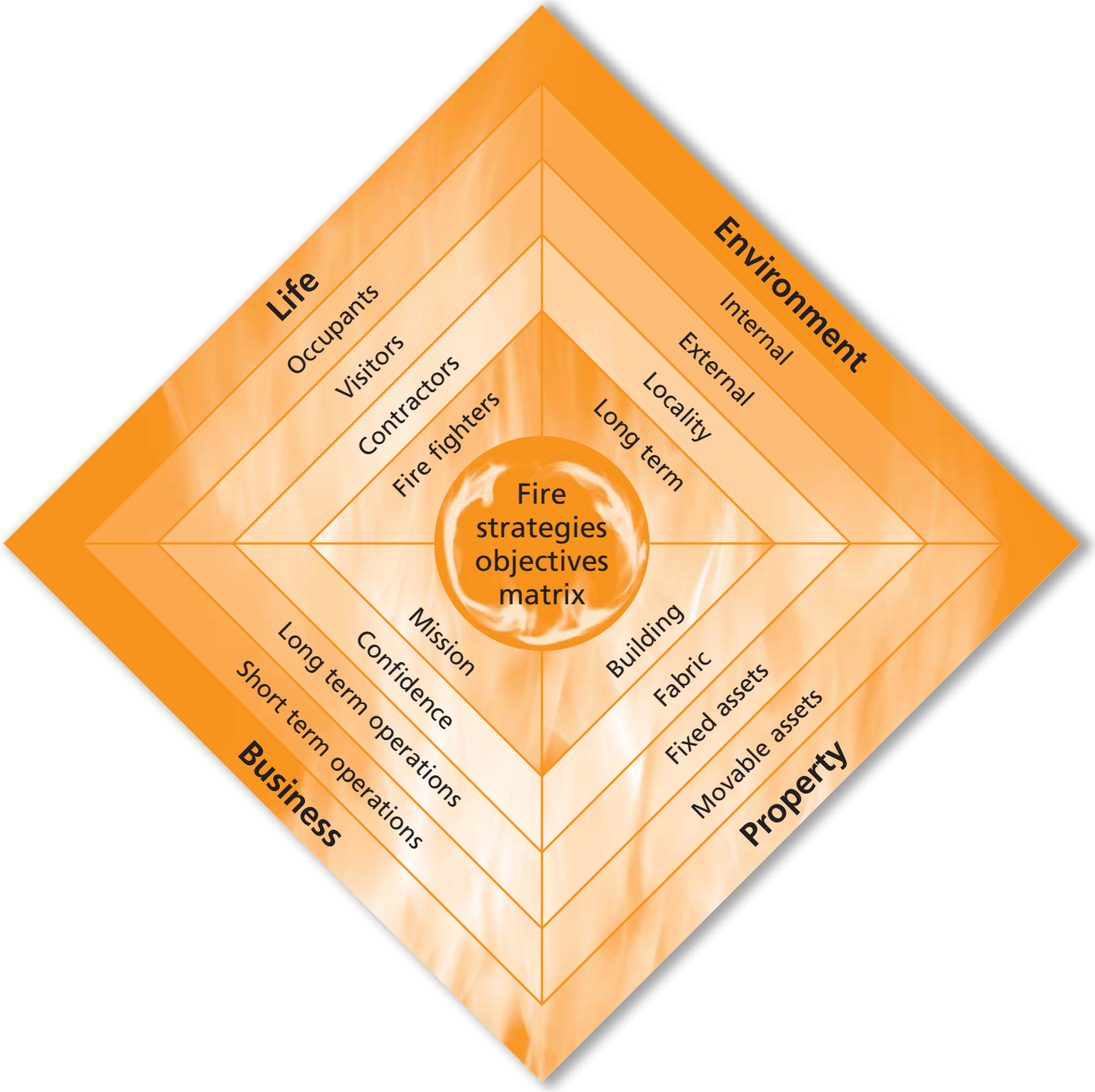
6.4 Objectives setting

6.4.1 General considerations

Although a key objective for a fire strategy is to demonstrate compliance with the mandatory framework, all objectives behind the fire strategy should be determined. This will help steer the analysis to concentrate on the key and most appropriate issues outside of those pre-determined by regulation or rules, or to guide design criteria where such codes and standards are inappropriate. In many cases, the objectives behind fire safety and protection are classified as either life safety or property protection. However, the other key objectives of business protection (or continuity) and protection of the environment may play equal roles in some circumstances. Consequently, it is recommended that these objectives are also considered as part of the evaluation process.

Figure 3 illustrates these four key objectives and sub-divides each objective into four key elements for further consideration.

Figure 3 – Fire strategy objectives matrix (© Kingfell)



6.4.2 Life safety objectives

Objectives for life safety will, in practically all cases, be paramount to the strategy. The main objective will be to ensure that all persons can be evacuated safely from the building in the event of a single fire incident. If there is a requirement for the strategy to consider more than one simultaneous fire incident, then this should be highlighted at an early stage of the strategy formulation and investigated accordingly. Furthermore, the strategy may need to consider the life safety of fire-fighters (if this is a part of the strategy requirement) who may need to enter during and after the evacuation of occupants.

6.4.2.1 Occupants

Occupants are the persons who work in, or use the building on a regular basis. They are likely to be knowledgeable of the building, its layout and its processes. Considerations for the life safety of occupants may include:

a) What methods of alerting occupants are most appropriate?
b) What methods of horizontal and vertical evacuation are most suitable?
c) How far should a person travel to a place of safety?
d) How quickly should evacuation be achieved from the location of the fire incident and from the building in its entirety?
e) What are the designated places of "relative safety" and "safety"?
f) What assistance will be required to help the evacuation process?
g) What are the training requirements necessary to ensure safe evacuation?

NOTE *Occupant characteristics are covered in* ***6.7****.*

6.4.2.2 Visitors

Visitors are persons who do not occupy the building but who may use part of the building regularly or may be in the building for specific purposes. The general public come under this group. The considerations as highlighted for occupants are also relevant to visitors. However, visitors need to be treated as a separate subset as they will not be knowledgeable of the building layout and will be unfamiliar with the evacuation procedure. Furthermore, the numbers of visitors at any given time may have a major effect on evacuation analysis results. Additional considerations may include:

a) What methods of alerting visitors are most appropriate?
b) Are there any supplementary requirements for the warning systems and procedures?
c) What specific measures need to be used to guide visitors to the areas of "relative safety" and "safety"?

NOTE *Contractors characteristics are covered in* ***6.7****.*

6.4.2.3 Contractors

Contractors are persons who may be employed directly or indirectly to undertake works on the building and its processes, or who may be used for specific tasks within the building. Contractors are similar to visitors in that they do not occupy the building but may use parts of the building regularly or may be in the building for specific purposes. The considerations as highlighted for occupants are also relevant to contractors. However, as with visitors, they should be treated as a separate subset. Contractors may have received general training prior to starting work in the building. They will not be knowledgeable of the building layout and may be unfamiliar with the evacuation procedure. Furthermore, the numbers of contractors at any given time may imbalance the evacuation analysis. They may also be located in parts of the building not frequented by occupants or visitors and may require an additional stand down time prior to evacuation to complete special processes. Additional considerations may include:

a) What methods of alerting contractors are most appropriate?
b) Are there any supplementary requirements or extensions for the warning systems and procedures?
c) What procedures may be required additional to the evacuation procedure (e.g. climbing down from scaffolds, or making their way from confined space areas)? How will this impact on the time to evacuation?
d) What specific measures need to be used to guide contractors to the areas of "relative safety" and "safety"?

NOTE *Contractors characteristics are covered in* ***6.7****.*

6.4.2.4 Fire-fighters

In some cases, national regulations require that those designing or modifying buildings consider the safety of fire-fighters. Where fire-fighters are required to enter the building or to assist with evacuation, or to fight fires within proximity to the building, their safety should be considered by the strategy. Considerations in such cases should include:

a) What processes or systems should be in place to allow fire-fighters to undertake their tasks quickly and in relative safety?
b) Are the fire-fighting access and facilities adequate?
c) What processes or systems are in place to allow

fire-fighters to get to the seat of the fire in relative safety?

d) What information is necessary to assist the fire-fighters?

> ***NOTE*** *Further information can be found in* ***BS 5588-12****.*

6.4.3 Property protection objectives

Objectives for property protection will, in many cases, be over and above the requirements of national legislation, but may be required by bodies such as insurers and by special interest groups. There are four main subsets to be separately considered when protecting the building and its contents (see **6.4.3.1** to **6.4.3.4**).

6.4.3.1 The building

The building may or may not be seen as a crucial part of the fire strategy. Conceivably, if all persons have been safely evacuated from the building, then the consequential collapse of the building may be acceptable. However, in many cases, controlling a fire to prevent the destruction of the building is seen as an objective. In such cases, considerations may include:

a) What parts of the building structure are most vulnerable to a fire incident?

b) How big will a fire need to be to constitute a threat to the building?

c) What aspects of the structure should be changed to prevent a fire from travelling throughout the building?

d) What parts of the building are most critical for protection and what parts are secondary?

6.4.3.2 The building fabric

The loss of the building fabric, i.e. the walls, doors, floors, ceilings and divisions, and their decorations and fittings, may be acceptable as the rebuild costs may not be of primary importance when weighed against the cost of their protection. For buildings of historical importance or where special building materials and fabrics have been introduced, the fabric may be viewed as important as the building itself. Considerations may include:

a) What parts of the building fabric are most vulnerable to a fire incident?

b) What forms of damage are unacceptable (e.g. damage from smoke, from convected heat from a fire, etc.)?

c) How much of the building fabric is seen as an "acceptable loss"?

d) What parts of the building fabric are most critical for protection and what parts are secondary?

6.4.3.3 Fixtures and fittings

Fixtures and fittings may be furnishings, equipment, machinery and plant within the building that cannot be easily moved, especially in the event of a fire incident. Of special consideration may be IT equipment and data. How important the fixtures and fittings are in terms of value will often be a subjective decision and may be part of the consideration covered by the insurers or management or special interest parties. Considerations may include:

a) What fixtures and fittings are deemed as a priority for protection and what are secondary?

b) What forms of damage are unacceptable (e.g. damage from smoke, from convected heat from a fire, etc.)?

c) How easily can the fixtures or fittings be replaced?

d) What forms of protection are most appropriate?

e) What parts of the building are most critical for protection and what parts are secondary?

f) What special requirements are there for fire-fighters?

g) What salvage processes are appropriate to full equipment reinstatement/replacement?

6.4.3.4 Moveable items

Moveable items may be small furnishings, computer equipment, works of art, tools and test equipment housed within the building but can be moved out of the building in the event of a fire incident. The importance of the moveable items, as with fixtures and fittings, in terms of value, will often be a subjective decision and may be part of the consideration covered by the insurers or management or special interest parties. Considerations may include:

a) What moveable items are deemed as a priority for protection and what are secondary?

b) What forms of damage are unacceptable (e.g. damage from smoke, from convected heat from a fire, etc.)?

c) What areas can be designated as places of safety for moved items?

d) What procedures are required to move the items to a place of safety?

e) What fire and security protection is required for the designated location of the moved items?

f) How easily can the moveable items be replaced?

g) What forms of protection are most appropriate?

h) What salvage processes are appropriate for full item reinstatement/replacement?

6.4.4 Business continuity objectives

As with property protection, objectives for business continuity will, in many cases, be over and above the requirements of national legislation, but may be required by bodies such as insurers and by special interest groups. When dealing with issues relating to the direct and indirect consequences of a fire there are four main subsets to be separately considered (see **6.4.4.1** to **6.4.4.4**).

6.4.4.1 Short term operations

This is the assessment of how a fire will have an immediate and near immediate impact on the business. Considerations may include:

a) In what ways will a fire affect the running of the business on a day to day basis?
b) What are the most critical short term aspects of the business that require special attention?
c) What are the short term contingency arrangements that can be put into place following a partial and/or total fire?
d) What would be the acceptable down time following a fire?

6.4.4.2 Long term operations

This is the assessment of how a fire will have a longer term impact on the business. Considerations may include:

a) In what ways will a fire affect the running of the business in the long term?
b) What are the most critical longer term issues of the business that require special consideration?
c) What are the long term contingency arrangements that can be put into place?
d) What changes to the business processes can be implemented if the business cannot continue in its present form following a fire?

6.4.4.3 Confidence

This is the assessment of how a fire will have an impact on the confidence of stakeholders. Considerations may include:

a) How will a fire affect the confidence of employees?
b) What changes in working arrangements would need to be implemented as a consequence of a fire?
c) How will a fire impact on the confidence of customers and suppliers in the business and its ability to continue to operate?
d) How will a fire affect its relationship with the community?

6.4.4.4 Mission

This is the assessment of how a fire will have an impact on the ability of the business to follow its corporate objectives. Considerations may include:

a) How will the fire impact on the core values of the business?
b) What impact will a fire have on the business's ability to trade?
c) How will the business be perceived over the longer term?
d) What are the legal, commercial and logistical implications of a fire and how will they manifest themselves?

BS 25999-1 provides guidance on business continuity management.

6.4.5 Environmental protection objectives

The environmental impact of a fire can be severe and could have much larger consequences than may at first be considered. As with property and business protection, objectives for environmental protection may be over and above the requirements of national legislation, but this may change with increasing national interest in environmental issues. There are four main subsets to be separately considered when protecting the environment against the direct and indirect consequences of a fire (see **6.4.5.1** to **6.4.5.4**).

6.4.5.1 Internal impact

This is the assessment of how the environment within the building may be affected by a fire. Considerations may include:

a) What are the possible products of combustion that could be released in a fire?
b) What other products could be released into the local environment in a fire?
c) How could these products circulate around the building environment?
d) What are the forms of contamination that could result from a fire?
e) Will the release of products cause secondary contamination (such as entering the building's water supplies)?
f) What processes or systems can be put into place to limit the spread of contaminants within the building?
g) What are the immediate and longer term health and safety aspects relevant to using the building following a fire?

h) What costs can be associated with any clean-up operations within the building?

6.4.5.2 External impact

This is the assessment of how the environment in the external area immediately adjacent to the building may be affected by a fire. Considerations may include:

a) What are the possible products of combustion that could be released externally in a fire?
b) What other products could be released into the external environment in a fire?
c) In what forms could contamination products leave the building in a fire?
d) What are the implications of fire fighting water run-off?
e) What will be the direct impact on neighbouring buildings?
f) Will the release of products cause secondary contamination (such as entering the communal water supplies or sewers)?
g) What processes or systems can be put into place to limit the spread of contaminants from the building?
h) What are the immediate and longer term health and safety aspects relevant to using the building and its neighbouring buildings following a fire?
i) What costs can be associated with any clean-up operations for the neighbouring area?

6.4.5.3 Impact on the locality

This is the assessment of how the region in which the building is located may be affected by a fire. Considerations may include:

a) What are the possible products of combustion that could be released within the locality of the building due to a fire and what are the estimates of the potential areas affected?
b) What other products could be released into the environment and what are the estimates of the potential area affected?
c) In what forms could contamination affect the locality? How large an area could be affected?
d) Will the release of products cause secondary regional contamination (e.g. entering rivers)?
e) What processes or systems can be put into place to limit the spread of containments to the locality?
f) What are the immediate and longer term health and safety aspects relevant to the locality following a fire?
g) What costs can be associated with any clean-up operations within the potentially affected areas?

6.4.5.4 Longer term impact

This is the assessment of how the fire could have longer term consequences, possibly over many years. Considerations may include:

a) What are the longer term physical implications of a fire?
b) What are the longer term health and safety implications of a fire?

6.4.6 Identifying the key objectives for further assessment

A thorough examination of the objectives criteria and answering the questions listed in the previous sections should lead to a list of objectives for the strategy, i.e. a list of requirements that the strategy will need to cover. On a first pass, the list of objectives may be large and there may be a number of duplicated or similar issues.

Each objective should be reassessed to ensure it is "SMART":

Specific: The objective should be clear, concise and understandable. Objectives that are ambiguous or too generic should be reviewed.

Measurable: The objective should be quantified in some way relevant to the requirement so that it can subsequently be assessed and determined if it has been met by the strategy.

Achievable: Each objective should be viable on technical, logistical and commercial grounds. When assessing commercial viability, it is worthwhile estimating the cost of failing to reach the objective.

Realistic: The objective and the actions required to meet the objective should take into account constraints that may prevent the objective being met.

Time – related: Where appropriate, operational times or best or worse case time scenarios should be included.

Following an assessment of objectives, those deemed not to be "SMART" should be re-evaluated or deleted. The final list of objectives should then be evaluated by all interested parties and prioritized into primary and secondary objectives. It is the primary objectives that should all be met by the fire strategy. The secondary objectives should also be met where possible, or where not, an alternative solution could be found. Any objective subsequently not met by the fire strategy should be stated in the introduction, so that, as the building changes, these can be re-evaluated.

6.4.7 Consideration of extreme events

This is typically not included within the main objectives given in clauses **6.4.2** to **6.4.5** as the consideration of

extreme events may not be covered by a fire strategy. Extreme events will be events that may not be calculable or cannot be predetermined. However, they may be fire events that are not covered by the scope of the fire strategy. UK fire legislation is based around the concept of a single fire starting in a building at any one time. Consequently, fires starting simultaneously in different parts of the building could be described as an extreme event. Extreme events may also include explosion or terrorist actions, which may cause extensive damage to more than one aspect of the fire strategy. Fire strategies should specifically state that extreme events are not covered unless certain scenarios are specifically included.

6.5 Risk and hazard assessment

6.5.1 General

When assessing existing buildings, a fire risk and hazard assessment will focus the strategy on those aspects of the building that could lead to an actual fire incident. Consequently such an assessment is normally an integral part of any strategy preparation. Those undertaking the risk assessment and hazard analysis may be part of the team preparing the fire strategy. Alternatively, it is recommended that those trained and/or qualified in the undertaking of fire risk assessments are utilized for this phase of the assessment. For new build projects, an assessment of the proposed uses of the building should be examined together with relative locations.

6.5.2 Risk assessment methodologies

For new or concept buildings, the risk assessment will need to evaluate the proposals for the building, its occupancies and uses and make suitable judgements of the potential risks. Risk profiling of the building against buildings of similar complexity and use can greatly assist the assessment.

A full fire risk assessment of existing buildings should be carried out to identify and evaluate the risks from all hazards that may impact on the primary and secondary objectives determined in **6.4**. Where the objectives are purely life safety based, then the risk assessment should only examine the risks for those who may be in the building. Where the objectives also cover property, business and/or environment protection, then the risk assessment should be extended to evaluate these risks.

The fire risk assessment should be a systematic and structured assessment of the fire risk in the building for the purpose of determining the current level of fire risk and the adequacy of existing fire precautions. It should also be used to highlight hazards that require further examination as part of the strategy preparation.

Fire risk assessments can vary considerably in content scope, inputs and outputs. Some may be extensions of an overall health and safety assessment whilst others could be industry or even building specific to particular fire threats.

An approach for detailed fire risk assessments can be found in PAS 79.

6.5.3 Risk Profiling

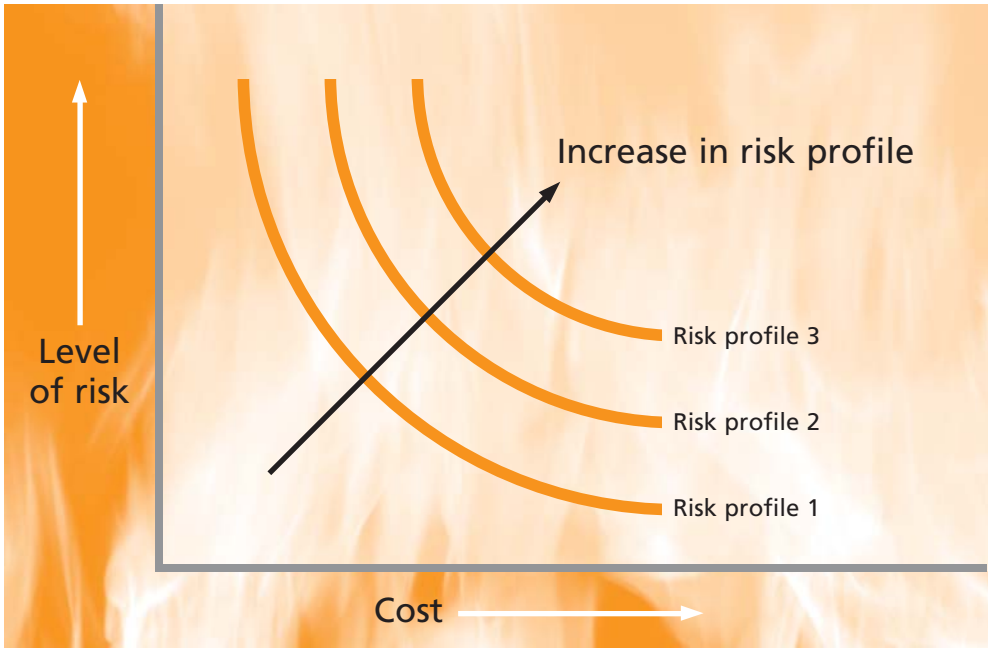
Risk profiling (or comparative risk assessment) is another form of risk assessment. This is where the risk for types of building are based on data already derived from research, experience and actual events. Data obtained from similar buildings to the building subject to the strategy can reveal where hazards may be found and the probability and impact of a fire in these areas.

The use of risk profiles for different types of building can overcome any subjectivity in the undertaking of risk assessments or can help to support findings of site risk assessments. One of the outcomes of risk profiling is in gaining an understanding that the level of cost invested to reduce the risk level varies with different risk profiles. Figure 4 illustrates this in the form of risk profile curves (the idea originating from economic supply and demand curves). Buildings covered by a specific risk profile, can reduce the level of risk by investing in appropriate fire systems and processes. Initially a small amount of additional cost will help to reduce the risk drastically with further cost expended to reduce the risk further until a stage where further investment provides little additional benefit.

The amount spent to reach a certain level of risk will vary for different risk profiles. Similarly, the reduction of risk to a certain level will require different levels of investment based on the risk profile. In effect, the higher the level of risk of a building, the greater the level of investment required to reduce the risk to a specific level, and consequentially, buildings with a higher risk profile will have a greater level of residual risk with the same amount of investment. It may be possible to "jump" risk profiles down to those with a lower risk. This will require global changes to the building's management of processes, to its control of the building, linings, and furnishings and to the way it manages fire safety, rather than the inclusion of additional fire systems (which will simply lower the level of risk). Consequentially, risk profile jumping is more to do with wholesale changes to the building, processes and management rather than implementation of fire precautions and systems.

Cost benefit analysis may assist in the decision to include or exclude some provision (see also **6.8.3**).

Figure 4 – Risk profile curves (© Kingfell)



Relevant fire safety legislation requires that the designated "responsible person" for the building, make a suitable and sufficient assessment of the risks to which relevant persons are exposed for the purpose of identifying the general fire precautions he / she needs to take to comply with the requirements and prohibitions imposed on him by or under the Fire Safety Order.

PAS 79 is a Publicly Available Specification providing guidance and recommendations for the preparation of risk assessments. Note that the scope is only applicable to the life safety of building occupants.

Risk Assessments and Profiling is covered in Clause 5 of **DD 9999**.

Comparative, probabilistic and deterministic risk assessments are described in **BS 7974**.

6.5.4 Risk reduction and "ALARP"

As risks are identified, control actions could be introduced prior to the implementation of the strategy to bring the level of risk to an "acceptable" level. This could negate the need for more refined or detailed requirements at a later stage. Risks described as ALARP (As Low As Reasonably Practicable) may not require special provisions or consideration within the strategy if all parties agree that this level has been reached for specific aspects of the building.

> HSE Research report 151, *Good Practice and Pitfalls in Risk Assessment* contains useful information on risk reduction and ALARP.

6.5.5 Assessment of hazards and evaluation of scenarios

It should be noted that there is a distinct difference between fire risk and fire hazard. A hazard is acknowledged as a source or a situation with a potential for harm to persons or damage to property.

The results of a fire risk assessment will help guide the fire strategy towards an effective set of measures

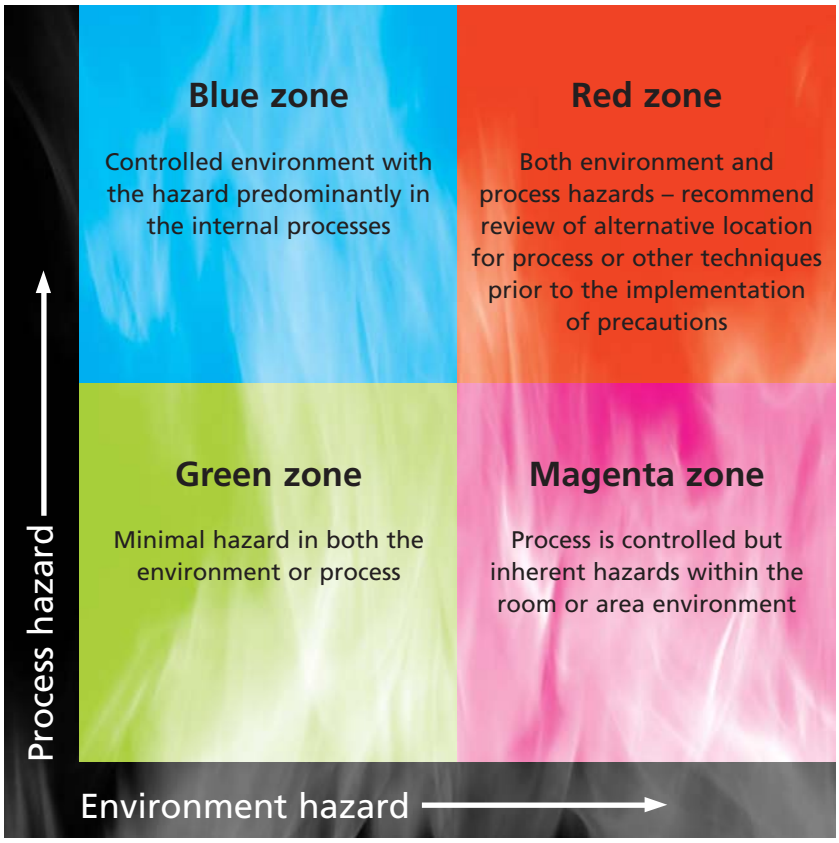
Hazard analysis is often an integral part of the assessment using a performance based approach although it can also assist where a prescriptive approach is used. A systematic review of a proposed scheme should be conducted to establish the fire-related hazards within the building and their potential consequences. The review should take account of factors such as:

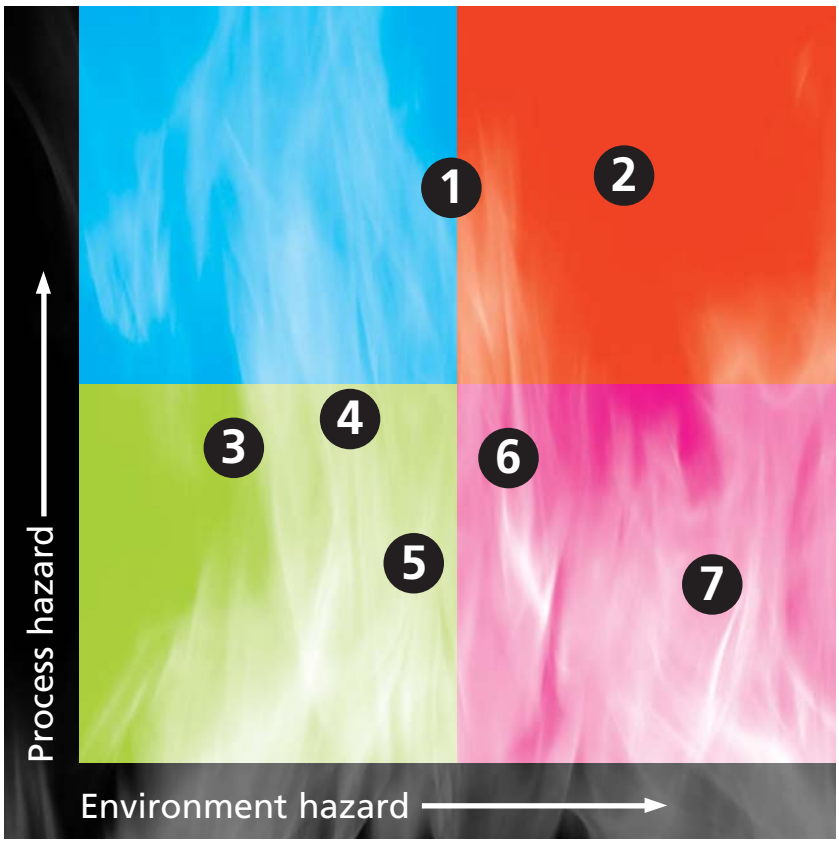
a) ignition sources;
b) combustible contents;
c) materials of construction;
d) nature of the activities in the building;
e) any unusual factors.

Hazards will be identified by the fire risk assessment. However, as an alternative to assessing hazards on a probability and impact basis, hazards can be assessed on a comparative basis. It should be noted that the hazard may not just be limited to the creation of a fire event, but aspects that may, for example, impede evacuation should similarly be described as a hazard.

Identified hazards should be reviewed and those deemed to be significant, and which could impact on the objectives for the strategy, should be subject to detailed investigation. Identification of significant hazards in complex scenarios may be difficult as there may be a large number of hazards deemed "significant". The "Significant Hazards Matrix" (illustrated in Figure 5) can be used to identify those hazards that are most significant and those that can be catered for without detailed analysis.

Figure 5 – "Significant" hazard matrix (© Kingfell)





Example building and hazard assessment

1 Canteen
2 Manufacturing area
3 Office 212
4 Boardroom
5 Office 311
6 Archive room
7 Store room

The tool allows the analysis of the hazards based on two perspectives; those found in the environment of the room or area assessed and those found in the processes within that room or area. Environmental hazards may incorporate the structure, fabric or fixtures and fittings. Process hazards will be those that can be described as "dynamic" and are introduced into the vicinity. Process hazards can include those related to persons and their activities. The tool allows each area to be plotted onto a grid so that the key hazards, i.e. those in the red area, are most obvious. Once hazards have been identified, they can be subject to one of two actions:

a) Control actions are initiated to reduce the risk associated with the hazard (see **6.5.3**).

b) The hazards are subjected to further analysis.

Once hazards have been established, setting scenarios can greatly assist in the assessment process to determine possible consequences, especially in helping identify possible weaknesses in an existing fire strategy or shortcomings in the proposed strategy.

"What if" analysis can take a hazard and look at the possible worst case scenarios. This could be calculated, assessed by relevant experts or modelled using computer simulations.

Hazard analysis is covered in BS 7974 as part of the qualitative design review (QDR) process.

6.5.6 Fire modelling and simulation techniques

It is possible to assess hazards in a qualitative manner or quantitatively using industry approved formula. However, where the scenarios are complex, or where alternative arrangements need to be considered, computer based fire modelling techniques could be used. These models are often used to estimate the ASET (Available Safe Egress Time) and then model appropriate solutions such as smoke control measures if necessary. There are two main types of computer based fire models used in the industry today, each of which has advantages and disadvantages. These models are described in **6.5.7** and **6.5.8**.

6.5.7 Zone models

Zone models are computer programs that assess specific rooms or areas for growth of fire, smoke and gases independently of other parts of a building. This information can provide a quick and readily available assessment of fire growth and smoke movement within the room and area. Zone models are largely based upon empirical data collected from experiments undertaken over many decades. The model effectively represents a three dimensional room as a two dimensional space and typically divides this space into two zones, the hot gas layer and the cool layer.

Advantages include:

- Quick and easy to setup and run simulations;
- Validated- proven to work for certain scenarios;
- Free downloads available from a number of distributors.

Disadvantages include:

- Typically do not conserve momentum, therefore gas velocities are not calculated;
- Two-dimensional in nature;
- Layers are homogeneous and as such do not contain gradients;
- Assumes rectangular rooms and flat ceilings;
- Should not be used for complex geometries outside of original experimental parameters;
- Instantaneous hot layer, fire development is not considered;
- Specialist knowledge and understanding of limitations required by the user.

6.5.8 Fire field models

A Fire Field Model (FFM) provides a three-dimensional, time dependant solution to the conservation laws of mass, energy, momentum and chemical species. The space being modelled is divided into a number of smaller volumes over which each of the conservation laws are solved.

Fire field models are essentially made up of two components; the fire model and the Computational Fluid Dynamics (CFD) engine. The fire model is where the parameters of the fire including the models for turbulence, radiation and combustion and various boundary conditions are specified and the CFD engine is where the vast number of algebraic equations are solved that are necessary to determine the solutions to the conservation laws and sub-models. A FFM will typically contain sub models for turbulence, radiation and combustion.

The solution of FFM's is computationally intensive. As a simplified example, a space divided into 100,000 volumes and solving 20 dependant variables over a period of 600 seconds would require the solution of a minimum of 1,200,000,000 equations.

Advantages include:

- Three dimensional, time dependant solutions are produced;

- Unlike zone models mass, energy and crucially momentum are conserved;
- Accuracy of the results can be improved by increasing the number of volumes that the space is sub-divided into;
- Can be used to model simple and complex scenarios.

Disadvantages include:

- Computationally intensive to run simulations;
- Time consuming to set up;
- Specialist knowledge required by the user.

Where computer based fire modelling is used, the following is recommended:

a) The program should be supplied from a recognized organization or research establishment;

b) It should be ensured that the model is suitable for the type of analysis required;

c) Those required to use the modelling program should be fully trained in its use;

d) Input data should be verified and approved by appropriately competent persons prior to its use.

6.6 Building characteristics

6.6.1 General considerations

The strategy should assess the following aspects of the existing or proposed building:

a) The location of the building and any geographical or structural features that could affect any aspect of the strategy;

b) The construction of the building and in particular, its load-bearing capacity;

c) The provision of fire resisting elements in the external walls, linings and roof coverings to prevent fire spread from the building to neighbouring buildings;

d) The arrangement of internal fire compartments and separations;

e) Openings within the building that could allow routes for uncontrolled fire or smoke spread;

f) Structural measures to prevent fire and smoke spread via cavities and voids;

g) The reaction to fire properties of external and internal walls and linings, floors, ceilings and roof coverings;

h) Materials used in the building and within certain voids where fire spread might pose a threat.

The Building Regulations Approved Document B [5] provides requirements for building design fire safety for new and modified buildings.

DD 9999 provides general guidance on the fire safety requirements of buildings.

6.6.2 Location

The location of the building could play a key part in the efficacy and success of the strategy. The following should be considered:

a) Proximity to the fire service and the expected attendance time;

b) Physical features that could impede the arrival and operations of the fire service;

c) Potential impact of a fire starting in a neighbouring building;

d) Obstacles that may impede the evacuation of persons away from the building;

e) Potential for the ground around the building to become inaccessible due to adverse weather conditions;

f) Features that may prevent fire-fighters from fighting the fire from all appropriate areas around the building.

6.6.3 Building Construction

The proposed or existing building structure should be assessed for its stability in a fire scenario. The main purposes for this are:

a) To allow all building occupants to evacuate from the building to a place of safety;

b) To allow time for fire-fighters to enter the building to either fight the fire or undertake search and rescue missions;

c) To minimize the possibility of danger from falling debris or building collapse to persons within the vicinity of the building or to neighbouring buildings.

An assessment of building stability and possible minimum time to collapse under specific fire scenarios will need to be assessed as this will impact on the evacuation and fire fighting requirements of the strategy. For new build projects, the building can be designed to cater for expected worst case evacuation and fire fighting scenarios. For existing buildings, the evacuation and fire fighting planning will need to be prepared to meet with the worst case scenario of the buildings loss of integrity, unless extensive structural modification of the building is planned. Elements of construction should be assessed in accordance with national codes.

6.6.4 Fire compartments and separations

The building under consideration is likely to be sub-divided into a number of fire compartments and fire separations, the purpose of these being to limit the spread of fire throughout the building. The separating elements need to provide an adequate standard of:

1) insulation, to avoid the unexposed side of the element becoming hot enough to ignite material in contact with or in the vicinity of that element; and

2) integrity, to avoid the formation of openings or cracks in the element that allow flame or hot gases to pass through it, to ignite the unexposed surface or materials on the unexposed side of the element.

All fire compartments and separations should be assessed. Considerations should include:

a) Is there an existing strategy for fire compartmentation?
b) How does the strategy deviate from conventional guidance?
c) How does the compartmentation strategy conform to the existing/proposed evacuation and fire protection strategies?
d) How do the fire compartments and separations match with the features of the building?
e) Are designated fire compartments and separations complete (i.e. structural slab to slab)?
f) Do the stated rating requirements match the physical features?
g) Are there any accepted variations to the requirements for fire compartmentation due to the provision of other fire protection measures (e.g. sprinkler systems)?
h) How are fire doors utilized – how effective are they in actual building use?
i) How are fire dampers utilized – how effective are they in actual building use?

6.6.5 Means of escape

Existing or proposed means of escape should allow occupants of the building to evacuate from the building in the shortest possible time and in minimum danger. Key accepted guiding principles are:

a) Every occupant of the building should have two available routes of evacuation. Where this is not possible, additional fire safety and protection provisions may be required to protect the single route of escape;
b) Dead end corridor conditions should be minimized;
c) Horizontal travel distances to an escape route should be minimized. Horizontal travel, should, as far as possible, be on the same level;
d) Escape routes from any occupant position should, as far as possible, be kept free from obstructions;
e) Designated vertical escape routes should be protected from the effects of a fire for a pre-determined period;
f) Vertical escape routes should be capable of allowing the numbers of persons to evacuate as detailed in the evacuation strategy;
g) Any means of vertical escape should not, as far as possible, be reliant on electrical or mechanical means except where specifically designed for this purpose;
h) Where persons are not able to directly evacuate from the building, they should be able to go to a place of relative safety from which they can be assisted in their escape;
i) All means of escape should ultimately lead directly outside of the building (other than where there are designated places of relative safety). No means of escape should lead back into a potential fire affected area;
j) All means of escape should be appropriately illuminated;
k) All means of escape should have appropriate signage;
l) Special provisions may be required for disabled persons.

Attention is drawn to the following documents which provide guidance on fire safety provisions for disabled persons.

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

BS 5588-12, *Fire precautions in the design, construction and us eof buildings: Managing fire safety*

DD 9999, *Code of practice for fire safety in the design, construction and use of buildings*

Proposed or existing means of escape provisions should be assessed against the above criteria and any other criteria deemed appropriate to the strategy.

6.6.6 Potential for fire and smoke movement throughout the building

The building should be assessed for the potential and ease with which fire, smoke and toxic products can move around the building. Considerations will include:

a) How can nominated escape routes be kept clear for the duration of the evacuation and fire fighting action?

b) What forms of natural ventilation exist – are they suitable for the expected type and quantities of smoke envisaged?

c) Where smoke extract is deemed appropriate, what are the logistics of installing forced extract systems within the designated areas?

d) Have potential fire and smoke paths been identified?

e) What is the potential for fire and smoke to spread through concealed or unidentified paths?

6.6.7 Plant and engineering services in buildings

Plant and engineering services in buildings should be assessed against the following criteria:

a) Do they constitute a hazard? This should have been separately evaluated by the risk assessment and hazard analysis process.

b) How susceptible are key services to a fire? In this case, location and separation from other risk areas will need to be assessed.

c) How could plant contribute to fire, smoke and toxic gas movement throughout the building (such as may be the case with ventilation)?

d) How easy will it be to access critical services in the event of a fire? As part of this assessment, the location of fire detection and alarm control and indicating equipment and equipment to control smoke extract equipment should be considered. In this case, the relative location and accessibility to means of escape or other safe area will need to be assessed.

The strategy will need to determine if the services are located in the most appropriate positions and/or the fire precautions necessary to achieve the desired solution have been provided.

6.6.8 Internal linings and furnishings

The reaction to fire properties of all building linings including walls, floor and ceilings (including any aesthetic constructions) used should be assessed. The assessment should consider ease of ignition, rate of heat release, surface flame spread rate, smoke production rate and total potential heat release.

It should be noted that, in many cases, the contents of a building will have more influence on the size and growth rate of a fire than the fabric. Building contents should be assessed as part of the fire risk assessment and hazard analysis.

Typically, the surface flame spread and heat release rate characteristics of the lining material should be of a higher rating in circulation spaces and escape routes than in other areas. Similarly, furnishings should be assessed for their fire properties.

6.6.9 Internal processes

All internal processes should be examined against the following criteria. Internal processes may include manufacturing areas, test and inspection areas, operational areas, etc. Similarly, areas where any activity takes place regularly should be regarded as process areas:

a) Do they constitute a hazard? This should have been separately evaluated by the risk assessment and hazard analysis process.

b) How susceptible are the processes to a fire? In this case, location and separation from other risk areas will need to be assessed.

c) How easy will it be to access critical processes in the event of a fire? As part of this assessment, the location of fire detection and alarm control and indicating equipment should be considered. In this case, the relative location and accessibility to means of escape or other safe area will need to be assessed.

d) The strategy will need to determine if the processes are appropriate in their existing location, are located in the most appropriate positions and/or the fire precautions are necessary to achieve the desired solution.

6.6.10 Provisions for fire-fighting

Provisions for fire fighting at any part of the building should be identified and assessed for reliability and availability in the event of a fire. The location of, for instance, risers should be examined and assessed if modifications need to be made to allow accessibility. Furthermore, water supply availability and pressure levels should be investigated and confirmed as suitable.

6.7 Occupant characteristics

6.7.1 General considerations

The occupant profile of the building will help determine the most appropriate evacuation strategy. Every building has a distinct group of uses and thus every building will need to be treated individually. Occupants can be knowledgeable of the building or may be transient, i.e. passing through the building, possibly for the first time. They may vary in a number of ways and there may be occasions when a variety of occupant types may co-exist in various parts of the building. They may also not be evenly distributed around the building but may be concentrated in a few key areas. In a fire condition, it is therefore vital to ensure that every aspect of the occupancy make up at the time of a fire can be catered for. For proposed buildings, the assessment of occupancy can take information from similar buildings.

6.7.2 Occupancy profiles and numbers

Objectives setting (see **6.4**) groups life safety considerations into four types; occupants; visitors; contractors; fire-fighters. Three of these groups are likely to be within or around the building in the event of fire.

6.7.2.1 Occupants

Those who normally occupy the building may have the following characteristics:

a) They are knowledgeable of the building, its layout and possibly fire and other exit routes from the building;
b) They would probably have received training on what to do in a fire incident;
c) They may have undertaken fire drills;
d) Some of them may be appointed as fire wardens;
e) They may be aware of the fire systems and procedures;
f) Their range of abilities to evacuate in a fire would be largely known;
g) There would be systems or procedures currently in place for those who are not readily able to evacuate;
h) "Pre-movement time" would be minimal due to the understanding of the existing evacuation strategy.

6.7.2.2 Visitors

Visitors to the building will come in a large variety of types, especially when the visitors are the general public. Some may be transient, i.e. passing through the building (such as is the case for railway stations and airports). Others may be there for some time.

The assessment of visitor numbers is likely to be much more complex than the evaluation of normal occupants. Visitors may typically have the following characteristics:

a) They may not be knowledgeable of the building and in a fire incident may rely strongly on what little knowledge of the building they have;
b) Their numbers may change greatly throughout the day and on different days;
c) Density of visitors may vary greatly within the building, with a greater concentration in parts;
d) There may be national variations in the way they may react to a fire warning;
e) Language and comprehension of alarm messages may be an issue;
f) Their range of abilities to evacuate in a fire would be largely unknown;
g) "Pre-movement time" may potentially be longer than desired due to their lack of knowledge of the existing evacuation strategy.

6.7.2.3 Contractors

Contractors are persons who may be employed directly or indirectly to undertake works on the building and its processes, or who may be used for specific tasks within the building. Their characteristics may include:

a) Knowledge of the building may vary between different contractor groups, although most are likely to have received relevant training prior to working within the building. Some may only have knowledge of a specific part of the building;
b) Their numbers may change greatly throughout the day and on different days. They may also work overnight;
c) Density of contractors may vary greatly within the building, with a greater concentration in parts, some of which may be in confined or normally unused areas;
d) Language and comprehension of alarm messages may be an issue;
e) Their range of abilities to evacuate in a fire may not be totally known;
f) "Pre-movement time" may potentially be longer than desired due to their lack of knowledge of the existing evacuation strategy.

6.7.3 Methods of evacuation

There are many forms of evacuation strategy. The final choice of evacuation process and system(s) should be based on the findings of the occupancy profile assessment. The evacuation process can take the

following forms:

Total Evacuation: This is where all persons are simultaneously evacuated from the building, possibly automatically following detection of a fire condition. The main consideration here is that means of escape can cater for the numbers of persons evacuated safely and within the specified evacuation period.

Phased Evacuation: This is where persons are evacuated in stages. An evacuation alarm may be given in the designated areas or floors whilst an alert alarm is given in other areas. In this case, the passive and active fire protection arrangement should ensure that those remaining in the building are separated from the fire for the full duration of the waiting period and up until they reach a place of designated safety.

Coded Evacuation: This is where a coded alert message is given to relevant building personnel and is not readily understood by others. This will give time for relevant personnel to investigate the incident and make appropriate decisions. Coded evacuation procedures rely on effective training of key personnel.

Manual evacuation: This is where evacuation is controlled by building personnel only and may vary depending on the incident. Messages may be given via a PA system. This relies on suitable training of key personnel and detailed, approved, procedures and parameters in order to be effective.

6.7.4 Evacuation analysis

6.7.4.1 ASET/RSET Analysis and the Evacuation Strategy

Consideration of ASET/RSET conditions is covered in **BS 7974** and **DD 9999**.

One of the primary objectives of an evacuation strategy is to evacuate all persons whilst there is still time to safely do so. When following prescriptive guidance, the meeting of specific criteria based on occupancy and building characteristics should normally be sufficient to ensure a safe evacuation of personnel. However, for performance based assessments and where prescriptive guidance may not be conclusive, a more detailed assessment will need to be made. Two terms are used to determine whether the evacuation strategy is likely to be successful or whether additional measures will need to be put into place. The available safe escape time (ASET) is the time between the ignition of a fire and the stage at which evacuation is likely to become impossible, i.e. the escape routes have become untenable. The required safe escape time (RSET) is the estimated or calculated time required for escape. Impediments to evacuation can include the following conditions:

a) Loss of visibility;
b) Exposure to toxic and irritant products;
c) Exposure to heat;
d) Structural failure;
e) Too many people using the same route at the same time;
f) Escape routes being unavailable.

Where required, the strategy will need to determine the RSET and ASET levels and to ensure that the RSET is well within the ASET. The overall evacuation time as given by the RSET is made up of the following periods:

a) Time to detect a fire and sound an alarm;
b) The pre-movement time;
c) The travel time to, and within, places of relative and/or ultimate safety.

The ASET can be extended by the use of passive and active fire protection methods. The RSET can be reduced by reducing the variables given above.

6.7.4.2 Pre-movement time estimation

Pre-movement time, i.e. the time between the raising of an alarm and the commencement of evacuation can greatly affect the success of the strategy, and especially the evacuation strategy. It is commonly known that persons react differently to different forms of alarm. Pre-movement time can be greatly reduced when occupants receive direct, clear and relevant information such as instructions given by a public address system or directly by persons. Pre-movement times are likely to be longest when the alarm is not so conclusive, such as that given by bells or sounders. Further information and research should be available via national fire organizations. A suitable estimate of the pre-movement time should be established to allow an assessment of the total time to evacuation.

6.7.4.3 Population density

This is an estimate of the likely number of persons per unit area, based on typical building profiles and may be provided by national codes or may be collated by the building representatives.

NOTE *This may assume that persons are evenly distributed within the building, which in many cases may not be the case.*

6.7.4.4 "Hot spot" identification

This is where a build up of persons may occur and will skew the population density assessment. Examples could be in the build up of personnel waiting on platforms of a railway station.

6.7.4.5 Movement rate of persons

This is an estimate of likely or average speed persons may travel to get to an escape route. As highlighted above, travel speeds may vary considerably based on age and mobility. In actual evacuation conditions, speed of travel will be dictated by the slowest persons who may be mobility impaired but able to walk unaided.

NOTE *Mobility impairment does not just apply to the disabled but is equally applicable to elderly persons, persons under the effect of alcohol or drugs and persons who may be temporarily impaired by luggage, etc.*

6.7.4.6 Escape route dimensioning

The dimensions of the escape route should be assessed together with any pinch points and aspects that may slow travel of persons. National or local codes may, for instance, be able to base flow of persons within a staircase or along a passageway at, say, x persons/metre width per second/per minute.

6.7.4.7 Allowable forms of vertical travel

In most cases, the accepted form of travel may be via fixed staircases. There may, however, be special provisions for the use of other form of vertical travel such as lifts and escalators. Allowable forms of vertical escape will need to be agreed at an early stage of the strategy evaluation.

6.7.4.8 Evacuation assistance

The types and methods of evacuation assistance should be evaluated as to how it can affect the overall evacuation process.

6.7.5 Calculating evacuation times

There are essentially two methods available for calculating evacuation times; the more traditional hand calculation approach and with the use of computer modelling techniques. Although it is possible to get a good indication of the total evacuation times in relatively low populated buildings by using the hand calculation approach, the introduction of significant areas of congestion in highly populated and complex buildings and structures means that computer based evacuation modelling may be more appropriate.

6.7.6 Evacuation modelling techniques

Evacuation models have been developed over recent years in an attempt to address design criteria which were not covered in the prescriptive codes. For this reason, evacuation models can help determine RSET (Required Safe Egress Time).

Evacuation models can be classified into two main categories; simple models which just consider the occupants' movement within the enclosure, and more complex models which consider the occupant's movement, but also take into consideration the occupant's behaviour, singularly and in groups. Each type has its advantages and disadvantages.

6.7.7 Simple evacuation models

These models are sometimes referred to as "ball-bearing" models. They do not take into account aspects associated with the psychological attributes of the occupants. Issues such as pre-movement times are not considered for the evacuation time calculations and when they are considered, they assume that the whole population will have the same behaviour, undermining individual behaviour. Depending on the model used, some of them do consider the impact of the fire products on the occupant's movement.

Advantages include:

- Quick and easy to set up and run simulations;
- Validated/proven to work for certain scenarios (i.e. a first qualitative analysis).

Disadvantages include:

- For complex geometries, they might underestimate the evacuation time;
- Do not represent realistically the interactions: occupants-occupants; occupants-fire and occupants-geometry.

6.7.8 More complex evacuation models

These evacuation models take into account physical and psychological attributes of the occupants for the evacuation time calculations, and are therefore more realistic. As a consequence of the increasingly complicated human behaviour included in the models, simulation times can be significantly increased over simpler models, especially in complicated geometries with large populations. The models rely heavily on a good understanding of human behaviour and as such the model should be continually updated and improved to take into account new research in the field. They are usually capable of taking into account the impact of fire on the occupants' movement.

The main advantage is that, if properly used, realistic and meaningful results can be obtained.

Disadvantages include:

- Depending on the model and on the scenario, it can be computationally intensive to run;
- It is time consuming to set up;
- It requires the user to have specialist knowledge.

The following is recommended where evacuation models are used:

a) The program should be supplied from a recognized organization or research establishment;
b) It should be ensured that the model is suitable for the type of analysis required;
c) Those required to use the modelling program should be fully trained in its use;
d) Input data should be verified and approved by appropriately competent persons prior to its use.

6.7.9 Warning of a fire incident

There are many ways in which a fire warning can be made. The final choice of the method of warning in the event of a fire will be based upon the evacuation process and the occupancy profile assessment.

> Types of warning system are covered in **BS 5839-1**.

Alarm announcements may take the following forms:

a) Manual warning using bells or voice;
b) Alarm bells connected directly to the fire detection and alarm system;
c) Alarm sounders connected directly to the fire detection and alarm system;
d) Voice alarm system, possibly linked to the fire detection and alarm system;
e) Public address system, which may be linked to the fire detection and alarm system or may be stand alone;
f) Visual alarm systems that may be used to supplement sound based systems or may be designated for persons;
g) Personal alert systems that may, for example, cause a device to vibrate. This may be appropriate for persons with hearing difficulties or for persons located in remote areas of the building not covered by the building alarm system.

It may be found that more than one type of system may be required to overcome specific building or occupancy issues. The correct choice of system should help reduce ambiguity and "pre-movement time" which may be a major factor in achieving an effective evacuation.

6.8 Practical issues

6.8.1 General considerations

As identified in **6.4**, all fire strategy objectives should be achievable and realistic. They should also adopt a degree of pragmatism. There will be a number of ways in which "real parameters" impact on the ability to provide the perfect strategy. It is in the practical assessment and working around the constraints that a strategy will be effective and usable.

6.8.2 Understanding and evaluating the constraints

Constraints may be found in many forms. The following are some examples:

Technical: Features of the building could restrict the choice of system or process. For example, buildings with high levels of electromagnetic interference may restrict the use of some types of fire detection system, or may cause failures or false alarms.

Logistical: Features of the building that may physically restrict some aspects of the strategy. For example, a gaseous fire extinguishing system may be appropriate for a risk area but it may be found that the storage requirements cannot be physically catered for.

Commercial: Some aspects deemed appropriate may not be commercially viable. For instance, the requirement for an additional means of escape for an existing multi-storey building may be justifiable but unrealistic.

Understanding and highlighting the constraints on the strategy should be discussed at an early stage of its preparation. Where the requirement is part of a primary objective, then a suitable alternative solution should be found. Where it is a requirement of a secondary objective and an alternative solution cannot be found, then the objective will need to be re-evaluated. Consideration will need to be given to the maintainability of the strategy over the long term. An inappropriate or overly complicated strategy is likely to be misinterpreted, underused, or "binned". This in itself should be regarded as a constraint. Decisions with regard to constraints should be made in consultation with all interested parties.

6.8.3 Over-protection

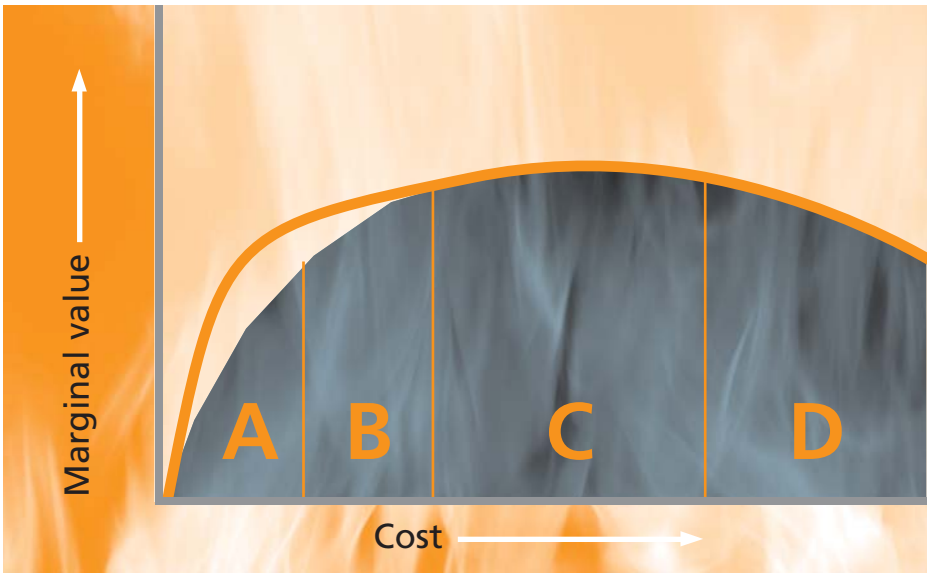
The concept of "overprotection" is where requirements of the strategy are over and above that which is strictly required. There may be a number of reasons for this:

a) External parties make additional demands of the strategy than those which are strictly necessary.
b) Those preparing the strategy may take a 'risk averse' approach and prefer to over specify.
c) Those involved in the process cannot agree on one

or more aspects of the strategy and thus take the "best case" option.

Figure 6 illustrates how overprotection can lead to a reduction in the marginal value of additional resources. One of the aims of the strategy will need to be the provision of a cost effective solution. This will be expected by the building users. Consequently, decisions made should be periodically reviewed on a cost / benefit basis.

Figure 6 – "Overprotection" illustration (© Kingfell)



- **A** Initial fire precautions providing high benefit for relatively small outlay
- **B** Additional fire precautions and measures adding to the effectiveness of the overall fire strategy
- **C** The optimum level of precautions, procedures and systems providing an appropriately costed and effective strategy
- **D** Additional measures introduced that provide little, if any, additional benefit to the fire strategy

Where existing fire system information is inconclusive, it may be advisable to undertake a fire system "health check".

7 Formulating the strategy

7.1 The formulation process

7.1.1 General

The preparation process will normally be as complex as the building on which the strategy is based. In some cases, it may be preferable that the preparation process is conducted within a team rather than by an individual. This will allow proper peer consideration and should highlight problems before they form part of the final strategy. Where a performance based approach is used, national codes may already include a process which, if acceptable, could be used.

7.1.2 Fire strategies for new buildings

When developing a fire strategy for a building in concept stage, there is an obvious advantage if the strategy is prepared as part of the feasibility study and those preparing the strategy are part of the building design team. In this way, this should ensure that all factors are appropriately considered at an early stage and that re-design at a later stage due to fire safety or fire protection issues are largely avoided. With reference to the strategy inputs and design basis given in Figure 1, some of the inputs may be limited in applicability and scope to new buildings. In particular, risk and hazard assessment can only be based on those perceived risks and hazards expected when the building is occupied, albeit that this exercise is worthwhile even at concept level. Similarly, practical issues can be reduced by effective and sympathetic building design.

The process of preparing a fire strategy for new or concept buildings should follow the national approved building or architectural stages from Inception through to Outline Proposal / Scheme Outline Design. The results of the fire strategy should be used to determine detailed designs. Consequently, the strategy should be agreed and used before the detailed design stage arises.

Within the UK, the most appropriate guidance for New Building design and build stages is prepared by the Royal Institute of British Architects (RIBA) Plan of Work. These are:

Stages A and B: Inception and Feasibility

This covers consideration of the client's requirements through to the carrying out of preparatory work to determine the feasibility of the building design. This will be the appropriate stage in which the fire strategy inputs and design basis are evaluated. By Stage B, the basis of the fire strategy should be agreed in principle.

Stages C and D: Outline Proposals and Scheme Design

This covers a more developed proposal and an indicative and outline scheme design. Relevant permissions and approvals by external parties will be sought at this stage. By Stage C, the fire strategy should be suitably developed such that by Stage D the Strategy is approved and can be implemented to outline design level for the fire safety and protection systems.

Stages E to L: Detail Design, Installation, Commissioning to Completion

Through these stages the procedures and systems are designed and implemented in line with the requirements of the Fire Strategy.

With extensive variations in building design and occupancy, a fire strategy will need to be developed that is specific to the building's needs.

The Fire Strategy Panel should meet at key stages of the strategy development

7.1.3 Fire strategies for existing buildings

For existing buildings, all the Fire Strategy Inputs given in Figure 1 will be applicable to a greater or lesser extent. Where no other guidance exists, the flow chart given in Figure 7 could be followed. This covers the following:

a) *Planning Meeting(s):* Procedure, timescales and design basis are agreed;

b) *Research:* All data, records, documents and relevant codes are subjected to detail review;

c) *Liaison:* All relevant persons and bodies involved are consulted;

d) *Site Activities:* For existing buildings this will incorporate audits and surveys of the building, occupants, services, systems, etc;

e) *First Review:* Collation and review of information received with relevant stakeholders. Where the information is found insufficient or ambiguous, further investigations may be required. This may include, for instance, the requirement for system health checks. This will involve one or more meetings with stakeholders;

f) *Outline Draft Strategy:* To prepare a strategy with the key findings to date and the overall structure;

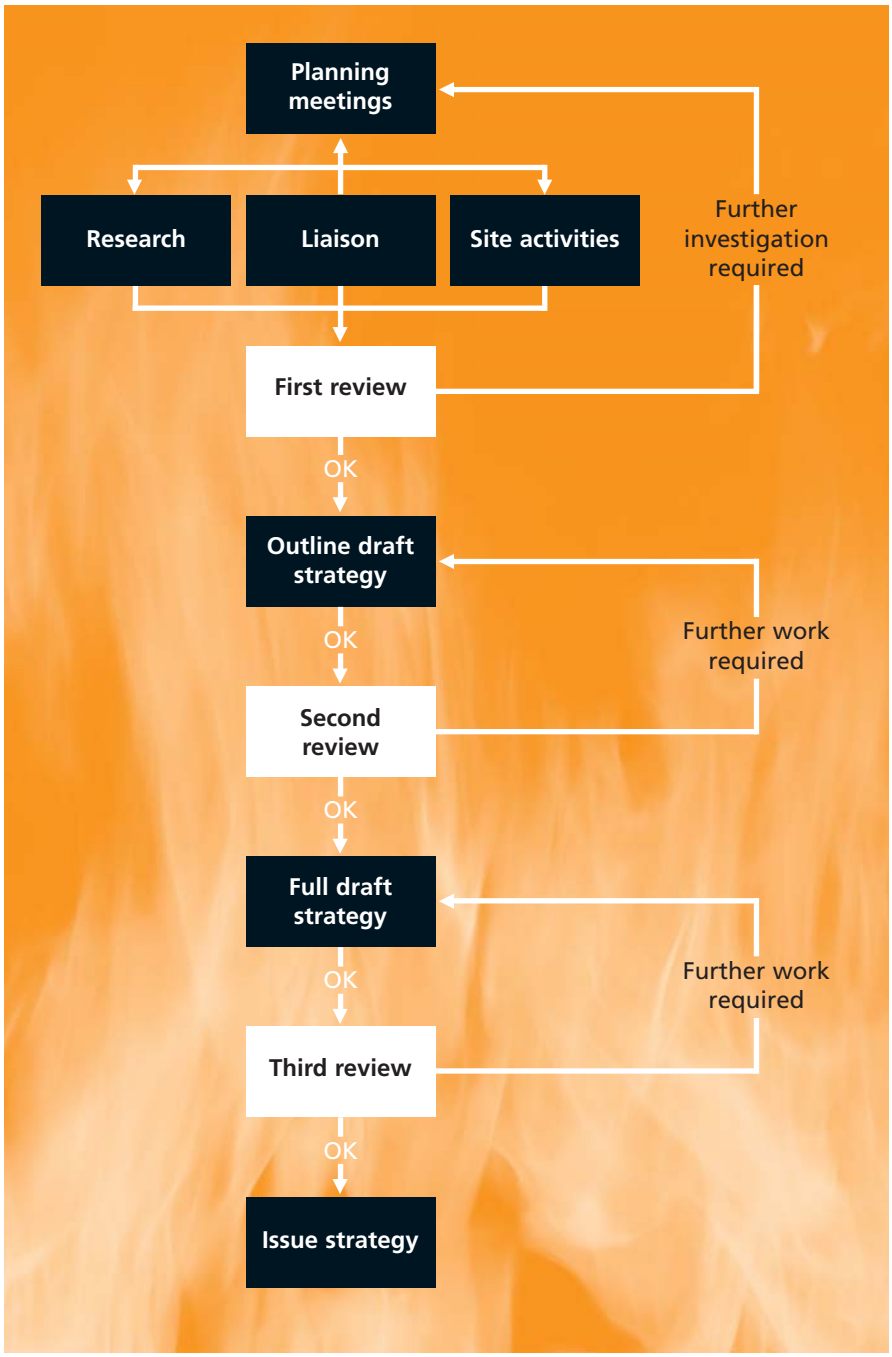
g) *Second Review:* Consideration of the first draft together with further recommendations for investigation. This is also the point to determine if the objectives set are "SMART". This will involve one or more meetings with stakeholders. At this point, issues not properly resolved or covered can be reassessed in a revised outline draft strategy;

h) *Final Draft Strategy:* To prepare the full draft strategy;

i) *Third Review:* Consideration of the final draft. This will involve one or more meetings with stakeholders. At this point, any final issues would need to be corrected prior to release of the strategy as a working document;

j) Issue Strategy: The strategy is issued as a working document.

Figure 7 – Strategy process chart for existing buildings (© Kingfell)



7.2 The unification of the components of the fire strategy

The aim of the Fire Strategy Document is to provide a clear set of measures encompassing fire precautions, management of fire safety and fire protection. It is vital that these measures have been assessed both independently and for their mutual dependency and that each process and system performs in a unified manner to properly meet the requirements derived from the inputs described earlier. This PAS provides two tools to assist in the verification of that the component parts of the strategy and how they interact. These are:

a) Components of the fire strategy: Flow Chart;

b) Components of the fire strategy: Timeline.

The first is shown in Figure 8 and illustrates, in flow chart format, how each process and system may interact from initial detection of a fire, to the realizing of two base objectives of extinguishing the fire (fire out) and evacuating all personnel (people out). The flow chart illustrates a sequence of events that may be appropriate. By considering each path separately, the extent of methodology of provisions can be identified. In a number of fire strategies some of the paths listed may not be necessary. The flow chart does, however, highlight the following base conclusions:

a) A fire detection system on its own can have no impact on the fire strategy;

b) A system purely designed for life safety may need to do more than raise an alarm;

c) In order to achieve specific system objectives, a number of actions may need to be initiated;

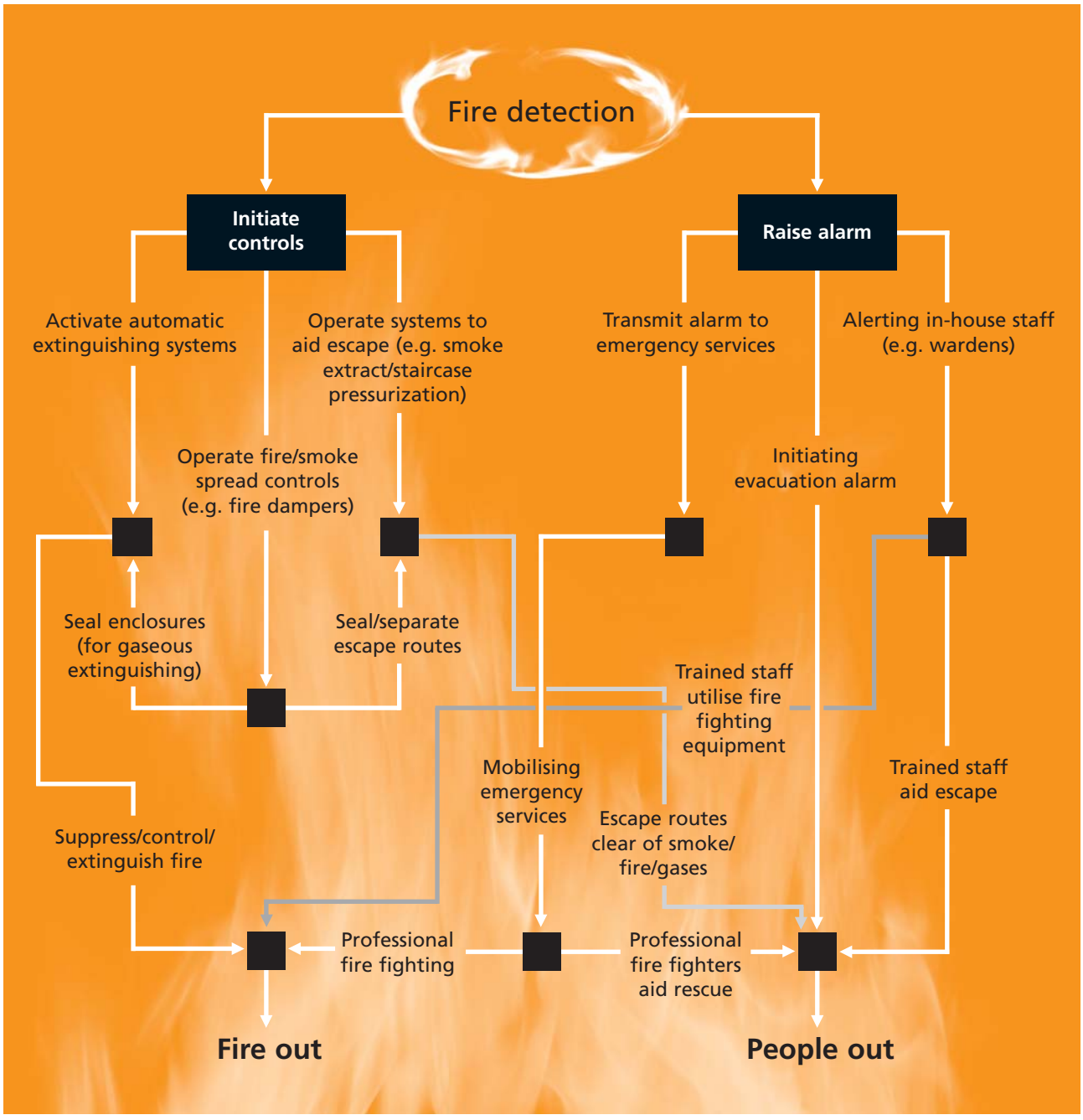
d) A strategy for fire containment/extinguishment and one for life safety only are not mutually exclusive.

It is recommended that each path is examined by the person(s) preparing the fire strategy to determine if the path is necessary and, if it is, what measures are put into place.

Complex or unusual building arrangements may point towards a performance based design basis.

The output of the fire strategy may, for instance, determine that a form of automatic fire suppression, such as a sprinkler system, is most appropriate.

Figure 8 – Components of the fire strategy: flow chart (© Kingfell)



The second tool is based upon the Available Safe Egress Time (ASET) model as given in BS 7974 – Figure 4, but expands it to cover all the main aspects of the strategy. This follows on from the requirement for objectives to be time dependant. The purpose of the tool is to allow all time related factors to be entered onto a time line. This may highlight two issues:

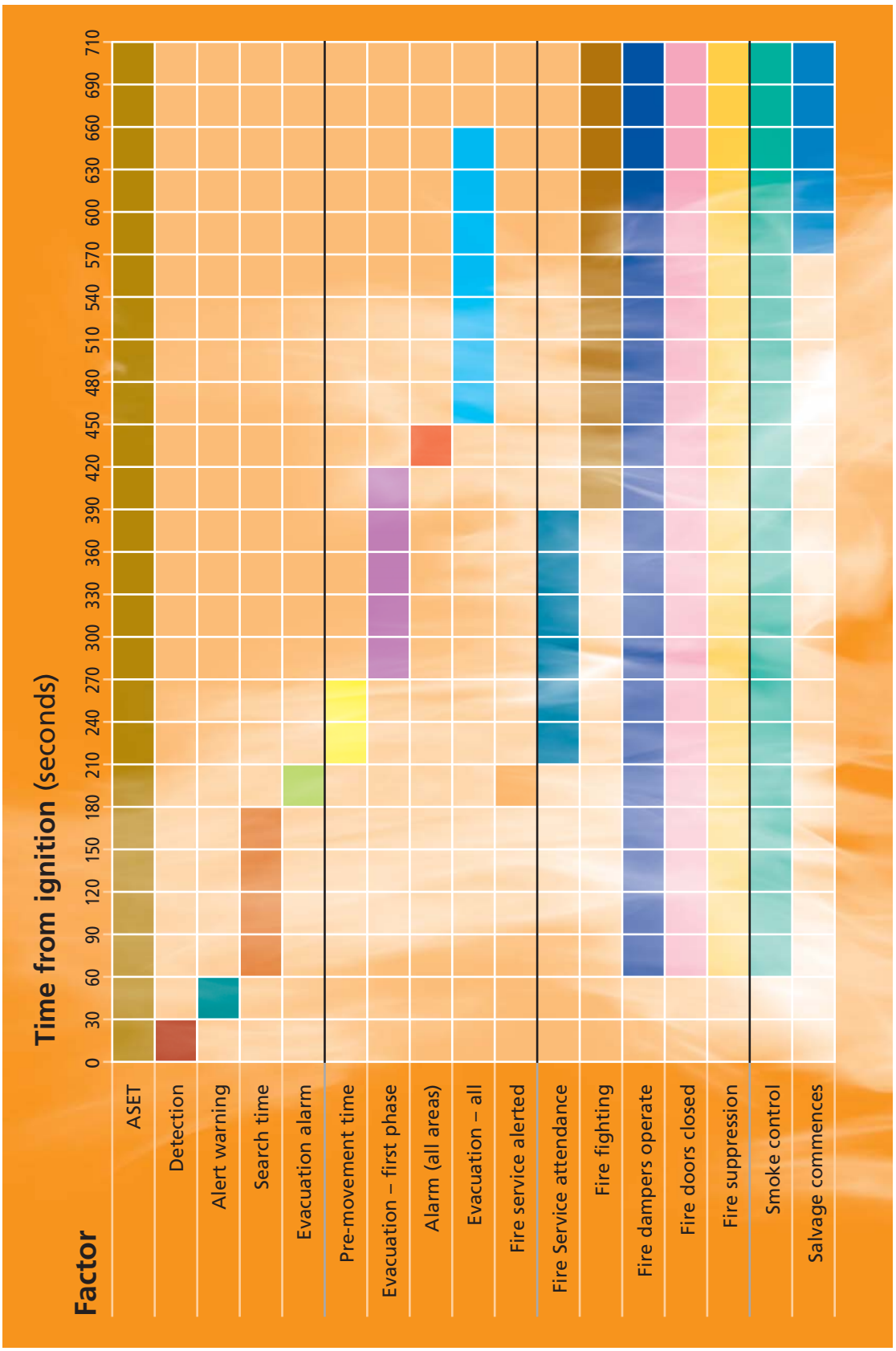
a) That, by trying to enter a time to each of the factors, some aspects may not be known or may be hard to quantify;

b) Inconsistencies in the time related factors of the strategy may require review.

This model as given in Table 1 is how the model could look. The factors and timeline parameters would be strategy based and thus will be different from that given in the example.

Table 1 – Components of the fire strategy: example of a time line

(Taken from the ASET model of Figure 4 of BS 7974).



7.3 Consideration of options

A properly prepared strategy should investigate appropriate options in the development of specific solutions. In many cases, there may be a preferred option whereby this may be the most appropriate method. There may be others that are less obvious and assessment of optional arrangements will be paramount. As an example, major options could be in the use of sprinkler systems as a variation against the specification of fire compartments. This is also referred to as "equivalency". Other options may be in the choice of detection methods. There may be various methods of assessing options, from consideration in national codes to preferences given in corporate specifications.

Table 2 provides another method to assess alternative propositions and bases the assessment from three perspectives;

Performance (how effective will the option be in a given scenario);

Logistics (the relative ease in which the option can be provided);

Economics (how commercially viable is the option).

Each option should be scored appropriately.

The maximum score (x, y or z) can be chosen by the interested parties in terms of what are seen as most important. For example, if Performance is seen as more important than Logistics which, in turn is seen as more important than Economics, the relative max scores could be x = 10, y = 7 and z = 5. By multiplying each of the scores, a quantified evaluation of each option can be obtained, weighted according to the relative values of each criteria used. Table 3 gives an example of how the table could be used when considering detection options for an area with high ornate ceilings. In this case, the wireless system looks the most preferable.

Table 2 – Quantified assessment of options (© Kingfell)

Criteria	Option A	Option B	Option C
Performance *(Score from x)*	N1 out of x	N2 out of x	N3 out of x
	Multiply by	***Multiply by***	***Multiply by***
Logistics *(Score from y)*	N4 out of y	N5 out of y	N6 out of y
	Multiply by	***Multiply by***	***Multiply by***
Economics *(Score from z)*	N7 out of z	N8 out of z	N9 out of z
Total Score			

Table 3 – Example of using quantified assessment of options

Criteria	Wired point type smoke detection	Wireless point type smoke detection	CCTV based point smoke detection
Performance *(Score from 10)*	8	7	7
	Multiply by	***Multiply by***	***Multiply by***
Logistics *(Score from 7)*	2	5	4
	Multiply by	***Multiply by***	***Multiply by***
Economics *(Score from 6)*	4	5	4
Total Score	64	175	112

7.4 Value analysis

Those preparing the strategy should regularly undertake a value analysis of the provisions to ensure that there is no over specification that could lead to "overprotection" (see **6.8.3**). Although under specification could be potentially disastrous, specifying more than is strictly necessary, could lead to the following:

a) The strategy becomes overly complex and possibly unusable;

b) The precautions required will lead to additional unnecessary costs in system designs;

c) Longer term maintenance costs will be higher than necessary.

The following tool could assist in any value analysis. Figure 9 gives eight "solutions". These are based on eight possible outcomes from a fire strategy focusing on issues from fire prevention through to active and passive fire protection and manual intervention. Every type of system, process or precaution could be placed under one of the eight solution categories. By scoring how vital each solution is (out of 5), a relative measurement of where the strategy focuses on can be assessed. It could be argued that each factor is equally and highly important. This may be true in some cases, but not in a majority of cases. For instance, a historic building may incorporate fire compartments but has a history of fire doors being left open. To overcome this "reality", early detection may be seen as a priority to overcome this realistic deficiency in fire compartmentation. Consequently, fire compartmentation cannot be scored as highly as fire detection.

Figure 10 shows how the grid can be used. As a rough guide the greater the area within the shape, the more complex and the more expensive the strategy is likely to be. It also readily shows the priorities for the strategy and those not seen as being so important. Consequently the tool can help visualize the strategy and can help in the reconsideration of the strategy "crutches" – those aspects relied on the most.

Figure 9 – Strategy value grid (© Kingfell)

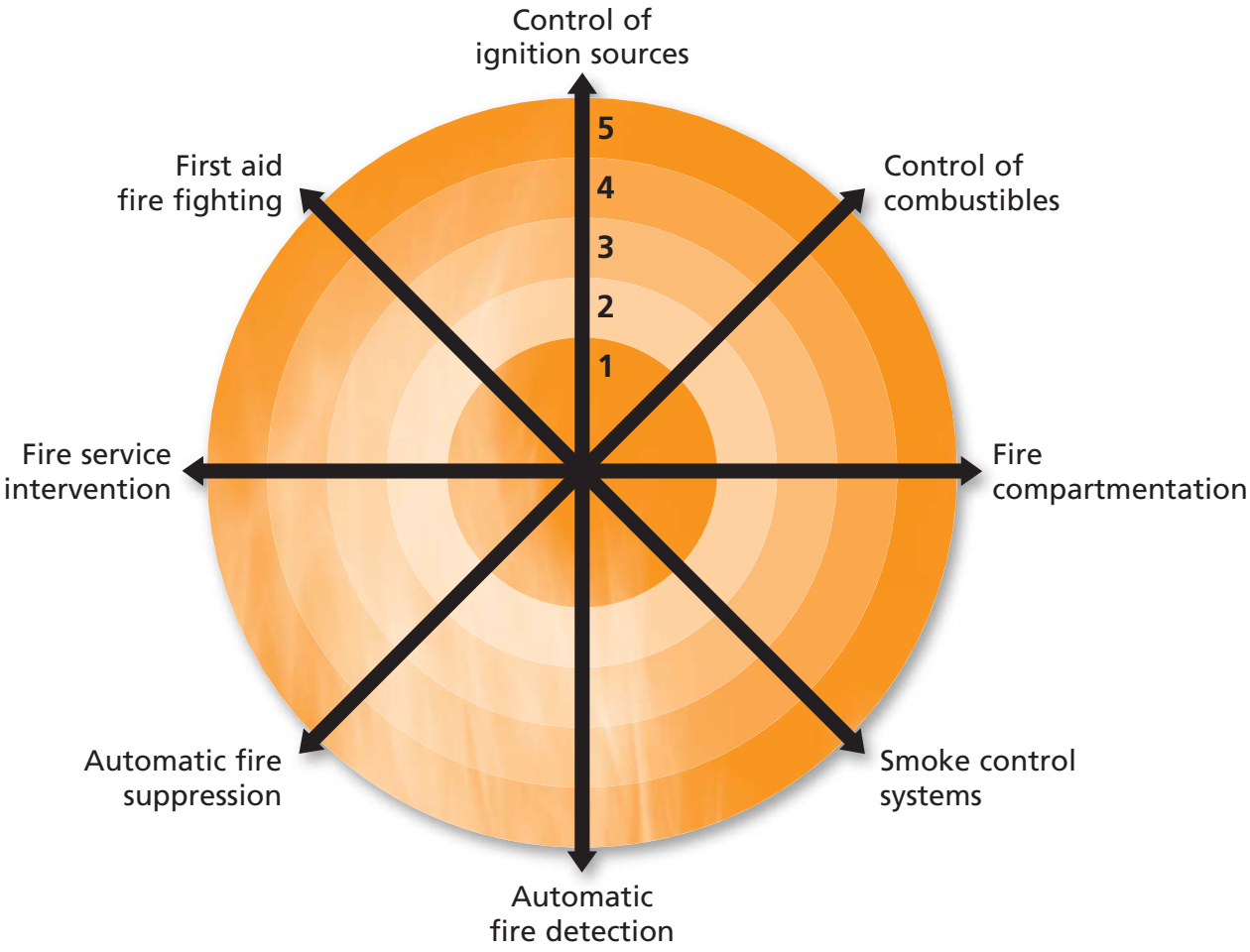
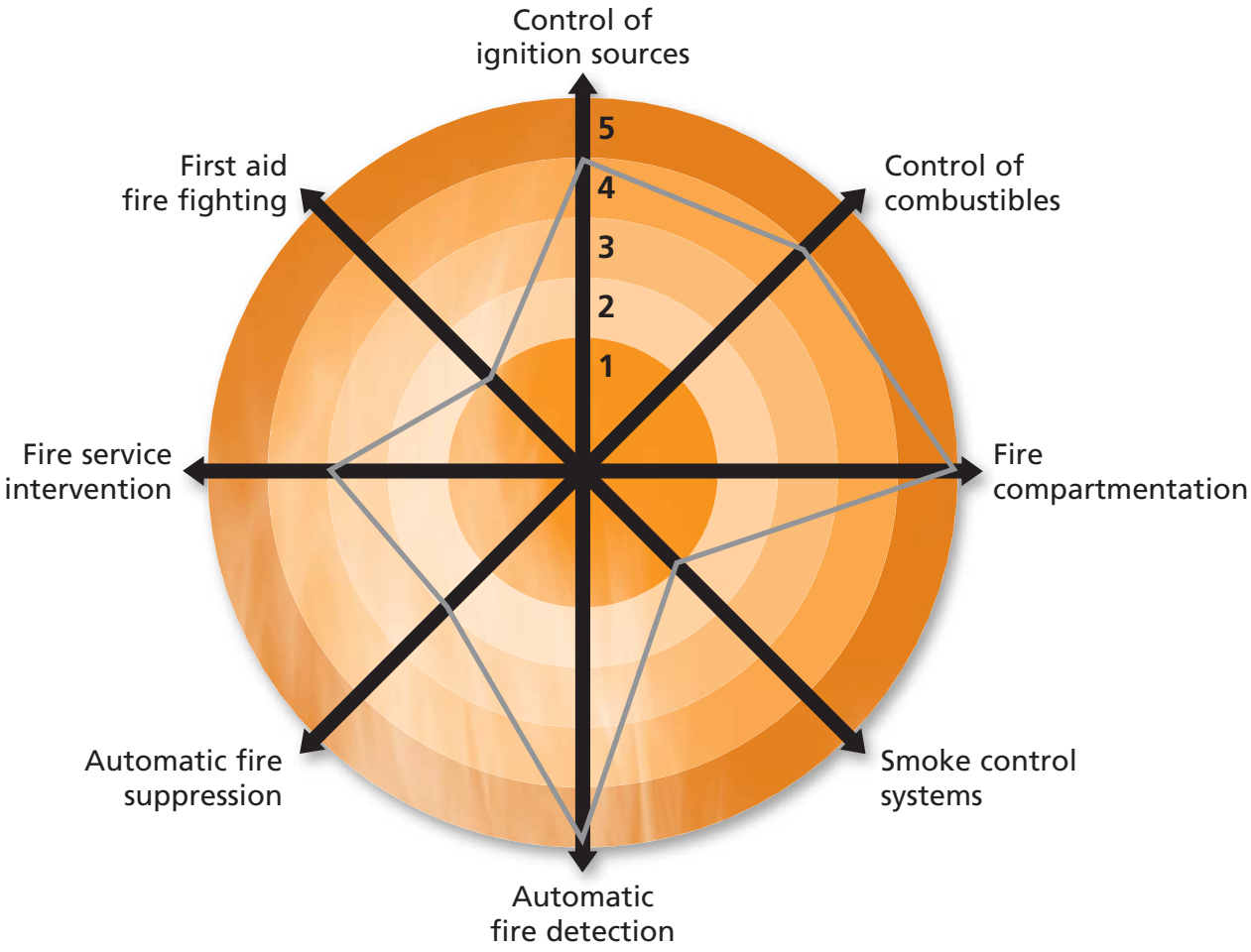


Figure 10 – Use of the strategy value grid (© Kingfell)



8 Fire strategy outputs

8.1 General considerations

The fire strategy is normally a single document with a number of sections. To help ensure that all relevant aspects have been considered, this PAS has subdivided the strategy into specialized groupings, or sub-strategies. These sub-strategies are:

a) The fire strategy statement, providing an overview and basis for the strategy;
b) The fire safety (management) strategy;
c) The evacuation strategy;
d) The fire fighting strategy;
e) The fire and smoke control strategy;
f) The fire protection strategy.

These sub-divisions do not mean that each part is independent of the other parts. As highlighted in Clause 7, one of the prime purposes of a strategy is to ensure a consistent and complementary set of measures.

The sub-strategies do, however, allow for revisions of one aspect of the overall strategy without reviewing all parts. For instance, changes to occupancy numbers may primarily impact on the evacuation strategy. Therefore this sub-strategy could be reviewed without impacting on all other parts. Nevertheless, one change may impact on more than one sub-strategy. Because of this, any review should be undertaken by person(s) with the same level of competency as those involved in its original preparation.

The possible outputs of each of the sub-strategies are given below. From **8.3**, the criteria and outputs are listed in tabular form. There is also a tick list enabling those areas to be identified as being included within the strategy and those that have been deemed to be not applicable. Further information and detail should be obtained from the relevant National Codes.

It should be noted that the lists provided in 8.3 to 8.7 are not exhaustive. In addition, all the criteria given may not be relevant in every case.

8.2 The fire strategy statement

The fire strategy statement could form part or the entire introduction to the strategy. The statement should include the following together with any other relevant information:

a) Those involved in the preparation of the strategy and when it was prepared;
b) The purpose(s) of the fire strategy;
c) The primary and secondary objectives for the building;
d) Those persons with responsibility for the fire strategy and its maintenance;
e) Agreed limitations to the strategy and assumptions made;
f) It may also include discussion of the main hazards found.

8.3 Strategy for management of fire safety

Table 4 – Management of fire safety strategy checklist

Criteria	Output	Included	Not applicable
Management overview	Details of responsible persons for fire safety		
	Reporting structure for fire safety		
	Procedures for review and authorization		
Prevention of fire	Fire prevention policies		
	Procedure for risk assessment		
	Housekeeping procedures		
	Control of processes		
Maintaining compliance	Control of works within the building that could impact on the strategy		
	Maintenance of fire systems		
	Compliance audits		
	Review of efficacy of fire precautions		
Training	Fire safety training		
	Contractor training		
	Fire drills		
	Training reviews		

8.4 Evacuation strategy

Table 5 – Evacution strategy checklist

Criteria	Output	Included	Not applicable
Means of escape	Identification of primary and secondary means of escape		
	Identification of places of relative safety		
	Horizontal travel requirements		
	Vertical travel requirements		
	Illumination of escape routes and provision of signage		
	Special requirements for disabled persons		
Evacuation methodology	Type of evacuation process		
	Warning arrangements		
	Evacuation assistance		
	Performance criteria		

Proper analysis of the occupant profile of a premises will help determine the most appropriate evacuation strategy.

8.5 Fire and smoke control strategy

Table 6 – Fire and smoke control strategy checklist

Criteria	Output	Included	Not applicable
Control of external spread of fire	Control measures for external spread of fire via walls		
	Control measures or external spread of fire via roofs		
Control of internal spread of fire (linings)	Ease of ignition rating of materials		
	Spread of fire rating of materials		
Control of internal spread of fire (structure)	Building stability requirements		
	Control measures for spread of fire between connected buildings		
	Requirements for internal fire compartments and separations		
	Control measures for the prevention of fire spread via concealed spaces		
Smoke control and management	Ventilation and extract arrangements for ground and upper levels		
	Ventilation and extract arrangements for basement and sub-basement levels		
	Control measures for the containment of smoke and products of combustion		
	Measures for the protection of escape routes from smoke		

8.6 Fire-fighting strategy

Table 7 – Fire-fighting strategy checklist

Criteria	Output	Included	Not applicable
First Aid Fire Fighting	Personnel and training requirements for occupants		
	Provision of first aid fire-fighting equipment		
Fire Service intervention	Attendance criteria		
	Vehicular access arrangements		
	Fire service escort arrangement		
	Access to fire equipment and systems		
Fire fighting water supplies	Details of provisions		
	Layout and accessibility		
	Special requirements		
Access arrangements	Arrangements for fire service access into the building		
	Arrangements for fire service access to upper or lower levels		
	Access criteria to fire system control and indicating equipment		
	Arrangements for fire service access to special areas		

8.7 Fire protection strategy

Table 8 – Fire protection strategy checklist

Criteria	Output	Included	Not applicable
Detection of fire	Type of detection required		
	Coverage		
	Control and indicating equipment		
	Performance requirements		
	Interfaces with other services		
Warning of fire	Type of warning system required		
	Coverage		
	Control and indicating equipment		
	Remote indication of a fire		
	Performance requirements		
Control of the movement of smoke and fire	Type(s) of system required		
	System arrangement criteria		
	Performance requirements		
Suppression of a fire	Types of system required		
	System arrangement criteria		
	Performance requirements		
Maintaining integrity of compartmentation	Type(s) of system required		
	Performance requirements		
	System arrangement criteria		

9 Finalising the fire strategy document

9.1 Format

Organizations and individuals competent to prepare fire strategies all have an in-house style that may be totally relevant to the building under assessment. This may be acceptable to all interested parties. However it is recommended that the style is agreed at an early stage. This style for approval could be in the form of a contents page. It is also likely that the style and arrangement of the document will differ whether a prescriptive or performance based approach is utilized. Suitable formats could follow national fire regulations or codes. Alternatively, the sub-strategy outputs given in Clause 8 could be followed as section headings.

The fire strategy document should be clear and concise. It is recommended that supporting research or calculations are contained in an annex or annexes rather than within the body of the report.

9.2 Level of detail

The strategy is designed to be a single overview of all relevant fire precautions specific to the building. It is not meant to specify detailed designs or arrangements but is there to give sufficient guidance for more detailed assessments and designs. In this way, it is likely to continue to be relevant throughout minor changes to the building, its occupants, etc. However, it should also not be so vague as to lead to ambiguous or misleading conclusions.

The following examples clarify the level of detail appropriate:

Example 1: Fire compartmentation

Not enough detail: *"Fire compartmentation should be utilized around the building as appropriate"*

Too much detail: *"Fire separations should be constructed using a layer of plasterboard each side of a wooden frame and should be..."*

About right: *"All identified means of escape should be protected by half hour fire rated construction as indicated in plan A1, ...identified areas of higher risk should be compartmented to a one hour standard..."*

Example 2: Fire detection

Not enough detail: *"Fire detection should be installed in all parts of the building"*

Too much detail: *"Fire detectors should be installed in Room A2 within 3 metres of the door..."*

About right: *"Fire detection should be installed to Categories L3/P2 of BS 5839 Part 1"* (The UK national code for fire detection system installation)

It will be for those involved in the strategy preparation to ultimately determine the level of detail necessary.

9.3 Document control

The strategy should be viewed as a live document and thus should be effectively controlled as such.

9.4 Maintenance of the strategy

The strategy should be reviewed on a periodic basis, and following any changes that are likely to have an impact on it. It is recommended that those with responsibility for the strategy undertake an in house review annually. It is also recommended that a more formal review is undertaken within every five years by persons competent to prepare strategies.

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BS 5810: 1979, *Code of practice for access for the disabled to buildings*

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BS 8300:2001, *Design of buildings and their approaches to meet the needs of disabled people – Code of practice*

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[2] GREAT BRITAIN, Fire (Scotland) Act 2005.

[3] GREAT BRITAIN, Fire and Rescue Services (Northern Ireland) Order 2006.

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