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Insurer requirements for the implementation of fire safety engineering solutions

RISCAuthority
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1.1 Background

1.1.1 What is fire safety engineering?

The Institution of Fire Engineers (IFE) defines fire safety engineering as 'the application of scientific and engineering principles, rules and expert judgement, based on an understanding of the phenomena and effects of fire and of the reaction and behaviour of people to fire, to protect people, property and the environment from the destructive effects of fire.' For the purposes of this document, the term 'fire safety engineer' does not include those who simply apply prescriptive fire safety codes and standards to the design of buildings. Neither does it include those who undertake fire risk assessments of such premises using simple techniques and checklists.

Fire safety engineers use their knowledge of fire behaviour, reaction of materials to fire and human behaviour in a fire to develop unique fire safety solutions. This work often involves calculation and the use of engineering judgement.

Fire safety engineering is being used more and more frequently in the UK as an alternative to the application of prescriptive fire safety codes and standards. It may be the only practical way to achieve a satisfactory level of fire safety in some large and complex buildings, and in buildings containing different types of occupancy. Additionally, it offers the designer more freedom to create innovative buildings, and, because fire safety engineering removes the possibility of unquantified 'over-design' related to the prescriptive approach, a fire safety solution may offer a more cost-effective solution.

When developing fire safety engineered solutions for buildings, it is common practice for the fire safety engineer to be instructed to concentrate solely on life safety and evacuation because these are the elements mandated by the building regulations process. Although life safety is of utmost importance, a solution which focuses exclusively on life safety can have a detrimental effect on property and business protection when compared with a prescriptive codes solution. This is of concern to the insurance industry and it is the purpose of this document to address that concern.

1.1.2 About this document

Although this document has been written on behalf of insurers, the technical content is intended for use by fire safety engineers and everyone who has involvement in the development and delivery of a fire engineering solution. The format and framework that it follows is based on the British Standard for fire safety engineering in buildings, BS 7974: 2001: **Application of fire safety engineering principles to the design of buildings. Code of practice** (ref. 1; see also 'Note regarding BS 7974' below). The techniques described will easily be recognised by competent fire safety engineers.

Throughout this document, the importance of contact and consultation with the insurer is stressed. This is because this document is not a 'national standard'. All insurers have their own views on fire safety engineering, its risks and the appropriate ways of addressing those risks. This document simply describes the broad principles which the fire safety engineer should follow. Where detail is given, it is only by way of example.

It should be highlighted that the insurer of a project during its design and build phase will often **not** be the organisation that will finally end up insuring the building on occupation. If the final insurer has not been identified at the design stage of the project, then the fire safety engineer has little choice but to follow the broad principles described here. However, it must be highlighted that the specific expectations of individual insurers will differ, and standards which are higher (or lower) than those quoted may be called for.

If both the design and build phase insurer **and** the final insurer can be identified, then the whole project should be signed off by both. In the event of a conflict of interest between these two insurers, priority should be with the final insurer, but this is a matter which must be resolved by the insurers themselves, not the fire safety engineer.

Consultation will usually involve non-technical discussions between the insurer, the fire safety engineer, the designer and the end user regarding the insurer's specific expectations in terms of property protection, the avoidance of business interruption, fire safety management and so on. If the fire safety engineer wants detailed technical guidance, or if the insurer wishes to understand a particular point of fire engineering practice, this document will not provide an explanation.

Insurers can obtain fully independent technical guidance on matters of fire safety engineering from the Fire Engineering Services group of the Technical Division of the FPA.

Tel: 01608 812 500; Email: fse@thefpa.co.uk

NOTE REGARDING BS 7974

The following statement is taken from the Foreword to BS 7974:

'BS 7974 is intended to provide a framework for the application of fire safety engineering principles to the design of buildings. It is supported by the PD 7974 series of Published Documents that contain guidance and information on how to undertake detailed analysis of specific aspects of fire safety engineering in buildings. PD 7974-0 to 7 provide a summary of the state of the art and it is intended that they will be updated as new theories, calculation methods and/or data become available. PD 7974 is structured as follows:

Part 0: Guide to the design framework and fire safety engineering procedures;

Part 1: (Sub-system 1) Initiation and development of fire within the enclosure of origin;

Part 2: (Sub-system 2) Spread of smoke and toxic gases within and beyond the enclosure of origin;

Part 3: (Sub-system 3) Structural response and fire spread beyond the enclosure of origin;

Part 4: (Sub-system 4) Detection of fire and activation of fire protection systems;

Part 5: (Sub-system 5) Fire service intervention;

Part 6: (Sub-system 6) Evacuation;

Part 7: Probabilistic fire risk assessment.

This code of practice [BS 7974] can be used to identify and define one or more fire safety design issues to be addressed using fire safety engineering. The appropriate part(s) of PD 7974 can then be used to set specific acceptance criteria and undertake detailed analysis.'

1.2 Foreword

The **FPA Design guide for the fire protection of buildings: Essential principles** (ref. 2) document states that fire safety engineering may be used as an alternative to following the guidance contained in the **FPA Design guide**, but:

- it is important that early consultation with insurers during the building design phase is carried out. This should ensure that the most effective fire protection measures appropriate to the specific property, end use application and business protection needs are suitably satisfied;
- an appropriate fire safety engineering standard must be followed in full. BS 7974 is recommended, although **CIBSE Guide E: Fire engineering** (ref. 3) is also acceptable;
- the essential principles of the **FPA Design guide** must be achieved to the extent that they would be if the **Design guide** was followed in full (when assessed as a comparative approach); and
- the objectives of the fire safety engineering design must include the:
  - preservation of the structure and fabric of the building;
  - preservation of the building contents;
  - protection of ongoing business viability; and
  - maintenance of the corporate image.

This document explains a series of requirements placed upon fire safety engineering solutions which must be followed if the essential principles of the **Design guide** are to be met in such buildings.

1.3 Application

The requirements contained in this document are applicable to any new building, and to the alteration of any existing building, in which the fire safety design does not follow the solutions contained in approved guidance documents – including the **FPA Design guide** – and where fire safety engineering is to be used to provide an alternative approach to fire safety.

Where the fire safety of a building has been designed using the principles of fire safety engineering and this document, the building may be limited in terms of its flexibility of use. Therefore, the suitability of an existing fire engineered building may need to be re-assessed using this document when it undergoes a change, such as a change of use, a change of occupier, a material alteration or a change in the nature of materials stored or processes carried out.

In general, fire safety engineering design only considers the fire safety of a building once it has been occupied. However, buildings are at their most vulnerable to fire during their construction phase. Because of their reliance on active fire safety measures, such as fire detection and/or suppression, this can be particularly true in the case of buildings where fire safety engineering has been employed. As a result, the requirements contained in this document include fire safety considerations which must be followed during construction or alteration.

1.4 Terms and definitions

1.4.1 Acceptance criteria

Those criteria, including performance requirements and essential conditions, which must be met before the fire engineering design/strategy is accepted.

In practice, following quantified analysis, the results need to be compared with the acceptance criteria identified during the QDR (see below). Three basic approaches can be considered by the QDR team when setting acceptance criteria:

- comparative;
- deterministic; and
- probabilistic.

These are defined in PD 7974-0.

1.4.2 Fire safety engineering

The application of scientific and engineering principles, rules and expert judgement, based on an understanding of the phenomena and effects of fire and of the reaction and behaviour of people to fire, to protect people, property and the environment from the destructive effects of fire (definition from the Institution of Fire Engineers).

1.4.3 Fire load

The sum of the calorific energies which could be released by the complete combustion of all the combustible materials in a space, including the facings of the walls, partitions, floors and ceilings.

1.4.4 Fire load density

The fire load divided by the floor area.

1.4.5 Qualitative design review (QDR)

A meeting at which the scope and objectives of the fire safety design are defined, performance criteria established and one or more potential design solutions proposed. Key information is also gathered to enable evaluation of the design solutions in the quantitative analysis.

2. ESSENTIAL PRINCIPLES AND FIRE ENGINEERING REQUIREMENTS

The objectives of this document are based upon the essential principles of the **FPA Design guide**. These objectives may be met by following a series of principles (see Table 1 opposite).

2.1 Essential principles

While the detailed recommendations of the **FPA Design guide** are not mandatory, the essential principles shall be regarded as being of vital importance and need to be considered in detail by building designers, fire safety engineers, consultants, occupiers or building owners.

It is essential that insurers are consulted at the earliest possible stage of design, so that factors that influence the ability of the building owner to secure insurance at the most attractive terms can be identified.

2.2 Summary of requirements

This document defines a series of requirements placed upon fire safety engineering solutions which must be followed if the essential principles of the **Design guide** are to be met in such buildings (see Table 2 overleaf).

2.3 Stakeholders

2.3.1 Regulatory requirements

In order to gain approval for the construction of most buildings in England and Wales, their design must comply with the current Building Regulations (ref. 5). In Scotland, designs must comply with the Building (Scotland) Regulations (ref. 6), and in Northern Ireland, the Building Regulations (Northern Ireland) (ref. 7).

In terms of fire safety, guidance on meeting the regulatory requirements described above is given in the following documents:

England and Wales: Approved Document B to the Building Regulations 2000: **Fire Safety (Volume 2): Buildings other than Dwelling Houses** (ref. 8)

Scotland: Scottish Building Standards Technical Handbook (Non-domestic), Section 2: Fire (ref. 9)

Northern Ireland: Technical Booklet E to the Building Regulations (Northern Ireland) 2000: **Fire Safety** (ref. 10)

The primary emphasis of all these documents is the prevention of injury and death in the event of fire.

For example, **Technical Booklet E** (for Northern Ireland) says that:

'Building Regulations are intended to ensure that an adequate standard of life safety is provided in case of fire. The protection of property, including the building itself, may require additional measures and insurers will in general seek their own measures if they are to accept the insurance risk.'

It is therefore tempting to assume that a building constructed in compliance with such guidance would contain **no** measures to protect the structure of the building or its contents from fire. However, this assumption would be wrong.

The approach taken by the guidance documents is that life safety is delivered by a combination of methods. In general, these methods include reasonable means of escape from fire, reasonable means to prevent fire spread, reasonable measures to ensure structural stability in the early stages of fire and reasonable measures for fire service access (see Figure 1a).

Consequently, although the only regulatory requirement for the design of new buildings is that they must ensure the safety of occupants in the event of fire, a by-product of this requirement is that the structure of a building and its contents usually have a degree of protection from fire as well.

2.3.2 Insurer interest

During construction and occupation, buildings are usually insured. Historically, the risk which insurers have taken on has benefited from an element of structural fire protection which has been provided as a consequence of prescriptive life safety requirements. Premiums have always been calculated based on this assumption.

However, as has already been described, a performance-based approach can be employed to meet the same life safety objectives without providing structural fire resistance (see Figure 1b).

To ensure that the most effective fire safety measures appropriate to the specific property are applied, early consultation with the insurer and consideration of this document is essential. Failure to do so at an early stage could result in additional measures being required after construction, the use of the building being restricted or insurance premiums and/or deductibles being increased.

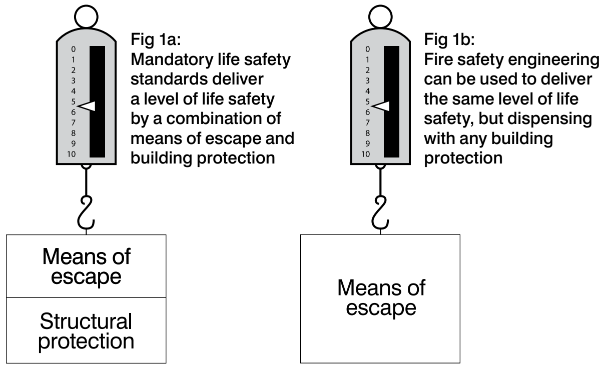


Fig 1a: Mandatory life safety standards deliver a level of life safety by a combination of means of escape and building protection

Fig 1b: Fire safety engineering can be used to deliver the same level of life safety, but dispensing with any building protection

Table 1: Essential principles

Reaction in the event of fire	
Principle 1	The building shall be constructed in such a manner that if a fire starts, the extent of fire and smoke damage will be minimised and confined as close to the source of fire outbreak as is practical/feasible.
Principle 2	With the exception of joinery products, the building shall be constructed from building materials/products that will not make a significant contribution to the early stages of a fire or contribute to the spread of fire.
Principle 3	Suitable measures will be taken for the prevention of premature structural collapse and excessive deflection.
Principle 4	Consideration should be given at the design stage regarding potential damage from firefighting water and to ensure as far as practical that the effect on the environment of the fire effluent will be minimised.
Workmanship	
Principle 5	As a minimum, all fire protection products shall be third-party certified to an appropriate product or performance-based standard (attestation level 1 for CE marking).
Principle 6	All fire protection products/systems shall be installed by adequately trained specialist installers.
Principle 7	The building shall be fitted with an appropriate automatic fire alarm system.
Principle 8	The fire protection systems shall be regularly maintained so that they are able to perform their intended function throughout the life of the building.
Fire prevention	
Principle 9	There shall be adequate provision to prevent an arson attack.
Principle 10	The building shall be so constructed that fire cannot spread into the premises from an adjoining building or other external fire source.
Fire safety management	
Principle 11	The building owner shall ensure an adequate standard of fire safety management throughout the life of the building.
Principle 12	Any fuel burning appliance and services or electrical appliance and services shall be designed, constructed and installed in a manner that reduces their potential as an accidental source of ignition.

Table 2: Fire engineering requirements

Requirement 1	To meet the requirements of the insurance industry, wherever practicable, the insurer must be invited to join the QDR team. Buildings are particularly vulnerable to fire during the construction phase, so the invitation must be extended to the insurer of the building during its construction phase or to the principal contractor's insurer.
Requirement 2	To meet the requirements of the insurance industry, the fire safety objectives of the QDR must include the matters detailed in this document to the extent determined by the agreed acceptance criteria.
Requirement 3	In order to minimise insured losses, fire suppression or containment (where used) must be initiated prior to critical damage to property or business taking place.
Requirement 4a	Table 9 of PD 7974-0 (ref. 4) gives an example of property protection objectives which may be set as deterministic acceptance criteria. In this document, Table 1 presents objectives which must be met in order to satisfy insurer requirements.
Requirement 4b	If a probabilistic approach is used to set acceptance criteria, then the objectives which must be met in order to satisfy insurer requirements must be discussed with the insurer. Broad guidance is described elsewhere in this document.
Requirement 4c	The degree of structural protection, loss prevention and business continuity assurance provided by a fire safety engineering solution must be at least as high as that provided by a fire safety design for an equivalent building which fully complies with an appropriate code or standard.
Requirement 5	To enable a third party to establish that the fire safety engineering study has been carried out by a person with appropriate expertise, the name, qualifications and experience of the individual fire safety engineer(s) responsible for the study must be provided. In addition, the fire engineer(s) will follow a recognised set of fire engineering guidelines (such as BS 7974) from the beginning to end of a project. The fire safety engineer(s) must provide a note of their current professional indemnity insurer, including the policy number and limit of indemnity.
Requirement 6	To meet the requirements of the insurance industry, the fire engineering solution must take a realistic view of the level of fire safety management which will be applied to the building during its foreseeable future, and must demonstrate that this level of management is sustainable. The fire safety engineer must demonstrate that every effort has been made to gather this information. Fire safety management requirements such as testing, servicing and maintenance (in particular those aspects upon which the fire safety engineering relies) must be described in the fire safety engineer's report.
Requirement 7	Fire safety management of construction sites is always important, but to meet the requirements of the insurance industry, where the fire safety design of a building is engineered, then a risk assessment of the implications of the fire engineering to the construction phase fire risk must be carried out and must be available to the insurer.
Requirement 8	With respect to the issues addressed by this document, the fire engineer's report must contain a non-technical explanation of how the requirements 1 to 7 have been met. In the case of large or complex projects, it may be necessary to produce this information as a separate report for the insurer.

2.4 The design process

2.4.1 General

A framework for a fire engineered approach to building design is described in BS 7974 and illustrated in Figure 2. Clause 4.1 of that code of practice divides the framework into three stages:

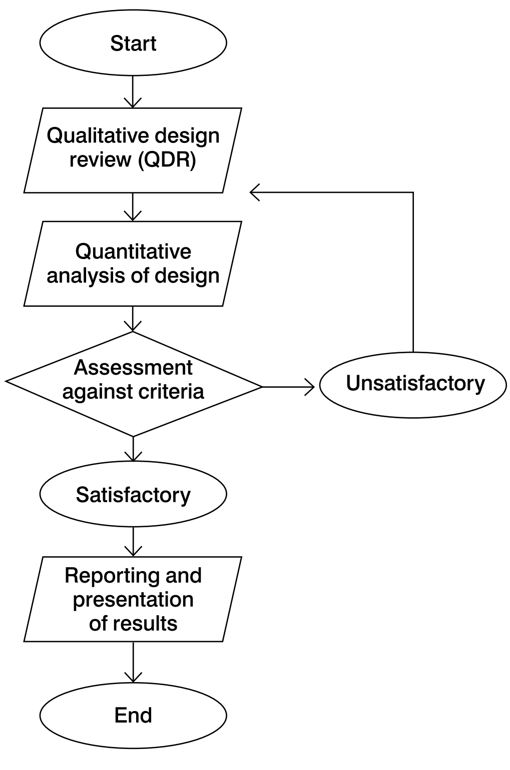
- **the qualitative design review (QDR)**, where the scope and objectives of the fire safety design are defined, and where performance criteria are established and acceptance criteria set;
- **quantitative analysis**, where engineering methods are used to evaluate potential solutions; and
- **assessment against criteria**, where the results of the quantitative analysis are compared against the acceptance criteria.

2.4.2 The qualitative design review

2.4.2.1 Personnel involved in conducting the QDR

Attention is drawn to Clause 6.1.2 of PD 7974-0, which states that **'the QDR team on a major project might include'** a representative of the **'approvals body and/or insurer'**, and to Clause 6.2 of BS 7974 which states that **'for smaller projects the QDR may be carried out by a smaller study group'**.

Fig 2: Basic fire safety engineering process (BS 7974)



Requirement 1: To meet the requirements of the insurance industry, wherever practicable, the insurer must be invited to join the QDR team. Buildings are particularly vulnerable to fire during the construction phase, so the invitation must be extended to the insurer of the building during its construction phase or to the principal contractor's insurer.

In some cases, the insurers may not deem it necessary to attend the QDR meeting. In other cases, the owner may not have approached an insurer at the QDR stage of the project. In such circumstances, if the requirements of this document can be demonstrated to have been met, then when selected, the insurers are more likely to be satisfied that the standard of fire safety meets their expectations (although this cannot be guaranteed).

2.4.2.2 Fire safety objectives

Clause 6.3.1 of PD 7974-0 states that **'the fire safety objectives that might typically be addressed in a fire safety engineering study [include] loss control'**. Clause 6.3.3 goes on to describe this particular objective in more detail. It says that **'it might be desirable to take measures to reduce the potential for large financial losses'**. And that **'consideration may be given to minimise the damage to:**

a) the structure and fabric of the building;

b) the building contents;

c) the ongoing business viability;

d) the corporate image.'

Clause 6.3.3 of PD 7974-0 also states that fire safety engineering can be used to assist in an environmental impact assessment of a fire. Clause 6.3.4 goes on to describe this particular objective in more detail:

'Consideration may, therefore, need to be given to the limitation of:

a) the effects of fire on adjacent buildings or facilities;

b) the release of hazardous materials into the environment;

c) methods of firefighting (eg avoidance of river pollution).'

Requirement 2: To meet the requirements of the insurance industry, the fire safety objectives of the QDR must include the matters detailed in this document (listed in 2.4.2.2 above) to the extent determined by the agreed acceptance criteria (see 2.4.3).

2.4.3 Acceptance criteria

2.4.3.1 General

Following the quantitative analysis, it is the function of the QDR team to decide whether a satisfactory fire safety solution has been delivered (see Figure 2). In order for this decision to be made without controversy, the QDR team must agree how this decision will be made before the quantitative analysis is started.

Clause 6.4.6.1.1 of BS 7974 describes four methods of judging the adequacy of a proposed solution:

- **Deterministic** in which the quantitative analysis must show that a predetermined set of circumstances are met. For example, a solution may be considered successful if it can be determined that evacuation will be completed before the ceiling temperature exceeds 100˚C.
- **Probabilistic** in which the probability of a particular event is shown to be acceptably low. For example, a solution may be considered successful if the probability of a fire spreading beyond its room of origin is less than 1:1000.
- **Comparative** in which the level of fire safety provided by the proposed solution can be shown to be equivalent to that of a similar building which fully complies with approved guidance.
- **Financial** in which the probability and extent of fire and smoke damage are weighed against the provision of additional fire safety measures in a cost-benefit analysis.

PD 7974-0 expands on these criteria in terms of recommendations for loss control objectives. This present document goes further in that it looks at these criteria in terms of **insurer requirements** for loss control objectives.

Figure 3 overleaf shows part of a timeline comparison between fire development and evacuation/damage to property. It is taken from BS 7974. This type of diagram could be used to summarise the fact that a set of deterministic criteria have been met – in this case, evacuation is completed before the tenability limit is reached. However, it is reproduced here to draw attention to two things:

- the fact that 'critical damage to property/business' must be included in any such analysis; and
- that it shows fire causing 'critical damage to property/business' before suppression, containment or extinguishment occur – indeed, before evacuation has been completed. Although it is accepted that this timeline is only intended as an illustration in BS 7974, it would almost inevitably be unacceptable to insurers as an actual result of a quantitative analysis.

Requirement 3: In order to minimise insured losses, fire suppression or containment (where used) must be initiated prior to critical damage to property or business taking place.

NOTE: Fire suppression systems must be designed, installed and subsequently maintained in accordance with acceptable codes and agreed with the relevant insurer for the project.

2.4.3.2 Deterministic criteria

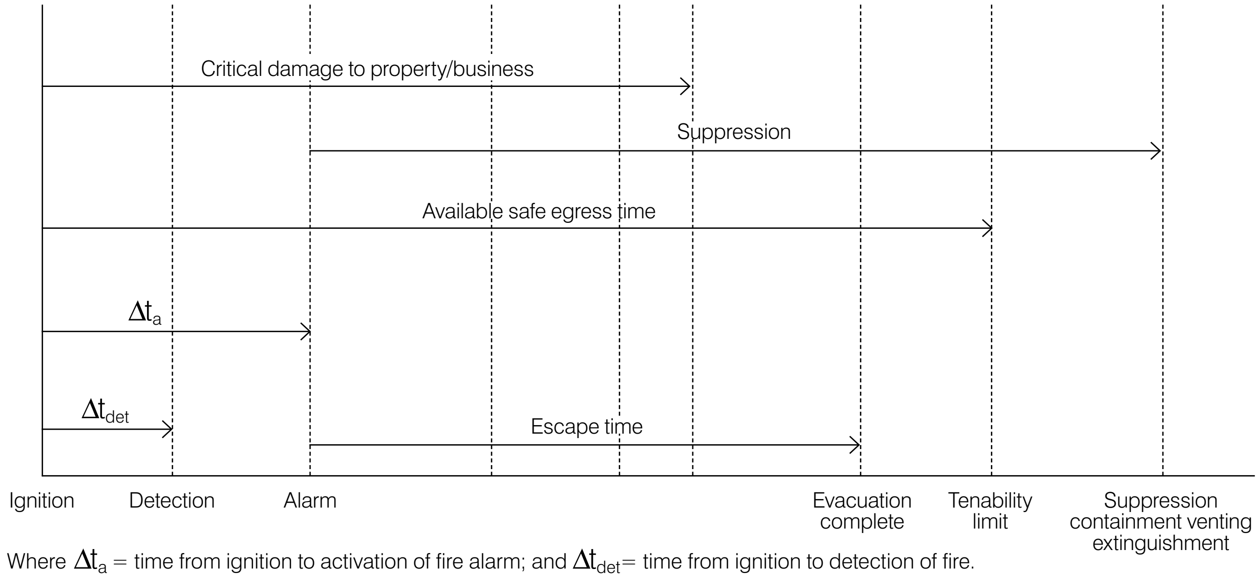
It is unreasonable to set property protection criteria for a fire safety engineering design which are any higher than those normally found in a building designed to a prescriptive code. (Ideally, the prescriptive code from which property protection criteria will be taken will be the **FPA Design guide** or the insurer's own standard, but mandatory life safety codes may be used.) In setting deterministic design objectives, it has therefore been assumed that in a building designed to a prescriptive code:

- a 'small fire' (one which does not spread beyond the item first ignited) causes very little damage;
- a 'medium-sized fire' (one which does not spread beyond the room of origin) will damage the contents of the room of origin, but does not cause structural damage; and
- a 'large fire' will cause widespread damage to contents and structural damage.

However, it is feasible for a fire safety engineering design to lack structural fire protection and fire separation. Therefore, what would be a small- to medium-sized fire in a building designed to a prescriptive code could result in a large fire in a building designed by fire safety engineering. Therefore, stating an acceptable amount of damage for a given fire size is not appropriate.

As an alternative, in this document, determined design targets are based on fire load density. It is assumed that what is normally

Figure 3: Part of an example of a timeline comparison between fire development and evacuation/damage to property (BS 7974)



Where Δt_a = time from ignition to activation of fire alarm; and Δt_{det}= time from ignition to detection of fire.

a small fire remains small because it spreads slowly and is detected and dealt with before it has time to ignite neighbouring materials. A medium fire is larger because the fire load density is larger and fire growth is more rapid. A large fire is catastrophic because the ate of fire spread through a high fire load even outstrips the ability of the fire and rescue service to intervene.

Requirement 4a: Table 9 of PD 7974-0 gives an example of property protection objectives which may be set as deterministic acceptance criteria. In this document, Table 1 presents objectives which must be met in order to satisfy insurer requirements.

2.4.3.3 Probabilistic criteria

When setting probabilistic criteria as design targets, it is necessary to consider not only the probability of a fire of a particular size occurring, but it is also necessary to take into account the damage such a fire could cause.

In a store of inexpensive raw materials, a relatively large fire may have few financial implications. However, the same fire in a store of finished goods could be catastrophic for a business.

PD 7974-0 uses an equation to calculate the Average Potential Loss (APL) of a fire. That equation is reproduced here in a slightly modified form:

$$APL_I = V_I \times DL \times F_{mf}$$

where:

- APL_I is average potential insured loss;
- V_I is the insured loss resulting from a given fire;
- DL is the design life of the building (in years); and
- F_{mf} is the frequency of a given fire (in fires per year).

Detailed guidance on the application of probabilistic risk assessment techniques to fire safety engineering is given in PD 7974-7 (ref. 13).

Requirement 4b: If a probabilistic approach is used to set acceptance criteria, then the objectives which must be met in order to satisfy insurer requirements must be discussed with the insurer.

In the absence of specific insurer requirements, we recommend the following approach.

For a fire which involves the average fire load density for the building*:

$$APL_I < (\text{annual insurance premium} \times DL) / 2$$

For a fire which involves the 80% fractile fire load density for the building*:

$$APL_I < (\text{annual insurance premium} \times DL) / 1.25$$

* If actual figures are not available or cannot be calculated, the fire load densities from Table A.19 of PD 7974-1 may be used.

An alternative objective which would also be acceptable would be to demonstrate that:

$$(V_I \times DL \times F_{mf}) \le (\bar{V}_I \times DL \times \bar{F}_{mf})$$

where:

- F_{mf} is the predicted frequency of a given fire (in fires per year) in the engineered building;
- V_I is the predicted insured loss resulting from a given fire in the engineered building;
- $\bar{F}_{mf}$ is the frequency of a given fire (in fires per year) across all buildings of a similar use, type and size; and
- $\bar{V}_I$ is the normal insured loss resulting from a given fire in all buildings of a similar use, type and size.

Any probabilistic values or sources of values must be agreed with the insurer during the QDR process. The insurer will wish to be certain that values used are appropriate to the operations and practices of the specific business.

Statistics based on broad generalisations may not be acceptable. Statistics for the frequency of fires in warehouses, for example, may mask a split between a high frequency of fires in warehouses where fork lift trucks are charged and a low frequency of fires in warehouses where they are not.

In applying this objective, it may be determined that insured losses in the fire engineered building would be higher than in a building designed to prescriptive codes, but that this is compensated for by a demonstration that the probability of any given fire size is reduced sufficiently to keep APL_I in the fire engineered building as low as, or lower than, APL_I across all buildings of a similar use, type and size.

2.4.3.4 Comparative criteria

Clause 6.6.2 of PD 7974-0 points out that **'if it is explicitly demonstrated by logical deduction or calculation that the proposed design provides an equivalent or superior level of fire safety to a building complying with an appropriate prescriptive code, the comparative criteria will be met'**.

As such, the use of the comparative approach to setting acceptance criteria represents the most reliable method of demonstrating that a design is satisfactory. This is true whether the design objectives are life safety or building/property protection.

In terms of building and property protection, the insurer requirements for a successful demonstration of comparative success are simply that:

Requirement 4c: The degree of structural protection, loss prevention and business continuity assurance provided by a fire safety engineering solution must be at least as high as that provided by a fire safety design for an equivalent building which fully complies with an appropriate code or standard.

2.4.3.5 Financial criteria

Clause 6.8.3 of PD 7974-0 makes the point that when considering the level of fire protection engineered into a building, the cost of installation, maintenance and operational impact may be weighed against the benefit of the added protection. The clause makes this point in respect to probabilistic acceptance criteria, but it is equally applicable to any of the methods discussed in 2.4.3.2 to 2.4.3.4 above.

For example, consider the requirement to ensure that structural damage will not occur as a result of a fire which involves the average fire load density for the building. The implication of clause 6.8.3 of PD 7974-0 is that, if it is calculated that:

Table 3: Developing specific performance criteria based on objectives

Objective	Design target	Performance criteria
Protect the building structure	Where the fire load density is average or below average, ensure that structural damage will not occur as a result of a fire.	These targets may be achieved in many ways. For example, by limiting the fire load density, by the use of fire suppression, by separation of the fire load to restrict growth or by the use of appropriate structural fire protection.
	Where the fire load density is between average and the 80% fractile, ensure that structural collapse will not occur as a result of a fire.	
Limit the loss of the building contents	Where the fire load density is average or below average, ensure that fire damage to contents will be restricted to the item first ignited.	These targets may be achieved in many ways. For example, by limiting the fire load density, by the use of fire suppression, by separation of the fire load to restrict growth or by the use of appropriate structural fire protection.
	Where the fire load density is between average and the 80% fractile, ensure that fire damage to contents will be restricted to the room of origin or to an area not exceeding the maximum compartment size normally allowed for the building in question (whichever is smaller).	
Maintain ongoing business viability	Where the fire load density is average or below average, ensure that a fire will not interrupt normal business for more than 48 hours(1).	These targets may be met by fire protection measures, but they may also be met by appropriate business continuity planning(2). For example, even if a fire is left to develop to a large size, normal business may be resumed quickly if business critical information is copied and stored off site(3).
	Where the fire load density is between average and the 80% fractile, ensure that a fire will not interrupt normal business for more than one week(1).	

Notes on Table 1:

If actual figures for fire load density are not available or cannot be calculated, the fire load densities from Table A.19 of PD 7974-1 (ref. 11) may be used.

The design targets and performance criteria in this table are examples only. It is essential that consultation with the insurer is carried out at the earliest possible stage to ensure that their own specific expectations are addressed.

1. The time periods stated are examples only. Some organisations such as financial institutions and those in the communication sector may incur significant insured losses if their normal activity is interrupted for only an hour or so. In such cases, the 'acceptable' period of business interruption will be much shorter than that stated here.
2. Business interruption can be more costly to the insurer than property loss. Business continuity is therefore a high profile issue with insurers and any fire safety engineering business continuity planning must be agreed with the insurer prior to being adopted into a strategy.
3. Further information on business continuity planning can be obtained from the insurance company that will insure the building on occupation or, if this has not been finalised, from the FPA's **Guidance Note: Business Resilience. A Guide to Protecting your Business and its People** (ref. 12).

total cost of structural damage caused by a fire which involves the average fire load density (direct fire loss, business interruption, loss of corporate image, etc) = £N

and

total cost of fire safety measures to prevent such a fire causing structural damage (installation costs, maintenance costs, operational impact costs, etc) = £2.5N

then as long as no more than two such fires occur during the lifetime of the building, the most cost-effective solution is not to install the fire precautions.

This calculation of whether it is worth investing in fire protection can be carried out in many different ways, with the above being one example. What is important is to view this whole issue from the perspective of the insurer. The insurer is not mentioned in clause 6.8.3 of PD 7974-0, and in an insured building the cost of fire damage and any subsequent business interruption is borne by the insurer. The £N mentioned in the example is the insurance company's money. It is therefore only right that any decision as to the cost effectiveness of different levels of fire protection should either be made directly by the insurer or by the insured, having fully briefed the insurer and having an accurate indication of the effect on the cost of insurance.

2.5 Quality assurance

2.5.1 Qualification requirements and accreditation

Clause 9.11 of PD 7974-0 states:

'In most fire safety engineering studies, it will be necessary to make some engineering judgements and the expertise of the fire safety engineer will often play a major part in defining the initial design assumptions. To enable a third party to establish that the fire safety engineering study has been carried out by a person with appropriate expertise, the name, qualifications and experience of the individual fire safety engineer(s) responsible for the study should be provided.'

It would be useful to define a particular qualification or accreditation which a fire engineer should hold before being accepted as having 'appropriate expertise'. However, no such qualification or accreditation exists.

Chartered fire engineers who are members of the Engineering Council Division of the IFE have demonstrated competence in fire safety engineering according to its modern definition. However, their numbers are relatively small and they are not bound to follow any particular set of guidelines, other than the competence standards set by the Engineering Council UK, laid down in UK-SPEC (UK Standard for Professional Engineering Competence) and the IFE Code of Professional Conduct.

Equally, graduates of fire science, fire safety management and even fire engineering may have had little or no training in the practical application of the quantitative analysis of fire or the application of fire prevention and protection measures.

There is therefore no obvious way to identify whether a particular fire safety engineer has the appropriate skills and experience to undertake a particular job.

2.5.2 Application of appropriate fire safety engineering techniques

As a result of the lack of generally recognised qualifications for fire safety engineers, all that can be required is this:

Requirement 5: To enable a third party to establish that the fire safety engineering study has been carried out by a person with appropriate expertise, the name, qualifications and experience of the individual fire safety engineer(s) responsible for the study must be provided. In addition, the fire engineer(s) will follow a recognised set of fire engineering guidelines (such as BS 7974) from the beginning to end of a project.

The fire safety engineer(s) must provide a note of their current professional indemnity insurer, including the policy number and limit of indemnity.

It should be stressed that experience in the application of prescriptive codes is not evidence of competence in fire safety engineering.

2.6 Fire safety management

Good ongoing management of fire safety systems is essential in any building. In a building whose fire safety relies on a fire engineering solution, this is especially so.

In buildings designed to prescriptive codes, a reasonable level of all types of fire safety measures are installed to cope with the majority of expected fires. Thus, in most cases, there is a degree of leeway when it comes to the testing and maintenance of systems, alterations to operations within the building and changes in the fire load.

In buildings designed to fire engineering principles, this may not be the case. Fire safety engineering is often viewed as a bespoke fire safety solution which addresses the specific risks and hazards of the building in question. Alternatively, it could be viewed as a solution which is adequate by the smallest margin. Any alterations to the building or its contents, or any failure in a particular fire safety system, could render the whole solution invalid.

Requirement 6: To meet the requirements of the insurance industry, the fire engineering solution must take a realistic view of the level of fire safety management which will be applied to the building during its foreseeable future, and must demonstrate that this level of management is sustainable. The fire safety engineer must demonstrate that every effort has been made to gather this information.

Fire safety management requirements such as testing, servicing and maintenance (in particular those aspects upon which the fire safety engineering relies) must be described in the fire safety engineer's report.

If there is evidence that the occupier of the building has a history of good fire safety management, maintaining systems and risk assessing changes to the building environment so that fire safety measures can be updated accordingly, then insurers are more likely to be satisfied with a fire engineered solution which relies quite heavily on robust fire safety management. If no such evidence exists, or if there is evidence to the contrary, then insurers will expect a fire engineering solution which is robust in itself.

2.7 Issues associated with the construction phase

Buildings are at their most vulnerable to fire during their construction phase. There is often a high fire load present as building materials are stored on site prior to installation. Hot work may be carried out, there may be a multitude of potential ignition sources as contractors use electrical equipment in varying states of repair, and poor site security can lead to arson attack.

In a building whose fire safety is designed to a prescriptive code, a fire which breaks out during construction can have a devastating effect prior to the completion of fire separation and fire protection of the structure. In a building whose fire safety is designed using a fire engineered approach, this situation may be even worse. If the intention is for fire safety to rely on automatic detection and sprinklers, rather than fire separation and protection, then the building is at great risk from fire, right up until the commissioning of the fire safety systems.

Requirement 7: Fire safety management of construction sites is always important, but to meet the requirements of the insurance industry, where the fire safety design of a building is engineered, then a risk assessment of the implications of the fire engineering to the construction phase fire risk must be carried out and must be available to the insurer.

2.8 Reporting and presentation

According to clause 9.1 of PD 7974-0, the format of a fire engineer's report will depend on the nature and scope of the study, and on the style of the individual engineer. However, the clause specifies that 'typically' the report should contain the following information:

- objectives of the study;
- building description;
- results of the QDR;
- quantified analysis;
- comparison with acceptance criteria;
- fire safety strategy;
- management requirements;
- conclusions;
- references; and
- qualifications and experience of the fire safety engineer.

Requirement 8: With respect to the issues addressed by this document, the fire engineer's report must contain a non-technical explanation of how the requirements 1 to 7 have been met. In the case of large or complex projects, it may be necessary to produce this information as a separate report for the insurer.

The information required to be contained within the fire engineer's general report, or within the report produced specifically for the insurer, is described in Appendix A.

REFERENCES

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

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5. The Building Regulations 2000 (as amended), Statutory Instrument 2000 No. 2531, The Stationery Office, 2000.

6. The Building (Scotland) Regulations 2004 (as amended), Scottish Statutory Instrument 2004 No. 406, The Stationery Office, 2004.

7. The Building Regulations (Northern Ireland) 2000 (as amended), Statutory Rule 2000 No. 389, The Stationery Office, 2000.

8. Approved Document B to the Building Regulations 2000: **Fire Safety (Volume 2): Buildings other than Dwelling Houses** (2006 edition), NBS for the Department for Communities and Local Government, 2007.

9. **Scottish Building Standards Technical Handbook (Non-domestic)**, Section 2: Fire, The Stationery Office, 2008.

10. **Technical Booklet E to the Building Regulations (Northern Ireland) 2000: Fire Safety,** Department of Finance and Personnel for Northern Ireland, 2006.

11. PD 7974-1: 2003: **Application of fire safety engineering principles to the design of buildings. Initiation and development of fire within the enclosure of origin (Sub-system 1)**, British Standards Institution.

12. **Guidance Note: Business Resiliance. A Guide to Protecting your Business and its People**, Fire Protection Association for InFiReS, 2005.

13. PD 7974-7: 2003: **Application of fire safety engineering principles to the design of buildings. Probabilistic risk assessment**, British Standards Institution.

APPENDIX A

Information required by the insurer

Integration of insurer requirements (Requirement 1)

Explain how the requirements of this document were integrated into the design process, including:

- confirmation that insurer interest was raised with the client; and
- description of the level of insurer involvement at QDR stage:
    - application of this document with direct insurer involvement; or
    - application of this document following contact with insurer; or
    - application of this document without contacting insurer.

Property protection fire safety objectives (Requirement 2)

Confirm that the property protection fire safety objectives of the project included at least:

- the structure and fabric of the building;
- the building contents; and
- the ongoing business viability.

Business criticality statement (Requirement 3)

Confirm that preventing business-critical property damage has been given a sufficiently high priority.

Property protection acceptance criteria (Requirement 4)

Describe the type of acceptance criteria that have been selected for property protection issues (deterministic, probabilistic or comparative), and explain the reason for the selection.

Comparison against acceptance criteria (Requirement 4)

Describe specific objectives within the particular acceptance criteria selected, and explain how those objectives have been met.

It is important to stress that non-technical descriptions are required in the report, although these descriptions must be backed up by quantitative analysis which can be assessed by a third party if it is deemed necessary.

Comparison against acceptance criteria (Requirement 4)

Describe specific design targets and discuss performance criteria within the particular design objectives.

Qualifications and experience of the fire safety engineer(s) (Requirement 5)

Provide the name, qualifications and experience of the fire safety engineer(s) responsible for the study.

Fire engineering guidelines followed (Requirement 5)

Cite the recognised set of fire engineering guidelines that have been followed. If the guidelines have been deviated from in any way, explain the reason for the deviation.

Interaction of fire engineering with fire safety management (Requirement 6)

Describe the predicted level of fire safety management that will be applied to the building on occupation.

Explain the basis on which the prediction above is founded.

Describe how the chosen fire engineered solution has taken account of the predicted level of fire safety management in respect to property protection issues.

Impact of fire engineering on construction phase (Requirement 7)

Describe the impact of the fire engineered solution on fire safety during the construction phase of the project, and explain how adverse effects are to be managed.

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