Fire safety and sustainability in building design
Fire safety and sustainability in building design - Scope

Regulatory minimum standards of structural fire safety are generally intended to protect the health and safety of those inside and near to buildings.

The purpose of this document is to encourage all those involved in the specification, planning, design and construction of fire safety in buildings to think a little wider than health and safety. This document is intended to help people consider how to make a building sustainable in the face of fire with a low environmental impact.

This document is not limited to large commercial new builds. It can be applied to any buildings including small projects, domestic and residential buildings and refurbishments.

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Figure 1. Overview of process
1 Introduction

1.1 Achieving sustainability

Part of being a sustainable building that has a low environmental impact is the ability of that building to avoid disproportionate damage in the event of a fire.

In all parts of the UK and most countries beyond, there exist minimum regulated standards that building designs must meet in order to ensure the safety from fire of those in and around buildings. However, complying with these life safety (minimum) regulatory standards in the fire safety design process does not necessarily deliver a building that can avoid disproportionate damage in the event of a fire. This is because minimum life safety standards are typically focussed on evacuation of occupants; they do not directly address other issues such as:

- property protection;
- organisational resilience;
- the impact of fire loss on individuals and the community; or
- the environmental impact of fire or firefighting.

To help building design go beyond life safety measures and to consider sustainability and the environment, a number of publications exist that give recommendations that go further than minimum fire safety standards. They describe processes that give the building design the opportunity to fully embrace sustainability and low environmental impact.

The purpose of this document is to distil some of those recommendations into a single publication to assist those who wish to contribute to sustainability through a robust fire safety design procedure.

It is also worth noting that while this document is not targeted at protecting health and safety in case of fire, following a fire safety design process that delivers a sustainable building will often have a by-product of delivering enhancements to life safety in case of fire.

The consideration of life safety objectives is generally a matter addressed by regulatory requirement and is not the subject of this document.

This document is concerned with the sustainability objectives such as loss control and environmental impact.

1.2 Defining sustainability

A building that is sustainable in the face of fire is one that not only minimises the environmental impacts of fire but also minimises the economic and social impacts of fire.

For example:

- If a building suffers a fire, the environmental impact comes from the smoke and other toxic gases and particles that are released into the environment and can have an adverse effect on human health. These pollutants will come from the contents of the building as well as the materials used in the structure of the building itself.
- Environmental impact can also come from firefighting water run-off. Large quantities of the water used by the fire and rescue service to fight fire runs off from the building. This water will have picked up toxins as it passed over burnt material. If it enters water courses or ground water, it can have a damaging effect on the environment.

  NOTE: A management system complying with BS EN ISO 14001:2004: Environmental management systems. Requirements with guidance for use will require control of environmental impacts under emergency conditions, including fire. Such controls could include managing local pollution pathways and receptors for firewater run-off. They could also include steps to minimise the circumstances under which firefighting foam may be used.

- Many building materials can be recycled at the end of the life of a building. However if a building ends its life in a fire, a further environmental impact is realised as many materials will not be fit for re-use and may have to go to landfill.
- The economic impact of fire comes from the direct loss of the building and the contents of the building that are destroyed. However, there is further indirect loss caused by business interruption. It is not uncommon for business interruption costs to be equal to, or even higher than, the cost of the material loss and some businesses never recover from a fire.
- Direct loss and business interruption may be insured against, however these still must be counted as economic losses because the cost of insurance is ultimately passed on to society through the price of finished goods.
- Another source of indirect loss stems from the impact of a fire on the surrounding infrastructure. A fire in one building can force the temporary closure of neighbouring businesses, resulting in further financial losses. A fire in a building that is adjacent to a road or railway line can cause the closure of that road or railway line which can potentially cause financial loss to many businesses that are quite remote from the fire itself.
- At an individual level, social and economic impact may include job losses as a result of fire damaging business, on-going ill health and bereavement, and disruption of services to the community.
- The social impact of fire is also felt when public buildings such as schools and churches are damaged. In the case of schools, not only is the education of children threatened by fire, but many schools are used for community activities outside school hours. A building damaged by fire impacts on these community activities.

These are just a few of the negative environmental, economic and social effects of fire in buildings. Reducing the impact of fire therefore has many benefits in terms of sustainability.

However, in the widest meaning of the term, 'sustainability' also applies to the embodied energy and the carbon footprint of construction products. Fire safety systems and materials themselves have embodied energy so in order to deliver a building that is sustainable in the round, the case for improving the sustainability of a building by providing fire protection must be balanced against the negative effects on sustainability of using additional construction products to provide that fire protection.
To get a true picture of the sustainability of a building, all construction products (including those intended for fire protection) need to be profiled for their individual sustainability in terms of raw materials, manufacturing, transport and recycling as well as their performance in fire.

By following the process described in this document, the relative benefits of a number of different solutions can be compared.

By way of examples:

- A fire detection and alarm system may be specified to provide early warning of a fire in a building or a sprinkler system may be specified to control fire in its early stages. Both of these systems may be shown to make a positive contribution to the sustainability of the building in the event of fire but the materials used in them may have a negative environmental impact and a financial cost. The positive and the negative effects need to be balanced to show that the building is sustainable overall.

- Slightly different examples are items like fire-resisting doors and walls that are used to control fire spread within a building. Once again these systems may be shown to make a positive contribution to sustainability, but the materials used in them may have a negative impact. However, construction products such as these will often be sited in places where ‘normal’ construction products (such as doors and walls) were required anyway. The positive impact on fire protection therefore only has to be balanced against the negative impact of the difference between a ‘normal’ door or wall and a fire-resisting door or wall.

- Another example is building design. Simply altering the internal layout of a building can make a positive contribution to the sustainability of the building in the event of fire. Carried out at plan stage, a design alteration may require no additional construction materials to be used and therefore have no negative impact on overall sustainability.

- Designing the building with fire safety management in mind and providing adequate information about the fire safety systems to the occupier are other examples of measures that can contribute to fire prevention and fire protection.

Reducing the impact of fire on a building is likely to have some negative effect on its overall sustainability as additional and ‘upgraded’ construction products are used to provide fire protection. It has been stated above that these negative effects can be balanced against the many positive impacts on sustainability that are achieved by protecting a building from fire.

However, quantifying that balance is made complicated by the fact that the embodied energy of any additional fire protection products will become part of the building from the day of construction. In contrast, the positive impacts on sustainability that are achieved by protecting a building from fire only will be realised if the building is actually involved in fire. Therefore when balancing one against the other, it is appropriate to weight the positive aspects in proportion to the probability of fire in the building in question.

**NOTE 1:** British Standard PD 7974-7:2003. Application of fire safety engineering principles to the design of buildings - Probabilistic risk assessment gives guidance on assessing the probability of fire in a range of different building types and sizes.

**NOTE 2:** Some measures such as designing a building so that fire safety management is more straightforward can help prevent fires starting in the first place. As a result, positive contributions to sustainability are delivered by the lack of fire.

### 1.4 The design brief

The initial design brief should state the intent to deliver a building that is sustainable against fire. Mandatory fire safety standards are intended to deliver life safety but it cannot be assumed that they also deliver sustainability.

The most important design objective, and the underpinning principle behind this voluntary guide is this: To be described as ‘sustainable against fire’, a building must emerge from the construction process such that if it is involved in fire, it will have a lower environmental, economic and social impact than it would have done if it had only observed mandatory fire safety standards.

The initial design brief should specify the objectives of:

- securing the health and safety of those in and around the building in case of fire*;
- property protection (building and contents) against fire;
- minimising the impact of fire loss on the community;
- minimising the environmental impact of fire or firefighting.

* Although human health and life safety can be considered as an important factor in sustainability it is not directly addressed in this document because it is already covered by mandatory fire safety standards.

The basic approach taken by this document is that sustainability against fire is incorporated into building design by a process that involves satisfactory consultation with appropriate people and organisations at the appropriate time. See Figure 1 on page 13.

An alternative approach would be to list actual fire protection systems and to say that a building is sustainable if those systems are installed. However, this approach would not work because every building is different and exists in a different environment. Systems that make one building truly sustainable against fire may be completely unsuitable in another building.

Thus, it is the process of successful consultation, agreement and good installation that contributes to fire safety and sustainable design.

By way of an example, compare the effects of a fire in a hospital with the effects of a fire in a DIY superstore. Assuming that means of escape ensure life safety in both cases, the social and economic impact of a fire in a hospital is likely to be much greater than a fire in a DIY superstore.

Therefore, to make both buildings ‘sustainable in the face of fire’ a great deal more fire protection would be required in the hospital than in the DIY superstore.

Both completed buildings would be significantly different in terms of their level of fire protection, but both would have followed the same process to identify that the level of fire protection was appropriate. Hence both buildings would be considered equal in their environmental, economic and social sustainability.
2 Setting design objectives

PD 7974-0: Application of fire safety engineering principles to the design of buildings: Part 0: Guide to design framework and fire safety engineering procedures.

The process described here is taken from the field of fire safety engineering but it is equally applicable to the development and delivery of the design brief for a building that does not adopt a fire safety engineered approach.

At an early stage of the design process, the objectives of the fire safety design should be clearly defined. Whilst the protection of life is the main objective of fire safety legislation, the financial impact of fire on a business as a result of direct property damage or lost production might also be important considerations.

In some cases, it can be relatively straightforward to comply with the statutory provisions for life safety by reference to prescriptive codes (e.g. in a warehouse), but a fire safety engineered assessment can be particularly useful in assessing the costs and benefits of fire protection for loss prevention purposes.

A fire in a building used for the processing or storage of quantities of toxic or radioactive materials can have an adverse impact on the local environment. Fire safety engineering techniques can assist in an environmental impact assessment.

Fire safety engineering design procedures may be used to develop a total fire safety strategy or may simply be used to consider one aspect of the design (e.g. the environmental impact of a fire). It is, therefore, essential that the objectives for a fire safety engineering study are established and agreed with interested parties at an early stage during the qualitative design review (QDR).

The fire safety objectives that might typically be addressed in a fire safety engineering study are:

a) life safety;

b) loss control;

c) environmental impact.

This list is not exhaustive and not all items need necessarily be considered in a particular study.

* Although human health and life safety can be considered as an important factor in sustainability it is not directly addressed in this document because it is already covered by mandatory fire safety standards.

2.1 Loss control

The effects of a fire on the continuing viability of a business can be substantial and consideration may be given to minimising the damage to:

a) the structure and fabric of the building;

b) the building contents;

c) the ongoing business viability;

d) the corporate image;

e) heritage and historic artefacts;

f) the wider social impact of the loss of the building and contents.

The list above is only illustrative. The actual aspects of ‘loss control’ that may be considered could be more or less than described above.

NOTE: Some approaches to loss control do not equate to sustainable buildings.

For example, a ‘value engineered approach’ is sometimes taken to managing property loss whereby a building is constructed at minimum cost with minimum fire safety systems on the basis that if it does catch fire, the building may be completely destroyed, but the financial loss will be minimal.

Another example could be a building that is constructed at minimum cost with minimum fire safety systems but ongoing business viability in case of fire is achieved by having alternative sites that can fill the gap left by a fire damaged building.

These approaches are not environmentally sustainable and to achieve recognition, loss control must be delivered by systems that protect property from fire not by systems that compensate for fire loss.

Records of loss control design objectives should be maintained, along with a record explaining the rationale behind the choice of objectives.

The QDR design team should include a range of stakeholders and consultees who are affected by the selected design objectives*.

Loss control objectives should be delivered by a fire safety design that protects property from loss.

* See step 3.3 on feedback to consultees.

The first stage in any engineering design is to establish the basic parameters of the project. This includes a review of the scheme, identification of any overriding constraints and definition of the design objectives. This initial stage will draw on the expertise and experience of the engineer and design team. Quantification will normally only follow when the design parameters have been established. For the purposes of fire safety engineering this preliminary stage is described in BS 7974:2001 as the qualitative design review (QDR).
2.2 Environmental impact

A conflagration involving several buildings or the release of quantities of hazardous materials can have a significant impact on the environment. Consideration should, therefore, be given to minimising:

a) the effects of fire on adjacent buildings or facilities;
b) the release of hazardous materials into the environment;
c) methods of firefighting (e.g. avoidance of river pollution).

The list above is not exhaustive. The actual aspects of ‘environmental impact’ that may be considered could be wider than those described above.

3 Building Regulations and fire safety procedural guidance

At the early stages of a project the designer should seek advice about the fire safety aspects of the scheme.

3.1 Early consultation with regulatory bodies

Most building work will be subject to compliance with regulations covering the initial fire safety design, and also subject to compliance with regulations covering fire safety management once occupied.

3.2 Early consultation with other appropriate bodies

As well as life safety, fire safety design and fire safety management after occupation should address sustainability issues. A large proportion of these additional issues will be outside the scope of regulatory bodies.

2.3 Other fire safety objectives

To deliver sustainability, life safety, loss control and environmental impact are not the only objectives that might be addressed by a fire engineering study or the development of a design brief. Other issues that may be considered include financial, social and economic effects on neighbouring buildings and environmental considerations as a whole.

Records of environmental design objectives should be maintained, along with a record explaining the rationale behind the choice of objectives.

The QDR design team should include a range of stakeholders and consultees who are affected by the selected design objectives*.

Environmental impact objectives should include minimising:

- the effects of fire on adjacent buildings or facilities;
- the release of hazardous materials into the environment;
- methods of firefighting (e.g. avoidance of river pollution).

* See step 3.3 on feedback to consultees.
3.3 Consultation

Undertaking early, non-statutory, consultation with regulatory bodies and other parties does not in itself deliver a sustainable building. For example, a designer could engage in wide consultation about sustainability matters, but then fail to incorporate any of the advice received.

Equally, it is unrealistic to expect every single suggestion made by every consultee to be incorporated into the final design in order to define the building as sustainable against fire.

The approach to be taken is that:

a) Consultation should be undertaken with people and organisations that are appropriate to the sustainability aspect of the design brief.

b) Consultees must be realistic in making their recommendations. They should have regard to the objectives of the design brief and should follow a sound design stage risk assessment process to develop and distinguish between ‘high priority recommendations’ and ‘low priority recommendations’.

c) Consultees must recognise that not all of their recommendations will be incorporated into the final design, however;

d) THE DESIGN CANNOT IGNORE HIGH PRIORITY FIRE SAFETY RECOMMENDATIONS THAT HAVE BEEN DEVELOPED THROUGH A SOUND DESIGN STAGE RISK ASSESSMENT PROCESS AND STILL BE CONSIDERED ‘SUSTAINABLE’ JUST BECAUSE THE PROCESS OF CONSULTATION WAS FOLLOWED. IT IS ESSENTIAL THAT THE RESULTS OF CONSULTATION ARE IMPLEMENTED TO THE SATISFACTION OF THE THIRD PARTY CONSULTEES.

In order to demonstrate that the consultation process will actually deliver a sustainable building, the regulatory bodies and the independent third party consultees should ‘close the consultation loop’ by stating in writing that they are content with the final design decisions.

Being ‘content’ does not necessarily mean that every one of their recommendations has been incorporated. A written statement of content would only be withheld by a consultee if, without good reason (see below), ‘high priority recommendations’ were not implemented which meant that, in their opinion, the design failed to provide reasonable:

- property protection (building and contents) against fire;
- reduction of the impact of fire loss on the community; or
- reduction of the environmental impact of fire or firefighting.

Inevitably, there will be occasions when recommendations that are aimed at delivering sustainability are rejected from the building design. There must be good reasons for rejecting such recommendations.

One example of a good reason for rejection may be that a recommendation is made to protect a building to ensure that it delivers social sustainability, but that level of protection requires the use of materials that individually are not sustainable in terms of manufacturing, transport and recycling.

3.4 Preparing for occupation

If the occupier is known at the design stage, the occupier should be involved in the design stage fire risk assessment process.

The design stage fire risk assessment should consider and address the risk of a fire in the building causing property loss, organisational disruption, adverse impact on individuals and the community and it should consider the environmental impact of fire and firefighting.

If the facility exists, the designer should ask the regulatory authority to provide a completion certificate when the work is complete.
4 Independent schemes of certification and accreditation

The Building Regulations 2010 (England) Approved Document B – Fire Safety (Volume 2, Buildings other than dwellinghouses)

The steps being described in this process of building fire safety design are intended to lead to a truly sustainable building. That is, one that not only provides for safety of occupants, but that also avoids disproportionate damage in the event of a fire.

However, there is often only a blurred line between those fire safety measures that are provided for life safety and those that are provided for property protection or to reduce the wider social impact of fire. For example, compartment walls or sprinklers that are provided to slow down the spread of fire and to assist with evacuation also limit the amount of fire damage to property, the amount of smoke produced by fire and the amount of water required to bring a fire under control.

The performance of all fire systems, products, components or structures (whether provided ostensibly for life safety or otherwise) must therefore be reliable. Performance is dependent upon satisfactory site installation, testing and maintenance.

Independent schemes of certification and accreditation for installers and maintenance firms provide confidence in the appropriate standard of workmanship being provided.

Confidence that the required level of performance can be achieved will be demonstrated by the use of a system, material, product or structure which is provided under the arrangements of a product conformity certification scheme and an installer accreditation scheme.

Third party accredited product conformity certification schemes provide a means of identifying materials and designs of systems, products or structures which have demonstrated that they have the requisite performance in fire. They also additionally provide confidence that the systems, materials, products or structures actually supplied are provided to the same specification or design as that tested/assessed.

Third party certification of installers of systems, materials, products or structures provide a means of ensuring that installations have been conducted by knowledgeable contractors to appropriate standards, thereby increasing the reliability of the anticipated performance in fire.

Schemes should be assessed by a certification body accredited by a national accreditation service (e.g. UKAS in the United Kingdom).

NOTE: Records of the use of independent schemes described above should be maintained and should be passed on from the designer to the occupier in the package of information handed over on occupation (see below).

5 Confirmation of design brief

Prior to occupation, a preliminary fire risk assessment should be carried out as part of the design verification process to ensure that the building meets the original design brief and is suitably sustainable in case of fire.

6 Further Building Regulations and fire safety procedural guidance

On occupation, the design stage fire risk assessment and the fire strategy, along with other fire safety information, should be passed on to the person responsible for the fire safety management of the building.

It will act as a record of the rationale behind the fire safety design of the building and thereby enable them to develop their fire risk assessment with environmental, economic and social sustainability in mind.

There is already a regulatory requirement to hand over information to assist with the fire risk assessment of occupied buildings. The information described above could be passed on in the same manner.

It may be appropriate for ‘as built’ drawings to be kept on site and provided to the local fire and rescue service*.

* BS 9999:2008 Code of practice for fire safety in the design, management and use of buildings: Clause 27

NOTE: The package of information handed over from the designer to the occupier should include all fire safety design measures in appropriate detail and with sufficient accuracy to assist the occupier to operate and maintain the building in reasonable safety and with due regard to sustainability and the wider impact of fire.

The exact amount of information and level of detail necessary will vary depending on the nature and complexity of the building’s design from the relatively simple to design details of complex fire protection systems and maintenance schedules.
Design process start

Fire safety design objectives including:
- Loss Control
- Environmental and others

Records of consultations showing feedback to consultees and satisfaction with outcomes

Consultation with regulatory bodies

Consultation with ‘other bodies’

Where optional, request completion certificate from regulatory body

Design stage fire risk assessment

Construction process start

Occupation of building

Figure 1. Overview of process

Use products, components materials and structures that are certified under independent schemes

Installation and maintenance provided by individuals or companies that are certified under independent schemes

Preliminary fire risk assessment

Fire safety information passed on to person responsible for fire safety management