

Application of fire safety engineering principles to the design of buildings — Code of practice

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Committees responsible for this British Standard

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- British Automatic Sprinkler Association
- Building Research Establishment (BRE) — Fire and Risk Sciences
- Department for Transport, Local government and the Regions (DTLR)
- Fire Safety Development Group
- Home Office
- Institute of Building Control
- Institute of Fire Safety
- London Fire and Emergency Planning Authority
- National House-building Council (NHBC)
- Nuclear Industry Fire Safety Co-ordinating Committee
- Timber Research and Development Association

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Foreword

This British Standard has been prepared by Technical Committee FSH/24/1. It supersedes DD 240-1:1997 and DD 240-2:1997 which will be withdrawn on 31 December 2002. Additional guidance on fire safety engineering, sub-systems and risk assessment will be provided in a series of new Published Documents (PD 7974-0, PD 7974-1, PD 7974-2, PD 7974-3, PD 7974-4, PD 7974-5, PD 7974-6 and PD 7974-7).

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 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.

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

NOTE It has been assumed in the drafting of this British Standard that the execution of its provisions is entrusted to appropriately qualified and competent people.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Attention is drawn to the following statutory regulations: Building Regulations [1], [2], [3], Fire Precautions Act [4] and Fire Precautions (Workplace) Regulations 1997 (as amended) [5].

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 28, an inside back cover and a back cover.

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Introduction

This code of practice provides a framework for developing a rational methodology for design of buildings using a fire safety engineering approach based on the application of scientific and engineering principles to the protection of people, property and the environment from fire.

For most buildings the prescriptive recommendations on design in existing codes and guides as given in BS 5588-0 may be found to be adequate but this code of practice can be used for developing and assessing fire safety engineering proposals.

A fire safety engineering approach that takes into account the total fire safety package can often provide a more fundamental and economical solution than more prescriptive approaches to fire safety (see BS 5588-0). It may in some cases be the only viable means of achieving a satisfactory standard of fire safety in some large and complex buildings.

Fire safety engineering can have many benefits. The use of this code of practice will facilitate the practice of fire safety engineering and in particular it will:

- a) provide the designer with a disciplined approach to fire safety design;
- b) allow the safety levels for alternative designs to be compared;
- c) provide a basis for selection of appropriate fire protection systems;
- d) provide opportunities for innovative design;
- e) provide information on the management of fire safety for a building.

Fire is an extremely complex phenomenon and gaps still exist in the available knowledge. This code of practice is intended to provide a framework for a flexible but formalized approach to fire safety design that can also be readily assessed by the approvals bodies.

This code of practice is supported by a series of Published Documents that contain guidance and information on how to undertake detailed analysis of specific aspects of fire safety engineering. This does not preclude the use of appropriate methods and data from other sources. Figure 1 shows the structure of the code of practice and the Published Documents. This code of practice:

- provides means of establishing acceptable levels of fire safety economically and without imposing unnecessary constraints on aspects of building design;
- provides guidance on the design and assessment of fire safety measures in buildings;
- gives a structured approach to assessing the effectiveness of the total fire safety system in achieving the design objectives;
- provides a framework for and describes the philosophy of fire safety engineering;
- outlines the principles involved in the application of the philosophy to the fire safety engineering of particular buildings;
- can be used to identify and define one or more fire safety design issues to be addressed using fire safety engineering;

NOTE The appropriate part(s) of PD 7974 can then be used to set specific acceptance criteria and undertake detailed analysis.

- provides some alternative approaches to existing codes and guides for fire safety and also allows the effect of departures from more prescriptive codes to be evaluated; and
- recognizes that the design objectives may be achieved by a range of alternative and complementary fire protection strategies.

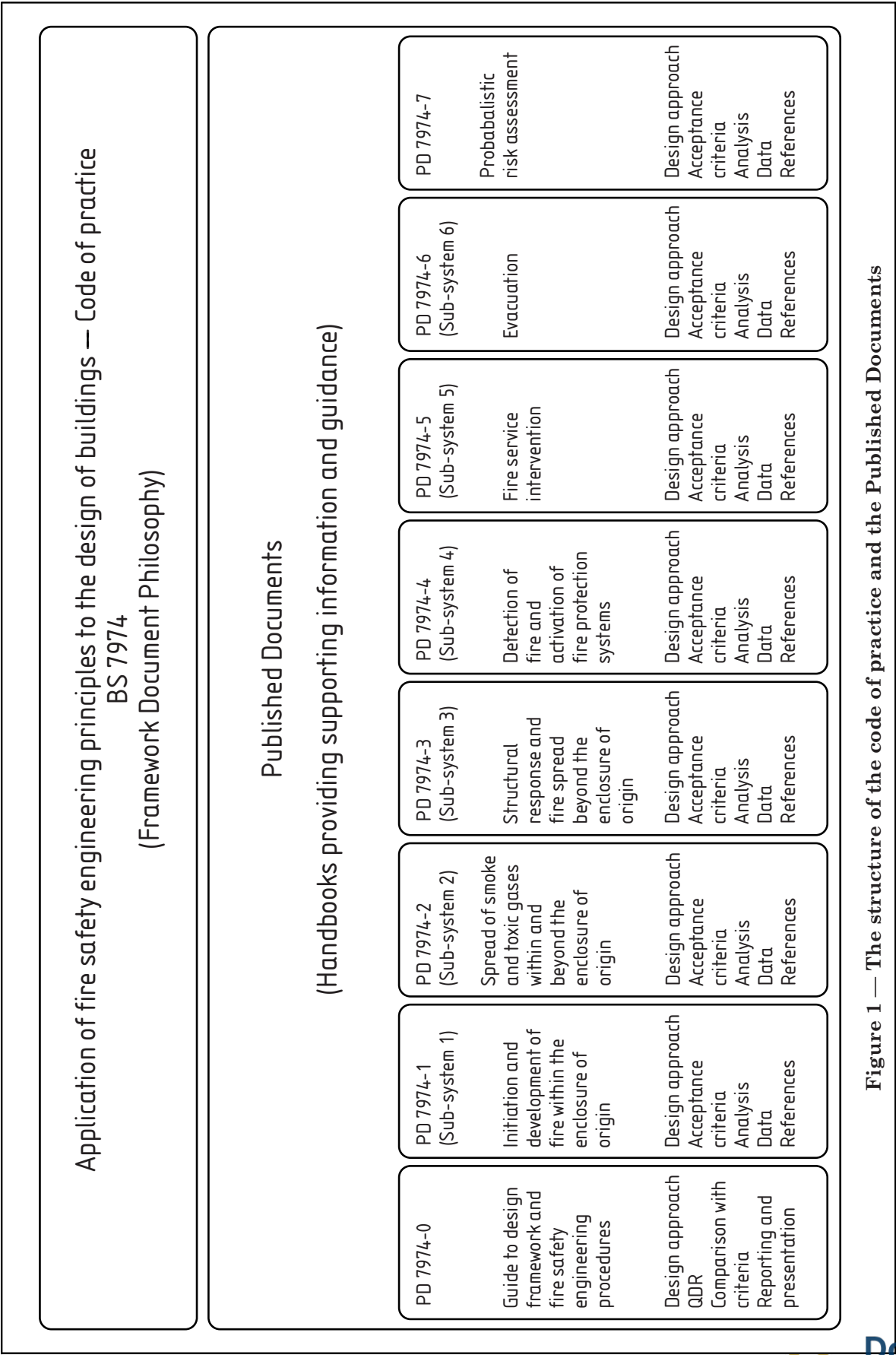


Figure 1 — The structure of the code of practice and the Published Documents

1 Scope

This code of practice provides a framework for an engineering approach to the achievement of fire safety in buildings by giving recommendations and guidance on the application of scientific and engineering principles to the protection of people, property and the environment from fire. This code of practice applies to the design of new buildings and the appraisal of existing buildings.

This code of practice does not provide specific guidance on buildings used for the bulk storage or processing of flammable liquids or explosive materials. The intrinsic risks associated with such buildings will often necessitate special consideration, which is beyond the scope of this document.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of this British Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the publication referred to applies.

BS 5588-0, *Fire precautions in the design, construction and use of buildings — Part 0: Guide to fire safety codes of practice for particular premises/applications*.

3 Terms and definitions

For the purposes of this British Standard the following terms and definitions apply.

3.1

approvals body

organization responsible for approving the fire safety aspects of a building

NOTE Examples of approvals bodies are the local authority building control, approved inspectors, and the fire authority.

3.2

available safe egress time (ASET)

calculated time available between ignition of a fire and the time at which tenability criteria are exceeded in a specified space in a building

3.3

calorific value

total amount of heat released when a unit quantity of a fuel (measured at 25 °C and atmospheric pressure) is oxidized during its complete combustion in oxygen under specified test conditions

NOTE In a fire only a proportion of this energy will be released.

3.4

compartment

building or part of a building constructed to prevent the spread of fire to or from another part of the same building or an adjoining building

3.5

escape time

calculated time from ignition until the time at which all the occupants of a specified part of a building are able to reach a place of safety

3.6

deterministic study

methodology, based on physical relationships derived from scientific theories and empirical results, that for a given set of initial conditions will always produce the same outcome

3.7

enclosure

space defined by boundary elements (on all sides)

3.8

evacuation time

interval between the time of a warning of fire being transmitted to the occupants and the time at which all of the occupants are able to reach a place of safety

3.9

exit

doorway or other suitable opening giving access towards a place of safety

3.10

fire hazard

source of possible injury or damage from fire

3.11

fire load

quantity of heat which could be released by the complete combustion of all the combustible materials in a volume including the facing of all boundary surfaces

3.12

fire load density

fire load divided by the floor area

3.13

fire risk

product of probability of occurrence of a fire to be expected in a given technical operation or state in a defined time, and consequence or extent of damage to be expected on the occurrence of a fire

3.14

fire safety engineer

person suitably qualified and experienced in fire safety engineering (see also Foreword)

3.15

fire safety engineering

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

3.16

fire safety manual

document providing all necessary information for the effective management of fire safety in the building

3.17

fire scenario

set of circumstances, chosen as an example, that defines the development of fire and the spread of combustion products throughout a building or part of a building

3.18

flashover

sudden transition from a localized fire to the ignition of all exposed flammable surfaces within an enclosure

3.19

management

person or persons in overall control of the premises whilst people are present, exercising this responsibility either in their own right, e.g. as the owner, or by delegation (of statutory duty)

3.20

means of escape

means whereby safe routes are provided for persons to travel from any point in a building to a place of safety

3.21

phased evacuation

process by which a limited number of floors (usually the fire floor and the storey above) is evacuated initially and the remaining floors are evacuated when necessary

3.22**place of safety**

predetermined place in which persons are in no immediate danger from the effects of fire

NOTE The place of safety may be inside or outside the building depending upon the evacuation strategy.

3.23**pre-movement time**

time interval between the warning of fire being given (by an alarm or by direct sight of smoke or fire) and the first move being made towards an exit

3.24**probabilistic risk assessment**

methodology to determine statistically the probability and outcome of events

3.25**smouldering**

combustion of a material without flame and light being visible

3.26**tenability criteria**

maximum exposure to hazards from a fire that can be tolerated without causing incapacitation

3.27**travel distance**

actual distance that needs to be travelled by a person from any point within a building to the nearest exit, having regard to the layout of walls, partitions and fittings

3.28**travel time**

time needed once movement has begun, for all of the occupants of a specified part of a building to move to a place of safety

3.29**trial fire safety design**

package of fire safety measures which in the context of the building may meet the specified fire safety objectives

4 Application**4.1 General**

This code of practice provides a framework for an engineering approach to fire safety which may be applied to both the design of new buildings and the appraisal of existing buildings, and to show that regulatory and/or financial requirements can be satisfied. The use of this framework is not a guarantee that the resulting design will be adequate. Approvals bodies should be consulted before final decisions are taken about the fire safety design.

The engineering approach may be used in conjunction with other guidance documents (see BS 5588-0). It may also be used to justify alternative approaches to those in other guidance documents.

The framework for an engineering approach to fire safety described in this code of practice should be applied using the following three main stages (see Figure 2).

a) Qualitative design review (QDR)

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.

b) Quantitative analysis

Engineering methods are used to evaluate the potential solutions identified in the QDR. Quantitative analysis can be time-based analysis using appropriate sub-systems (see 4.2) to reflect the impact of the fire on people and property at different stages of its development. Steady state and limit state analysis can also be used.

c) Assessment against criteria

The output of the quantitative analysis is compared to the acceptance criteria identified in the QDR to test the acceptability of the proposals.

In order to substantiate a fire safety engineered design these three distinct stages should be worked through. Each of the stages should be fully documented so that they are readily accessible to a third party, e.g. approvals bodies, insurers, owner occupiers of buildings.

4.2 The sub-systems

To simplify the evaluation of the fire safety design, the fire safety engineering process should be further broken down into six sub-systems (SS). The sub-systems can be used individually to address specific issues or together to address all of the main aspects of fire safety.

NOTE Figure 3 indicates some of the potential interactions between sub-systems.

The sub-systems should be used as follows.

a) SS1: initiation and development of fire within the enclosure of origin (see PD 7974-1)

SS 1 provides guidance on evaluating fire growth and/or size within the enclosure taking into account the four main stages of fire development:

- 1) pre-flashover (including early growth and development);
- 2) flashover;
- 3) fully developed fire (where all the fuel is burning);
- 4) decay.

b) SS2: spread of smoke and toxic gases within and beyond the enclosure of origin (see PD 7974-2)

SS 2 provides guidance by which the following may be evaluated:

- 1) the spread of smoke and toxic gases within and beyond the enclosure of fire origin;
- 2) the characteristics of the smoke and the toxic gases at the location of interest.

c) SS3: structural response and fire spread beyond the enclosure of origin (see PD 7974-3)

SS3 provides guidance so that the following can be evaluated:

- 1) the fire severity, in terms of temperature and heat flux within the enclosure; and
- 2) the ability of the elements forming the enclosure, directly or in part, to withstand exposure to the prevailing fire severity.

d) SS4: detection of fire and activation of fire protection systems (see PD 7974-4)

SS4 gives guidance on the calculation of the following with respect to time:

- 1) detection of the fire;
- 2) activation of the alarm and fire protection systems, e.g. sprinklers, smoke venting systems, roller shutters, etc.;
- 3) fire service notification.

e) SS5: fire service intervention (see PD 7974-5)

SS5 provides guidance on the evaluation of the rate of build up of fire extinguishing resources of the fire service, including the activities of in-house or private fire brigades and in particular:

- 1) the time interval between the call to the fire service and the arrival of the fire service pre-determined attendance;
- 2) the time interval between the arrival of the fire service and the initiation of attack on the fire by the fire service;
- 3) the time intervals related to the build up of any necessary additional fire service resources;
- 4) the extent of firefighting resources and extinguishing capability available at various times.

f) SS6: evacuation (see PD 7974-6)

SS6 provides guidance on how to assess the response of people to fire, including their evacuation time from any space inside a building. Once the evacuation time has been established it can be compared with the outputs from sub-systems 1 to 4 within the quantitative analysis. Criteria for acceptance are contained in this sub-system.

NOTE 1 The various parts of PD 7974 (PD 7974-1 to -6 respectively) for these sub-systems give selected data and engineering relationships (including information on their applicability) that may be used for design. However, this code of practice recognizes the use of alternative information.

All six sub-systems together can be used to produce a time-based analysis of fire safety.

NOTE 2 Figure 4 shows an example of a time line comparison between fire development and evacuation/damage to property.

4.3 PD 7974-0 and PD 7974-7

In addition to PD 7974-1 to -6 that cover the sub-systems, two other documents, PD 7974-0 and PD 7974-7, address other aspects of fire safety engineering.

a) PD 7974-0: guide to design framework and fire safety engineering procedures

Part 0 provides a commentary on how the principles of engineering can be applied to fire safety, including an overview of the interaction of sub-systems, the selection of appropriate analytical approaches and the selection of methods.

b) PD 7974-7: probabilistic fire risk assessment

Part 7 provides guidance on how to analyse the risk to a building and its contents, occupants and fire control systems with the intention of determining:

- 1) the frequency that certain fire scenarios can occur;
- 2) the level risk associated with fire; and
- 3) the extra measures required to reduce any unacceptable risks.