

Code of practice for

Assessment of hazard to life and health from fire

Part 1. General guidance

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Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee FSH/16, Hazards to life from fire, upon which the following bodies were represented:

- British Cable Makers Confederation
- British Electrical Systems Association (BEAMA Ltd.)
- British Plastics Federation
- British Railways Board
- British Rigid Urethane Foam Manufacturers' Association
- British Rubber Manufacturers' Association Ltd.
- British Textile Technology Group
- Chemical Industries Association
- Chief and Assistant Chief Fire Officers Association
- Consumer Policy Committee of BSI
- Department of Health
- Department of the Environment (Building Research Establishment)
- Department of Trade and Industry (Consumer Safety Unit, CA Division)
- Home Office
- International Wool Secretariat
- Loss Prevention Council
- Queen Mary and Westfield College
- RAPRA Technology Ltd.
- Warrington Fire Research Centre

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Foreword

This Part of BS 7899 has been prepared by Technical Committee FSH/16.

It has been developed from DD 180 : 1989 *Guide for the assessment of toxic hazards in fire in buildings and transport*.

This Part of BS 7899 together with Part 2 will supersede DD 180, which will be withdrawn when Part 2 is published.

The major hazards to life and health from fires are exposure to toxic fire effluents and heat. Exposure to these hazards, together with visual obscuration by smoke, also affect the ability of people to escape from fires.

Existing prescriptive safety regulations and codes contribute to the control of life threat in fires, but despite their influence there was an increasing incidence of death and injury from fires during the 1960s, 1970s and 1980s, particularly in relation to death and injury resulting from exposure to toxic smoke.

In addition to the current unacceptable incidence of death and injury from fire, a further problem is that the existing prescriptive control methods such as those given in the Building Regulations are inadequate for control of modern systems, as well as providing a potential restriction on useful novel developments. There is therefore a great need for the development of effective methods for the assessment of life threat in fire and its regulation, based upon sound fire safety engineering principles.

Major advances have been made in recent years in the development of fire engineering tests and calculation methods for the prediction of fire behaviour, and for the prediction of hazards to life and health from exposure to fire effluents. A basis now exists for making evaluations of the hazards to life in fires, and BSI is currently participating in work on the development of test and evaluation methods being developed in the UK, in the EU generally and in the International Organization for Standardization (ISO).

This methodology is not yet completely available, but questions of hazards to life and health from fires still have to be faced. BS 7899 provides the best advice currently available for the assessment of hazard to life and health from fires, although further developments are expected in the future.

In order to provide guidance on how these processes can be assessed, BS 7899 is written in a number of parts. This Part (Part 1) provides an outline guide to the factors which should be considered when assessing the hazards to life and health presented by fires in structures (buildings and transport).

At appropriate points it calls up other documents in the series, which provide specific practical guidance on how the various elements of the hazard assessment can be performed. At present two further Parts are in preparation, but other documents may be added in future to cover different aspects of the subject. Two further Parts of BS 7899 are in preparation as follows:

Part 2 — *Guidance on methods for the quantification of hazards to life and health and estimation of time to incapacitation and death in fires*

Part 3 — *Worked examples illustrating hazard assessments of various types*

It has been assumed in the preparation of this standard that the execution of its provisions will be entrusted to appropriately experienced or informed people for whose guidance it has been prepared.

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

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 12, an inside back cover and a back cover.

Code of practice

Introduction

BS 7899 has been designed to provide a code of practice to be followed when assessing hazards to life and health for potential fire scenarios.

Hazards to life arise from the interaction between people and the products of fire: heat and toxic smoke. For any fire in an occupied structure, the survival of occupants is determined by the outcome of two parallel processes:

- a) the developing life threat from the fire, which incorporates ignition, fire growth, the yields of toxic smoke and heat, smoke movement and the interactions of these fire processes with the structure and with passive and active fire protection. Assessment of this process in any particular scenario is aimed at calculating the time when an occupant would receive an incapacitating or lethal exposure dose;
- b) the process by which occupants escape, which incorporates detection, the provision of warnings, motivation, the design of escape routes, escape behaviour including wayfinding and movement velocity, and the psychological and physiological influence of exposure to heat and smoke on escape behaviour.

For any system, safe design should be aimed at preventing occupants from coming into contact with heat and toxic smoke in case of fire, but in many situations it is not possible to prevent some degree of exposure. It is therefore important to examine the extent and consequences of such exposures, so that any exposure should not impair escape behaviour to such an extent that occupants would be overcome by the growing fire, or suffer injury during and after escape or rescue.

Although the direct threat to life from a fire derives from toxic smoke and heat, exposure to these hazards results from the combination of the whole range of fire parameters listed in item a). Failure to take account of any of these factors will give misleading conclusions. Guidance on the application and limitations of small scale tests, particularly toxic potency tests, is presented in annex A. A simple worked example illustrating the use of toxic potency data in hazard analysis is presented in annex B. This example demonstrates how important is the aspect of fire growth and how it can reverse a simplistic conclusion based purely on toxic potency measurements instead of a comprehensive fire hazard analysis.

It is recognized that the processes involved in the development of hazards to life and health in fires and the processes involved in escape from fires can involve almost the whole range of elements of fire safety engineering. It is therefore not possible to provide detailed guidance on all these aspects in this

standard. Many of these aspects are already covered by other British Standards. The main object of this standard is to provide detailed guidance on the nature of hazards to life and health from exposure to fire effluents and on methods for their assessment. It is however considered important to place the direct hazards from fire effluent into the context of the other factors involved, all of which need to be considered in performing an overall life threat hazard assessment.

When using this Part of BS 7899 account should be taken of any statutory or control requirements. These fall into two major categories, building regulations, which apply to the design and construction of new buildings and alterations to existing buildings (e.g. for England and Wales guidance under the Building Regulations is given in Approved Document B [1]) and legislation and other regulations for fire safety in occupied buildings (e.g. guidance for hotels under the Fire Precautions Act is given in the Home Office/Scottish Office Guide to fire precautions in premises used as hotels and boarding houses which require a fire certificate [2]). Other information which should be considered is given in fire tests such as those provided in BS 476, published literature on non-standard tests and analytical and biological studies of fire atmospheres (see references [3] and [4] and PD 6503). Relevant background information on the assessment of the toxic effects of fire effluents, and other relevant issues is given in BS ISO TR 9122 and the related ISO standard ISO CD 13344. BSI is currently supporting the development of a British Standard guidance document for fire safety engineering (currently published as DD 240), which is intended to cover many aspects of the guidance required on aspects not covered in detail in Parts 1 to 3 of the present standard. It is planned that wherever possible methods and data should be cited from DD 240.

BS 7899 is intended to enable assessments to be made of the likely hazards to occupants of existing buildings and transport for a very wide range of possible scenarios, from the hazards presented by the overheating of small objects to those presented by major fire disasters. The contribution of different elements to the overall hazard should be assessable, as well as the effect alterations to materials or structures, or other factors such as warning systems, can have on the overall hazard. The standard is intended to assist manufacturers in the design of products, and to aid architects, planners and engineers to design and equip new buildings and transport to improve the safety of occupants in the event of fire. It is intended to be complementary to the advice given in the various Parts of BS 5588, BS 6853 and in BS 6336, in particular for furniture and plastics.

1 Scope

This Part of BS 7899 is intended to provide guidance, for fire safety practitioners, including manufacturers, architects, planners and engineers, on the factors which need to be considered when assessing the hazard to life and health presented by fires in structures (buildings and transport). The assessment can be applied to various possible fire scenarios in order to determine if conditions hazardous to life could develop, and to estimate the risk that they might occur. If the development of hazardous conditions is considered possible in any particular scenario it is necessary to estimate the time taken for the development of conditions capable of incapacitating occupants and to compare it with the time required for escape. Where conditions are considered unacceptable it is possible to estimate the effects that alterations may have on the possible hazards.

Because of the great complexity of fires, the standard cannot provide an absolute guarantee of safety, but it does set out the major parameters that need to be considered, with guidance on practical methods for making assessments.

2 Informative references

This Part of BS 7899 refers to other publications that provide information and guidance. Editions of these publications current at the time of issue of this standard are listed on the inside back cover, but reference should be made to the latest editions.

3 Definitions

For the purposes of this Part of BS 7899 the following definitions apply.

3.1 asphyxiant

A substance which can cause loss of consciousness or death by depriving the brain tissues of oxygen.

3.2 circumstances

The facts or conditions which affect the hazard created by a defined fire scenario, e.g. the ignition source, the first material ignited, how the fire spreads.

3.3 combustion toxicity

The capacity of a substance within a fire effluent to cause injury to a living organism.

NOTE. This definition is based on an ISO/IEC Guide 52 definition and PD 6503.

3.4 exposure dose

The potential dose of a toxicant available by inhalation expressed as the exposure concentration multiplied by the exposure time.

3.5 fire effluents

The total gaseous, volatile and particulate (liquid or solid) products from combustion or pyrolysis.

3.6 fire hazard

A physical situation with a potential for harm to life or limb, or damage to property, or both, from the effect of fire (see BS 6336).

3.7 fire scenario

A generalized description of an actual or hypothetical fire incident.

3.8 fractional effective dose (FED)

The average exposure dose of one or more toxic effluents present in a fire over a defined period of time divided by the exposure dose required to obtain a defined toxic endpoint (incapacitation or death).

3.9 fractional irritant concentration (FIC)

The concentration of one or more irritant effluents present in a fire at any time divided by the exposure concentration required to obtain a defined toxic endpoint (escape impairment, incapacitation or death).

3.10 irritant

A substance which can cause discomfort, pain or tissue damage to the mucous membranes of the eyes, nose, throat and lungs, which can lead to a degree of incapacitation, or death.

3.11 LC₅₀ (Lethal concentration, 50 %)

The concentration of a toxic gas or fire effluent statistically calculated to cause the deaths of 50 % of the animals exposed for a specified time. The LC₅₀ is expressed as ppm for a toxic gas and in g·m⁻³ for a fire effluent.

NOTE. When comparing LC₅₀ data, both the exposure duration and the post-exposure period over which the deaths were scored need to be taken into account.

3.12 LCt₅₀ (Lethal exposure dose)

The product of the LC₅₀ and the exposure duration over which it was determined. The LCt₅₀ is expressed as ppm·min for a toxic gas and in g·m⁻³·min for a fire effluent.

3.13 life and health hazard

The consequences, (injury or loss of life) to be expected from the effects of exposure to toxic effluent and heat in fires, with respect to their nature, quantity and rate of production and concentration (see PD 6503).

3.14 life and health risk

The expected extent of injury or loss of life from a fire. This is expressed in terms of probability as the product of:

- frequency of occurrence of an undesired event to be expected in a given technical operation or state; and
- life and health hazard.

3.15 mass loss

Mass of material consumed by or otherwise lost during burning.