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Guide to the development of fire tests, the presentation of test data and the role of tests in hazard assessment

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Committees responsible for this British Standard

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- Department of Trade and Industry — Consumer Safety Unit, C A Division
- Health and Safety Executive
- Home Office
- Loss Prevention Council
- Society of British Aerospace Companies Limited

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Foreword

This British Standard was prepared under the direction of Technical Committee FSH/3. It supersedes BS 6336 : 1982 which is withdrawn.

The first edition of BS 6336 was published in 1982 and was derived from DD 64 : 1979.

By 1995, BS 6336 needed to be revised to take account of developments in the subject, particularly in the areas of fire safety engineering and terminology. The major changes were to restructure the document so that the guidance was contained in the main body of the document and the descriptive elements were separated into annexes. In addition the term 'hazard concept' was rephrased as 'hazard component'.

The guidance in this British Standard is generally in line with the approach to fire testing being developed in the International Organization for Standardization (ISO), though in some respects it may not accord with the national practices of other countries.

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 26, an inside back cover and a back cover.

Introduction

There are over 450 000 fires each year in the UK and the cost is high: about 700 lives lost, many thousands of serious injuries and hundreds of millions of pounds worth of direct damage. A wide variety of materials, products, structures and assemblies is involved and for a number of years much concern has been expressed, both in the UK and internationally, over the use of inappropriate and possibly misleading results from fire test methods to assess the behaviour of such objects in fires. There has also been concern over the use of misleading fire terminology and the misuse of fire test data, particularly small-scale test results, as the sole indicators of fire safety.

It is hoped that the use of this British Standard will ensure in the interests of public safety that no one will misrepresent facts about fire tests or use their results in such a way as to give a false impression of fire safety.

This British Standard is intended to help anyone who prepares a specification or code of practice involving a material or product that can ignite, burn or overheat to take due account of any fire hazard which may arise from the use of that material or product. This it does by indicating the steps which are necessary in designing or updating fire tests, and by showing how the results should be applied in fire engineering and other fields.

This British Standard gives guidance to those concerned with maintaining acceptable standards of safety from fire and those concerned in any way with fire tests, fire test data and fire hazard assessment. It is intended to help writers of specification standards; standards, regulatory and enforcement bodies; fire safety engineers; designers and architects; manufacturers and fabricators; wholesalers and retailers; safety managers; consumer advice services and educational bodies; and any group which needs to use fire terminology.

The standard is also intended to help anyone purchasing, specifying or using materials or products to understand the need to consider the possible fire hazard and the way in which fire tests may help in assessing that fire hazard. It will help them too to understand the need to consider any special precautions that may be required for the safe use of these items in specific environments.

Fire tests in isolation can never guarantee fire safety.

1 Scope

This British Standard provides guidance on the development and use of fire tests, including advice on the circumstances when new tests should be standardized. It sets the need for fire tests into the context of the assessment of fire hazard. Recommendations on the use of related terminology are included as is a qualitative outline of fire theory.

2 References

2.1 Normative references

This British Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are made at the appropriate places in the text and the cited publications are listed on page 26. For dated references, only the edition cited applies; any subsequent amendments to, or revisions of, the cited publication apply to this British Standard only when incorporated in the reference by amendment or revision. For undated references, the latest edition of the cited publication applies, together with any amendments.

2.2 Informative references

This British Standard refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on page 26, but reference should be made to the latest edition.

3 Definitions

For the purposes of this British Standard, the following definitions apply.

NOTE. Some of the technical terms used in this standard are not defined elsewhere. However, where definitions have been extracted or derived from another source, that source is given.

3.1 assembly

Unit or structure composed of a combination of materials or products or both.¹⁾

3.2 fire

- a) Process of combustion characterized by the emission of heat and effluent accompanied by flame, and/or glowing.
- b) Rapid combustion spreading uncontrolled in time and space.¹⁾

3.3 fire hazard

Potential for injury and/or damage from fire.¹⁾

3.4 fire model/modelling

Simulation of some aspects of fire by mathematical or physical means.

¹⁾ Taken from ISO/IEC Guide 52

3.5 fire resistance (time)

Ability of an assembly, part or structure, to fulfil for a stated period of time the required load bearing capacity, fire integrity, thermal insulation and/or other functions, specified in a fire resistance test standard.

NOTE. Fire resistant (adjective) refers only to this ability.

3.6 fire risk

Product of:

- a) the probability of occurrence of a fire to be expected in a given technical operation or state; and
- b) the consequence or extent of damage to be expected on the occurrence of a fire.¹⁾

3.7 fire scenario

Description of conditions, including environmental, of one or more of the stages from before ignition to the completion of combustion in an actual fire at a specific location, or in a full scale simulation.¹⁾

3.8 fire test

Procedure designed to measure or assess the response of an object to conditions simulating one or more aspects of fire.

3.9 flame (verb)

To undergo combustion in the gaseous phase with emission of light.¹⁾

3.10 flame (noun)

Zone of combustion in the gaseous phase usually with emission of light.¹⁾

3.11 flashover

Rapid transition from a localized fire to the combustion of all exposed surfaces within a room or compartment.

3.12 flashback (backdraft, backdraught)

Rapid transformation from a fuel rich fire to general combustion in an enclosure, that has been triggered by some change in circumstances which makes new supplies of oxygen available.

3.13 hazard component

Characteristic type of behaviour which is capable of contributing to a fire hazard.

3.14 ignition risk

Probability that, if a source of heat is allowed into close proximity or contact with a combustible material, ignition will result.

3.15 intermediate-scale test

Test performed on an item of intermediate dimensions.

NOTE. A test performed on a specimen of which the maximum dimension is between 1 m and 3 m is usually called 'an intermediate-scale test'.¹⁾

3.16 large-scale test

Test which cannot be carried out in a typical laboratory chamber, performed on a product or a test specimen of large dimensions.

NOTE. A test performed on a specimen of which the maximum dimension is greater than 3 m is usually called 'a large-scale test'.¹⁾

3.17 life risk (from fire)

Probability that, if a fire occurs, an individual or individuals will suffer death or serious injury.

3.18 property risk (from fire)

Probability that, if a fire occurs, damage to property of a given magnitude will result.

3.19 real scale test

Test which simulates a given application which takes into account the real scale, the real way of working or set up, and the use environment.¹⁾

3.20 risk of fire spread

Probability of a fire, once started, growing to a size and character that could produce life risk or property risk or both.

3.21 screening test

Test used for ascertaining whether a material, product or structure exhibits (or not) certain unusual or expected characteristics according to a standardized test method.¹⁾

3.22 small-scale test

Test, which can be carried out in a typical laboratory chamber, performed on a product or test specimen of small dimensions.

NOTE. A test performed on a specimen of which the maximum dimension is less than 1 m is usually called 'a small-scale test'.¹⁾

3.23 smouldering

Slow combustion of material without visible light and generally evidenced by smoke and an increase in temperature.¹⁾

3.24 toxic hazard (from fire)

Potential for injury or loss of life by exposure to toxic effluent in fires, with respect to their potency, quantity, concentration and duration of exposure.¹⁾

3.25 toxic potency

- a) Measure of the amount of toxicant required to elicit a specific toxic effect.

NOTE. The smaller the amount required, the greater the potency.¹⁾

- b) As applied to inhalation of smoke or its component gases; a quantitative expression relating to concentration and exposure time to a particular degree of adverse physiological response, for example, death, on exposure of humans or animals.

¹⁾ Taken from ISO/IEC Guide 52

3.26 toxic risk

Product of

- a) the probability of occurrence of a toxic hazard to be expected in a given technical operation or state; and
- b) the consequence or extent of injury to be expected on the occurrence of a toxic hazard.¹⁾

3.27 toxicity

- a) Inherent properties of a substance to produce adverse effects upon a living organism (irritation, narcosis, death, etc).¹⁾
- b) Propensity of a substance to produce adverse biochemical or physiological effect.

3.28 unacceptable hazard

A degree of hazard that is regarded by society in general as too great to occur repeatedly.

4 Advice about fire behaviour

A brief introduction to fire behaviour is given in annex A. The first step to be taken by anyone concerned about fire hazards is to obtain expert advice.

A 'fire expert' can advise in general terms about how, when and where fires are likely to start and to develop. It is essential that decisions about how such general principles should be applied in a given situation should only be taken by people fully conversant with the technical details and likely usage or application of materials and components in that situation.

As an illustration of this, a fire specialist will be able to point to the likely ignition sources that could start a fire in the combustible materials in a car.

Examples of the fuels available are the upholstery covering and padding, the floor and head covering, the wiring insulation and the petrol or diesel fuel for the engine. The specialist can also advise on how a fire, once started, could spread, and on measures to prevent this. However, only someone familiar in detail with the construction of cars will be able to identify the materials used, how exactly they will behave and the possibility of substituting materials with different fire properties. Thus, joint consultation is needed to determine the likelihood of a fire starting, the chances of its developing and the feasible means of halting the fire's progress. In this context the criteria of feasibility are suitability of non-fire behaviour, economic viability, ready availability, ease of manufacture etc. Similar considerations apply wherever a fire could start and develop.

This general approach of interdisciplinary consultation has been formalized in DD 240 : Part 1 : 1997. This subject is outlined in annex B and its relationship to fire testing is shown in clause 7.

¹⁾ Taken from ISO/IEC Guide 52

5 Fire hazard

5.1 General

It is implicit in the definition of fire hazard that the hazard exists in a particular physical situation. A piece of insulated wire, a ceiling tile or a flammable liquid cannot be considered as a fire hazard in isolation. A situation has to be envisaged in which the article is placed or used in such a way that some possibility of harm to life, health or property arises. This situation is termed the fire scenario. It is inherent in such scenarios that some way exists in which a source of heat can arise. Many other factors may also determine whether a fire hazard is present, and if it does how severe the consequences might be.

NOTE. See also annexes C and D.

5.2 Fire hazard assessment

5.2.1 General

If any possibility of harm from the effects of fire can be envisaged in a given situation, the hazard should be assessed. It cannot be emphasized too strongly that attention to this has to be paid at an early stage in any proposal or design for a new product or building. Once the design has taken shape, the reduction of fire hazard is likely to be much more difficult and costly. The recommendations in DD 240 are intended to be used at this stage for exactly these reasons.

The assessment process may have to be repeated many times, according to the different ways in which the material, product or design concerned can be involved in a physical situation with a potential for harm.

As in forecasting the behaviour of fire, (see clauses 4 and 8), joint consultation should take place between a fire expert and specialists in the relevant materials, plant, equipment or building who are familiar with their characteristics under normal, everyday conditions. In this way, the general theory of fire can be applied to realistic hypothetical situations, and decisions can be taken about the severity of fire hazards and the prospect of reducing them.

5.2.2 Acceptability

Once identified, the acceptability or otherwise of a fire hazard has to be decided. The point at which the hazard becomes unacceptable should be determined, if possible quantitatively. For instance, the use of a flammable form of electrical or thermal insulation may only be an acceptable fire hazard if the material does not exceed a specified thickness. Whether or not a certain severity of fire hazard is acceptable depends on factors which may be practical, financial, social, psychological or even political. Figure 1 summarizes these factors. It should not be forgotten

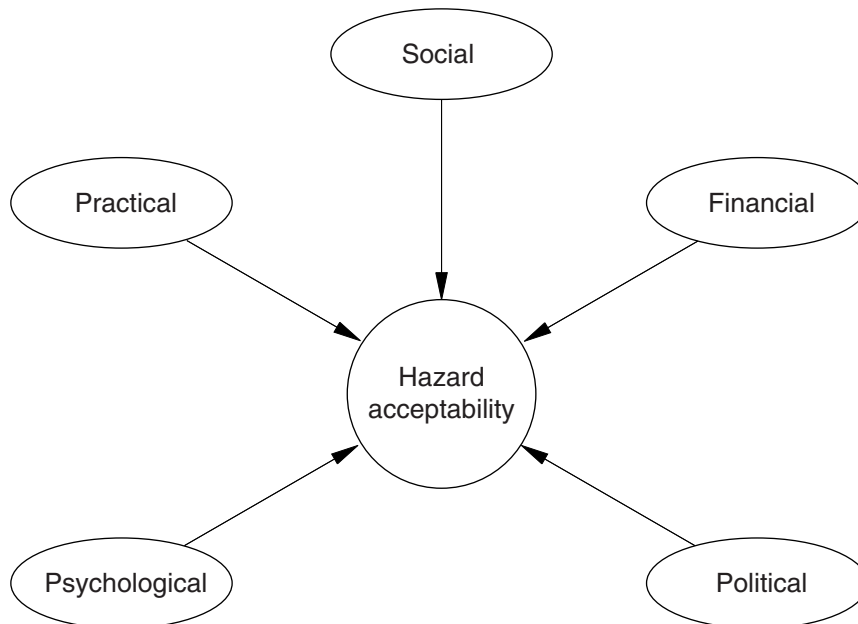


Figure 1. Factors affecting acceptability of hazard

that fire hazard can in some circumstances be controlled by fire protection and even fire-fighting measures. The spur for the development of fire safety engineering was the need to offset undesirable properties of materials or products by improvements in design processes, fire protection installations and fire safety management.

In most cases, the final decision on acceptability will lie with a regulatory or control authority with statutory powers.

5.2.3 Fire hazard control

When a fire hazard has been identified and assessed, steps should be taken to control the hazard, i.e. to bring it within the limits of acceptability. This task is made easier if the risk of harm is separated into its component probabilities. The course of action required should then be more evident. These probabilities can be expressed as follows:

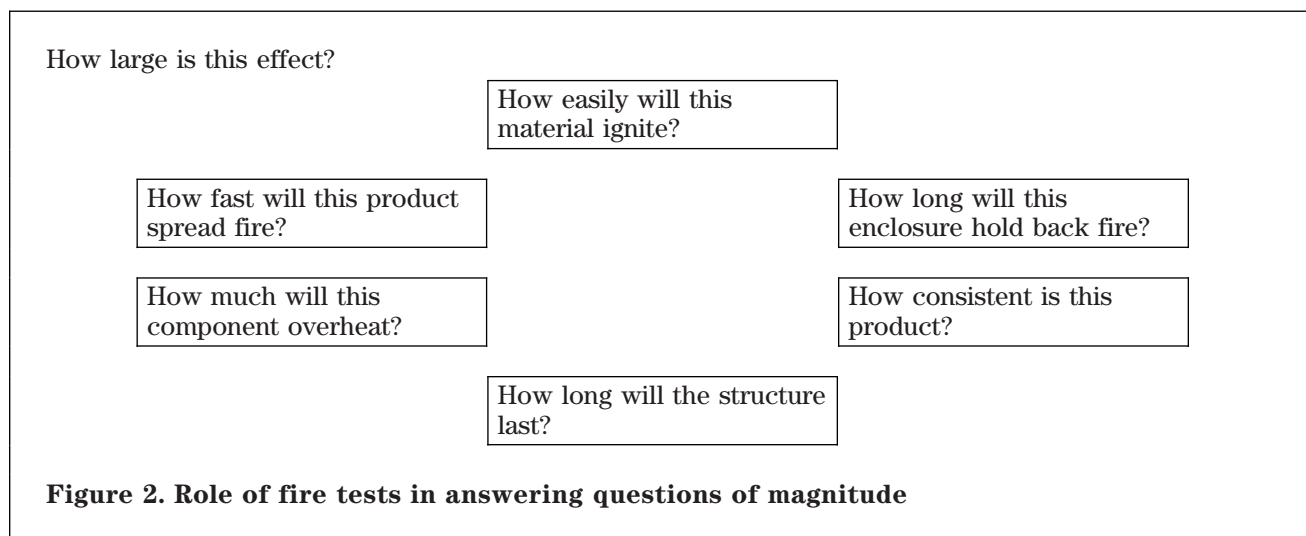
- a) fire risk, comprising
 - 1) ignition risk;
 - 2) risk of fire spread;
- b) life risk;
- c) property risk.

The probabilities involved can be developed as illustrated in C.3. Two examples of overall consideration of fire hazard are given in annex D.

6 The role of fire tests

Fire tests can be a vital factor in seeking detailed answers to the questions that have to be put in identifying and assessing fire hazards. They will be of help in ascertaining whether one material is likely to be the starting point of a fire through chance contact with a source of heat; whether another material, product or design will tend to spread fire rapidly; whether an enclosure or barrier will hold back fire for long enough; whether an assembly of electrical components will overheat dangerously under overload, etc. This view of the role of fire tests is summarized with examples in figure 2. Annex E categorizes fire tests in greater detail and justifies some recommendations of this standard.

If a fire test is correctly designed and performed, it may in some cases be the only available and reliable indication of an article's behaviour in a particular fire situation. However, because of the complex behaviour of fire, as described in annex A, the ability of a fire test result to provide information should not be overestimated. It can virtually never predict the course of an actual fire. It can only predict the behaviour of the test object in the unavoidably restricted situation of the test itself. This means that a fire test cannot evaluate fire hazard, though it can contribute to the assessment of some part of it. A fire test result that shows an acceptable performance by the test object can never of itself guarantee safety. One of the most important parts of any fire test method document is a list of the limitations of the test, as advised in 14.3.



7 The relationship between fire tests and fire safety engineering

Fire tests provide much of the input data required for the calculations and procedures performed by fire safety engineers. This use of test results will become even more important in the future, so the development of tests should aim to assist this usage. Tests which attempt to measure parameters for the prediction of fire development should be designed to yield data of the types and in the forms needed for this later usage. Part of the interface between the two areas is already common to both, in that the list of hazard components provided by the first edition of this British Standard is widely used. There is however a difference in approach between the typical fire test and the typical fire safety engineering exercise. The former often relates to specific, early events in the course of a fire. The latter deals to a greater extent with many, late occurring events. This is not a fundamental division, as it has arisen from the practicalities and economics of testing. Some large-scale fire scenarios can never be tested. Others cannot be tested on a regular basis. This is the gap in testing that fire safety engineering procedures are intended to fill. The difference of approach does mean that it is important that all fire tests clearly explain the scenarios, and particularly the limitations of the scenarios, to which they are intended to apply. The techniques of fire safety engineering will only produce results that are as reliable as the data used. Some fire tests need to have their precision improved before reliable engineering use can be made of the data produced. In other cases suitable data will be missing. Further, buildings are subject to constant change (e.g. the layout of departments in a store may alter). Even if the facts relating to an initial situation are known, constant attention will be needed by safety personnel to ensure that the assumptions of an initial review of the design are not nullified unwittingly.

8 Mathematical models

In recent years techniques have been in development for predicting the course of real fires by computer calculations on the basis of a limited number of fundamental parameters measured by specific tests. At present, this objective cannot be fully achieved. If it were attained, fire dangers might be reduced by less costly means than the present test regimes. In other circumstances, for example, to assess the hazards of an unbuilt building, it may be impossible to perform fire test procedures. In these cases the predictions of mathematical models might be substituted for fire test results. The principles of this British Standard should therefore also be applied to this new type of performance prediction. In addition, the following other special precautions should be taken before using predicted model results to evaluate safety.

- a) Before utilizing results, the theoretical science on which the calculations are based should be rigorously validated and subjected to peer review. This aspect is dealt with more extensively in 6.2 of ISO/DIS 13389.
- b) Before utilizing results, the software codes should be checked by a third party using the guidelines in 6.6 of ISO/DIS 13389.
- c) The limitations on the accuracy of the predictions should be shown whenever results are used. These will consist of two classes, the first being the uncertainties in the measured data and the second the numerical accuracy of the calculation algorithms. These are covered in clauses 8 and 7 respectively of the ISO document.
- d) Predictions affecting life safety should always be checked by actual tests and measurements. The computed results may allow these tests to be focussed on to critical aspects, so reducing the number and cost of tests.

These precautions are intended to uncover hidden assumptions and to evaluate their validity. If the assumptions are made explicit, the limits of validity of calculated results become clearer, and therefore the applicability of a model to situations changed by the availability of new products can be better judged. Mathematical predictions *in isolation* can never guarantee fire safety.

Further details of the current state of the art in deterministic mathematical modelling are given in annex F.

9 Development of fire tests

9.1 Analyse responses to fire

A detailed analysis is required to determine whether or not a fire hazard exists. This analysis should show what properties are possessed by an item, or in which ways it can behave, such that it can contribute to the hazard. This will in turn indicate what tests are necessary to assess the response of the item to one or more of the stages of fire described in A.2. An example of these steps is given in D.2.

9.2 Hazard components

In the great majority of cases, the main properties or functions requiring to be examined will consist of one or more of the following:

- a) ignitability;
- b) combustibility;
- c) softening and melting;
- d) surface spread of flame;
- e) rate of heat release;
- f) rate of smoke (or gas) release;
- g) toxicity of combustion products;
- h) fire resistance;
- i) flame penetration;
- j) smoke (or gas) penetration.

These properties or functions are not basic single physical concepts, but may combine several more fundamental phenomena. They are elements of the ways in which a material or assembly can contribute to fire hazard, and are referred to as 'hazard components' (see 3.13). More detailed explanations of all of these components will be found in annex G.

9.3 Fire test formulation

9.3.1 General

With the exception of one-off simulations, fire tests do not exist in isolation, but form part of a system intended to control materials or products. It is necessary that tests are used to check an object against the levels of acceptability in a specification standard, or for conformity to a regulation, if there is to be uniform performance of products, assemblies or buildings.

The development of a fire test is therefore often undertaken as part of the development of a specification standard, though certain test series are called up by legislation as well as national or international specification standards. It is important that such standards apply to all materials and products intended for a particular purpose rather than to particular materials and products. If, for simplicity, regulations and specification standards are grouped together, the processes which produce specifications and tests are shown in figure 3.

9.3.2 Hazard component selection

The first stage of the development process should be to assess the hazard. The subsidiary steps of identification and quantification should be performed with the assistance of appropriate experts both in fire and the article to be controlled (see clause 4). If the hazard is judged to be acceptable with respect to the influences described in 5.2.2 and figure 1, the regulation or specification standard need not control the hazard nor use a fire test. If the hazard assessment proves to be unacceptable, a test will be needed to measure the critical parameters. At this stage, test development, as distinct from the development of a specification standard, should be started, as shown in figure 3.

9.3.3 Choice of fire test method

Once the characteristics to be covered in a test have been decided, the next step to be taken is a survey of existing tests. If one of these is considered satisfactory, this test should be used. In this way the proliferation of similar but not identical tests can be slowed. This is a worthwhile end in itself, but economies of time and resources will also be made by using an existing test.

Six general criteria may be used to decide upon the fire test to be used. In order of importance these are:

- a) relevance to reality;
- b) precision;
- c) discrimination;
- d) apparatus independence;
- e) operator safety;
- f) ease of use.

These criteria are described in greater detail in annex H.

If no test is found to be suitable, the factors listed above need to be considered in formulating a test, although in some cases it may be necessary to compromise if different factors are contradictory. The example given in D.1 on the fire hazard arising in the use of polystyrene tiles should be reviewed.