



BSI Standards Publication

Fire tests on building materials and structures –

Part 10: Guide to the principles, selection, role and application of fire testing and their outputs

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Foreword

Publishing information

This part of BS 476 is published by BSI and came into effect on 1 January 2009. It was prepared by Technical Committee FSH/21, *Reaction to fire tests*, and FSH/22, *Fire resistance tests*. A list of organizations represented on these committees can be obtained on request to their secretaries.

Supersession

This part of BS 476 supersedes BS 476-10:1983, which is withdrawn.

Relationship with other publications

This part of BS 476 describes the general principles and application of the methods in the series of standards for fire testing.

Fire tests are used extensively in support of national fire safety legislation, primarily in the context of prescriptive regulations (or regulatory guidance). The outputs of these tests may also be used, with caution, to support a fire safety strategy that has been generated using the functional approach to regulations. Any of the tests used to characterize the reaction to fire, or fire resistance of a material/construction, only represents one of many possible fire scenarios.

Outputs from fire tests are used in the assessment of fire risks and, similarly to using the results in the context of a fire safety strategy, the limitations on the validity of the results need to be considered when applying them. Guidance on the use of fire tests in the context of hazard assessment is found in BS 6336.

Because of the UK's membership of the EU and its adoption of the Construction Products Directive (CPD) [1], UK legislation now fully embraces the range of European test and classification standards produced by CEN. These standards are required to support the harmonized Product Standards and European Technical Approvals (ETAs) used for the purpose of CE marking of construction products. These European Standards sometimes measure similar characteristics to the British Standards, but some of them measure totally different fire characteristics. Where there are "equivalent" standards to those within the British Standards, these are identified and the differences are discussed.

Similarly, with the growth in world trade, the International Standards Organization (ISO) has taken on a more important role. Under the Vienna Agreement, much effort has been allocated to harmonizing CEN and ISO tests. This has resulted in the production of a number of identical EN ISO fire test standards. Additionally, a range of ISO fire test methods is also available that reflects the more diverse requirements of the international market. Where possible, the equivalent ISO test method is identified and the differences are given. However, for the avoidance of doubt, it needs to be understood that the use of ISO fire test methods (except when they have been adopted by CEN) is only voluntary in the UK, and the results obtained cannot be used for the purpose of CE marking of construction products.

The titles of the parts are as follows:

- a) Fire tests for (products) materials:
 - Part 4: *Non-combustibility test for materials*;
 - Part 6: *Method of test for fire propagation for products*;
 - Part 7: *Method of test to determine the classification of the surface spread of flame of products*;
 - Part 11: *Method for assessing the heat emission from building materials*;
 - Part 12: *Method for measuring the ignitability of products using direct flame impingement*;
 - Part 13: *Method of measuring the ignitability of products subjected to thermal irradiance*;
 - Part 15: *Method of measuring the rate of heat release of products*;
 - Part 33: *Full-scale room test for surface products*.
- b) Fire resistance tests for elements of building construction:
 - Part 20: *Method for determination of the fire resistance of elements of construction (general principles)*;
 - Part 21: *Methods for the determination of the fire resistance of load bearing elements of building construction*;
 - Part 22: *Methods for the determination of the fire resistance of non-loadbearing elements of construction*;
 - Part 23: *Methods for the determination of the contribution provided by components and elements to the fire resistance of a structure*;
 - Part 24: *Method for determination of the fire resistance of ventilation ducts*.
- c) Fire test for external fire exposure:
 - Part 3: *Classification and method of test for external fire exposure to roofs*.
- d) Miscellaneous fire tests:
 - Part 31.1: *Methods for measuring smoke penetration through doorsets and shutter assemblies at ambient temperatures*;
 - Part 32: *Guide to full scale fire tests within buildings*.

The results of tests performed in accordance with BS 476 are not to be used to demonstrate conformity to Essential Requirement 2 (ER2) of the European Construction Products Directive (CPD) [1] or any associated classification system, and therefore are not to be used for the purposes of CE marking of products.

Information about this document

This is a full revision of the standard, taking into account changes in legislation and new standards published since 1983.

This part of BS 476 is not intended to be used for determining the conformity of any product or construction to Essential Requirement 2 of the European Construction Product Directive [1].

Hazard warnings

WARNING. This British Standard calls for the use of substances and/or procedures that can be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

Use of this document

As a guide, this part of BS 476 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.

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The provisions in this standard are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is “should”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

Introduction

Fire in buildings produces a scenario that puts lives at risk either directly, by exposure to the fire conditions, or indirectly, as a result of the response of the building to exposure to fire. Potential responses of the building that could represent a risk to life safety include:

- a) ease of ignition, resulting in early involvement;
- b) high rates of heat release;
- c) rapid spread of fire on surfaces;
- d) production of excessive volumes of smoke;
- e) excessive heat flow through separating elements of structure;
- f) excessive distortion of the structure;
- g) collapse of the structure under self-weight or imposed loads;
- h) other unspecified behaviour, e.g. melting and dripping.

These characteristics are established by the engineering application of data generated by well-targeted fire tests. Generally, characteristics that relate to the response of the materials are established by means of reduced scale “bench” tests, and those characteristics that control the behaviour of elements of construction are determined by larger scale tests on specimens of the structural elements.

It is important that these tests are repeatable and reproducible and have some relationship with a reference scenario. Product or construction characteristics determined against ad hoc tests have limited applicability outside the testing parameters that were modelled by the test arrangements, e.g. ignition source, fuel quantity and rate of heat release and oxygen availability. The intention of standard test methods derived by a representative body is to achieve repeatability and reproducibility (albeit many tests are now published as desk studies without the desired “round robin” testing taking place), but this is notoriously difficult to demonstrate for fire resistance, in particular, because of variations in conditions and test furnaces from one test facility to another. Reproducibility and repeatability of individual product performance can only be adequately demonstrated for that particular product by repeat testing in different test facilities.

Historically, the tests used within the design/regulatory framework were national tests designed for evaluating products and/or constructions generated in the country in which the final structure was being built because these reflect both the indigenous building forms and the national acceptance of risk (either stated or inferred). In the UK, the methods of test that most reflected these national aspects were British Standards generated by Technical Committees that included most stakeholders, e.g. regulators, manufacturers, designers, and end-users, who produced testing standards by consensus.

Major changes have taken place in the recent past, including:

- 1) the single European market for construction products has come into being;
- 2) the growth in world trade has increased significantly giving any designer a wide choice of products;

- 3) there is now a greater awareness of the field of application of fire tests: direct, extended and project-specific field of application, partly as a result of 1).

These changes ultimately led to the generation of the Construction Products Directive (CPD [1]), which laid down common objectives that materials and elements had to satisfy if they were not to compromise the perceived levels of safety that exists in the individual member states.

These targets were transformed into criteria which, in turn, became the basis for differentiating between products within a new pan-European range of fire tests generated by CEN (Committee European de Normalisation). As with British Standards, these European Standards were derived by representative groups of stakeholders, mainly regulators and testing authorities from across the European Union, and accepted by weighted voting. Whilst the European Standards attempted to incorporate procedures and apparatus that were in use throughout Europe, they invariably required major adaptations, or the design of new apparatus to achieve the agreed objectives.

Tests on structural elements to determine the fire resistance of constructions always had a fairly common basis (ISO 834, first published in 1965) around the world. Therefore, harmonization of the larger scale tests generated less radical changes to the procedures than was the case with material tests. European tests developed to determine the “reaction to fire” of materials required the generation of new apparatus and procedures, whereas most of the changes were either procedural or related to the instrumentation in the field of fire resistance.

World trade evolved a need for a range of standards to be available around the world to allow international trade in construction products. As in Europe, there are a number of regional trading alliances that allow the free passage of products within those areas but which have little or no relevance in other parts of the world. The International Standards Organization (ISO) was set up to generate standards for use across the globe.

This has a double objective: when multi-national bodies procure products they can be specified against procedures and standards that are available worldwide, and the standards can be adopted quickly and economically by nations that do not have their own standards in place for any product or procedure. As with CEN, these standards have been drawn up with stakeholder input, this time drawn from the whole of the world.

International Standards are not intended to have a divisive influence: they are required to reflect existing national and regional standards as much as possible. As a consequence, a number of the available ISO standards are a fusion between European, American and Pacific Rim Standards.

To reduce the amount of deviation between standards, agreements have been reached, e.g. the Vienna Accord between CEN and ISO. It imposes a need to consider the suitability of each other's existing standards on both organizations, adopting them where possible, rather than generating new tests or product standards.

The final change in relation to the development and use of standards relates to the validity of the application of the results. In prescriptive regulations, it was enough to pass the test prescribed in the legislation. With the move away from prescriptive to functional legislation, much greater responsibility stays with the design team who have to assure that the building will satisfy the fire objectives against which it was designed.

When dealing with most tests, results established at test scale will not be reproduced at the as-built size. However, most standard fire tests (BS, EN and to a lesser extent ISO) have been developed to classify construction products. This provides a basis against which products can be bench-marked. Depending on the specific test, some might provide data that can be used in engineering analysis, but some will simply pass/fail or classify the product. Where data is available, it can be fed into models and algorithms to predict what might happen at larger scale.

To some extent, the details of a test, i.e. the instrumentation and the procedures, are not very important. Minor differences between British Standards, European Standards and International Standards are of lesser importance than knowing, for example, the mode of failure, the distortion during fire exposure and expansion when establishing by how much the size may be varied. The test conditions specified in any British Standard, European Standard or International Standard that are used to prove a product can have a significant result on the classification that it achieves but make little or no difference to the factors used to determine the extended size. Whilst test methods can vary between CEN and ISO for the sake of harmonization, fire and the response of materials and constructions to it is the same the world over. In certain aspects of engineering judgement, the data needed to demonstrate fire safety are independent of the method that generated the information, albeit any extended application process needs to take into account any differences in the test conditions.

Characterizing the behaviour of a material/product for engineers in order to predict the fire performance of a structure might not always need the product to be tested. It is common practice for a construction to have its fire performance "assessed" in lieu of the testing. This is based upon the results of tests on variations of the material or construction, or by using public domain/generic data, which permits the result to be predicted. Indeed, if the field of extended application is to be established, the performance will have to be assessed using justified methods of interpolation and extrapolation where the onus is on the end user to determine whether the method is technically robust.

The full characterization of a material or construction will generally require a well-planned testing programme designed to evaluate some of the critical parameters in order that the others or the interaction between them can be derived by assessment. It is important that the primary evidence used for establishing the field of extended application of a construction is generated using the test for which the extended application is being derived. However, supporting, or secondary evidence to be used in quantifying the performance may be generated using tests that vary slightly in exposure or criteria as long as the potential influence of the variation test conditions is known and quantifiable.

Part of the concept of the European single market is the ability to mark products with a symbol that identifies that the product conforms to the essential (safety) requirements, including fire, in an unambiguous manner. This CE mark may only be awarded to a product if it conforms to any appropriate EN Product Standard or European Technical Approval. The product(s) have to satisfy the criteria in the European Standard or ETAG (European Technical Approved Guideline) related to the product. The field of direct or extended application is expected to encompass the parameters of the product as installed, hence the need for such assessments.

In anything other than a very simple prescriptive legislative framework, performance claims need to consider the field of application of the results, which is covered in this part of BS 476. This includes the use of direct and extended application as derived from the results of the European Standards as part of the way of expressing the result in the context of the Construction Products Directive (CPD) [1].

The family of tests used to characterize the fire performance of a material have unquantified levels of reproducibility and repeatability, partly due to the uncertainty of measurement that accompanies some of the tests, in particular fire resistance tests where the application of some of the instrumentation is operator dependent.

This subject is addressed in this guide. It sets out to identify the scope and role of the British Standard fire test procedures that form part of the British Standard series of fire tests. It also relates them to European and International Standards test methods for characterizing that specific parameter of the product.

1 Scope

This part of BS 476 describes the general principles of fire testing and identifies the specific objectives/outputs of the BS 476 series of test methods and their related European (EN) and International (ISO) Standards.

It provides guidance as to which test should be used for which purpose and how the results from those tests generally define the role of the test in any prescriptive or functional regulatory regime.

It is not intended to be used for determining the conformity of any product or construction to Essential Requirement 2 of the European Construction Product Directive [1].

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 476-3, *Fire tests on building materials and structures – Part 3: Classification and methods of test for external fire exposure to roofs*

BS 476-4, *Fire tests on building materials and structures – Part 4: Non-combustibility test for materials*

BS 476-6, *Fire tests on building materials and structures – Part 6: Method of test for fire propagation on products*

BS 476-7, *Fire tests on building materials and structures – Part 7: Method of test to determine the classification of the surface spread of flame of products*

BS 476-11, *Fire tests on building materials and structures – Part 11: Method for assessing the heat emission from building materials*

BS 476-12, *Fire tests on building materials and structures – Part 12: Method of test for ignitability of products by direct flame impingement*

BS 476-13, *Fire tests on building materials and structures – Part 13: Method of measuring the ignitability of products subjected to thermal irradiance*

BS 476-15, *Fire tests on building materials and structures – Part 15: Method for measuring the rate of heat release of products*

BS 476-20, *Fire tests on building materials and structures – Part 20: Method for the determination of the fire resistance of elements of construction (general principles)*

BS 476-21, *Fire tests on building materials and structures – Part 21: Methods for determination of the fire resistance of loadbearing elements of construction*

BS 476-22, *Fire tests on building materials and structures – Part 22: Methods for determination of the fire resistance of non-loadbearing elements of construction*

BS 476-23, *Fire tests on building materials and structures – Part 23: Methods for determination of the contribution of components to the fire resistance of a structure*

BS 476-24, *Fire tests on building materials and structures – Part 24: Methods for determination of the fire resistance of ventilation ducts*

BS 476-31.1, *Fire tests on building materials and structures – Part 31: Methods for measuring smoke penetration through doorsets and shutter assemblies – Section 1: Method of measurement under ambient temperature conditions*

BS 476-32, *Fire tests on building materials and structures – Part 32: Guide to full scale fire tests within buildings*

BS 476-33, *Fire tests on building materials and structures – Part 33: Full-scale room test for surface products*

BS 4422, *Fire – Vocabulary*

3 Terms and definitions

For the purposes of this part of BS 476, the terms and definitions given in BS 4422 and the following apply.

3.1 assessment

opinion of the likely performance of a component or element of structure if it were to be subjected to a standard fire test

NOTE In a majority of cases, an assessment is the evaluation of a product in lieu of a fire resistance test that could be carried out in a standard size furnace, e.g. 3 m × 3 m for wall furnaces. Examples of such assessments are assessing modest size increases in doors, changes in fixing centres etc. For the product to be given this type of assessment, no significant redesign or reengineering needs to be undertaken. This type of assessment is not limited by furnace design – size increases beyond standard furnace sizes can be included provided there is a valid technical argument given. However, large size increases and complex assessments are the subject of engineering appraisals. Assessments of this type and engineering appraisals can be used for the purpose of demonstrating compliance with the national building regulations¹⁾, but cannot be used within the context of the CE marking.

3.2 element of construction

part of a building or structure with its own functional identity

3.3 expert opinion

results of a dialogue between a group of experts who are accepted by their peers as being knowledgeable in a particular fire test and the performance of products in that test, in order to derive the extended application rules

NOTE Such dialogue takes place within a recognized and properly constituted forum for an institution of the European Union (EU), such as CEN TC127. These agreed expert opinions are then transformed into rules that can form the basis of extended application.

¹⁾ In the UK, these are the Building Regulations 2000 [2], the Building (Scotland) Regulations 2004 [3], and the Building Regulations (Northern Ireland) 2000 [4].

3.4 expert judgement

view of a recognized expert in a particular fire test and the performance of products in that test that can be used for the purpose of interpreting or applying results of that test in connection with the application of the particular product into parts of works for the purposes of satisfaction of national regulations

NOTE Expert judgement cannot form any part of extended application for CE marking.

3.5 material

physical substance used in manufacturing a product

3.6 product

that which is produced for permanent incorporation in construction works as well as those temporary items of furniture and fittings installed in the completed building

3.7 fields of application**3.7.1 direct field of application (of test results)**

outcome of a process (involving the application of defined rules) whereby a test result is deemed to be equally valid for variations in one or more of the product properties and/or intended end use applications

3.7.2 extended field of application (of test results)

outcome of a process (involving the application of defined rules that may incorporate calculation procedures) that predicts, for a variation of a product property and/or its intended end use application(s), a test result on the basis of one or more test results to the same test standard

4 Selection of the appropriate test method

When utilizing test evidence to demonstrate the acceptability of a material/product or element of construction in the context of the envisaged fire hazard, it is important that the correct test is selected to evaluate the appropriate fire performance characteristic(s).

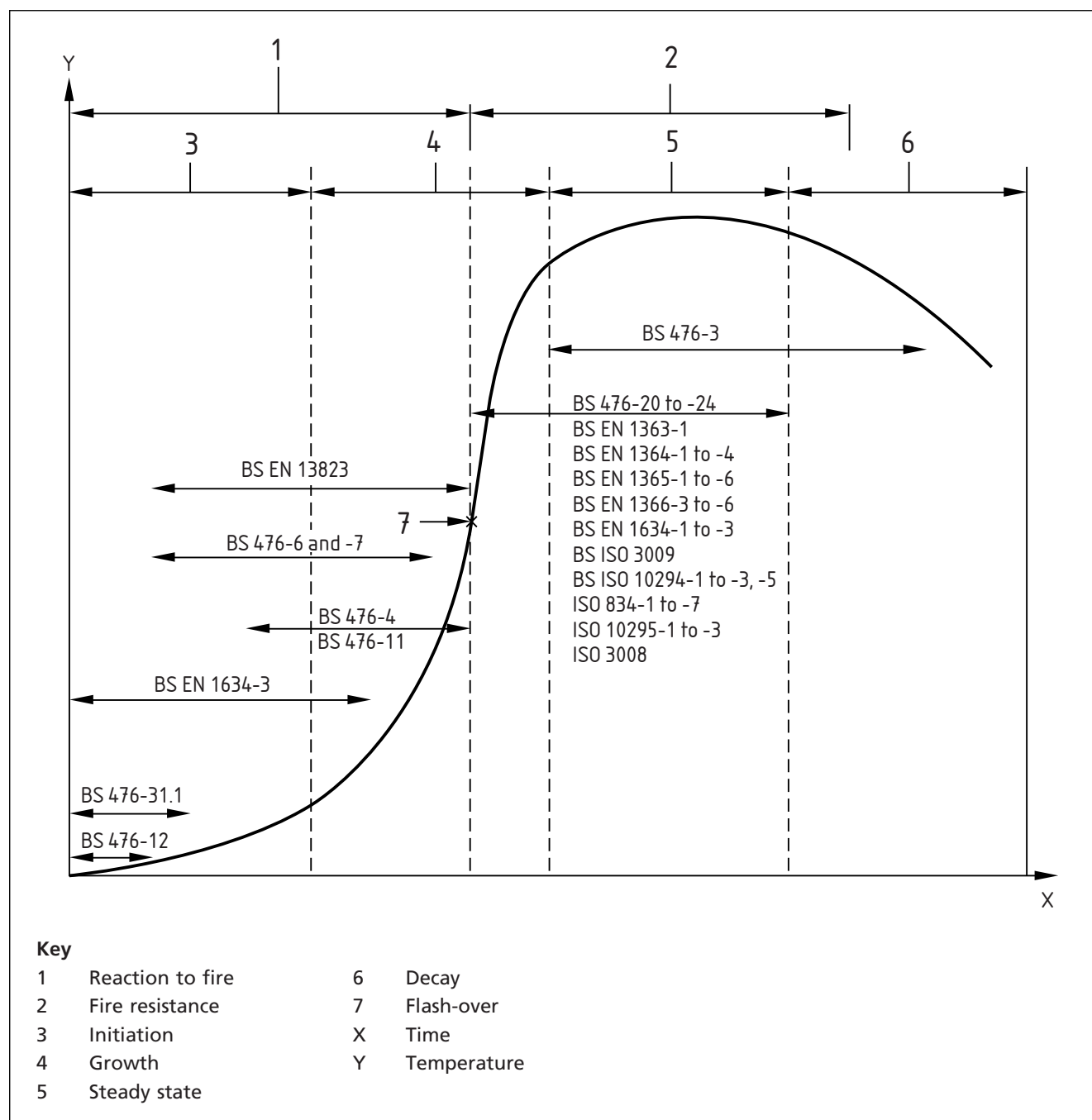
Fire tests set out to measure the following fire characteristics:

- propensity of a material/product to ignite/burn;
- propensity of the material/product to spread fire;
- propensity of material/product to release heat;
- propensity of a material/product to produce smoke;
- ability of an element of construction to contain fire or protect structures;
- ability of an element of construction to contain smoke (doors only).

Figure 1 shows the typical fire development of an unsprinklered, conventionally furnished, modest sized compartment fire. Superimposed on it are the times and temperatures where the fire tests are relevant.

Tests that characterize the ignitability, surface spread of flame, release of heat and production of smoke are known as "reaction to fire" tests, and these are discussed in Clause 5.

Figure 1 Typical temperature/time relationship of a fire with the various fire tests superimposed on it to show their limits of applicability



Tests that characterize the fire containment properties of an element of construction, including those designed to protect the frame from collapse and to restrict the spread of smoke, are referred to as "fire resistance" tests, and are discussed in Clause 6.

There is an increase in the use of semi-natural fire tests. These expose the interaction between elements and the BS 476 semi-natural tests, and are discussed in Clause 7.

Since the 1983 edition of BS 476-10 was published, there has been an increase in the understanding of how the tests' outputs are used. All European Standards incorporate a field of application statement, which is necessary if the scope of the performance is to be defined for

CE marking purposes. The need for the output from tests to be subject to a defined field of application is not restricted to European Standards. All fire test results need to be considered in this context.

Broadly, there can be considered to be three sub-categories of field of application:

- *direct* field of application;
- *extended* field of application; and
- *project-specific* field of application.

Direct and *extended* have been defined within CEN in relation to European fire test methods for the purposes of CE marking (see Clause 3). These definitions are explicit and are intended to ensure that the process of extended application of test results within Europe is transparent.

It is important to understand the roles of *expert opinion* and *expert judgement* within the context of CE marking and the process of standardizing extended application rules. Expert judgement does not form any part of the extended application process for CE marking.

When carrying out an extended application, it is necessary to identify all of the parameters that might change or, in the case of a project-specific field of application extension, the actual parameters that have changed, and to identify the factors that will change for each parameter in turn. It is then necessary to consider the influence of the factors on each of the relevant criteria in turn.

In some cases, the influence on the criteria can be quantified using appropriate mathematical techniques, or can be based upon rules developed and agreed by industry consensus. In many cases, the influence can be resolved solely by expert judgement.

These differences are significant when extended application is carried out for the purposes of CE marking of construction products. In such cases, in an attempt to ensure that extended applications are generally accepted across the Member States of the EC, expert judgement is excluded from the process. However, expert judgement is accepted for purposes outside of CE marking and might be accepted when demonstrating conformity to the requirements of the national building regulations²⁾.

Field of application is discussed in greater detail in 5.3, 6.7 and 8.3.

²⁾ In the UK, these are the Building Regulations 2000 [2], the Building (Scotland) Regulations 2004 [3], and the Building Regulations (Northern Ireland) 2000 [4].