INTERNATIONAL STANDARD

ISO 10840

Second edition
2008-06-01

Plastics — Guidance for the use of standard fire tests

Plastiques — Lignes directrices pour l'utilisation d'essais au feu normalisés

Reference number
ISO 10840:2008(E)

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 10840 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 4, *Burning behaviour*.

This second edition cancels and replaces the first edition (ISO 10840:2003), which has been technically revised.

Introduction

Many of the current reaction-to-fire tests were developed, prior to the widespread use of synthetic polymers, to assess products incorporating materials such as wood (in the building industry), paper (in electrical wires and cables), and naturally occurring fibres such as cotton, wool and horsehair (in many textile, furniture and electrical applications). The reaction-to-fire characteristics of these so-called traditional materials are often very different from those of synthetic materials, especially thermoplastics.

ISO/TC 61/SC 4 recognizes the need for guidance for users of fire-test standards commonly applied to materials and products made of, or incorporating, plastics. In 2003, the first edition of ISO 10840 was published, based on the now withdrawn ISO Technical Report ISO/TR 10840:1993, *Plastics — Burning behaviour — Guidance for development and use of fire tests*, which listed a series of potential problems associated with the reaction-to-fire testing of plastics materials and products. ISO/TR 10840, however, provided users of the test methods with no practical assistance on how to cope with the potential problems listed.

Although the first edition of ISO 10840 addressed the provision of such assistance, the general guidance that it gave on the mounting and fixing of test specimens was found in many cases to be insufficient. More specific guidance, relevant to the various end-use conditions of plastics products, was required. This second edition of ISO 10840 includes a new annex that provides more detailed information about how to conduct standard fire tests which are more relatable to the real conditions of plastics products in a variety of applications.

With more concerns expressed about the environmental impact of fires involving plastics, additional guidance has been included in this second edition. This information is general at present but it is proposed to provide further guidance as the technology develops.

Particular attention is given to the provision of guidance for inexperienced users who may need to assess the fire performance of materials or products made of, or incorporating, plastics. This International Standard also provides answers to frequently asked questions concerning fire tests; these cover factors such as cost, duration, complexity, required operator skills, quality of the data produced, relevance to fire hazard assessment as well as test repeatability and reproducibility. This International Standard contains a bibliography of the most frequently used fire tests applied to the materials and products within the scope of ISO/TC 61/SC 4.

The main focus of this International Standard is on reaction-to-fire testing. Fire-resistance testing has also been considered, however, to take account of the widespread use of advanced polymer composites and related materials with superior thermo-mechanical stability which may be used in applications where there is a demand for some degree of fire resistance. Further development of such plastics composites and related products will predictably increase the demand for fire-resistance testing.

This International Standard also provides guidance on some standard fire tests which give data that is applicable for assessment of the potentially adverse environmental impact of combustion products that may be generated in large-scale fires involving plastics materials and products.

NOTE The term “adverse environmental impact” covers undesirable direct effects on the environment as well as indirect effects on people through environmental exposure.

This page is intentionally blank.

Plastics — Guidance for the use of standard fire tests

1 Scope

This International Standard covers the following aspects of fire testing of plastics materials and products:

— selection of appropriate tests that reflect realistic end-use conditions;

— grouping of the reaction-to-fire characteristics that any given test or tests can measure;

— assessment of tests as to their relevance in areas such as material characterization, quality control, pre-selection, end-product testing, environmental profiling and DfE (Design for the Environment);

— definition of potential problems that may arise when plastics are tested in standard fire tests.

The scope of this International Standard does not include the development or design of new fire tests for plastics. However, the flexibility of approach that is indicated with respect to the mounting and fixing of test specimens will be valuable when fire-testing laboratories and certification bodies are considering how to evaluate ranges of plastics that are used in different ways.

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.

ISO 390, *Products in fibre-reinforced cement — Sampling and inspection*

ISO 1887, *Textile glass — Determination of combustible-matter content*

ISO 13943:2008, *Fire safety — Vocabulary*

EN 312, *Particleboards — Specifications*

EN 520, *Gypsum plasterboards — Definitions, requirements and test methods*

EN 13238, *Reaction to fire tests for building products — Conditioning procedures and general rules for selection of substrates*

EN 13823:2002, *Reaction to fire tests for building products — Building products excluding floorings exposed to the thermal attack by a single burning item*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13943 and the following terms and definitions apply.

3.1
test specimen
test piece that may be cut from a sample of a product, or prepared by moulding or otherwise, as specified by the test procedure, or a representative sample of the product itself

3.2
sample
representative part of a manufactured product or piece of a material or semi-finished product

3.3
end-product test
fire hazard assessment test on a complete product, piece, part, component or sub-assembly

3.4
pre-selection test
combustion characteristic test made on a standardized shape, for example a rectangular bar prepared using standard moulding procedures

3.5
flashover
⟨stage of fire⟩ transition to a state of total surface involvement in a fire of combustible materials within an enclosure

[ISO 13943:2008]

3.6
spalling
the breaking off of fragments or solid particles from a heated surface

NOTE This effect is similar to the splintering or chipping that occurs on heating some stone or concrete surfaces.

3.7
smouldering
combustion of a material without flame and without visible light

NOTE Smouldering is generally manifested by an increase in temperature accompanied by emission of effluent.

3.8
glowing combustion
flameless combustion of a solid material with emission of light from the combustion zone

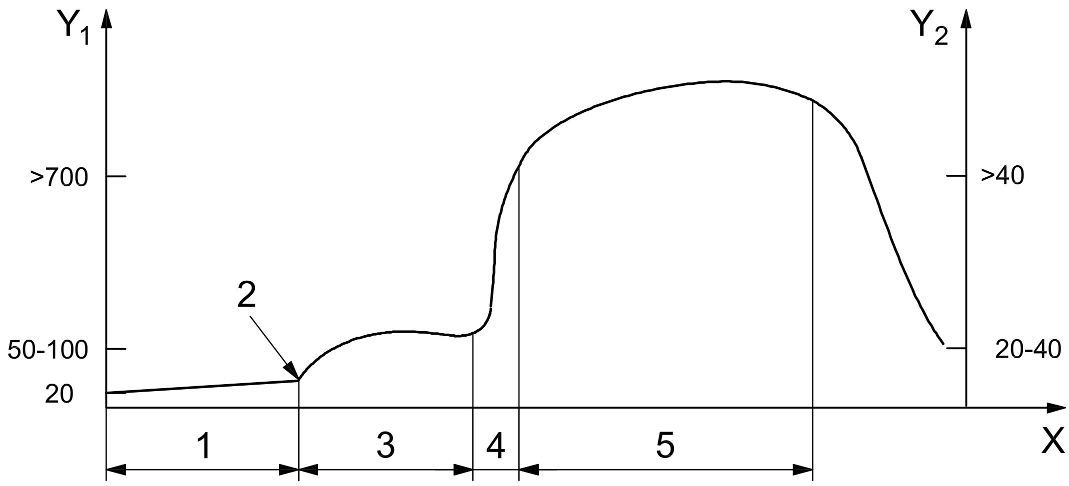
3.9
uncertainty of measurement
parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand

4 Enclosure fire scenarios

4.1 General

A number of fire parameters influence the development of a fire and, moreover, the fire parameters measured during the pre-flashover and the post-flashover stages differ greatly.

There are four main stages of fire development within an enclosure, which are assessed using measurements of temperature and time as shown in Figure 1.



Key

X time, t (minutes)

Y_1 average temperature, T, in fire compartment (°C)

Y_2 average irradiance, I, in fire compartment (kW/m^2)

1 time to ignition

2 ignition point, at which the local conditions in the enclosure close to the ignited item will be $T > 100$ °C and $I > 25$ kW/m^2

3 developing fire

4 flashover

5 fully developed fire

Figure 1 — Typical course of a fire in an enclosure going to flashover

4.2 Initiation and early growth

This stage includes the exposure of a product to a heat source, ignition and early development of a fire. Two types of combustion may exist at this stage, smouldering and flaming. Smouldering is a slow, flameless combustion producing very little heat, but having the potential to fill an enclosure with smoke and toxic gases.

After ignition, the development of a flaming fire will depend on the following effects:

— fire growth on the first item to be ignited;

— fire spread to other items;

— the effect of intervention (portable extinguishers, sprinklers, fire brigades);

— the ventilation conditions.

4.3 Development of fire

As a fire develops, a hot smoke and gas layer usually builds up below the ceiling. The radiant heat transfer to combustible items accelerates the thermal decomposition of material below the smoke layer, and the rate of fire spread increases.

Flashover, which usually occurs at temperatures around 600 °C, corresponds to an abrupt transition from a localized fire to the ignition of the gas layer and the subsequent sudden ignition of all exposed flammable surfaces, leading to a fully developed fire. The rate of heat release increases rapidly to reach a maximum value. Flashover is uncommon in large enclosures, as the required temperature conditions are not often reached.

4.4 Fully developed fire

A fire is regarded as fully developed when all fuel within an enclosure is burning. This stage usually follows flashover, but some fires may become fully developed without passing through the flashover phase.

4.5 Decay

The decay stage of a fire is reached when all the combustible material or available air has been consumed, or when the fire is suppressed. In the pre-flashover phase, reaction-to-fire characteristics of products are important, while in the post-flashover phase resistance-to-fire parameters of complete assemblies apply.

Fire building regulations make a distinction between these two conditions. Table 1 summarizes the important fire parameters associated with reaction to fire and resistance to fire.

Table 1 — Phases of a fire

Phase	Stage	Parameters
Pre-flashover	Initiation	Ignitability
	Developing fire	Fire growth (ignitability, flame spread, and release of heat, smoke and toxic effluent)
Post-flashover	Developed fire	Resistance to fire (load-bearing capability, integrity, insulating capability)

5 Categories of fire test

5.1 Material characterization tests

5.1.1 Tests done on behalf of customers who will undertake no further reaction-to-fire testing

This type of testing imposes an obligation on the material supplier to assess reaction-to-fire characteristics of the material likely to be of relevance to the application of the customer's product, or foreseeable misuse of the product as may be imposed by product stewardship aspects of Responsible Care programmes, or product liability litigation, or both. The objective should be to provide answers to questions such as:

a) Do the properties of thermal-decomposition products (smoke density, toxicity or corrosivity) pose a foreseeable problem?

b) Is the thermo-mechanical response of the material (e.g. melting or retreating from the heat source) likely to constitute a hazard or an advantage in the customer's product application, or in foreseeable misuse scenarios?

5.1.2 Tests done on behalf of customers seeking compliance with reaction-to-fire tests on a finished product

In this case, the test method(s) used by the material manufacturer should provide an indication of the likely influence on the product test result of material characteristics such as melting, dripping and retreat from the heat source.

5.2 Quality-control tests

To select a quality-control test, it is important to:

— decide which characteristics should be tested;

— select or develop the appropriate test methodology;

— specify the required performance criteria;

— compare test results to ensure that the parameter measured by the quality-control test correlates with the key performance parameter being investigated.

It is necessary to specify:

— the characteristics which have to be checked by testing;

— the appropriate test procedure;

— the required pass (acceptance) and fail (rejection) criteria;

and then to compare the test results with the specified criterion/criteria (acceptance level).

Repeatability is of crucial importance in tests selected for the purpose of quality control; in this context, the relevance of the test to any given application of the material is of secondary importance.

5.3 Pre-selection tests

Data developed using pre-selection tests require careful consideration to ensure their relevance to the intended application and to avoid misuse and erroneous interpretation.

The actual fire performance of a product is affected by its surroundings, design variables such as shape and size, fabrication techniques, heat-transfer effects, the type of potential ignition source and the length of exposure to it.

The advantages of pre-selection testing are as follows:

a) To a first approximation a material which reacts more favourably than another when tested as a standard test specimen will usually also react more favourably when used as a finished part in the product. This will be valid provided that no overriding interactive, product-specific effects are present.

b) Data concerning relevant combustion characteristics can aid the selection of materials, components and sub-assemblies during the design stage.

c) The precision of pre-selection tests is usually higher, and their sensitivity may be superior when compared with end-product tests.

d) Pre-selection tests may be used in a decision-making process directed to minimize the fire hazard. Where applicable for the purpose of fire hazard assessment, they may lead to a reduction in the number of end-product tests with a consequent reduction in the total testing effort.

e) When fire hazard requirements need to be upgraded quickly, it may be possible to do this by upgrading the requirements of a pre-selection test before modifying the end-product test.

f) The grading and classification obtained from the pre-selection test results may be used to specify a basic minimum performance of materials used in product specifications.

It should be noted that, when pre-selection testing is used to replace some of the end-product testing, it is necessary to fix an increased margin of safety in an attempt to ensure satisfactory performance of the end product. Following a pre-selection procedure, it may be necessary to carry out a value analysis on the end product, in order not to over-specify materials where a more economical material can be used. In this case, an end-product test may be necessary.

5.4 End-product tests

These tests should reflect the end-use application scenario as far as is possible. Important factors to consider include the relevance of configuration, orientation, ventilation and the nature of the ignition source.

Reaction-to-fire testing for fire safety and for fire hazard assessment of products should be programmed as follows:

a) specify the fire hazard to be assessed (e.g. vision impairment by smoke);

b) define the relevant product-application (or misuse) scenario and specify the required safety criterion;

c) select the appropriate test method and specify the pass/fail criterion;

d) conduct the tests and analyse the data;

e) select acceptable or reject unacceptable candidate materials or products.

6 Important considerations in the fire testing of plastics materials and products

6.1 Influence of the chemical or physical nature of the test specimen

Various chemical and/or physical aspects of the material may affect the performance of the specimen at the high temperatures encountered in standard fire-testing procedures. These may be categorized under various headings, depending on whether the observed phenomena are associated with the specimen itself and/or the test apparatus and/or the execution of the test procedure and/or the interpretation of the test results.

6.2 Thermal-decomposition products

6.2.1 General

When an ignition source is applied to any plastic test specimen made from pure, compounded or laminated material, thermal-decomposition products will be generated. The nature of the decomposition products is not determined exclusively by the chemical composition of the test specimen. Other determinant factors are:

a) the energy output of the ignition source;

b) the nature of the ignition source:

- flaming or non-flaming,
- impingement or non-impingement on the specimen;

c) the nature of the test apparatus:

- high or low ventilation,
- high or low thermal inertia (i.e. significance of heat-sink effects).

6.2.2 The nature of the thermal-decomposition products

These may consist of:

a) toxic decomposition products;

b) corrosive decomposition products;

c) smoke and soot;

d) char and intumesced layers.

6.3 Problems posed by specimen decomposition

The following types of effect may occur:

a) additive evaporation or sublimation;

b) out-gassing or intumescence;

c) char-layer formation;

d) delamination;

e) spalling;

f) smouldering;

g) glowing combustion.

6.4 Health, safety and local environmental considerations

The following factors should be taken into account:

a) operator safety, especially from fast fire-growth, as in flashovers, and from exposure to smoke and toxic effluents, particularly in large-scale tests such as ISO 9705;

b) effects of heat on structures in large-scale test procedures (dangers of structural collapse);

c) the need for personal protective equipment;

d) the local environmental impact on the air, the water and the soil;

e) compliance with local regulations;

f) avoidance of local nuisance as required by Responsible Care commitment;

g) identification and control of effluents;

h) equipment corrosion;

i) smoke or gas explosion hazards.

6.5 Specimen size and geometry

It is important to define selection criteria for test specimens taken from finished products.

Influential factors include:

a) *Specimen thickness*: Heat and smoke release depend on thickness. Thicker specimens may release much more heat and smoke than thin specimens. Thin specimens may ignite more easily than thick specimens because of thermal-inertia effects.

b) *Specimen size*.

c) *Specimen form*, as determined by the specimen's shape and aspect ratio.

d) *Edge effects*: Sharp edges may ignite more readily than rounded edges.

e) *Orientation and ventilation*: Flame spread will depend on the air-to-gas ratio and the flow of gaseous species in the vicinity of the flame.

f) *Specimen support, including air gaps*: Conductive air-flow between the specimen and its support system may affect temperature rise profile and, consequently, the ignitability and flame-spread behaviour of the specimen. Limitation of specimen movement by the specimen support system may also affect specimen response to the ignition source.

6.6 Characteristics of ignition sources

The relevance of ignition sources depends on the selection of fire scenarios in which the product is to be evaluated for fire hazard. Fundamentally, heat flow from the heat source to the specimen is a major parameter in such evaluation; it also depends on the relative sizes of the specimen and the ignition source. Thus the test result may depend on many design features of the test system. The following characteristics of the ignition source should be taken into account:

a) radiant, conductive and convective properties;

b) whether the source is a flaming or non-flaming one;

c) whether the flame impinges on the specimen or not;

d) precision and quantification of measurements;

e) flame instability.

6.7 Sample and test specimen preparation and conditioning

The preparation of material samples and test specimens can be of extreme importance in the fire-testing of plastics materials and products. Preparation covers selection, sampling, and the cutting-out and conditioning of the specimens. Conditioning is important because variations, especially in the moisture content of a specimen, will affect the test results.

It is important to remove moulding flash and other similar adventitious residues from the surfaces and edges of specimens.

The initial temperature of the specimen may influence its ease of ignition in the test.

Particular attention should be paid to thermo-formed test specimens. The conditions of the thermo-forming operation, such as injection moulding or extrusion, should be rigorously controlled to minimize and, if possible, eliminate any specimen-to-specimen variations in residual stress, anisotropy, specific gravity and degree of crystallinity. All of these variables influence the thermo-mechanical properties of the specimen and, consequently, its response to the application of heat from the fire-test ignition source.

6.8 Operating procedures in the event of specimen collapse or deformation

Problems arise in the fire testing of many plastics because of common thermo-mechanical effects such as specimen slumping and sagging as well as edge-effects such as the curling of thin specimens towards or away from the ignition source.

Interpreting test results can also be problematical when the operator has to cope with and report variations in incident flux and/or ignition conditions (impingement/non-impingement of the flame) because of changes in the source-to-specimen distance. Examples of other problem areas concern interpretation of observed non-ignition of the specimen due to its shrink-back from the ignition source and interpreting the effects on the test result of restraining and supporting devices such as clamps, grids and wires, including the masking of specimen edges by such devices.

Such behaviour of the specimen should be reported by the operator in the test report. If the effect is so extreme as to make it impossible to obtain test data, this should be reported as the reason why the test could not be carried out.

Thermo-mechanical specimen responses in fire tests on plastics may give rise to localized withdrawal of the specimen from contact with the ignition source as a result of accelerated stress-relaxation within the specimen under the influence of heat from the ignition source. These effects may manifest themselves in various ways depending on the chemical and physical nature of the specimen, its dimensions and its orientation as determined by the specified test procedure. Examples are:

— shrinking;

— curling;

— sagging;

— slumping.

Gravitational effects on the test specimen are determined by its mass, dimensions and orientation. Depending on these factors, the action of gravity may result in sagging or slumping of the specimen. These effects may aggravate or attenuate specimen deformation caused by internal thermo-mechanical stress-relaxation processes. It may be noted in this connection that problems of thermoplastic specimen slumping encountered in the NBS Smoke Chamber (ASTM E 662) were resolved by ISO/TC 61/SC 4 in ISO 5659-2.

6.9 Complications caused by melting effects in thermoplastics

Melting effects can include flaming and non-flaming drip formation, adhesion of the specimen to an ignition source such as a glow-wire, and melt-pool formation below the test specimen, which may be feeding fuel into, or away from, the ignition zone.

If the test conditions correspond to foreseeable end-use scenarios, these results should be reported because they are relevant to hazard and risk assessment. If there is no likely relevance of the test conditions to the end-use, it should be reported that the test could not be carried out as specified, and an alternative test procedure should be selected.

6.10 Advantages and disadvantages of scale in fire tests

6.10.1 General

Difficulties are often experienced in extrapolating upwards from small-scale to large-scale performance, for there are always implications to be taken into account in the trade-off between test precision and test relevance to end-use hazard assessment.

6.10.2 Large-scale tests

Such tests may offer the only available realistic assessment of the gross effects of thermal deformation and gravity and the effects of fixings and joints under end-use conditions in real fires (see Annex A). This raises questions about the acceptability of small-scale test data on parts of products (or on materials used in products) given that these effects play a key role in the fire safety of the product in its application scenario.

The large-scale ISO 9705 room/corner test has been used to validate the cone calorimeter for wall- and ceiling-linings; it is the reference scenario for European Union classification of building products. Other reference scenarios include large rooms, ducts, corridors, stair-wells and façades.

The advantage of large-scale tests lies in their relevance to end-use hazard assessment. Their disadvantages include potential operational safety and local environmental hazards, cost, uncertain reproducibility as well as the fact that the information that they provide is intrinsically scenario-specific and, consequently, of restricted applicability.

6.10.3 Intermediate-scale tests

The major benefits of intermediate-scale tests are associated with their ability to reflect more accurately the fire conditions of real fires than small-scale tests. The following are examples:

Specimen mounting: Due to the larger test apparatus, specimens can incorporate more readily end-use fixtures, joints and air gaps (see Annex A). In addition, thick and/or profiled products may be accommodated. This capability is valuable for sandwich panels, which can be up to 200 mm thick and may be faced with steel sheet containing 150-mm-deep profiles. It is also valid for pipes, pipe insulation, cable trays, GRP frames and similar products.

Ignition sources: The thermal characteristics of ignition sources can be related more closely to those of design fires. Intermediate-scale tests may use either flame or radiant-heat sources. Gas-burner sources tend to be more widely used with, typically, heat outputs in the range 30 kW to 300 kW and thermal attack on the specimen surface in the range 25 kW/m^2 to 75 kW/m^2. The energy supplied to test specimens by ignition sources in small-scale tests lies in the range 0,000 3 kW·h to 0,3 kW·h, whereas it lies between 1 kW·h and 10 kW·h in intermediate-scale tests (and in the range, 30 kW·h to 150 kW·h in large-scale tests).

Test specimen size and orientation: Intermediate-scale tests allow fire growth to be more realistically evaluated; hence, the ability to measure flame spread away from the impingement zone of the ignition source is a desirable feature.

In addition, since many products (especially thermoplastics) rapidly deform or melt when exposed to ignition sources, more representative behaviour may be observed with intermediate-scale specimens, which are often larger than 1 m^2.

Disadvantages of intermediate-scale tests are associated with their inability to totally simulate a real-scale scenario (for example, not reproducing all ventilation conditions, which would be important to characterize flashover or smoke generation adequately) and the increased effluent and cost compared to small-scale tests. Hence, there may be a tendency to reduce the number of test specimens, which could possibly result in lower repeatability and reproducibility.

6.10.4 Small-scale tests

In a small-scale test, it is not easy to simulate the area, thickness, profile and orientation of the product in its end-use, or to replicate actual mountings or fixings. This also applies to joints and air gaps, that may have a critical influence on real-life product performance (see Annex A).

The advantage of small-scale tests is that, provided they are correlatable with the large scale, they can provide reproducible data which can be used for mathematical modelling.

NOTE Small-scale tests have been successfully used in predicting fire performance of wall-linings, furniture and cable and floor coverings in large-scale scenarios.

The disadvantages of small-scale tests are:

a) these tests are often carried out using standard substrates for the test specimens; these substrates may not replicate real-scale conditions;

b) they cannot replicate the range of conditions found in fires (including the size and duration of application of ignition sources).

6.11 Influence of test apparatus design on the applicability of test data

Important criteria in the assessment of the relevance of the test procedure and apparatus to the intended end-use scenario include:

Ventilation effects: Particular care is called for when interpreting results obtained in closed-box apparatuses where the ratio of specimen mass to chamber volume is important. The significance of under/over-ventilation conditions relative to the end-use scenario, and its relevance to apparatuses such as the cone calorimeter, the cable tray used in cable tests and the radiant panel used in flooring tests should be taken into account. This raises questions about the relevance of wind-assisted versus wind-opposed flame-spread regimes.

Mechanical effects: Mechanical restraint of specimen during thermal expansion can result in specimen warping or fracture. The use of restraining devices such as grids may prevent the formation of a beneficial cohesive char layer on the specimen surface.

Thermal effects: Heat sinks and incident-flux variations or an incident-flux gradient over the surface of the specimen should be considered. Every effort should be made to eliminate such effects or, if they are unavoidable, they should be taken account of in the final appraisal of the results.

Further details are given in ISO 16312-1 and ISO/TR 16312-2.

6.12 Calibration of the test apparatus and attainable precision

The equipment used to measure the following parameters should be calibrated, and the results for each item of apparatus should be kept in the records of the test laboratory:

heat flux, temperature, gas and air flow, gas concentration, air humidity, time, size and mass.

A heat-flux meter calibration standard, ISO 14934, has been developed by ISO/TC 92/SC 1.

The precision attainable is considered when each fire test method standard is developed, and is reflected in the standard. It may be possible to give an indication of the precision attainable for a given fire test method standard in the form of general guidance in the standard itself.

6.13 Uncertainty associated with fire test measurements

Users of fire test data often need a quantitative indication of the quality of the data presented in a test report. This quantitative indication is referred to as the measurement uncertainty. ISO/IEC 17025 requires that competent testing and calibration laboratories include uncertainty estimates for the results that are presented in a test report. General principles for evaluating and reporting measurement uncertainties are described in ISO/IEC Guide 98-3 [republication of the *Guide to the expression of uncertainty in measurement (GUM)*] and the application of this Guide to fire test data is now being addressed by ISO/TC 92, *Fire safety*.

For the determination of measurement uncertainty, it is assumed that the test and measurement equipment is fully in compliance with the test standards. It is also assumed that the operator follows exactly the standardized test procedure and that this is within all the tolerances specified.

The objective of a measurement is to determine the value of the measurand, i.e. the physical quantity that needs to be measured. Every measurement is subject to error even when it is carefully conducted. Each laboratory should determine what data is available to them and what can be used to determine the total uncertainty. Typical influences on the uncertainty of measurements in fire tests are the calibration and positioning of thermocouples, the use of weighing devices, and the calorific value of gases used in gas burners.

7 Potentially problematical specimen behaviour

7.1 Tests developed for materials other than plastics

The potential problems with such tests are given in Table 2.

Table 2 — Potential problems with tests developed for materials other than plastics

Fire test	Title	Potential problems
ISO 5657	*Reaction to fire tests — Ignitability of building products using a radiant heat source*	Intumescence; extinguishing of pilot flame with highly flame retarded plastics
ISO 5658-2	*Reaction to fire tests — Spread of flame — Part 2: Lateral spread on building and transport products in vertical configuration*	Softening/slumping of thermoplastic sheets
ISO 5660-1	*Reaction-to-fire tests — Heat release, smoke production and mass loss rate — Part 1: Heat release rate (cone calorimeter method)*	Melting; intumescence; edge-effects in GRPs and in façade products, especially foam panels
ISO 11925-2	*Reaction to fire tests — Ignitability of building products subjected to direct impingement of flame — Part 2: Single-flame source test*	Detection of flaming drips; shrinkage of thermoplastic foams; relevance of flame-impingement aspect (edge or face)
ISO 11925-3	*Reaction to fire tests — Ignitability of building products subjected to direct impingement of flame — Part 3: Multi-source test*	Detection of flaming drips; shrinkage of thermoplastic foams; softening/slumping of thermoplastic sheets

7.2 Shrinking

This effect causes a contraction of the test specimen when heated so that it becomes smaller in size or extent. In extreme cases, this shrivelling or withdrawal effect may cause problems with the fixing of the test specimen in the specimen holder. Laboratories should decide if modified constraining devices (see 7.6) would be justified as a realistic way to test these specimens.

7.3 Bubbling

Bubbling may be described as a gas blow-out process that may occur when a test specimen becomes liquid upon heating. Vigorous discharge of bubbles from a molten plastic may cause deposits on hot surfaces (such as the heated coils of a cone radiator) and these may then generate effluent that is different from that caused when a test specimen is retained in its normal position in the specimen holder. If vigorous bubbling resulting in spitting or deposition onto the hot surface of an ignition source is observed during a fire test, it should be described in the test report.

7.4 Intumescence

This effect occurs with some plastics exposed to radiant heat in tests such as ISO 5657, ISO 5660-1 and ISO 5659-2. Some formulations exhibit excessive swelling into the cone radiators or onto the pilot igniters in these tests. Where this behaviour is expected, laboratories may increase the separation of the specimen surface to the lower part of the cone radiators (e.g. from 25 mm separation to 60 mm separation in ISO 5660-1:2002, Subclause 7.5). It is important, however, to maintain the same irradiance at the surface of the test specimen in this modified procedure as in the normal procedure.

7.5 Extinguishing of pilot flames by highly flame retarded plastics

This problem can occur with tests such as ISO 5657 and ISO 5659-2 due to the release of copious quantities of vapour-phase-active flame-quenching species. Most pilot burners used with radiant-cone or radiant-panel tests have diffusing flames, which are more readily extinguished than pilot flames where some premixing with air occurs in the burner. An alternative pilot igniter that is less prone to extinguishing is the spark igniter used in ISO 5660-1.

7.6 Slumping of thermoplastic sheets

When vertically oriented thermoplastic sheets are exposed to radiant heat in tests such as ISO 5658-2, the specimens soften and often slump towards the source of radiant heat. Whilst this effect is realistic for certain fire conditions, the slumping behaviour may inhibit fire development (especially flame spread) and it should be decided whether it is realistic to introduce constraining devices (such as wires, nails or metal bands).

7.7 Detection of flaming drips

The confirmation of a discontinuous flame spread hazard created by flaming drips is usually done by using a detector below the test specimen. This is preferred to the simple subjective reporting of an observation of flaming drips. In addition, it helps to establish the possibility that the flaming drips may act as a secondary ignition source to induce sustained flaming in other combustible material below the seat of the fire (e.g. flaming drips falling from a product at ceiling height onto furnishings below or at floor level).

The detection of flaming drips in tests such as ISO 11925-2 and ISO 11925-3 is usually performed with paper sheets (e.g. standard filter-paper or cigarette paper) or with cotton wool. The distance of the detector below the test specimen needs to be sufficiently large (e.g. about 300 mm for small bar specimens) so that flaming drips and any ignited detector will not significantly affect the flame spread behaviour of the test specimen.

7.8 Edge effects

Whilst many building products are supplied in relatively large area sheets, the reaction-to-fire characteristics of the edges of these sheets can be significantly different from the behaviour when the same fire source is applied away from the edges. This effect is determined in ISO 11925-2 by applying a small flame to both the edge and the face of the specimen in duplicate tests; generally, ignition is easier when ignition sources are applied to edges.

Edge effects are also observable when specimens with joints are tested, e.g. in ISO 5658-2 and in ISO 9705. The design of the joint (e.g. butt, T-piece, or taped or overlapping sections) governs the contribution of the specimen; for example, some surface coatings may delaminate from the joint.

In the cone calorimeter test (ISO 5660-1 and ISO 5660-2), specimens are mounted in a pan-shaped holder and the edges are protected by a steel cover. This cover reduces the access of flames and air to the vulnerable edges of products such as GRP sheets and metal-faced, rigid foam sandwich panels.

7.9 Profiled products

Many tests (e.g. ISO 5658-2) for construction products are designed for use with substantially flat specimens. Hence, when tests of profiled plastic products are required, the specimen holders and ignition sources may not be suitable. When necessary, if special specimen mounting arrangements are used, these should be accurately described in the test report. Whenever possible, the mounting of the test specimens should be representative of the conditions of end-use of the profiled product. ISO 5658-2 has now been revised to give guidance about testing plastics pipes for use on ships.

Annex A
(normative)

End-use-relevant preparation of test specimens

A.1 General considerations

This annex is intended to provide basic rules which are generally valid for the mounting and fixing of plastics products in reaction-to-fire test standards. These mounting and fixing rules are intended to ensure that the reaction-to-fire test results are representative of the product behaviour, in one or more end-use applications, when exposed to a fire in the relevant fire scenario.

Plastics products are to be tested and classified in relation to their end-use application, and mounting and fixing instructions serve that purpose. The plastics product, as put on the market, should be submitted to the tests in order to obtain classifications that are relevant to the end-use. Mounting and fixing options may apply and define the field of application of the classification. Generic products are to be tested and classified in a consistent manner.

Two options for mounting and fixing are available for consideration:

— standardized mounting and fixing to cover a group of, or possibly all, end-use applications;

— mounting and fixing that is representative of a specific end-use application.

Standardized mounting and fixing should be defined in a technical specification, respecting the general rules laid down in the supporting fire standards, to enlarge the field of application of a test result. For all standardized mounting and fixing specifications, its field of application shall be defined, using the principle that the performance in the standardized mounting and fixing is equal to or lower than the performance in the end-use applications covered.

Without standardized mounting and fixing arrangements, all end-use applications should be tested. Using standardized mounting and fixing arrangements, this can be limited to a few or even one end-use application.

In the fire tests, the product shall be tested so that, as far as possible, the classification relates to its performance in the end-use application. Composite products are tested as such. However, if underlying layers can be exposed in the end-use application, the ignitability test shall be carried out on the edge of the test specimens so as to assess the ignitability of the underlying layers.

For products that are covered by another surface product in the end-use application, the thermal attack in the testing should be on the surface product of the assembly of products that is tested.

Where the end-use application is known, the product may be tested accordingly or using standardized mounting and fixing. Products may be tested using a specific mounting and fixing arrangement advised by the producer; the applicability of the resulting classification is likely to be limited [to the end-use application(s) represented by the chosen mounting and fixing arrangement].

The following product and end-use application parameters, and their variability, should be taken into account:

— thickness;

— density;

— colour;

— surface coating;

— composition of product;

— geometry and structure, e.g. shape and number and composition of layers;

— substrate;

— method of fixing;

— joints, type and position;

— air gaps;

— edges;

— product orientation;

— exposure to thermal attack.

Parameters may be neglected if it can be demonstrated that they have no effect on the reaction-to-fire performance or if they are not relevant to the product(s) under consideration.

A.2 Small-scale vertically oriented test specimens

A.2.1 General

The guidance given in this clause may be applied to small-scale fire tests in which the test specimen is vertically oriented. For instance, ISO 11925-2 is a small bench-scale test and, because of the effects of scaling on reaction to fire performance, it may not always be appropriate (or even possible) to introduce all features of real-scale mounting and fixing in order to achieve a test arrangement that adequately represents the product behaviour in one or more end-use applications when exposed to a fire in the relevant fire scenario.

A.2.2 Influence of fixings/attachments and supports

Fixings/attachments and supports may influence the test result. Important parameters for these are composition, type, size, position and number. If an adhesive is used, the type and amount of adhesive, the way it is applied (over the whole area, in dots or in waves) and curing are important. An adhesive may fail (and the product may become partly or fully detached from its support) or contribute to the fire. Warping of the specimen in the specimen holder may change the distance from the burner and thus affect the exposure during the test. The clamping technique used may be critical for thin and flexible products. The specimen holder can have a “heat sink” effect or the screws in the frame can impede flame spread in the case of multilayer products with flame spread along a vertical edge.

The method of fixing should be specified in any mounting and fixing arrangement used. It should include at least the composition, type, size, position and number of fixings. If mechanical fixings are used, care should be taken that the fixings do not interfere with flame application or with potential flame spread.

A.2.3 Influence of substrates

Substrates may influence the test result. Important parameters are thickness, density, heat capacity, heat conductivity, deformation and the contribution of the substrate to the fire development. A substrate may be re-used after cleaning and reconditioning if it is fully intact and undeformed after the test. A substrate is deemed to have remained intact if its integrity and density are completely maintained. This is to verify that its chemical and physical state is unchanged. Minor damage, e.g. small pinholes from nailing or screwing, can be tolerated. Joints are not recommended for use in substrates.

A.2.4 Influence of air gaps and cavities

Air gaps are spaces between a building product and the neighbouring elements of a building. They are created when the product is installed in its end-use application.

Structural or characteristic cavities in a building product such as honeycombs, internal cavities in bricks and air-filled spaces within sandwich elements all form part of the building product itself and should not be referred to as air gaps.

An effect of air gaps may be that flames attack both sides of the building product and attack sub-constructions and adjacent elements of the building (insulation, ceilings, floors, walls). This attack may be caused by open or opening joints (vertical or horizontal), by burning through, by melting or by falling parts of the product. The heating of an air gap may lead to a chimney effect, substantially increasing the severity of the thermal attack.

As many of the effects of air gaps are not relevant in small-scale fire tests, it is generally not necessary to include an air gap in the test specimen.

A.2.5 Influence of edges

For the purpose of this International Standard, an edge of a plastics product is a surface that is fastened together at a joint or it is the boundary part of a structure formed from one (or more) component(s). For products with a core (e.g. metal-faced sandwich panels), progress of internal combustion could be affected by the degree of sealing of the edges. The same applies to products with a cavity behind them.

A.2.6 Influence of joints

A joint may be defined as the place at which two parts (edges) of products are joined together. The joint may involve more than two components, some of which are only present in the overall assembly at the joint proximity itself (e.g. sealants, tape, etc.).

Joints may influence the test result. Flames may reach the back side of the test specimen and/or a core via the joints. Products may deform at the joints, leading to small air gaps behind the product.

The main principle in small-scale methods is to test a specimen made of one piece. Secondly, edges are tested under edge flame attack if edges can be exposed under end-use conditions. Thus joints should generally not be part of the test specimen.

A.2.7 Product orientation

Two orientation variations should be distinguished:

— The positioning of a product surface facing towards or away from the fire. In this case, the two positions are interchanged by 180° rotation around an axis in the plane of the product. This may be relevant to an asymmetrical product.

— The positioning of a directional effect in (the surface of) the product in the horizontal or vertical (or, in principle, any) direction. In this case, the positions are interchanged by rotation around an axis perpendicular to the plane of the product. This may be relevant for any product not consisting of one or more flat layers of constant thickness.

NOTE In general, a third variation in orientation can also be distinguished: the horizontal versus vertical position. In ISO 11925-2, however, all building products are tested in the vertical position.

For non-symmetrical products, the performance of the sides may be very different due to e.g. very different top layers.

At one side, a product may have different reaction-to-fire performance due to a directional effect (like a surface with linear trapezoidal profiles). The flame spread may be blocked or guided by the directional effect (the profile direction).

Symmetrical products should be tested on one side only. This is also valid for asymmetrical products (i.e. products whose cross-section has no plane of symmetry) that can be installed with only one of the sides exposed to the initial thermal attack.

Where orientation effects are relevant and occur on a single face and more than one orientation can occur in the end-use application, then all orientations should be tested.

A.2.8 Influence of exposure to thermal attack

The term “exposure to thermal attack” describes the position of the product relative to the small-flame attack in the test. The thermal attack can be directly on the product under consideration or, for products that are incorporated in the building in its end-use application, it can be on surface products in front of the product under consideration in order to simulate correctly its end-use application.

The surface and edge flame attacks are the relevant flame exposure conditions in small-flame tests. Edge flame attack may be bottom edge or side edge attack, depending on the thickness of the product. The severity of the two edge flame exposures can be quite different.

A.3 Intermediate-scale corner-shaped test specimen in EN 13823

A.3.1 General

EN 13823 is an intermediate-scale test and, because of the effects of scaling on reaction-to-fire performance, it may not always be appropriate (or even possible) to introduce all features of real-scale mounting and fixing in order to achieve a test arrangement that adequately represents the product behaviour in one or more end-use applications when exposed to a fire in the relevant fire scenario.

A.3.2 Influence of fixings/attachments and supports

Fixings/attachments and supports may influence the test result. Important parameters for these are composition, type, size, position and number. If mechanical fixings are used, the distance chosen between fixings may influence the test result.

EXAMPLES

— If a product separates from a support, the product may start burning at both sides. A large number of fixings in this case may often lead to a better test result.

— If the product separates from a support and falls apart, a large part of the product may fall away from the burner flame. A large number of fixings in this case may often lead to a worse test result.

If an adhesive is used, the type and amount of adhesive, the way it is applied (over the whole area, in dots or in waves) and curing are important. An adhesive may fail (and the product may become partly or fully detached from its support) or contribute to the fire.

Important parameters for a support are mechanical deformation and the “heat sink” effect. If the support represents a rigid construction (e.g. a concrete wall), mechanical deformation should be prevented.

EXAMPLES

— Mechanical deformation of a support will probably lead to deformation of the product tested; this may damage fixings and may open joints.

— Thin products in contact with a support may lose a significant amount of heat to the support, limiting the progress of the flame front.

The method of fixing should be specified in any mounting and fixing arrangement used. It should include at least the composition, type, size, position and number of fixings, as well as the position of supporting elements like battens.

If no influence of the fixing on the reaction-to-fire performance is expected and a product does not collapse or distort during testing, the test specimen should just be mechanically pressed by the backing board against the U-profiles of the apparatus.

For rigid free-standing products which can stand without support and which are expected not to collapse during testing, distance holders should be used between the product and the backing board and the product should be held only at the periphery of the product.

For the following free-standing products, a supporting frame and spacers should be used (the supporting frame should be representative of the end-use application):

— those supported in end-use;

— those expected to collapse, fall apart or melt;

— those for which the test specimen has to be assembled from a number of smaller pieces to obtain the necessary test specimen size.

It is recommended that screws be used to fix products to a frame. If washers are used, their diameter should not exceed 30 mm. The number of fixings and their spacing should be representative of the end-use application.

A distance holder can be any profile of limited combustibility mounted on the reverse side of the frame at the upper and lower edges of the test specimen. In the case of self-supporting specimens, distance holders may be mounted on the front side of the backing board. Distance holders should not substantially affect specimen ventilation.

For products mechanically fixed to a substrate, screws, nails and staples are often used for mechanical fixing. If washers are used, their diameter should not exceed 30 mm. Test specimens should preferably be clamped on a frame. For products held by screws or pins, the preferred position of the screws/pins should also be represented. The same positions can be used in the case of a planar substrate.

When a product is smaller than the standard single burning item (SBI) test specimen, such as a tile, a number of products should be combined. The fixing of each product should correspond as closely as possible to its end-use application. The supporting construction should be adapted to the required fixing position.

A.3.3 Influence of substrates

Substrates may influence the test result. Important parameters are thickness, density, heat capacity, heat conductivity, deformation and the contribution of the substrate to the fire development.

Table A.1 — List of standard substrates for wall and ceiling surface products

Material	Density kg/m^3	Thickness mm
Fibre cement board (see ISO 390)	1 800 ± 200	6 ± 1
Calcium silicate board	870 ± 50	11 ± 2
Rock fibre mineral wool slab, mass loss less than 3 % at 550 °C (ISO 1887)	50 ± 20	20 ± 1
Steel sheet	7 850 ± 50	0,8 ± 0,1
Aluminium sheet	2 700 ± 50	1,0 ± 0,2
Gypsum plasterboard (paper faced) (see EN 520)	800 ± 100	12 ± 1
Particle board, non-fire-retardant-treated, for internal use (see EN 312)	680 ± 50	12 ± 2

A substrate may be re-used after cleaning and reconditioning if it is fully intact and undeformed after the test. A substrate is deemed to have remained intact if its integrity and density is completely maintained. This is to verify that its chemical and physical state is unchanged. Minor damage, e.g. small pinholes from nailing or screwing, can be tolerated.

If the substrate with the product to be tested includes vertical and/or horizontal joints in the end-use application, the joints in the SBI test should be arranged as described in EN 13823:2002, Subclause 5.2.2, item e).

The joints of the product and those of the substrate are normally arranged in a staggered configuration with respect to each other in the SBI test. The distances given in 5.2.2 e) of EN 13823:2002 for the horizontal joint and for the vertical joint apply to the product and not to the substrate.

If the product is fixed to the substrate in such a way that it forms a composite product (for example, a laminate glued to a substrate), then this composite product should be positioned as described in 5.2.2 e) of EN 13823:2002. Special consideration of the joint is not necessary in the case of the standard substrates given in EN 13238.

A.3.4 Influence of air gaps

A.3.4.1 General

Air gaps are spaces between a building product and the neighbouring elements of a building. Air gaps should be part of the mounting system. They are created when the product is installed in its end-use application.

NOTE Structural or characteristic holes in a building product like honeycombs, structural holes in a brick or air-filled spaces within a sandwich element form part of the building product itself and are not addressed as air gaps.

Air gaps may influence the test result. An effect of air gaps may be that flames attack both sides of the building product and attack sub-constructions and adjacent elements of the building (insulation, ceilings, floors, walls). This attack may be caused by open or opening joints (vertical or horizontal), by burning through, by melting or by falling parts of the product under test.

The heating of an air gap may lead to a chimney effect, substantially increasing the severity of the thermal attack.

If a building product is intended to be installed with air gaps in its end-use application, it should be tested with air gaps.

A.3.4.2 Types of air gap

Air gaps may be distinguished by the type of circulation of air in the gap:

— ventilated (e.g. open side and top edges of the test specimens, but not the bottom);

— non-ventilated (e.g. a tightly enclosed void, or tight battens enclosing the air gap on all sides).

Note the possibility that ventilation can be partly limited by obstructions in the cavity, like battens.

A.3.4.3 Size of air gaps

For products with an air gap that are not self-supporting, the preferred depth is at, or just above, 40 mm. Product-specific deviations should be given in the test report. An air gap of a specific size can be obtained with a frame, supporting elements or spacers of the required size.

A frame or supporting elements may limit the ventilation. This should be a realistic representation of the end-use application.

A.3.4.4 Ventilation of air gaps

Test specimens always stand on the trolley floor of the SBI apparatus.

To test building products with “non-ventilated” air gaps, the test specimen should be prepared by closing the top and side edges with a strip of a non-combustible product (preferably calcium silicate board or mineral wool).

Test specimens with ventilated air gaps should have open borders/edges. The airflow allowed by frames, spacers, etc., should be as similar as possible to the end-use application.

A.3.5 Influence of edges

For products with a core (e.g. metal-faced sandwich panels), the progress of internal combustion could be affected by the degree of sealing of the edges. The same applies to products with a cavity behind them.

The edges of test specimens should be installed in a way which is as close as possible to the end-use application.

In many applications, the edge of a product is covered by another component (such as a mounting frame). For these products, the test should be performed on the product with the edge covered.

A.3.6 Influence of joints

A.3.6.1 General

Joints may influence the test result. Flames may reach the back side of the test specimen and/or a core via the joints. Products may deform at the joints, leading to small air gaps behind the product.

A.3.6.2 All joints

The parts of the structure may be joined in various ways depending on the orientation of the joint. In the SBI test, the following joints may be included:

— wall joint: internal or external, horizontal or vertical;

— corner joint: internal or external, both vertical (wall with wall);

— joints in linear products: vertical, horizontal or inclined.

A joint may be

— fixed with adhesive;

— left open with a gap;

— filled with elastomeric sealant, filler or grout that meets specified end-use requirements.

It is important that, before a jointed specimen is subjected to a fire test, the sealant, filler or grout be cured for sufficient time to achieve its end-use properties. The minimum time for curing should be specified by the manufacturer.

For joints that are made tight in order to maintain the effectiveness of the seal (for example, to provide a liquid barrier in cleaning operations or to provide a vapour seal in air-conditioned units), the manufacturer should specify what lateral pressure or restraint is required in typical end-use conditions. Wherever possible, this restraint should be simulated in the preparation of the test specimen.

The joints used should be clearly specified by indicating their type and width as well as the nature of any filler, profile, sealant or adhesive used.

A.3.6.3 Joints formed with adhesive

The end-use application should be followed concerning the surface to which the adhesive is applied (product or substrate). The adhesive may be a generic type or a specific one. The adhesive may be applied to the edges of the joint (for thick products) or to the face of the product by which it is bonded to a substrate (for thin products). Particular care should be taken to ensure even application of the adhesive, especially at the edges of the joint.

A.3.6.4 Joints formed with sealant

The amount of sealant applied should correspond to that applied in the end-use application.

A.3.6.5 Butt joints

Particular care should be taken in cutting products when joints are to be formed by butting two edges together (e.g. wall joints) or by butting one edge against a face of the second part (e.g. a corner joint in the SBI test). In cases where poor cutting has created difficulties in butting the parts together uniformly, gaps should be filled using best end-use practice and the procedure utilized should be described in the test report.

A.3.6.6 Profiled or interlocking joints

Some products (e.g. sandwich panels) are designed to be jointed with interlocking sections with or without additional components such as sealing strips or intumescent agents. It is important to reproduce the jointing conditions that are found in practice, especially the application of appropriate lateral pressure to the joint. In addition, the use of joint fixings to simulate how panels are attached to sheeting rails can affect how these products perform in the SBI test.

A.3.6.7 Metal flashings for corner joints

In the case of metal flashings, the dimensions and thickness should represent the minimum thickness and dimension in the end-use application.

A.3.6.8 Joints in substrates

Where joints are present in substrates, the joints on any covering material should be staggered so that the joints in the substrate and covering material do not coincide.

A.3.7 Description of product orientation

Two orientation variations should be distinguished:

— The positioning of a product surface facing towards or away from the fire. In this case, the two positions are interchanged by 180° rotation around an axis in the plane of the product. This may be relevant to an asymmetrical product.

— The positioning of a directional effect in (the surface of) the product in the horizontal or vertical (or, in principle, any) direction. In this case, the positions are interchanged by rotation around an axis perpendicular to the plane of the product. This may be relevant for any product not consisting of one or more flat layers of constant thickness.

NOTE In general, a third variation in orientation can also be distinguished: the horizontal versus vertical position. In the SBI test, however, all building products are tested in the vertical position.

For non-symmetrical products, the performance of the sides may be very different due to e.g. very different top layers.

At one side, a product may have different reaction-to-fire performance due to a directional effect (like a surface with linear trapezoidal profiles). The flame spread may be blocked or guided by the directional effect (the profile direction).

Symmetrical products should be tested on one side only. This is also valid for asymmetrical products (i.e. products whose cross-section has no plane of symmetry) that can be installed with only one of the sides exposed to the initial thermal attack.

Asymmetrical products that can be installed with any of the sides facing towards the initial fire should be tested on both sides. The performance of the side with the lower performance can be used for classification of the product or, if the different sides can be clearly distinguished, the classification of each of the sides can be declared separately.

Some facings or coatings may have the same appearance but different reaction-to-fire performance. Where orientation effects occur on a single face and more than one orientation can occur in the end-use applications, then all applications should be tested. Where orientation effects might be relevant, the technical specification writer should take this into account.

A.3.8 Influence of thermal attack

The term “exposure to thermal attack” describes the position of the product relative to the test flame. Thermal attack is made on the product itself unless the product is intended to be incorporated within the building structure in its end-use application. In such cases, thermal attack is made on the surface of the front of the product under consideration.

Reaction-to-fire performance is determined not only by the nature of the product itself, but also by the nature of any other intervening product. Test results are influenced by the manner of exposure to the thermal attack.

When the surface of the product is not directly exposed in end-use applications, one or more other products can be placed immediately in front so as to simulate the performance of these combinations of products in their end-use applications.

Annex B
(informative)

Environmental-impact assessment

B.1 General

As it is practically impossible to carry out quantitative or qualitative analysis of combustion effluents from data on the composition of plastics materials and products, it is generally necessary to conduct combustion tests and analyse the effluents using apparatus which simulates as far as possible the actual combustion process.

This annex provides general guidance on the role that standard fire tests can play in the assessment of the adverse environmental impact of uncontrolled combustion processes involving plastics.

B.2 Scope

Uncontrolled combustion processes involving large-scale and smaller-scale fires, depending on the extent of the environment under consideration, include fires within enclosed structures, fires in breached structures and unenclosed fires in the open.

B.3 Stepwise procedure for the assessment of adverse environmental impact

Combustion effluents may be released from a fire in the following forms:

a) plumes of gases, vapours and particulate matter;

b) liquid run-off to the soil, drainage systems, rivers and aquifers;

c) liquid run-off to, and plume deposition on, forests, woodland and other natural or man-made systems.

Such man-made systems include enclosed and open structures such as buildings and their infrastructure, occupants and contents.

B.4 Determination of combustion conditions

As the generation of combustion effluents depends not only on the type of plastics material and product involved but also on the combustion conditions (such as the ambient oxygen concentration, atmospheric flow characteristics and temperature) and the thermal environmental conditions (such as irradiance, convection and flame characteristics), the combustion conditions at and near the seat of the fire need to be identified as accurately as possible for use in post-fire investigations of the potential adverse environmental effects of the fire effluents.

B.5 Combustion effluents and release of heat

All major predictable thermal-decomposition products that could have an adverse environmental impact should be identified; these include physical effluents, such as respirable fibres, particulate matter, smoke and ash. The quantity of heat released and the rate of heat release are also important. Potential environmental damage may be assessable by consideration of the impact of such effluents on specific environmental areas. Combustion effluents that are released into atmospheric, terrestrial or aquatic environments may be absorbed and accumulate, with the potential to cause longer-term pathological effects in people, animals and plants. Physical and chemical fire effluents which are known to provoke serious adverse impact are subject to regulatory control in the form of legislation governing health and environmental protection.

B.6 Life-cycle considerations

The total life-cycle of plastics materials and products should be assessed wherever possible so that the adverse environmental impact can be minimized. This assessment should include the fire risks involved in the production, storage, distribution, end-use and waste-disposal phases of the life-cycles of such materials and products.

Bibliography

General

[1] ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

[2] ISO/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement*

[3] IEC 60695-4, *Fire hazard testing — Part 4: Terminology concerning fire tests for electrotechnical products*

[4] British Standard BS 7982, *Guidance on the environmental impact of large-scale fires involving plastics materials*

Fire tests for plastics and related products

[5] ISO 871, *Plastics — Determination of ignition temperature using a hot-air furnace*

[6] ISO 3582, *Flexible cellular polymeric materials — Laboratory assessment of horizontal burning characteristics of small specimens subjected to a small flame*

[7] ISO 4589-1, *Plastics — Determination of burning behaviour by oxygen index — Part 1: Guidance*

[8] ISO 4589-2, *Plastics — Determination of burning behaviour by oxygen index — Part 2: Ambient-temperature test*

[9] ISO 4589-3, *Plastics — Determination of burning behaviour by oxygen index — Part 3: Elevated-temperature test*

[10] ISO 6940, *Textile fabrics — Burning behaviour — Determination of ease of ignition of vertically oriented specimens*

[11] ISO 6941, *Textile fabrics — Burning behaviour — Measurement of flame spread properties of vertically oriented specimens*

[12] ISO 9772, *Cellular plastics — Determination of horizontal burning characteristics of small specimens subjected to a small flame*

[13] ISO 9773, *Plastics — Determination of burning behaviour of thin flexible vertical specimens in contact with a small-flame ignition source*

[14] ISO 10093, *Plastics — Fire tests — Standard ignition sources*

[15] ISO 12992, *Plastics — Vertical flame spread determination for film and sheet*

[16] ISO 13927, *Plastics — Simple heat release test using a conical radiant heater and a thermopile detector*

[17] ISO 14934 (all parts), *Fire tests — Calibration and use of heat flux meters*

[18] IEC 60695-11-10 (supersedes ISO 1210), *Fire hazard testing — Part 11-10: Test flames — 50 W horizontal and vertical flame test methods*

[19] IEC 60695-11-20 (supersedes ISO 10351), *Fire hazard testing — Part 11-20: Test flames — 500 W flame test methods*

Fire tests for construction products

[20] ISO 834-1, *Fire-resistance tests — Elements of building construction — Part 1: General requirements*

[21] ISO/TR 834-3, *Fire-resistance tests — Elements of building construction — Part 3: Commentary on test method and test data application*

[22] ISO 1182, *Reaction to fire tests for building products — Non-combustibility test*

[23] ISO 1716, *Reaction to fire tests for building products — Determination of the heat of combustion*

[24] ISO 3008, *Fire-resistance tests — Door and shutter assemblies*

[25] ISO 5657, *Reaction to fire tests — Ignitability of building products using a radiant heat source*

[26] ISO/TS 5658-1, *Reaction to fire tests — Spread of flame — Part 1: Guidance on flame spread*

[27] ISO 5658-2, *Reaction to fire tests — Spread of flame — Part 2: Lateral spread on building and transport products in vertical configuration*

[28] ISO 9239-1, *Reaction to fire tests for floorings — Part 1: Determination of the burning behaviour using a radiant heat source*

[29] ISO 9705, *Fire tests — Full-scale room test for surface products*

[30] ISO/TR 11925-1, *Reaction to fire tests — Ignitability of building products subjected to direct impingement of flame — Part 1: Guidance on ignitability*

[31] ISO 11925-2, *Reaction to fire tests — Ignitability of building products subjected to direct impingement of flame — Part 2: Single-flame source test*

[32] ISO 11925-3, *Reaction to fire tests — Ignitability of building products subjected to direct impingement of flame — Part 3: Multi-source test*

[33] ISO 14696, *Reaction-to-fire tests — Determination of fire and thermal parameters of materials, products and assemblies using an intermediate-scale calorimeter (ICAL)*

Fire tests for furniture

[34] ISO 12952-1, *Textiles — Burning behaviour of bedding items — Part 1: General test methods for the ignitability by a smouldering cigarette*

[35] ISO 12952-2, *Textiles — Burning behaviour of bedding items — Part 2: Specific test methods for the ignitability by a smouldering cigarette*

[36] ISO 12952-3, *Textiles — Burning behaviour of bedding items — Part 3: General test methods for the ignitability by a small open flame*

[37] ISO 12952-4, *Textiles — Burning behaviour of bedding items — Part 4: Specific test methods for the ignitability by a small open flame*

Fire tests for electrical wire and cable

[38] IEC 60332-1-2, *Tests on electric and optical fibre cables under fire conditions — Part 1-2: Test for vertical flame propagation for a single insulated wire or cable — Procedure for 1 kW pre-mixed flame*

[39] IEC 60332-2-2, *Tests on electric and optical fibre cables under fire conditions — Part 2-2: Test for vertical flame propagation for a single small insulated wire or cable — Procedure for diffusion flame*

[40] IEC 60332-3 (all sections), *Tests on electric cables under fire conditions — Part 3: Test for vertical flame spread of vertically-mounted bunched wires or cables*

[41] IEC 61034-2, *Measurement of smoke density of cables burning under defined conditions — Part 2: Test procedure and requirements*

Fire tests used in other application sectors

[42] ISO 340, *Conveyor belts — Laboratory scale flammability characteristics — Requirements and test method*

[43] ISO 7176-16, *Wheelchairs — Part 16: Resistance to ignition of upholstered parts — Requirements and test methods*

[44] ISO 8030, *Rubber and plastics hoses — Method of test for flammability*

[45] ISO 8124-2, *Safety of toys — Part 2: Flammability*

[46] ISO 13774, *Rubber and plastics hoses for fuels for internal-combustion engines — Methods of test for flammability*

[47] ISO 15025, *Protective clothing — Protection against heat and flame — Method of test for limited flame spread*

[48] ISO 15027-3, *Immersion suits — Part 3: Test methods*

[49] ISO 18906, *Imaging materials — Photographic films — Specifications for safety film*

Environmental aspects

The following categorized list contains International Standards and other ISO publications that may be applicable in assessments of aspects of the environmental impact of physical and chemical effluents generated in fires involving plastics.

a) Fire safety engineering

[50] ISO/TR 13387-4, *Fire safety engineering — Part 4: Initiation and development of fire and generation of fire effluents*

[51] ISO/TR 13387-5, *Fire safety engineering — Part 5: Movement of fire effluents*

b) Effluent heat, smoke and gases

[52] ISO 5659-1, *Plastics — Smoke generation — Part 1: Guidance on optical-density testing*

[53] ISO 5659-2, *Plastics — Smoke generation — Part 2: Determination of optical density by a single-chamber test*

[54] ISO/TR 5659-3, *Plastics — Smoke generation — Part 3: Determination of optical density by a dynamic-flow method*

[55] ISO 5660-1:2002, *Reaction-to-fire tests — Heat release, smoke production and mass loss rate — Part 1: Heat release rate (cone calorimeter method)*

[56] ISO 5660-2, *Reaction-to-fire tests — Heat release, smoke production and mass loss rate — Part 2: Smoke production rate (dynamic measurement)*

[57] ISO/TR 5660-3, *Reaction-to-fire tests — Heat release, smoke production and mass loss rate — Part 3: Guidance on measurement*

[58] ISO 5660-4, *Reaction-to-fire tests — Heat release, smoke production and mass loss rate — Part 4: Measurement of heat release for determination of low levels of combustibility*

[59] ISO/TR 5924, *Fire tests — Reaction to fire — Smoke generated by building products (dual-chamber test)*

[60] ISO 16312-1, *Guidance for assessing the validity of physical fire models for obtaining fire effluent toxicity data for fire hazard and risk assessment — Part 1: Criteria*

[61] ISO/TR 16312-2, *Guidance for assessing the validity of physical fire models for obtaining fire effluent toxicity data for fire hazard and risk assessment — Part 2: Evaluation of individual physical fire models*

[62] ISO/TS 19700, *Controlled equivalence ratio method for the determination of hazardous components of fire effluents*

[63] ISO 21367, *Plastics — Reaction to fire — Test method for flame spread and combustion product release from vertically oriented specimens*

[64] ISO 24473, *Fire tests — Open calorimetry — Measurement of the rate of production of heat and combustion products for fires of up to 40 MW*

[65] IEC/TS 60695-7-50, *Fire hazard testing — Part 7-50: Toxicity of fire effluent — Estimation of toxic potency — Apparatus and test method*

[66] ASTM E 662, *Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials*

c) Effluent corrosivity

[67] ISO 11845, *Corrosion of metals and alloys — General principles for corrosion testing*

[68] ISO 10062, *Corrosion tests in artificial atmosphere at very low concentrations of polluting gas(es)*

[69] ISO 9223, *Corrosion of metals and alloys — Corrosivity of atmospheres — Classification*

[70] ISO 9224, *Corrosion of metals and alloys — Corrosivity of atmospheres — Guiding values for the corrosivity categories*

[71] ISO 9225, *Corrosion of metals and alloys — Corrosivity of atmospheres — Measurement of pollution*

[72] ISO 9226, *Corrosion of metals and alloys — Corrosivity of atmospheres — Determination of corrosion rate of standard specimens for the evaluation of corrosivity*

[73] ISO 11907-1, *Plastics — Smoke generation — Determination of the corrosivity of fire effluents — Part 1: Guidance*

[74] ISO 11907-2, *Plastics — Smoke generation — Determination of the corrosivity of fire effluents — Part 2: Static method*

[75] ISO 11907-3, *Plastics — Smoke generation — Determination of the corrosivity of fire effluents — Part 3: Dynamic decomposition method using a travelling furnace*

[76] ISO 11907-4, *Plastics — Smoke generation — Determination of the corrosivity of fire effluents — Part 4: Dynamic decomposition method using a conical radiant heater*

[77] IEC 60695-5-1, *Fire hazard testing — Part: 5-1: Corrosion damage effects of fire effluent — General guidance*

[78] IEC/TS 60695-5-2, *Fire hazard testing — Part 5-2: Corrosion damage effects of fire effluent — Summary and relevance of test methods*

[79] IEC/TS 60695-5-3, *Fire hazard testing — Part: 5-3: Corrosion damage effects of fire effluent — Leakage-current and metal-loss test method*

[80] GANDHI, P.D., Modeling Gas Collection Systems for Corrosion Testing, *Fire Safety Journal* (UK), Vol. 21, No. 1, pp. 47-68, 1993

[81] HIRSCHLER, M.M., Smoke corrosivity test methods — Analysis of existing tests and of their results, *Fire and Materials*, Vol. 17, pp. 231-247, 1993

[82] BOTTIN, M.F., The ISO Static Test Method for Measuring Smoke Corrosivity, *Journal of Fire Sciences* (USA), Vol. 10, No. 2, pp. 160-168, Mar.-Apr. 1992

ICS 13.220.40; 83.080.01
Price based on 29 pages