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Plastics — Guidance for the use of standard fire tests

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

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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 In 2003, the first edition of ISO 10840 was published, based on the now withdrawn ISO Technical Report ISO/TR 10840:1993, *Plastics — Burning behaviour — Guidance for development and use of fire tests*, which listed a series of potential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.

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

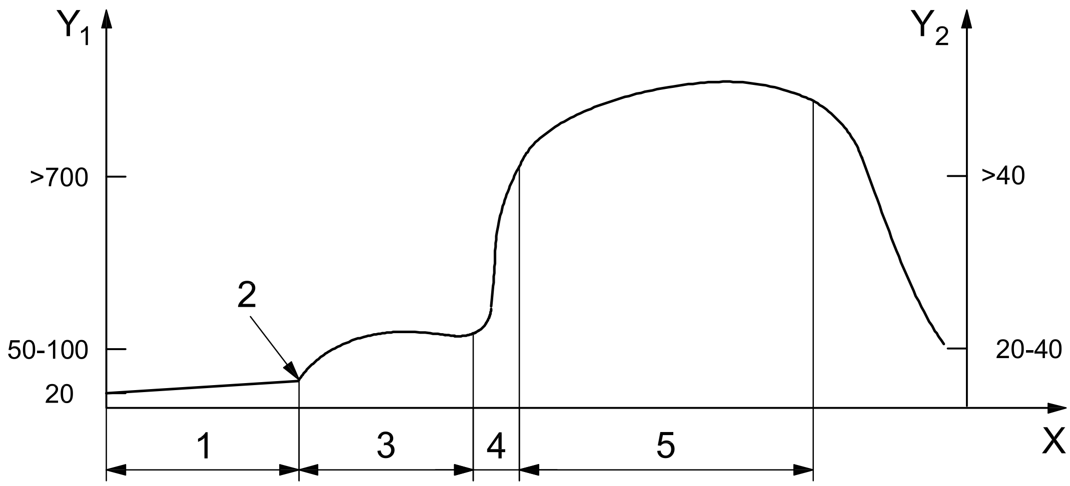
3.9
uncertainty of measurement
parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand

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;

