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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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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
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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 first edition of ISO 10840 cancels and replaces ISO/TR 10840:1993, 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 “traditional” or “older-generation” materials are often very different from those of synthetic materials, especially thermoplastics.

ISO/TC 61/SC 4 has, for a number of years, recognized the need for guidance for users of fire-test standards commonly applied to materials and products made of, or incorporating, plastics. During 1997, it decided to develop a guidance document in the form of an International Standard using ISO/TR 10840, and particularly its Annex A, as the basis.

Annex A of ISO/TR 10840:1993 listed a series of potential problems associated with the reaction-to-fire testing of plastics materials and products. However, it provided users of the test methods with no practical assistance on how to cope with the difficulties listed.

Plastics — Guidance for the use of standard fire tests

1 Scope

This International Standard covers the following aspects of fire testing:

- selection of appropriate test(s);
- listing of reaction-to-fire characteristics which the test(s) can measure;
- assessment of the test(s) for their suitability for material characterization, quality control, pre-selection and/or end-product testing;
- problems that can arise when plastics specimens are tested in standard fire tests.

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 standard fire tests; these cover factors such as cost, test duration, complexity, required operator skills, quality of the data produced, relevance to fire hazard assessment as well as test repeatability and reproducibility. Preparation of this International Standard has involved a review and assessment 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 in this International Standard is on reaction-to-fire testing. Fire-resistance testing has also been considered, however, in order 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.

The scope of this International Standard does not include the development or design of fire tests for plastics.

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 13943, *Fire Safety — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13943 and the following 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 material or semi-finished product

3.3
plastics end-product test
test made on a complete product, piece, part, component or sub-assembly

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

4 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 in the development of a fire within an enclosed space. These are assessed using measurements of temperature and time as shown in Figure 1.

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 enclosed space with smoke and toxic gases.

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

- fire growth on the item first 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.

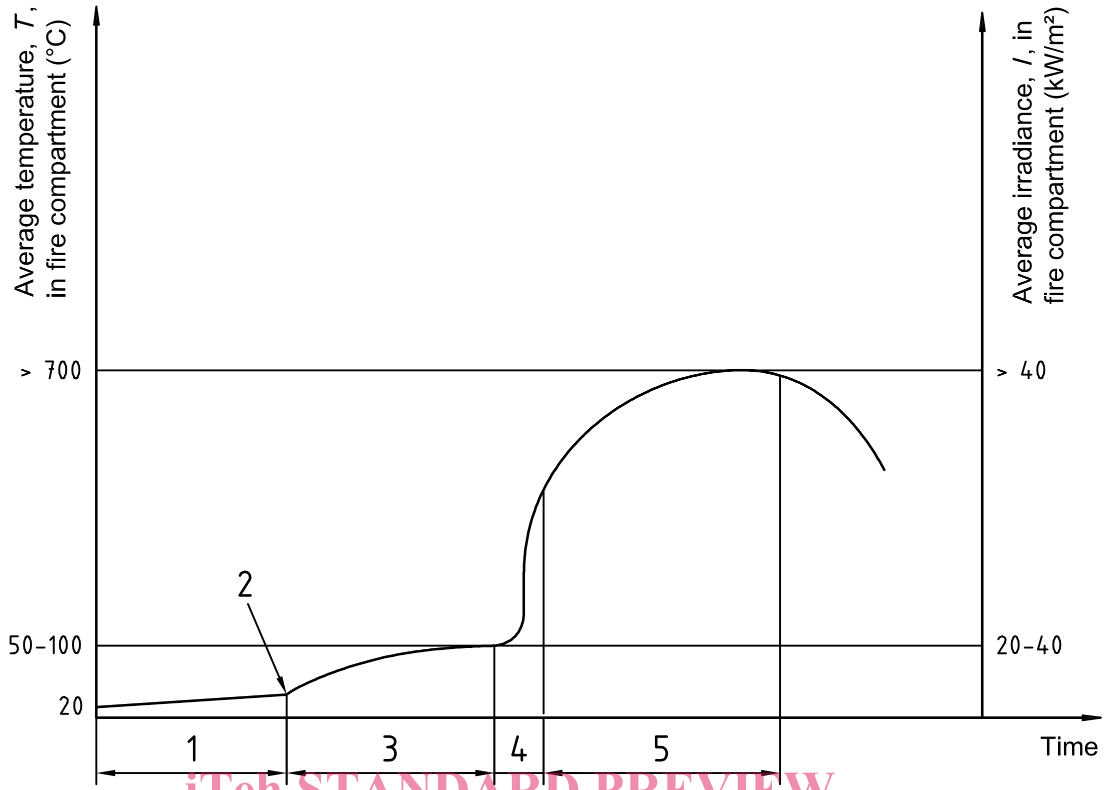
The radiant heat transfer to combustible items accelerates the thermal decomposition of material below the smoke layer, and the rate of fire spread increases.

Flashover is the sudden transition from a localized fire to the ignition of the gas layer and subsequently of all exposed flammable surfaces, and will lead to a fully developed fire. Flashover is uncommon in large enclosed spaces, as the temperature conditions required are not often reached.

Flashover usually occurs at temperatures around 600 °C; thereafter, the rate of heat release increases rapidly to reach a maximum value.

4.4 Fully developed fire

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



Key

1 time to ignition

2 $T > 100$ °C, $I > 25$ kW/m^2 close to ignited item

3 developing fire

4 flashover

5 fully developed fire

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

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 heat, smoke and toxic-effluent release)
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 carried out on behalf of customers who will undertake no further reaction-to-fire testing on the material, or on products manufactured from the material

This type of testing imposes an obligation on the material supplier to assess those 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 carried out on behalf of a customer who seeks compliance with reaction-to-fire test(s) on the finished product

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

5.2 Quality-control tests

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

a) decide which characteristics should be checked by the test;

b) select or develop the appropriate test method;

c) specify the required performance criteria;

d) compare test results to ensure that the parameter measured by the quality-control test is correlatable with the key performance parameter being investigated.

It is necessary to specify:

a) the characteristics which have to be checked by the test;

b) the appropriate test procedure;

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

and then to compare the test results with the specified 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 requires careful consideration to ensure their relevance in relation 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 tested as a finished product or component. This will be valid provided that no overriding, interactive, product-specific effects are present.

b) Data concerning relevant combustion characteristics can aid in 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 test 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 for 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 is suitable. In this case, an end-product test may be needed.

5.4 End-product tests

These tests should reflect the end-use scenario as far as is possible. Important factors to consider include the relevance of configuration, orientation and 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 Possible influence of the chemical or physical nature of the specimen on the execution of the tests

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.

