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Plastics — Development and use of intermediate-scale fire tests for plastics products —

Part 2: Use of intermediate-scale tests for semi-finished and finished products

Plastiques — Développement et utilisation des essais au feu à une échelle intermédiaire pour les produits plastiques —

Partie 2: Utilisation des essais à une échelle intermédiaire pour les produits semi-finis et les produits finis

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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

A list of all parts in the ISO 15791 series can be found on the ISO website.

Introduction

The major benefit in intermediate-scale testing is the ability to reflect more accurately the fire conditions of real fires than small-scale tests. For example:

— *Specimen mounting*. Specimens can incorporate end-use fixings, joints and air-gaps (see Annex A) in the larger test apparatus. In addition, thick and/or profiled products may be accommodated. This capability is valuable for testing thick multilayer composites (such as sandwich structures). It is also useful for testing profiled product such as pipes, pipe insulations, cable trays, GRP frames and similar products.

— *Test specimen size and orientation*. Intermediate-scale tests allow to evaluate fire growth. The ability to measure flame spread beyond the impingement zone of the ignition source is a desirable feature.

— *Observation of actual phenomena of products (especially thermoplastics) exposed to ignition sources*. Representative behaviour may be observed with intermediate-scale test specimens.

The test results may be useful to the manufacturers of the products and regulation authorities[9].

However, intermediate-scale tests may have the following disadvantages because of their large scale.

— Intermediate-scale tests may develop an increased amount of fire effluent.

— Intermediate-scale tests may require higher cost.

— An intermediate-scale test may limit the fire scenario and cannot realize a wide range of fire behaviours.

An intermediate-scale test can be used as a screening test for large-scale tests for the purpose of research and product development.

In addition to the usage mentioned above, this document has been prepared for manufacturers of semi-finished plastics products. These semi-finished products may be tested for production control or developmental reasons. They cannot always be tested in the end-use conditions (such as mounting and fixing) that are appropriate for finished products.

This document is intended to support the information that product manufacturers may require as part of a quality assurance scheme. In addition, it should be recognized that this document is not intended to replace finished product technical specifications for products containing a semi-finished plastics component.

The information given in this document is in accordance with the principles recommended in ISO 10840 that was established to develop a general policy and philosophy for the development and use of fire tests for plastics.

Plastics — Development and use of intermediate-scale fire tests for plastics products —

Part 2:
Use of intermediate-scale tests for semi-finished and finished products

1 Scope

This document provides guidelines and specifies requirements for the development and use of intermediate-scale fire tests applicable to semi-finished and finished products made of, or containing, plastics.

This document covers typical applications of such tests, as well as methods of preparation and mounting of test specimens.

This document applies to planar, linear or profiled plastics products. These products can be tested in horizontal or vertical orientation.

This document defines the parameters to be measured, the way that test results are expected to be reported and explains how they can be used for direct product assessment or as input data for scaling studies.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 834-12, *Fire resistance tests — Elements of building construction — Part 12: Specific requirements for separating elements evaluated on less than full scale furnaces*

ISO 5658-2:2006, *Reaction to fire tests — Spread of flame — Part 2: Lateral spread on building and transport products in vertical configuration*

ISO 10840, *Plastics — Guidance for the use of standard fire tests*

ISO 13943, *Fire safety — Vocabulary*

ISO 14697, *Reaction-to-fire tests — Guidance on the choice of substrates for building and transport products*

ISO 25762, *Plastics — Guidance on the assessment of the fire characteristics and fire performance of fibre-reinforced polymer composites*

ISO 30021, *Plastics — Burning behaviour — Intermediate-scale fire-resistance testing of fibre-reinforced polymer composites*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 10840 and ISO 13943 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
end-use application
real application of a product including method of installation

3.2
finished product
manufactured article ready for end-use

3.3
intermediate-scale fire test
fire test performed on a test specimen of smaller dimensions than the final end-use product/system

3.4
pre-selection test
test which provides data for the process of assessing and choosing candidate materials, components or subassemblies for making an end-product

3.5
product parameter
aspect of a product which may vary and which may have an influence on the product's fire performance

EXAMPLE Thickness, composition and density.

3.6
profiled product
homogenous product with a non-planar surface

3.7
sample
representative part of a manufactured product or piece of a material or semi-finished product

3.8
semi-finished product
manufactured article ready for assembly for an end-use application

3.9
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

4 Different applications of intermediate-scale fire tests

4.1 General

The intermediate-scale fire test can be used for direct product assessment when a test specimen of a finished product can be tested in end-use conditions.

Intermediate-scale tests can evaluate several parameters such as ignitability, flame spread, orientation and the mounting effects of products. These parameters may be used to indicate the behaviour of products in large-scale or full-scale fire tests.

An intermediate-scale tests may be used

— as a pre-selection test to evaluate the influence of product parameters on the fire behaviour of semi-finished products and to aid the development process, and

— to evaluate, as far as possible, end-use conditions.

The ways in which different types of tests are used are explained in the following subclauses.

4.2 Pre-selection tests on semi-finished products

An intermediate-scale test can be used as a pre-selection test

— to aid the selection of materials, components and sub-assemblies during the design stage when small-scale tests are not appropriate because of the complexity of the product, and

— to study the influence of product parameters on the fire behaviour of the products.

4.3 End-product tests

If it is possible to reproduce the end-use of a product, then the test can be used for end-product testing.

These tests should reflect the end-use application scenario as far as is possible. Important factors to consider include 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) define the relevant product-application (or misuse) scenario;

b) specify the fire hazard to be assessed (e.g. vision impairment by smoke) and the required safety criteria;

c) select the appropriate test method;

d) conduct the tests and analyse the data with respect to the defined criteria;

e) select acceptable or unacceptable for the candidate materials or products.

Intermediate-scale fire test methods permit measurement of the principal fire parameters (ignitability, spread of flame, heat release, ignited droplets and smoke).

NOTE A guide for extended application is found in EN/TS 15117[8].

Table 1 summarizes which test methods with a test specimen size of less than 1 m^2 can be used and which measurements are possible.

Table 1 — Examples of the applicability of intermediate-scale fire tests

Use/requirements	Test methods			
	ISO 9239-1 ISO 9239-2	ISO 5658-4[a]	ISO 21367	ISO 14696
Preselection test	Only for flat products	Yes	Yes	Yes
End-product test	Only for horizontal flat products	Only for vertical product Adaptation of test specimen for profiled product	Only for vertical product Adaptation of test specimen for profiled product	Only for vertical product Adaptation of test specimen for profiled product
Additional parameters	Possible presence of joints	Possible presence of joints	Possible presence of joints	Possible presence of joints
Requirements for ignitability	Yes	Yes	Yes	Yes
Requirements for spread of flame	Only lateral spread of flame	Lateral and vertical spread of flame	Lateral and vertical spread of flame	Vertical spread of flame
Requirements for ignited droplets	No	Yes	Yes	Yes
Requirements for heat release	No	No	Yes	Yes
Requirements for smoke opacity	Yes	No	Yes	Yes
Requirements for smoke toxicity	No[b]	No[b]	No[b]	No[b]

[a] The standardized size of the test specimen is 1,5 m × 1,0 m. This method could apply on a test specimen with reduced size (e.g. 1 m × 1 m).

[b] Measurement using Fourier transform infrared (FTIR) spectroscopy following the guidance of ISO 19702[5] is technically possible, but has not been standardized. Care should be taken concerning the dilution of the fire effluent and the limits of quantification.

5 Types of plastics and typical products

5.1 Generic types

All of the following types of plastics materials or products can be involved in a fire performance assessment:

— thermoplastics;

— thermosets;

— fibre-reinforced polymer composites;

— honeycomb composites-contained plastics;

— sandwich panels-contained cellular plastics.

5.2 Typical products

5.2.1 General

Some applications of plastics which present particular problems in small-scale tests for their fire performance assessment and which may require the use of intermediate-scale fire testing are described in 5.2.2 and 5.2.3.

5.2.2 Complex products ready for assembly for an end-use application

Complex products ready for assembly for an end-use application may be tested as semi-finished products. They include:

— boards/sheets with coating and joints;

— insulation materials with surface covering layers;

— composites:

  — laminates, e.g. melamine-formaldehyde-covered chipboard;

  — laminated film and sheet, e.g. weatherproofing membranes;

  — moulded foams, e.g. for packaging;

  — structural mouldings, e.g. for ships, lorries, coaches, trains, aircraft;

  — composite panels, e.g. rigid foams faced with metal sheets (especially steel or aluminium sheets) or inorganics (especially gypsum or plasterboard) for thermal insulation;

  — fibre-reinforced products.

5.2.3 Profiled products

Profiled products may be tested as finished products. They include:

— housings for electrical appliances;

— profiled sheets, e.g. roofing or panels for containers;

— profiles, e.g. conduits for electric cables, window-frames, extruded sections;

— weatherproof glazing for agricultural buildings;

— foam pipe-sections;

— pipes, e.g. rainwater drainage and discharge pipes;

— pipes for air ventilation systems in, for example, ships, trains, aircraft;

— containers for liquids, e.g. oil, kerosene;

— waste containers (for recycling materials or for rubbish).

6 Method of preparation and mounting of test specimens

6.1 General method of preparation and mounting of test specimens

6.1.1 Finished products

In tests on a finished product, the preparation and mounting of the test specimen should aim to match the end-use application as best as practicably possible.

The general principles are specified in Annex A.

6.1.2 Substrates

Products which are self-standing or not applied to any substrate in the end-use condition will not require a substrate.

The substrate required in the end-use condition is used in the test. The method of choice of the substrate is given by ISO 14697.

6.1.3 Backing boards

Backing boards are required for many tests. For the backing board, alternatives are available:

a) panels of calcium silicate board with thickness and density specified in each test standard, or

b) for products that are fixed to a substrate identical to the backing board, only one backing board behind each test specimen is required.

Non-combustible substrates and backing boards can be reused if they are not contaminated with any residue which may result in significant contribution to the rate of heat release, flame spread, smoke production or other burning behaviour and if the board is not cracked or in other ways damaged. If mechanical fixing has left holes with a diameter greater than 3 mm, the board is considered damaged and cannot be reused.

6.1.4 Joint

If the joint in end-use is covered or sealed, this should also be the case in the test.

6.1.5 Fixing of test specimens to substrates

6.1.5.1 General

Methods of fixing the test specimens to substrates specified in this document shall be used if not specified in the relevant product standard.

6.1.5.2 Mechanical fixing

The method of mechanical fixing of a test specimen to a substrate should be the same as that used in the end-use condition as far as is practicable. The following is an alternative recommended method.

Boards which are mechanically fixed to a substrate should be fixed using screws unless otherwise specified. The number of fixings should be 10 per metre. The fixings should be evenly distributed on the boards and none of them closer than 25 mm from any edges.

Insulating materials which are mechanically fixed shall be fixed using pins and washers having sufficient diameter to keep the materials in their end-use position. The number of fixings should be the same as for boards.

6.1.5.3 Glue

Products that are glued to a substrate shall be glued using the glue and the procedure specified by the sponsor. If product manufacturers have not specified a glue, the following specification is recommended:

Silica (as SiO_2)	(30 ± 2) %
Total alkali (as Na_2O)	(10 ± 1) %
Water	(60 ± 3) %
Weight ratio SiO_2/Na_2O	3,1 to 3,4/1
Viscosity at 20 °C	0,65 Pa·s to 1,20 Pa·s

Gluing shall be done according to the end-use conditions. Thus, in some cases, the glue has to be applied only as dots and not for the whole area.

6.1.6 Air gap between test specimen and backing board

For some products, an air gap between the test specimen and the backing board is required. If the product is self-supporting, the air gap is made using distance holders at the top and bottom of the test specimen. Additional distance holders may be required if the test specimen could deform during the test. If the product is not self-supporting, it should be mounted according to end-use conditions on request by the supplier.

6.2 Preparation and mounting method for specific types of products

6.2.1 Boards/sheets

6.2.1.1 General

The test methods which are listed in Table 1 can be used to test these products as pre-selection tests or end-use tests if the test specimen is prepared or mounted as the following.

6.2.1.2 Free-standing boards with an air gap

Free-standing boards shall be fixed to a frame using appropriate fixings. If the product maintains its stability during the test and is not fixed in its end-use condition, it may be tested without the frame and the fixings.

Multi-layered products with an air gap (e.g. polycarbonate) shall be tested with vertical channels. The openings at the edges shall be closed according to the instructions of the manufacturer.

6.2.2 Surface coatings

If, in practice, the products are equipped with surface coatings in the manufacturing procedure, they are to be tested together with the surface coating. However, plastic foils for transport protection shall be removed before conditioning.

If the surfaces of the products are coated/painted only after leaving the factory, representative coatings/paints shall be applied using the end-use amount/thickness. The representative coating/paint shall be as similar as practicable to the end-use material. In tests on building boards, a dispersion based paint can be used to simulate other wall paints.

A surface coating applied in the manufacturing process and appearing in end-use shall be a part of the product tested.

A surface coating attached to a product at the construction site shall be treated and evaluated as an independent surface coating product but shall be tested with the substrate (whether it is non-combustible or combustible) to which the coating is applied.

6.2.3 Joints and sealing materials for joints and other arrangements

In order to evaluate the fire performance of joints, a joint used in the end-use application of the product shall be included in the test specimen. In order to simulate joints between massive mineral elements (e.g. concrete, masonry), angles of calcium silicate boards (see 6.1.3) shall be used as supporting construction.

Joints shall be built up in the test specimen according to the specification provided by the manufacturer.

6.2.4 Insulation materials

6.2.4.1 Rigid foams

The method of applying rigid foam insulation shall be in accordance with the relevant product standard.

The product shall be fixed to the substrate of calcium silicate boards or fibre cement boards according to 6.1.5.

6.2.4.2 Insulating materials with a surface covering layer

Insulating materials with a surface covering layer shall be tested with minimum and maximum thickness of the insulation specified in the product specification. The method of applying the insulation shall be in accordance with the specification of the product.

For mineral wool products, only the maximum thickness needs to be tested. Joints shall be constructed as in practice.

6.2.4.3 Vapour barriers for roofs

Vapour barriers for roofs, which in practice are used in connection with mineral wool insulation, shall be tested in contact with, but without physical fixing to, the mineral insulation used in the end-use product, if known. If the insulation used in the end-product is not known, the one described in ISO 14697 shall be used.

Vapour barriers for roofs, which in practice are used without insulation, shall be tested with an air gap of 25 mm from the backing board.

6.2.5 Composites

Guidance for tests on composites is given in ISO 25762. Fire resistance test methods for polymer composites are specified in ISO 834-12 and ISO 30021.

Some fibre-reinforced composites have gel-coats on their surfaces. The gel-coat may be similar to the unreinforced resin. But in many cases, a different resin or a modified resin is used.

Composites often have a sandwich construction, combining monolithic or fibre reinforced polymer skins with thermoset plastic foams, balsa wood or honeycomb core material. The fire laboratory performing a test should record composition and assembly details of the test specimen. These details may include type of joint and other fixings, air-gap, edge covering, skin or facing, metal inserts or reinforcement. In the case of fibre reinforced composites, additional parameters, such as the nature of the fibres, the number of layers, weaving structure influence and fire behaviour, shall be recorded.

Many tests are designed for use with substantially flat test specimens. Hence, the test specimen holders and ignition sources may not be suitable for profiled plastic products. When necessary, special test specimen mounting arrangements may be used and shall be carefully described in the test report. Whenever possible, the mounting of the test specimens should be representative of end-use conditions of the profiled product.

For example, for plastic pipes, there are two ways to prepare the test specimen according to the test methods.

— The test specimen is fabricated by cutting pipes lengthwise into individual sections and then assembling the sections into a test specimen that is as representative as possible of a flat surface. A procedure is described in ISO 5658-2:2006, Annex F. The test specimen represents a semi-finished product.

— The pipe can be fixed with steels brackets in front of the backing board. In this case, the test specimen represents an end-use finished product.

6.2.6 Pipe and pipe insulation

The procedures described in 6.2.5 for composites pipes are applied to all pipes in order to prepare and mount the test specimens.

NOTE A small room fire test for pipe insulation is described in ISO 20632[6].

6.2.7 Roof lights and light diffusers

In the testing of roof lights and light diffusers, free-standing plastic sheet shall be fixed to a frame using appropriate fixings. If the product maintains its stability during the test and is not fixed in its end-use condition, it may be tested without the frame and the fixings.

Multi-layered products with air channels (e.g. polycarbonate) shall be tested with vertical channels. The openings at the edges shall be closed according to the instructions of the manufacturer.

6.2.8 Curtain walling

When testing curtain walling, two orientations should be distinguished.

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

— The positioning of a directional effect in (the surface of) the product in horizontal or vertical (or principally 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.

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.

The method of choice of the substrate is given by ISO 14697.

7 Matters relevant for semi-finished or finished plastic products

7.1 Sample conditioning and test specimen preparation

Conditioning and preparation of samples and test specimens are of extreme importance. Specimen preparation includes selection and sampling. Conditioning is important because variations in moisture content of a test specimen will affect test results.

It is also important to remove moulding flash and other similar adventitious residue from surfaces and edges of test specimens.

The initial temperature of the test 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 in order to minimize and, if possible, eliminate any test 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 test specimen and, consequently, its response to application of heat from the fire-test ignition source.

7.2 Practical advice on operating procedures in the event of test specimen collapse or deformation on exposure to heat from standard ignition sources

Problems arise in the fire testing of many plastics because of common thermo-mechanical effects such as test specimen slumping and sagging as well as edge-effects such as the curling of the thin test 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) because of changes in the source-to-test specimen distance. Examples of other problem areas concern interpretation of observed non-ignition of the test 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, wires and masking of test specimen edges.

Such behaviour of the test 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 test specimen responses in fire tests on plastics may give rise to localized withdrawal of the test specimen from contact with the ignition source as a result of accelerated stress-relaxation within the test 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 test 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, effects of gravity may result in sagging or slumping of the test specimen; these effects may aggravate or attenuate test specimen deformation caused by internal thermo-mechanical stress-relaxation processes.

7.3 Problem–solving approaches to complications caused by melting effects in thermoplastics

Melting effects can include flaming and non-flaming drip formation, adhesion of the test specimen to an ignition source, 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 condition to the end-use, the test report shall state that the test could not be carried out as specified, and an alternative test procedure should be selected.

7.4 Intumescence

Intumescence occurs with some plastics when exposed to the heat source in fire tests.

Some formulations exhibit excessive swelling near the heat source or on the pilot igniters in these tests; where this behaviour is expected, laboratories may increase the separation of the test specimen surface to the heat source. 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 Slumping of the thermoplastic sheets

When vertically oriented thermoplastic sheets are exposed to radiant heat in tests, the test specimens soften and often slump towards the source of radiant heat. While this effect is realistic for certain fire conditions, the slumping behaviour may inhibit fire development (especially flame spread) and laboratories in conjunction with manufacturers shall decide whether it is realistic to introduce constraining devices (such as wires, nails or metal bands).

7.6 Flaming debris

The confirmation of a discontinuous flame spread hazard created by flaming debris (drips and solid elements), as described in 7.3, is usually done by using a detector below the test specimen. This is preferred to the simple subjective reporting of an observation of flaming debris. 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).

7.7 Profiled products

When tests of profiled plastic products are required, the test specimen holders and ignition sources may not be suitable. When necessary, special test specimen mounting arrangements may be used but their use shall be carefully described in the test report. Whenever possible, the mounting of the test specimens should be representative of end-use conditions of the profiled product.