มาตรฐานผลิตภัณฑ์อุตสาหกรรม

THAI INDUSTRIAL STANDARD

มอก. 2249 – 2548

ISO 10840 : 2003

พลาสติก – ข้อแนะนำการใช้ประโยชน์ จากการทดสอบไฟมาตรฐาน

PLASTICS – GUIDANCE FOR THE USE OF STANDARD FIRE TESTS

สำนักงานมาตรฐานผลิตภัณฑ์อุตสาหกรรม

กระทรวงอุตสาหกรรม

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สำนักงานมาตรฐานผลิตภัณฑ์อุตสาหกรรม
กระทรวงอุตสาหกรรม ถนนพระรามที่ 6 กรุงเทพฯ 10400
โทรศัพท์ 0 2202 3300

ประกาศในราชกิจจานุเบกษา ฉบับประกาศและงานทั่วไป เล่ม 122 ตอนที่ 121ง
วันที่ 22 ธันวาคม พุทธศักราช 2548

เพื่อให้ข้อแนะนำการใช้ประโยชน์จากการทดสอบไฟมาตรฐานสำหรับพลาสติกของหน่วยทดสอบ ผู้ทำ และผู้ที่เกี่ยวข้องเป็นมาตรฐานเดียวกัน จึงกำหนดมาตรฐานผลิตภัณฑ์อุตสาหกรรม พลาสติก – ข้อแนะนำการใช้ประโยชน์จากการทดสอบไฟมาตรฐาน ขึ้น

มาตรฐานผลิตภัณฑ์อุตสาหกรรมนี้กำหนดขึ้นโดยรับ ISO 10840 : 2003 Plastics – Guidance for the use of standard fire tests มาใช้ในระดับเหมือนกันทุกประการ (identical) โดยใช้ ISO ฉบับภาษาอังกฤษเป็นหลัก

มาตรฐานผลิตภัณฑ์อุตสาหกรรมนี้กำหนดขึ้นเพื่อให้ทันกับความต้องการของผู้ใช้ และจักได้แปลเป็นภาษาไทยในโอกาสอันสมควร หากมีข้อสงสัยโปรดติดต่อสอบถามที่สำนักงานมาตรฐานผลิตภัณฑ์อุตสาหกรรม

คณะกรรมการมาตรฐานผลิตภัณฑ์อุตสาหกรรมได้พิจารณามาตรฐานนี้แล้ว เห็นสมควรเสนอรัฐมนตรีประกาศตามมาตรา 15 แห่งพระราชบัญญัติมาตรฐานผลิตภัณฑ์อุตสาหกรรม พ.ศ. 2511

ประกาศกระทรวงอุตสาหกรรม

ฉบับที่ 3418 (พ.ศ. 2548)

ออกตามความในพระราชบัญญัติมาตรฐานผลิตภัณฑ์อุตสาหกรรม

พ.ศ. 2511

เรื่อง กำหนดมาตรฐานผลิตภัณฑ์อุตสาหกรรม

พลาสติก – ข้อแนะนำการใช้ประโยชน์จากการทดสอบไฟมาตรฐาน

อาศัยอำนาจตามความในมาตรา 15 แห่งพระราชบัญญัติมาตรฐานผลิตภัณฑ์อุตสาหกรรม พ.ศ. 2511 รัฐมนตรีว่าการกระทรวงอุตสาหกรรมออกประกาศกำหนดมาตรฐานผลิตภัณฑ์อุตสาหกรรม พลาสติก – ข้อแนะนำการใช้ประโยชน์จากการทดสอบไฟมาตรฐาน มาตรฐานเลขที่ มอก. 2249-2548 ไว้ ดังมีรายการละเอียดต่อท้ายประกาศนี้

ประกาศ ณ วันที่ 31 สิงหาคม พ.ศ. 2548

นายสุริยะ จึงรุ่งเรืองกิจ

รัฐมนตรีว่าการกระทรวงอุตสาหกรรม

มาตรฐานผลิตภัณฑ์อุตสาหกรรม

พลาสติก – ข้อแนะนำการใช้ประโยชน์จากการทดสอบไฟมาตรฐาน

บทนำ

มาตรฐานผลิตภัณฑ์อุตสาหกรรมนี้กำหนดขึ้นโดยรับ ISO 10840 : 2002 Plastics – Guidance for the use of standard fire tests มาใช้ในระดับเหมือนกันทุกประการ (identical) โดยใช้ ISO ฉบับภาษาอังกฤษเป็นหลัก

ขอบข่าย

เป็นข้อแนะนำเกี่ยวกับวิธีทดสอบคุณลักษณะของไฟ โดยมีจุดมุ่งหมายดังนี้

- เพื่อให้ได้วิธีทดสอบที่เหมาะสม
- เพื่อบันทึกลักษณะต่าง ๆ ของปฏิกิริยาที่เกิดไฟซึ่งสามารถวัดได้
- เพื่อประเมินวิธีทดสอบที่เหมาะสมสำหรับลักษณะของวัสดุที่ใช้ทดสอบ การควบคุมคุณภาพ การเลือกทดสอบผลิตภัณฑ์ตั้งแต่ขั้นตอนการเตรียมก่อนทดสอบจนถึงทดสอบแล้วเสร็จ
- เพื่อให้ทราบปัญหาที่เกิดขึ้นจากการทดสอบชิ้นตัวอย่างตามมาตรฐานนี้

ข้อแนะนำนี้ประสงค์ให้ผู้ทดสอบที่ยังไม่มีประสบการณ์ในการประเมินประสิทธิภาพของวัสดุหรือผลิตภัณฑ์พลาสติกสามารถนำไปปฏิบัติได้และทำให้ได้ข้อมูลที่เกี่ยวข้องกับการทดสอบไฟ เช่น ราคา ช่วงเวลาของการทดสอบ ความซับซ้อน ความชำนาญในการทดสอบ คุณภาพของผลทดสอบ การประเมินอันตรายที่อาจได้รับ และการทวนซ้ำได้และความทำซ้ำได้ มาตรฐานนี้ได้รับการทบทวนและประเมินเป็นประจำ โดย ISO/TC 61/SC4

มาตรฐานนี้นอกจากมีรายละเอียดเกี่ยวกับการทดสอบปฏิกิริยาการเกิดไฟแล้ว ยังมีวิธีทดสอบการต้านไฟอีกด้วย โดยมีแนวโน้มว่าวิธีทดสอบการต้านทานไฟจะเป็นที่นิยมมากขึ้นสำหรับทดสอบเสถียรภาพการเปลี่ยนทางกลของพลาสติก

มาตรฐานนี้ไม่ครอบคลุมการพัฒนาหรือการออกแบบการทดสอบพลาสติก

เอกสารอ้างอิง

ISO 13943, Fire Safety – Vocabulary

บทนิยาม

ความหมายของคำที่ใช้ในมาตรฐานผลิตภัณฑ์อุตสาหกรรมนี้ให้เป็นไปตามที่ระบุไว้ใน ISO 10840 : 2003 ข้อ 3

ภาพรวมพฤติกรรมไฟ

ภาพรวมพฤติกรรมไฟในมาตรฐานผลิตภัณฑ์อุตสาหกรรมนี้ให้เป็นไปตามที่ระบุไว้ใน ISO 10840 : 2003 ข้อ 4

รายชื่อวิธีทดสอบ

รายชื่อวิธีทดสอบในมาตรฐานผลิตภัณฑ์อุตสาหกรรมนี้ให้เป็นไปตามที่ระบุไว้ในข้อ ISO 10840 : 2003 ข้อ 5

ข้อพิจารณาที่สำคัญในการทดสอบไฟของวัสดุพลาสติกลและผลิตภัณฑ์พลาสติก

ข้อพิจารณาที่สำคัญในการทดสอบไฟของวัสดุพลาสติกลและผลิตภัณฑ์พลาสติกในมาตรฐานผลิตภัณฑ์อุตสาหกรรมนี้ให้เป็นไปตามที่ระบุไว้ใน ISO 10840 : 2003 ข้อ 6

ปัญหาที่อาจเกิดขึ้นกับพลาสติกจากการทดสอบ

ปัญหาที่อาจเกิดขึ้นกับพลาสติกจากการทดสอบในมาตรฐานผลิตภัณฑ์อุตสาหกรรมนี้ให้เป็นไปตามที่ระบุไว้ใน ISO 10840 : 2003 ข้อ 7

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.

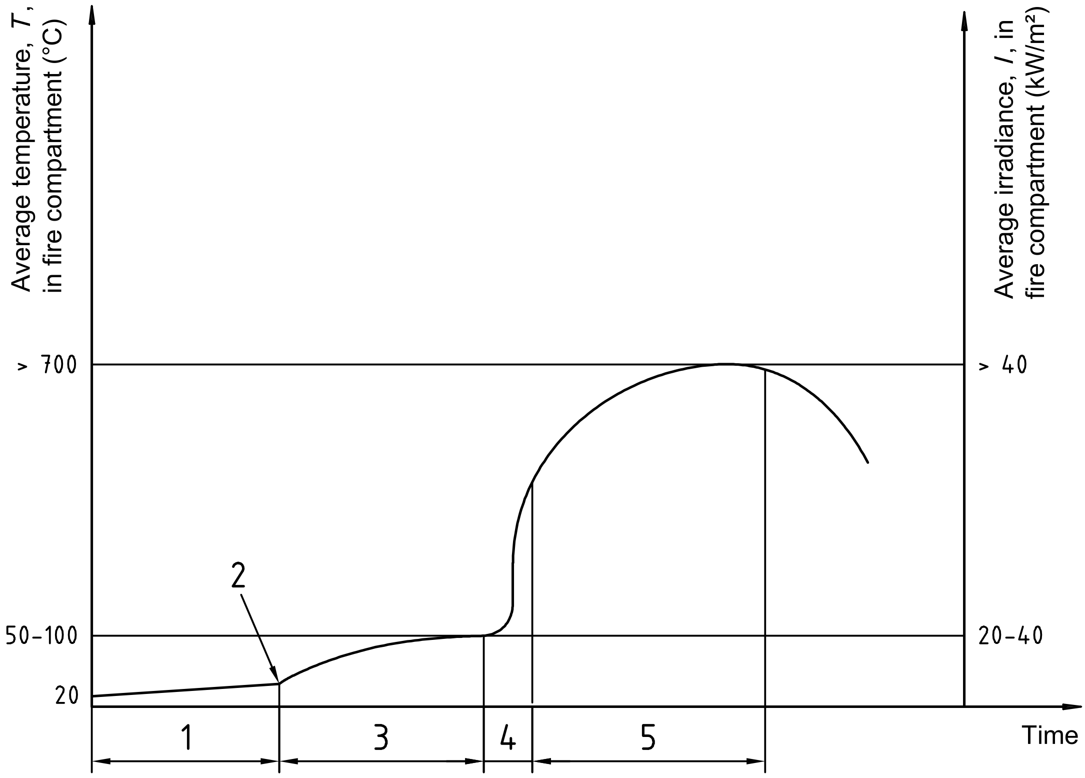
The radiant heat transfer to combustible items accelerates the thermal decomposition of material below the smoke layer, and the rate of fire spread increases.

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.

6.2 Thermal-decomposition products

6.2.1 General

When an ignition source is applied to any plastics 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 of the source 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 or corrosive decomposition products;

b) smoke and soot;

c) charred and intumesced layers.

6.3 Practical problems posed by specimen decomposition effects

The following types of effect may occur:

a) evaporation or sublimation of additives;

b) out-gassing or intumescence;

c) char-layer formation;

d) delamination;

e) spalling;

f) punking.

6.4 Health, safety and environmental considerations relevant to fire-test operation and post-test clean-up procedures

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 Considerations related to specimen geometry

It is important to define selection criteria for specimens removed from a sample such as a TV set.

Other influential factors may be:

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.

Specimen size.

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

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

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.

Specimen support, including air-gaps: Conductive air-flow between the specimen and its support system may affect the 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 the specimen's response to the ignition source.

6.6 Ignition-source characteristics that influence the test results and the interpretation of the results

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) flaming or non-flaming;

c) impingement or non-impingement of ignition source on specimen;

d) precision and quantification of measurements;

e) flame stability.

6.7 Specimen conditioning and preparation

Specimen conditioning and preparation can be of extreme importance in the fire testing of plastics materials and products. Such preparation covers selection, sampling and the cutting-out and conditioning of the specimens. Conditioning is important because variations in the moisture content of specimens 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 in order 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 Practical advice on contingency operating procedures in the event of specimen collapse or deformation on exposure to heat from the ignition source

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 the 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 ignition source) because of changes in the source-to-specimen distance. Examples of other problem areas are 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 and the masking of specimen edges.

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 effect 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 slumping of thermoplastics specimens have been resolved by ISO/TC 61/SC 4 in ISO 5659-2.

6.9 Problem-solving approaches to 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, full-scale and real-scale tests

Such tests may offer the only available realistic assessment of the gross effects of thermal deformation and gravity and the effects of fixtures and joints under end-use conditions in real fires. 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 is their relevance to end-use hazard assessment.

Their disadvantages lie in the operational hazards involved, including safety and environmental aspects, their cost and their uncertain reproducibility.

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; for example:

Specimen mounting: Due to the larger test apparatus, specimens can incorporate more readily end-use fixtures, joints and air-gaps. 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 is 0,000 3 kW·h to 0,3 kW·h compared to 1 kW·h to 10 kW·h in intermediate-scale tests (and 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 ignition-source impingement zone 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 fixtures. This also applies to joints and air-gaps, which may have a critical influence on real-life product performance.

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) they are often carried out using standard substrates for the test specimens, and 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 Implications of the test apparatus design for the applicability of the test data to the purpose intended by the test user

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 relative to the end-use scenario, and its relevance to apparatus 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 the specimen during thermal expansion can result in specimen warping or fracture. The use of restraining devices such as grids may also prevent the formation of a beneficial cohesive char layer on the specimen surface.

Thermal effects: The possible presence of 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.

6.12 Restrictions which apply when plastics are assessed using tests developed for other materials

Similar considerations may arise if tests developed for specific classes of plastics such as cellular products are used to assess other types of plastics product.

Account should be taken of behaviour such as melting, shrinking, slumping, swelling and bubbling.

6.13 Factors relating to the calibration of the test apparatus, attainable precision of measurements and operator training in observation and quantification of specimen damage

The equipment used to measure heat flux, temperature, gas/air-flow, gas concentration, time, size, mass and air humidity should be calibrated. The laboratory should keep records of the calibration of this equipment.

A Technical Specification concerning the calibration of heat release measurement devices (ISO/TS 14934-1, *Reaction-to-fire tests — Calibration and use of radiometers and heat flux meters — Part 1: General principles*) has been developed by ISO/TC 92/SC 1.

Precision data is considered when each test method standard is developed, and reflected in the standard. If necessary, any further aspects of guidance on calibration are included in guidance form within each standard.

7 Problems that may occur with plastics in standard fire tests

7.1 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 heater or onto the pilot igniter in these tests. Where this behaviour is expected, laboratories may increase the distance separating the specimen surface from the lower part of the cone radiator (e.g. from 25 mm to 60 mm in ISO 5660-1:2002, Subclause 7.5). It is important, however, to maintain the same irradiance at the surface of the specimen in this modified procedure as in the normal procedure.

7.2 Extinction of pilot flames by highly flame-retardant 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 in 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 extinction is the spark igniter used in ISO 5660-1.

7.3 Slumping of thermoplastics sheets

When vertically oriented thermoplastics 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 laboratories must decide whether it is realistic to introduce constraining devices (such as wires, nails or metal bands).

7.4 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.

7.5 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.

7.6 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 plastics products are required, the specimen holders and ignition sources may not be suitable. When necessary, special specimen-mounting arrangements may be used, but their use must be carefully 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.

7.7 Examples of fire tests that may be problematical for plastics

Fire test	Title	Problems
ISO 5657:1997	*Reaction to fire tests — Ignitability of building products using a radiant heat source*	Intumescence; extinction of pilot flame with highly flame-retardant plastics
ISO 5658-2:1996	*Reaction to fire tests — Spread of flame — Part 2: Lateral spread on building products in vertical configuration*	Softening/slumping of thermoplastics sheets
ISO 5660-1:2002	*Reaction-to-fire tests — Heat release, smoke production and mass loss rate — Part 1: Heat release (cone calorimeter method)*	Melting; intumescence; edge effects in GRPs; façade products, especially foam panels
ISO 11925-2:2002	*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 thermoplastics foams Relevance of flame-impingement aspect (edge or face)
ISO 11925-3:1997	*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 thermoplastics foams; softening/slumping of thermoplastics sheets

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