INTERNATIONAL STANDARD

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Plastics — Fire tests — Standard ignition sources

Plastiques — Essais au feu — Sources d'allumage normalisées

ISO 10093:1998(E)

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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.

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.

International Standard ISO 10093 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 4, *Burning behaviour*.

This second edition cancels and replaces the first edition (ISO 10093:1994), which has been technically revised.

This edition differs from the 1994 edition in that all methods that had not been standardized internationally were eliminated. The sources which were eliminated were S/DF4, which was based on the ASTM E 84 burner, and the sources S/C1, S/C2 and S/C3, which were small cribs used in British Standard tests. Two extra burners, S/DF5 and S/DF6, have been introduced in this revision. These are based on the IEC 60332-3:1992 and the ISO 9705:1993 ignition sources. Sources P/PF2 and P/PF3 in the 1994 edition have been integrated into a single source, P/PF2, with two definitions of fuel supply for the same burner.

Annexes A and B of this International Standard are for information only.

Introduction

Fires are caused by a wide range of possible ignition sources. Statistical analysis of fires has identified the main primary and secondary sources, especially for fires in buildings. The most frequent sources of fires have been found to be as follows:

a) cooking appliances;

b) space-heating appliances;

c) electric wiring, connectors and terminations;

d) other electrical appliances (such as washing machines, bedwarmers, televisions, water heaters);

e) cigarettes;

f) matches and smokers' gas lighters;

g) blow-lamps, blow-torches and welding torches;

h) rubbish burning;

i) candles.

The above list covers the major primary ignition sources for accidental fires. Other sources may be involved in fires raised maliciously. Research into causes of fires has shown that primary ignition sources (e.g. glowing cigarettes or dropped flaming matches) can set fire to waste paper, which then acts as a secondary ignition source of greater intensity.

When analysing and evaluating the various ignition sources for applications involving plastics materials, the following questions need to be answered on the basis of detailed fire statistics:

a) What is the significance of the individual ignition sources in various fire risk situations?

b) What proportion is attributable to secondary ignition sources?

c) Where does particular attention have to be paid to secondary ignition sources?

d) To what extent are different ignition sources responsible for fatal fire accidents?

The following laboratory ignition sources are intended to simulate actual ignition sources that have been shown to be the cause of real fires involving plastics. Laboratory ignition sources are preferred over actual ignition sources due to their consistency which results in greater data repeatability within a laboratory and greater reproducibility between laboratories.

These laboratory ignition sources may be used to develop new test procedures.

Plastics — Fire tests — Standard ignition sources

1 Scope

This International Standard describes and classifies a range of laboratory ignition sources for use in fire tests on plastics and products consisting substantially of plastics. These sources vary in intensity and area of impingement. They may be used to simulate the initial thermal abuse to which plastics may be exposed in certain actual fire risk scenarios.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 1337:1980, *Wrought coppers (having minimum copper contents of 99,85 %) — Chemical composition and forms of wrought products.*

ISO 5657:1997, *Reaction to fire tests — Ignitability of building products using a radiant heat source.*

ISO 8191-1:1987, *Furniture — Assessment of the ignitability of upholstered furniture — Part 1: Ignition source: smouldering cigarette.*

ISO 8191-2:1988, *Furniture — Assessment of the ignitability of upholstered furniture — Part 2: Ignition source: match-flame equivalent.*

ISO 9705:1993, *Fire tests — Full-scale room test for surface products.*

ISO 11925-2:1997, *Reaction to fire tests — Ignitability of building products subjected to direct impingement of flame — Part 2: Single flame source test.*

IEC 60332-3:1992, *Tests on electric cables under fire conditions — Part 3: Tests on bunched wires or cables.*

IEC 60695-2-1/0:1994, *Fire hazard testing — Part 2: Test methods — Section 1/sheet 0: Glow-wire test methods — General.*

IEC 60695-2-2:1991, *Fire hazard testing — Part 2: Test methods — Section 2: Needle-flame test.*

IEC 60695-2-4/1:1991, *Fire hazard testing — Part 2: Test methods — Section 4/sheet 1: 1 kW nominal pre-mixed test flame and guidance.*

IEC 60695-2-4/2:1994[1)], *Fire hazard testing — Part 2: Test methods — Section 4/sheet 2: 500 W nominal test flames and guidance.*

IEC 60695-2-20:1995, *Fire hazard testing — Part 2: Glowing/Hot wire based test methods — Section 20: Hot-wire coil ignitability test on materials.*

1) Future editions of this standard are expected to be published under the designation IEC 60695-11-3.

IEC 60695-11-4:—[2], *Fire hazard testing — Part 11: Test flame — Section 4: 50 W apparatus and confirmational test methods.*

ASTM D 5025:1994, *Standard specification for a laboratory burner used for small-scale burning tests on plastic materials.*

DIN 50051:1977, *Testing of materials; Burning behaviour of materials; Burner.*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1
afterflame
persistence of flaming of a material after the ignition source has been removed

3.2
afterflame time
length of time for which a material continues to flame, under specified test conditions, after the ignition source has been removed [also called duration of flame(s)]

3.3
afterglow
persistence of glowing of a material after cessation of flaming or, if no flaming occurs, after the ignition source has been removed

3.4
afterglow time
length of time for which a material continues to glow, under specified test conditions, after the ignition source has been removed and/or cessation of flaming

3.5
combustion
exothermic reaction of a substance with an oxidizer, generally accompanied by flames and/or glowing and/or emission of smoke

3.6
ease of ignition
ease with which a material can be ignited under specified test conditions

3.7
exposed surface
that surface subjected to the heating conditions of the test

3.8
flame (verb)
to undergo combustion in the gaseous phase with emission of light

3.9
flaming debris
material separating from the specimen during the test procedure and falling below the initial lower edge of the specimen and continuing to flame as it falls

3.10
glowing combustion
combustion of a material in the solid phase without flame but with emission of light from the combustion zone

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2) To be published.

3.11
ignitability
measure of the ease with which a specimen can be ignited due to the influence of an external heat source under specified test conditions

3.12
ignite (transitive verb)
to initiate combustion

3.13
ignite (intransitive verb)
to catch fire with or without the application of an external heat source

3.14
ignition
initiation of combustion

3.15
ignition source
applied source of heat which is used to ignite combustible materials or products

3.16
ignition temperature
minimum temperature of a material at which sustained combustion can be initiated under specified test conditions

3.17
irradiance
⟨at a point of a surface⟩ radiant flux incident on an infinitesimal element of the surface containing the point divided by the area of that element

3.18
minimum ignition time
minimum time of exposure of a material to an ignition source to obtain sustained combustion under specified test conditions

3.19
primary ignition source
the first applied ignition source

3.20
punking
propagation of a smouldering combustion front after removal of the ignition source

3.21
secondary ignition source
heat source which is activated following ignition from a primary source

3.22
sustained flaming
after withdrawal of the ignition source, the inception of a flame on the surface of a material that persists for at least 10 s

3.23
transitory flaming
after withdrawal of the ignition source, the appearance of flashes or flames which are not sustained for a continuous 10 s

4 Ignition processes

4.1 When plastics are exposed to thermal energy, flammable vapours may be generated from their surface. Under suitable conditions (especially high temperatures), a critical concentration of flammable vapour may form and spontaneous ignition will result. If a flame is present as the sole energy source, or as a supplementary source, the ignition process will be assisted; this mechanism is sometimes known as pilot ignition.

4.2 A specimen of plastic is regarded as ignited when flames appear on the surface of the plastic or when glowing combustion is evident.

4.3 After ignition has occurred, some burning plastics create additional fire hazards by forming flaming debris or drips. If this flaming debris falls on to combustible material, secondary ignition may occur and the fire will spread more rapidly.

4.4 The localized application of a heat source to some plastics results in glowing combustion. With some thermoplastic foams and foams from thermosetting materials the localized application of a heat source results in punking which produces a carbonaceous char.

5 Characteristics of ignition sources

5.1 The main characteristics of ignition sources and their relation to the test specimen may be defined by the following factors:

a) The intensity of the ignition source. This is a measure of the thermal load on the specimen resulting from the combined conduction, convection and radiation effects caused by the ignition source.

b) The area of impingement of the ignition source on the specimen.

c) The duration of exposure of the specimen and whether it is continuous or intermittent.

d) The presentation of the ignition source to the specimen and whether or not it impinges.

e) The orientation of the specimen in relation to the ignition source.

f) The ventilation conditions in the vicinity of the ignition source and exposed surface of the specimen.

5.2 The ignition sources described in clause 7 provide a range of intensities and areas of impingement to be considered for use in fire tests of plastics.

NOTE Factors c) to f) may be determined when the specific fire test conditions have been decided.

6 Experimental principles

6.1 Flame ignition sources of two types have been selected.

6.1.1 Diffusion flame source

To form a diffusion flame source, gas (usually propane, methane or butane) flows through stainless-steel tubes without ingress of air prior to the base of the flame.

NOTE These flames simulate natural flames well but they often fluctuate and are not convenient to direct if any angular presentation is required toward the specimen.

6.1.2 Premixed flame source

To form a premixed flame source, a gas burner (usually using propane, methane or butane) fitted with air inlet ports or an air intake manifold is used.

NOTES

1 Premixed flame sources are more directional than diffusion flame sources and are more suitable for some laboratory quality assurance tests.

2 Premixed flame sources are generally hotter than diffusion flame sources.

6.2 It is recommended (mandatory for some test methods) that gas burners are always set up to conform to precise gas flow rates and/or flame heights. Secondary checks of flame temperature or heat flux should be performed periodically but criteria on these parameters should not be an essential part of the laboratory procedure. After setting up the burner for a particular test (i.e. often at an acute angle to the test specimen), it is desirable to leave the burner in this orientation throughout a series of experiments. This objective is conveniently satisfied if the operator only has to maintain the gas flow constant to the burner.

6.3 The gas burners are connected to the gas supply by flexible tubing via a cylinder regulator providing an outlet pressure, on-off valve, fine-control valve and flowmeter.

6.4 Difficulties sometimes occur with the supply and measurement of butane or propane when the cylinders need to be stored in an environment cooler than the defined test conditions and/or some distance from the test rig. When difficulties occur, a sufficient length of tubing is needed inside the controlled environment (15 °C to 30 °C) to ensure that the gas equilibrates to the required temperature before flow measurement.

NOTE One way to facilitate this equilibration is to pass the gas (before flow measurement) through a metal tube immersed in water maintained at 25 °C.

6.5 It is important to exercise great care with the measurement and setting of the flow rate of the gas. It is necessary to check direct-reading flowmeters, even those obtained with a direct calibration for the gas used initially, and at regular intervals during testing, with a method capable of measuring accurately the absolute gas flow at the burner tube.

NOTE One way of doing this is to connect the burner tube with a short length of tubing (about 7 mm internal diameter) to a soap bubble flowmeter. Passage of a soap film meniscus in a glass tube (e.g. a calibrated burette) over a known period of time gives an absolute measurement of the flow. Also, fine-control valves that can each be preset to one of the desired gas flow rates, with simple means for switching from one to the other, have proved helpful.

7 Ignition sources

7.1 General

The classification of ignition sources available for use in testing plastics is shown in table 1. Each class will indicate whether a source simulates a primary or secondary ignition source by using a prefix, where "P" refers to primary and "S" refers to secondary.

Table 1 — Classification of ignition sources

Class	Type	Example
S_m	Smouldering	Cigarette
E	Electric	Overheated wire; arcs
DF	Diffusion flame	Match; candle
PF	Premixed flame	Laboratory-burner; blow-lamp
R	Non-contacting radiant	Electric fire; radiant heat from a developing or established accidental fire

NOTES

1 Where a heat flux figure is quoted for any of the following sources, this represents the measured heat flux at the point on the surface at which the flame impinges.

2 Where an area of impingement is quoted for any of the following sources, this represents the area the flame will cover when the closest edge of the burner orifice is situated 5 mm from a vertical flat surface.

7.2 Ignition source P/S_m1

7.2.1 This source is typical of a common cigarette, which is recognized to cause many fires involving upholstered furniture and bedding as discussed in ISO 8191-1. The untipped (unfiltered) cigarette shall comply with the following requirements:

length	70 mm ± 4 mm
diameter	8,0 mm ± 0,5 mm
mass	1,0 g ± 0,1 g
smouldering rate	12,0 min/50 mm ± 3,0 min/50 mm

7.2.2 The smouldering rate is verified on one specimen from each batch of 10 cigarettes used as follows:

a) condition the cigarette before the test for 72 h in indoor ambient conditions and then for at least 16 h in an atmosphere having a temperature of 20 °C ± 5 °C and a relative humidity of (50 ± 20) %;

b) mark the cigarette at 5 mm and 55 mm from the end to be lit;

c) light the cigarette and draw air through it until the tip glows brightly; do not consume more than 3 mm of the cigarette in this operation;

d) impale the cigarette in draught-free air on a horizontal wire spike, inserting not more than 13 mm of the spike into the unlit end of the cigarette;

e) record the time taken to smoulder from the 5 mm to the 55 mm mark.

7.3 Ignition source P/E1

7.3.1 This ignition source referenced in IEC 60695-2-1/0 is called a glow-wire. This source simulates overheating of electrical wiring, particularly within electrotechnical equipment, by heating the glow-wire to one of the following temperatures:

550 °C ± 10 °C

650 °C ± 10 °C

750 °C ± 10 °C

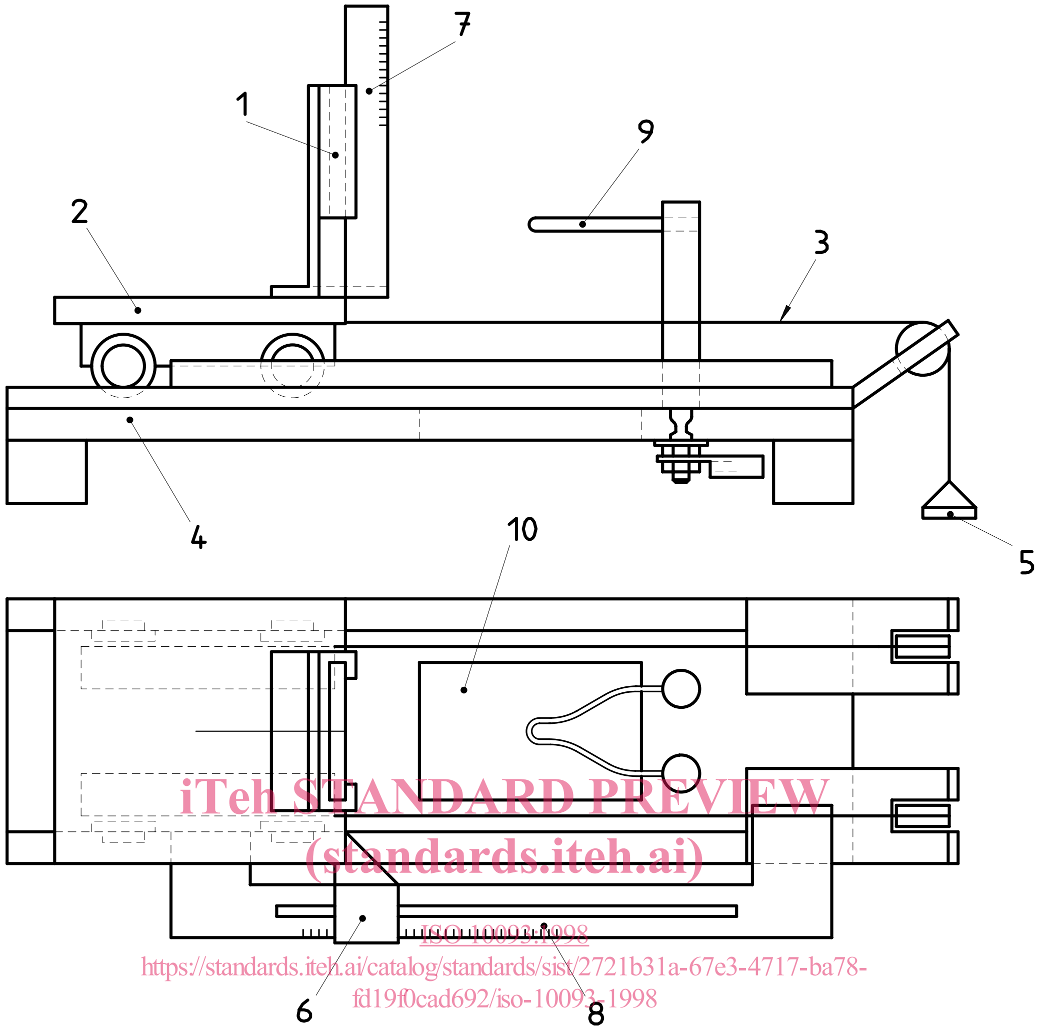
850 °C ± 15 °C

960 °C ± 15 °C

7.3.2 The glow-wire apparatus and ignition source is shown in figure 1. The glow-wire itself consists of a loop of nickel/chromium (80/20) wire 4 mm in nominal diameter.

7.3.3 The temperature of the glow-wire is measured by the use of a sheathed fine-wire thermocouple (NiCr/NiAl) having a nominal overall diameter of 0,5 mm.

7.3.4 The test apparatus positions the glow-wire in a horizontal plane while applying a force of 1,0 N ± 0,2 N to the specimen. This force is maintained when the glow-wire is moved horizontally towards the specimen or *vice versa*. The movement of the tip of the glow-wire into the specimen when pressed against it is mechanically limited to 7 mm.



Key

1 Positioning clamp	6 Stop
2 Carriage	7 Scale to measure height of flame
3 Tensioning cord	8 Scale for penetration
4 Baseplate	9 Glow-wire
5 Weight	10 Cut-out in baseplate for particles falling from specimen

Figure 1 — Ignition source P/E1

7.4 Ignition source P/E2

7.4.1 This ignition source, referenced in IEC 60695-2-20, is an electrically heated hot wire that simulates the overloading of a live part in direct contact with a test specimen.

7.4.2 Hot-wire ignition tests are carried out on bar-shaped specimens, of dimensions 125 mm ± 5 mm long, 13,0 mm ± 0,3 mm wide and 3,0 mm ± 0,1 mm thick. Specimens are wrapped with five turns of 0,5 mm diameter nickel/chromium (80/20) wire of approximate length 250 mm and with a nominal cold resistance of 5,28 Ω/m, spaced 6,35 mm ± 0,5 mm between turns. The test apparatus and ignition source are shown in figure 2.

7.4.3 The specimen is tested in a horizontal position by heating the wire electrically so that 0,26 W is generated per mm length of wire, and the wire has a temperature of approximately 930 °C.