TECHNICAL REPORT

ISO/TR 10093

First edition
2017-11

Plastics — Fire tests — Standard ignition sources

Plastiques — Essais au feu — Sources d'allumage normalisées

Reference number
ISO/TR 10093:2017(E)

Contents

Page

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.

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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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.

The committee responsible for this document is Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 4, *Burning behaviour*.

This first edition of ISO/TR 10093 cancels and replaces ISO 10093:1998, which has been technically revised.

The main changes compared to the previous edition are as follows:

— the document has been updated and converted from an International Standard to a Technical Report;

— several additional ignition sources have been added, including some that originate in standards that have not been issued by ISO or IEC;

— no details of wood crib and paper bag ignition sources are included;

— Annex A and Annex B have been deleted;

— the information that used to be in Annex A on confirmatory procedure for evaluating test flames is described in IEC 60695-11 and in ASTM D5207;

— the bibliography formerly contained in Annex B has been extended.

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; and

i) candles.

The above list covers the major primary ignition sources for accidental fires. Other sources can 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, it is important to answer the following questions on the basis of detailed fire statistics.

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

2) What proportion is attributable to secondary ignition sources?

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

4) 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 can be used to develop new test procedures.

Plastics — Fire tests — Standard ignition sources

1 Scope

This document 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 are suitable for use to simulate the initial thermal abuse to which plastics are potentially exposed in certain actual fire risk scenarios.

Different standards developing organizations have issued many standard test methods, specifications and regulations to assess fire properties of plastics or of products containing plastic materials. Many of those standards contain ignition sources associated with flaming and non-flaming ignition. This document describes the ignition sources and references the associated standard.

This compilation of ignition sources does not discuss the application of the standard where the ignition source is described and is likely not to be a fully comprehensive list of ignition sources.

This document does not address detailed test procedures.

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 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.

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 https://www.iso.org/obp

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

3.2
afterflame time
duration of flame
length of time for which a material continues to flame, under specified test conditions, after the ignition source has been removed

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
surface subjected to the heating conditions of the test

3.8
flame
rapid, self-sustaining, sub-sonic propagation of *combustion* (3.5) in a gaseous medium, usually with emission of light

3.9
flame
to produce *flame* (3.8)

3.10
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* (3.9) as it falls

3.11
glowing combustion
combustion (3.5) of a material in the solid phase without *flame* (3.8) but with emission of light from the combustion zone

3.12
ignitability
measure of the ease with which a specimen can be *ignited* (3.13) due to the influence of an external heat source under specified test conditions

3.13
ignite, transitive verb
initiate *combustion* (3.5)

3.14
ignite, intransitive verb
catch fire with or without the application of an external heat source

3.15
ignition
initiation of *combustion* (3.5)

3.16
ignition source
applied source of heat which is used to *ignite* (3.13) combustible materials or products

3.17
ignition temperature
minimum temperature of a material at which sustained *combustion* (3.5) can be initiated under specified test conditions

3.18
irradiance
ratio of the radiant flux incident on a small but measurable element of surface containing the point, by the area of that element

3.19
minimum ignition time
minimum time of exposure of a material to an *ignition source* (3.16) to obtain sustained *combustion* (3.5) under specified test conditions

3.20
primary ignition source
first applied *ignition source* (3.16)

3.21
punking
propagation of a smouldering *combustion* (3.5) front after removal of the *ignition source* (3.16)

3.22
secondary ignition source
heat source which is activated following *ignition* (3.15) from a primary source

3.23
sustained flaming
flame (3.8), on or over the surface of a test specimen, which persists for longer than a defined period of time

3.24
transitory flaming
flame (3.8), on or over the surface of a test specimen, which persists for a defined short period of time

Note 1 to entry: Compare with the term *sustained flaming* (3.23).

4 Ignition processes

4.1 When plastics are exposed to thermal energy, flammable vapours are often generated from their surface. Under suitable conditions (especially high temperatures), it is possible that a critical concentration of flammable vapour will 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 piloted 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, it is possible that secondary ignition will 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 following factors are the main characteristics describing ignition sources and their relation to the test specimen:

a) intensity of the ignition source, which 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) area of impingement of the ignition source on the specimen;

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

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

e) orientation of the specimen in relation to the ignition source;

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

NOTE Factors c) to f) are often a function of the specific fire test conditions.

5.2 Several of the ignition sources provide a range of intensities and areas of impingement to be considered for use in fire tests of plastics.

6 General principles

6.1 Flaming ignition sources

6.1.1 Diffusion flame ignition source

To form a diffusion flame ignition source, a gas (usually propane, methane or butane) flows through metallic tubes without ingress of air prior to the base of the flame. These flames simulate natural flames well but they often fluctuate and are not convenient to direct if any angular presentation is required towards 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. Premixed flame sources are typically more directional than diffusion flame sources and are generally hotter than diffusion flame sources.

6.2 Issues associated with flaming ignition sources

Gas burners are always set up to conform to precise gas flow rates and/or flame heights. Periodic checks of flame temperature or heat flux precede the setup, but criteria on these parameters are not necessarily 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.

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.

Difficulties sometimes occur with the supply and measurement of butane or propane when the cylinders have been 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 used inside the controlled environment (15 °C to 30 °C) to ensure that the gas equilibrates to the appropriate 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.

It is important to exercise great care with the measurement and setting of the flow rate of the gas and to check direct-reading flowmeters, even those obtained with a direct calibration for the gas used initially, 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 pre-set to one of the desired gas flow rates, with simple means for switching from one to the other, have proved helpful.

6.3 Non-flaming ignition sources

The following clauses/subclauses describe ignition sources as follows (see Table 1):

Clause 7: smouldering (cigarette)

Clause 8: Non-flaming electrical ignition sources

8.1 Glow-wire ignition

8.2 Hot-wire ignition

Clause 9: Radiant ignition sources

9.1 Conical radiant ignition

9.2 Other radiant ignition

Clause 10: Infrared heating ignition

Clause 11: Diffusion flame ignition

11.1 Needle flame ignition

11.2 Burning match

11.3 Burners generating 50 W or 500 W flames

Clause 12: Premixed flame ignition

12.1 Premixed burner for 1 kW flame

12.2 Vertical cable tray burners

12.3 Burners for large scale horizontal tests

12.4 Burners for room corner tests

12.5 Burners for individual product heat release tests

Clause 13: Other ignition sources

13.1 Wood cribs

13.2 Paper bags

Table 1 — Classification of ignition sources

Type of ignition source	Standard(s) using ignition source	Clause/subclause
Smouldering (cigarette)	ISO 8191-1, NFPA 260, NFPA 261	7
Non flaming electrical ignition sources		8
Glow-wire ignition	IEC 60695–2-10, IEC 60695–2-11, ASTM D6194	8.1
Hot-wire ignition	IEC/TS 60695–2-20, ASTM D3874	8.2
Radiant ignition sources		9
Conical radiant ignition	ISO 5657, ISO 5659-2, ISO 5660-1, ASTM E1354, ASTM E1995, NFPA 270	9.1
Other radiant ignition	ISO 871, ASTM D1929, ASTM E906, ASTM E1321	9.2
Infrared heating ignition sources	ASTM E2058, NFPA 287	10
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Diffusion flame ignition sources		11
Needle flame ignition	IEC 60695–11–5	11.1
Burning match	ISO 8191-2, ISO 11925-2	11.2
Burners generating 50 W or 500 W flames	IEC/TS 60695–11–3, IEC/TS 60695–11–4, ASTM D635, ASTM D5025, UL 94	11.3
Premixed flame ignition sources		12
Premixed burner for 1 kW flame	IEC 60695–11–2, IEC 60332–1–2, IEC 60332–2–1	12.1
Vertical cable tray burners	IEC 60332–3–10, ASTM D5424, ASTM D5537, UL 1666, UL 1685, UL 2556	12.2
Burners for large scale horizontal tests	ASTM E84, NFPA 262	12.3
Burners for room corner tests	ISO 9705,-1 ASTM E2257, NFPA 265, NFPA 286	12.4
Burners for individual product heat release tests	ASTM E1537, ASTM E1590, ASTM E1822, NFPA 289	12.5
Other ignition sources		13
Wood cribs		13.1
Paper bags		13.2

7 Smouldering (cigarette) ignition sources

7.1 Traditional cigarettes

7.1.1 This source is typical of a common commercial cigarette, which is known to cause many fires involving upholstered furniture and bedding as discussed in ISO 8191-1. The untipped (unfiltered) cigarette meets the following:

— length: (70 ± 4) mm

— diameter: (8,0 ± 0,5) mm

— mass: (1,0 ± 0,1) g

— smouldering rate: (12,0/50 ± 3,0/50) min/mm

7.1.2 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 ± 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; and

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

7.1.3 In many countries, including in the European Union and the United States, regulations that apply to commercial cigarettes mean that they meet the characteristics of reduced ignition propensity (RIP) cigarettes, by being tested in accordance with ISO 12863 or ASTM E2187. Thus, such RIP cigarettes have become replacement commercial cigarettes for the commercial cigarettes available when ISO 8191-1 was developed. The new commercial RIP cigarettes are less likely to provide a severe smouldering ignition source than the traditional non-RIP cigarettes.

7.2 Non-reduced ignition propensity cigarettes

Standard reference material cigarettes (SRM 1196) were designed to simulate the ignition strength of those cigarettes that were in commercial use in the United States before the development of ISO 12863 or ASTM E2187. They have been identified as having a strong ignition potential and do not conform to the specifications of RIP cigarettes. The cigarettes are described as NIST SRM 1196[1)] cigarettes and they are cigarettes without filter tips, made from natural tobacco (83 ± 2) mm long with a tobacco packing density of (0,270 ± 0,020) g/cm^3 and a total weight of (1,1 ± 0,1) g. These cigarettes are used in NFPA 260 and NFPA 261.

8 Non-flaming electrical ignition sources

8.1 Glow-wire ignition

8.1.1 This ignition source is referenced in IEC 60695-2-10, IEC 60695-2-11 and ASTM D6194. It 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 ± 10) °C

— (650 ± 10) °C

— (750 ± 10) °C

— (850 ± 15) °C

— (960 ± 15) °C

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

1) Available from the US National Institute of Standards and Technology (NIST), http://www.nist.gov/srm/index.cfm.

