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Plastics — Fire tests — Standard ignition sources

Plastiques — Essais au feu — Sources d'allumage normalisées

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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.

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 of 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 www.iso.org/iso/foreword.html.

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

This third edition cancels and replaces the second edition (ISO/TR 10093:2018), which has been technically revised.

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

— mandatory information have been added throughout the document;

— referenced standards have been deleted from the bibliography and moved to the normative references clause (see Clause 2).

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Fires are caused by a wide range of possible ignition sources. Statistical analysis of fires has identified the major 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.

This 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 laboratory ignition sources described in this document 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.

This compilation of standard ignition sources describes the ignition sources used by different standards development organizations and contained in standard test methods, specifications, or regulations used to assess the fire properties or plastics and of products containing plastic materials. The ignition sources described in this document are associated with flaming and non-flaming ignition. This document describes the relevant ignition sources and references the associated standard.

This compilation of ignition sources does not discuss the application of the standard referenced in any specific clause in which the ignition source is described, and this compilation 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 871, *Plastics — Determination of ignition temperature using a hot-air furnace*

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

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

ISO 5659-2, *Plastics — Smoke generation — Part 2: Determination of optical density by a single-chamber test*

ISO 5660-1, *Reaction-to-fire tests — Heat release, smoke production and mass loss rate — Part 1: Heat release rate (cone calorimeter method) and smoke production rate (dynamic measurement)*

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

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

ISO 9705-1, *Reaction to fire tests — Room corner test for wall and ceiling lining products — Part 1: Test method for a small room configuration*

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

ISO 12136, *Reaction to fire tests — Measurement of material properties using a fire propagation apparatus*

ISO 12863, *Standard test method for assessing the ignition propensity of cigarettes*

ISO 12949, *Standard test method for measuring the heat release rate of low flammability mattresses and mattress sets*

ISO 13943, *Fire safety — Vocabulary*

IEC 60332-1-1, *Tests on electric and optical fibre cables under fire conditions — Part 1-1 Test for vertical flame propagation for a single insulated wire or cable — Apparatus*

IEC 60332-1-2, *Tests on electric and optical fibre cables under fire conditions — Part 1-2: Test for vertical flame propagation for a single insulated wire or cable — Procedure for 1 kW pre-mixed flame*

IEC 60332-3-10, *Tests on electric and optical fibre cables under fire conditions — Part 3-10: Test for vertical flame spread of vertically-mounted bunched wires or cables — Apparatus*

IEC 60695-1-21, *Fire hazard testing — Part 1-21: Guidance for assessing the fire hazard of electrotechnical products – Ignitability — Summary and relevance of test methods*

IEC 60695-2-10, *Fire hazard testing — Part 2-10: Glowing/hot-wire based test methods — Glow–wire apparatus and common test procedure*

IEC 60695-2-11, *Fire hazard testing — Part 2-11: Glowing/hot-wire based test methods — Glow-wire flammability test method for end-products (GWEPT)*

IEC 60695-2-12, *Fire hazard testing — Part 2-12: Glowing/hot-wire based test methods — Glow-wire flammability index (GWFI) test method for materials*

IEC 60695-2-13, *Fire hazard testing — Part 2-13: Glowing/hot-wire based test methods — Glow-wire ignition temperature (GWIT) test method for materials*

IEC/TS 60695-2-20, *Fire hazard testing — Part 2-20: Glowing/hot-wire based test methods — Hot wire ignition test — Apparatus, confirmatory test arrangement and guidance (withdrawn)*

IEC/TS 60695-11-2, *Fire hazard testing — Part 11-2: Test flames — 1 kW pre-mixed flame — Apparatus, confirmatory test arrangement and guidance*

IEC 60695-11-3, *Fire hazard testing — Part 11-3: Test flames — 500 W flames — Apparatus and confirmational test methods*

IEC 60695-11-4, *Fire hazard testing — Part 11-4: Test flames — 50 W flame — Apparatus and confirmational test method*

IEC 60695-11-5, *Fire hazard testing — Part 11-4: Test flames — Needle-flame test method — Apparatus, confirmatory test arrangement and guidance*

IEC 60695-11-10, *Fire hazard testing — Part 11-10: Test flames — 50 W horizontal and vertical flame test methods*

IEC 60695-11-20, *Fire hazard testing — Part 11-20: Test flames — 500 W flame test method*

ASTM D635, *Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position*

ASTM D1929, *Standard Test Method for Determining Ignition Temperature of Plastics*

ASTM D3874, *Standard Test Method for Ignition of Materials by Hot Wire Sources*

ASTM D5025, *Standard specification for a laboratory burner used for small-scale burning tests on plastic materials*

ASTM D5424, *Standard Test Method for Smoke Obscuration of Insulating Materials Contained in Electrical or Optical Fiber Cables When Burning in a Vertical Cable Tray Configuration*

ASTM D5537, *Standard Test Method for Heat Release, Flame Spread, Smoke Obscuration, and Mass Loss Testing of Insulating Materials Contained in Electrical or Optical Fiber Cables When Burning in a Vertical Cable Tray Configuration*

ASTM D6194, *Standard Test Method for Glow-Wire Ignition of Materials*

ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*

ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750 °C*

ASTM E662, *Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials*

ASTM E906/E906M, *Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using a Thermopile Method*

ASTM E1321, *Standard Test Method for Determining Material Ignition and Flame Spread Properties*

ASTM E1354*Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter*

ASTM E1537, *Standard Test Method for Fire Testing of Upholstered Furniture*

ASTM E1590, *Standard Test Method for Fire Testing of Mattresses*

ASTM E1822, *Standard Test Method for Fire Testing of Stacked Chairs*

ASTM E1995, *Standard Test Method for Measurement of Smoke Obscuration Using a Conical Radiant Source in a Single Closed Chamber, With the Test Specimen Oriented Horizontally*

ASTM E2058, *Standard Test Methods for Measurement of Material Flammability Using a Fire Propagation Apparatus (FPA)*

ASTM E2187, *Standard Test Method for Measuring the Ignition Strength of Cigarettes*

ASTM E2257, *Standard Test Method for Room Fire Test of Wall and Ceiling Materials and Assemblies*

ASTM E2574/E2574M, *Standard Test Method for Fire Testing of School Bus Seat Assemblies*

NFPA 260, *Standard Methods of Tests and Classification System for Cigarette Ignition Resistance of Components of Upholstered Furniture*

NFPA 261, *Standard Method of Test for Determining Resistance of Mock-Up Upholstered Furniture Material Assemblies to Ignition by Smoldering Cigarettes*

NFPA 262, *Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces*

NFPA 265, *Standard Methods of Fire Tests for Evaluating Room Fire Growth Contribution of Textile or Expanded Vinyl Wall Coverings on Full Height Panels and Walls*

NFPA 270, *Standard Test Method for Measurement of Smoke Obscuration Using a Conical Radiant Source in a Single Closed Chamber*

NFPA 286, *Standard Methods of Fire Tests for Evaluating Contribution of Wall and Ceiling Interior Finish to Room Fire Growth*

NFPA 287, *Standard Test Methods for Measurement of Flammability of Materials in Cleanrooms Using a Fire Propagation Apparatus (FPA)*

NFPA 289, *Standard Method of Fire Test for Individual Fuel Packages*

UL 1666, *Standard for Test for Flame Propagation Height of Electrical and Optical-Fibre Cables Installed Vertically in Shafts*

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:

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

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

3.1
afterflame
flame (3.8) that persists after the ignition source has been removed

[SOURCE: ISO 13943:2017, 3.11]

3.2
afterflame time
length of time for which an *afterflame* (3.1) persists under specified conditions

[SOURCE: ISO 13943:2017, 3.12]

3.3
afterglow
persistence of glowing combustion after both removal of the ignition source and the cessation of any flaming combustion

[SOURCE: ISO 13943:2017, 3.13]

3.4
afterglow time
length of time for which an *afterglow* (3.3) persists under specified conditions

[SOURCE: ISO 13943:2017, 3.14]

3.5
combustion
exothermic reaction of a substance with an oxidizing agent

[SOURCE: ISO 13943:2017, 3.55, modified — note has been omitted.]

3.6
ease of ignition
measure of the ease with which a test specimen can be ignited, under specified conditions

[SOURCE: ISO 13943:2017, 3.212]

3.7
exposed surface
surface of a test specimen subjected to the heating conditions of a fire test

[SOURCE: ISO 13943:2017, 3.106]

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

[SOURCE: ISO 13943:2017, 3.159]

3.9
flame, verb
produce *flame* (3.8)

[SOURCE: ISO 13943:2017, 3.160]

3.10
flaming debris
burning material separating from a burning item and continuing to *flame* (3.9) on the floor, during a fire or fire test

Note 1 to entry: Alternatively, flaming debris can be burning material, other than drops, which has detached from a test specimen during a fire or fire test and continues to burn.

Note 2 to entry: Compare with the terms *flaming droplets* (3.11).

[SOURCE: ISO 13943:2017, 3.176]

3.11
flaming droplets
flaming molten or flaming liquefied drops which fall from the test specimen during the fire test and continue to burn on the floor

Note 1 to entry: Compare with the term *flaming debris* (3.10).

[SOURCE: ISO 13943:2017, 3.177]

3.12
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

[SOURCE: ISO 13943:2017, 3.197]

3.13
ignitability
measure of the ease with which a specimen can be *ignited* (3.14), under specified conditions

[SOURCE: ISO 13943:2017, 3.212]

3.14
ignite, transitive verb
initiate *combustion* (3.5)

[SOURCE: ISO 13943:2017, 3.215]

3.15
ignite, intransitive verb
catch fire with or without the application of an external heat source

[SOURCE: ISO 13943:2017, 3.214]

3.16
ignition
initiation of *combustion* (3.5)

[SOURCE: ISO 13943:2017, 3.217]

3.17
ignition source
source of energy that initiates *combustion* (3.5)

[SOURCE: ISO 13943:2017, 3.219]

3.18
ignition time
duration of exposure of a test specimen to a defined *ignition source* (3.17) required for the initiation of sustained *combustion* (3.5) under specified conditions

[SOURCE: ISO 13943:2017, 3.220]

3.19
irradiance
ratio of the radiant flux incident on a small but measurable element of surface containing the point, by the area of that element

[SOURCE: ISO 13943:2017, 3.236]

3.20
minimum ignition temperature
minimum temperature of a material at which sustained *combustion* (3.5) can be initiated under specified test conditions

[SOURCE: ISO 13943:2017, 3.327]

3.21
primary ignition source
first applied *ignition source* (3.17)

3.22
punking
propagation of a smouldering *combustion* (3.5) front after removal of the *ignition source* (3.17)

3.23
secondary ignition source
heat source which is activated following *ignition* (3.16) from a primary source

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

Note 1 to entry: Compare with the term *transitory flaming* (3.25).

[SOURCE: ISO 13943:2017, 3.380]

3.25
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* (3.24).

[SOURCE: ISO 13943:2017, 3.408]

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 for a critical concentration of flammable vapour to form and spontaneous ignition to result. If a flame is present as the sole energy source, or as a supplementary source, the ignition process is then 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 for a secondary ignition to occur and for the fire to 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.

5.3 IEC 60695-1-21 provides guidance on ignition sources relevant to the fire testing of electrotechnical products.

6 General principles

6.1 Flaming ignition sources

6.1.1 Diffusion flame ignition sources

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 it is necessary to point any angular presentation toward the specimen.

6.1.2 Premixed flame sources

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.

6.1.3 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), the burner shall be left in this orientation throughout a series of experiments. This objective is conveniently satisfied if the operator simply maintains 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 shall be used inside the controlled environment (15 °C to 30 °C) to ensure that the gas equilibrates to the appropriate temperature before flow measurement.

NOTE 1 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 essential 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 2 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 been proven helpful.

6.2 Non-flaming and flaming ignition sources

6.2.1 Non-flaming ignition sources shall be classified in the following categories: smouldering (cigarettes; as required by Clause 7), glow-wire ignition (as required by 8.1), hot-wire ignition (as required by 8.2), radiant ignition (as required by Clause 9) and infrared heating ignition (as required by Clause 10). The details shall be as described in Table 1.

6.2.2 Flaming ignition sources shall be as classified in the following categories: diffusion flame ignition (as required by Clause 11), premixed flame ignition (as required by Clause 12) and other ignition sources (wood cribs and paper bags, as required by Clause 13). The details shall be as described in Table 1.

The ignition sources shall be as defined in Table 1.

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	Clause 7
Non-flaming electrical ignition sources		Clause 8
Glow-wire ignition	IEC 60695–2–10, IEC 60695–2–11, IEC 60695-2–12, IEC 60695-2–13, ASTM D6194	8.1
Hot-wire ignition	IEC/TS 60695–2–20, ASTM D3874	8.2
Radiant ignition sources		Clause 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, ISO 5658-2, ASTM E1321	9.2
Infrared heating ignition sources	ISO 12136, ASTM E2058, NFPA 287	Clause 10
+		
Diffusion flame ignition sources		Clause 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 60695–11–3, IEC 60695–11–4, ASTM D635, ASTM D5025, UL 94	11.3
Premixed flame ignition sources		Clause 12
Premixed burner for 1 kW flame	IEC 60695–11–2, IEC 60332-1–1, IEC 60332-1–2	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		Clause 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 shall comply with the following requirements:

— length: (70 ± 4) mm;

— diameter: (8,0 ± 0,5) mm;

— mass: (1,0 ± 0,1) g;

— smouldering rate: (12,0 ± 3,0) min to reach from 5 mm to 50 mm mark.

7.1.2 The smouldering rate shall be 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;

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 "reduced ignition propensity 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, IEC 60695-2-12, IEC 60695-2-13 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 temperatures in the range of 550 °C (± 10 °C) to 950 °C (± 15 °C) or 960 °C (± 15 °C).

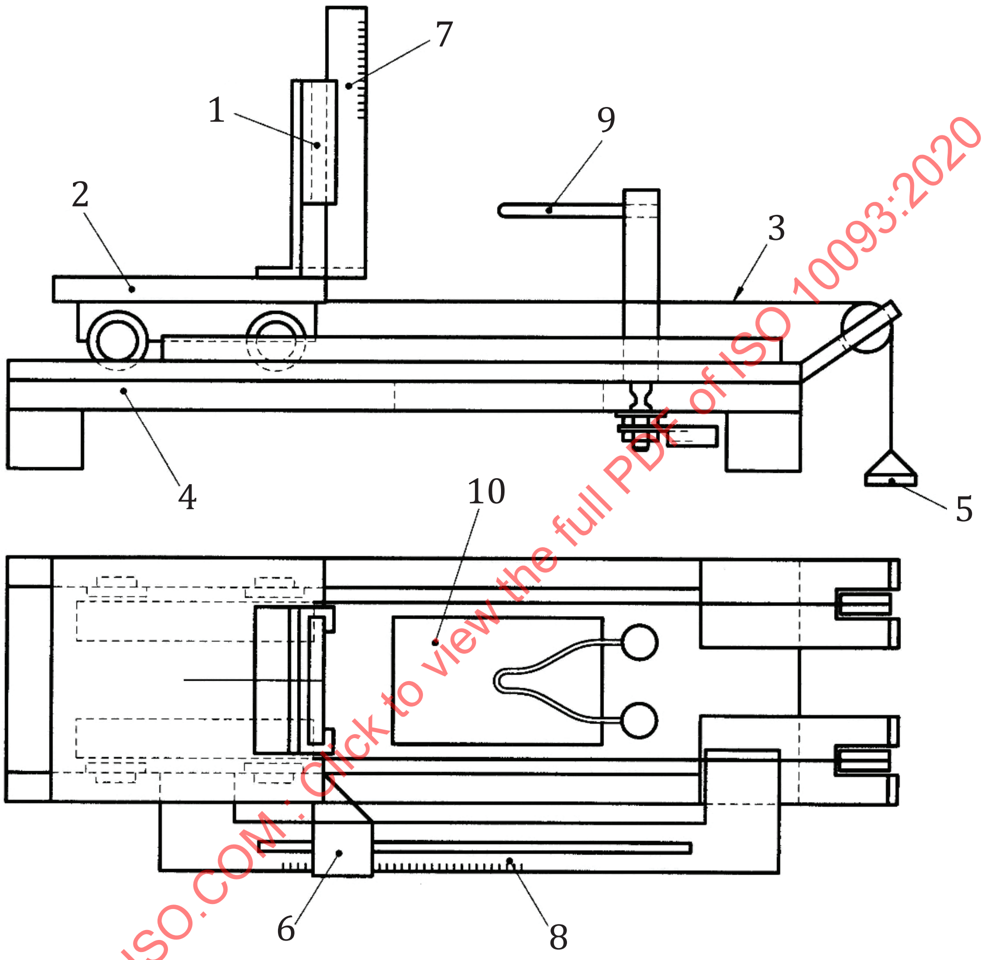
8.1.2 The glow-wire apparatus and ignition source are shown in Figure 1. The glow-wire itself consists of a loop of nickel/chromium (80/20) wire 4 mm in nominal diameter.

8.1.3 The temperature of the glow-wire shall be measured by the use of a sheathed fine-wire Type K thermocouple [Nickel–Chromium (NiCr) or Nickel–Aluminium (NiAl)] having a nominal overall diameter of 0,5 mm or 1,0 mm. The thermocouple sheath shall be constructed of a metal with properties such that the thermocouple is able to perform its function in air at sheath temperatures of at least 1 050 °C. The thermocouple shall be arranged in a pocket hole, drilled in the tip of the glow-wire. The thermal contact between the walls of the bored hole in the glow-wire shall be maintained by pinning the sheathed thermocouple in place. The thermocouple follows the movement of the tip of the glow-wire resulting from elongation caused by thermal heating. A temperature indicator for Type K thermocouples capable of reading up to 1 000 °C shall be used. The supply circuit shall be capable of supplying up to 150 A at

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

2,1 V, with smooth continuous adjustment of voltage to provide the appropriate current to maintain the required glow-wire tip temperature.

8.1.4 The test apparatus positions the glow-wire in a horizontal plane while applying a force of (1,0 ± 0,2) N to the specimen. This force shall be 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 shall be mechanically limited to 7 mm.



Key

1 positioning clamp
2 carriage
3 tensioning cord
4 baseplate
5 weight
6 stop
7 scale to measure height of flame
8 scale for penetration
9 glow-wire
10 cut-out in base plate for particles falling from specimen

Figure 1 — Glow-wire ignition source

8.2 Hot-wire ignition

8.2.1 This ignition source is referenced in IEC/TS 60695-2-20 and in ASTM D3874. It is an electrically heated hot-wire that simulates the overloading of a live part in direct contact with a test specimen.

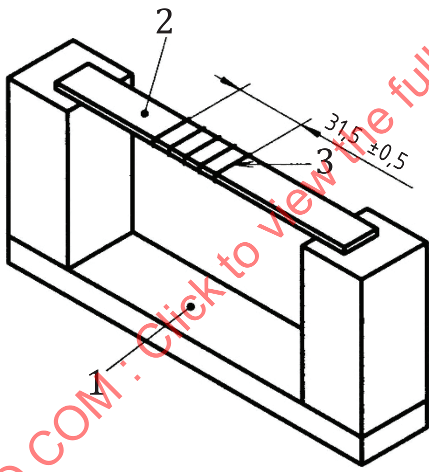
8.2.2 The heater wire shall be a loop of iron-free nickel/chromium wire (80 % nickel and 20 % chromium, iron-free), 0,05 mm in nominal diameter. The wire has a nominal cold resistance of 5,28 Ω/m and has a length-to-mass ratio of 580 m/kg. The wire length for each test shall be approximately 250 mm and it shall have been previously calibrated. Before testing, each straight length of wire shall be annealed by energizing the wire to dissipate 0,26 W/mm of length for 8 s to 12 s to relieve internal wire stress.

8.2.3 The supply circuit used to electrically energize the heater wire shall have sufficient capacity to maintain a continuous linear 50 Hz to 60 Hz power density of at least 0,31 W/mm over the length of the heater wire at or near unity power factor. When the supply circuit operates at a current of 60 A with a voltage of 1,5 V, this results in an approximate power density of 0,3 W/mm. Essential devices include those for voltage adjustment and power measurement (within ±2 %), an easily actuated on-off switch for the test power, and timers to record the duration of the application of test power.

8.2.4 Hot-wire ignition tests are carried out on bar-shaped specimens, of dimensions (125 ± 5) mm long, (13,0 ± 0,3) mm wide and (3,0 ± 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 ± 0,5) mm between turns. The test apparatus and ignition source are shown in Figure 2.

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

Dimensions in millimetres



Key

1 test fixture

2 test specimen

3 hot-wire (five turns with 6,35 mm ± 0,5 mm between turns)

Figure 2 — Hot-wire ignition source

9 Radiant ignition sources

9.1 Conical radiant ignition sources

9.1.1 General

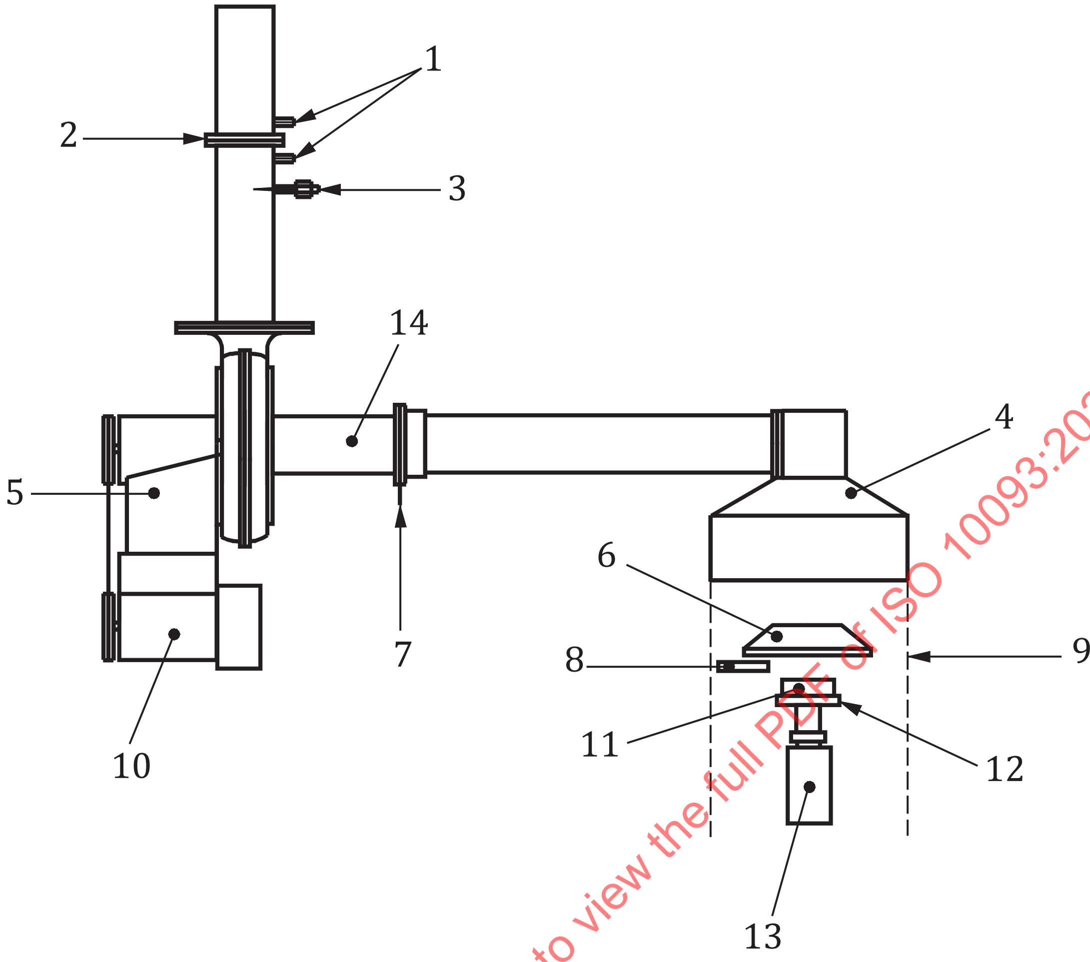
Table 2 compares the three conical ignition sources described in 9.1.2 to 9.1.4.

Table 2 — Details of radiant ignition sources with conical radiators

Standard	Heat flux range kW/m^2	Specimen size cm^2	Pilot ignition source	Specimen orientation
ISO 5657	10 to 50	154	Propane flame	Horizontal
ISO 5659-2, ASTM E1995, NFPA 270	10 to 50	56	Propane flame	Horizontal
ISO 5660-1, ASTM E1354	10 to at least 75	100	Spark igniter	Horizontal or vertical

9.1.2 Cone calorimeter ignition source

9.1.2.1 This ignition source is described in ISO 5660-1 and in ASTM E1354. The ignition source is composed of the following major components: a conical radiant electric heater (able to be used in the horizontal or vertical orientations), a temperature controller, a radiation shield, an electric ignition spark plug and a test specimen holder (which depends on the test orientation). The test specimen shall be (100 × 100) mm and the heat flux range shall be from 0 kW/m^2 to at least 75 kW/m^2. There is no pilot flame. A schematic of the apparatus is shown in Figure 3 and one for the conical heater is shown in Figure 4.



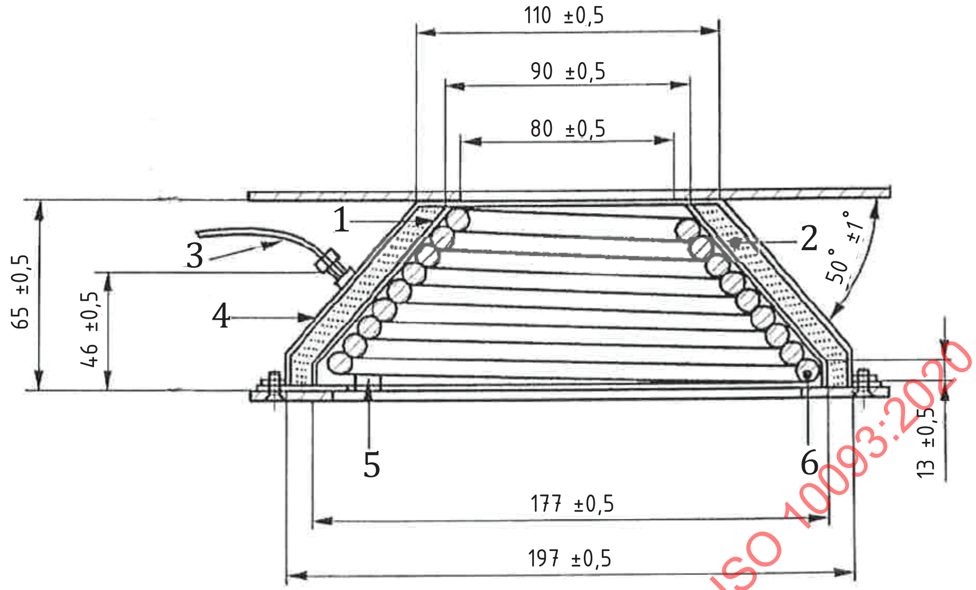
Key

1 pressure ports
2 orifice plate
3 thermocouple (located on stack centreline)
4 hood
5 blower
6 heater
7 gas sampling ring probe
8 spark plug
9 optional screens
10 blower motor
11 retainer frame and specimen
12 specimen holder
13 weighing device
14 smoke measurement section

NOTE Source: ISO 5660-1:2015, Figure 1.

Figure 3 — Cone calorimeter apparatus schematic

Dimensions in millimetres



Key

1 inner shell
2 refractory fibre packing
3 thermocouple
4 outer shell
5 space block
6 heating element

NOTE Source: ISO 5660-1:2015, Figure 2.

Figure 4 — Cone calorimeter conical heater schematic

9.1.2.2 The active element of the conical heater consists of an electrical heater rod, rated at 5 000 W at 240 V, tightly wound into the shape of a truncated cone (Figure 4). The heater shall be encased on the outside with a double-wall stainless steel cone, packed with a refractory fibre material of approximately 100 kg/m^3 density. The heater shall be hinged so that it can be swung into either a horizontal or a vertical orientation. The irradiance shall be uniform within the central (50 × 50) mm area of the test specimen to within ±2 % in the horizontal orientation and to within ±10 % in the vertical orientation. The heater irradiance from the heater shall be able to be held at a pre-set level by means of a temperature controller and three type K stainless steel sheathed thermocouples, symmetrical around the heater element. The thermocouples shall be of equal length and wired in parallel to the temperature controller.

9.1.2.3 The heater shall be controlled by a temperature controller capable of holding the element temperature steady to within ±2 °C. A suitable system shall be a three-term controller (proportional, integral and derivative) and a thyristor unit capable of switching currents up to 25 A at 240 V. The temperature input range of the controller shall be up to 1 000 °C, with a scale capable of being read to 2 °C or better and automatic cold junction compensation. The heater temperature shall be monitored by a meter capable of being read to ±2 °C or better, which is often incorporated into the temperature controller.

9.1.2.4 A removable radiation shield protects the test specimen from the heat flux prior to the start of a test. The shield shall be made of non-combustible material with a total thickness not to exceed 12 mm. The shield shall be either:

a) a water-cooled shield coated with a durable matte black finish of surface emissivity e = 0,95 ± 0,05; or

b) a shield that is not water-cooled but is provided with either a metallic reflective top surface or a ceramic non-metallic top surface, in order to minimize radiation transfer.

The shield shall be equipped with a handle or other suitable means for quick insertion and removal. The cone heater base plate shall be equipped with the means for holding the shield in position and allowing its easy and quick removal.

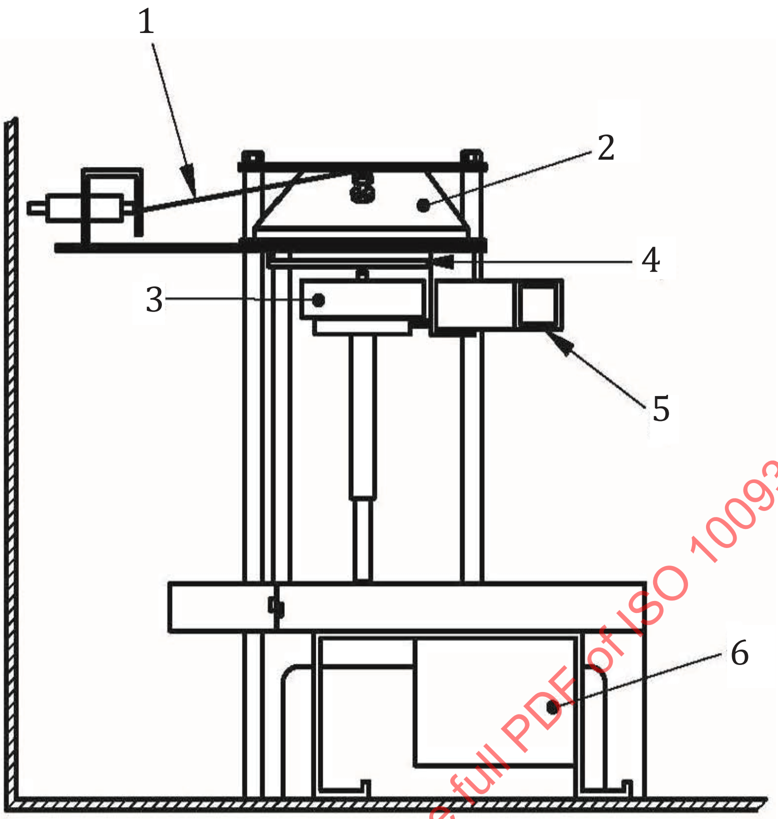
9.1.2.5 The actual ignition is accomplished by a 10 kV discharge across a 3 mm spark gap located 13 mm above the centre of the test specimen (when used for the horizontal location). The spark igniter power source shall be either a transformer designed for spark-ignition use or a spark generator. The spark discharge operates continuously at 50 Hz to 60 Hz until sustained flaming is achieved. The igniter shall be removed when sustained flaming is achieved. The sensitivity of the timing device for measuring time to ignition (also known as time to sustained flaming) is such that it is capable of recording elapsed time to the nearest second and is accurate to within 1 s in 1 h. In the case of testing in the vertical orientation, the spark gap shall be located in the test specimen face plane and 5 mm above the top of the specimen holder.

9.1.2.6 The horizontal test specimen holder has its bottom lined with a layer of low-density (nominal density 65 kg/m^3) refractory fibre blanket with a thickness of at least 13 mm. The distance between the bottom surface of the cone heater and the top of the test specimen shall be adjusted to be 25 mm. The vertical test specimen holder includes a small drip tray to contain a limited amount of molten material. A test specimen shall be installed in the vertical test specimen holder by backing it with a layer of refractory fibre blanket (nominal density 65 kg/m^3), the thickness of which depends on test specimen thickness, but the blanket shall be at least 13 mm thick. A layer of rigid, ceramic fibre millboard shall be placed behind the fibre blanket layer. The millboard thickness shall be such that the entire assembly is rigidly bound together once the retaining spring clip is inserted behind the millboard. When testing in the vertical orientation, the cone heater height shall be set so the centre lines up with the test specimen centre.

9.1.3 Smoke chamber conical heater

9.1.3.1 This ignition source is described in ISO 5659-2 as well as in ASTM E1995 and in NFPA 270. The ignition source is similar to that in the cone calorimeter (see 9.1.3) but is smaller. The following are specified in these standards as the essential components: a conical radiant electric heater, a test specimen holder, a radiation shield, a pilot burner and a spark igniter to reignite the pilot burner. The test specimen shall be (75 × 75) mm and the heat flux range shall be 25 kW/m^2 or 50 kW/m^2, either with or without an external pilot flame. Schematics of the conical heater and the arrangement are found in Figure 5 and Figure 6.

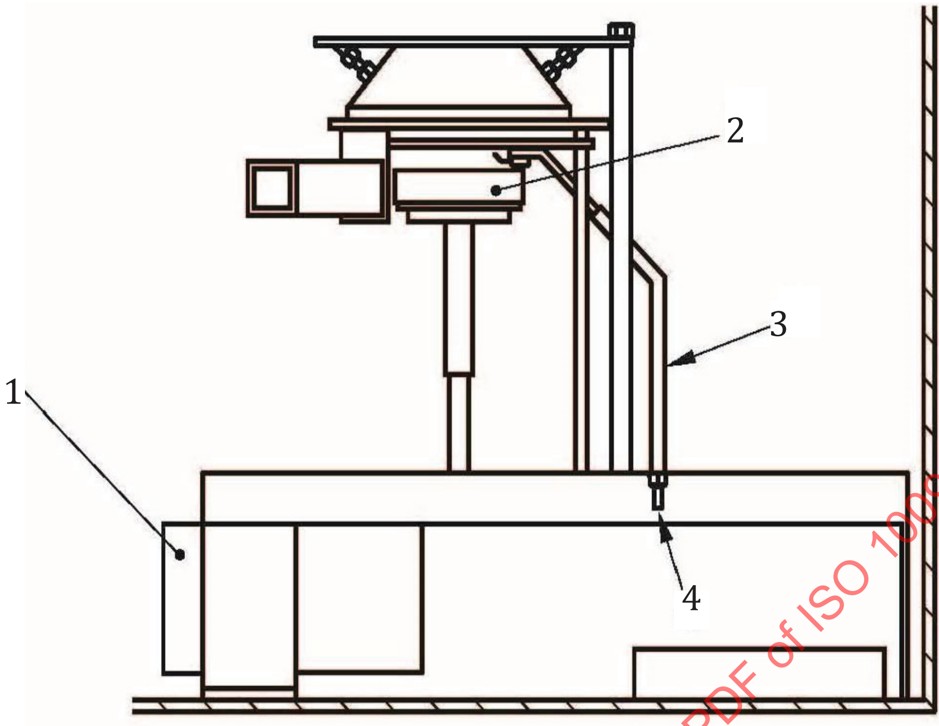
9.1.3.2 The active element of the conical heater consists of an electrical heater rod, rated at 450 W at 240 V, tightly wound into the shape of a truncated cone. The heater shall be encased on the outside with a double-wall stainless steel cone, packed with a refractory fibre material of approximately 100 kg/m^3 density. The heater provides irradiances on the surface of the test specimen of 10 kW/m^2 to 50 kW/m^2, as measured at the centre of the surface of the test specimen. The irradiance shall also be determined at positions of (25 ± 2) mm to each side of the test specimen centre, and the irradiance at these two positions shall be not less than 85 %, and not more than 115 % of the irradiance at the centre of the test specimen. The heater irradiance shall be capable of being held at a pre-set level (25 kW/m^2 and 50 kW/m^2) by means of a temperature controller and three type K stainless steel sheathed thermocouples, symmetrically disposed and in contact with but not welded to the heater element. The thermocouples are of equal length and wired in parallel to the temperature controller. The cone heater shall be secured from the vertical rods of the support framework and located so that the lower rim of the cone heater is (25 ± 1) mm above the upper surface of the test specimen.



Key

1 thermocouple
2 radiator cone
3 specimen holder
4 radiator shield
5 heat flux meter
6 spark ignition housing

Figure 5 — Typical arrangement of ISO 5659-2 radiator cone ignition source specimen holder and radiator shield (side view)



Key

1 spark ignition housing

2 specimen holder

3 pilot burner and ignition electrode

4 propane and air

Figure 6 — Typical arrangement of ISO 5659-2 radiator cone ignition source specimen holder and radiator shield (front view)

9.1.3.3 The heater temperature controller shall be capable of holding the element temperature steady to within ±2 °C. A suitable system is a three-term controller (proportional, integral, and derivative) and a thyristor unit capable of switching currents up to 25 A at 240 V. The controller has a temperature input range of 0 °C to 1 000 °C, a set scale capable of being read to 2 °C or better, and automatic cold junction compensation. The cone heater temperature shall be monitored by a meter capable of being read to ±2 °C, or better, which is often incorporated into the temperature controller.

9.1.3.4 The cone heater shall be provided with a removable radiation shield to protect the test specimen from the irradiance prior to the start of the test. The radiation shield shall be made of a non-combustible material with a total thickness not to exceed 12 mm, and conforms to the same specifications as that of the cone calorimeter radiation shield (see 9.1.2.4).

9.1.3.5 The actual ignition is caused by a pilot burner. The flame from the single-flame burner has a length of (30 ± 5) mm and shall be positioned horizontally (10 ± 1) mm above the top face of the test specimen. The colour of the flame is blue with a yellow tip. The tip of the burner shall be aligned with the edge of the test specimen.

9.1.3.6 A small spark ignition device shall be placed next to the outlet tube of the burner to cause reignition of the flame without the need to open the chamber door. A suitable system is a spark plug with a 3 mm gap, powered from a 10 kV transformer. A suitable electrode length and spark plug location is such that the spark gap is located 13 mm above the test specimen, close to the pilot burner.

9.1.4 Ignition source from periodic flaming ignition test

9.1.4.1 This ignition source is used in ISO 5657. It is a conical radiant heater, somewhat similar to those described in 9.1.2 and in 9.1.3 but with different characteristics. It differs from other radiant heaters in terms of the heater itself, the characteristics of the igniter and the test specimen. It is a radiant cone heater which allows specimens to be exposed to thermal radiation on their upper surfaces at selected levels of constant heat flux within the range 10 kW/m^2 to 50 kW/m^2, at the aperture of a masking plate and in a reference plane coinciding with the underside of the masking plate. It represents a non-contacting thermal radiant exposure from a primary fire at those heat fluxes. A pilot flame shall be applied at regular intervals to a position 10 mm above the centre of each specimen to ignite any volatile gases given off. The test specimen shall be (165 × 165) mm and the heat flux range shall be 10 kW/m^2 to 50 kW/m^2. Details are shown in Figure 7.

9.1.4.2 The active element of the heater consists of an electrical heater rod, rated at 3 000 W at 240 V, tightly wound into the shape of a truncated cone. The heater shall be encased on the outside with a double-wall stainless steel cone, packed with a refractory fibre material of approximately 100 kg/m^3 density. The distribution of the irradiance provided by the heater at the reference plane shall be such that:

a) the variation of the irradiance within a circle of 50 mm diameter, drawn from the centre of the masking plate aperture, is not more than ±3 % of that at the centre; and

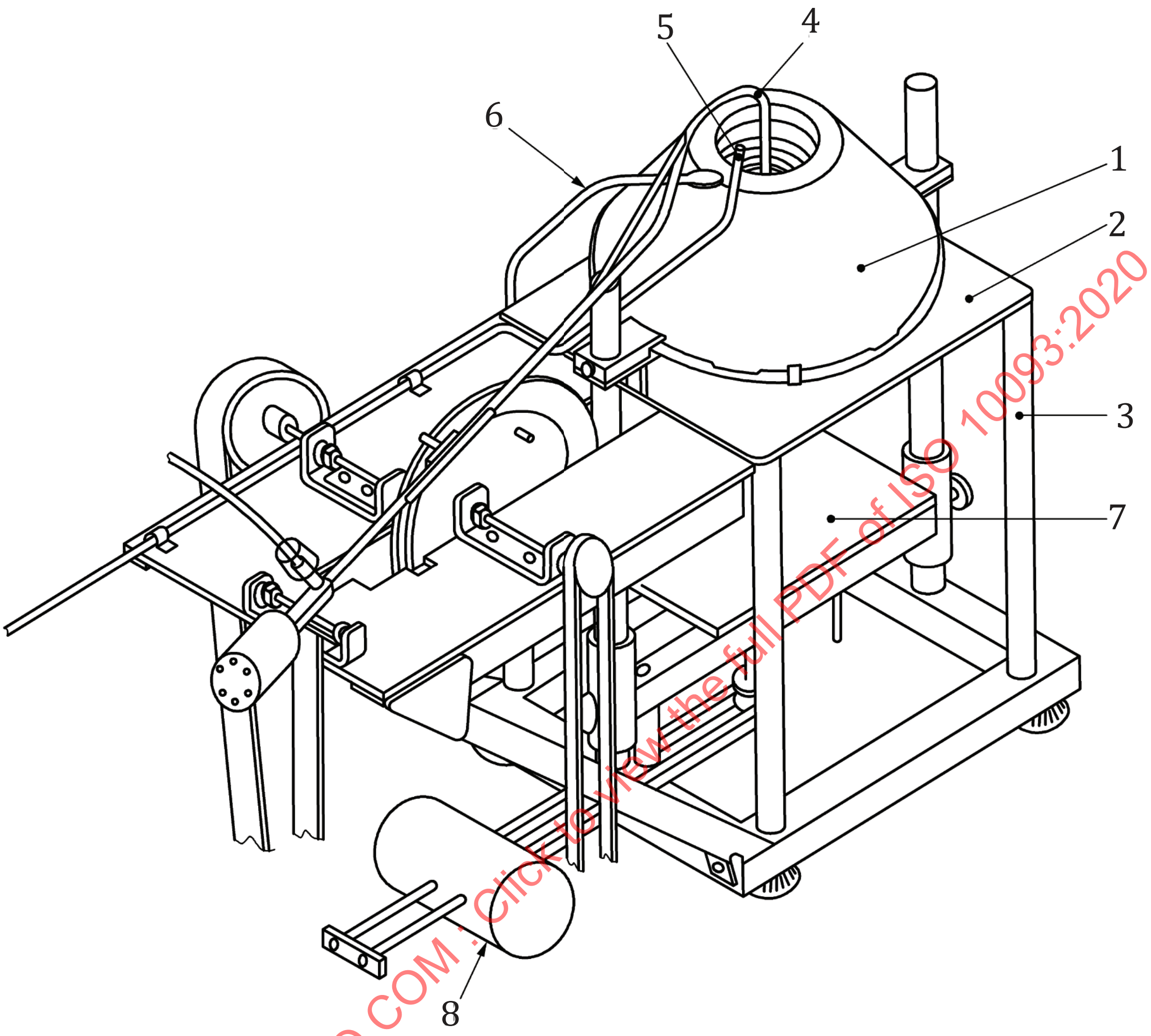
b) the variation of the irradiance within a circle of 100 mm diameter, drawn from the centre of the masking plate aperture, is not more than ±5 % of that at the centre.

The surface area of the specimen exposed to this thermal radiation shall be 154 cm^2. The heat flux shall be checked with a calibrated radiometer prior to testing.

9.1.4.3 The apparatus shall be provided with a pilot flame and a secondary ignition source. The pilot flame stainless steel nozzle tube shall be fed with a mixture of propane and air which is achieved by regulating the propane flow rate to 19 ml/min to 20 ml/min and the airflow rate to 160 ml/min to 180 ml/min. The flow rates are fed directly into the pilot flame from the flowmeters.

9.1.4.4 The apparatus has a mechanism capable of bringing the pilot flame from its “off” position outside and above the cone heater [at a height of (10 ± 1) mm above the underside of the masking plate] to its “test” position within the cone (at a distance of 10 mm above the test specimen), through the cone and through the aperture in the masking plate. When the flame is in the “off” position, it issues horizontally over the centre point of the aperture in the masking plate and perpendicular to the plane of the movement of the pilot arm, with the centre of the orifice in the nozzle positioned at the indicated height. The mechanism shall be such that the pilot flame moves every 4 s (+0,4 – 0 s) from the “off” position to the “test” position in no more than 0,5 s, then stays there for 1 s (+0,1 – 0 s) and then returns in a time of no more than 0,5 s.

9.1.4.5 The secondary ignition source shall be one of the following: a propane gas flame 15 mm long from a nozzle with an internal diameter of 1 mm to 2 mm (50 W in heat output) and a hot-wire or a spark igniter. The dipping of the pilot flame shall be continuous until ignition of the test specimen.



Key

1 radiator cone
2 masking plate
3 support framework
4 pilot flame source
5 secondary ignition source
6 heater cable
7 pressing plate
8 sliding counterweight

NOTE Source: IEC 60695-11-5:2016, Figure 1.

Figure 7 — Conical heater from periodic flaming ignition test schematic

9.2 Other radiant ignition sources

9.2.1 Glowbars ignition source

9.2.1.1 The ignition source described as the radiant heater from the Ohio State University rate of heat release apparatus is described in ASTM E906. A very similar version is used by the aviation authorities for assessing the ignitability and flammability of materials.

9.2.1.2 It consists of a radiant heat source for generating a heat flux of up to 100 kW/m^2 and uses four silicon carbide elements, Type LL, (508 ± 3) mm × (16 ± 1) mm, with a nominal resistance of 1,6 V. The silicon carbide elements are mounted in the stainless-steel panel box by inserting them through 15,9 mm holes in 0,8 mm thick ceramic fibre. A diamond-shaped mask, constructed of 24-gauge stainless steel, shall be added to provide uniform heat flux over the area occupied by a (150 × 150) mm vertical sample. The power supply provides 16,5 kVA, adjustable from 0 V to 270 V. The normal orientation of the test specimen is vertical.

9.2.1.3 The radiant source described in 9.2.1.2 has two pilot burners. The lower pilot burner, with nominally 11,3 mm outside diameter, a nominally 0,8 mm wall, and stainless-steel tubing, shall be used in all tests and is fed with an air/gas fuel mixture. The gas shall be methane or natural gas having 90 % or more methane. The fuel mixture shall be a methane–air mixture (120 cm^3/min gas, and 850 cm^3/min air). An upper pilot burner (which is used without air) shall be used when an impinging flame is used to obtain information at a heat flux below which the pyrolysis rate of the test specimen can maintain a combustible gas phase. It consists of a straight length of nominally 6,3 mm outside diameter, nominally 0,8 mm wall, and stainless-steel tubing nominally 360 mm long. At a heat flux above that producing a combustible gas mixture over the surface of the sample there is a choice of piloted or unpiloted ignition. In addition to piloted and non-piloted modes of operation, it is possible to accomplish pilot ignition of a test specimen by locating the pilot flame at different positions relative to the sample surface in such a fashion that the flame only impinges on the test specimen surface when necessary, with the location chosen depending on the nature of the ignition to be simulated by the test.

9.2.2 Lateral ignition and flame spread test (LIFT) radiant panel heater.

9.2.2.1 This ignition source is described in ISO 5658-2 and ASTM E1321 and it consists of a main frame, test specimen holders, a stack, a radiant panel and a pilot igniter. A series of test specimens [of dimension (155 × 155) mm] are exposed in ASTM E1321 to a nearly uniform heat flux and the time to flame attachment, using piloted ignition, is determined. The same ignition source is used in ISO 5658-2 and in ASTM E1321 to assess flame spread, using a test specimen of dimensions 155 mm × 800 mm.

9.2.2.2 The main frame consists of two separate sections, the radiant-panel support frame and the test specimen support frame. The two frame sections are joined so as to allow adjustments in the relative position of the radiant panel to the test specimen to be made easily.

9.2.2.3 The radiant panel consists of a radiation surface of porous refractory tiles mounted at the front of a stainless-steel plenum chamber to provide a flat radiating surface of approximately (280 × 483) mm. The plenum chamber includes baffle plates and diffusers to distribute the gas/air mixture evenly over the radiation surface. The gas/air mixture enters the plenum chamber at one of the short sides to facilitate easy connection when the panel is mounted from the frame. A reverberatory screen shall be provided immediately in front of the radiating surface to enhance the combustion efficiency and increase the radiant output.

9.2.2.4 The appropriate air and fuel flow-metering devices, gas control valves, pressure reducer and safety controls to support combustion at the radiant panel are all mounted on the panel support frame. The air supply shall be of approximately (8,33 × 10^{-3}) m^3/s at a pressure sufficient to overcome the friction loss through the line, metering device and radiant panel. The radiant-panel pressure drop amounts to approximately 20 Pa to 30 Pa. Flow rates are measured with a flowmeter suitable for indicating airflow over the range of 2 to (15 × 10^{-3}) m^3/s and with a flowmeter suitable for indicating methane flow rates over the range of 0,1 to (1,1 × 10^{-3}) m^3/s. The fuel gas used shall be either natural gas or methane. A constant supply pressure shall be maintained by means of a pressure regulator. Gas shall be either controlled by a manually adjusted needle valve or by a Venturi mixer. The Venturi mixer allows control of the flux level of the panel by adjusting only the air valve. The fuel gas-flow shall be roughly 0,26 to (1,03 × 10^{-3}) m^3/s at a pressure sufficient to overcome line pressure losses.

9.2.3 Setchkin ignition

9.2.3.1 ISO 871 and ASTM D1929 shall use as an ignition source the Setchkin apparatus furnace.

9.2.3.2 The equipment consists primarily of an electrical heating unit and a test specimen holder. The furnace has a furnace tube and an inner ceramic tube. The furnace tube shall be a vertical tube with an inside diameter of (100 ± 5) mm and a length of (230 ± 20) mm, made of a ceramic that is able to withstand at least 750 °C. The vertical tube stands on the furnace floor, fitted with a plug for the removal of accumulated residue. The ceramic tube shall be built to withstand at least 750 °C, with an inside diameter of (75 ± 5) mm, a length of (230 ± 20) mm, and a thickness of approximately 3 mm. It shall be placed inside the furnace tube and positioned (20 ± 2) mm above the furnace floor on three small spacer blocks. The top shall be covered by a disk of heat-resistant material with a (25 ± 2) mm diameter opening in the centre that is used for observation and passage of smoke and gases. The pilot flame shall be located immediately above the opening. An electrical heating unit, contained within a mineral fibre sleeve and constructed of 50 turns of (1,3 ± 0,1) mm Nichrome V alloy wire, shall be wound around the furnace tube and embedded in heat-resistant cement. Thermal insulation consists of a layer of mineral fibre, approximately 60 mm thick and covered by a metal jacket. The equipment is shown in Figure 8 (ISO 871:2006, Figure 1). Ignition is conducted either with or without a pilot igniter.

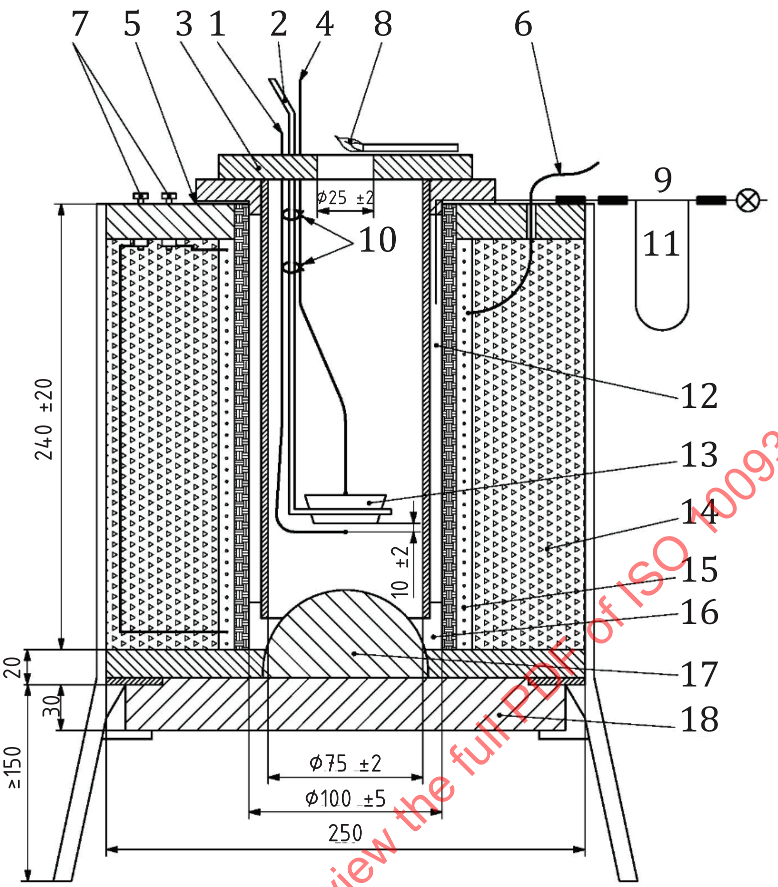
9.2.3.3 An outside air source shall be used to supply clean air near the top of the annular space between the ceramic tubes through a copper tube at a steady and controllable rate. Air shall be heated and circulated in the space between the two tubes and enters the inner furnace tube at the bottom. Air shall be metered by a rotameter or other suitable device.

9.2.3.4 The pilot igniter consists of a nominal (1,8 ± 0,3) mm inside diameter (ID) copper tubing attached to a gas supply of 94 % minimum purity propane and placed horizontally (5 ± 1) mm above the top surface of the disk cover. The pilot flame shall be adjusted to (20 ± 2) mm in length and centred above the opening in the disk cover.

9.2.3.5 The test specimen shall be placed inside a pan that consists of a metal container of approximately 0,5 mm thick steel measuring (40 ± 2) mm in diameter by (15 ± 2) mm in depth. It shall be held in a ring of approximately 2,0 mm diameter stainless steel welding rod. The ring shall be welded to a length of the same type of rod extending through the cover of the furnace. The bottom of the test specimen pan shall be located (185 ± 5) mm down from the top of the inner furnace tube.

9.2.3.6 Three thermocouples, 0,5 mm in diameter, either Chromel-Alumel (Type K) or Iron-Constantan (Type J), are used for temperature measurement. They are connected to a calibrated recording instrument with a tolerance not exceeding ±2 °C. Thermocouple TC_1 shall be used to measure the temperature of the test specimen and shall be located as close as possible to the centre of the upper surface of the test specimen when the test specimen is in place within the furnace. The thermocouple wire shall be attached to the test specimen support rod. Thermocouple TC_2 shall be used to indicate the temperature of the air travelling past the test specimen. It shall be located (10 ± 2) mm below the centre of the test specimen pan. The thermocouple wire shall be attached to the test specimen support rod. Thermocouple TC_3 shall be used to measure the temperature of the heating coil. It shall be located adjacent to the furnace heating coil and used as a reference for temperature adjustment purposes because of its faster response. Heating control shall be conducted by means of a variable transformer or an automatic controller connected in series with the heating coils.

Dimensions in millimetres



Key

1 thermocouple TC_2
2 support rod
3 refractory disc cover
4 thermocouple TC_1
5 gasket
6 thermocouple TC_3
7 heater terminals
8 pilot flame
9 air supply
10 metal fasteners
11 air-flow meter (not part of furnace)
12 air flow tangential to cylinder
13 specimen pan
14 mineral fibre wool
15 50 turns of no. 16 Nichrome wire in heat-resistant
16 three refractory blocks to space inner tube and
17 inspection plug (removable)
18 thermal insulation (removable)

NOTE Source: ISO 871:2006, Figure 1.

Figure 8 — Ignition source from Setchkin apparatus schematic

10 Infrared heating system

10.1 This ignition source is used in the fire propagation test apparatus developed by FM Global and it is described in ISO 12136, ASTM E2058 and in NFPA 287. The ignition source consists of the following components: an infrared heating system, a power controller, an ignition pilot flame and an ignition timer.

10.2 The ignition source shall be an infrared heating system. Each of four 241 mm long infrared heaters contains six tungsten-filament tubular quartz lamps in a compact reflector body that, for a 120 V input, produces 190 kW/m^2 of radiant flux in front of the quartz window that covers the lamps. The emitter of each lamp shall be a 127 mm long tungsten filament in an argon atmosphere enclosed in a 9,5 mm outer-diameter clear quartz tube. The emitter operates at a minimum of 2 475 K for a 120 V input to produce a spectral energy peak at 1,15 µm.

10.3 A power controller maintains the appropriate output voltage for the heater array despite variations in the line voltage and load impedance through the use of phase angle power control to match the hot/cold resistance characteristics of the tungsten-quartz lamps. The controller also incorporates average voltage feedback to linearize the relationship between the voltage set by the operator and the output voltage to the lamps.

10.4 A pilot ignition consists of an ethylene–air (60–40 by volume) flame adjusted for a 10 mm length and anchored at the horizontal end of a 50 mm long, 6,35 mm outer diameter, 4,70 mm inner diameter, stainless steel tube. The horizontal section of the tube contains a four-hole ceramic insert to produce a stable flame and prevent flashback. The pilot flame tube shall be able to be rotated and elevated to position the horizontal flame at specified locations near the specimen.

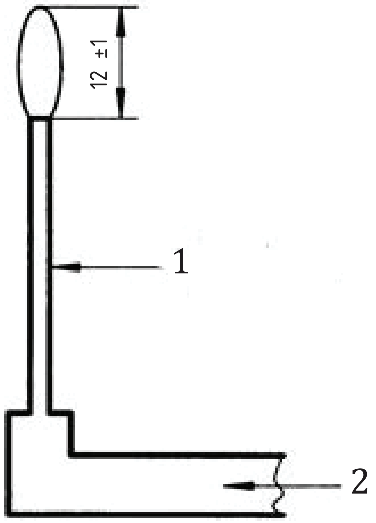
10.5 An ignition timer to assess time to ignition (also known as time to sustained flaming) shall be capable of recording elapsed time to the nearest 0,1 s and has an accuracy of better than 1 s in 1 h.

11 Diffusion flame ignition

11.1 Needle flame ignition

This ignition source, which is described in IEC 60695-11-5, consists of a needle flame which provides a low-intensity, low-area diffusion flame. This source is intended to simulate the effect of small flames resulting from fault conditions within electrical equipment. The needle burner consists of a piece of stainless-steel hypodermic tubing with the tapered end cut off. The burner has a minimum length of 35 mm with a bore of (0,5 ± 0,1) mm and an outer diameter not exceeding 0,9 mm. The burner shall be connected with flexible tubing to a cylinder containing butane or propane. The gas purity shall be of at least 95 %. Butane gas shall be the typical standard reference gas, but propane gas is also acceptable. With the axis of the needle burner in the vertical position, the gas supply shall be adjusted so that the length of the flame is (12 ± 1) mm. See Figure 9.

Dimensions in millimetres



Key

1 outside diameter: 0,9 mm maximum; bore diameter: (0,5 ± 0,1 mm)

2 gas supply from regulated flowmeter

NOTE Source: IEC 60695-11-5:2016, Figure 1.

Figure 9 — Needle flame ignition source schematic

11.2 Burning match

11.2.1 This ignition source is described in ISO 8191-1 and is a diffusion flame with a calorific output approximating to that of a burning match. A flame exposure time of (15 ± 2,0) s is approximately equivalent to the burning of one match.

11.2.2 The burner barrel consists of a stainless-steel tube with an outside diameter of (8,0 ± 0,1) mm, an internal diameter of (6,5 ± 0,1) mm and a length of (200 ± 5) mm.

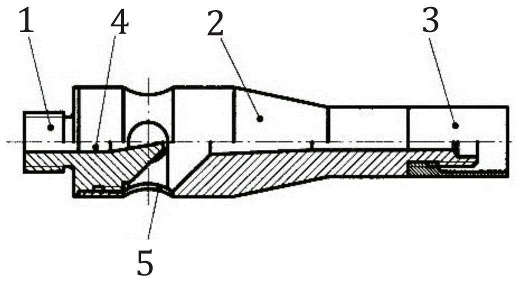
11.2.3 The burner tube shall be connected with flexible tubing to a cylinder containing propane and the flexible tubing between the flowmeter and the burner tube has an internal diameter of 8 mm and a length of (2,0 ± 0,2) m. The flowmeter shall be calibrated to supply a propane gas flow rate, at 25 °C, of (45 ± 2) ml/min. Under the above conditions, the flame height is approximately 40 mm. The area of impingement on the exposed surface of a specimen is (7,5 ± 0,2) cm^2 and the heat flux is (40 ± 2) kW/m^2. Butane gas shall be the typical standard reference gas, but propane gas is also acceptable.

11.2.4 An alternate burner with a similarly low intensity is described in ISO 11925-2. This ignition source is a laboratory burner constructed as shown in Figure 10 and designed so that it can be used vertically or tilted at 45° with respect to the vertical axis. The burner shall be fitted with a fine-adjustment valve to ensure accurate control of the flame height and provides a stable and directable flame.

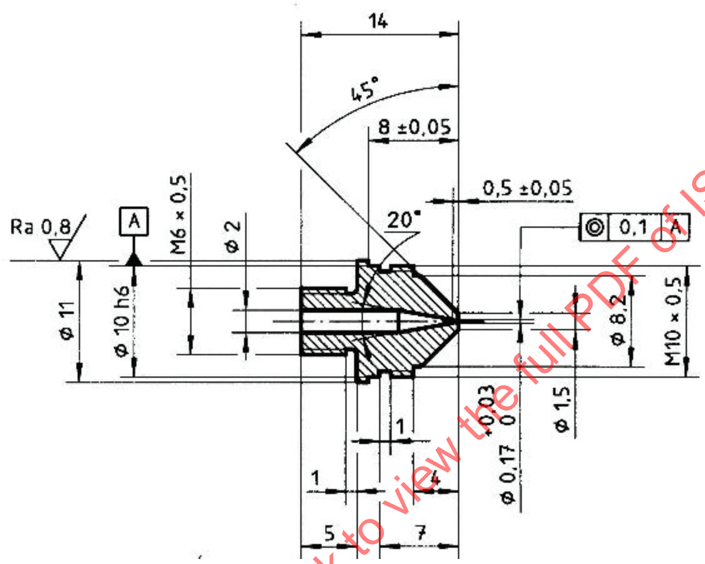
11.2.5 The burner shall be connected with flexible tubing to a cylinder containing propane (95 % minimum purity). The burner shall be brought into a vertical position and the flame adjusted by means of a needle valve to a height of (20 ± 1) mm.

11.2.6 The gas flow rate used in this ignition source shall be (25 ± 1) ml/min at 25 °C. The area of impingement on the exposed surface of a specimen shall be (4,2 ± 0,3) cm^2 and the heat flux shall be (37 ± 2) kW/m^2.

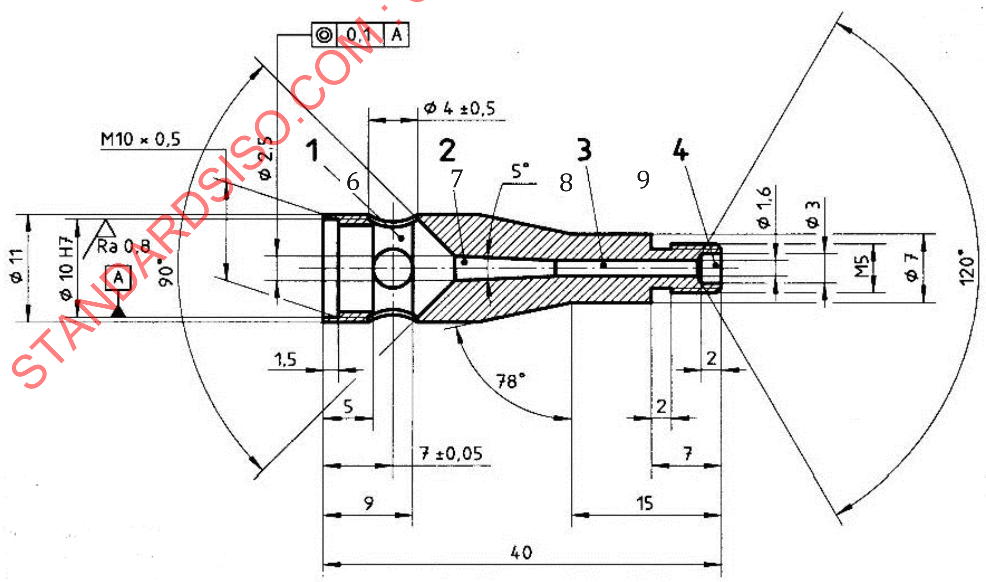
Dimensions in millimetres



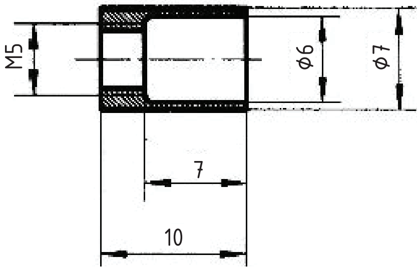
a) Burner assembly



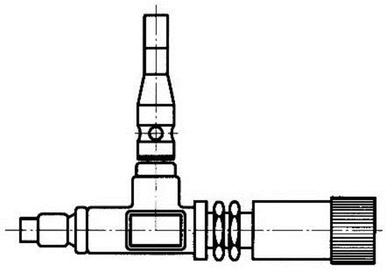
b) Gas jet



c) Burner tube



d) Flame stabilizer



e) Burner and adjustment valve

Key

1 gas jet
2 burner tube
3 flame stabilizer
4 choke tube
5 notch fitted in during assembly
6 gas mixing zone
7 acceleration section
8 conducting section
9 outlet

NOTE Source: ISO 11925-2:2010, Figure 2.

Figure 10 — Diffusion burner

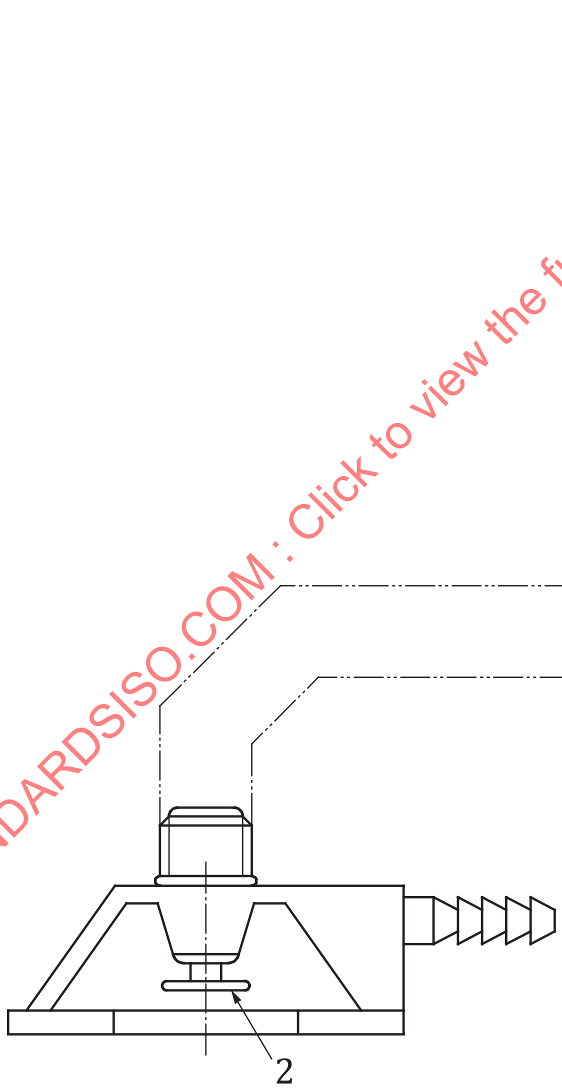
11.3 Burners generating 50 W or 500 W flames

11.3.1 This ignition source is a laboratory burner described in IEC 60695-11-4 and IEC 60695-11-10 for a 50 W flame and in IEC 60695-11-3 and IEC 60695-11-20 for a 500 W flame, as well as in ASTM D5025, for both types of flames. The burner consists of a barrel threading onto a one-piece base and gas inlet. The components are constructed of metal, typically of brass or aluminium. This burner is also suitable for use in the horizontal orientation, for example as used in ASTM D635 or in UL 94, or for testing at an angle of 60°, as used by aviation authorities (see Figure 11).

11.3.2 The burner barrel consists of a mixing tube and threaded air-inlet adapter. The mixing tube shall be of seamless construction, with an inside diameter of (9,5 ± 0,3) mm. The length of the barrel from the top of the air-inlet openings to the top of the mixing tube shall be (100 ± 10) mm. The top of the mixing tube is not equipped with end attachments, such as stabilizers. The air-inlet adapter, located at the bottom of the mixing tube, is approximately 25 mm high and 20 mm in overall diameter. The minimum area of the air-inlet openings is 225 mm^2 distributed equidistant around the adapter. With the barrel fully screwed into the base and the lock nut in place, it is essential that the air-inlet openings be completely closed.

11.3.3 The minimum area of the air-inlet openings has commonly been obtained by using three openings, approximately (6,5 × 12,5) mm. The base of the burner shall be equipped with an orifice of (0,90 ± 0,03) mm in diameter and (1,60 ± 0,05) mm in length and with a machined needle valve to restrict the orifice opening and regulate gas velocity through the burner. A knurled knob shall be provided for adjustment of the valve. The needle valve shall be machined with a conical point using an angle of 40° with a maximum flat top of 0,4 mm. The needle aligns with the orifice in the valve seat. Alignment can be confirmed by removing the barrel and igniting the fuel gas directly at the orifice. It is essential for the flame to remain vertical. If the flame slants, possible reasons include, but are not limited to, the orifice being off-centre or the needle being worn. The alignment shall be confirmed periodically, and appropriate actions shall be taken to ensure that the flame remains vertical. The base of the burner shall be provided with a serrated fitting for connection to the gas supply. The burner is also (optionally) provided with a lock nut that threads onto the base. This allows the barrel to be tightened securely against the lock nut when the particular test flames are associated with such positioning of the barrel that the air-inlet openings are partially or fully open.

Dimensions in millimetres



Key

1 internal diameter: (9,5 ± 0,3) mm

2 needle valve adjustment

Figure 11 — Burner for 50 W or 500 W flames

11.3.4 The characteristics of burners for a 50 W and a 500 W flame, including their associated dimensions, are given in Table 3.

Table 3 — Characteristics of 50 W and 500 W flame burners

Gas composition	Gas flow rate (ml/min)	Area of impingement (cm^2)	Minimum gas purity (%)
50 W: 20 mm high flame			
Methane	105	1,8	98
Propane	42	1,8	98
Butane	33	1,8	95
500 W: 125 mm high flame with 40 mm inner blue cone			
Methane	965	18	98
Propane	380	18	98
Butane	300	18	95

11.3.5 Information for the calibration of these gas diffusion burners is found in IEC 60695-11 and in ASTM D5207.

12 Premixed burners

12.1 Premixed burner for 1 kW flame

12.1.1 This ignition source is described in IEC 60695-11-2 and is also used in IEC 60332-1-1 and in IEC 60332-1-2. It provides a high-intensity premixed flame of uniform flux. It is intended to simulate the effect on materials of a secondary source arising from other flaming items in the vicinity, or from a fire in its early stages.

12.1.2 The burner (see Figure 12) consists of a brass barrel tube of the following dimensions: 17,0 mm outside diameter, 12,0 mm internal diameter and 110 mm length. The burner barrel is fitted with a gas injector and flame stabilizer which are removable for cleaning purposes. Both air [oil-free laboratory air, metered at (10 ± 0,5) L/min, at 23 °C, 101 kPa] and propane [of purity not less than 95 % and at a flow rate equivalent to (650 ± 30) ml/min, at 23 °C, 101 kPa] are metered separately to the base of the burner barrel. The area of impingement on the exposed surface of a test specimen is approximately 20 cm^2. The flow rates are for the preferred Method A.