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BASIC SAFETY PUBLICATION

PUBLICATION FONDAMENTALE DE SÉCURITÉ

Fire hazard testing –
Part 6-30: Smoke obscuration – Small-scale static method – Apparatus

Essais relatifs aux risques du feu –
Partie 6-30: Opacité des fumées – Méthode statique à petite échelle – Appareillage

IEC/TS 60695-6-30:2013

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

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- The subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC 60695-6-30, which is a technical specification, has been prepared by IEC technical committee 89: Fire hazard testing.

This second edition of IEC/TS 60695-6-30 cancels and replaces the first edition published in 1996. It constitutes a technical revision.

It has the status of a basic safety publication in accordance with IEC Guide 104 and ISO/IEC Guide 51.

This technical specification is to be used in conjunction with IEC/TS 60695-6-31.

The main changes with respect to the previous edition are listed below:

– This publication is to be re-designated as a technical specification.
– The title has been modified to align with the IEC Directives.
– The FOREWORD has been revised and updated.
– An INTRODUCTION has been added.
– The Scope has been updated.
– The normative references has been updated.
– The terms and definitions has been updated.
– Clause 4: Relevance of test data and special observations has been revised.
– Detailed editorial updates have been added throughout the document.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
89/1056/DTS	89/1094/RVC

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 60695 series, under the general title of *Fire hazard testing*, can be found on the IEC website.

Part 6 consists of the following parts:

Part 6-1: Smoke obscuration – General guidance
Part 6-2: Smoke obscuration – Summary and relevance of test methods
Part 6-30: Smoke obscuration – Small scale static method – Apparatus
Part 6-31: Smoke obscuration – Small-scale static test – Materials

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

• transformed into an International standard,
• reconfirmed,
• withdrawn,
• replaced by a revised edition, or
• amended.

INTRODUCTION

The risk of fire needs to be considered in any electrical circuit, and the objective of component, circuit and equipment design, and the choice of materials, is to reduce the likelihood of fire, even in the event of foreseeable abnormal use, malfunction or failure.

Electrotechnical products, primarily as victims of fire, may nevertheless contribute to the fire. One of the contributing hazards is the release of smoke, which may cause a reduction of visibility and/or orientation which could impede escape from the building, or could impede fire fighting.

Consequently, a reduction in the amount and the rate of generation of smoke produced by materials/products during a fire reduces damage to equipment, facilitates evacuation of people and facilitates the intervention of emergency services.

FIRE HAZARD TESTING –

Part 6-30: Smoke obscuration – Small-scale static method – Apparatus

1 Scope

This part of IEC 60695 describes the apparatus, calibration procedures and basic experimental procedures for the determination of the specific optical density of smoke produced by materials exposed vertically to a radiant heat source with or without the application of a pilot flame. The test specimens are of a defined size. The determination of the optical density is carried out in a pressure-controlled chamber previously calibrated with reference materials.

The test methods are only applicable to flat, solid, non-metallic test specimens, of materials used in electrotechnical products.

This technical specification does not provide a classification system for the behaviour of materials.

The test methods are not applicable for materials that melt and flow away from the direct impingement of heat flux.

The test methods are not recommended for further development for electrotechnical products nor are they recommended as the basis for regulation or other controls on smoke release due to the limitations of the physical fire model and the test specimen geometry – see Clause 4.

This basic safety publication is intended for use by technical committees in the preparation of standards in accordance with the principles laid down in IEC Guide 104 and ISO/IEC Guide 51.

One of the responsibilities of a technical committee is, wherever applicable, to make use of basic safety publications in the preparation of its publications. The requirements, test methods or test conditions of this basic safety publication will not apply unless specifically referred to or included in the relevant publications.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60584-1:1995, *Thermocouples – Part 1: Reference tables*

IEC 60584-2:1982, *Thermocouples – Part 2: Tolerances*
Amendment 1 (1989)

ISO 5659-2:2012, *Plastics – Smoke generation – Part 2: Determination of optical density by a single-chamber test*

ISO 19706:2011, *Guidelines for assessing the fire threat to people*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply:

3.1
fire effluent
totality of gases and aerosols, including suspended particles, created by combustion or pyrolysis in a fire

[SOURCE: ISO 13943, definition 4.105]

3.2
fire hazard assessment
evaluation of the possible causes of fire, the possibility and nature of subsequent fire growth, and the possible consequences of fire

3.3
fire-safety engineering
application of engineering methods based on scientific principles to the development or assessment of designs in the built environment through the analysis of specific fire scenarios or through the quantification of risk for a group of fire scenarios

[SOURCE: ISO 13943, definition 4.126]

3.4
fire scenario
qualitative description of the course of a fire with respect to time, identifying key events that characterise the studied fire and differentiate it from other possible fires

Note 1 to entry: It typically defines the ignition and fire growth processes, the fully developed fire stage, the fire decay stage, and the environment and systems that impact on the course of the fire.

[SOURCE: ISO 13943, definition 4.129]

3.5
heat flux
amount of thermal energy emitted, transmitted or received per unit area and per unit time

Note 1 to entry: The typical units are watts per square metre ($W \times m^{-2}$).

[SOURCE: ISO 13943, definition 4.173]

3.6
obscuration by smoke
reduction in the intensity of light due to its passage through smoke

Note 1 to entry: In practice, obscuration of smoke is usually measured as the transmittance, which is normally expressed as a percentage.

Note 2 to entry: Obscuration of smoke causes a reduction in visibility.

[SOURCE: ISO 13943, definition 4.242]

3.7
opacity of smoke
ratio of incident light intensity to transmitted light intensity through smoke, under specified conditions

Note 1 to entry: Opacity of smoke is the reciprocal of transmittance.

Note 2 to entry: The opacity of smoke is dimensionless.

[SOURCE: ISO 13943, definition 4.243]

3.8
optical density of smoke
measure of the attenuation of a light beam passing through smoke expressed as the logarithm to the base 10 of the opacity of smoke

cf. **specific optical density**, D_s (3.13)

Note 1 to entry: The optical density of smoke is dimensionless.

[SOURCE: ISO 13943, definition 4.244]

3.9
physical fire model
laboratory process, including the apparatus, the environment and the fire test procedure intended to represent a certain phase of a fire

[SOURCE: ISO 13943, definition 4.251]

3.10
real-scale fire test
fire test that simulates a given application, taking into account the real scale, the real way the item is installed and used, and the environment

Note 1 to entry: Such a fire test normally assumes that the products are used in accordance with the conditions laid down by the specifier and/or in accordance with normal practice.

[SOURCE: ISO 13943, definition 4.273]

3.11
small-scale fire test
fire test performed on a test specimen of small dimensions

Note 1 to entry: A fire test performed on a test specimen of which the maximum dimension is less than 1 m is usually called a small-scale fire test.

[SOURCE: ISO 13943, definition 4.292]

3.12
smoke
visible part of fire effluent

[SOURCE: ISO 13943, definition 4.293]

3.13
specific optical density, *Ds*
optical density of smoke multiplied by a geometric factor, plus a filter factor

Note 1 to entry: The geometric factor is $V/(A \times L)$, where V is the volume of the test chamber, A is the area of the exposed surface of the test specimen, and L is the light path length.

Note 2 to entry: The use of the term “specific” does not denote “per unit mass” but rather denotes a quantity associated with a particular test apparatus and area of the exposed surface of the test specimen.

Note 3 to entry: The filter factor is a number that is calculated from the optical density of a moveable neutral density filter (see Clause 7.2).

Note 4 to entry: The specific optical density of smoke is dimensionless.

3.14
transmittance
⟨smoke⟩ ratio of transmitted light intensity through smoke to incident light intensity, under specified conditions

Note 1 to entry: Transmittance through smoke is the reciprocal of opacity of smoke.

Note 2 to entry: The transmittance is dimensionless and is usually expressed as a percentage.

cf. **obscuration of smoke** (3.6).

[SOURCE: ISO 13943 definition 4.346]

4 Relevance of test data and special observations

This small-scale fire test apparatus has been in worldwide use since about 1970, primarily for material evaluation purposes. In the early 1990s, ISO TC 61 developed a similar apparatus that was designed, in part, to overcome a number of limitations of the IEC apparatus, and in 1994 the first edition of ISO 5659-2 was published. It is now recognised that ISO 5659-2 overcomes the following significant limitations:

a) The heat flux is relatively low; consequently the method is only able to replicate conditions found in ISO 19706 fire stage 1b and, possibly, fire stage 2.

b) The test specimen is vertically mounted, which excludes liquids and some thermoplastics. Test specimens which swell towards the furnace also give problems, as the incident heat flux experienced by the front of the test specimen increases significantly, and the pilot flames can be extinguished, rendering the test invalid.

c) The limitations of the low heat flux and test specimen geometry mean that it is difficult to establish a link between data from the apparatus and real fire scenarios.

d) There are no means of monitoring the test specimen mass during the test

Further limitations include the following:

e) There is little or no correlation between data from this apparatus, and the behaviour of products in fires or real-scale fire tests.

f) The air supply is limited and the test specimen ceases to burn if the oxygen concentration falls below approximately 14 %.

g) The deposition of smoke on the walls is significant.

The test methods do however offer the useful option to evaluate smoke production from both flaming and non-flaming combustion, albeit at a low heat flux.

The data generated are not suitable for use as input to fire hazard assessment or for fire safety engineering.

Overall, these test methods are not recommended for further development for electrotechnical products. Neither are they recommended as the basis for regulation or other controls on smoke release for electrotechnical products, due to the limitations of the physical fire model and the test specimen geometry.

5 Principle

A test specimen, mounted vertically, is exposed to a controlled thermal radiation in a pressure-controlled chamber, with or without the application of a pilot flame.

A photometric system is used to measure the opacity of the smoke generated.

6 Apparatus

6.1 General

This apparatus is able to measure a maximum specific optical density of 528 with the moveable filter in place, and 924 without this filter.

WARNING: Appropriate safety measures are to be taken as toxic and harmful fire effluents may be produced by pyrolysis or combustion of test specimens.

A description of the test apparatus is given in Annex A (Figures A.1 to A.8).

The details of construction are given in Annex B.

The calibration procedure and suggestions for maintenance are given in Annex C.

Two examples of the test apparatus are given in Annex D.

6.2 Test chamber

6.2.1 Volume and dimensions

The test chamber has a nominal volume of 0,51 m³ and the following internal dimensions:

– width: 914 mm ± 3 mm
– depth: 610 mm ± 3 mm
– height: 914 mm ± 3 mm

The interior surfaces shall be suitable for periodic cleaning and resistant to corrosion.

NOTE Example of panel construction: interior surface made of enamelled steel, core panels made of thermally insulating material, exterior surface made of galvanized steel.

6.2.2 Pressure control

When closed, the chamber shall be capable of maintaining positive pressure during test periods, in accordance with 6.3. A water manometer is suitable for measuring the chamber pressure.

A blow-out sheet of aluminium foil approximately 0,04 mm thick is used to cover an aperture in the floor of the chamber, to provide protection against a sudden increase in pressure. Before installing, carefully degrease, clean and wipe the floor of the chamber around the aperture.

Care shall be taken not to wrinkle the foil so that no leakage develops at any creases.

A stainless steel grid can be placed over the aluminium foil to protect it. A stainless steel receptacle can be placed under the test specimen holder to collect flow from a melting test specimen which might damage the aluminium foil.

6.2.3 Exhaust system

An exhaust system complying with environmental safety regulations shall be connected to the smoke outlet.

6.2.4 Temperature measurement

A thermocouple shall be fixed to the centre of the inner surface of the wall opposite the door to measure the inside temperature (see B.9).

IEC 60584-1 contains reference tables for thermocouples, and IEC 60584-2 gives tolerances.

6.3 Furnace (radiant heat source)

The furnace is a ceramic tube with an inside diameter of approximately 76,2 mm, containing an electric heating element (see Figure A.2) and constructed and positioned as described in B.2.

The furnace and its support are positioned so that the distance between the heating element and the test specimen surface is 76,2 mm ± 1,0 mm.

The furnace operation shall be permanently monitored by means of an appropriate system. The output from the furnace shall be controlled such that the radiance level is maintained within the specified limits of 25 kW × m^{-2} ± 0,5 kW × m^{-2} averaged over a 38,1 mm diameter circle at the centre of the test specimen position (see Annex C).

6.4 Test specimen holder and support

The test specimen holder (see Figure A.4 and Clause B.3) is placed on a support attached to the furnace support so that the centre of the test specimen can be moved by an appropriate device along the centreline of the furnace.

A blank test specimen holder, consisting of a refractory plate 76,2 mm × 76,2 mm shall be located in front of the furnace opening, whenever the furnace is energised, except during testing or calibration.

The refractory plate is held against the lips of the front of the test specimen holder by a spring and retaining rod.

NOTE A plate with a nominal density of between 800 kg × m^{-3} and 970 kg × m^{-3} and a minimum thickness of 10 mm has been found to be satisfactory.

6.5 Gas burner

During flaming exposure tests, a burner (see B.5) with a row of six tubes is fixed so that the tips of the horizontal tubes are centred 6,4 mm ± 1,5 mm above the lower opening of the test specimen holder (N dimension in Figure A.4) and 6,4 mm ± 0,8 mm away from the test specimen area (dimension M in Figure A.4).

The fuel used shall be a mixture of propane (purity 95 % or better) and air at flowrates of 50 cm^3 × min^{-1} ± 5 cm^3 × min^{-1} and 500 cm^3 × min^{-1} ± 25 cm^3 × min^{-1} respectively. The flow-rates are adjusted by needle valves and measured by two flow meters.

6.6 Photometric system

6.6.1 General

The photometric system consists of a light source and photodetector oriented vertically to reduce measurement variations resulting from stratification of the smoke (see Figure A.5 and Clause B.6).

The photometric system shall ensure the recording of optical densities over 6 sensitivity ranges for the measurement of the transmittance factors comprised between 0,000 1 % and 100 %.

The photometer shall have an accuracy of better than ± 3 % of the maximum reading on any sensitivity range. The output of the photodetector is connected to a recording device.

6.6.2 Light source

The light source is an incandescent tungsten filament lamp (nominally 6,5 V) mounted in a light-tight box separated from the test chamber by a window located in the floor, heated to about 50 °C in order to prevent condensation.

This box shall contain the necessary optics to provide a collimated light beam of 38,1 mm diameter passing vertically through the chamber.

6.6.3 Photodetector

The photodetector is a photomultiplier tube with a dark current of less than 1 nA and an S-4 spectral sensitivity response in accordance with the ILC[1], located at the top of the chamber opposite the light source in a light-tight box isolated from the test chamber by a window located in the ceiling. A converging lens shall be used to focus the beam on the detector. A removable neutral filter with a nominal optical density of 2, is used to extend the range of measurements of the optical density.

6.7 Radiometer

A radiometer shall be available to measure the heat flux from the furnace (see B.7).

6.8 Measuring and recording devices

A data recorder shall be available to measure:

– the radiometer output voltage when calibrating the furnace (see Annex C);
– the photodetector output voltage during the tests (see 6.6).

7 Calibration and verification

7.1 Furnace calibration

Before any calibration or test, the temperature of the rear wall panel of the test chamber shall be stabilised at 33 °C ± 4 °C, the apparatus cleaned of any residues from previous tests, and flushed with air for at least 2 min.

The furnace shall be calibrated using the following procedure:

Remove the burner, mount the radiometer in the furnace in the stand-by position and connect to the electrical and gas services. Place the blank test specimen holder in position in front of the furnace. Move the radiometer in front of the furnace by displacing the blank test specimen holder against the stop on the supporting framework, and check the accuracy of the radiometer alignment relative to the furnace opening using the 38,1 mm gauge, and make any necessary adjustments (see C.1.2).

NOTE This test is sensitive to small variations in the position of the radiometer and of test specimens relative to the radiant heat source. The furnace gauge can also be used for checking the position of test specimen holders.

Return the radiometer and blank test specimen holder to their former positions, bring the apparatus to its normal operating condition with the chamber wall temperature remaining steady at 33 °C ± 4 °C, and move the radiometer to be in front of the furnace by displacing the blank test specimen holder against the stop.

[1] ILC: International Lighting Commission