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INTERNATIONAL STANDARD

NORME INTERNATIONALE

BASIC SAFETY PUBLICATION

PUBLICATION FONDAMENTALE DE SÉCURITÉ

Fire hazard testing –
Part 6-2: Smoke obscuration – Summary and relevance of test methods

Essais relatifs aux risques du feu –
Partie 6-2: Opacité des fumées – Résumé et pertinence des méthodes d'essais

IEC 60695-6-2:2011

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FIRE HAZARD TESTING –

**Part 6-2: Smoke obscuration –
Summary and relevance of test methods**

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 60695-6-2 has been prepared by IEC technical committee 89: Fire hazard testing.

This standard cancels and replaces IEC/TS 60695-6-2 published in 2005. This first edition constitutes a technical revision.

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

– this publication has been re-designated as an International Standard;
– updated normative references;
– updated terms and definitions;
– new test method Clause 7.3.2;
– numerous editorial changes of a technical nature throughout the publication.

This standard is to be used in conjunction with IEC 60695-6-1.

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

The text of this standard is based on the following documents:

Enquiry draft	Report on voting
89/1057/FDIS	89/1071/RVD

Full information on the voting for the approval of this standard 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: Guidance and test methods on the assessment of obscuration hazard of vision caused by smoke opacity from electrotechnical products involved in fires – Small scale static method – Determination of smoke opacity – Description of the 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

- 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 loss of vision and/or disorientation which could impede escape from the building, or fire fighting.

This international standard describes smoke test methods in common use to assess the smoke release from electrotechnical products, or from materials used in electrotechnical products. It forms part of the IEC 60695-6 series which gives guidance to product committees wishing to incorporate test methods for smoke obscuration in product standards.

FIRE HAZARD TESTING –

Part 6-2: Smoke obscuration – Summary and relevance of test methods

1 Scope

This part of IEC 60695 provides a summary of the test methods that are used in the assessment of smoke obscuration. It presents a brief summary of static and dynamic test methods in common use, either as international standards or national or industry standards. It includes special observations on their relevance to electrotechnical products and their materials and to fire scenarios, and it gives recommendations on their use.

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 referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60695-6-1:2005, Fire hazard testing – Part 6-1: *Smoke obscuration – General guidance*

IEC Guide 104:, *The preparation of safety publications and the use of basic safety publications and group safety publications*

ISO/IEC 13943:2008, *Fire safety – Vocabulary*

ISO 5725-2:1994, *Accuracy (trueness and precision) of measurement methods and results – Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method*

ISO 19706:2007[1], *Guidelines for assessing the fire threat to people*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 13943, some of which are reproduced below for users' convenience, apply.

3.1
combustion
exothermic reaction of a substance with an oxidising agent

[1] This publication cancels and replaces ISO 9122-1:1989, Toxicity testing of fire effluents – Part 1: General.

NOTE Combustion generally emits fire effluent accompanied by flames and/or glowing.

[ISO/IEC 13943, definition 4.46]

3.2
extinction area of smoke
product of the volume occupied by smoke and the extinction coefficient of the smoke

NOTE It is a measure of the amount of smoke, and the typical units are square metres (m^2).

[ISO/IEC 13943, definition 4.92]

3.3
extinction coefficient
natural logarithm of the ratio of incident light intensity to transmitted light intensity, per unit light path length

NOTE Typical units are reciprocal metres (m^{-1}).

[ISO/IEC 13943, definition 4.93]

3.4
fire
(general) process of combustion characterized by the emission of heat and fire effluent and usually accompanied by smoke, flame, glowing or a combination thereof

NOTE In the English language the term "fire" is used to designate three concepts, two of which, fire (3.5) and fire (3.6), relate to specific types of self-supporting combustion with different meanings and two of them are designated using two different terms in both French and German.

[ISO/IEC 13943, definition 4.96]

3.5
fire
(controlled) self-supporting combustion that has been deliberately arranged to provide useful effects and is limited in its extent in time and space

[ISO/IEC 13943 definition 4.97]

3.6
fire
(uncontrolled) self-supporting combustion that has not been deliberately arranged to provide useful effects and is not limited in its extent in time and space

[ISO/IEC 13943 definition 4.98]

3.7
fire effluent
totality of gases and aerosols, including suspended particles, created by combustion or pyrolysis in a fire

[ISO/IEC 13943, definition 4.105]

3.8
fire hazard
physical object or condition with a potential for an undesirable consequence from fire

[ISO/IEC 13943, definition 4.112]

3.9
fire model
fire simulation
calculation method that describes a system or process related to fire development, including fire dynamics and the effects of fire

[ISO/IEC 13943, definition 4.116]

3.10
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 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.

[ISO/IEC 13943 definition 4.129]

3.11
heat flux
amount of thermal energy emitted, transmitted or received per unit area and per unit time

NOTE The typical units are watts per square metre ($W \cdot m^{-2}$).

[ISO/IEC 13943, definition 4.173]

3.12
ignition
sustained ignition (deprecated)
(general) initiation of combustion

[ISO/IEC 13943, definition 4.187]

3.13
ignition
sustained ignition (deprecated)
(flaming combustion) initiation of sustained flame

[ISO/IEC 13943 definition 4.188]

3.14
mass optical density of smoke
optical density of smoke multiplied by a factor, $V/(\Delta m\ L)$, where V is the volume of the test chamber, Δm is the mass lost from the test specimen, and L is the light path length

NOTE The typical units are square metres per gram ($m^2 \times g^{-1}$).

[ISO/IEC 13943, definition 4.225]

3.15
obscuration by smoke
reduction in the intensity of light due to its passage through smoke

cf. **extinction area of smoke** (3.2) and **specific extinction area of smoke** (3.23).

NOTE 1 In practice, obscuration by smoke is usually measured as the transmittance, which is normally expressed as a percentage.

NOTE 2 Obscuration by smoke causes a reduction in visibility.

[ISO/IEC 13943 definition 4.242]

3.16
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 of smoke** (3.24)

NOTE The optical density of smoke is dimensionless.

[ISO/IEC 13943, definition 4.244]

3.17
physical fire model
laboratory process, including the apparatus, the environment and the fire test procedure intended to represent a certain phase of a fire

[ISO/IEC 13943, definition 4.251]

3.18
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 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.

[ISO/IEC 13943, definition 4.273]

3.19
small-scale fire test
fire test performed on a test specimen of small dimensions

NOTE 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.

[ISO/IEC 13943, definition 4.292]

3.20
smoke
visible part of fire effluent

[ISO/IEC 13943, definition 4.293]

3.21
smoke production rate
amount of smoke produced per unit time in a fire or fire test

NOTE 1 It is calculated as the product of the volumetric flow rate of smoke and the extinction coefficient of the smoke at the point of measurement.

NOTE 2 The typical units are square metres per second ($m^2 \times s^{-1}$).

[ISO/IEC 13943 definition 4.295]

3.22
smoke release rate
see **smoke production rate** (3.21)

3.23
specific extinction area of smoke
extinction area of smoke produced by a test specimen in a given time period divided by the mass lost from the test specimen in the same time period

NOTE The typical units are square metres per gram ($m^2 \cdot g^{-1}$).

[ISO/IEC 13943 definition 4.301]

3.24
specific optical density of smoke
optical density of smoke multiplied by a geometric factor

NOTE 1 The geometric factor is $V/(A \cdot L)$, 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 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 The specific optical density of smoke is dimensionless.

[ISO/IEC 13943 definition 4.303]

3.25
visibility
maximum distance at which an object of defined size, brightness and contrast can be seen and recognized

[ISO/IEC 13943 definition 4.350]

4 Types of of test method

4.1 General

Test methods are characterised by whether they are static or dynamic and/or by the nature of the test specimen.

4.2 Physical fire model

The amount and rate of smoke released from a given material or product is not an inherent property of that material or product, but is critically dependent on the conditions under which that material or product is burnt. Decomposition temperature, amount of ventilation and fuel composition are the main variables which affect the composition of fire effluent, and hence the amount of smoke and smoke production rate.

It is critical to show that the test conditions defined in a standardised test method (the physical fire model) are relevant to, and replicate the desired stage of a real fire. ISO has published a general classification of fire stages in ISO 19706, shown in Table 1. The important factors affecting smoke production are oxygen concentration and irradiance/temperature.

4.3 Static test methods

A static smoke test is one in which the smoke generated is allowed to accumulate within the test chamber. Some re-circulation and secondary combustion of smoke particles may occur. The obscuration by smoke may be affected by deposition, agglomeration, stirring and progressive oxygen depletion.

4.4 Dynamic test methods

A dynamic smoke test is one in which there is a continuous flow of fire effluent through the measuring device without re-circulation. In this test, the smoke particles generated are not allowed to accumulate and are dispersed in the controlled air flow through the test apparatus. Decay of the smoke can occur in a dynamic test, and may involve coagulation of particles and/or their deposition on cooling.

Table 1 – Characteristics of fire stages (ISO 19706)

Fire stages	Heat flux to fuel surface kW/m²	Max. temperature °C		Oxygen volume %		Fuel/air equivalence ratio (plume)	$\frac{[CO]}{[CO_2]}$ v/v	$\frac{100 \times [CO_2]}{([CO_2]+[CO])}$ % efficiency
		Fuel surface	Upper layer	Entrained	Exhausted			
1. Non-flaming								
a. self-sustaining (smouldering)	not applicable	450 to 800	25 to 85 [d]	20	20	—	0,1 to 1	50 to 90
b. oxidative pyrolysis from externally applied radiation	—	300 to 600 [a]	[b]	20	20	< 1	[c]	[c]
c. anaerobic pyrolysis from externally applied radiation	—	100 to 500	[b]	0	0	>> 1	[c]	[c]
2. Well-ventilated flaming [d]	0 to 60	350 to 650	50 to 500	≈ 20	≈ 20	< 1	< 0,05 [e]	> 95
3. Under-ventilated flaming [f]								
a. small, localized fire, generally in a poorly ventilated compartment	0 to 30	300 to 600 [a]	50 to 500	15 to 20	5 to 10	> 1	0,2 to 0,4	70 to 80
b. post-flashover fire	50 to 150	350 to 650 [g]	> 600	< 15	< 5	> 1 [h]	0,1 to 0,4 [i]	70 to 90

a The upper limit is lower than for well-ventilated flaming combustion of a given combustible.

b The temperature in the upper layer of the fire room is most likely determined by the source of the externally applied radiation and room geometry.

c There are few data; but for pyrolysis, this ratio is expected to vary widely depending on the material chemistry and the local ventilation and thermal conditions.

d The fire's oxygen consumption is small compared to that in the room or the inflow, the flame tip is below the hot gas upper layer or the upper layer is not yet significantly vitiated to increase the CO yield significantly, the flames are not truncated by contact with another object, and the burning rate is controlled by the availability of fuel.

e The ratio may be up to an order of magnitude higher for materials that are fire-resistant. There is no significant increase in this ratio for equivalence ratios up to ≈ 0,75. Between ≈ 0,75 and 1, some increase in this ratio may occur.

f The fire's oxygen demand is limited by the ventilation opening(s); the flames extend into the upper layer.

g Assumed to be similar to well-ventilated flaming.

h The plume equivalence ratio has not been measured; the use of a global equivalence ratio is inappropriate.

i Instances of lower ratios have been measured. Generally, these result from secondary combustion outside the room vent.

5 Types of test specimen

The test specimen may be a manufactured product, a component of a product, a simulated product (representative of a portion of a manufactured product), a basic material (solid or liquid), or a composite of materials.

6 Published static test methods

6.1 General

The static test methods reviewed below were selected on the basis that they are published international, national or industry standards, and are in common usage in the electrotechnical field. It is not intended to review all possible test methods.

NOTE These summaries are intended as a brief outline of the test methods, and should not be used in place of full published standards.

6.2 Determination of smoke opacity in a 0,51 m^3 chamber

6.2.1 Standards which use a vertically oriented test specimen

6.2.1.1 Standards

Two international and four national standards are based on testing a vertically oriented test specimen in a single chamber of 0,51 m^3 volume.

NOTE The chamber was developed in the USA by the National Bureau of Standards (now known as the National Institute of Standards and Technology) and is often referred to as the "NBS chamber".

These are: IEC/TR 60695-6-30 [1][2] and IEC 60695-6-31 [2], ASTM E662 [3], BS 6401 [4], NF C20-902-1 [5] and NF C20-902-2 [6].

6.2.1.2 Purpose and principle

This small-scale fire test is used to assess the opacity of the smoke generated by a vertically oriented test specimen of material exposed to a specified thermal irradiance, with or without pilot flames, in a closed chamber 0,51 m^3 in volume. The luminous flux through the smoke is continuously recorded.

6.2.1.3 Test specimen

The test specimen is a flat piece 76,2 mm × 76,2 mm, with a maximum thickness of 25,4 mm.

6.2.1.4 Method

The method employs an electrical radiant energy source mounted so as to produce a heat flux of 25 kW/m^2 on a vertically mounted test specimen. Two modes of test are commonly used:

a) non-flaming, where only the radiant energy source is used, or

b) flaming, where a small burner is used in addition to the radiant energy source. This burner produces a row of pilot flames along the lower edge of the test specimen, which ignite any combustion products.

A photometric system using polychromatic white light, with a vertical light path is used to measure the variation in light transmission during the test.

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2 Figures in square brackets refer to the Bibliography.