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Edition 2.0 2018-06

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 60695-6-2:2018-06(en-fr)

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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 60695-6-2 published in 2011. This second edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) updated introduction;
b) updated normative references;
c) new text in 4.1;
d) deletion of references to IEC 60695-6-30 and -31 (withdrawn)
e) updates with respect to ISO 5659-2;

f) deletion of references to BS 6853 and CEI 20-37-3 (superseded);
g) deletion of references to ISO/TR 5924 (withdrawn);
h) updated text with respect to EN 50399;
i) updated text with respect to ISO 5660-1;
j) addition of new Subclause 7.5
k) deletion of Annex B;
l) deletion of Annex E;
m) additional bibliographic references.

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:

FDIS	Report on voting
89/1399/FDIS	89/1405/RVD

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

This document 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 *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

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

In the design of an electrotechnical product the risk of fire and the potential hazards associated with fire need to be considered. In this respect the objective of component, circuit and equipment design, as well as the choice of materials, is to reduce the risk of fire to a tolerable level even in the event of reasonably foreseeable (mis)use, malfunction or failure. IEC 60695-1-10 [1][1], IEC 60695-1-11 [2], and IEC 60695-1-12 [3] provide guidance on how this is to be accomplished.

Fires involving electrotechnical products can also be initiated from external non-electrical sources. Considerations of this nature are dealt with in an overall fire hazard assessment.

The aim of the IEC 60695 series is to save lives and property by reducing the number of fires or reducing the consequences of the fire. This can be accomplished by:

- trying to prevent ignition caused by an electrically energised component part and, in the event of ignition, to confine any resulting fire within the bounds of the enclosure of the electrotechnical product.
- trying to minimise flame spread beyond the product's enclosure and to minimise the harmful effects of fire effluents including heat, smoke, and toxic or corrosive combustion products.

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

[1] Numbers in square brackets refer to the bibliography.

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 commonly used test methods for 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 gives recommendations on their use.

This basic safety publication shall be used 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 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.

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

ISO/IEC Guide 51, *Safety aspects – Guidelines for their inclusion in standards*

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

ISO 5660-1:2015, *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 13943:2008, *Fire safety – Vocabulary*

ISO 19706:2011, *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 13943:2008, some of which are reproduced below for users' convenience, and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
combustion
exothermic reaction of a substance with an oxidising agent

Note 1 to entry: Combustion generally emits fire effluent accompanied by flames and/or glowing.

[SOURCE: ISO 13943:2008, 4.46]

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

Note 1 to entry: It is a measure of the amount of smoke, and the typical units are square metres (m^2).

[SOURCE: ISO 13943:2008, 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 1 to entry: Typical units are reciprocal metres (m^{-1}).

[SOURCE: ISO 13943:2008, 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 1 to entry: 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.

[SOURCE: ISO 13943:2008, 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

[SOURCE: ISO 13943:2008, 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

[SOURCE: ISO 13943:2008, 4.98]

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

[SOURCE: ISO 13943:2008, definition 4.105]

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

[SOURCE: ISO 13943:2008, 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

[SOURCE: ISO 13943:2008, 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 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 13943:2008, 4.129]

3.11
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 × m^{-2}).

[SOURCE: ISO 13943:2008, 4.173]

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

[SOURCE: ISO 13943:2008, 4.187]

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

[SOURCE: ISO 13943:2008, 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 1 to entry: The typical units are square metres per gram (m^2 × g^{-1}).

[SOURCE: ISO 13943:2008, 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 to entry: In practice, obscuration by smoke is usually measured as the transmittance, which is normally expressed as a percentage.

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

[SOURCE: ISO 13943:2008, 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** (3.25)

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

[SOURCE: ISO 13943:2008, 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

[SOURCE: ISO 13943:2008, 4.251]

3.18
plenum
area located above false ceilings where heating, ventilating or air-conditioning ducts are located, as well as communication cables and other utilities

3.19
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 13943:2008, 4.273]

3.20
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 13943:2008, 4.292]

3.21
smoke
visible part of fire effluent

[SOURCE: ISO 13943:2008, 4.293]

3.22
smoke production rate
amount of smoke produced per unit time in a fire or fire test

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

[SOURCE: ISO 13943:2008, 4.295]

3.23
smoke release rate
see **smoke production rate** (3.21)

3.24
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 1 to entry: The typical units are square metres per gram ($m^2 \cdot g^{-1}$).

[SOURCE: ISO 13943:2008, 4.301]

3.25
specific optical density of smoke
optical density of smoke multiplied by a geometric 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 specific optical density of smoke is dimensionless.

[SOURCE: ISO 13943:2008, 4.303]

3.26
visibility
maximum distance at which an object of defined size, brightness and contrast can be seen and recognized

[SOURCE: ISO 13943:2008, 4.350]

4 Types of of test method

4.1 General

In cases where fire tests are not yet specified, and need to be developed or altered for the special purpose of an IEC technical committee, this shall be done in liaison with the relevant IEC technical committee.

The test method(s) selected shall be relevant to the fire scenario of concern.

4.2 The 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 19706:2011, 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 recirculation 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 recirculation. 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 19706:2011)

Fire stage	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)	n.a.	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.