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INTERNATIONAL STANDARD

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BASIC SAFETY PUBLICATION

PUBLICATION FONDAMENTALE DE SÉCURITÉ

AMENDMENT 1

AMENDEMENT 1

Fire hazard testing –
Part 6-1: Smoke obscuration – General guidance

Essais relatifs aux risques du feu –
Partie 6-1: Opacité des fumées – Lignes directrices générales

IEC 60695-6-1:2005/A1:2010

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FOREWORD

This amendment has been prepared by IEC technical committee 89: Fire hazard testing.

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

CDV	Report on voting
89/905/CDV	89/946A/RVC

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

The committee has decided that the contents of this amendment and the base 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- withdrawn,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.

2 Normative references

Replace the text of this clause with the following:

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 60695-1-10, *Fire hazard testing – Part 1-10: Guidance for assessing the fire hazard of electrotechnical products – General guidelines*

IEC 60695-1-11[1], *Fire hazard testing – Part 1-11: Guidance for assessing the fire hazard of electrotechnical products – Fire hazard assessment*

IEC 60695-4:2005, *Fire hazard testing – Part 4: Terminology concerning fire tests for electrotechnical products*

IEC 60695-6-2[2], *Fire hazard testing – Part 6-2: Smoke obscuration – Summary and relevance of test methods*

IEC 60695-6-30:1996, *Fire hazard testing – Part 6: Guidance and test methods on the assessment of obscuration hazard of vision caused by smoke opacity from electrotechnical products involved in fires – Section 30: Small-scale static method – Determination of smoke opacity – Description of the apparatus*

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1 To be published.

2 To be published.

IEC 60695-6-31:1999, *Fire hazard testing – Part 6-31: Smoke obscuration – Small-scale static test – Materials*

IEC Guide 104:1997, *The preparation of safety publications and the use of basic safety publications and group safety publications*

ISO/IEC Guide 51:1999. *Safety aspects – Guidelines for inclusion in standards*

ISO 5659-2:2006, *Plastics – Smoke generation – Part 2: Determination of optical density by a single-chamber test*

ISO 5660-2:2002, *Reaction-to-fire tests – Heat release, smoke production and mass loss rate – Part 2: Smoke production rate (dynamic measurement)*

ISO 13943:2008, *Fire safety – Vocabulary*

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

NOTE ISO 9122-1:1989, *Toxicity testing of fire effluents – Part 1: General,* has been withdrawn and replaced by ISO 19706:2007.

ASTM E 1354:2008, *Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter*

EN 13823:2002, *Reaction to fire tests for building products – Building products, excluding floorings, exposed to thermal attack by a single burning item*

3 Terms, definitions and symbols

3.1 Terms and definitions

Replace the text of this subclause with the following:

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

3.1.1
combustion
exothermic reaction of a substance with an oxidizing agent

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

[ISO/IEC 13943, definition 4.46]

3.1.2
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]

3.1.3
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]

3.1.4
fire
〈general〉 process of combustion characterized by the emission of heat and fire effluent and usually accompanied by smoke, flame or glowing or a combination thereof

NOTE In the English language the term "fire" is used to designate three concepts, two of which, fire (3.1.5) and fire (3.1.6), 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]

3.1.5
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]

3.1.6
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]

3.1.7
fire effluent
totality of gases and aerosols, including suspended particles, created by combustion or pyrolysis in a fire

[ISO/IEC 13943, definition 4.105]

3.1.8
fire hazard
physical object or condition with a potential for an undesirable consequence from fire

[ISO/IEC 13943, definition 4.112]

3.1.9
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]

3.1.10
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]

3.1.11
flashover
⟨stage of fire⟩ transition to a state of total surface involvement in a fire of combustible materials within an enclosure

[ISO/IEC 13943, definition 4.156]

3.1.12
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]

3.1.13
ignition
sustained ignition (deprecated)

⟨general⟩ initiation of combustion

[ISO/IEC 13943, definition 4.187]

3.1.14
ignition
sustained ignition (deprecated)

⟨flaming combustion⟩ initiation of sustained flame

[ISO/IEC 13943, definition 4.188]

3.1.15
large-scale fire test
fire test, that cannot be carried out in a typical laboratory chamber, performed on a test specimen of large dimensions

NOTE A fire test performed on a test specimen of which the maximum dimension is greater than 3 m is usually called a large-scale fire test.

[ISO/IEC 13943, definition 4.205]

3.1.16
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 ($m^2 \cdot g^{-1}$).

[ISO/IEC 13943, definition 4.225]

3.1.17
obscuration by smoke
reduction in the intensity of light due to its passage through smoke

cf. **extinction area of smoke** (3.1.2) and **specific extinction area of smoke** (3.1.26).

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]

3.1.18
opacity of smoke
ratio of incident light intensity to transmitted light intensity through smoke, under specified conditions

cf. **obscuration by smoke** (3.1.17)

NOTE 1 Opacity of smoke is the reciprocal of transmittance.

NOTE 2 The opacity of smoke is dimensionless.

[ISO/IEC 13943, definition 4.243]

3.1.19
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** (3.1.26)

NOTE The optical density of smoke is dimensionless.

[ISO/IEC 13943, definition 4.244]

3.1.20
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]

3.1.21
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]

3.1.22
SMOGRA
smoke growth rate parameter that is a function of the rate of smoke production and the time of smoke production

NOTE Further details are given in 6.2.4.

3.1.23
SMOGRA index
maximum value of SMOGRA during a defined test period

NOTE Further details are given in 6.2.4.

3.1.24
smoke
visible part of fire effluent

[ISO/IEC 13943, definition 4.293]

3.1.25
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 ($m^2 \cdot s^{-1}$).

[ISO/IEC 13943, definition 4.295]

3.1.26
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]

3.1.27
specific optical density of smoke
optical density of smoke multiplied by a geometric factor

NOTE 1 The geometric factor is equal to $V/(A \cdot L)$, 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]

3.1.28
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 General aspect of smoke test methods

4.1 Fire scenarios and fire models

Replace, in the first paragraph, the text of the third line with the following:

Table 1 shows how the different types of fire relate to the changing atmosphere.

Replace the text of the third paragraph of this subclause with the following:

General guidance for the fire hazard assessment of electrotechnical products is given in IEC 60695-1-10.

Table 1 – General classification of fires (ISO/TR 9122-1)

Replace the existing title and table with the following:

Table 1 – Characteristics of fire stages (ISO 19706)

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)	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.

Figure 1 – Chart of different phases in the development of a fire within a compartment

Replace the Figure 1 and the title with the following:

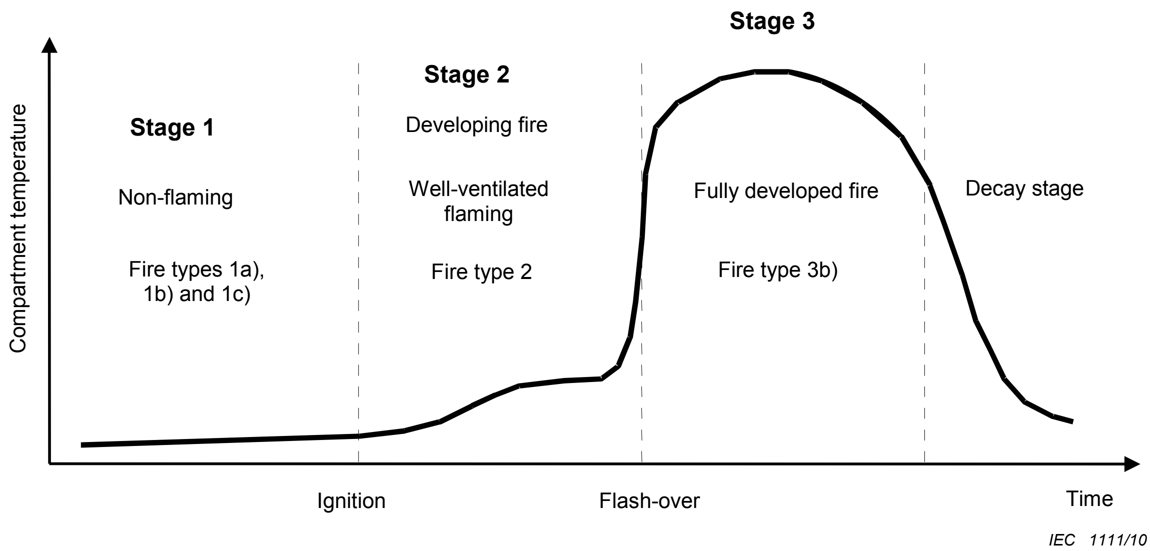

Figure 1 – Different phases in the development of a fire within a compartment

6 Static and dynamic methods

Replace the text of the existing Clause 6 with the following new text:

6.1 Static methods

6.1.1 Principles

In a static smoke test, the test specimen burns in a closed chamber and the smoke produced builds up over time. In some tests, a fan stirs the smoke to prevent layering and to make it homogeneous. The amount of smoke is measured by monitoring the attenuation of a light beam shining through the smoke.

6.1.2 Extinction area

The extinction area of the smoke is a useful measure of the amount of smoke produced, and is a function of the opacity of the smoke, (I/T), the volume of the chamber, V, and the light path length, L.

$$S = (V/L)\ln(I/T) \qquad (17)$$

This equation only applies if the smoke is homogeneous. The units of extinction area are typically square metres (m^2).

6.1.3 Specific optical density

In some tests, including IEC 60695-6-30 and ISO 5659-2, the amount of smoke is calculated from the optical density of the smoke, and it is normalised to the surface area of the test specimen, A. The quantity calculated is D_s, the specific optical density.

$$D_s = [V/(AL)]\log_{10}(I/T) \qquad (18)$$

The thickness of the test specimen will affect the amount of smoke produced. D_s values should not be directly compared for test specimens of different thicknesses. Conversely, if comparisons are made, then the test specimen thickness should be kept constant.

6.1.4 Prediction of visibility

The purpose of measuring D_s (or S) is to enable the prediction of visibility. However, the visibility within the test chamber is not usually what is required to be known. What is required is an estimation of visibility in a given scenario. It is possible to make such estimations based on data obtained in static tests such as IEC 60695-6-30 but it must be appreciated that such calculations are only estimates, as changing the fire model will probably change both the smoke production process and the way in which the smoke will age.

6.2 Dynamic methods

6.2.1 Principles

In dynamic tests, the smoke from the test specimen is drawn through an exhaust system at a measured flow rate and the opacity of the smoke stream is measured at regular intervals by monitoring the transmitted intensity of a light beam shining through the smoke (see Figure 4). The flow rate of the smoke is measured at a position close to where the opacity is measured.

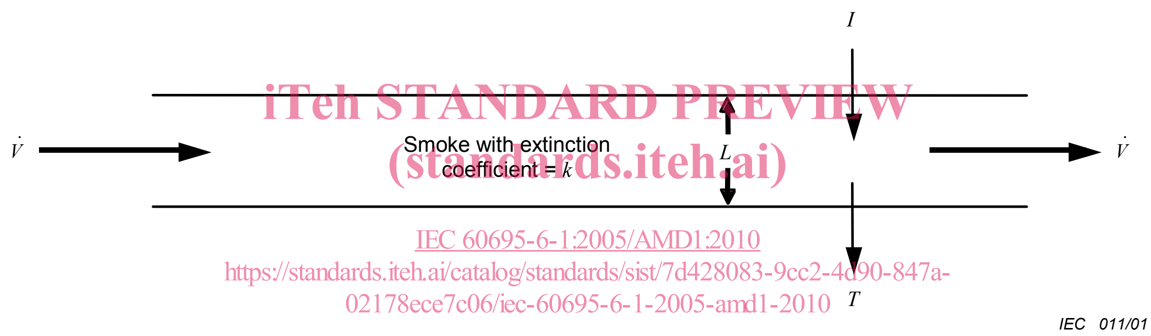

Figure 4 – Dynamic smoke measurement

6.2.2 Smoke production rate

The smoke production rate at any given moment ($\dot{S}$) is calculated using the equation:

$$\dot{S} = k\dot{V} \tag{19}$$

where

$\dot{V}$ is the volume flow rate of the exhaust gases.

$\dot{S}$ has units of area/time, e.g. $m^2 \cdot s^{-1}$.

The smoke production rate is readily ascertained in dynamic systems. It expresses the extinction area of smoke produced per unit time.

$$\dot{S} = k\dot{V} = (1/L)\ \ln(I/T)\dot{V} \tag{20}$$

When the exposed test specimen area involved is known, as in the cone calorimeter ASTM E 1354 and ISO 5660, or furniture calorimeters, the smoke production rate can be normalized per unit area of the exposed test specimen. The units then become reciprocal time, e.g. $(m^2/s)/m^2$, i.e. s^{-1}.