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Edition 2.0 2021-10

INTERNATIONAL STANDARD

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Fire hazard testing –
Part 7-2: Toxicity of fire effluent – Summary and relevance of test methods

Essais relatifs aux risques du feu –
Partie 7-2: Toxicité des effluents du feu – Résumé et pertinence des méthodes d'essai

IEC 60695-7-2:2021-10(en-fr)

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FIRE HAZARD TESTING –

Part 7-2: Toxicity of fire effluent – Summary and relevance of test methods

FOREWORD

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International Standard IEC 60695-7-2 has been prepared by IEC technical committee 89: Fire hazard testing.

This second edition cancels and replaces the first edition published in 2011. This edition constitutes a technical revision.

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

– New text in the introduction;
– New text in the scope;
– Clause 2 has been updated;
– Many terms and definitions in Clause 3 reproduced from ISO 13943 have been deleted. Other terms and definitions have been added.
– New text in Subclauses 4.3 and 4.4;
– New text in Subclause 6.1;

– References to IEC 60695-7-50 and -51 (now withdrawn) have been removed;
– Reference to DEF STAN 07-247 has been added;
– Details of ISO/TS 19021 have been added;
– Details of EN 17084 have been added;
– New text added concerning ISO/TS 19700;
– New text added concerning the IMO FTP toxicity test;
– New Subclause 7.1 has been added;
– The Annex in Edition1 has been replaced by new Clause 8;
– The bibliography has been updated.

The text of this International Standard is based on the following documents:

Draft	Report on voting
89/1489/CDV	89/1508/RVC

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

The language used for the development of this International Standard is English.

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

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

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

IEC 60695-7 consists of the following parts:

Part 7-1: *Toxicity of fire effluent – General guidance*
Part 7-2: *Toxicity of fire effluent – Summary and relevance of test methods*
Part 7-3: *Toxicity of fire effluent – Use and interpretation of test results*

In this document the following print types are used:

– Words *in italics* in the text are defined in Clause 3.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document 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, IEC 60695-1-11 [1][1], and IEC 60695-1-12 [2] 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 of standards 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.

Electrotechnical products, primarily as the objects of a fire, may contribute to the fire hazard due to the release of toxic effluent, which may be a significant contributing factor to the overall fire hazard.

The IEC 60695-7 series provides guidance to IEC product committees on the adoption and implementation of the recommendations of ISO for the minimization of toxic hazard from fires involving electrotechnical products.This part of IEC 60695-7 describes fire effluent toxicity test methods in common use to assess electrotechnical products or materials used in electrotechnical products.

IEC product committees incorporating requirements for the assessment of toxic hazard from fire in product standards should note that *toxic potency* and other measurements of toxicity which are described in this part of IEC 60695 should not be used directly in product specifications. Data from *toxic potency* test methods should only be used as part of a toxic hazard assessment, in conjunction with other product-based reaction to fire data such as mass loss rate.

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1 Numbers in square brackets refer to the bibliography.

FIRE HAZARD TESTING –

Part 7-2: Toxicity of fire effluent – Summary and relevance of test methods

1 Scope

This part of IEC 60695-7 gives a brief summary of the test methods that are in common use in the assessment of the toxicity of fire effluent. It includes special observations on their relevance to real fire scenarios and gives recommendations on their use.

It advises which tests provide *toxic potency* data that are relevant to real fire scenarios, and which are suitable for use in fire hazard assessment and fire safety engineering.

The list of test methods is not to be considered exhaustive.

This summary cannot be used in place of published standards which are the only valid reference documents.

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

IEC 60695-7-1, *Fire hazard testing - Part 7-1: Toxicity of fire effluent - General guidance*

IEC 60695-7-3, *Fire hazard testing - Part 7-3: Toxicity of fire effluent - Use and interpretation of test results*

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

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

ISO 13943:2017, *Fire safety – Vocabulary*

ISO 13344, *Estimation of the lethal toxic potency of fire effluents*

ISO 13571:2007, *Life-threatening components of fire – Guidelines for the estimation of time available for escape using fire data*

ISO/TR 16312-2, *Guidance for assessing the validity of physical fire models for obtaining fire effluent toxicity data for fire hazard and risk assessment – Part 2: Evaluation of individual physical fire models*

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

ISO 29903:2012, *Guidance for comparison of toxic gas data between different physical fire models and scales*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13943:2017, some of which are reproduced below for the user's 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
acute toxicity
toxicity that causes rapidly occurring toxic effects

Note 1 to entry: Compare with the term *toxic potency* (3.16).

[ISO 13943:2017, definition 3.8]

3.2
asphyxiant
toxicant (3.17) that causes hypoxia, which can result in central nervous system depression or cardiovascular effects

Note 1 to entry: Loss of consciousness and ultimately death may occur.

[ISO 13943:2017, definition 3.23]

3.3
concentration
mass of a dispersed or dissolved material in a given volume

Note 1 to entry: For a fire effluent the typical unit is g· m^{-3}.

Note 2 to entry: For toxic gas, concentration is usually expressed as a *volume fraction* (3.18) at T = 298 K and P = 1 atm, with typical units of μL/L (= cm^3/m^3 = 10^{-6}).

Note 3 to entry: The concentration of a gas at a temperature, T, and a pressure, P, can be calculated from its volume fraction (assuming ideal gas behaviour) by multiplying the volume fraction by the density of the gas at that temperature and pressure.

Note 4 to entry: Pascal (Pa) is the SI unit for pressure; however, atmosphere (atm) is typically used in this context, where 1 atm = 101,3 kPa.

[ISO 13943:2017, definition 3.62]

3.4
effective concentration 50
EC_{50}
concentration (3.3) of a toxic gas or fire effluent, statistically calculated from concentration-response data, that causes a specified effect in 50 % of a population of a given species within a specified exposure time and post-exposure time

Note 1 to entry: Compare with the term IC_{50} (ISO 13943:2017, 3.211).

Note 2 to entry: For fire effluent, the typical unit is g × m^{-3}.

Note 3 to entry: For toxic gas, the typical unit is µL/L (T = 298 K and P = 1 atm); see *volume fraction* (3.18).

Note 4 to entry: The observed effect is usually a behavioural response, *incapacitation* (3.8), or death. The EC_{50} for incapacitation is termed the IC_{50}. The EC_{50} for lethality is termed the LC_{50} (3.11).

3.5
exposure dose
measure of the maximum amount of a toxic gas or fire effluent that is available for inhalation, calculated by integration of the area under a *concentration*-time curve

Note 1 to entry: For fire effluent, the typical unit is g × min × m^{-3}.

Note 2 to entry: For toxic gas, the typical unit is µL × min × L^{-1} (T = 298 K and P = 1 atm); see *volume fraction* (3.18).

[ISO 13943:2017, definition 3.107]

3.6
fractional effective concentration
FEC
ratio of the *concentration* (3.3) of an *irritant* (3.9) to that concentration expected to produce a specified effect on an exposed subject of average susceptibility

Note 1 to entry: Compare with the term F factor (ISO 13943:2017, 3.112).

Note 2 to entry: As a concept, FEC may refer to any effect, including *incapacitation* (3.8), lethality or other endpoints.

Note 3 to entry: When not used with reference to a specific irritant, the term FEC represents the summation of FEC values for all irritants in a fire-generated atmosphere.

Note 4 to entry: The FEC is dimensionless.

[ISO 13943:2017, definition 3.187]

3.7
fractional effective dose
FED
ratio of the *exposure dose* (3.5) for an *asphyxiant* (3.2) to that exposure dose of the asphyxiant expected to produce a specified effect on an exposed subject of average susceptibility

Note 1 to entry: As a concept, FED may refer to any effect, including *incapacitation* (3.8), lethality or other endpoints.

Note 2 to entry: When not used with reference to a specific asphyxiant, the term FED represents the summation of FED values for all asphyxiants in a combustion atmosphere.

Note 3 to entry: The FED is dimensionless.

[ISO 13943:2017, definition 3.188]

3.8
incapacitation
state of physical inability to accomplish a specific task

Note 1 to entry: An example of a specific task is to accomplish escape from a fire.

[ISO 13943:2017, definition 3.225]

3.9
irritant, noun
<sensory/upper respiratory> gas or aerosol that stimulates nerve receptors in the eyes, nose, mouth, throat and respiratory tract, causing varying degrees of discomfort and pain with the initiation of numerous physiological defence responses

Note 1 to entry: Physiological defence responses include reflex eye closure, tear production, coughing, and bronchoconstriction.

[ISO 13943:2017, definition 3.237]

3.10
irritant, noun
<pulmonary> gas or aerosol that stimulates nerve receptors in the lower respiratory tract, which may result in breathing discomfort

Note 1 to entry: Examples of breathing discomfort are dyspnoea and an increase in respiratory rate. In severe cases, pneumonitis or pulmonary oedema (which may be fatal) may occur some hours after exposure.

[ISO 13943:2017, definition 3.238]

3.11
lethal concentration 50
LC_{50}
concentration (3.3) of a toxic gas or fire effluent, statistically calculated from concentration-response data, that causes death of 50 % of a population of a given species within a specified exposure time and post-exposure time

Note 1 to entry: Compare with the term *effective concentration 50* (3.4).

Note 2 to entry: For fire effluent, the typical unit is g × m^{-3}.

Note 3 to entry: For toxic gas, the typical unit is µL/L (T = 25 °C and P = 1 atm; see *volume fraction* (3.18).

[ISO 13943:2017, definition 3.241]

3.12
lethal exposure dose 50
LCt_{50}
product of LC_{50} (3.11) and the exposure time over which it was determined

Note 1 to entry: Compare with the terms *concentration* (3.3), *effective exposure dose 50* (ISO 13943:2017, 3.87), *exposure dose* (3.5) and *lethal exposure time 50* (ISO 13943:2017, 3.243).

Note 2 to entry: LCt_{50} is a measure of *lethal toxic potency* (3.13).

Note 3 to entry: For fire effluent, the typical unit is g·min·m^{-3}.

Note 4 to entry: For toxic gas, the typical unit is µL·min·L^{-1}) (T = 25 °C and P = 1 atm); see *volume fraction* (3.18).

[ISO 13943:2017, definition 3.242]

3.13
lethal toxic potency
toxic potency (3.16) where the specific toxic effect is death

Note 1 to entry: Compare with the terms *lethal concentration 50* (LC_{50}) (3.11) and *lethal exposure dose 50* (LCt_{50}) (3.12).

[ISO 13943:2017, definition 3.244]

3.14
mass loss concentration
⟨closed system⟩ mass of the test specimen consumed during combustion divided by the test chamber volume

Note 1 to entry: The typical unit is g × m^{-3}.

[ISO 13943:2017, definition 3.262]

3.15
mass loss concentration
⟨open system⟩ mass of the test specimen consumed during combustion divided by the total volume of air passed through the test apparatus

Note 1 to entry: The definition assumes that the mass is dispersed in the air flow uniformly over time.

Note 2 to entry: The typical unit is g × m^{-3}.

[ISO 13943:2017, definition 3.263]

3.16
toxic potency
measure of the amount of *toxicant* (3.17) required to elicit a specific toxic effect

Note 1 to entry: Compare with the terms *effective exposure dose 50* (ISO 13943:2017, 3.87) and *lethal exposure dose 50* (3.12).

Note 2 to entry: A small value of toxic potency corresponds to a high toxicity, and vice versa.

ISO 13943:2017, definition 3.402

3.17
toxicant
toxin
toxic substance

ISO 13943:2017, definition 3.404

3.18
volume fraction
⟨gas in a gas mixture⟩ ratio of the volume that the gas alone would occupy at a defined temperature and pressure, to the volume occupied by the gas mixture at the same temperature and pressure

Note 1 to entry: The *concentration* (3.3) of a gas at a temperature, T, and a pressure, P, can be calculated from its volume fraction (assuming ideal gas behaviour) by multiplying the volume fraction by the density of the gas at that temperature and pressure.

Note 2 to entry: Unless stated otherwise, a temperature of 298 K and a pressure of 1 atm are assumed.

Note 3 to entry: The volume fraction is dimensionless and is usually expressed in terms of μL/L (= cm^3/m^3 = 10^{-6}), or as a percentage.

ISO 13943:2017, definition 3.421

3.19
volume yield
volume, at 298 K and 1 atm, of a component of fire effluent divided by the mass loss of the test specimen associated with the production of that volume

Note 1 to entry: The typical unit is $m^3 \times g^{-1}$.

ISO 13943:2017, definition 3.422

4 Role of small-scale toxicity tests

4.1 General

Small-scale toxicity tests, and *toxic potency* tests in particular, serve a very specific purpose – to generate data to be used in toxic hazard assessments, fire hazard assessments, or fire-safety engineering calculations.

These tests are often wrongly interpreted as providing data which give a direct indication of the toxicity or toxic hazard associated with a material or product. Such interpretations are invalid and are contrary to the guidance given in ISO 19706 and IEC 60695-7-1, and are likely to lead to incorrect assumptions about the contribution of a given material or product to toxic hazard.

Therefore, the data from small-scale toxicity tests should not be used directly in product specifications, or to imply in isolation, any level of toxic hazard.

Data from *toxic potency* test methods should only be used as part of a toxic hazard assessment in conjunction with other product based reaction to fire data such as mass loss rate.

Guidance for the comparison of toxic gas data between different physical fire models and scales is given in ISO 29903:2012.

4.2 *Toxic potency*

The term *toxic potency* is a specific technical term in fire science. It is the measure of the amount of *toxicant* required to elicit a specific toxic effect. One specific *toxic potency* that is commonly used is the *exposure dose* that causes the death of 50 % of exposed organisms. This is known as the LCt_{50} (*lethal exposure dose 50*).

The *exposure dose* of the i^{th} toxic component, $[D]_i$, in a mixture of toxic components, is defined by the following equation:

$$[D]_i = \int C_i \, dt = X_i \frac{1}{V} \int m \, dt = X_i \, D_m$$

or, if the *volume fraction* of the i^{th} toxic component is constant over time,

$$[D]_i = C_i \times t$$

where

C_i is the *volume fraction* of the i^{th} toxic component;

X_i is the *volume yield* of the i^{th} toxic component from a *toxic potency* test;

D_m is the mass loss concentration integral, which is the integral of the mass lost over the exposure time, t, divided by the volume of the fire effluent;