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INTERNATIONAL STANDARD

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HORIZONTAL PUBLICATION

Fire hazard testing –
Part 5-1: Corrosion damage effects of fire effluent – General guidance

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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CONTENTS

FOREWORD 3
INTRODUCTION 2
1 Scope 8
2 Normative references 8
3 Terms and definitions 8
4 Fire scenarios and physical fire models 9
5 General aspects of the corrosivity of fire effluent 13
5.1 Corrosion damage scenarios 13
5.2 Types of corrosion damage effects 15
5.2.1 Introduction 15
5.2.2 Metal loss 15
5.2.3 Moving parts becoming immobile 15
5.2.4 Bridging of conductor circuits 15
5.2.5 Formation of a non-conducting layer on contact surfaces 15
5.3 Factors affecting corrosivity 16
5.3.1 Introduction 16
5.3.2 The nature of fire effluent 16
5.3.3 The corrosion environment 17
6 Principles of corrosion damage measurement 17
6.1 Introduction 17
6.2 Generation of the fire effluent 17
6.2.1 General 17
6.2.2 Selection of the test specimen to be burned 18
6.2.3 Selection of the physical fire model 18
6.3 Assessment of corrosive potential 18
6.3.1 General 18
6.3.2 Indirect assessment 18
6.3.3 Simulated product testing 19
6.3.4 Product testing 19
6.4 Consideration of corrosivity test methods 20
7 Relevance of data to hazard assessment 21
Bibliography 23

Figure 1 – Different stages in the development of a fire within a compartment 13
Figure 2 – Evaluation and consideration of corrosion damage test methods 21

~~Table 1 – General classification of fires (ISO/TR 9122-1) .....~~
Table 1 – Characteristics of fire stages (from Table 1 of ISO 19706:2011) 14
Table 2 – Summary of corrosivity test methods 19

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FIRE HAZARD TESTING –

Part 5-1: Corrosion damage effects of fire effluent – General guidance

FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC 60695-5-1:2002. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 60695-5-1 has been prepared by IEC technical committee 89: Fire hazard testing.

This third edition cancels and replaces the second edition, published in 2002, and constitutes a technical revision.

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

a) References to IEC TS 60695-5-3 (withdrawn in 2014) have been removed.
b) References to IEC 60695-1-1 are now to its replacements: IEC 60695-1-10 and IEC 60695-1-11.
c) ISO/TR 9122-1 has been revised by ISO 19706.
d) Table 1 has been updated.
e) References to ISO 11907-2 and ISO 11907-3 have been removed.
f) Terms and definitions have been updated.
g) Text in 6.4 has been updated.
h) Bibliographic references have been updated.

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

FDIS	Report on voting
89/1539/FDIS	89/1543/RVD

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.

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.

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

In this standard, the following print types are used:

Arial **bold**: terms referred to in Clause 2

This standard is to be read in conjunction with IEC TS 60695-5-2.

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

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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

~~The risk of fire should be considered in any electrical circuit. With regard to this risk, the circuit and equipment design, the selection of components and the choice of materials should contribute towards reducing the likelihood of fire even in the event of foreseeable abnormal use, malfunction or failure. The practical aim should be to prevent ignition caused by electrical malfunction but, if ignition and fire occur, to control the fire preferably within the bounds of the enclosure of the electrotechnical product.~~

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, and IEC 60695-1-12 [1][1] 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.

All **fire effluent** is corrosive to some degree and the level of potential to corrode depends on the nature of the fire, the combination of combustible materials involved in the fire, the nature of the substrate under attack, and the temperature and relative humidity of the environment in which the **corrosion damage** is taking place. There is no evidence that **fire effluent** from electrotechnical products offers greater risk of **corrosion damage** than the **fire effluent** from other products such as furnishings~~,~~ or building materials~~, etc~~.

The performance of electrical and electronic components can be adversely affected by **corrosion damage** when subjected to **fire effluent**. A wide variety of combinations of small quantities of effluent gases, **smoke** particles, moisture and temperature may provide conditions for electrical component or system failures from breakage, overheating or shorting.

Evaluation of potential **corrosion damage** is particularly important for high value and safety-related electrotechnical products and installations.

Technical committees responsible for products will choose the test(s) and specify the level of severity.

The study of **corrosion damage** requires an interdisciplinary approach involving chemistry, electricity, physics, mechanical engineering, metallurgy and electrochemistry. In the preparation of this part of IEC 60695-5, all of the above have been considered.

IEC 60695-5-1 defines the scope of the guidance and indicates the field of application.

IEC TS 60695-5-2 provides a summary of test methods including relevance and usefulness.

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1 Numbers in square brackets refer to the bibliography.

~~IEC 60695-5-3 provides details of a small-scale test method for the measurement of leakage current and metal loss caused by fire effluent.~~

FIRE HAZARD TESTING –

Part 5-1: Corrosion damage effects of fire effluent – General guidance

1 Scope

This part of IEC 60695 provides guidance on the following:

a) general aspects of **corrosion damage** test methods;

b) methods of measurement of **corrosion damage**;

c) consideration of test methods;

d) relevance of **corrosion damage** data to hazard assessment.

This basic safety publication is primarily 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. It is not intended for use by manufacturers or certification bodies.

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 60695-1-1:1999, *Fire hazard testing – Part 1-1: Guidance for assessing the fire hazard of electrotechnical products – General guidelines*~~

~~IEC/TS 60695-5-2:2002, *Fire hazard testing – Part 5-2: Corrosion damage effects of fire effluent – Summary and relevance of test methods*~~

~~IEC/TS 60695-5-3, *Fire hazard testing – Part 5-3: Corrosion damage effects of fire effluent – Leakage current and metal loss test method*~~ [2]

~~IEC 60754-1:1994, *Test on gases evolved during combustion of materials from cables – Part 1: Determination of the amount of halogen acid gas*~~

~~IEC 60754-2:1991, *Test on gases evolved during combustion of electric cables – Part 2: Determination of degree of acidity of gases evolved during the combustion of materials taken from electric cables by measuring pH and conductivity*~~

~~IEC 60754-2, Amendment 1 (1997)~~

~~ISO/TR 9122-1:1989, *Toxicity testing of fire effluents – Part 1: General*~~

[2] ~~To be published.~~

~~ISO 11907-2:1995, *Plastics – Smoke generation – Determination of the corrosivity of fire effluents – Part 2: Static method*~~

~~ISO 11907-3:1998, *Plastics – Smoke generation – Determination of the corrosivity of fire effluents – Part 3: Dynamic decomposition method using a travelling furnace*~~

~~ISO 11907-4:1998, *Plastics – Smoke generation – Determination of the corrosivity of fire effluents – Part 4: Dynamic decomposition method using a conical radiant heater*~~

~~ISO/IEC 13943:2000, *Fire safety – Vocabulary*~~

~~ASTM D 2671 – 00, *Standard Test Methods for Heat-Shrinkable Tubing for Electrical Use*~~

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

IEC TS 60695-5-2, *Fire hazard testing – Part 5-2: Corrosion damage effects of fire effluent – Summary and relevance of test methods*

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 11907-1:2019, *Plastics – Smoke generation – Determination of the corrosivity of fire effluents – Part 1: General concepts and applicability*

ISO 13943:2017, *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 following terms and definitions~~, some of which have been taken from ISO/IEC 13943,~~ 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
corrosion damage
physical and/or chemical damage or impaired function caused by chemical action

[SOURCE: ~~ISO/IEC 13943, definition 25~~ ISO 13943:2017, 3.69]

3.2
corrosion target
sensor used to determine the degree of **corrosion damage** (3.1), under specified conditions

Note 1 to entry: This sensor may be a product, a component~~, or a reference material used to simulate them~~. It may also be a reference material or object used to simulate the behaviour of a product or a component.

[SOURCE:~~ ISO/IEC 13943, definition 26~~ ISO 13943:2017, 3.70]

~~**3.3**~~
~~**critical relative humidity**~~
~~level of relative humidity that causes leakage current to exceed a value defined in the product specification~~

3.3
fire decay
stage of fire development after a fire has reached its maximum intensity and during which the heat release rate and the temperature of the fire are decreasing

[SOURCE: ISO 13943:2017, 3.122]

3.4
fire effluent
~~totality of~~ all gases and~~/or~~ aerosols, ~~(~~including suspended particles~~)~~, created by combustion or **pyrolysis** (3.9) and emitted to the environment

[SOURCE:~~ ISO/IEC 13943, definition 45~~ ISO 13943:2017, 3.123]

~~**3.5**~~
~~**fire effluent decay characteristics**~~
~~physical and/or chemical changes in fire effluent due to time and transport~~

~~**3.6**~~
~~**fire effluent transport**~~
~~movement of fire effluent away from the location of the fire~~

3.5
fire scenario
~~detailed description of conditions, including environmental, of one or more stages from before ignition to after completion of combustion in an actual fire at a specific location or in a real-scale simulation~~

~~[ISO/IEC 13943, definition 58]~~

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

Note 1 to entry: See **fire scenario cluster** (ISO 13943:2017, 3.154) and **representative fire scenario** (ISO 13943:2017, 3.153).

Note 2 to entry: It typically defines the ignition and fire growth processes, the fully developed fire stage, the **fire decay** (3.3) stage, and the environment and systems that will impact on the course of the fire.

Note 3 to entry: Unlike deterministic fire analysis, where fire scenarios are individually selected and used as design fire scenarios, in fire risk assessment, fire scenarios are used as representative fire scenarios within fire scenario clusters.

[SOURCE: ISO 13943:2017, 3.152]

~~**3.8**~~
~~**ignition source**~~
~~source of energy that initiates combustion~~

~~([ISO/IEC 13943, definition 97]~~

3.6
flashover
<stage of fire> transition to a state of total surface involvement in a fire of combustible materials within an enclosure

[SOURCE: ISO 13943:2017, 3.184]

3.7
full developed fire
state of total involvement of combustible materials in a fire

[SOURCE: ISO 13943:2017, 3.192]

3.8
leakage current
electrical current flowing in an undesired circuit

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 13943:2017, 3.298]

3.10
pyrolysis
chemical decomposition of a substance by the action of heat

Note 1 to entry: Pyrolysis is often used to refer to a stage of fire before flaming combustion has begun.

Note 2 to entry: In fire science, no assumption is made about the presence or absence of oxygen.

[SOURCE: ISO 13943:2017, 3.316]

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

Note 1 to entry: There is no clear upper limit for the dimensions of the test specimen in a small-scale fire test. In some instances, a fire test performed on a test specimen with a maximum dimension of less than 1 m is called a small-scale fire test. However, a fire test performed on a test specimen of which the maximum dimension is between 0,5 m and 1,0 m is often called a medium-scale fire test.

[SOURCE: ISO 13943:2017, 3.346]

3.12
smoke
visible part of a fire effluent

[SOURCE: ~~ISO/IEC 13943, definition 150~~ ISO 13943:2017, 3.347]

4 Fire scenarios and physical fire models

During recent years, major advances have been made in the analysis of **fire effluent**s. It is recognized that the composition of the mixture of combustion products is particularly dependent upon the nature of the combusting materials, the prevailing temperatures and the ventilation conditions, especially access of oxygen to the seat of the fire. Table 1 shows how the different stages of a fire relate to the changing atmosphere. Conditions for use in laboratory scale tests can be derived from the table in order to correspond, as far as possible, to full-scale fires.

Fire involves a complex and interrelated array of physical and chemical phenomena. As a result, it is difficult to simulate all aspects of a real fire in laboratory scale apparatus. This problem ~~of fire model validity~~ is perhaps the single most perplexing technical problem associated with all fire testing.

General guidance for assessing the fire hazard of electrotechnical products is given in IEC 60695-1-10. Guidance concerning fire hazard assessment is given in IEC 60695-1-11.

ISO 11907-1 defines terms related to smoke corrosivity as well as smoke acidity and smoke toxicity. It presents the scenario-based approach that controls smoke corrosivity. It describes the test methods to assess smoke corrosivity at laboratory scale and deals with test applicability and post-exposure conditions.

After ignition, fire development may occur in different ways depending on the environmental conditions, as well as on the physical arrangement of the combustible materials. However, a general pattern can be established for fire development within a compartment, where the general temperature-time curve shows three stages, plus a **fire decay** stage (see Figure 1).

Stage 1 (non-flaming decomposition) is the incipient stage of the fire prior to sustained flaming, with little rise in the fire room temperature. Ignition and **smoke** generation are the main hazards during this stage.

Stage 2 (developing fire) starts with ignition and ends with a rapid rise in fire room temperature. Spread of flame and heat release are the main hazards in addition to **smoke** during this stage.

Stage 3 (fully developed fire) starts when the surface of all of the combustible contents of the room has decomposed to such an extent that sudden ignition occurs all over the room, with a rapid and large increase in temperature (**flashover**).

At the end of Stage 3, the combustibles and/or oxygen have been largely consumed and hence the temperature decreases at a rate which depends on the ventilation and the heat and mass transfer characteristics of the system. This is known as the **fire decay** stage.

In each of these stages, a different mixture of decomposition products may be formed and this, in turn, influences the corrosive potential of the **fire effluent** produced during that stage.

Characteristics of these fire stages are given in Table 1.