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INTERNATIONAL STANDARD

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inside

HORIZONTAL PUBLICATION

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

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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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a) References to IEC TS 60695-5-3 (withdrawn in 2014) have been removed.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*~~

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[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 effluents**. 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.

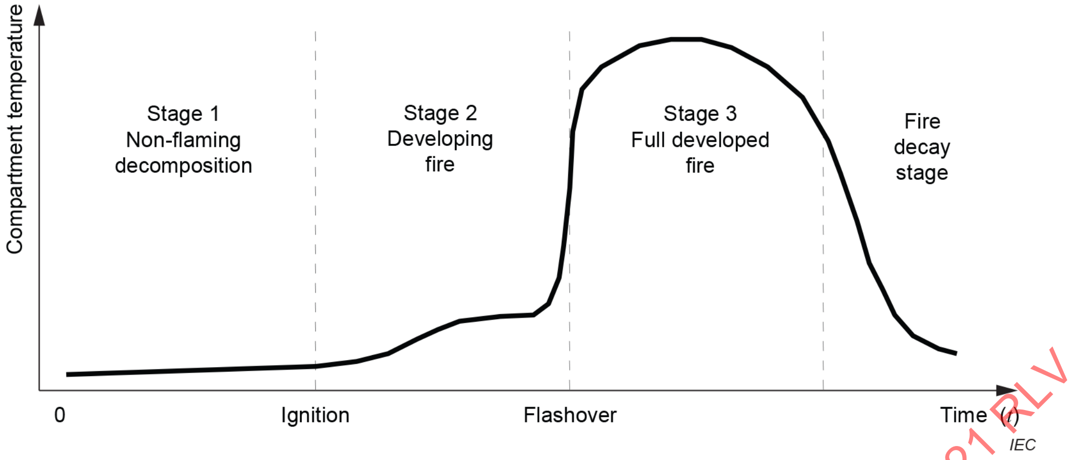

Figure 1 – Different stages in the development of a fire within a compartment

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

~~Stages of fire~~		~~Oxygen *~~ ~~%~~	~~CO_2/CO ratio **~~	~~Temperature *~~ ~~°C~~	~~Irradiance ***~~ ~~kW·m^{-2}~~
~~Stage 1~~	~~Non-flaming decomposition~~				
	~~a) Smouldering (self-sustaining)~~	~~21~~	~~Not applicable~~	~~<100~~	~~Not applicable~~
	~~b) Non-flaming (oxidative)~~	~~5 to 21~~	~~Not applicable~~	~~<500~~	~~<25~~
	~~c) Non-flaming (pyrolytic)~~	~~<5~~	~~Not applicable~~	~~<1 000~~	~~Not applicable~~
~~Stage 2~~	~~Developing fire (flaming)~~	~~10 to 15~~	~~100 to 200~~	~~400 to 600~~	~~20 to 40~~
~~Stage 3~~	~~Fully developed fire (flaming)~~				
	~~a) Relatively low ventilation~~	~~1 to 5~~	~~<10~~	~~600 to 900~~	~~40 to 70~~
	~~b) Relatively high ventilation~~	~~5 to 10~~	~~<100~~	~~600 to 1 200~~	~~50 to 150~~

~~* General environmental condition (average) within compartment.~~

~~** Mean value in fire plume near to fire.~~

~~*** Incident irradiance onto test specimen (average).~~

5 General aspects of the corrosivity of fire effluent

5.1 Corrosion damage scenarios

With respect to electrotechnical equipment and systems, there are three **corrosion damage** scenarios which are of concern~~. These are where corrosion damage is caused by fire effluent in the following situations~~:

a) within electrotechnical equipment and systems when exposed to **fire effluent** caused by unusual, localized, internal sources of excessive heat and ignition;

b) within electrotechnical equipment and systems when exposed to **fire effluent** caused by external sources of flame or excessive heat;

c) within building structures when exposed to **fire effluent** emitted from electrotechnical equipment and systems.

Table 1 – Characteristics of fire stages (from Table 1 of ISO 19706:2011)

Fire stage	Heat flux to fuel surface kW/m^2	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. Underventilated 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 can 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.

5.2 Types of corrosion damage effects

5.2.1 Introduction

Four types of **corrosion damage** effect are recognized. These are

a) metal loss,

b) moving parts becoming immobile,

c) bridging of conductor circuits,

d) formation of a non-conducting layer on contact surfaces.

5.2.2 Metal loss

Metal loss is caused by oxidation of elemental metal to a positive oxidation state. One of the simplest reactions of this type is with an acid to form a metal salt and water, and this is why early efforts to combat potential corrosion were directed at reducing the acid gas production in **fire effluent**.

However, it is not necessary for an acid to be present for oxidation to occur. If a metal is in contact with an electrically conductive solution, the free ions of the solution can facilitate corrosion of contacting metals by either reacting directly with the metal or by depolarizing the area around the reacting metal. The rate of corrosion will depend on the area of metal affected, the temperature, and on the magnitude of the difference between the electrode potentials of the oxidizing and reducing couples. Metals higher in the electrochemical series are more prone to corrosion.

Metal loss can cause many undesired effects. In buildings it can result in a weakening or failure of structural elements. In electrical equipment it can cause a decrease in electrical conductivity or ultimately the breaking of a circuit.

5.2.3 Moving parts becoming immobile

Fire effluent can cause moving parts in mechanical or electromechanical equipment to become immobile, e.g. a ball bearing or parts in a circuit breaker. This may be because of the deposition of sticky particulate matter or because of the formation of chemical corrosion products between surfaces.

5.2.4 Bridging of conductor circuits

Fire effluent may contain conductive particulates, e.g. graphitic carbon or ionic species. Metal corrosion also produces ionic species. These conductive species can bridge the small gaps between the copper tracks on circuit boards causing undesired **leakage current**s. This is of particular concern with digital telecommunications equipment.

5.2.5 Formation of a non-conducting layer on contact surfaces

This is a particular case of metal loss. Corrosion at the interface of a metal contact can result in the formation of a layer of non-conducting material resulting in the loss of the circuit. This is particularly likely if the contact is between dissimilar metals because they will form an electrochemical cell when in contact with a conductive medium.

5.3 Factors affecting corrosivity

5.3.1 Introduction

The significant **corrosion damage** effects of **fire effluent** are assessed in terms of the rate of functional impairment of the circuit or material affected. This impairment is dependent on a number of factors. Some are related to the nature of the **fire effluent**, e.g.

- the chemical and physical nature and concentration of the **fire effluent**;
- interactions within the **fire effluent** such as **smoke** particulate ageing, agglomeration and settling, condensation of liquid species, precipitation phenomena, and the absorption by **smoke** particles of chemically reactive effluents.

These will in turn depend on the nature of the material being burned and on the **physical fire model** being used.

Some factors are related to the corrosion environment, e.g.

- the physical and chemical nature of the affected circuits or materials;
- the prevailing conditions of temperature and relative humidity;
- the time of exposure;
- whether or not an electrical circuit is present and energized;
- post-exposure cleaning.

5.3.2 The nature of fire effluent

Many factors affect the production of **fire effluent** and its properties. A full description of such properties is not possible, but the influence of several important variables is recognized.

Fire effluent is a consequence of both **pyrolysis** and combustion. Combustion may be flaming or non-flaming, including smouldering, and these different modes of combustion may produce quite different types of effluent. In **pyrolysis** and non-flaming combustion, volatiles are evolved at elevated temperatures. When they mix with cool air, they condense to form spherical droplets which appear as a light-coloured **smoke** aerosol. Flaming combustion produces a black carbon-rich **smoke** in which the particles have a very irregular shape. The **smoke** particles from flaming combustion are formed in the gas phase and in regions where the oxygen concentrations are low enough to cause incomplete combustion. The most abundant species in most **fire effluents** are carbon dioxide, water, carbon monoxide and carbon-rich **smoke**.

However, many other chemicals may be present, including inorganic acids, organic acids and ionic species. It is predominantly these last three types of material which cause **fire effluent** to have a corrosive nature. The amounts of these materials which are present in **fire effluent** will depend on the nature of the material being burnt and on the stage of the fire.

The heat flux on the test specimen influences how the material burns. It is good practice to evaluate the effluent generated from materials at low levels of incident irradiance (e.g. 15 $\text{kW} \times \text{m}^{-2}$ to 25 $\text{kW} \times \text{m}^{-2}$) as well as at higher levels (e.g. 40 $\text{kW} \times \text{m}^{-2}$ to 50 $\text{kW} \times \text{m}^{-2}$). In this way, the effects of the growth stages of a fire on the corrosive nature of the effluent can be assessed.

The particle size distribution of **smoke** aerosols changes with time; **smoke** particles coagulate as they age. Some properties also change with temperature so that the properties of aged, or cold, **smoke** may be different from young, hot **smoke**. These factors may affect the way in which **smoke** particles can cause short-circuits between electrical components.

5.3.3 The corrosion environment

The potential for **corrosion damage** can be reduced by protecting susceptible surfaces, generally by using paint or lacquers. However, in many cases involving electrotechnical equipment, this is not a practical solution.

The chemical nature of the exposed material will affect its susceptibility to **corrosion damage**. Metals higher in the electrochemical series are more reactive. Those low in the series such as gold and platinum are effectively inert. If dissimilar metals are in contact, one of them will be particularly prone to corrosion because they make an electrochemical cell when in contact with a conducting medium.

In many **fire scenario**s the affected materials will be at a high temperature, and temperature has a major effect on the rate of corrosion. On average, the rate of a chemical reaction doubles with a 10 ~~°C~~ K rise in temperature. The use of low heat release rate materials will help to reduce fire temperatures and thus will reduce corrosive damage.

Relative humidity also affects corrosion reactions. Many reactions will not proceed in the absence of water. Unfortunately, almost all fires produce water vapour as a major component of the **fire effluent** so the relative humidity in the corrosion environment is likely to be high. Also, if automatic water spray systems or fire fighters have been used, large quantities of liquid water are likely to be present.

Two exposure times are involved. There is the time of exposure to the **fire effluent** when the fire is occurring, and there is the subsequent exposure time to the prevailing conditions after the fire has ceased. Both exposure times will affect the degree of **corrosion damage**. Some reactions are auto-catalytic and therefore are initially slow but after a certain time will progress rapidly. Also, some metals have a passive layer on their surface and again initial reaction will be slow but when the passive layer has been removed, subsequent reaction may be rapid.

A special problem with electrotechnical equipment is that exposed circuits may be energized. This can cause electrochemical reactions that would not otherwise occur, and in some cases can lead to destructive bridging or arcing phenomena.

6 Principles of corrosion damage measurement

6.1 Introduction

Corrosion damage measurement involves essentially two stages:

a) generation of the **fire effluent**;

b) assessment of the corrosive nature of the **fire effluent**.

However, each of these stages is complex and they both involve the selection of test parameters from a wide range of possible choices.

6.2 Generation of the fire effluent

6.2.1 General

In a **corrosion damage** test, there are essentially two stages involved in the generation of the **fire effluent**:

a) selection of the test specimen to be burned;

b) selection of an appropriate physical **fire model** relevant to the hazard being considered.

6.2.2 Selection of the test specimen to be burned

Different types of test specimens may be tested. In product testing, the test specimen is a manufactured product. In simulated product testing, the test specimen is a representative portion of a product. The test specimen may also be a basic material (solid or liquid) or a composite of materials.

The nature of the test specimen is governed to a large extent by the scale of the test. **Small-scale fire tests** are suited more to the testing of materials and small products or representative samples of larger products. On a larger scale, whole products may be tested. Given a choice, it is always preferable to select a test specimen that most closely reflects its end use.

6.2.3 Selection of the physical fire model

It is important to consider the **physical fire model** or models most relevant to the hazard being assessed, and to select tests which have fire ~~models~~ characteristics similar to those being assessed (see IEC TS 60695-5-2).

6.3 Assessment of corrosive potential

6.3.1 General

It is desirable that the test procedure be designed in such a manner that the results are valid for the application of an analysis of corrosion hazard, and also as part of an analysis of total fire hazard. ~~Work on the design of reaction-to-fire tests to ensure that results are valid for assessment of hazard is in its early stages (see IEC 60695-1-1 for early guidance). The guidance in this subclause will therefore be superseded as work progresses.~~

There are two approaches to the assessment of the corrosive potential of **fire effluent**. One involves the exposure of a specific target to the effluent, and some measurement of impairment. In this case, the target may be an actual product or it may be a simulated product, e.g. a test circuit or a thin sheet of metal. The other approach is indirect and involves the measurement of certain chemical properties of the **fire effluent** from which the corrosive potential may, under defined conditions, be estimated or assessed. A summary of test methods is given in Table 2.

6.3.2 Indirect assessment

Indirect assessment involves the dissolution of a known quantity of **fire effluent** in a known volume of water. The resulting solution is then tested. Measurements are made, for example, of pH, conductivity or concentration of acids. Such assessments have the advantage of being relatively simple, but have the disadvantage that they do not measure **corrosion damage**. An assumption has to be made that a certain level of the measured parameter will correspond to an unacceptable corrosive potential. This will be valid for a given scenario only if independent measurements have been made to establish such a correlation.

IEC 60754-1 [2] determines the level of halogen acid in an aqueous solution of **fire effluent**. IEC 60754-2 [3] determines the pH and conductivity in an aqueous solution of **fire effluent**.

NOTE IEC 60754-3 [4] measures low levels of halogen in an aqueous solution of **fire effluent**. The method is intended for materials with an individual halogen content not exceeding 10 mg/g and therefore is not relevant to the prediction of corrosivity.

6.3.3 Simulated product testing

In this case, the **corrosion target** is typically a reference circuit, a thin sheet of metal or a metal mirror. Depending on their design, reference circuits can be used to measure an increase in resistance due to metal loss, or an increase in **leakage current** due to the deposition of conductive materials. Metal sheets and metal mirrors are used to measure metal loss. The effects of **fire effluent** on the reference material can be assessed by measurements such as change in aspect, weight, mechanical, physical or electrical characteristics. These methods have the advantage of directly measuring the **corrosion damage** effect. However, as with indirect assessment, an assumption has to be made that a certain level of the measured parameter will correspond to an unacceptable corrosive potential. This will be valid for a given scenario only if independent measurements have been made to establish such a correlation.

ISO 11907-4 [5] and ASTM D5485 [6] both describe the use of a conical heater to generate **fire effluent**, using resistance targets to measure corrosion. ASTM D2671 [7] (Sections 89-95) describes corrosion testing using copper (in various forms) as the target.

6.3.4 Product testing

In this case the **corrosion target** is a manufactured product. Examples include a printed wiring board, a switchboard, a washing machine, a computer, or a telephone handset~~, etc~~. The effects of **fire effluent** on the product can be assessed by degradation of function as determined by inspection or measurement.

Table 2 – Summary of corrosivity test methods

~~Test method~~	~~Type of test method~~	~~Limitations on test specimen~~	~~Relevance to stage of fire~~					
			~~1(a)~~	~~1(b)~~	~~1(c)~~	~~2~~	~~3(a)~~	~~3(b)~~
~~Determination of halogen acid in combustion gases, e.g. IEC 60754-1~~	~~Indirect~~	~~500 mg to 1 000 mg of the material to be tested, cut into small pieces~~	~~No~~	~~No~~	~~Yes~~	~~No~~	~~No~~	~~No~~
~~Determination of the acidity and conductivity of combustion gases dissolved in an aqueous solution, e.g. IEC 60754-2~~	~~Indirect~~	~~500 mg to 1 000 mg of the material to be tested, cut into small pieces~~	~~No~~	~~No~~	~~Yes~~	~~No~~	~~No~~	~~No~~
~~Copper mirror test ASTM D 2671~~	~~Simulated product (metal loss)~~	~~2,5 cm long samples cut from heat-shrinkable tubing~~	~~No~~	~~Yes~~	~~No~~	~~No~~	~~No~~	~~No~~
~~Static method ISO 11907-2~~	~~Simulated product (metal loss)~~	~~600 mg of the material to be tested, in the form of granules or chips~~	~~No~~	~~No~~	~~No~~	~~Yes~~	~~No~~	~~No~~
~~Travelling furnace ISO 11907-3~~	~~Simulated product (metal loss)~~	~~400 mm long × 15 mm wide. Thickness to give a mass of 4,8 g~~	~~No~~	~~Yes~~	~~Yes~~	~~Yes~~	~~Yes~~	~~Yes~~
~~Cone corrosimeter, e.g. ISO 11907-4~~	~~Simulated product (metal loss)~~	~~100 mm × 100 mm × 6 mm cut from a representative sample of the material or end product~~	~~No~~	~~Yes~~	~~No~~	~~Yes~~	~~No~~	~~Yes~~
~~IEC 60695-5-3~~	~~Simulated product (leakage current and metal loss)~~	~~1 g of the material to be tested~~	~~Yes~~	~~No~~	~~No~~	~~Yes~~	~~Yes~~	~~No~~

Test method	Type of test method	Approximate size of test specimen	Relevance to stage of fire					
			1(a)	1(b)	1(c)	2	3(a)	3(b)
Determination of halogen acid in combustion gases, e.g. IEC 60754-1 [2]	Indirect	500 mg to 1 000 mg of the material to be tested, cut into small pieces	No	No	Yes	No	No	No
Determination of the acidity and conductivity of combustion gases dissolved in an aqueous solution, e.g. IEC 60754-2 [3]	Indirect	995 mg to 1 005 mg of the material to be tested, cut into small pieces	No	No	Yes	No	No	No
Cone corrosimeter ISO 11907-4 [5] and ASTM D5485 [6]	Simulated product (metal loss)	100 mm × 100 mm × 6 mm cut from a representative sample of the material or end product	No	Yes	No	Yes	No	Yes
Copper corrosion tests ASTM D2671 [7] Sections 89-95	Simulated product (metal loss)	2,5 cm long samples cut from heat-shrinkable tubing	No	Yes	No	No	No	No

6.4 Consideration of corrosivity test methods

In the selection of test methods, the following questions should be asked of each method under consideration:

- Does the test measure **corrosion damage** or a parameter known to correlate with corrosion?
- Does the test replicate the stage of fire being studied?
- Does the test assess the type or types of corrosive damage which are of concern?

~~If the answer to any of these questions is no, the method under consideration will need modification, or an alternative method should be considered.~~

If the answer to any of these questions is no, the method under consideration shall either be modified or an alternative method shall be considered. The test method(s) selected shall be relevant to the **fire scenario** of concern.

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 TC 89.

A flow chart outlining the stages to be followed in assessing the suitability of an existing method for a new application is shown in Figure 2.

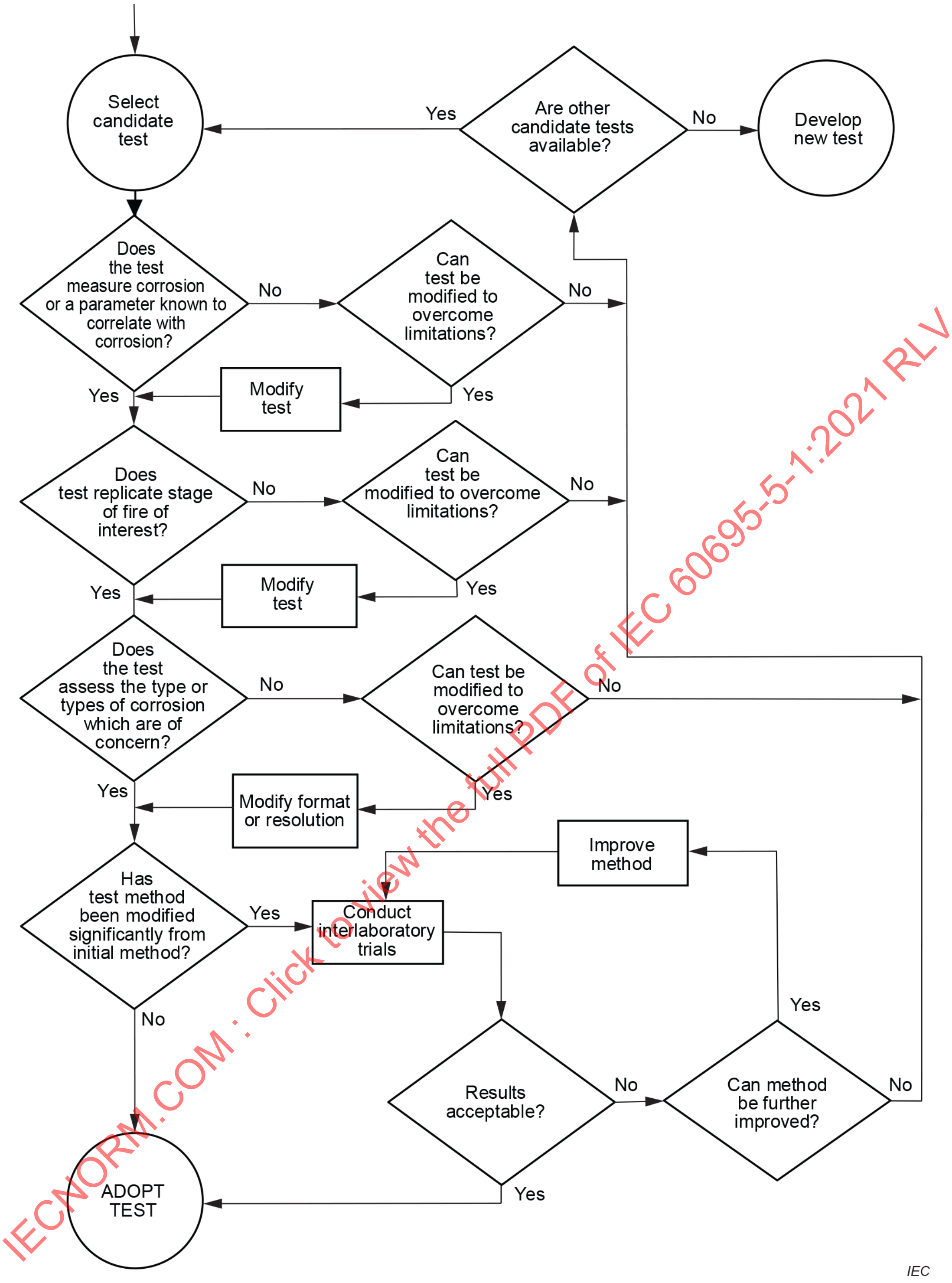

Figure 2 – Evaluation and consideration of corrosion damage test methods

7 Relevance of data to hazard assessment

The potential hazard due to the corrosive nature of **fire effluent** depends on a number of factors including:

- the chemical composition of the burning material;
- the **fire scenario**;
- the chemical and physical nature of the affected materials or products;

- the type of **corrosion damage** considered to be of importance, i.e. weakening of structure, rendering immobile a normally moving part, breaking of an electrical circuit or creation of an undesired electrical circuit;
- the temperature and humidity of the environment where the **corrosion damage** can occur;
- the length of time that the **fire effluent** is in contact with the materials or products that may be affected.

It follows therefore that realistic assessments of the corrosive potential of the **fire effluent** from a burning test specimen can only be obtained by testing a full-scale test specimen in the form and orientation in which it is actually used, and by exposing full-scale items to the **fire effluent** in realistic end-use conditions.

An isolated **small-scale fire test**, not representative of the final use of either the burning test specimen or the affected product, can only indicate the response of a product to the fire ~~model~~ test selected. Equally, reference **corrosion target**s can only simulate the response of full-scale items to the **fire effluent**.

It is emphasized that no single **corrosion damage** test can, in normal circumstances, measure corrosion hazard; in addition, it cannot be assumed that satisfactory results of a single standard test will guarantee a given level of safety. Results from a variety of fire tests will provide information to assist in the determination and subsequent control of fire and corrosive hazards.

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[4] IEC 60754-3, *Test on gases evolved during combustion of materials from cables – Part 3: Measurement of low level of halogen content by ion chromatography*

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

Essais relatifs aux risques du feu – Partie 5-1: Effets des dommages de corrosion des effluents du feu – Recommandations générales

IEC 60695-5-1:2021-10(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FIRE HAZARD TESTING –

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

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 60695-5-1 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.

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, 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 effluent**s 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.

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.

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 60695-1-10, *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 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 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. It may also be a reference material or object used to simulate the behaviour of a product or a component.

[SOURCE: ISO 13943:2017, 3.70]

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
all gases and aerosols, including suspended particles, created by combustion or **pyrolysis** (3.9) and emitted to the environment

[SOURCE: ISO 13943:2017, 3.123]

3.5
fire scenario
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]

3.6
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 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 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.

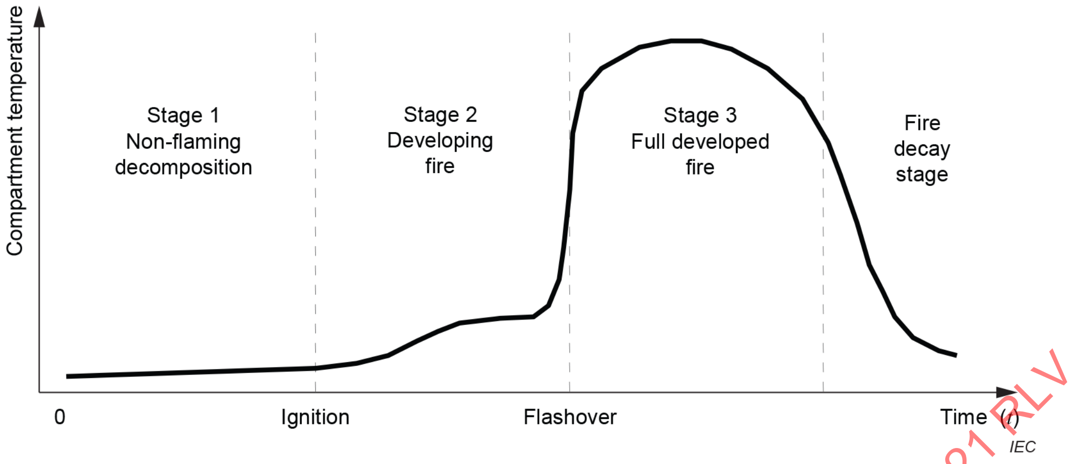

Figure 1 – Different stages in the development of a fire within a compartment

5 General aspects of the corrosivity of fire effluent

5.1 Corrosion damage scenarios

With respect to electrotechnical equipment and systems, there are three **corrosion damage** scenarios which are of concern:

a) within electrotechnical equipment and systems when exposed to **fire effluent** caused by unusual, localized, internal sources of excessive heat and ignition;

b) within electrotechnical equipment and systems when exposed to **fire effluent** caused by external sources of flame or excessive heat;

c) within building structures when exposed to **fire effluent** emitted from electrotechnical equipment and systems.

Table 1 – Characteristics of fire stages (from Table 1 of ISO 19706:2011)

Fire stage	Heat flux to fuel surface kW/m^2	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. Underventilated 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 can 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.

5.2 Types of corrosion damage effects

5.2.1 Introduction

Four types of **corrosion damage** effect are recognized. These are

a) metal loss,
b) moving parts becoming immobile,
c) bridging of conductor circuits,
d) formation of a non-conducting layer on contact surfaces.

5.2.2 Metal loss

Metal loss is caused by oxidation of elemental metal to a positive oxidation state. One of the simplest reactions of this type is with an acid to form a metal salt and water, and this is why early efforts to combat potential corrosion were directed at reducing the acid gas production in **fire effluent**.

However, it is not necessary for an acid to be present for oxidation to occur. If a metal is in contact with an electrically conductive solution, the free ions of the solution can facilitate corrosion of contacting metals by either reacting directly with the metal or by depolarizing the area around the reacting metal. The rate of corrosion will depend on the area of metal affected, the temperature, and on the magnitude of the difference between the electrode potentials of the oxidizing and reducing couples. Metals higher in the electrochemical series are more prone to corrosion.

Metal loss can cause many undesired effects. In buildings it can result in a weakening or failure of structural elements. In electrical equipment it can cause a decrease in electrical conductivity or ultimately the breaking of a circuit.

5.2.3 Moving parts becoming immobile

Fire effluent can cause moving parts in mechanical or electromechanical equipment to become immobile, e.g. a ball bearing or parts in a circuit breaker. This may be because of the deposition of sticky particulate matter or because of the formation of chemical corrosion products between surfaces.

5.2.4 Bridging of conductor circuits

Fire effluent may contain conductive particulates, e.g. graphitic carbon or ionic species. Metal corrosion also produces ionic species. These conductive species can bridge the small gaps between the copper tracks on circuit boards causing undesired **leakage currents**. This is of particular concern with digital telecommunications equipment.

5.2.5 Formation of a non-conducting layer on contact surfaces

This is a particular case of metal loss. Corrosion at the interface of a metal contact can result in the formation of a layer of non-conducting material resulting in the loss of the circuit. This is particularly likely if the contact is between dissimilar metals because they will form an electrochemical cell when in contact with a conductive medium.

5.3 Factors affecting corrosivity

5.3.1 Introduction

The significant **corrosion damage** effects of **fire effluent** are assessed in terms of the rate of functional impairment of the circuit or material affected. This impairment is dependent on a number of factors. Some are related to the nature of the **fire effluent**, e.g.

- the chemical and physical nature and concentration of the **fire effluent**;
- interactions within the **fire effluent** such as **smoke** particulate ageing, agglomeration and settling, condensation of liquid species, precipitation phenomena, and the absorption by **smoke** particles of chemically reactive effluents.

These will in turn depend on the nature of the material being burned and on the **physical fire model** being used.

Some factors are related to the corrosion environment, e.g.

- the physical and chemical nature of the affected circuits or materials;
- the prevailing conditions of temperature and relative humidity;
- the time of exposure;
- whether or not an electrical circuit is present and energized;
- post-exposure cleaning.

5.3.2 The nature of fire effluent

Many factors affect the production of **fire effluent** and its properties. A full description of such properties is not possible, but the influence of several important variables is recognized.

Fire effluent is a consequence of both **pyrolysis** and combustion. Combustion may be flaming or non-flaming, including smouldering, and these different modes of combustion may produce quite different types of effluent. In **pyrolysis** and non-flaming combustion, volatiles are evolved at elevated temperatures. When they mix with cool air, they condense to form spherical droplets which appear as a light-coloured **smoke** aerosol. Flaming combustion produces a black carbon-rich **smoke** in which the particles have a very irregular shape. The **smoke** particles from flaming combustion are formed in the gas phase and in regions where the oxygen concentrations are low enough to cause incomplete combustion. The most abundant species in most **fire effluents** are carbon dioxide, water, carbon monoxide and carbon-rich **smoke**.

However, many other chemicals may be present, including inorganic acids, organic acids and ionic species. It is predominantly these last three types of material which cause **fire effluent** to have a corrosive nature. The amounts of these materials which are present in **fire effluent** will depend on the nature of the material being burnt and on the stage of the fire.

The heat flux on the test specimen influences how the material burns. It is good practice to evaluate the effluent generated from materials at low levels of incident irradiance (e.g. 15 kW × m^{-2} to 25 kW × m^{-2}) as well as at higher levels (e.g. 40 kW × m^{-2} to 50 kW × m^{-2}). In this way, the effects of the growth stages of a fire on the corrosive nature of the effluent can be assessed.

The particle size distribution of **smoke** aerosols changes with time; **smoke** particles coagulate as they age. Some properties also change with temperature so that the properties of aged, or cold, **smoke** may be different from young, hot **smoke**. These factors may affect the way in which **smoke** particles can cause short-circuits between electrical components.

5.3.3 The corrosion environment

The potential for **corrosion damage** can be reduced by protecting susceptible surfaces, generally by using paint or lacquers. However, in many cases involving electrotechnical equipment, this is not a practical solution.

The chemical nature of the exposed material will affect its susceptibility to **corrosion damage**. Metals higher in the electrochemical series are more reactive. Those low in the series such as gold and platinum are effectively inert. If dissimilar metals are in contact, one of them will be particularly prone to corrosion because they make an electrochemical cell when in contact with a conducting medium.

In many **fire scenario**s the affected materials will be at a high temperature, and temperature has a major effect on the rate of corrosion. On average, the rate of a chemical reaction doubles with a 10 K rise in temperature. The use of low heat release rate materials will help to reduce fire temperatures and thus will reduce corrosive damage.

Relative humidity also affects corrosion reactions. Many reactions will not proceed in the absence of water. Unfortunately, almost all fires produce water vapour as a major component of the **fire effluent** so the relative humidity in the corrosion environment is likely to be high. Also, if automatic water spray systems or fire fighters have been used, large quantities of liquid water are likely to be present.

Two exposure times are involved. There is the time of exposure to the **fire effluent** when the fire is occurring, and there is the subsequent exposure time to the prevailing conditions after the fire has ceased. Both exposure times will affect the degree of **corrosion damage**. Some reactions are auto-catalytic and therefore are initially slow but after a certain time will progress rapidly. Also, some metals have a passive layer on their surface and again initial reaction will be slow but when the passive layer has been removed, subsequent reaction may be rapid.

A special problem with electrotechnical equipment is that exposed circuits may be energized. This can cause electrochemical reactions that would not otherwise occur, and in some cases can lead to destructive bridging or arcing phenomena.

6 Principles of corrosion damage measurement

6.1 Introduction

Corrosion damage measurement involves essentially two stages:

a) generation of the **fire effluent**;

b) assessment of the corrosive nature of the **fire effluent**.

However, each of these stages is complex and they both involve the selection of test parameters from a wide range of possible choices.

6.2 Generation of the fire effluent

6.2.1 General

In a **corrosion damage** test, there are essentially two stages involved in the generation of the **fire effluent**:

a) selection of the test specimen to be burned;

b) selection of an appropriate **physical fire model** relevant to the hazard being considered.

6.2.2 Selection of the test specimen to be burned

Different types of test specimens may be tested. In product testing, the test specimen is a manufactured product. In simulated product testing, the test specimen is a representative portion of a product. The test specimen may also be a basic material (solid or liquid) or a composite of materials.

The nature of the test specimen is governed to a large extent by the scale of the test. **Small-scale fire tests** are suited more to the testing of materials and small products or representative samples of larger products. On a larger scale, whole products may be tested. Given a choice, it is always preferable to select a test specimen that most closely reflects its end use.

6.2.3 Selection of the physical fire model

It is important to consider the **physical fire model** or models most relevant to the hazard being assessed, and to select tests which have fire characteristics similar to those being assessed (see IEC TS 60695-5-2).

6.3 Assessment of corrosive potential

6.3.1 General

It is desirable that the test procedure be designed in such a manner that the results are valid for the application of an analysis of corrosion hazard, and also as part of an analysis of total fire hazard.

There are two approaches to the assessment of the corrosive potential of **fire effluent**. One involves the exposure of a specific target to the effluent, and some measurement of impairment. In this case, the target may be an actual product or it may be a simulated product, e.g. a test circuit or a thin sheet of metal. The other approach is indirect and involves the measurement of certain chemical properties of the **fire effluent** from which the corrosive potential may, under defined conditions, be estimated or assessed. A summary of test methods is given in Table 2.

6.3.2 Indirect assessment

Indirect assessment involves the dissolution of a known quantity of **fire effluent** in a known volume of water. The resulting solution is then tested. Measurements are made, for example, of pH, conductivity or concentration of acids. Such assessments have the advantage of being relatively simple, but have the disadvantage that they do not measure **corrosion damage**. An assumption has to be made that a certain level of the measured parameter will correspond to an unacceptable corrosive potential. This will be valid for a given scenario only if independent measurements have been made to establish such a correlation.

IEC 60754-1 [2] determines the level of halogen acid in an aqueous solution of **fire effluent**.
IEC 60754-2 [3] determines the pH and conductivity in an aqueous solution of **fire effluent**.

NOTE IEC 60754-3 [4] measures low levels of halogen in an aqueous solution of **fire effluent**. The method is intended for materials with an individual halogen content not exceeding 10 mg/g and therefore is not relevant to the prediction of corrosivity.

6.3.3 Simulated product testing

In this case, the **corrosion target** is typically a reference circuit, a thin sheet of metal or a metal mirror. Depending on their design, reference circuits can be used to measure an increase in resistance due to metal loss, or an increase in **leakage current** due to the deposition of conductive materials. Metal sheets and metal mirrors are used to measure metal loss. The effects of **fire effluent** on the reference material can be assessed by measurements such as change in aspect, weight, mechanical, physical or electrical characteristics. These methods have the advantage of directly measuring the **corrosion damage** effect. However, as with indirect assessment, an assumption has to be made that a certain level of the measured parameter will correspond to an unacceptable corrosive potential. This will be valid for a given scenario only if independent measurements have been made to establish such a correlation.

ISO 11907-4 [5] and ASTM D5485 [6] both describe the use of a conical heater to generate **fire effluent**, using resistance targets to measure corrosion. ASTM D2671 [7] (Sections 89-95) describes corrosion testing using copper (in various forms) as the target.

6.3.4 Product testing

In this case the **corrosion target** is a manufactured product. Examples include a printed wiring board, a switchboard, a washing machine, a computer, or a telephone handset. The effects of **fire effluent** on the product can be assessed by degradation of function as determined by inspection or measurement.

Table 2 – Summary of corrosivity test methods

Test method	Type of test method	Approximate size of test specimen	Relevance to stage of fire					
			1(a)	1(b)	1(c)	2	3(a)	3(b)
Determination of halogen acid in combustion gases, e.g. IEC 60754-1 [2]	Indirect	500 mg to 1 000 mg of the material to be tested, cut into small pieces	No	No	Yes	No	No	No
Determination of the acidity and conductivity of combustion gases dissolved in an aqueous solution, e.g. IEC 60754-2 [3]	Indirect	995 mg to 1 005 mg of the material to be tested, cut into small pieces	No	No	Yes	No	No	No
Cone corrosimeter ISO 11907-4 [5] and ASTM D5485 [6]	Simulated product (metal loss)	100 mm × 100 mm × 6 mm cut from a representative sample of the material or end product	No	Yes	No	Yes	No	Yes
Copper corrosion tests ASTM D2671 [7] Sections 89-95	Simulated product (metal loss)	2,5 cm long samples cut from heat-shrinkable tubing	No	Yes	No	No	No	No

6.4 Consideration of corrosivity test methods

In the selection of test methods, the following questions should be asked of each method under consideration:

- Does the test measure **corrosion damage** or a parameter known to correlate with corrosion?
- Does the test replicate the stage of fire being studied?
- Does the test assess the type or types of corrosive damage which are of concern?

If the answer to any of these questions is no, the method under consideration shall either be modified or an alternative method shall be considered. The test method(s) selected shall be relevant to the **fire scenario** of concern.

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 TC 89.

A flow chart outlining the stages to be followed in assessing the suitability of an existing method for a new application is shown in Figure 2.

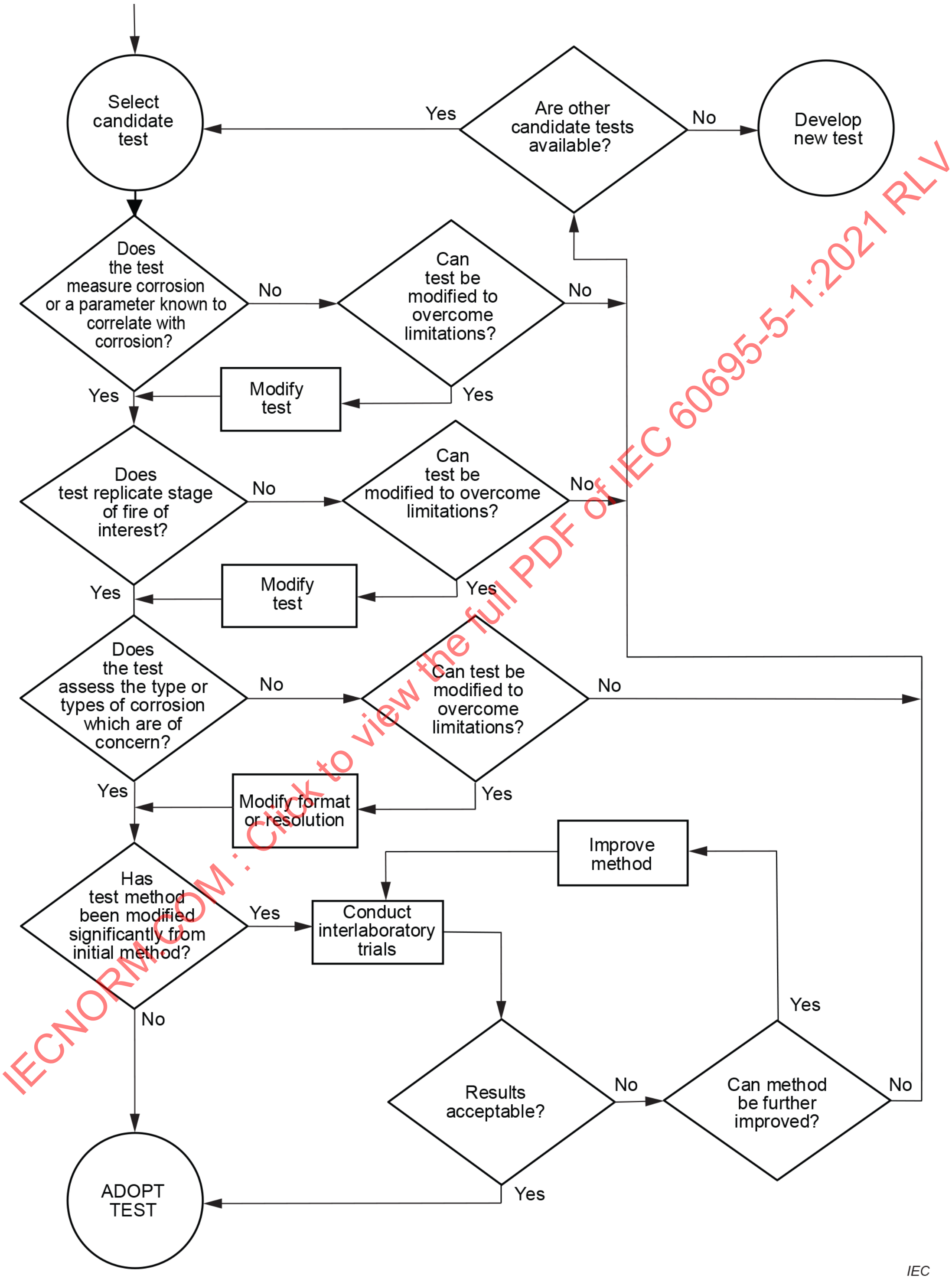

Figure 2 – Evaluation and consideration of corrosion damage test methods

7 Relevance of data to hazard assessment

The potential hazard due to the corrosive nature of **fire effluent** depends on a number of factors including:

- the chemical composition of the burning material;
- the **fire scenario**;
- the chemical and physical nature of the affected materials or products;
- the type of **corrosion damage** considered to be of importance, i.e. weakening of structure, rendering immobile a normally moving part, breaking of an electrical circuit or creation of an undesired electrical circuit;
- the temperature and humidity of the environment where the **corrosion damage** can occur;
- the length of time that the **fire effluent** is in contact with the materials or products that may be affected.

It follows therefore that realistic assessments of the corrosive potential of the **fire effluent** from a burning test specimen can only be obtained by testing a full-scale test specimen in the form and orientation in which it is actually used, and by exposing full-scale items to the **fire effluent** in realistic end-use conditions.

An isolated **small-scale fire test**, not representative of the final use of either the burning test specimen or the affected product, can only indicate the response of a product to the fire test selected. Equally, reference **corrosion target**s can only simulate the response of full-scale items to the **fire effluent**.

It is emphasized that no single **corrosion damage** test can, in normal circumstances, measure corrosion hazard; in addition, it cannot be assumed that satisfactory results of a single standard test will guarantee a given level of safety. Results from a variety of fire tests will provide information to assist in the determination and subsequent control of fire and corrosive hazards.

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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ESSAIS RELATIFS AUX RISQUES DU FEU –

Partie 5-1: Effets des dommages de corrosion des effluents du feu – Recommandations générales

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La Norme internationale IEC 60695-5-1 a été établie par le comité d'études 89 de l'IEC: Essais relatifs aux risques du feu.

Cette troisième édition annule et remplace la deuxième édition, parue en 2002 et constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) les références à l'IEC TS 60695-5-3 (supprimée en 2014) ont été supprimées;

b) les références à l'IEC 60695-1-1 correspondent désormais aux normes suivantes: IEC 60695-1-10 et IEC 60695-1-11;

c) l'ISO/TR 9122-1 a été révisée par l'ISO 19706;

d) le Tableau 1 a été mis à jour;

e) les références à l'ISO 11907-2 et à l'ISO 11907-3 ont été supprimées;

f) les termes et définitions ont été mis à jour;

g) le texte de 6.4 a été mis à jour;

h) les références bibliographiques ont été mises à jour.

Le texte de cette Norme internationale est issu des documents suivants:

FDIS	Rapport de vote
89/1539/FDIS	89/1543/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à son approbation.

La langue employée pour l'élaboration de cette Norme internationale est l'anglais.

Le présent document a été rédigé selon les Directives ISO/IEC, Partie 2, il a été développé selon les Directives ISO/IEC, Partie 1 et les Directives ISO/IEC, Supplément IEC, disponibles sous www.iec.ch/members_experts/refdocs. Les principaux types de documents développés par l'IEC sont décrits plus en détail sous www.iec.ch/standardsdev/publications.

Il a le statut d'une publication fondamentale de sécurité conformément au Guide IEC 104 et au Guide ISO/IEC 51.

Dans la présente norme, les caractères d'imprimerie suivants sont utilisés:

Arial **gras**: termes qui se réfèrent à l'Article 2

Cette norme doit être lue conjointement avec l'IEC TS 60695-5-2.

Une liste de toutes les parties de la série IEC 60695, publiées sous le titre général *Essais relatifs aux risques du feu*, peut être consultée sur le site web de l'IEC.

Le comité a décidé que le contenu du présent document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous webstore.iec.ch dans les données relatives au document recherché. À cette date, le document sera

- reconduit,
- supprimé,
- remplacé par une édition révisée, ou
- amendé.

INTRODUCTION

Lors de la conception d'un quelconque produit électrotechnique, il est nécessaire de prendre en considération le risque d'incendie et les dangers potentiels liés au feu. À cet égard, la conception des composants, circuits et produits, ainsi que le choix des matériaux ont pour objectif de réduire à un niveau acceptable le risque d'incendie même en cas de mauvais usage raisonnablement prévisible, de dysfonctionnement ou de défaillance.

L'IEC 60695-1-10, l'IEC 60695-1-11 et l'IEC 60695-1-12 [1][1] fournissent des recommandations relatives aux applications correspondantes.

Les feux impliquant des produits électrotechniques peuvent également être déclenchés par des sources externes non électriques. Ces éléments sont pris en considération lors de l'évaluation globale du danger d'incendie.

La série IEC 60695 a pour objet de sauver des vies et des biens en réduisant le nombre d'incendies ou en limitant leurs conséquences. Pour ce faire, il est possible:

- de tenter d'empêcher l'allumage provoqué par un composant mis sous tension et, en cas d'allumage, de circonscrire l'incendie à l'intérieur des limites de l'enceinte du produit électrotechnique;
- de tenter de réduire le plus possible la propagation de flamme au-delà de l'enceinte du produit et les effets dommageables des **effluents du feu**, y compris la chaleur, la **fumée** et les produits de combustion toxiques ou corrosifs.

Tous les **effluents du feu** sont corrosifs à un certain degré et le niveau de leur potentiel de corrosion dépend de la nature du feu, de la combinaison des matériaux combustibles concernés par le feu, de la nature du substrat touché et de la température et de l'humidité relative de l'environnement dans lequel les **dommages de corrosion** se manifestent. Il n'est pas démontré que les **effluents du feu** des produits électrotechniques présentent un risque de **dommages de corrosion** plus important que ceux d'autres produits, tels que les matériaux d'ameublement ou de construction.

Les performances des composants électriques et électroniques peuvent être sérieusement affectées par les **dommages de corrosion** quand ils sont soumis aux **effluents du feu**. Une grande variété de combinaisons de faibles quantités d'effluents de gaz, de particules de **fumée**, d'humidité et de température sont autant d'éléments susceptibles de créer les conditions de la défaillance d'un composant électrique ou d'un système par rupture, surchauffe ou court-circuit.

Il est particulièrement important d'évaluer un **dommage** potentiel de **corrosion** pour les produits et les installations électrotechniques de prix élevé et liés à la sécurité.

Il incombe aux comités d'études responsables des produits de choisir l'essai ou les essais et de spécifier leur niveau de sévérité.

L'étude des **dommages de corrosion** exige une approche pluridisciplinaire qui englobe la chimie, l'électricité, la physique, l'ingénierie mécanique, la métallurgie et l'électrochimie. Toutes ces disciplines ont été prises en considération dans le cadre de l'élaboration de la présente partie de l'IEC 60695-5.

L'IEC 60695-5-1 définit le domaine d'application des recommandations et en indique les limites.

L'IEC 60695-5-2 présente un résumé des méthodes d'essai, y compris leur pertinence et leur utilité.

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[1] Les chiffres entre crochets se réfèrent à la bibliographie.

ESSAIS RELATIFS AUX RISQUES DU FEU –

Partie 5-1: Effets des dommages de corrosion des effluents du feu – Recommandations générales

1 Domaine d’application

La présente partie de l'IEC 60695 fournit des recommandations concernant:

a) les aspects généraux des méthodes d’essai des **dommages de corrosion**;

b) les méthodes de mesure des **dommages de corrosion**;

c) la prise en considération des méthodes d’essai;

d) la pertinence des données concernant les **dommages de corrosion** pour l’estimation du danger.

La présente publication fondamentale de sécurité est essentiellement destinée à être utilisée par les comités d'études dans le cadre de l'élaboration de normes conformément aux principes établis dans le Guide IEC 104 et le Guide ISO/IEC 51. Elle n'est pas destinée à être utilisée par des fabricants ou des organismes de certification.

L'une des responsabilités d'un comité d'études consiste, le cas échéant, à utiliser les publications fondamentales de sécurité dans le cadre de l'élaboration de ses publications. Les exigences, les méthodes ou les conditions d'essai de la présente publication fondamentale de sécurité s'appliquent seulement si elles sont spécifiquement citées en référence ou incluses dans les publications correspondantes.

2 Références normatives

Les documents suivants sont cités dans le texte de sorte qu’ils constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l’édition citée s’applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60695-1-10, Essais relatifs aux risques du feu – *Partie 1-10: Lignes directrices pour l'évaluation des risques du feu des produits électrotechniques – Lignes directrices générales*

IEC 60695-1-11, *Essais relatifs aux risques du feu – Partie 1-11: Lignes directrices pour l'évaluation du danger du feu des produits électrotechniques – Évaluation du danger du feu*

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

IEC GUIDE 104, *The preparation of safety publications and the use of basic safety publications and group safety publications* (disponible en anglais seulement)

ISO/IEC Guide 51, *Aspects liés à la sécurité – Principes directeurs pour les inclure dans les normes*

ISO 11907-1:2019, *Plastiques – Production de fumées – Détermination de la corrosivité des effluents du feu – Partie 1: Concepts généraux et applicabilité*

ISO 13943:2017, *Sécurité au feu – Vocabulaire*

ISO 19706:2011, *Lignes directrices pour l’évaluation des dangers du feu pour les personnes*

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions suivants s’appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

3.1
dommage de corrosion
dommage physique ou chimique, ou bien détérioration de fonctions résultant d’une action chimique

[SOURCE: ISO 13943:2017, 3.69]

3.2
cible de corrosion
élément sensible utilisé pour déterminer le degré du **dommage de corrosion** (3.1), dans des conditions spécifiées

Note 1 à l'article: Cet élément peut être un produit ou un composant. Il peut également s’agir d’un matériau ou d’un objet de référence utilisé pour simuler le comportement du produit ou du composant.

[SOURCE: ISO 13943:2017, 3.70]

3.3
déclin du feu
étape de développement d’un feu après que le feu a atteint son intensité maximale et au cours de laquelle le débit calorifique et la température du feu diminuent

[SOURCE: ISO 13943:2017, 3.122]

3.4
effluents du feu
ensemble des gaz et aérosols, y compris les particules en suspension, dégagés par combustion ou par **pyrolyse** (3.9) et diffusés dans l’environnement

[SOURCE: ISO 13943:2017, 3.123]

3.5
scénario d’incendie
description qualitative du déroulement d’un incendie dans le temps, identifiant les événements clés qui caractérisent l’incendie et le différencient des autres incendies potentiels

Note 1 à l'article: Voir **groupe de scénarios d’incendie** (ISO 13943:2017, 3.154) et **scénario d’incendie représentatif** (ISO 13943:2017, 3.153).

Note 2 à l'article: Il définit typiquement les processus d’allumage et de croissance du feu, le stade de feu pleinement développé, le stade de **déclin du feu** (3.3), ainsi que l’environnement et les systèmes qui interviennent dans le déroulement de l’incendie.

Note 3 à l'article: Contrairement à une analyse d’incendie déterministe où les scénarios d’incendie sont individuellement sélectionnés et utilisés en tant que scénarios d’incendie de dimensionnement, une évaluation du risque d’incendie utilise les scénarios d’incendie en tant que scénarios représentatifs au sein de groupes de scénarios d’incendie.

[SOURCE: ISO 13943:2017, 3.152]

3.6

embrasement généralisé - flashover

<stade d'incendie> passage à l'état de combustion généralisée en surface des matériaux combustibles exposés à un feu dans une enceinte

[SOURCE: ISO 13943:2017, 3.184]

3.7

feu pleinement développé

état dans lequel l'ensemble des matériaux combustibles est impliqué dans un incendie

[SOURCE: ISO 13943:2017, 3.192]

3.8

courant de fuite

courant électrique qui s'écoule vers un circuit non désiré

3.9

modèle physique du feu

procédé de laboratoire, incluant l'appareillage, l'environnement et le mode opératoire d'essai au feu, destiné à représenter une certaine étape d'un incendie

[SOURCE: ISO 13943:2017, 3.298]

3.10

pyrolyse

décomposition chimique d'une substance provoquée par l'action de la chaleur

Note 1 à l'article: Le terme est souvent utilisé pour se référer à un stade du feu avant que la combustion avec flamme ne commence.

Note 2 à l'article: En science du feu, aucune hypothèse n'est émise quant à la présence ou l'absence d'oxygène.

[SOURCE: ISO 13943:2017, 3.316]

3.11

essai au feu à petite échelle

essai au feu effectué sur une éprouvette d'essai de petites dimensions

Note 1 à l'article: Il n'y a pas de limite supérieure clairement définie pour les dimensions de l'éprouvette d'un essai au feu à petite échelle. Dans certains cas, un essai au feu effectué sur une éprouvette dont la dimension maximale est inférieure à 1 m est appelé "essai au feu à petite échelle". Toutefois, un essai au feu effectué sur une éprouvette dont la dimension maximale est située entre 0,5 m et 1,0 m est souvent appelé "essai au feu à moyenne échelle".

[SOURCE: ISO 13943:2017, 3.346]

3.12

fumée

partie visible des effluents du feu

[SOURCE: ISO 13943:2017, 3.347]