

INTERNATIONAL STANDARD



HORIZONTAL PUBLICATION

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



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INTERNATIONAL STANDARD



HORIZONTAL PUBLICATION

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- a) References to IEC TS 60695-5-3 (withdrawn in 2014) have been removed.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

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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.

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 method²~~

~~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 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.

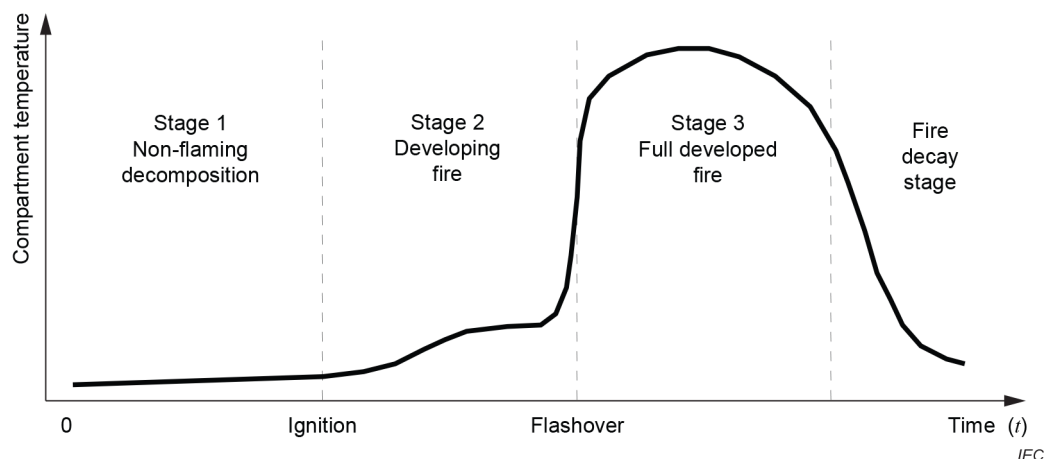


Figure 1 – Different stages in the development of a fire within a compartment

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:~~

- within electrotechnical equipment and systems when exposed to **fire effluent** caused by unusual, localized, internal sources of excessive heat and ignition;
- within electrotechnical equipment and systems when exposed to **fire effluent** caused by external sources of flame or excessive heat;
- 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)	$\frac{[\text{CO}]}{[\text{CO}_2]}$ v/v	$\frac{100 \times [\text{CO}_2]}{([\text{CO}_2] + [\text{CO}])}$ % 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. $15 \text{ kW} \times \text{m}^{-2}$ 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 scenarios** 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 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.