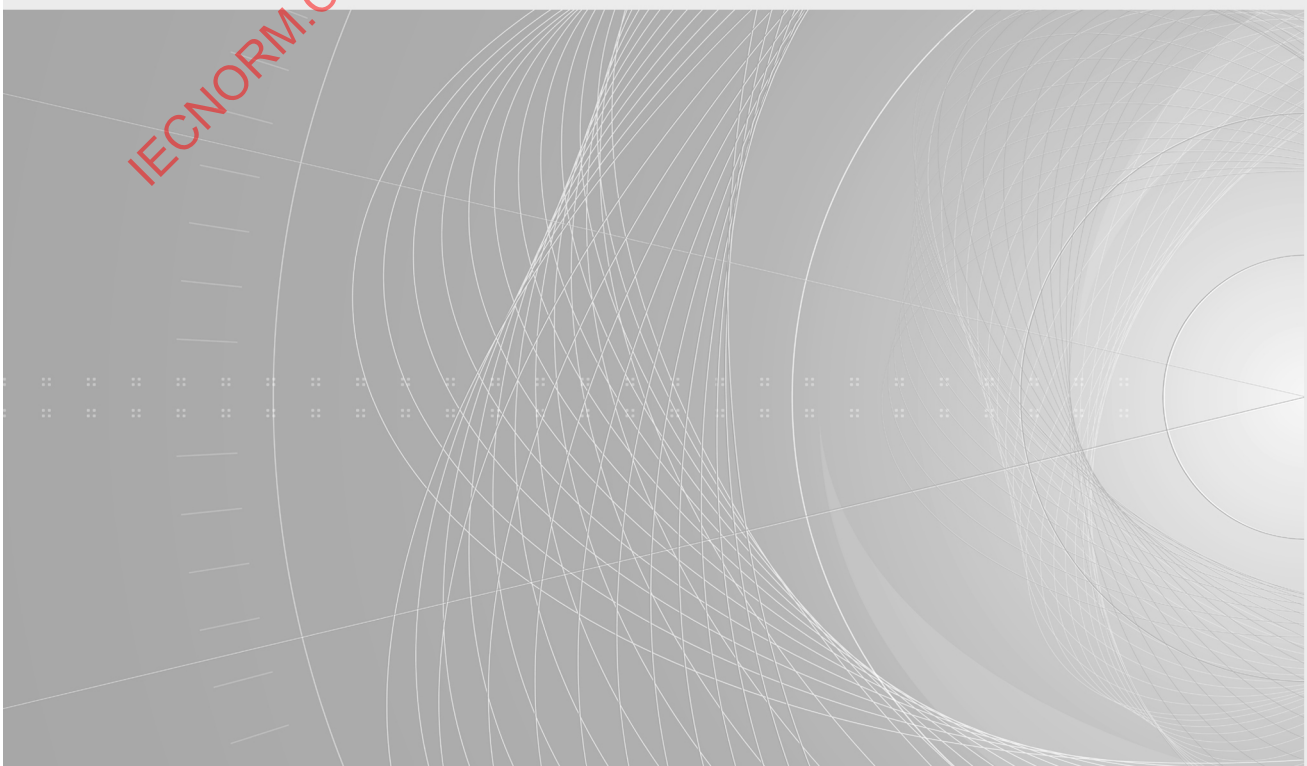
IEC TS 60695-5-2

Edition 3.0 2021-06

TECHNICAL SPECIFICATION

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



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INTERNATIONAL
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FIRE HAZARD TESTING –

Part 5-2: Corrosion damage effects of fire effluent – Summary and relevance of test methods

FOREWORD

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IEC 60695-5-2, which is a technical specification, has been prepared by IEC technical committee 89: Fire hazard testing.

This third edition cancels and replaces the second edition published in 2002.

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

– References to IEC TS 60695-5-3 (withdrawn in 2014) have been removed.
– ISO/TR 9122-1 has been revised by ISO 19706.
– References to ISO 11907-2 and ISO 11907-3 have been removed.
– Terms and definitions have been updated.
– Text in 5.4 has been updated.
– Text in 5.5.8 (5.7.8 in Ed. 2) has been updated.
– Text in Clause 6 (7 in Ed. 2) has been updated.

– Bibliographic references have been updated.

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

The text of this technical specification is based on the following documents:

Draft	Report on voting
89/1473/DTS	89/1506/RVDTS

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 Technical Specification 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.

In this technical specification, the following print types are used:

Arial bold: terms referred to in Clause 3

This technical specification is to be read in conjunction with IEC 60695-5-1.

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 [1][1], IEC 60695-1-11 [2], and IEC 60695-1-12 [3] 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 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, 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 the 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, all of the above have been considered.

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

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

[1] Numbers in square brackets refer to the bibliography.

FIRE HAZARD TESTING –

Part 5-2: Corrosion damage effects of fire effluent – Summary and relevance of test methods

1 Scope

This part of IEC 60695, which is a technical specification, gives a summary of the test methods that are used in the assessment of the corrosivity of **fire effluent**. It presents a brief summary of test methods in common use, either as international standards or national or industry standards. It includes special observations on their relevance, for electrotechnical products and their materials, to real **fire scenario**s and gives recommendations on their use.

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 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 60695-4:2012, *Fire hazard testing – Part 4: Terminology concerning fire tests for electrotechnical products*

IEC 60695-5-1, *Fire hazard testing – Part 5-1: Corrosion damage effects of fire effluent - General guidance*

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

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

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 terms and definitions given in IEC 60695-4:2012 and ISO 13943:2017 (some of which are reproduced below), apply.

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 test 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 effluent
all gases and aerosols, including suspended particles created by combustion or **pyrolysis** (3.6) and emitted to the environment

[SOURCE: ISO 13943:2017, 3.123]

3.4
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 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]

3.5
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]

3.6
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]

3.7
smoke
visible part of a **fire effluent** (3.3)

[SOURCE: ISO 13943:2017, 3.347]

4 Classification of test methods

4.1 General

Test methods can be classified according to three criteria:

a) the nature of the test specimen which is burned;

b) the **physical fire model** used in the test;

c) the nature of the measurement of corrosivity.

4.2 Test specimen

4.2.1 Product testing

The test specimen is a manufactured product or a representative portion of a product. Examples include: a printed circuit board, a switchboard, a computer or a cable.

4.2.2 Material or composite sample testing

The test specimen is a basic material (solid or liquid), or composite of materials.

4.3 The physical fire model

Test methods use a wide variety of heat sources and geometries. The amount, the rate of production and the corrosive nature of **fire effluent** released from a given material or product is not an inherent property of that material or product, but is critically dependent on the conditions under which that material or product is burnt. In a **fire scenario** or a fire test, the chemical nature of the fuel, the decomposition temperature and the amount of ventilation are the main variables which affect the composition of **fire effluent**.

It is critical to show that the test conditions defined in a standardized test method are relevant to, and replicate, the desired stage of a real fire. ISO has published a general classification of fire stages in ISO 19706, shown in Table 1. The important factors affecting effluent production are oxygen concentration and irradiance/temperature.

4.4 The nature of the corrosivity measurement

4.4.1 Product as target

In these cases the **corrosion target** is a manufactured product or a representative portion of a product. Examples include: printed wiring boards, switchboards, washing machines and computers.

The **corrosion damage** effects of **fire effluent** on the product can be assessed by degradation of function as determined by inspection or measurement.

4.4.2 Simulated product as target

When a simulated product is used as the target, the **corrosion target** is typically a reference circuit, a thin sheet of metal or a metal mirror. The **corrosion damage** effects of **fire effluent** on the target can be assessed by changes in appearance, mass or measurements of mechanical, physical or electrical characteristics.

Table 1 – Characteristics of fire stages (from Table 1 in 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.

4.4.3 Indirect assessment

An indirect method of assessment is one that uses no **corrosion target** but measures a characteristic of the gases and vapours evolved. For example, the amount of halogen acid produced, or the pH and/or the conductivity of a solution in which the gases and vapours evolved by combustion have been dissolved.

5 Published test methods

5.1 General

The test methods reviewed in this clause were selected on the basis that they are published in international, national or industry standards, and are in common usage in the electrotechnical field. It is not intended to review all possible test methods.

NOTE These summaries are intended as a brief outline of the test methods and as such not meant to be used in place of full published standards.

5.2 Tests for the determination of halogen acid in combustion gases

5.2.1 Standards

International standard IEC 60754-1 [4], which is a test on cable materials, is based on the method described in 5.2.2 to 5.2.6.

5.2.2 Purpose and principle

The standard specifies the procedure for the determination of the amount of halogen acid gas, other than hydrofluoric acid, evolved during the combustion of compounds based on halogenated polymers, and compounds containing halogenated additives, taken from cable constructions.

For reasons of precision this method is not recommended for reporting values of halogen acid evolved less than 5 mg/g of the sample taken.

5.2.3 Test specimen

The test specimen has a mass of between 0,5 g to 1,0 g cut into a number of small pieces.

5.2.4 Test method

The test specimen is heated in a tube furnace in a stream of air. The temperature of the test specimen is raised at a uniform rate to 800 °C over a time of 40 min and held at 800 °C for 20 min. The air flow is 0,0157 × $(D/\text{mm})^2$ litres per hour (where D is the diameter of the furnace tube) so as to give an air velocity in the tube of 20 m × h^{-1} (0,56 cm × s^{-1}). At the exit of the tube the gases produced by the thermal decomposition of the test specimen pass through two wash bottles each containing at least 220 ml of 0,1 M sodium hydroxide solution so that any acid gases are absorbed by the alkaline solution. The amount of halogen acid, expressed as hydrochloric acid, is found by titration with silver nitrate and ammonium thiocyanate.

5.2.5 Repeatability and reproducibility

No interlaboratory test data are currently available.

5.2.6 Relevance of test data to corrosion hazard assessment

The method is intended for the type testing of individual components used in cable construction. It is an analytical chemistry test for halogen acid (other than hydrofluoric acid) and does not directly measure **corrosion damage**. It is known that halogen acids cause corrosion, but many other chemical species are also corrosive and these will not be detected by this test. A high halogen acid production will therefore indicate a high corrosive potential, but a low halogen acid content will not necessarily mean a low corrosive potential.

The combustion conditions used in this test are designed to maximize the halogen acid production from materials which contain halogen. They are not designed to model any particular stage of a fire, but they most closely correspond to stage 1c of Table 1, i.e. non-flaming pyrolytic decomposition.

5.3 Tests for the determination of the acidity and conductivity of combustion gases dissolved in an aqueous solution

5.3.1 Standards

One international standard, IEC 60754-2 [5], and many national standards, for example, CAN/CSA C22.2 [6], DIN VDE 0472-Part 813 [7] and NF C 20-453 [8], are based on the method described in 5.3.2 to 5.3.6.

Annex A lists differences between some of these methods.

5.3.2 Purpose and principle

Fire effluent, evolved from the **pyrolysis** or combustion of a test specimen, is bubbled through distilled or demineralized water. The pH, or pH and conductivity, of the resulting aqueous solution is then measured.

Such an assessment has the advantage of being both relatively simple and cheap, but has the disadvantage that it does not directly measure **corrosion damage**. An assumption is 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.

5.3.3 Test specimen

The test specimen has a mass of about 1,0 g cut into a number of small pieces.

5.3.4 Test method

An annular furnace is set to a temperature specified in the relevant standard of between 750 °C and 950 °C. The test specimen is located in a porcelain boat inside a quartz glass combustion tube within the furnace. Air is injected upstream of combustion and the combustion gases are bubbled through wash bottles containing distilled or demineralized water.

5.3.5 Repeatability and reproducibility

Repeatability and reproducibility have been determined during interlaboratory trials used to develop the French standard, NF C 20-453:

– repeatability: 4 % to 7 %;
– reproducibility: 9 % to 11 %.

The values depend on test conditions and materials (see Annex B).

5.3.6 Relevance of test data to corrosion hazard assessment

For strong acids and bases, it is known by experience that within a generically similar family of materials the acid/basic gas test can rank materials in the order of their corrosive potential towards a given substrate. It is also known by experience that this may not be true in comparing different families of materials. It is also known by experience that the corrosive potential of an aqueous medium is related to its electrical conductivity.

5.4 Tests for the determination of corrosive gases by evaluation of copper corrosion in ASTM D 2671 – Sections 89 to 95 [9]

5.4.1 Purpose and principle

Three tests are described for heat-shrinkable insulating tubing. Procedure A is a non-contact test using a copper mirror at elevated temperature. Procedure B is contact corrosion with heat. Procedure C is a cyclical-corrosion test using humidity and copper dust.

5.4.2 Test specimen

The test specimens are cut from the tubing (strips which have a total outside area of about 150 mm^2 if the diameter is less than 10,2 mm; a 6 mm × 25 mm strip if the diameter is greater than or equal to 10,2 mm).

5.4.3 Test methods

a) Procedure A

Metal mirrors are used as targets. These are 25 mm long by 6 mm wide. The mirror is vacuum deposited copper with a thickness which gives between 5 % and 15 % transmission of normal incident light of wavelength 500 nm. Corrosion is considered to be removal of the copper and is measured as the percentage of the original coated area which has become transparent. The copper mirror is prepared by depositing copper on a previously cleaned plate of glass in a vacuum. The test pieces are placed in the bottom of a dry test tube, the lower part of which is immersed in an oil bath at the temperature and time specified in the specification. The copper mirror, suspended inside this tube and kept at a temperature of less than 60 °C throughout the test, is used to assess the corrosivity of the products evolved.

b) Procedure B

Tubing is slid over bare copper conductors that are then heated under specified conditions. Afterwards the tubing is slit open and the copper is examined pitting and blackening.

c) Procedure C

Tubing is dusted with powdered copper and then temperature cycled under specified conditions. After this heat treatment the copper is examined for any evidence of extensive green or brown discolouration.

5.4.4 Special observations

These methods are qualitative. Preparation of the copper mirror is a delicate operation (see ASTM D 2671, sections 85 to 95 [9]). The degradation of the test specimen corresponds to stage 1b of Table 1, i.e. non-flaming oxidative decomposition.

5.4.5 Repeatability and reproducibility

No interlaboratory test results are currently available.

5.4.6 Relevance of test data to corrosion hazard assessment

The test method indicates the potential of a test specimen to generate species capable of corroding copper when undergoing non-flaming oxidative decomposition.

5.5 Cone corrosimeter method

5.5.1 Standards

Two standards are based on this method, ISO 11907-4 [11] and ASTM D 5485 [12].

5.5.2 Purpose and principle

This test measures the **corrosion damage** effect, by loss of metal from a target, of the combustion effluents of materials, components or products. The metal loss is calculated from the increase in electrical resistance of the target due to the decrease in conductive cross-sectional area.

5.5.3 Test specimen

The test specimen is limited to a material, component or finished product with a maximum size of 100 mm × 100 mm in area and normally 6 mm in thickness.

5.5.4 Corrosion target

The target is composed of two circuit elements of identical metal assembled on a non-reactive substrate. One circuit element is active and is used for measuring **corrosion damage**; the other, with a protective coating, is used as a reference. Both of the elements of the target are exposed to combustion products during the test. The type of **corrosion damage** identified is an increase in electrical resistance due to conductive metal loss. The corrosion-damage measuring instrument consists of a Kelvin bridge, modified for the measurement of the change in electrical resistance of **corrosion targets**. The reduction in thickness of the metal is calculated from the increase in electrical resistance.

The type of target used is determined by the application and by the range of **corrosion damage**. Two copper targets have been used to develop data on the corrosivity of combustion products. A target of 250 nm nominal thickness has been found to be susceptible to complete corrosion in some tests. To measure corrosion in excess of 250 nm, a target of 4 500 nm nominal thickness is recommended in addition to, or instead of, the 250 nm target. With the 250 nm target, metal loss values have been found to be different from those of the 4 500 nm target for the same experiment. Data from each target should therefore be considered separately, and not combined in reporting results for a material or product without appropriate reference to the target used.

A schematic diagram of a 4 500 nm target is depicted in Figure 1.

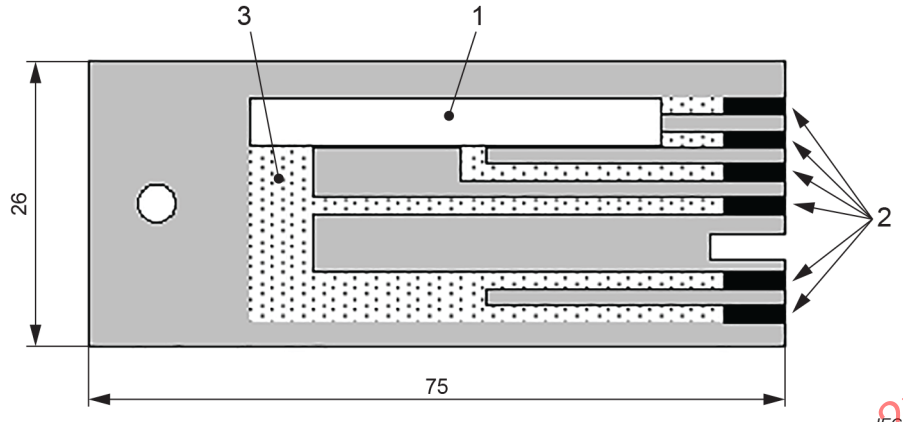
5.5.5 Test method

The test specimen is exposed to a radiant heat flux. A spark igniter is used to ignite the combustible vapours. The products of decomposition or combustion are channelled through a funnel, and a portion of them continuously flows through an exposure chamber which holds the **corrosion target**.

Two preliminary tests are run to determine the average 70 % mass loss value of the test specimen. In the subsequent **corrosion damage** test, if a 70 % mass loss is attained in less than 60 min, the target is exposed to the flowing gases until the 70 % mass loss value is obtained. The exposure chamber is then sealed and exposure continues until 60 min have elapsed from the start of the test. If a 70 % mass loss is not attained in less than 60 min, the target is exposed to the flowing gases until 60 min have elapsed from the start of the test.

After exposure, the metal loss is calculated from the increase in electrical resistance of the target. The target is then placed in a separate chamber, with a controlled relative humidity of 75 % and at a temperature of 23 °C, for 24 h after which the metal loss is again determined.

Dimensions in millimetres



Key

1 Active element

2 Connectors to corrosion-measuring instrument

3 Reference element

NOTE The reference element is protected with a non-reactive material.

Figure 1 – Schematic drawing of a typical corrosion target of defined metal thickness

5.5.6 Special observation

The method makes it possible to test some finished products and to assess the direct **corrosion damage** effects on copper in a printed circuit board.

ASTM D 5485 is intended for use in evaluations of electrical insulations or covering products, for additional data to assist in the design of electrical insulations or covering products, or for development and research of electrical insulations or coverings products. The ASTM test does not prescribe the heating flux level to be used but states that it should be relevant to the fire scenario being investigated (up to 100 kW × m^{-2}).

ISO 11907-4 is intended for the evaluation of materials or products, for additional data to assist in the design of products, and for development and research purposes. The ISO test recommends an irradiance of 50 kW × m^{-2} or other heating fluxes up to 100 kW × m^{-2}.

5.5.7 Repeatability and reproducibility

No interlaboratory test results are currently available.

5.5.8 Relevance of test data to corrosion hazard assessment

The method should be used to measure and describe the response of materials and/or products to heat and flame under controlled conditions but shall not be used to describe or appraise the fire hazard or fire risk of materials under actual fire conditions. However, results of this test may be used as elements of a fire hazard or risk assessment, insofar as they relate to a particular end use.

6 Overview of methods and relevance of data

The methods outlined in Clause 5 are summarized in Table 2, in terms of limitations of the test method, and applicability to the fire stages defined in Table 1. These methods are based on a wide variety of **physical fire model**s and test specimen geometries, which can have a major effect on way in which **fire effluent** is produced.

Product committees intending to adopt or modify any of these test methods shall ensure that the method is appropriate and suitable for the intended use.

The tests are intended to be used to evaluate the relative degree of possible **corrosion damage** effects of fire gases to exposed materials and products under controlled laboratory conditions, and should not be considered, or used, for describing or appraising the corrosion risk of materials, products or systems under actual fire conditions.

In order to assess the risk of **corrosion damage** when materials burn, the ranking of materials by corrosivity should be combined with their heat and flame response characteristics (for example, ignitability, surface spread of flame, rate of heat release). The assessment of risk of **corrosion damage** in the event of fire requires consideration of many factors including fuel load, intensity of burning, ventilation conditions, humidity levels and the nature of the exposed surfaces.

NOTE These methods are based on a wide variety of **physical fire model**s and test specimen geometries, which can affect the nature of the corrosive species generated from a material or product. Therefore it cannot be assumed that the rank ordering of corrosion data from materials or products from one test will be the same as the rank ordering from another test.

Table 2 – Overview of corrosivity test methods

Test method	Clause reference	Type of test method	Limitations on test specimen	Relevance to stage of fire						Limitations on use as an isolated test
				1(a)	1(b)	1(c)	2	3(a)	3(b)	
Determination of halogen acid in combustion gases	5.2	Indirect	500 mg to 1 000 mg of the material to be tested, cut into small pieces	No	No	Yes	No	No	No	Only where the correlation between the measured value and the corrosivity potential has been established
Determination of the acidity and conductivity of combustion gases dissolved in an aqueous solution	5.3	Indirect	995 mg to 1 005 mg of the material to be tested, cut into small pieces	No	No	Yes	No	No	No	Only where the correlation between the measured value and the corrosivity potential has been established
Copper corrosion	5.4	Simulated product (metal loss)	2,5 cm long samples cut from heat-shrinkable tubing	No	Yes	No	No	No	No	Only where metal loss is of concern
Cone corrosimeter	5.5	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	Only where metal loss is of concern

Annex A
(informative)

Acidity and conductivity of aqueous solutions – Test methods

Table A.1 shows test methods for the measurement of acidity and conductivity of aqueous solutions obtained after bubbling combustion effluent through water.

Table A.1 – Test methods for the measurement of acidity and conductivity of aqueous solutions obtained after bubbling combustion effluent through water

Parameters	IEC 60754-2 [5]	CAN/CSA C22.2 [6]	DIN VDE 0472, Part 813 [7]	NF C20-453 [8]
Temperature of combustion (°C)	950 ± 15	800 ± 10	750 to 800	800 ± 10
Test specimen mass (mg)	1 000 ± 5	500 ± 50	1 000	500 ± 1
Nature of test specimen	Divided into small pieces	–	–	One piece only
Air flow rate ($dm^3 \times h^{-1}$)	15 to 30	Approximately 6	10 ± 3	15 to 30
Volume of water for absorption (cm^3)	1 000	600	170	75 ± 5
Final volume for measurement (cm^3)	1 000	1 000	170	500
Time of measurement	After combustion	After combustion	During and after combustion	After combustion

Annex B
(informative)

Determination of repeatability and reproducibility – Comparative tests of solutions of combustion gases

These tests were carried out during the study of the French standard NF C 20-453 [8]. It was found that the repeatability and the reproducibility were better when the tested materials were homogeneous, without filler.

In Tables B.1, B.2 and B.3 each numerical value is the average obtained from four measurements, except when a different number of measurements is indicated in brackets, after the value of the parameter. In some cases minimum values or maximum values are given instead of the average value. The procedure used is described in French standard NF C 20-453 (see also Annex A).

Repeatability and reproducibility

The estimated value of these parameters are:

– repeatability: 4 % to 7 %;
– reproducibility: 9 % to 11 %.

(see experimental results in Tables B.1, B.2 and B.3).

Table B.1 – Determination of repeatability and reproducibility – Comparative pH tests on solutions of combustion gases

Laboratory no.	pH	Material A	Material B	Material C	Material D	Material E	Material F	Material G	Material H
1	Average	2,87	8,1	8,1 max.	4,03	6,33 max.	4,93	8,03	2,2
	Standard deviation	0,12	0	0,06	0,06	0,49	0,12	0,23	0,1
2	Average	2,67 min.	–	5,93 min.	4	4,23 min.	4,26 min.	6,18	2,26
	Standard deviation	0,06	–	0,15	0,11	0,03	0,04	0,1	0,08
3	Average	2,85	7,53	7,32	4,1	5,75	–	8,34	2,2
	Standard deviation	0,13	0,16	0,48	0,1	0,33	–	0,77	0,1
4	Average	3,02 max.	7,7	7,6 (n = 6)	4,28 max.	5,14 (n = 5)	4,67 (n = 7)	8,3	2,31 (n = 7)
	Standard deviation	0,03	0,09	0,17	0,08	0,18	0,18	0,26	0,07
5	Average	2,87	–	–	3,8	4,47	4,33	6,33	2,35 (n = 3)
	Standard deviation	0,08	–	–	0,05	0,06	0,06	0,23	0
6	Average	2,79	6,44 min.	6,25	4,11 (n = 14)	4,6	4,52	8,5 max.	2,12
	Standard deviation	0,06	0,1	0,05	0,28	0,08	0,02	0,26	0,01
7	Average	2,81	7,28	6,53	4,25	5,1	4,75	6,8	–
	Standard deviation	0,035	0,65	0,82	0,05	0,04	0,05	0,13	–
8	Average	2,74 (n = 1)	8,36 (n = 1)	8,32 (n = 1)	3,65 (n = 1)	6,31 (n = 1)	5,49 (n = 1)	7,36	1,95 max. (n = 2)
	Standard deviation	0	0	0	0	0	0	0,3	0,01
9	Average	2,72	7,07	7,1	3,86	5,93	4,78	6,01 min.	–
	Standard deviation	0,06	0,04	0,18	0,12	0,26	0,06	0,21	–