IEC TS 60695-5-2

Edition 3.0 2021-06
REDLINE VERSION

TECHNICAL SPECIFICATION

colour inside

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

Documents
Document Sharing Hub

IEC TS 60695-5-2:2021-06 RLV(en)

Full document details: IEC TS 60695-5-2 2021 RLV

THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2021 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, …). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC online collection - oc.iec.ch
Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 18 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

Documents
Document Sharing Hub

Full document details: IEC TS 60695-5-2 2021 RLV

IEC TS 60695-5-2

Edition 3.0 2021-06
REDLINE VERSION

TECHNICAL SPECIFICATION

colour inside

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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 13.220.99; 19.020; 29.020

ISBN 978-2-8322-9866-4

Warning! Make sure that you obtained this publication from an authorized distributor.

® Registered trademark of the International Electrotechnical Commission

Documents
Document Sharing Hub

Full document details: IEC TS 60695-5-2 2021 RLV

CONTENTS

FOREWORD 4
INTRODUCTION 2
1 Scope 9
2 Normative references 9
3 Terms and definitions 9
4 Classification of test methods 9
4.1 ~~Introduction~~ General 11
4.2 Test specimen 11
4.2.1 Product testing 11
4.2.2 Material or composite sample testing 11
4.3 The physical fire model 12
4.4 The nature of the corrosivity measurement 12
4.4.1 Product ~~testing~~ as target 12
4.4.2 Simulated product ~~testing~~ as target 12
4.4.3 Indirect assessment 14
5 Published test methods 14
5.1 ~~Introduction~~ General 14
5.2 Tests for the determination of halogen acid in combustion gases 14
5.2.1 Standards 14
5.2.2 Purpose and principle 14
5.2.3 Test specimen 15
5.2.4 Test method 15
5.2.5 Repeatability and reproducibility 15
5.2.6 Relevance of test data to corrosion hazard assessment 15
5.3 Tests for the determination of the acidity and conductivity of combustion gases dissolved in an aqueous solution 15
5.3.1 Standards 15
5.3.2 Purpose and principle 16
5.3.3 Test specimen 16
5.3.4 Test method 16
5.3.5 Repeatability and reproducibility 16
5.3.6 Relevance of test data to corrosion hazard assessment 16
5.4 Tests for the determination of corrosive gases by ~~using the copper mirror test in ASTM D 2671-00 [9]~~ evaluation of copper corrosion in ASTM D 2671 – Sections 89 to 95 0 16
5.4.1 Purpose and principle 16
5.4.2 Test specimen 16
5.4.3 Test methods 17
5.4.4 Special observations 17
5.4.5 Repeatability and reproducibility 17
5.4.6 Relevance of test data to corrosion hazard assessment 17
~~5.5 Static method (ISO 11907-2 [10]) .....~~
~~5.6 Travelling furnace method (ISO 11907-3 [11]) .....~~
5.5 Cone corrosimeter method 22
5.5.1 Standards 22
5.5.2 Purpose and principle 22

AVA Documents
Document Sharing Hub

Full document details: IEC TS 60695-5-2 2021 RLV

5.5.3 Test specimen 22
5.5.4 Corrosion target 22
5.5.5 Test method 22
5.5.6 Special observation 23
5.5.7 Repeatability and reproducibility 23
5.5.8 Relevance of test data to corrosion hazard assessment 23
~~6 Leakage current and metal loss (IEC 60695-5-3) .....~~
~~6.1 Purpose and principle .....~~
~~6.2 Test specimen .....~~
~~6.3 Corrosion targets .....~~
~~6.4 Test method .....~~
6 Overview of methods and relevance of data 25
Annex A (informative) Acidity and conductivity of aqueous solutions – Test methods 28
Annex B (informative) Determination of repeatability and reproducibility – Comparative tests of solutions of combustion gases 29
Bibliography 33

~~Figure – Schematic drawing of a serpentine-track resistance target .....~~
~~Figure – Interdigitated leakage current target .....~~
Figure 1 – Schematic drawing of a typical corrosion target of defined metal thickness 23

~~Table 1 – General classification of fire stages in accordance with ISO/TR 9122-1 .....~~
Table 1 – Characteristics of fire stages (from Table 1 in ISO 19706:2011) 13
Table 2 – Overview of corrosivity test methods 27
Table A.1 – Test methods for the measurement of acidity and conductivity of aqueous solutions obtained after bubbling combustion effluent through water 28
Table B.1 – Determination of repeatability and reproducibility – Comparative pH tests on solutions of combustion gases 30
Table B.2 – Determination of repeatability and reproducibility – Comparative resistivity tests on solutions of combustion gases 31
Table B.3 – Results obtained on brominated polycarbonate 32

Documents
Document Sharing Hub
Full document details: IEC TS 60695-5-2 2021 RLV

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

FIRE HAZARD TESTING –

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

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.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition IEC TS 60695-5-2:2002. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

Documents
Document Sharing Hub

Full document details: IEC TS 60695-5-2 2021 RLV

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.

Documents
Document Sharing Hub

Full document details: IEC TS 60695-5-2 2021 RLV

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.

Documents
Document Sharing Hub

Full document details: IEC TS 60695-5-2 2021 RLV

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 [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.

Documents
Document Sharing Hub
Full document details: IEC TS 60695-5-2 2021 RLV

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

Documents
Document Sharing Hub

Full document details: IEC TS 60695-5-2 2021 RLV

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:~~1993~~2012, *Fire hazard testing – Part 4: Terminology concerning fire tests for electrotechnical products*

IEC 60695-5-1~~:2002~~, *Fire hazard testing – Part 5-1: Corrosion damage effects of fire effluent - General guidance*

~~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 GUIDE 104~~:1997~~, *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~~/IEC~~ 13943:~~2000~~2017*, Fire safety – Vocabulary*

ISO 19706:2011*, Guidelines for assessing the fire threat to people*

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

3 Terms and definitions

~~For the purposes of this part of IEC 60695, the definitions given in ISO/IEC 13943 and IEC 60695-4, as well as the following definitions, apply.~~

~~[2] To be published.~~

Documents
Document Sharing Hub
Full document details: IEC TS 60695-5-2 2021 RLV

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~~/IEC~~ 13943:2017,~~ definition 25~~ 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~~, 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~~ 13943:2017,~~ definition 26~~ 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 effluent
~~totality of~~ all gases and~~/or~~ aerosols, ~~(~~including suspended particles~~)~~ created by combustion or **pyrolysis** (3.6) and emitted to the environment

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

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

~~[IEC 60695-4, definition 2.34]~~

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

~~[IEC 60695-4, definition 2.35]~~

3.4
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~~

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.

AVA Documents
Document Sharing Hub

Full document details: IEC TS 60695-5-2 2021 RLV

[SOURCE: ISO~~/IEC~~ 13943:2017,~~ definition 58~~ 3.152]

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

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

~~**3.9**~~
~~**leakage current**~~
~~electrical current flowing in an undesired circuit~~

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~~/IEC~~ 13943:2017,~~ definition 150~~ 3.347]

4 Classification of test methods

4.1 ~~Introduction~~ 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 Simulated product testing**~~

~~The test specimen is a representative portion of a product.~~

Documents
Document Sharing Hub
Full document details: IEC TS 60695-5-2 2021 RLV

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 ~~test specimen~~ 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 ~~(the fire model)~~ are relevant to, and replicate, the desired stage of a real fire. ISO has published a general classification of fire stages in ~~ISO/TR 9122-1~~ 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 ~~testing~~ 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 ~~testing~~ as target

~~In these cases the **corrosion target** is a printed circuit or a thin metal film which simulates a product.~~

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.

Documents
Document Sharing Hub
Full document details: IEC TS 60695-5-2 2021 RLV

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.

Documents
Document Sharing Hub
Full document details: IEC TS 60695-5-2 2021 RLV

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.

~~**Table 1 – General classification of fire stages in accordance with ISO/TR 9122-1**~~

~~Fire~~		~~Oxygen* %~~	~~CO_2/CO ratio**~~	~~Temperature* °C~~	~~Irradiance*** kW/m²~~
~~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 on to sample (average)~~

5 Published test methods

5.1 ~~Introduction~~ 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 ~~should~~ 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

~~An international standard, IEC 60754-1 [1][3], and a European standard, EN 50267-2-1 [2], are based on the method described below.~~

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

~~[3] Figures in square brackets refer to the bibliography.~~

Documents
Document Sharing Hub
Full document details: IEC TS 60695-5-2 2021 RLV

halogenated polymers, and compounds containing halogenated additives, taken from cable constructions.

~~For reasons of accuracy, the method is not recommended for use where the amount of halogen acid evolved is less than 5 mg/g of the test specimen.~~

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 consists of 500 mg to 1 000 mg of the material to be tested, cut into small pieces.~~

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]~~, two European standards, EN 50267-2-2 [4] and EN 50267-2-3 [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.

Documents
Document Sharing Hub
Full document details: IEC TS 60695-5-2 2021 RLV

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 ~~typically~~ has a mass of ~~0,5 g or~~ 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 ~~using the copper mirror test in ASTM D 2671-00 [9]~~ evaluation of copper corrosion in ASTM D 2671 – Sections 89 to 95 [9]

5.4.1 Purpose and principle

~~This test is performed on heat-shrinkable insulating tubing. The test method is used to detect material liable to evolve corrosion products when heated to elevated temperatures. The evolved products condense on to a copper mirror which is subsequently examined for corrosion damage.~~

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.

AVA Documents Document Sharing Hub

Full document details: IEC TS 60695-5-2 2021 RLV

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 ~~is~~ are qualitative. Preparation of the copper mirror is a delicate operation (see ASTM D 2671, sections 85 to 95 [9]). ~~A test duration of 16 h is usually sufficient to determine whether the material is corrosive or not under the conditions of the test.~~ 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 Static method~~ (ISO 11907-2 [10])

~~5.5.1 Purpose and principle~~

~~This test is used to assess the potential corrosivity of effluents evolved during combustion of a 600 mg test specimen in a 20 l cylindrical sealed chamber. Corrosivity is assessed by measuring the variation in the resistance of a copper printed wiring board (PWB).~~

~~This variation is due to the corrosive action of effluents condensing on the board. The test is intended to reproduce a defined stage in an actual fire, that is, the combustion of material followed by the condensation of the effluents on a cooled surface.~~

Documents
Document Sharing Hub
Full document details: IEC TS 60695-5-2 2021 RLV