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Edition 2.1 2019-11
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GROUP SAFETY PUBLICATION
PUBLICATION GROUPÉE DE SÉCURITÉ

Test on gases evolved during combustion of materials from cables – Part 2: Determination of acidity (by pH measurement) and conductivity

Essai sur les gaz émis lors de la combustion des matériaux prélevés sur câbles – Partie 2: Détermination de la conductivité et de l'acidité (par mesure du pH)

IEC 60754-2:2011-11+AMD1:2019-11 CSV(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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TEST ON GASES EVOLVED DURING COMBUSTION OF MATERIALS FROM CABLES –

Part 2: Determination of acidity (by pH measurement) and conductivity

FOREWORD

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This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

IEC 60754-2 edition 2.1 contains the second edition (2011-11) [documents 20/1265/FDIS and 20/1275/RVD] and its amendment 1 (2019-11) [documents 20/1883/FDIS and 20/1890/RVD].

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendment 1. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

International Standard IEC 60754-2 has been prepared by IEC technical committee 20: Electric cables.

It has the status of a group safety publication in accordance with IEC Guide 104.

This second edition constitutes a technical revision.

The significant technical changes with respect to the previous edition are as follows:

– improved definition of safety requirements relating to capture of gases;
– introduction of guidance on the preparation of test specimens for more even combustion;
– better expression of tolerances and precision;
– clarification of the conductivity and acidity functions;
– improved definition of the heating procedure;
– greater precision in the definition of the test temperature for the determination of pH value and conductivity;
– correction of the formulae for the calculation of the test results.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all the parts in the IEC 60754 series, published under the general title *Test on gases evolved during combustion of materials from cables*, can be found on the IEC website.

Le comité a décidé que le contenu de la publication de base et de son amendement ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives à la publication recherchée. A cette date, la publication sera

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INTRODUCTION

IEC 60754 consists of the following parts, under the general title *Test on gases evolved during combustion of materials from cables:*

– Part 1: *Determination of the halogen acid gas content*

– Part 2: *Determination of acidity (by pH measurement) and conductivity.*

– Part 3: *Measurement of low level of halogen content by ion chromatography*

IEC 60754-2 was originally developed due to concerns expressed by cable users over the amount of acid gas evolved when some cable insulating, sheathing and other materials are burned, as such corrosive effluent can cause extensive damage to electrical and electronic equipment not involved in the fire itself.

NOTE Guidance on the corrosivity of fire effluent is given in IEC 60695-5-1.

This standard provides a method for determining the acidity (by pH measurement) and conductivity of an aqueous solution of gases evolved during the combustion of materials so that limits can be agreed for cable specifications. As the test is not carried out on a complete cable test piece, for a hazard assessment the actual material volumes of the cable components should be taken into consideration.

The method provides an indirect assessment of corrosivity. However, the recommended limits of pH and conductivity can only be regarded as an indication, as the relationship between corrosion and these two parameters does not necessarily embrace all materials.

This part of IEC 60754 is linked with both IEC 60754-1~~, but the test procedure differs considerably~~ and IEC 60754-3. The test procedure for obtaining the absorption solution in this part of IEC 60754 is the same as for IEC 60754-3 but the test procedure differs considerably from IEC 60754-1.

TEST ON GASES EVOLVED DURING COMBUSTION OF MATERIALS FROM CABLES –

Part 2: Determination of acidity (by pH measurement) and conductivity

1 Scope

This part of IEC 60754 specifies the apparatus and procedure for the determination of the potential corrosivity of gases evolved during the combustion of materials taken from electric or optical fibre cable constructions by measuring the acidity (pH) and conductivity of an aqueous solution resulting from the gases evolved during the combustion. The heating (combustion) procedure of this part of IEC 60754 is the same as in IEC 60754-3.

The general method specified in this standard is intended for the testing of individual components used in a cable construction. Formulae are given for the calculation of a weighted value for a combination of materials found in a specified cable. The use of this method will enable the verification of relevant requirements for either individual components or combined components of a cable construction stated in the appropriate cable specification.

A simplified method is included for the testing of individual components where it is required only to demonstrate compliance with a stated performance requirement for quality control purposes.

NOTE 1 The relevant cable standard should indicate which components of the cable should be tested, and which method of calculation (see Clause 8) should be used in the case of dispute.

NOTE 2 This test method may be used to test materials to be used in cable manufacture, but a declaration of cable performance should not be made based on such a test.

NOTE 3 For the purposes of this standard, the term “electric cable” covers all insulated metallic conductor cables used for the conveyance of energy or signals.

2 Normative references

The following referenced documents are indispensable for the application 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.

ISO 1042, *Laboratory glassware – One-mark volumetric flasks*
(available only in French)

ISO 3696, *Water for analytical laboratory use – Specification and test methods*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
pH value
pH of an aqueous solution resulting from the gases evolved during the combustion of the material under the conditions given in this standard

3.2
conductivity value
conductivity of an aqueous solution resulting from the gases evolved during the combustion of the material under the conditions given in this standard

4 Test method principle

The material under test shall be heated in a stream of dry air. The evolved gases shall be trapped by bubbling through wash bottles filled with distilled or demineralized water.

The acidity of the resulting solution shall be assessed by determination of its pH value. The conductivity of the solution shall also be determined.

5 Test apparatus

5.1 General

The apparatus is shown in Figures 1 to 5.

The assembly of the components which constitute the test apparatus shall be leak-tight. The connecting distances between the quartz glass tube and the first bottle and between subsequent bottles shall be as short as possible. Glass or silicone rubber tubing shall be used for these connections.

NOTE 1 At the exit side of the quartz glass tube, as close to the end as possible, it is permitted to place a plug of silica wool to aid collection of condensates.

NOTE 2 A third empty bottle, of the same size as the gas washing bottles, placed before the gas washing bottles may be used to improve safety, i.e. to prevent suck back of water into the quartz glass tube.

5.2 Tube furnace

The length of the heating zone of the furnace shall be within the range 480 mm to 620 mm and its inside diameter shall be within the range 38 mm to 62 mm. It shall be equipped with an adjustable electrical heating system.

5.3 Quartz glass tube

For the test, a quartz glass tube shall be introduced into the tube furnace. The tube shall be approximately concentric to the furnace. It shall be resistant to the action of corrosive gases.

The inside diameter of the tube shall be within the range 30 mm to 46 mm. The tube shall protrude on the entrance side of the furnace by a length of between 60 mm to 200 mm, and on the exit side by between 60 mm to 100 mm. The initial clearance shall allow for thermal expansion. For the purposes of measurement of the protrusion distances, the tube shall be regarded as that part of essentially constant diameter.

NOTE The outer diameter of the tube should be chosen with due regard to the inside diameter of the tube furnace.

Prior to each test the tube shall be cleaned throughout its length by being calcined at approximately 950 °C.

5.4 Combustion boats

The combustion boat shall be made of porcelain, fused quartz or soapstone and shall have the following dimensions:

– external length: within the range 45 mm to 100 mm;

– external width: within the range 12 mm to 30 mm;

– internal depth: within the range 5 mm to 10 mm.

NOTE The dimensions of the boat should be chosen with due regard to the inside diameter of the quartz tube.

The preferred method for insertion of the combustion boat into the quartz glass tube is shown in Figure 1.

Prior to each test, the combustion boat shall be washed and calcined in a muffle furnace at approximately 950 °C for 4 h after which it shall be introduced into a desiccator and cooled to ambient temperature. The combustion boat shall then be weighed ~~to an accuracy of 0,1 mg until two identical consecutive weights~~ with an analytical balance until two identical consecutive measurements in mg, rounded to one decimal figure, are obtained. The accuracy is described in 5.7. This weight m_1 shall be recorded.

5.5 Bubbling devices for gases

At the exit of the quartz glass tube, the evolved gases shall be trapped by bubbling through two wash bottles (see Figure 2), each containing approximately 450 ml of distilled or demineralized water of a purity at least Grade 3 in accordance with ISO 3696.

The pH value of the water shall be between 5,5 and 7,5, and the conductivity less than 0,5 μS/mm.

A magnetic stirrer shall be introduced in the first gas washing bottle to get a good swirling motion and an effective absorbtion of the combustion gases. The tubes into the wash bottles shall have a maximum internal diameter at their tip of 5 mm in order to aid absorption.

The height of the liquid above the end of the tube shall be (110 ± 10) mm in each bottle.

NOTE Use of a standard laboratory glass bottle of internal diameter approximately 75 mm will enable this requirement to be met.

5.6 Air supply system

The gas used for combustion shall be air.

~~The flow rate of air introduced into the quartz tube shall be adjusted according to the actual internal cross-sectional area of the tube, such that the speed of air flowing across the sample is approximately 20 ml/mm^2/h.~~

~~The speed of air shall be regulated by reference to the flow rate of air. The flow rate of air shall be (0,0157 × D^2) l/h with a tolerance of ±10 %.~~

~~NOTE The derivation of the flow rate of air from the speed of air is:~~

$$\rho = V \times \frac{\pi D^2}{4}$$

~~where~~

~~D is the internal diameter of the tube (mm);~~

~~ρ is the flow rate of air (ml/h);~~

~~V is the speed of air (ml/mm^2/h).~~

The flow rate of air, ρ, shall be 20 m/h × (π/4) x D^2 x 10^{-3} with a tolerance of ±10 %, where D is the internal diameter of the quartz tube.

EXAMPLE

If D = 30 mm, 20 m/h × (π/4) × D^2 x 10^{-3} = 14,1 l/h, and the flow rate can be in the range 12,7 l/h to 15,5 l/h.

If D = 46 mm, 20 m/h × (π/4) × D^2 x 10^{-3} = 33,2 l/h, and the flow rate can be in the range 29,9 l/h to 36,5 l/h.

NOTE The flow rate of air, ρ, is related to the velocity, v , according to the formula

$$\rho = v \times \frac{\pi D^2}{4} \times 10^{-3}$$

where

D is the internal diameter of the tube (mm);

ρ is the flow rate of air (l/h);

v is the speed of air (m/h).

If v = 20 m/h, this becomes, ρ = 15,7 m/h × D^2 x 10^{-3}.

The air supply shall be adjusted and controlled by a needle valve, and the flow rate monitored by a flowmeter of the appropriate range.

The air supplied shall be selected from one of the following methods:

Method 1

This method uses synthetic air or compressed air from a bottle. The air shall be introduced on the inlet side of the quartz glass tube (see Figure 3).

Method 2

This method uses a laboratory compressed air supply. The air shall be filtered and dried and shall be introduced on the inlet side of the quartz glass tube ~~and shall be filtered and dried~~ (see Figure 4).

Method 3

This method uses the ambient air of the laboratory. The air shall be filtered and dried. In this case, the mixture of air and combustion gas shall be sucked by a pump (see Figure 5).

5.7 Analytical balance

The balance shall have a ~~precision~~ resolution and an accuracy of ± 0,1 mg or better.

5.8 Laboratory glassware

For pH and conductivity determination, the following laboratory glassware shall be available:

– one mark volumetric flask in accordance of ISO 1042 Class B with 1 000 ml capacity.

5.9 pH meter

The pH meter shall have a precision of ±0,02 and shall be equipped with a pH electrode.

5.10 Conductivity measuring device

The conductivity measuring device shall have a range of 10^{-1} µS/mm to 10^{+2} µS/mm and shall be equipped with an electrode.