BS EN 60754-2:2014

BSI Standards Publication

Test on gases evolved during combustion of materials from cables

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

bsi.

...making excellence a habit.™

National foreword

This British Standard is the UK implementation of EN 60754-2:2014. It is identical to IEC 60754-2:2011. Together with BS EN 60754-1:2014 it supersedes BS EN 50267-1:1999, BS EN 50267-2-1:1999, BS EN 50267-2-2:1999 and BS EN 50267-2-3:1999 which will be withdrawn on 27 January 2017.

The UK participation in its preparation was entrusted by Technical Committee GEL/20, Electric cables, to Subcommittee GEL/20/18, Electric Cables — Fire testing.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Published by BSI Standards Limited 2014

ISBN 978 0 580 62724 8

ICS 13.220.40; 29.020; 29.060.20

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 May 2014.

Amendments issued since publication

Amd. No.	Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 60754-2

April 2014

ICS 13.220.40; 29.020; 29.060.20

Supersedes EN 50267-1:1998 (partially), EN 50267-2-1:1998 (partially), EN 50267-2-2:1998 (partially), EN 50267-2-3:1998 (partially)

English version

Test on gases evolved during combustion of materials from cables - Part 2: Determination of acidity (by pH measurement) and conductivity
(IEC 60754-2:2011)

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)
(CEI 60754-2:2011)

Prüfung der bei der Verbrennung der Werkstoffe von Kabeln und isolierten Leitungen entstehenden Gase -
Teil 2: Bestimmung der Azidität (durch Messung des pH-Wertes) und Leitfähigkeit
(IEC 60754-2:2011)

This European Standard was approved by CENELEC on 2014-01-27. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Avenue Marnix 17, B - 1000 Brussels

Ref. No. EN 60754-2:2014 E

Foreword

This document (EN 60754-2:2014) consists of the text of IEC 60754-2:2011, prepared by IEC/TC 20 "Electric cables".

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2015-01-27
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2017-01-27

This document supersedes EN 50267-1:1998 (PART), EN 50267-2-1:1998 (PART), EN 50267-2-2:1998 (PART), EN 50267-2-3:1998 (PART).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

This standard covers the Principle Elements of the Safety Objectives for Electrical Equipment Designed for Use within Certain Voltage Limits (LVD - 2006/95/EC).

Endorsement notice

The text of the International Standard IEC 60754-2:2011 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following note has to be added for the standard indicated :

IEC 60695-5-1	NOTE	Harmonized as EN 60695-5-1.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
ISO 1042	-	Laboratory glassware - One-mark volumetric flasks	EN ISO 1042	-
ISO 3696	-	Water for analytical laboratory use - Specification and test methods	EN ISO 3696	-

CONTENTS

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.*

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 IEC 60754-1, but the test procedure differs considerably.

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 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 are obtained. 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 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. Air 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 of ± 0,1 mg.

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 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.

6 Test specimen

6.1 General

Three test specimens for the general method, or two for the simplified method, each consisting of (1 000 ±5) mg of the material to be tested, shall be prepared. Each test specimen shall be taken from a sample representative of the material. Each test specimen shall be cut into a number of smaller pieces.

NOTE Pieces with a maximum dimension of 3 mm have been found to be suitable.

6.2 Conditioning of specimen

The prepared test specimens shall be stored for at least 16 h at a temperature of (23 ±2) °C and a relative humidity of (50 ±5) %.

6.3 Mass of specimen

Weigh the combustion boat (m_1) with a precision of 0,1 mg (see 5.4). After conditioning, the test specimen shall be put into the combustion boat and evenly distributed on the bottom of the boat, which shall be weighed to an accuracy of 0,1 mg. The weight (m_2) shall be recorded.

The mass m of the test specimen shall be calculated as follows:

$$m = m_2 - m_1$$

where

m is the mass of the test specimen in grams;

m_1 is the mass of the combustion boat in grams;

m_2 is the mass of the combustion boat with the test specimen, in grams.

7 Test procedure

7.1 General

The test procedure and determination of pH value and conductivity value shall be carried out on each test specimen.

7.2 Test apparatus and arrangement

The test procedure defined in this clause shall be carried out using the apparatus detailed in Clause 5.

7.3 Heating procedure

The air flow shall be adjusted by means of a needle valve to the value specified in 5.6 and shall be kept constant during the test.

The temperature shall be measured by a thermocouple suitably protected against corrosion and placed inside the quartz glass tube. The heating system shall be adjusted such that the temperature at the designated position for the boat shall be not less than 935 °C and not more than 965 °C. The temperature at a position 300 mm from the designated position in the direction of the air flow shall be not less than 900 °C.

The boat containing the test specimen shall be quickly inserted into the heating zone of the tube to the designated position determined by the thermocouple measurement and the timer shall be started. The combustion boat shall be placed in such a way that the distance between the boat and the exit end of the effective heating zone is at least 300 mm. The effective heating zone is that zone where a temperature of not less than 900 °C has been determined by the thermocouple measurement.

The combustion procedure, under the air flow condition, shall be continued for (30 ±1) min in the furnace.

WARNING The operator should take precautions, e.g. the wearing of eye protection and suitable protective clothing, because certain materials ignite quickly, and can cause "blow back" of hot gases. Care should also be taken to avoid over-pressurization of the system, and to allow for venting of exhaust gases. Guidance on the avoidance of “blow back” is given in NOTE 2 of 5.1.

7.4 Washing procedure

Following the heating procedure, all the bottles used shall be disconnected, and the contents washed into a 1 000 ml volumetric flask. Using water with the properties given in 5.5, the bottles, the connecting links and, after cooling, the end of the quartz glass tube including the silica wool (if used) shall also be washed into the flask, and the contents made up to 1 000 ml.

7.5 Determination of the pH value and conductivity

The pH shall be measured using a pH meter calibrated as proposed by the instrument supplier.

The pH value of the solution shall be determined at (25 ±1) °C in accordance with the test procedures as prescribed by the supplier of the measuring instrument.

Conductivity value measurements shall also be performed at (25 ±1) °C in accordance with the test procedures as prescribed by the supplier of the conductivity measuring instrument.

The pH value and conductivity value shall preferably be read by using automatic temperature compensation. If such a facility is not available, the values shall be read when the temperature of the solution is at (25 ±1) °C.

NOTE Automatic temperature compensation is usually an integral feature of the pH and conductivity measuring instruments.

8 Evaluation of the test results

8.1 General method

From the three test determinations undertaken, the mean value, standard deviation and coefficient of variation shall be calculated for both pH and conductivity.

If the coefficient of variation is higher than 5 %, a further three tests shall be carried out and the mean value, standard deviation and coefficient of variation shall be recalculated using the six values.

8.2 Simplified method

From the two test determinations undertaken, the sample shall be considered to have met the performance requirement if both pH values are greater than or equal to the specified value and both conductivity values are less than or equal to the specified value.

If one test specimen fails to meet this requirement, the test procedure and determination shall be repeated on two further test specimens taken from the same sample of material. Both repeat test specimens shall comply with specified values for pH and conductivity.

8.3 Weighted values

8.3.1 General

Using the mean values determined in 8.1, the assessment of the pH and conductivity of the aqueous solution of the combustion gases expected to be evolved by a combination of materials found in a specified cable under similar test conditions shall be be estimated as follows:

8.3.2 Value of pH

Measure the weight w_i, of each non-metallic material, i, per unit length of cable.

The weighted value of pH, pH′, is calculated as follows:

$$pH' = \log_{10}\left[\frac{\Sigma w_i}{\Sigma\left(\frac{w_i}{10^x}\right)}\right]$$

where x is the pH of each non-metallic material, i.

8.3.3 Conductivity

Measure the weight, w_i, of each non-metallic material, i, per unit length of cable.

The weighted value of conductivity, c', is calculated as follows:

$$c' = \frac{\Sigma\ (c_i \times w_i)}{\Sigma\ w_i}$$

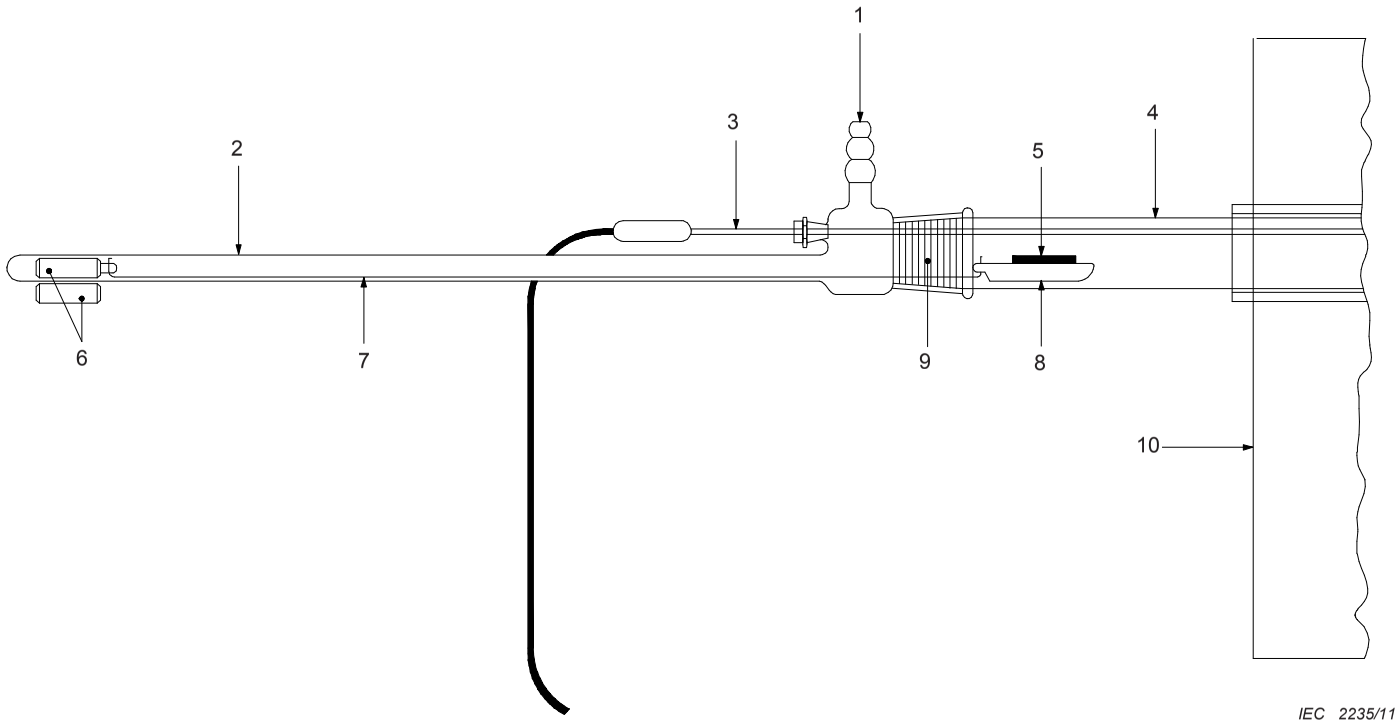
9 Performance requirement

The performance requirements for a particular compound or component taken from a wire or weighted value for a cable should preferably be given in the individual cable standard. In the absence of any given requirement it is recommended that those given in Annex A should be taken as acceptable levels.

10 Test report

The test report shall include the following information:

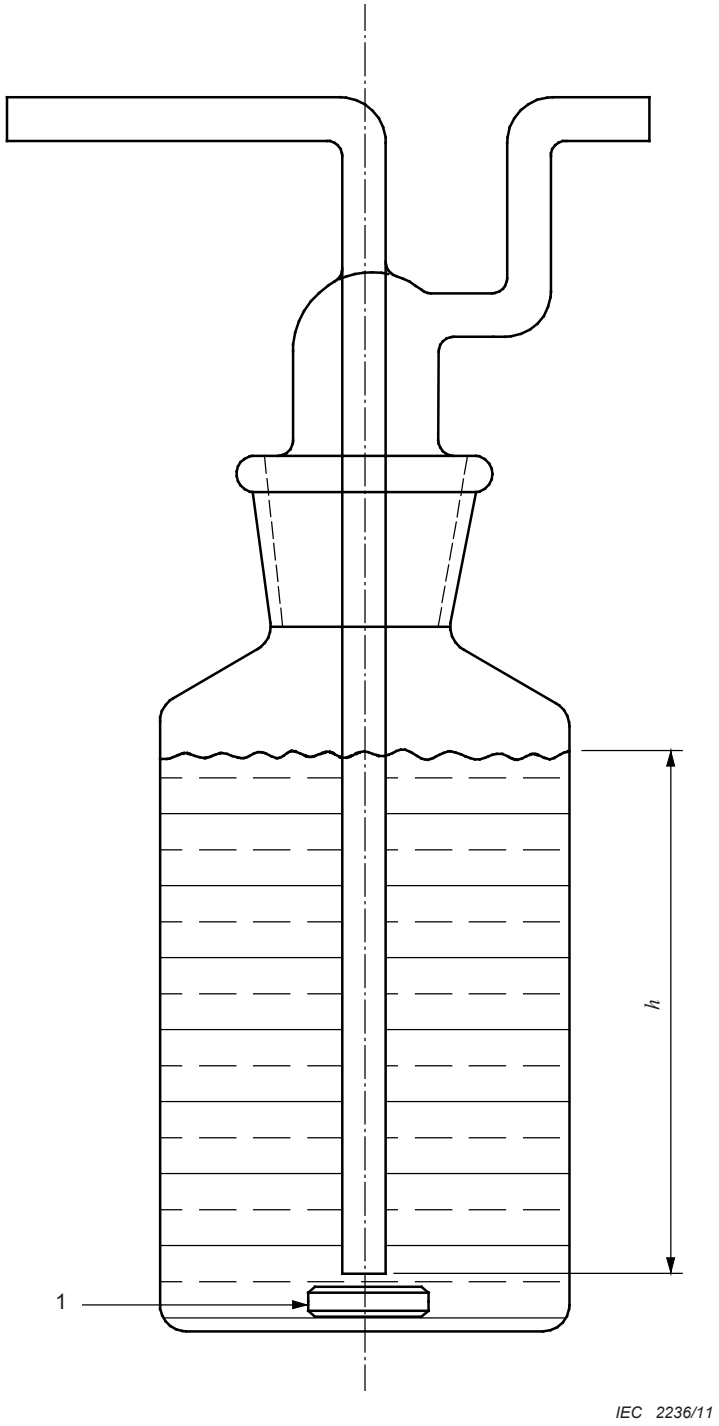
a) a full description of the material tested and the cable from which it was taken;
b) the number of this standard;
c) the mean pH value and the mean conductivity value of the material expressed at 25 °C;
d) the method used for the determination (general or simplified);
e) the calculated weighted values of the pH and conductivity for the cable tested (if required).



Key

1	Synthetic air or compressed air, filtered and dried	6	Bar magnets
2	Glass tube	7	Platinum wire
3	Thermocouple	8	Combustion boat
4	Quartz glass tube	9	Standard ground joint, size in correlation to the diameter of the quartz glass tube
5	Test specimen	10	Furnace

Figure 1 – Device for inserting combustion boat and test specimen

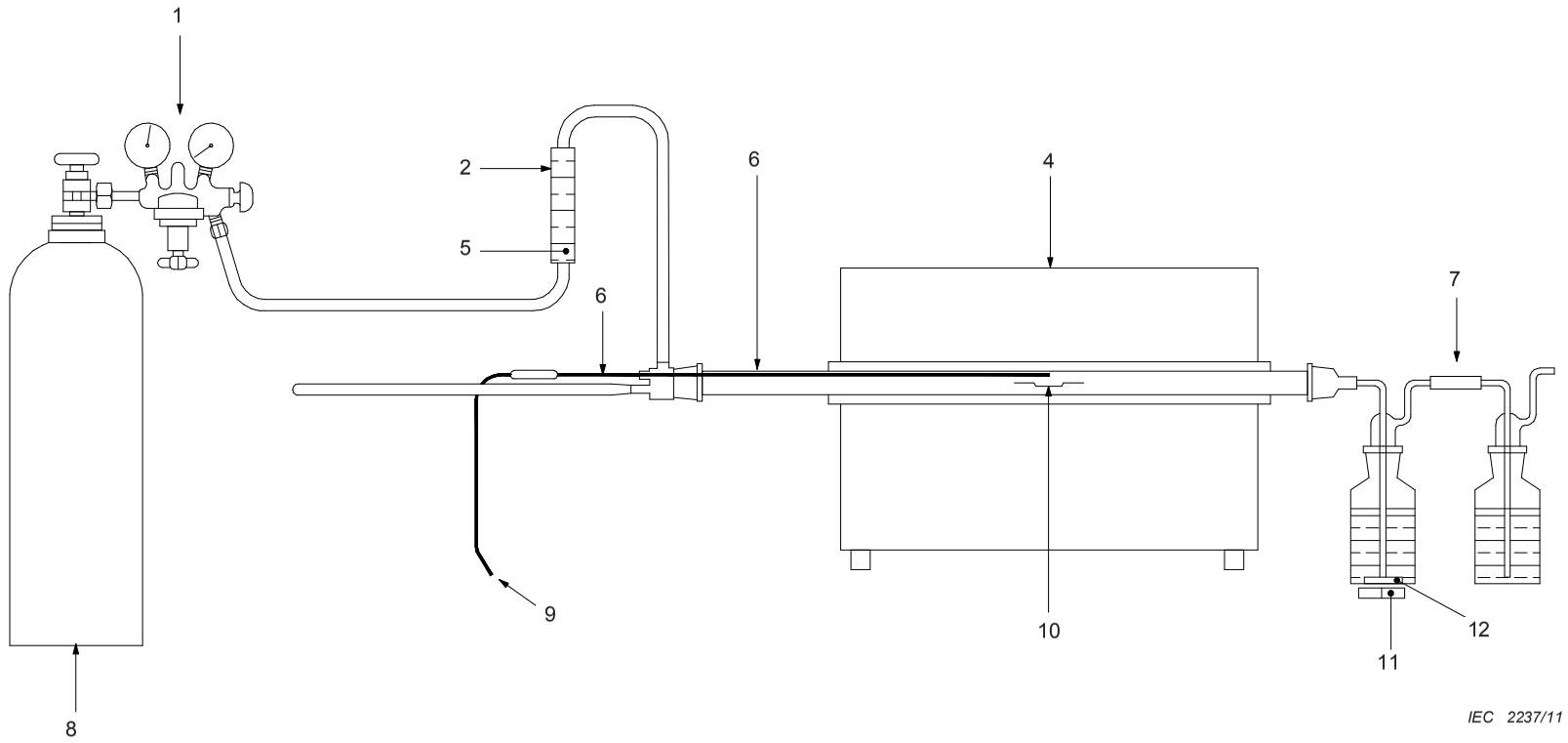


Key

1 Magnetic stirring bar

h 100 mm to 120 mm

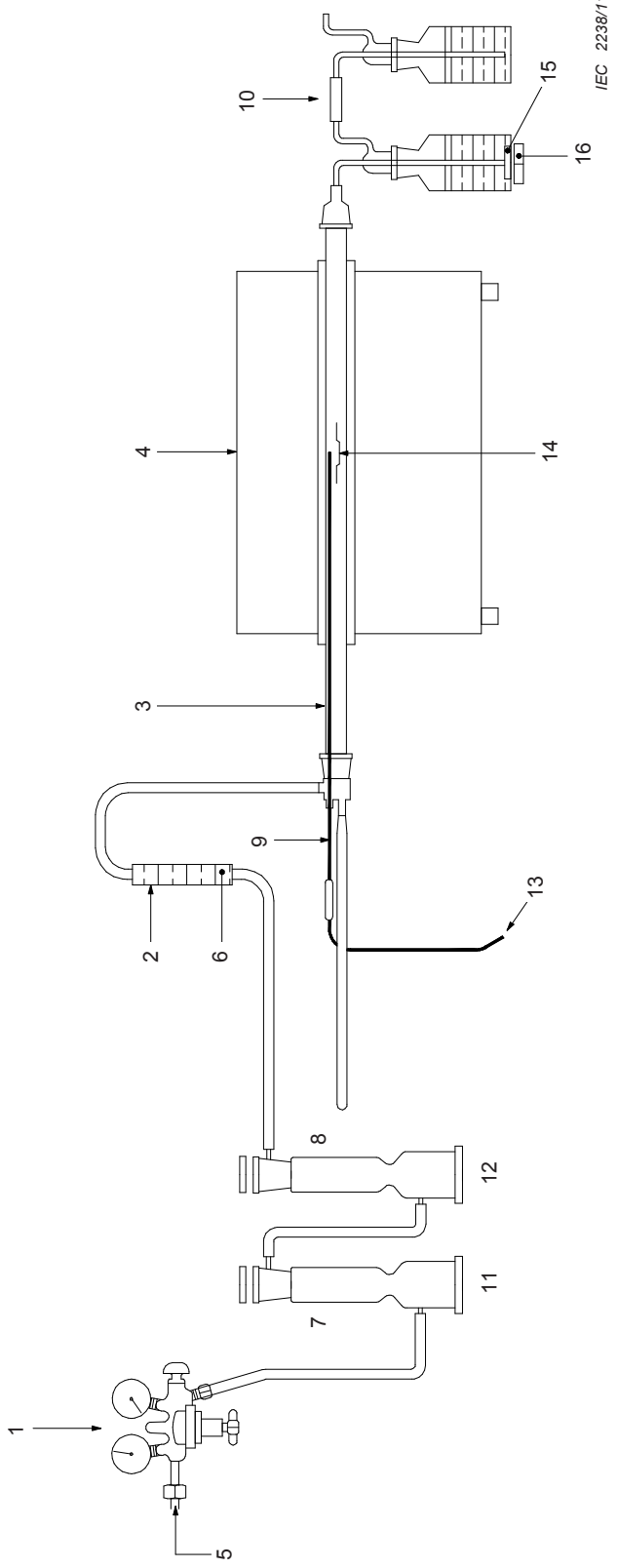
Figure 2 – Example of a gas washing bottle



Key

1	Pressure reducing valve	7	Gas washing bottles
2	Flow meter	8	Synthetic air
3	Quartz glass tube	9	Device for inserting combustion boat containing test specimen
4	Furnace	10	Combustion boat containing test specimen
5	Needle valve	11	Magnetic stirrer
6	Thermocouple	12	Magnetic stirring bar

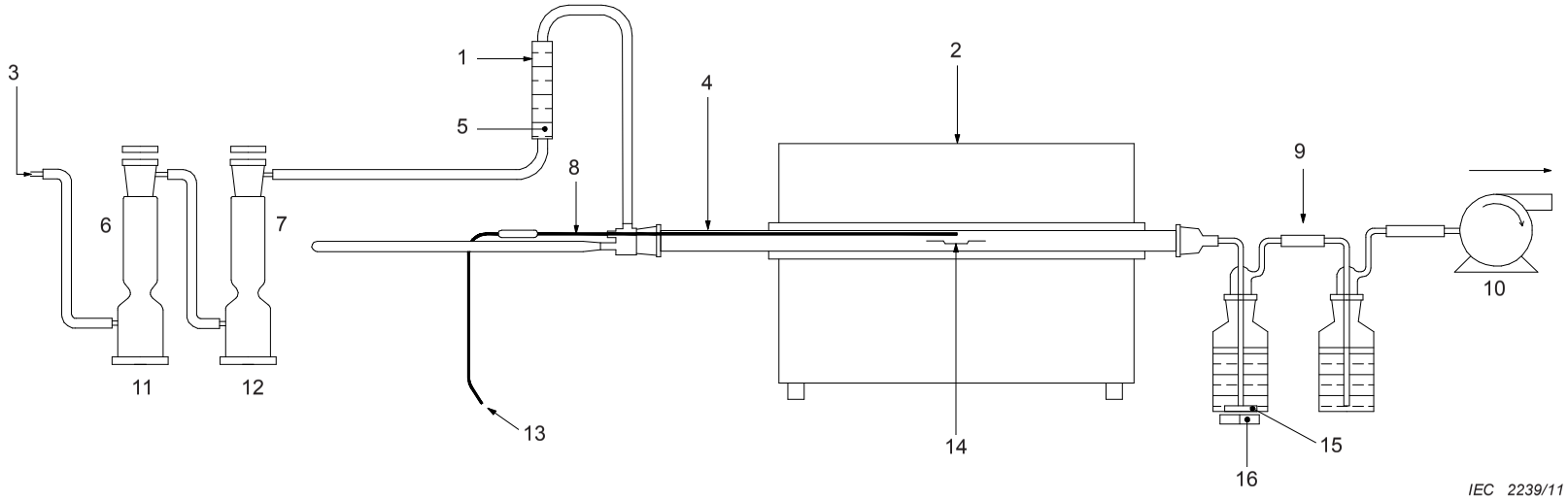
Figure 3 – Test apparatus: method 1 – Use of synthetic or compressed air from a bottle



Key

1	Pressure reducing valve	7	Activated charcoal	13	Device for inserting combustion boat containing test specimen
2	Flow meter	8	Silica gel	14	Combustion boat containing test specimen
3	Quartz glass tube	9	Thermocouple	15	Magnetic stirring bar
4	Furnace	10	Gas washing bottles	16	Magnetic stirrer
5	Compressed air	11	Air filtering		
6	Needle valve	12	Air drying		

Figure 4 – Test apparatus: method 2 – Use of laboratory compressed air supply



Key

1	Flow meter	7	Silica gel	13	Device for inserting combustion boat containing test specimen
2	Furnace	8	Thermocouple	14	Combustion boat containing test specimen
3	Ambient air	9	Gas washing bottles	15	Magnetic stirring bar
4	Quartz glass tube	10	Suction pump	16	Magnetic stirrer
5	Needle valve	11	Air filtering		
6	Activated charcoal	12	Air drying		

Figure 5 – Test apparatus: method 3 – Use of ambient air sucked by means of a suction pump

Annex A
(informative)

Recommended performance requirements

A.1 Cable weighted value

The weighted pH value, as determined in 8.3.2, should not be less than 4,3.

The weighted value of conductivity, as determined in 8.3.3, should not exceed 10 μS/mm.

A.2 Material value

The pH value as determined in 8.1 or 8.2, should not be less than 4,3.

The conductivity value, as determined in 8.1 or 8.2, should not exceed 10 μS/mm.

Bibliography

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*

_____

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

bsi.

...making excellence a habit.™