IEC 62899-505

Edition 1.0 2020-06

INTERNATIONAL STANDARD

Printed electronics –
Part 505: Quality assessment – Flexible gas sensor – Mechanical and thermal testing

IEC 62899-505:2020-06(en)

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 It also gives information on projects, replaced and withdrawn publications.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.

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 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC 62899-505

Edition 1.0 2020-06

INTERNATIONAL STANDARD

Printed electronics –
Part 505: Quality assessment – Flexible gas sensor – Mechanical and thermal testing

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 13.220.01

ISBN 978-2-8322-8490-2

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

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

PRINTED ELECTRONICS –

Part 505: Quality assessment – Flexible gas sensor – Mechanical and thermal testing

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.

International Standard IEC 62899-505 has been prepared by IEC technical committee 119: Printed Electronics.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
119/305/FDIS	119/309/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

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

A list of all parts in the IEC 62899 series, published under the general title *Printed electronics*, 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 "http://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

There is an increasing worldwide demand for flexible and/or wearable gas sensors for fire fighter's garment, industrial workwear, wearable patch, etc. In recent years, many efforts have been spent to develop and commercialize flexible and/or wearable gas sensors composed of a flexible substrate, electrode, and gas sensing layer. These printed flexible gas sensors should provide information about the level of gases in the surrounding environment regardless of mechanical deformations, which might happen for a flexible movement. Further, the surrounding temperature and humidity have a crucial effect on the performance of the gas sensor, since the sensing parts face directly outwards to detect gaseous molecules. However, these mechanical and thermal durabilities have been treated only to a minor extent. This document helps to unify the testing and qualification of printed flexible gas sensors manufactured using the printing process in order to push the commercial production of reliable printed flexible gas sensors containing wearable products.

PRINTED ELECTRONICS –

Part 505: Quality assessment – Flexible gas sensor – Mechanical and thermal testing

1 Scope

This part of IEC 62899 specifies mechanical and thermal test methods for the determination of the reliability characteristics of a printed flexible gas sensor, which is operated at relatively low temperature and is composed of a flexible substrate, electrode, and gas sensing layer. The examples of target gas include in-door air pollutants, combustion gas from a fire situation, and industrial flue gas.

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 60068-2-14, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60721-3-7, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 7: Portable and non-stationary use*

IEC 62899-201, *Printed electronics – Part 201: Materials – Substrates*

IEC 62899-501-1, *Printed electronics – Quality assessment – Part 501-1: Failure modes and mechanical testing – Flexible and/or bendable primary or secondary cells*

IEC 62899-502-1, *Printed electronics – Part 502-1: Quality assessment – Organic light emitting diode (OLED) elements – Mechanical stress testing of OLED elements formed on flexible substrates*

ISO 11999-3, *PPE for firefighters – Test methods and requirements for PPE used by firefighters who are at risk of exposure to high levels of heat and/or flame while fighting fires occurring in structures – Part 3: Clothing*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
gas sensor
component which is composed of a substrate, electrode, and gas sensing layer to produce an electric signal, when excited by a specific gas, for the purpose of providing information on the presence and/or concentration of a specific gas

3.2
test gas
target gas for which the gas sensor is claimed to be suitable

3.3
volume fraction
volume of a specified component divided by the volumes of all components of a gas mixture before mixing

3.4
temperature cycle
process of cycling through the relatively upper and relatively lower temperatures

4 Measurement of gas sensing performance

4.1 General

In all of the mechanical and thermal tests, the gas sensing performance should be measured at the end of the tests. The gas sensing performance shall be expressed as the consistency percentage between the actual concentration of the test gas and the sensing result.

4.2 Standard environmental conditions

4.2.1 Test gas

The test gas shall be used in a mixture with clean air. Clean air can be an appropriate mixture of N_2 and O_2 gases in the ratio of about 78:21. The volume fraction of the component within the test gas shall be known to a relative expanded uncertainty of ±2 % of the nominal value.

4.2.2 Temperature

The ambient air and test gas shall be held at a temperature constant of ±2 °C, for the duration of each test, unless otherwise specified for the particular test. The temperature condition shall be reported because it is critical for the mechanical and thermal tests.

4.2.3 Humidity

The ambient air and test gas shall be held at a relative humidity (RH), controlled to be within ±5 % RH, throughout each test unless otherwise specified for the particular test. The humidity condition shall be reported because it is critical for the mechanical and thermal tests. The properties of the measuring principle of the sensor shall be taken into account.

4.2.4 Pressure

The test shall be performed at an atmospheric pressure between 86 kPa and 106 kPa throughout the duration of each test, unless otherwise specified for the particular test.

4.2.5 Volume fraction of test gas

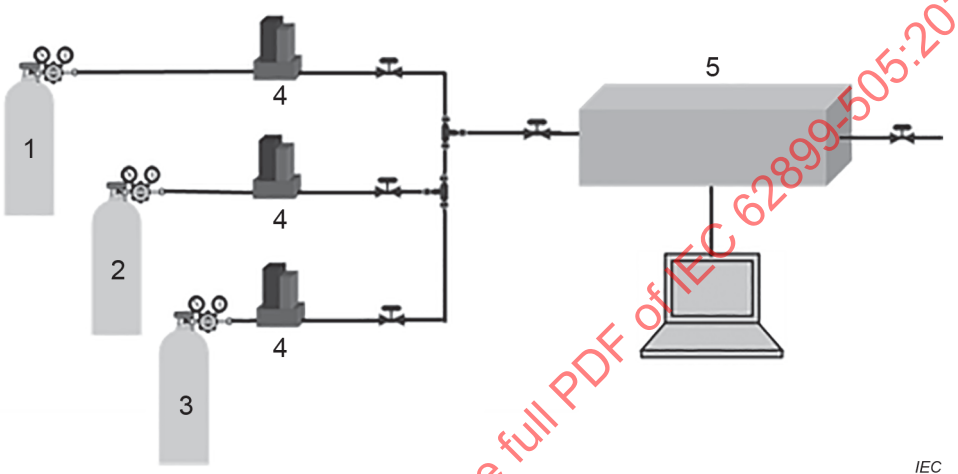
When the gas sensor is exposed to the test gases, the volume fraction of the gas shall be in accordance with the relevant specification.

4.3 Measurement procedure

The gas sensor shall be exposed to clean air followed by exposure to the test gas for longer than the stabilization time. The air can be supplied by mixing N_2 and O_2 gases (see Figure 1). The sensing results shall be taken at the end of each exposure to the air and test gas, unless otherwise stated.

The difference between the actual concentration of the test gas and the sensing result shall be within the range described in the product specification.

The gas sensing performance shall be expressed as the consistency percentage between the actual concentration of the test gas and the sensing result.



Key

1 Test gas
2 N_2 gas
3 O_2 gas
4 Flow controller
5 Test chamber

Figure 1 – Example of gas sensing apparatus

5 Mechanical test methods

5.1 General

The selection of the appropriate tests depends on the flexibility and application of the gas sensors. The testing conditions and the modification of the methods shall be defined between the customer and supplier.

The typical mechanical test is performed without an electric power supply to the gas sensor. If desired, it is possible to have a mechanical test with an electric power supply to the gas sensor during the mechanical test.

At the end of each test, measurement of the gas sensing performance shall be performed in accordance with 4.3, unless otherwise stated.

5.2 Bending test

5.2.1 General

The purpose of this test is to evaluate the stability and endurance of the printed flexible gas sensor against the dynamic bending stress which might happen for a flexible movement.

5.2.2 Test method

The apparatus and method for bending the printed flexible gas sensor shall be selected from the bending tests specified in IEC 62899-501-1 and IEC 62899-201 with the following specific requirements.

The bending cycle shall be performed by bending through an angle up to a predetermined value and returning to the neutral position.

After being subjected to all the bending cycles specified in the relevant specification, the measurement of the gas sensing performance shall be performed in accordance with 4.3, unless otherwise stated. The gas sensor shall still work and indicate the specified sensing result.

5.2.3 Report of the results

The report shall include the following items:

a) whether the printed flexible sensor works normally at the end of the test;

b) test gas;

c) test method;

d) number of bending cycles;

e) test conditions (bending radius, temperature and humidity).

5.3 Torsion test

5.3.1 General

The purpose of this test is to evaluate the stability and endurance of the printed flexible gas sensor against the dynamic torsion stress which might happen for a flexible movement.

5.3.2 Test method

The apparatus and method for twisting the printed flexible gas sensor shall follow the torsion test specified in IEC 62899-502-1 with the following specific requirements.

The torsion cycle shall be performed by rotating through an angle up to the predetermined value and returning to the neutral position.

After being subjected to all the torsion cycles specified in the relevant specification, the measurement of the gas sensing performance shall be performed in accordance with 4.3, unless otherwise stated. The gas sensor shall still work and indicate the specified sensing result.

5.3.3 Report of the results

The report shall include the following items:

a) whether the printed flexible sensor works normally at the end of the test;

b) test gas;

c) test method;

d) number of torsion cycles;

e) test conditions (torsion angle, temperature, and humidity).

5.4 Stretching test

5.4.1 General

The purpose of this test is to evaluate the stability and endurance of the printed flexible gas sensor against the dynamic stretching stress which might happen for a flexible movement.

5.4.2 Test method

The apparatus and method for stretching the printed flexible gas sensor shall follow the procedure specified in IEC 62899-502-1 with the following specific requirements.

The stretching cycle shall be performed by extending along the longitudinal axis until the stress or strain reaches the predetermined value and returning to neutral position.

After being subjected to all stretching cycles specified in the relevant specification, the measurement of the gas sensing performance shall be performed in accordance with 4.3, unless otherwise stated. The gas sensor shall still work and indicate the specified sensing result.

5.4.3 Report of the results

The report shall include the following items:

a) whether the printed flexible sensor works normally at the end of the test;

b) test gas;

c) test method;

d) number of stretching cycles;

e) test conditions (deformation distance, temperature, and humidity).

6 Thermal test methods

6.1 General

The purpose of this test is to evaluate the stability and endurance of the printed flexible gas sensor against the change of a dry or humid temperature which might happen in the gas sensing.

The typical thermal test is performed without an electric power supply to the gas sensor. If desired, it is possible to have a thermal test with the electrical power supply to the gas sensor during the heating and cooling of the gas sensor.

At the end of each test, measurement of the gas sensing performance shall be performed, unless otherwise stated.

6.2 Test method

6.2.1 Tolerances

The temperature and relative humidity of incident air delivered to the printed flexible gas sensor shall be within ±2 °C of the test temperature and ±5 % of the test relative humidity.

6.2.2 Conditioning

The temperature and relative humidity shall be stabilized at an ambient temperature of 25 °C ± 2 °C. During stabilization of the temperature, the relative humidity shall be within the specified limits.

6.2.3 Test cycle

The method for heating and cooling the printed flexible gas sensor shall be based on the procedures of the test cycles specified in IEC 60068-2-14. The various types of test cycles of IEC 60068-2-14 shall be combined into the following single procedure with the following specific requirements.

a) The temperature shall be raised to the upper temperature, T_A, specified in the relevant specification, in a period of $t_1/2$ or at a rate of r_1 (see Figure 2).

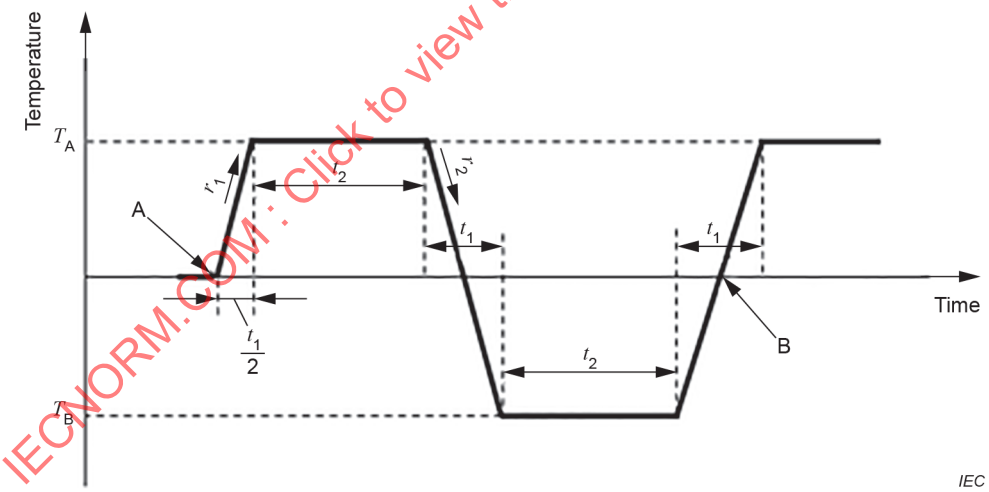
b) The temperature, T_A, shall then be maintained for the specified period t_2. During this period, the relative humidity shall be maintained at a constant value specified in the relevant specification.

c) The temperature shall then be lowered to the lower temperature, T_B, specified in the relevant specification, in a period of t_1 or at a rate of r_2.

d) The temperature, T_B, shall then be maintained for the specified period t_2. During this period, the relative humidity shall be maintained at a constant value specified in the relevant specification.

e) The temperature shall then be raised to the ambient temperature in a period of t_1 or at a rate of r_1.

f) This procedure constitutes one cycle.



Key

A start of first cycle

B end of first cycle and start of second cycle

Figure 2 – Temperature cycle

6.2.4 Performance measurement

After being subjected to all temperature cycles, the measurement of the gas sensing performance shall be performed in accordance with 4.3, unless otherwise stated. The gas sensor shall still work and indicate the specified sensing result.

6.3 Severities

The severities, as indicated by the temperature and humidity of the exposure, shall be specified in the relevant specification. The range of the temperature shall be in accordance with IEC 60721-3-7 and ISO 11999-3 with the following specific modifications. The upper and lower temperature shall be chosen in Table 1 and Table 2, respectively. For extremely high temperature applications, such as fire fighting garment, the upper temperature shall be extended to 260 °C as described in ISO 11999-3. The relative humidity shall be chosen in the range from 0 % RH to 100 % RH.

Table 1 – Upper temperature

+260 °C	+75 °C	+55 °C	+35 °C
+85 °C	+65 °C	+45 °C	+25 °C

Table 2 – Lower temperature

−65 °C	−35 °C	−5 °C	+25 °C
−55 °C	−25 °C	+5 °C	
−45 °C	−15 °C	+15 °C	

6.4 Report of the results

The report shall include the following items:

a) whether the printed flexible sensor works normally at the end of the test;
b) test gas;
c) test method;
d) number of temperature cycles;
e) test conditions (temperature and humidity).