



BSI Standards Publication

Electroacoustics — Measurement microphones

Part 2: Primary method for pressure calibration of laboratory standard microphones by the reciprocity technique

National foreword

This British Standard is the UK implementation of EN 61094-2:2009+A1:2022. It is identical to IEC 61094-2:2009, incorporating amendment 1:2022. It supersedes BS EN 61094-2:2009, will be withdrawn on 11 March 2025.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by A1 A1.

The UK participation in its preparation was entrusted to Technical Committee EPL/29, Electroacoustics.

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

Contractual and legal considerations

This publication has been prepared in good faith, however no representation, warranty, assurance or undertaking (express or implied) is or will be made, and no responsibility or liability is or will be accepted by BSI in relation to the adequacy, accuracy, completeness or reasonableness of this publication. All and any such responsibility and liability is expressly disclaimed to the full extent permitted by the law.

This publication is provided as is, and is to be used at the recipient's own risk.

The recipient is advised to consider seeking professional guidance with respect to its use of this publication.

This publication is not intended to constitute a contract. Users are responsible for its correct application.

© The British Standards Institution 2022
Published by BSI Standards Limited 2022

ISBN 978 0 539 15323 1

ICS 17.140.50; 25.160; 33.160.50

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 2009.

Amendments/corrigenda issued since publication

Date	Text affected
31 July 2022	Implementation of IEC amendment 1:2022 with CENELEC endorsement A1:2022

English version

**Electroacoustics -
Measurement microphones -
Part 2: Primary method for pressure calibration
of laboratory standard microphones
by the reciprocity technique
(IEC 61094-2:2009)**

Electroacoustique -
Microphones de mesure -
Partie 2: Méthode primaire
pour l'étalonnage en pression
des microphones étalons de laboratoire
par la méthode de réciprocité
(CEI 61094-2:2009)

Elektroakustik -
Messmikrofone -
Teil 2: Primärverfahren
zur Druckkammer-Kalibrierung
von Laboratoriums-Normalmikrofonen
nach der Reziprozitätsmethode
(IEC 61094-2:2009)

This European Standard was approved by CENELEC on 2009-03-01. 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 Central Secretariat 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 Central Secretariat has the same status as the official versions.

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

CENELEC

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

Central Secretariat: avenue Marnix 17, B - 1000 Brussels

Foreword

The text of document 29/671/FDIS, future edition 2 of IEC 61094-2, prepared by IEC TC 29, Electroacoustics, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61094-2 on 2009-03-01.

This European Standard supersedes EN 61094-2:1993.

EN 61094-2:2009 includes the following significant technical changes with respect to EN 61094-2:1993:

- an update of Clause 6 to fulfil the requirements of ISO/IEC Guide 98-3;
- an improvement of the heat conduction theory in Annex A;
- a revision of Annex F: Physical properties of humid air.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2009-12-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2012-03-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61094-2:2009 was approved by CENELEC as a European Standard without any modification.

European foreword to A1

The text of document 29/1108/FDIS, future IEC 61094-2/AMD1, prepared by IEC/TC 29 "Electroacoustics" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61094-2:2009/A1:2022.

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) 2022-12-11
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2025-03-11

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

Any feedback and questions on this document should be directed to the users' national committee. A complete listing of these bodies can be found on the CENELEC website.

Endorsement notice

The text of the International Standard IEC 61094-2:2009/AMD1:2022 was approved by CENELEC as a European Standard without any modification.

CONTENTS

1	Scope.....	7
2	Normative references	7
3	Terms and definitions	7
4	Reference environmental conditions	8
5	Principles of pressure calibration by reciprocity	8
5.1	General principles	8
5.1.1	General	8
5.1.2	General principles using three microphones	8
5.1.3	General principles using two microphones and an auxiliary sound source	8
5.2	Basic expressions	9
5.3	Insert voltage technique	10
5.4	Evaluation of the acoustic transfer impedance.....	10
5.5	Heat-conduction correction.....	12
5.6	Capillary tube correction.....	13
5.7	Final expressions for the pressure sensitivity	14
5.7.1	Method using three microphones	14
5.7.2	Method using two microphones and an auxiliary sound source	14
6	Factors influencing the pressure sensitivity of microphones.....	15
6.1	General	15
6.2	Polarizing voltage.....	15
6.3	Ground-shield reference configuration.....	15
6.4	Pressure distribution over the diaphragm	15
6.5	Dependence on environmental conditions	16
6.5.1	Static pressure	16
6.5.2	Temperature.....	16
6.5.3	Humidity	16
6.5.4	Transformation to reference environmental conditions	17
A1	6.6 Influence of leakage A1	17
7	Calibration uncertainty components	17
7.1	General	17
7.2	Electrical transfer impedance	17
7.3	Acoustic transfer impedance	18
7.3.1	General	18
7.3.2	Coupler properties	18
7.3.3	Microphone parameters	19
7.4	Imperfection of theory.....	20
7.5	Uncertainty on pressure sensitivity level.....	21
Annex A	(normative) Heat conduction and viscous losses in a closed cavity	23
Annex B	(normative) Acoustic impedance of a capillary tube.....	27
Annex C	(informative) Examples of cylindrical couplers for calibration of microphones	30
Annex D	(informative) Environmental influence on the sensitivity of microphones	35
Annex E	(informative) Methods for determining microphone parameters	38
Annex F	(informative) Physical properties of humid air.....	41

Figure 1 – Equivalent circuit for evaluating the acoustic transfer impedance $Z_{a,12}$	10
Figure 2 – Equivalent circuit for evaluating $Z'_{a,12}$ when coupler dimensions are small compared with wavelength.....	11
Figure 3 – Equivalent circuit for evaluating $Z'_{a,12}$ when plane wave transmission in the coupler can be assumed.....	11
Figure C.1 – Mechanical configuration of plane-wave couplers.....	31
Figure C.2 – Mechanical configuration of large-volume couplers.....	33
Figure D.1 – Examples of static pressure coefficient of LS1P and LS2P microphones relative to the low-frequency value as a function of relative frequency f/f_0	36
Figure D.2 – General frequency dependence of that part of the temperature coefficient for LS1P and LS2P microphones caused by the variation in the impedance of the enclosed air.....	37
Table 1 – Uncertainty components.....	22
Table A.1 – Values for Δ_H	25
Table B.1 – Real part of $Z_{a,C}$ in gigapascal-seconds per cubic metre (GPa·s/m ³).....	28
Table B.2 – Imaginary part of $Z_{a,C}$ in gigapascal-seconds per cubic metre (GPa·s/m ³).....	29
Table C.1 – Nominal dimensions for plane-wave couplers.....	32
Table C.2 – Nominal dimensions and tolerances for large-volume couplers.....	33
Table C.3 – Experimentally determined wave-motion corrections for the air-filled large-volume coupler used with type LS1P microphones.....	34
Table F.1 – Calculated values of the quantities in Clauses F.1 to F.5 for two sets of environmental conditions.....	44
Table F.2 – Coefficients used in the equations for humid air properties.....	45

ELECTROACOUSTICS ± MEASUREMENT MICROPHONES ±

Part 2: Primary method for pressure calibration of laboratory standard microphones by the reciprocity technique

1 Scope

This part of International Standard IEC 61094

- is applicable to laboratory standard microphones meeting the requirements of IEC 61094-1 and other types of condenser microphone having the same mechanical dimensions;
- specifies a primary method of determining the complex pressure sensitivity so as to establish a reproducible and accurate basis for the measurement of sound pressure.

All quantities are expressed in SI units.

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.

IEC 61094-1:2000, *Measurement microphones ± Part 1: Specifications for laboratory standard microphones*

ISO/IEC Guide 98-3, *Uncertainty of measurement ± Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*¹

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61094-1 and ISO/IEC Guide 98-3 as well as the following apply.

3.1

reciprocal microphone

linear passive microphone for which the open circuit reverse and forward transfer impedances are equal in magnitude

3.2

phase angle of pressure sensitivity of a microphone

for a given frequency, the phase angle between the open-circuit voltage and a uniform sound pressure acting on the diaphragm

NOTE Phase angle is expressed in degrees or radians (° or rad).

¹ ISO/IEC Guide 98-3:2008 is published as a reissue of the Guide to the expression of uncertainty in measurement (GUM), 1995.