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SLOVENSKI STANDARD
SIST EN 61094-2:2009/A1:2022

01-maj-2022

Elektroakustika - Merilni mikrofoni - 2. del: Primarna metoda za kalibriranje tlaka laboratorijskih standardnih mikrofonov z recipročno tehniko - Dopolnilo A1 (IEC 61094-2:2009/AMD1:2022)

Electroacoustics - Measurement microphones - Part 2: Primary method for pressure calibration of laboratory standard microphones by the reciprocity technique (IEC 61094-2:2009/AMD1:2022)

Elektroakustik - Messmikrofone - Teil 2: Primärverfahren zur Druckkammer-Kalibrierung von Laboratoriums-Normalmikrofonen nach der Reziprozitätsmethode (IEC 61094-2:2009/AMD1:2022)

Electroacoustique - Microphones de mesure - Partie 2: Méthode primaire pour l'étalonnage en pression des microphones étalons de laboratoire par la méthode de réciprocité (IEC 61094-2:2009/AMD1:2022)

Ta slovenski standard je istoveten z: EN 61094-2:2009/A1:2022

ICS:

17.140.50	Elektroakustika	Electroacoustics
33.160.50	Pribor	Accessories

SIST EN 61094-2:2009/A1:2022   **en**

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 61094-2:2009/A1

March 2022

ICS 17.140.50

English Version

Electroacoustics - Measurement microphones - Part 2: Primary method for pressure calibration of laboratory standard microphones by the reciprocity technique (IEC 61094-2:2009/AMD1:2022)

Electroacoustique - Microphones de mesure - Partie 2:
Méthode primaire pour l'étalonnage en pression des
microphones étalons de laboratoire par la méthode de la
réciprocité
(IEC 61094-2:2009/AMD1:2022)

Elektroakustik - Messmikrofone - Teil 2: Primärverfahren
zur Druckkammer-Kalibrierung von Laboratoriums-
Normalmikrofonen nach der Reziprozitätsmethode
(IEC 61094-2:2009/AMD1:2022)

This amendment A1 modifies the European Standard EN 61094-2:2009; it was approved by CENELEC on 2022-03-11. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this amendment the status of a national standard without any alteration.

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CENELEC

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

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

Ref. No. EN 61094-2:2009/A1:2022 E

EN 61094-2:2009/A1:2022 (E)

European foreword

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 (dop) 2022-12-11 level by publication of an identical national standard or by endorsement
- latest date by which the national standards conflicting with the (dow) 2025-03-11 document have to be withdrawn

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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.

IEC 61094-2

Edition 2.0   2022-02

INTERNATIONAL
STANDARD

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INTERNATIONALE

AMENDMENT 1
AMENDEMENT 1

iTeh STANDARD
PREVIEW
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Electroacoustics – Measurement microphones –
Part 2: Primary method for pressure calibration of laboratory standard microphones by the reciprocity technique

Électroacoustique – Microphones de mesure –
Partie 2: Méthode primaire pour l'étalonnage en pression des microphones étalons de laboratoire par la méthode de la réciprocité

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ELECTROACOUSTICS –
MEASUREMENT MICROPHONES –

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

AMENDMENT 1

FOREWORD

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Amendment 1 to IEC 61094-2:2009 has been prepared by IEC technical committee 29: Electroacoustics.

The text of this Amendment is based on the following documents:

Draft	Report on voting
29/1108/FDIS	29/1112/RVD

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 Amendment 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/.

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.

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5.5   Heat-conduction correction

Add, after the second existing paragraph, the following new paragraph:

At medium frequencies, transmission line theory, Equation (4), is applied to account for plane wave propagation in the coupler, but the influence of heat conduction at the ends of the coupler cannot be modelled accurately as impedances at the end surfaces. However, it can be demonstrated that, at frequencies where the pressure variations in the length direction of the coupler are moderate, the usable frequency range of the correction factor $\underline{\Delta}_H$ can be extended by application of $\underline{\Delta}_H$ to the cross-sectional area of the coupler, S_0, for the calculation of the acoustic impedance of the plane waves in the coupler, $Z_{a,0} = \rho c/S_0$ and setting α equal to zero and β equal to ω/c in Equation (4).

Add, after the last existing paragraph, the following notes:

NOTE 1   At the lowest frequencies, application of the correction factor $\underline{\Delta}_H$ to the cross-sectional area of the coupler in Equation (4) is effectively the same as application of the factor to the volume in Equation (3).

NOTE 2   The two methods described in this standard for accounting for heat conduction and viscosity are not entirely consistent at any frequency. However, a transition frequency range can be identified for plane wave couplers used for reciprocity calibration. Estimates for the frequency range of validity are given in Annex A.

6   Factors influencing the pressure sensitivity of microphones

Add, after the existing 6.5, the following new subclause:

6.6   Influence of leakage

At low frequencies, care should be taken to avoid leakage in the coupler as it affects the acoustic transfer impedance. Alternatively, a capillary tube can be used as a controlled leakage. In that case, its effects on the acoustic transfer impedance shall be calculated.

7.3.3.1   Front cavity

Replace "NOTE 1" *with* "NOTE".

Delete the existing Note 2.

7.3.3.2 Acoustic impedance

Replace the existing second and third paragraphs with the following new paragraph:

At low frequencies, heat conduction in the cavity behind the diaphragm and the pressure-equalizing tube of the microphone contribute significantly to the acoustic impedance of the microphone. The acoustic impedance $\underline{Z}_a$ of each microphone forms an important part of the acoustic transfer impedance $\underline{Z}_{a,12}$ of the system. At high frequencies, errors in the determination of $\underline{Z}_a$ influence the accuracy of the calibration in a complicated way.

Replace "NOTE" *with* "NOTE 1".

Add, after the existing note, the following new note:

NOTE 2   For type LS1 microphones, heat conduction and pressure equalization result in an increase of the diaphragm compliance that reaches 20 % to 25 % below the lower limiting frequency. For LS2 microphones, the increase is 6 % to 9 %.

Table 1 – Uncertainty components

Add, in column "Relevant subclause no.", *line* "Unintentional coupler/microphone leakage", *the references* "6.6; 7.3.2.1".

Delete, in column "Relevant subclause no.", *line* "Polarizing voltage", *the reference* "6.5.3".

Replace, in column "Relevant subclause no.", *line* "Static pressure corrections", *the reference* "6.5" *with* "6.5.1".

Replace, in column "Relevant subclause no.", *line* "Temperature corrections", *the reference* "6.5" *with* "6.5.2".

A.1   General

Add, before the last existing paragraph, the following new paragraph:

For plane wave couplers, it can be demonstrated that the low frequency solution correction, when applied to the cross-sectional area of the coupler, is valid at frequencies where pressure variations due to wave-motion are moderate, see [A.5][2].

A.2   Low frequency solution

Replace the existing text with the following new text:

At low frequencies, where the sound pressure can be assumed to be the same at all points in the coupler, the effect of heat conduction can be considered as an apparent increase in the coupler volume expressed by a complex correction factor $\underline{\Delta}_H$ to the geometrical coupler volume [A.4], V, in Equation (3) or to the cross-sectional area, S_0, in Equation (4) with $\underline{\chi} = 0 + j\omega c$.

---

2   Figures in square brackets refer to Clause A.4.

The correction factor is given by:

$$\underline{\Delta}_H = \kappa - (\kappa - 1)\underline{E}_p \tag{A.1}$$

where $\underline{E}_p$ is a complex quantity derived from the fundamental solution of the Fourier equation for heat conduction and which depends on the coupler geometry. For finite cylindrical couplers, the quantity $\underline{E}_p$ is given by

$$\underline{E}_p = \sum_{m=0}^{+\infty} \sum_{n=1}^{+\infty} \left[\frac{8/\pi^2}{\left(m+\dfrac{1}{2}\right)^2 \lambda_n^2} \underline{F}_{m,n} \right] \tag{A.2}$$

with

$$\underline{F}_{m,n} = \left(1 + \frac{\lambda_n^2 R^2 + (m+1/2)^2 \pi^2}{(1+2R)^2} \underline{X}_P^2 \right)^{-1}, \tag{A.3}$$

and where

$R = l_0 / (2a)$ is the length to diameter ratio of the coupler;

a is the radius of the coupler in metres (m);

λ_n are the roots of $J_0(\lambda_n) = 0$, see [A.6], for example; $J_0()$ is the cylindrical Bessel function of the first kind, zero order;

$\underline{X}_P$ $= A(1-j)/\left(V\sqrt{2}\right)\sqrt{\alpha_t/\omega}$;

A is the total area surface of the cavity (m²);

α_t is the thermal diffusivity of the enclosed gas in square metres per second (m²·s⁻¹).

Tabulated values of $\underline{\Delta}_H$ for typical dimensions of couplers are given in Table A.1 as function of frequency and at reference environmental conditions. The data can be used for validation of calculation software. The tabulated data given are considered accurate to 0,000 01. The quantity $\underline{E}_P$ converges more quickly at low frequencies and for small dimensions of couplers. For example, the modulus of $\underline{\Delta}_H$ is within 0,001 dB from the values in Table A.1 when calculated for $(m,n) = (100,100)$ at 1 995,3 Hz for the largest coupler and for $(m,n) = (2,2)$ at 1,995 3 Hz for the smallest coupler mentioned in Table A.1.

When the quantity $\underline{\Delta}_H$, as calculated from Equation (A.1), is applied to Equation (3), the calculated transfer admittance is assumed to be valid within 0,003 dB for the modulus and 0,01° for the phase at frequencies where $\lambda > 10^2 \cdot \sqrt[3]{V}$. When $\underline{\Delta}_H$ is applied to S_0 in Equation (4) with $\underline{\chi} = 0 + j\omega c$, the calculated transfer admittance is assumed to be valid within 0,003 dB and 0,01° at frequencies where $\lambda > 25 l_0$. This corresponds to frequencies approximately in the range 1 000 Hz to 3 450 Hz for plane-wave couplers in the range of dimensions given in Table C.1.

Table A.1 – Values for $\underline{\Delta}_H$

Frequency	a = 9,3 mm I_0 = 18,9 mm		a = 9,3 mm I_0 = 11,4 mm		a = 4,65 mm I_0 = 10,4 mm		a = 4,65 mm I_0 = 5,7 mm	
(Hz)	Re($\underline{\Delta}_H$)	Im($\underline{\Delta}_H$)	Re($\underline{\Delta}_H$)	Im($\underline{\Delta}_H$)	Re($\underline{\Delta}_H$)	Im($\underline{\Delta}_H$)	Re($\underline{\Delta}_H$)	Im($\underline{\Delta}_H$)
1,995 3	1,117 15	–0,091 65	1,141 80	–0,105 09	1,223 30	–0,134 20	1,278 08	–0,136 63
3,981 1	1,083 28	–0,070 22	1,101 15	–0,082 16	1,159 58	–0,113 26	1,198 79	–0,128 79
7,943 3	1,059 08	–0,052 43	1,071 82	–0,062 13	1,113 96	–0,089 93	1,142 13	–0,105 26
15,849	1,041 87	–0,038 50	1,050 92	–0,046 00	1,080 99	–0,068 69	1,101 39	–0,082 31
31,623	1,029 65	–0,027 95	1,036 08	–0,033 59	1,057 44	–0,051 19	1,071 99	–0,062 26
63,096	1,021 00	–0,020 14	1,025 55	–0,024 30	1,040 70	–0,037 54	1,051 04	–0,046 10
125,89	1,014 87	–0,014 44	1,018 09	–0,017 46	1,028 83	–0,027 23	1,036 16	–0,033 66
251,19	1,010 53	–0,010 31	1,012 81	–0,012 49	1,020 41	–0,019 61	1,025 61	–0,024 35
501,19	1,007 45	–0,007 34	1,009 07	–0,008 91	1,014 45	–0,014 05	1,018 14	–0,017 50
1 000,0	1,005 28	–0,005 22	1,006 42	–0,006 34	1,010 23	–0,010 03	1,012 84	–0,012 52
1 995,3	1,003 74	–0,003 71	1,004 55	–0,004 51	1,007 24	–0,007 14	1,009 09	–0,008 93

NOTE 1   The values given in this table are valid at reference environmental conditions only.

NOTE 2   The zero-frequency value of $\underline{\Delta}_H$ is κ.

A.3 Broad-band solution

Remove the penultimate existing paragraph.

Replace the existing last paragraph with the following new paragraph:

When calculated with Equation (4) using Equations (A.4) to (A.6), the transfer admittance is estimated to be valid within 0,003 dB and 0,02° at frequencies where $\lambda < 16 l_0 a$ (the factor 16 is an empirical factor, expressed in m^{-1}). This corresponds to frequencies approximately in the range 175 Hz to 1 150 Hz for plane-wave couplers in the range of dimensions given in Table C.1.

A.4 Reference documents

Replace the existing reference [A.4] with the following new reference:

[A.4] VINCENT, P.; RODRIGUES, D.; LARSONNIER, F.; GUIANVARC'H, C. and DURAND, S. Acoustic transfer admittance of cylindrical cavities in infrasonic frequency range, Metrologia, 2018, Vol. 56, No. 1

Add the following references:

[A.5] OLSEN, E.S., Microphone acoustic impedance in reciprocity calibration of laboratory standard microphones, Proceedings of Forum Acusticum 2020, Paper 1023, 2020

[A.6] WATSON, G.N. A treatise on the theory of Bessel functions. Cambridge University Press. Second edition, 1944