IEC 61094-2

Edition 2.0 2009-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

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

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: 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 corrigenda or an amendment might have been published.

- Catalogue of IEC publications: www.iec.ch/searchpub

The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: www.iec.ch/online_news/justpub

Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

- Electropedia: www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: www.iec.ch/webstore/custserv

If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:
Email: csc@iec.ch
Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00

A propos de la CEI

La Commission Electrotechnique Internationale (CEI) est la première organisation mondiale qui élabore et publie des normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

- Catalogue des publications de la CEI: www.iec.ch/searchpub/cur_fut-f.htm

Le Catalogue en-ligne de la CEI vous permet d'effectuer des recherches en utilisant différents critères (numéro de référence, texte, comité d'études,…). Il donne aussi des informations sur les projets et les publications retirées ou remplacées.

- Just Published CEI: www.iec.ch/online_news/justpub

Restez informé sur les nouvelles publications de la CEI. Just Published détaille deux fois par mois les nouvelles publications parues. Disponible en-ligne et aussi par email.

- Electropedia: www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International en ligne.

- Service Clients: www.iec.ch/webstore/custserv/custserv_entry-f.htm

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions, visitez le FAQ du Service clients ou contactez-nous:
Email: csc@iec.ch
Tél.: +41 22 919 02 11
Fax: +41 22 919 03 00

IEC 61094-2

Edition 2.0 2009-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX X

ICS 17.140.50

ISBN 978-2-88910-410-9

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTROACOUSTICS – MEASUREMENT MICROPHONES –

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

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 provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
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 61094-2 has been prepared by IEC technical committee 29: Electroacoustics.

This second edition cancels and replaces the first edition published in 1992. This second edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- 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 text of this standard is based on the following documents:

FDIS	Report on voting
29/671/FDIS	29/676/RVD

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

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

A list of all parts of the IEC 61094 series, published under the general title *Electroacoustics – Measurement microphones*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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.

3.3
electrical transfer impedance
for a system of two acoustically coupled microphones the quotient of the open-circuit voltage of the microphone used as a receiver by the input current through the electrical terminals of the microphone used as a transmitter

NOTE 1 Electrical transfer impedance is expressed in ohms (Ω).

NOTE 2 This impedance is defined for the ground-shield configuration given in 7.2 of IEC 61094-1:2000.

3.4
acoustic transfer impedance
for a system of two acoustically coupled microphones the quotient of the sound pressure acting on the diaphragm of the microphone used as a receiver by the short-circuit volume velocity produced by the microphone used as a transmitter

NOTE Acoustic transfer impedance is expressed in pascal-seconds per cubic metre (Pa·s/m^3).

3.5
coupler
device which, when fitted with microphones, forms a cavity of predetermined shape and dimensions acting as an acoustic coupling element between the microphones

4 Reference environmental conditions

The reference environmental conditions are:

–	temperature	23,0 °C
–	static pressure	101,325 kPa
–	relative humidity	50 %

5 Principles of pressure calibration by reciprocity

5.1 General principles

5.1.1 General

A reciprocity calibration of microphones may be carried out by means of three microphones, two of which shall be reciprocal, or by means of an auxiliary sound source and two microphones, of which one shall be reciprocal.

NOTE If one of the microphones is not reciprocal it can only be used as a sound receiver.

5.1.2 General principles using three microphones

Let two of the microphones be connected acoustically by a coupler. Using one of them as a sound source and the other as a sound receiver, the electrical transfer impedance is measured. When the acoustic transfer impedance of the system is known, the product of the pressure sensitivities of the two coupled microphones can be determined. Using pair-wise combinations of three microphones marked (1), (2) and (3), three such mutually independent products are available, from which an expression for the pressure sensitivity of each of the three microphones can be derived.

5.1.3 General principles using two microphones and an auxiliary sound source

First, let the two microphones be connected acoustically by a coupler, and the product of the pressure sensitivities of the two microphones be determined (see 5.1.2). Next, let the two microphones be presented to the same sound pressure, set up by the auxiliary sound source. The ratio of the two output voltages will then equal the ratio of the two pressure sensitivities.

Thus, from the product and the ratio of the pressure sensitivities of the two microphones, an expression for the pressure sensitivity of each of the two microphones can be derived.

NOTE In order to obtain the ratio of pressure sensitivities, a direct comparison method may be used, and the auxiliary sound source may be a third microphone having mechanical or acoustical characteristics which differ from those of the microphones being calibrated.

5.2 Basic expressions

Laboratory standard microphones and similar microphones are considered reciprocal and thus the two-port equations of the microphones can be written as:

$$\begin{aligned} \underline{z}_{11}\,\underline{i} + \underline{z}_{12}\,\underline{q} &= \underline{U} \\ \underline{z}_{21}\,\underline{i} + \underline{z}_{22}\,\underline{q} &= \underline{p} \end{aligned} \qquad (1)$$

where

$\underline{p}$	is the sound pressure, uniformly applied, at the acoustical terminals (diaphragm) of the microphone in pascals (Pa);
$\underline{U}$	is the signal voltage at the electrical terminals of the microphone in volts (V);
$\underline{q}$	is the volume velocity through the acoustical terminals (diaphragm) of the microphone in cubic metres per second (m^3/s);
$\underline{i}$	is the current through the electrical terminals of the microphone in amperes (A);
$\underline{z}_{11} = \underline{Z}_\text{e}$	is the electrical impedance of the microphone when the diaphragm is blocked in ohms (Ω);
$\underline{z}_{22} = \underline{Z}_\text{a}$	is the acoustic impedance of the microphone when the electrical terminals are unloaded in pascal-seconds per cubic metre (Pa·s·m^{-3}),
$\underline{z}_{12} = \underline{z}_{21} = \underline{M}_\text{p}\,\underline{Z}_\text{a}$	is equal to the reverse and forward transfer impedances in volt-seconds per cubic metre (V·s·m^{-3}), $\underline{M}_\text{p}$ being the pressure sensitivity of the microphone in volts per pascal (V·Pa^{-1}).

NOTE Underlined symbols represent complex quantities.

Equations (1) may then be rewritten as:

$$\begin{aligned} \underline{Z}_\text{e}\,\underline{i} + \underline{M}_\text{p}\,\underline{Z}_\text{a}\,\underline{q} &= \underline{U} \\ \underline{M}_\text{p}\,\underline{Z}_\text{a}\,\underline{i} + \underline{Z}_\text{a}\,\underline{q} &= \underline{p} \end{aligned} \qquad (1a)$$

which constitute the equations of reciprocity for the microphone.

Let microphones (1) and (2) with the pressure sensitivities $\underline{M}_{\text{p},1}$ and $\underline{M}_{\text{p},2}$ be connected acoustically by a coupler. From Equations (1a) it is seen that a current $\underline{i}_1$ through the electrical terminals of microphone (1) will produce a short-circuit volume velocity ($\underline{p}$ = 0 at the diaphragm) of $\underline{M}_{\text{p},1}\,\underline{i}_1$ and thus a sound pressure $\underline{p}_2 = \underline{Z}_{\text{a},12}\,\underline{M}_{\text{p},1}\,\underline{i}_1$ at the acoustical terminals of microphone (2), where $\underline{Z}_{\text{a},12}$ is the acoustic transfer impedance of the system.

The open-circuit voltage of microphone (2) will then be:

$$\underline{U}_2 = \underline{M}_{\text{p},2} \cdot \underline{p}_2 = \underline{M}_{\text{p},1}\,\underline{M}_{\text{p},2}\,\underline{Z}_{\text{a},12}\,\underline{i}_1$$

Thus the product of the pressure sensitivities is given by:

$$\underline{M}_{\mathrm{p},1}\,\underline{M}_{\mathrm{p},2} = \frac{1}{\underline{Z}_{\mathrm{a},12}}\,\frac{\underline{U}_2}{\underline{i}_1} \tag{2}$$

5.3 Insert voltage technique

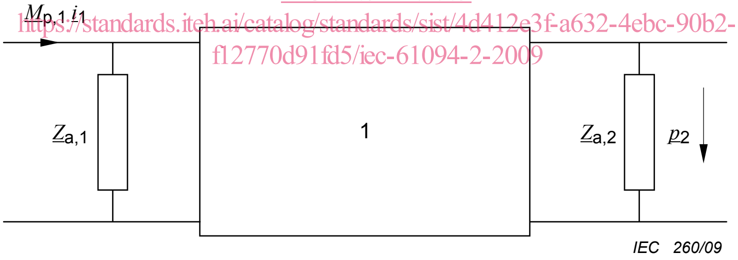
The insert voltage technique is used to determine the open-circuit voltage of a microphone when it is electrically loaded.

Let a microphone having a certain open-circuit voltage and internal impedance be connected to a load impedance. To measure the open-circuit voltage, an impedance, small compared to the load impedance, is connected in series with the microphone and a calibrating voltage applied across it.

Let a sound pressure and a calibrating voltage of the same frequency be applied alternately. When the calibrating voltage is adjusted until it gives the same voltage drop across the load impedance as results from the sound pressure on the microphone, the open-circuit voltage will be equal in magnitude to the calibrating voltage.

5.4 Evaluation of the acoustic transfer impedance

The acoustic transfer impedance $\underline{Z}_{\mathrm{a},12} = \underline{p}_2/(\underline{M}_{\mathrm{p},1}\underline{i}_1)$ can be evaluated from the equivalent circuit in Figure 1, where $\underline{Z}_{\mathrm{a},1}$ and $\underline{Z}_{\mathrm{a},2}$ are the acoustic impedances of microphones (1) and (2) respectively.



Key

1 Coupler

Figure 1 – Equivalent circuit for evaluating the acoustic transfer impedance $\underline{Z}_{\mathrm{a},12}$

In several cases, $\underline{Z}_{\mathrm{a},12}$ can be evaluated theoretically. Assume the sound pressure to be the same at any point inside the coupler (this will take place when the physical dimensions of the coupler are very small compared to the wavelength). The gas in the coupler then behaves as a pure compliance and, from the equivalent circuit in Figure 2, $\underline{Z}_{\mathrm{a},12}$ is given by $\underline{Z}'_{\mathrm{a},12}$ (assuming adiabatic compression and expansion of the gas):

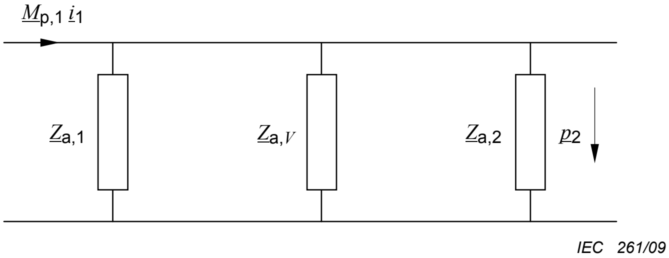


Figure 2 – Equivalent circuit for evaluating $\underline{Z}'_{a,12}$ when coupler dimensions are small compared with wavelength

$$\frac{1}{\underline{Z}'_{a,12}} = \frac{1}{\underline{Z}_{a,V}} + \frac{1}{\underline{Z}_{a,1}} + \frac{1}{\underline{Z}_{a,2}} = j\omega\left(\frac{V}{\kappa\, p_s} + \frac{\underline{V}_{e,1}}{\kappa_r\, p_{s,r}} + \frac{\underline{V}_{e,2}}{\kappa_r\, p_{s,r}}\right) \tag{3}$$

where

V	is the total geometrical volume of the coupler in cubic metres (m^3);
$\underline{V}_{e,1}$	is the equivalent volume of microphone (1) in cubic metres (m^3);
$\underline{V}_{e,2}$	is the equivalent volume of microphone (2) in cubic metres (m^3);
$\underline{Z}_{a,V} = \frac{\kappa p_s}{j\omega V}$	is the acoustic impedance of the gas enclosed in the coupler in pascal-seconds per cubic metre ($Pa \cdot s/m^3$);
ω	is the angular frequency in radians per second (rad/s);
p_s	is the static pressure in pascals (Pa);
$p_{s,r}$	is the static pressure at reference conditions in pascals (Pa);
κ	is the ratio of the specific heat capacities at measurement conditions;
κ_r	is κ at reference conditions.

Values for κ and κ_r in humid air can be derived from equations given in Annex F.

At higher frequencies, when the dimensions are not sufficiently small compared with the wavelength, the evaluation of $\underline{Z}_{a,12}$ generally becomes complicated. However, if the shape of the coupler is cylindrical and the diameter the same as that of the microphone diaphragms, then, at frequencies where plane-wave transmission can be assumed, the whole system can be considered as a homogeneous transmission line (see Figure 3).

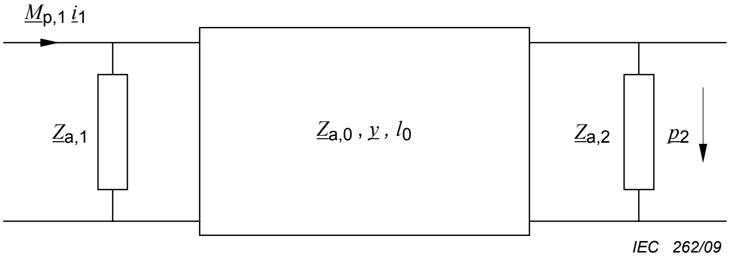


Figure 3 – Equivalent circuit for evaluating $\underline{Z}'_{a,12}$ when plane wave transmission in the coupler can be assumed

$\underline{Z}_{a,12}$ is then given by $\underline{Z}'_{a,12}$ (assuming adiabatic compression and expansion of the gas):

$$\frac{1}{\underline{Z}'_{\text{a},12}} = \frac{1}{\underline{Z}_{\text{a},0}}\left[\left(\frac{\underline{Z}_{\text{a},0}}{\underline{Z}_{\text{a},1}} + \frac{\underline{Z}_{\text{a},0}}{\underline{Z}_{\text{a},2}}\right)\cosh \underline{\gamma} l_0 + \left(1 + \frac{\underline{Z}_{\text{a},0}}{\underline{Z}_{\text{a},1}}\frac{\underline{Z}_{\text{a},0}}{\underline{Z}_{\text{a},2}}\right)\sinh \underline{\gamma} l_0\right] \tag{4}$$

where

$\underline{Z}_{\text{a},0}$	is the acoustic impedance of plane waves in the coupler. If losses in the coupler are neglected, then $\underline{Z}_{\text{a},0} = \rho c / S_0$;
ρ	is the density of the gas enclosed in kilograms per cubic metre (kg·m^{-3});
c	is the free-space speed of sound in the gas in metres per second (m·s^{-1});
S_0	is the cross-sectional area of the coupler in square metres (m^2);
l_0	is the length of the coupler, i.e. the distance between the two diaphragms in metres (m);
$\underline{\gamma} = \alpha + \mathrm{j}\beta$	is the complex propagation coefficient in metres to power minus one (m^{-1}).

Values for ρ and c in humid air can be derived from equations given in Annex F.

The real part of $\underline{\gamma}$ accounts for the viscous losses and heat conduction at the cylindrical surface and the imaginary part is the angular wave number.

If losses are neglected, $\underline{\gamma}$ may be approximated by putting α equal to zero and β equal to ω/c in Equation (4).

Allowance shall be made for any air volume associated with the microphones that is not enclosed by the circumference of the coupler and the two diaphragms (see 7.3.3.1).

5.5 Heat-conduction correction

The evaluation of $\underline{Z}'_{\text{a},12}$ in the preceding subclause assumes adiabatic conditions in the coupler. However, in practice, the influence of heat conduction at the walls of the coupler causes departure from purely adiabatic conditions, especially for small couplers and low frequencies.

At low frequencies, where the sound pressure can be considered the same at any point and under the assumption that the walls remain at a constant temperature, the influence of the heat conduction losses can be calculated and expressed in terms of a complex correction factor $\underline{\Delta}_{\text{H}}$ to the geometrical volume V in Equation (3). Expressions for the correction factor $\underline{\Delta}_{\text{H}}$ are given in Annex A.

At high frequencies, wave-motion will be present inside the coupler and the sound pressure will no longer be the same at all points. For right-cylindrical couplers where the transmission line theory can be applied (see 5.4), the combined effect of heat conduction and viscous losses along the cylindrical surface can be accounted for by the complex propagation coefficient and acoustic impedance for plane-wave propagation in the coupler. The additional heat conduction at the end surfaces of the coupler, the microphone diaphragms, can be accounted for by including further components in the acoustic impedances of the microphones. Expressions for the complex propagation coefficient and acoustic impedance for plane-wave propagation are given in Annex A.

5.6 Capillary tube correction

The coupler is usually fitted with capillary tubes in order to equalize the static pressure inside and outside the coupler. Two such capillary tubes also permit the introduction of a gas other than air.

The acoustic input impedance of an open capillary tube is given by:

$$\underline{Z}_{\mathrm{a,C}} = \underline{Z}_{\mathrm{a,t}} \tanh \underline{\gamma}\, l_{\mathrm{C}} \qquad (5)$$

where

$\underline{Z}_{\mathrm{a,t}}$ is the complex acoustic wave impedance of an infinite tube in pascal-seconds per cubic metre (Pa·s·m^{-3});

l_{C} is the length of the tube in metres (m).

The shunting effect of the capillary tubes can be taken into account by introducing a complex correction factor $\underline{\Delta}_{\mathrm{C}}$ to the acoustic transfer impedances given in Equations (3) and (4):

$$\underline{\Delta}_{\mathrm{C}} = 1 + n\frac{\underline{Z}''_{\mathrm{a,12}}}{\underline{Z}_{\mathrm{a,C}}} \qquad (6)$$

where

n is the number of identical capillary tubes used;

$\underline{Z}''_{\mathrm{a,12}}$ is the acoustic transfer impedance $\underline{Z}'_{\mathrm{a,12}}$ corrected for heat conduction according to 5.5.

An expression for the acoustic input impedance $\underline{Z}_{\mathrm{a,C}}$ of an open capillary tube is given in Annex B.

5.7 Final expressions for the pressure sensitivity

5.7.1 Method using three microphones

Let the electrical transfer impedance $\underline{U}_2/i_1$ (see 5.2) be denoted by $\underline{Z}_{\mathrm{e,12}}$ with similar expressions for other pairs of microphones.

Taking into account the corrections given in 5.5 and 5.6, the final expression for the modulus of the pressure sensitivity of microphone (1) is:

$$\left|\underline{M}_{\mathrm{p,1}}\right| = \left\{ \left|\frac{\underline{Z}_{\mathrm{e,12}}\,\underline{Z}_{\mathrm{e,31}}}{\underline{Z}_{\mathrm{e,23}}}\right| \left|\frac{\underline{Z}''_{\mathrm{a,23}}}{\underline{Z}''_{\mathrm{a,12}}\,\underline{Z}''_{\mathrm{a,31}}}\right| \left|\frac{\underline{\Delta}_{\mathrm{C,12}}\,\underline{\Delta}_{\mathrm{C,31}}}{\underline{\Delta}_{\mathrm{C,23}}}\right| \right\}^{1/2} \qquad (7)$$

Similar expressions apply for microphones (2) and (3).

The phase angle of the pressure sensitivity for each microphone is determined by a similar procedure from the phase angle of each term in the above expression.

NOTE When complex quantities are expressed in terms of modulus and phase, the phase information should be referred to the full four-quadrant phase range, i.e. 0 - 2π rad or 0 – 360°.

5.7.2 Method using two microphones and an auxiliary sound source

If only two microphones and an auxiliary sound source are used, the final expression for the modulus of the pressure sensitivity is:

$$\left|\underline{M}_{\mathrm{p,1}}\right| = \left|\frac{\underline{M}_{\mathrm{p,1}}}{\underline{M}_{\mathrm{p,2}}}\,\frac{\underline{Z}_{\mathrm{e,12}}}{\underline{Z}''_{\mathrm{a,12}}}\,\underline{\Delta}_{\mathrm{C}}\right|^{1/2} \qquad (8)$$

where the ratio of the two pressure sensitivities is measured by comparison against the auxiliary source, see 5.1.3.

6 Factors influencing the pressure sensitivity of microphones

6.1 General

The pressure sensitivity of a condenser microphone depends on polarizing voltage and environmental conditions.

The basic mode of operation of a polarized condenser microphone assumes that the electrical charge on the microphone is kept constant at all frequencies. This condition cannot be maintained at very low frequencies and the product of the microphone capacitance and the polarizing resistance determines the time constant for charging the microphone. While the open-circuit sensitivity of the microphone, as obtained using the insert voltage technique, will be determined correctly, the absolute output from an associated preamplifier to the microphone will decrease at low frequencies in accordance with this time constant.

Further, the definition of the pressure sensitivity implies that certain requirements be fulfilled by the measurements. It is essential during a calibration that these conditions are controlled sufficiently well so that the resulting uncertainty components are small.

6.2 Polarizing voltage

The sensitivity of a condenser microphone is approximately proportional to the polarizing voltage and thus the polarizing voltage actually used during the calibration shall be reported.

To comply with IEC 61094-1 a polarizing voltage of 200,0 V is recommended.

6.3 Ground-shield reference configuration

According to 3.3 of IEC 61094-1:2000, the open-circuit voltage shall be measured at the electrical terminals of the microphone when it is attached to a specified ground-shield configuration using the insert voltage technique described in 5.3 above. Specifications for ground-shield configurations for laboratory standard microphones are given in IEC 61094-1:2000.

The appropriate ground-shield configuration shall apply to both transmitter and receiver microphones during the calibration, and the shield should be connected to ground potential.

If any other arrangement is used, the results of a calibration shall be referred to the reference ground-shield configuration.

If the manufacturer specifies a maximum mechanical force to be applied to the central electrical contact of the microphone, this limit shall not be exceeded.

6.4 Pressure distribution over the diaphragm

The definition of the pressure sensitivity assumes that the sound pressure over the diaphragm is applied uniformly. The output voltage of a microphone presented with a non-uniform pressure distribution over the surface of the diaphragm will differ from the output voltage of the microphone when presented with a uniform pressure distribution having the same mean value, because usually the microphone is more sensitive to a sound pressure at the centre of the diaphragm. This difference will vary for microphones with various different non-uniformities of tension distribution on the diaphragm.

For cylindrical couplers, as described in Annex C, both longitudinal and radial wave motions (symmetric as well as asymmetric) will be present. The radial wave motion will result in a