

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE

Electroacoustics – Methods to determine corrections to obtain the free-field  
response of a sound level meter

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Électroacoustique – Méthodes de détermination de corrections pour obtenir la  
réponse en champ libre d'un sonomètre

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Électroacoustique – Méthodes de détermination de corrections pour obtenir la réponse en champ libre d'un sonomètre

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## CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	7
2 Normative references .....	8
3 Terms and definitions .....	8
4 Reference environmental conditions .....	9
5 Uncertainties of measurement .....	9
6 General requirements for measurement of adjustment value and corrections.....	10
7 Submission and inspection .....	12
8 Determination of the adjustment value at the calibration check frequency.....	12
9 Determination of corrections for the typical effects of reflections from the case of the sound level meter and diffraction of sound around the microphone .....	13
10 Determination of corrections for the deviation of the microphone free-field frequency response from a uniform frequency response .....	13
11 Determination of corrections for the use of windscreens and similar accessories.....	14
12 Determination of corrections over a range of frequencies when a sound calibrator is recommended for use by the sound level meter manufacturer.....	14
13 Determination of corrections over a range of frequencies when a comparison coupler is recommended for use by the sound level meter manufacturer .....	15
14 Determination of corrections over a range of frequencies when an electrostatic actuator is recommended for use by the sound level meter manufacturer .....	16
15 Documentation .....	16
Annex A (normative) Calibration check frequency – Determination of the adjustment value .....	18
Annex B (normative) Determination of the effects of reflections from the case of the sound level meter and diffraction of sound around the microphone .....	20
Annex C (normative) Determination of the effects of the use of windscreens and similar accessories .....	21
Annex D (informative) Determination of corrections for use with sound calibrators to determine equivalent free-field response at all frequencies of interest .....	22
Annex E (informative) Determination of corrections for use with comparison couplers to determine equivalent free-field frequency response at all frequencies of interest .....	25
Annex F (informative) Determination of corrections for use with electrostatic actuators to determine equivalent free-field frequency response at all frequencies of interest .....	28
Annex G (informative) Comparison techniques.....	31
Annex H (informative) Exact one-twelfth-octave frequencies .....	34
Annex I (informative) Example calculations of expanded uncertainty of measurement.....	36
Bibliography.....	40
Figure 1 – Mounting methods for the sound level meter .....	11
Figure A.1 – Diagrammatic representation of factors for consideration in optimising adjustment value at the calibration check frequency .....	19
Figure D.1 – Measurement steps using a sound calibrator .....	22
Figure E.1 – Measurement steps using a comparison coupler .....	25

Figure F.1 – Measurement steps using an electrostatic actuator .....	28
Table H.1 – Exact frequencies for one-twelfth-octave steps over one decade .....	35
Table I.1 – Description of likely uncertainty components .....	37
Table I.2 – Uncertainty example for a frequency of 1 kHz .....	38
Table I.3 – Uncertainty example for a frequency of 8 kHz .....	39

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**ELECTROACOUSTICS –  
METHODS TO DETERMINE CORRECTIONS TO OBTAIN  
THE FREE-FIELD RESPONSE OF A SOUND LEVEL METER**

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International Standard IEC 62585 has been prepared by IEC technical committee 29: Electroacoustics.

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

FDIS	Report on voting
29/770/FDIS	29/782/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 publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability 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

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## INTRODUCTION

The performance specification International Standard for sound level meters, IEC 61672-1, requires that at least one model of sound calibrator, conforming to the requirements of IEC 60942 be specified in the instruction manual for checking and maintaining the correct indication on the display of the sound level meter at the calibration check frequency. The sound level meter manufacturer specifies the adjustment value to be applied to obtain the required indication on the display in response to the sound pressure level generated by the sound calibrator, in order to optimize performance over the complete frequency range.

In addition, various corrections need to be available over a range of frequencies in order for a periodic test of a sound level meter to be performed according to IEC 61672-3. For example, corrections are needed for any effects of the sound level meter case or of accessories such as windscreens on the equivalent free-field sound level. Information on these corrections is also required by users of sound level meters and sound calibrators on a regular basis.

Also, a manufacturer producing a sound level meter to the specifications of IEC 61672-1, may recommend, in the instruction manual, the use of a sound calibrator, comparison coupler or electrostatic actuator to determine the acoustical response of a sound level meter at various frequencies. In this case the manufacturer is required to provide corrections to obtain equivalent sound levels that would be displayed under reference environmental conditions in response to plane progressive sinusoidal waves that are incident from the reference direction at each frequency used for periodic testing. These corrections will either be given in the instruction manual, or the instruction manual will state where they can be found.

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## ELECTROACOUSTICS – METHODS TO DETERMINE CORRECTIONS TO OBTAIN THE FREE-FIELD RESPONSE OF A SOUND LEVEL METER

### 1 Scope

This International Standard provides information on the corrections required over a range of frequencies in order for a periodic test of a sound level meter to be performed according to IEC 61672-3. These corrections include:

- corrections for the typical effects of reflections from the case of the sound level meter and diffraction of sound around the microphone;
- corrections for the deviation of the typical microphone frequency response from a uniform frequency response, where the actual microphone response cannot be measured;
- corrections for the influence on the frequency response of a typical microphone of a specified windscreen and any other accessory that is part of the configuration for normal use of the particular sound level meter submitted for testing.

This International Standard includes discussion about uncertainties of measurement of the required corrections. In some instances a maximum permitted expanded uncertainty for the manufacturer or testing laboratory is given. This maximum permitted expanded uncertainty excludes any component due to the variability of different samples of artefact (for example, microphone or windscreen). It should be noted that if large uncertainties of measurement are quoted for each of the individual corrections, when they are combined to account for the configuration of sound level meter under test, the large individual uncertainties may result in a failure to conform to the maximum permitted expanded uncertainties of measurement given in Table A.1 of IEC 61672-1:<sup>1</sup> and hence a failure of the sound level meter to conform to IEC 61672-1

In addition, this International Standard describes methods for determining these corrections, over the frequency range of interest, and explains the adjustment value at the calibration check frequency to be quoted by the manufacturer of the sound level meter (also required by IEC 61672-3).

When the sound level meter manufacturer recommends the use of a sound calibrator, comparison coupler, or an electrostatic actuator for periodic testing of the acoustical response of a sound level meter at various frequencies, this International Standard describes methods of measurement of the corrections required to adjust the indication on the sound level meter to an equivalent free-field level, over the frequency range of interest. These corrections relate to a specific model of sound calibrator, comparison coupler or electrostatic actuator, microphone and sound level meter (also required by IEC 61672-3).

The aim of this International Standard is to ensure that the adjustment value at the calibration check frequency and all corrections are determined using consistent and appropriate methods.

It is intended that this International Standard will be used by manufacturers to determine adjustment values and corrections, by laboratories performing pattern evaluation tests according to IEC 61672-2, and by laboratories performing periodic tests according to IEC 61672-3. Laboratories performing periodic tests according to IEC 61672-3 will also need to consult this International Standard to ensure that the expanded uncertainties of

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<sup>1</sup> Second edition to be published. (A revision of 61672-1:2002.)

measurement for the corrections quoted by the manufacturer do not exceed the maximum permitted values.

The corrections obtained by use of the methods given in this International Standard are the result of measurements made using samples of the devices. It is possible that these corrections may not be totally representative either for all batches produced or over time. Repeating the measurements at regular intervals is recommended to ensure that no changes are required to the corrections stated in the instruction manual.

This International Standard does not specifically cover the case where the sound level meter is fitted with a microphone intended for use in random-incidence sound fields, as information is given in IEC 61183.

## 2 Normative references

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.

IEC 60942, *Electroacoustics – Sound calibrators*

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

IEC 61094-5, *Measurement microphones – Part 5: Methods for pressure calibration of working standard microphones by comparison*

[IEC 62585:2012](#)

IEC 61094-6, *Measurement microphones – Part 6: Electrostatic actuators for determination of frequency response*

IEC/TS 61094-7, *Measurement microphones – Part 7: Values for the difference between free-field and pressure sensitivity levels of laboratory standard microphones*

IEC 61183, *Electroacoustics-Random-incidence and diffuse-field calibration of sound level meters*

IEC 61672-1: —2, *Electroacoustics – Sound level meters – Part 1: Specifications*

IEC 61672-2, *Electroacoustics – Sound level meters – Part 2: Pattern evaluation tests*

IEC 61672-3, *Electroacoustics – Sound level meters – Part 3: Periodic tests*

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

ISO/IEC Guide 99, *International vocabulary of metrology – Basic and general concepts and associated terms (VIM)*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in the ISO/IEC Guide 99, as well as the following apply.

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<sup>2</sup> Second edition to be published. (A revision of 61672-1:2002.)

### 3.1

#### **adjustment value at the calibration check frequency**

value, at the calibration check frequency, for adjusting the sensitivity of the sound level meter, as specified by the manufacturer to be added to the displayed value of the sound level meter to obtain the stated sound pressure level from the calibrator while the sound level meter is exposed to the sound pressure in the calibrator, in order to optimise performance of the sound level meter over the complete frequency range

Note 1 to entry: The adjustment value is expressed in decibels (dB).

### 3.2

#### **microphone**

#### **microphone cartridge**

electroacoustic transducer by which electrical signals are obtained from acoustic oscillations

### 3.3

#### **microphone reference point**

point specified on, or close to, the microphone to describe the position of the microphone

Note 1 to entry: The microphone reference point will usually be at the centre of the diaphragm of the microphone.

### 3.4

#### **free-field correction for sound level meter**

value, at a particular frequency, that, during calibration or verification, is added to the level displayed by the sound level meter to obtain its response to a progressive sound wave in the free field of sound pressure level equal to that produced or simulated by the sound source, dependent on the specific models and configurations of sound level meter and sound source

Note 1 to entry: The IEC 61672 series permits the use of a sound calibrator, a comparison coupler or an electrostatic actuator as the sound source. The values of the corrections for these sound sources are not necessarily equal.

Note 2 to entry: The value of this correction depends on the direction of incidence of the progressive sound wave.

Note 3 to entry: When the free-field correction is stated, the reference direction is assumed unless an alternative direction is given.

Note 4 to entry: A measurement with an electrostatic actuator is not an absolute measurement, but is referenced to a sensitivity at a particular frequency, for example the calibration check frequency.

Note 5 to entry: Corrections are expressed in decibels (dB).

## 4 Reference environmental conditions

Reference environmental conditions for specifying the adjustment value and corrections are:

- temperature: 23 °C
- static air pressure: 101,325 kPa
- relative humidity: 50 %

## 5 Uncertainties of measurement

Laboratories performing measurements of the corrections shall calculate the uncertainties associated with all measurements in accordance with the guidelines given in ISO/IEC Guide 98-3. Actual expanded uncertainties shall be calculated for a level of confidence of 95 %, using the necessary coverage factor, which shall be stated.

NOTE 1 Generally a coverage factor of 2 approximates to a level of confidence of 95 %, unless the contributions are such that it is necessary to use a different coverage factor to maintain the 95 % level of confidence.

The maximum permitted expanded uncertainties of measurement are given separately in the following clauses for the appropriate corrections. If the actual expanded uncertainty of measurement exceeds any of the maximum permitted values, the measurement shall not be used to evaluate the corrections provided in the instruction manual for the sound level meter.

NOTE 2 It is not possible to derive corrections for use in demonstrating conformance of the sound level meter to the requirements of IEC 61672-1 if the actual expanded uncertainty of measurement exceeds any of the maximum permitted values.

Calculation of the expanded uncertainty of measurement for a particular measurement should consider all relevant components. An example calculation is given in Annex I.

## 6 General requirements for measurement of adjustment value and corrections

For all measurements the laboratory shall use instruments that have been calibrated for the appropriate quantities at appropriate intervals. As required, the calibrations shall be traceable to national standards.

Measurements shall be performed within the following ranges of environmental conditions: 80 kPa to 105 kPa for static air pressure, 20 °C to 26 °C for air temperature and 25 % to 70 % for relative humidity. If the measurements are performed at a static pressure below 97 kPa an additional uncertainty component shall be included in the calculation of the uncertainty of the measured corrections to account for the deviations from the values at reference conditions. If specific data are not available this additional uncertainty component shall be an expanded uncertainty (k=2) of 0,15 dB at frequencies less than and equal to 3 kHz and 0,25 dB for frequencies above 3 kHz.

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Static air pressure, air temperature and relative humidity at the time of a measurement shall be recorded. Sufficient time shall be allowed for the components to stabilize before any measurements are performed. The range in air temperature during each test shall not exceed 1 °C.

For the sound calibrators used in the determination of the adjustment value at the calibration check frequency, evidence shall be available to demonstrate that the actual specimens of sound calibrator conform to the requirements for periodic testing of IEC 60942 for the appropriate performance class. In addition, where a sound calibrator is used in the determinations of corrections at various frequencies, evidence shall be available to demonstrate that the actual specimens of sound calibrator used conform to the requirements for periodic testing of IEC 60942 for a class 1 sound calibrator.

Where the sound level meter manufacturer recommends the use of a comparison coupler for periodic testing of the acoustical response of the sound level meter at various test frequencies, the comparison coupler used should preferably be designed in accordance with the examples given in IEC 61094-5.

Where the sound level meter manufacturer recommends the use of an electrostatic actuator for periodic testing of the acoustical response of the sound level meter at various test frequencies, the actuator used shall conform to the requirements of IEC 61094-6.

Where a sound calibrator is used, as applicable, the effect of the prevailing environmental conditions during the measurements on the sound pressure level produced in the coupler of the sound calibrator, relative to the sound pressure level produced under the reference environmental conditions, shall be accounted for in accordance with the procedure from the instruction manual for the sound calibrator and data from the most recent calibration of the sound calibrator.

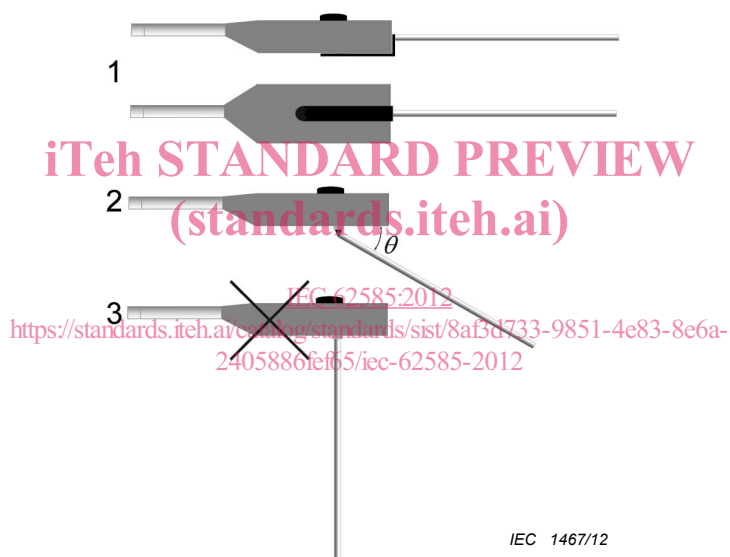
For any measurements performed in a free-field as part of the determination of the adjustment value or corrections, in order to avoid inclusion of unwanted effects, all microphones and microphone/preamplifier combinations, including reference microphones shall be mounted on

a rod the diameter of which is nominally the same as the diameter of the microphone. In addition, the distance from the source to the microphone shall be greater than 1 m, with the minimum distance from the source being at least six times the longest dimension of the sound level meter. Sound shall be incident in the reference direction.

It is recommended that the length of the mounting rod between the microphone and any mounting point of the rod should be at least 1 m.

The sound level meter shall be suspended in a free-field using a non-vertical rod at the rear, and accurate positioning shall be obtained, for example by use of laser alignment. Two suitable methods of mounting, 1 and 2, are shown in Figure 1. For mounting method 2 the angle  $\theta$  shall be less than  $60^\circ$ . Mounting method 3 is not suitable and shall not be used – see [1]<sup>3</sup>.

For reliable results to be obtained, particularly for mounting method 1, care should be taken to minimise the bulk of the mounting structure and to avoid any sharp edges.



**Figure 1 – Mounting methods for the sound level meter**

Where the acoustic frequency response of the sound level meter is required, the measured response needs to be compared with the response of a known reference microphone, for which the calibration is traceable to national standards. A calibrated reference microphone is also required if absolute measurements in a sound calibrator or comparison coupler are required.

Where an a.c. output or equivalent from the sound level meter is used, the testing laboratory shall verify that changes in the levels of applied signals produce changes in the signal levels indicated on the display device of the sound level meter and at the output in accordance with IEC 61672-1.

Where corrections are applied in software, it will be necessary not to change these corrections (for example by switching 'in' or 'out') during measurements described in this International Standard.

<sup>3</sup> Numbers in square brackets refer to the Bibliography.

Clauses 9 to 14 give further information on determination of various corrections that may be required in order for a periodic test of a sound level meter to be performed according to IEC 61672-3, or during testing to IEC 61672-2 to verify the data provided in the instruction manual, or by a manufacturer during the design process. Wherever possible the data for these corrections shall be provided separately.

NOTE If the configuration of the sound level meter includes use of extension cables this can result in a different value for the correction to that obtained when the microphone is directly mounted on the sound level meter case.

Care should be taken to ensure that ambient noise does not affect the measurement results, and this should be considered in the evaluation of the uncertainty components.

## 7 Submission and inspection

In general for all the test methods described, as applicable, at least three sound calibrators of the same model, one electrostatic actuator, one comparison coupler, three microphones of the same model and one sound level meter shall be submitted, allowing for various combinations to be tested. If the typical frequency response of a microphone is to be measured, at least five microphones shall be submitted. Appropriate instruction manuals applicable to the model and version of the sound level meter, the sound calibrator, comparison coupler and electrostatic actuator shall be supplied.

At least three samples of all relevant accessories, such as adaptors for the sound calibrator, and at least five samples of windscreen as appropriate, shall also be supplied.

If possible the five samples of windscreen should be taken from different production batches.

Prior to any measurements the sound level meter, sound calibrators, comparison couplers and electrostatic actuators, as appropriate, shall be visually inspected for any damage, and all appropriate controls shall be operated to ensure that they are in working order. It shall also be ensured that any power supplies are functioning within the specified operating limits.

## 8 Determination of the adjustment value at the calibration check frequency

According to IEC 61672-1 at least one model of sound calibrator, conforming to the requirements of IEC 60942, shall be specified in the instruction manual of the sound level meter for checking and maintaining the required indication on the display of the sound level meter at the calibration check frequency. Annex A of this International Standard gives the method for obtaining a suitable adjustment value at the calibration check frequency when adjusting the sensitivity of the sound level meter by application of the recommended sound calibrator.

IEC 61672-1 requires the manufacturer to specify the adjustment value, at reference conditions, to be applied to obtain the required indication on the display in response to the sound pressure level generated by the sound calibrator to optimize performance over the complete frequency range. The adjustment level shall account for the model of microphone, reflections from the sound level meter case and any diffraction effects, and may depend on the configuration in which the sound level meter is to be used, for example with or without extension cable. Any adaptor used with the sound calibrator shall be clearly identified, and referred to in the statement of the adjustment value. IEC 61672-3 requires that an adaptor of the same model shall then be used for any periodic testing of the sound level meter.

NOTE 1 As the manufacturer is optimizing over the complete frequency range it is possible that the adjustment value will not result in an indication at the calibration check frequency equivalent to the sound pressure level that would be indicated in response to plane progressive sound waves incident in the reference direction. There can be a small 'offset' to optimise performance of the sound level meter over the complete frequency range.

NOTE 2 An incorrect adjustment value could cause the sound level meter to not conform to the relevant specifications of IEC 61672-1.

The adjustment value has no associated uncertainty of measurement.

## 9 Determination of corrections for the typical effects of reflections from the case of the sound level meter and diffraction of sound around the microphone

IEC 61672-3 requires the use of corrections for the typical effects of reflections from the case of the sound level meter and diffraction of sound around the microphone of the sound level meter.

Annex B gives recommendations on methods for determining the corrections for the typical effects of reflections from the case of the sound level meter and diffraction of sound around the microphone, and possible measurement methods are given in Annex G.

The expanded uncertainty of measurement for the corrections for the typical effects of reflections from the case of the sound level meter and diffraction of sound around the microphone shall not exceed 0,25 dB up to and including 4 kHz, and 0,35 dB at all frequencies above 4 kHz. The manufacturer or testing laboratory shall state the expanded uncertainty of the actual measurements performed, together with the associated coverage factor, in the documentation supplied.

## 10 Determination of corrections for the deviation of the microphone free-field frequency response from a uniform frequency response

IEC 61672-3 requires the use of corrections for the deviation of the typical microphone free-field response from a uniform frequency response. This shall be interpreted as the deviation of the actual microphone response from a uniform frequency response, unless it is not possible to measure this, in which case the deviation of the typical microphone response shall be used.

Methods of measuring the frequency response are given in IEC 61094 (all parts).

Where a sound calibrator, comparison coupler or electrostatic actuator is used to measure the actual microphone response, corrections shall be available to obtain the microphone free-field response over the required range of frequencies.

Measurements shall be made at octave intervals over the frequency range 63 Hz to 16 kHz for microphones used on class 1 sound level meters, and from 63 Hz to 8 kHz for microphones used on class 2 sound level meters. Exact frequencies shall be used for the measurements and in reporting the results.

NOTE 1 Exact frequencies are specified in Annex H.

For microphones where the reference direction is not along the principal axis e.g. some microphones used outdoors, the reference direction defines a range of directions. In this case at least four measurements at equally spaced rotational intervals shall be made, and the mean value and the maximum deviation from the mean value shall be calculated and reported for each microphone measured. If the variation in the results obtained is greater than the applicable tolerance limit, the correction shall not be used to demonstrate conformance of the sound level meter to IEC 61672-1.

NOTE 2 This method is being used whilst further experience is gained for microphones where the reference direction is not along the principal axis.

Where a typical free-field response is determined by the manufacturer for inclusion in the instruction manual, measurements shall be made on at least five samples of the model of microphone. The mean value shall be calculated at each frequency, and this is considered to be the typical response. The maximum deviation from the mean shall also be specified.