SLOVENSKI STANDARD

SIST EN 61183:2002

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Electroacoustics - Random-incidence and diffuse-field calibration of sound level meters (IEC 61183:1994)

Electroacoustics - Random-incidence and diffuse-field calibration of sound level meters

Elektroakustik - Kalibrierung von Schallpegelmessern in einem Schallfeld mit stochastischem Schalleinfall und im diffusen Schallfeld

Electroacoustique - Etalonnage des sonomètres sous incidence aléatoire et en champs diffus

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English version

Electroacoustics — Random-incidence and diffuse-field calibration of sound level meters

(IEC 1183:1994)

Electroacoustique — Etalonnage des sonomètres sous incidence aléatoire et en champ diffus
(CEI 1183:1994)

Elektroakustik — Kalibrierung von Schallpegelmessern in einem Schallfeld mit stochastischem Schalleinfall und im diffusen Schallfeld
(IEC 1183:1994)

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CENELEC

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

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Foreword

The text of document 29(CO)167, as prepared by IEC Technical Committee 29, Electroacoustics, was submitted to the IEC-CENELEC parallel vote in July 1993.

The reference document was approved by CENELEC as EN 61183 on 8 March 1994.

The following dates were fixed:

— latest date of publication of an identical national standard (dop) 1995-07-01

— latest date of withdrawal of conflicting national standards (dow) 1995-07-01

Annexes designated "normative" are part of the body of the standard. Annexes designated "informative" are given only for information. In this standard, Annex A and Annex B are informative and Annex ZA is normative.

Contents

1 Scope

1.1 This International Standard describes a free-field calibration method for determining random-incidence sensitivity levels of sound level meters. Additionally, the standard describes a diffuse-field calibration method for determining diffuse-field sensitivity levels.

1.2 For the purpose of this International Standard, diffuse-field sensitivity level may be used interchangeably with random-incidence sensitivity level. Selection of calibration method depends on the facility available.

1.3 Results of calibrations conducted in accordance with this standard depend upon which components of a sound level meter are exposed to the sound field.

1.4 For the purpose of this standard, a sound level meter is considered to be a conventional sound level meter, an integrating-averaging sound level meter, or any other sound measuring system.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 50(801):1992, *International Electrotechnical Vocabulary (IEV), Chapter 801: Acoustics and electroacoustics.*

IEC 651:1979, *Sound level meters.*

IEC 804:1985, *Integrating-averaging sound level meters.*

IEC 1094-1:1992, *Measurement microphones — Part 1: Specifications for laboratory standard microphones.*

IEC 1260:199X, *Electroacoustics — Octave-band and fractional octave-band filters (in preparation).*

ISO 266:1975, *Acoustics — Preferred frequencies for measurements (revision in preparation).*

ISO 3741:1988, *Acoustics — Determination of sound power levels of noise sources — Precision methods for broad-band sources in reverberation rooms.*

ISO 3745:1977, *Acoustics — Determination of sound power levels of noise sources — Precision methods for anechoic and semi-anechoic rooms.*

3 Definitions

3.1 For the definitions of terms used in this International Standard, reference should be made to IEC 50(801). Certain additional terms are defined below for the purpose of this standard.

3.2
reference direction

the direction of sound incidence specified by the manufacturer for testing the free-field sensitivity level and directional characteristics of a sound level meter

3.3
random incidence sound field

at a given location and for a given frequency or frequency band centered on that frequency, a sound field consisting of free sound waves arriving successively from all directions with equal probability and level

3.4
diffuse sound field

at a given location and for a given frequency or frequency band centred on that frequency, a sound field consisting of sound waves arriving more or less simultaneously from all directions with equal probability and level

3.5
random-incidence sensitivity level

in decibels, of a sound level meter, for a given frequency or frequency band centred on that frequency, the time-average sound pressure level indicated by the instrument due to a random incidence sound field, minus the time-average sound pressure level at the position of the acoustical centre of the microphone, due to sound waves from the same sound source and in the absence of the instrument

3.6
diffuse-field sensitivity level

in decibels, of a sound level meter, for a given frequency or frequency band centred on that frequency, the time-average sound pressure level indicated by the instrument due to a diffuse sound field minus the time-average sound pressure level of the sound field at the position of the acoustical centre of the microphone and in the absence of the instrument

3.7
free-field sensitivity level

in decibels, of a sound level meter, for a given frequency or frequency band centred on that frequency, the sound pressure level indicated by the instrument due to a free sound-field incident from a specified direction minus the sound pressure level of the sound field at the position of the acoustical centre of the microphone and in the absence of the instrument

3.8
pressure sensitivity level

in decibels, of a sound level meter, for a given frequency or frequency band centred on that frequency, the sound pressure level indicated by the instrument due to a sound pressure uniformly applied over the surface of the diaphragm of the microphone minus the actual sound pressure level at the diaphragm

4 Calibration method based on free-field measurements

4.1 For each frequency or frequency band centred on that frequency, the random-incidence sensitivity level G_{RI} of a sound level meter shall be calculated, in decibels, from

$$G_{RI} = G_F - 10 \lg \gamma \tag{1}$$

where

- γ is the directivity factor of the sound level meter and is a measure of the deviation from an ideal omni-directional response with equal sensitivity at all possible angles of sound incidence on the microphone;
- G_F is the free-field sensitivity level, in decibels, of the sound level meter for the reference direction of sound incidence and equal to $L_{rd} - L_o$;

and where

- L_{rd} is the sound pressure level, in decibels, indicated by the sound level meter when exposed to a plane progressive sound wave arriving at the microphone from the reference direction of sound incidence;
- L_o is the sound pressure level, in decibels, of the same plane progressive sound wave in the absence of the sound level meter.

4.2 While $G_F = L_{rd} - L_o$ will usually vary for individual sound level meters, the directivity factor γ depends only on dimensions and geometry and is therefore the same for all instruments of the same model.

4.3 For determination of the directivity factor γ, consider the sound level meter located with the acoustical centre of the microphone at the origin of a reference coordinate system. The reference direction of the sound level meter coincides with the X-axis of the coordinate system. Sounds from different directions are incident on the sound level meter from a sound source located at a position on the surface of the sphere defined by a vector $\underline{r}$ from the origin; see Figure 1.

4.4 The directivity factor γ is calculated from the following equation:

$$\gamma = \frac{4\pi}{\int_S 10^{-0,1\,[L_{rd} - L(\underline{r})]}\, d\Omega} \tag{2}$$

where

$L(\underline{r})$ is the sound pressure level, in decibels, indicated by the sound level meter when exposed to a plane progressive wave arriving at the microphone from the direction of $\underline{r}$;

L_{rd} is the sound pressure level, in decibels, indicated by the sound level meter when exposed to a plane progressive wave arriving at the microphone from the reference direction;

$d\Omega$ is the elemental solid angle associated with source position $\underline{r}$ in steradians.

The integral is taken over all possible angles of incidence from locations over the surface of the surrounding sphere.

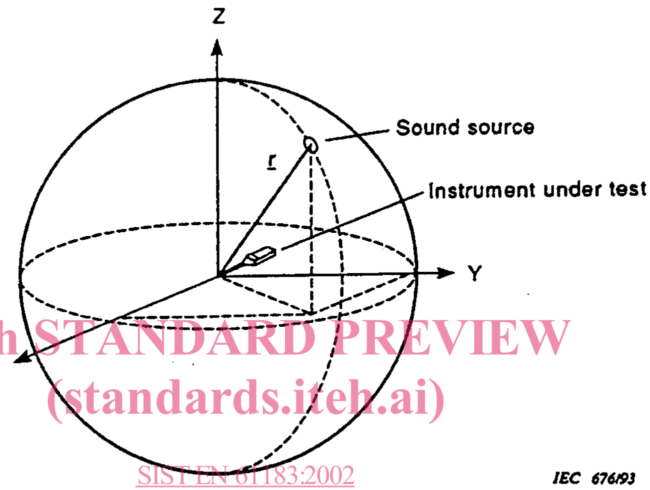

Figure 1 — Reference coordinate system for random-incidence sensitivity level calibration based on free-field measurements

4.5 For the purpose of practical measurements, it is convenient to describe the position of the sound source by means of a sound incidence angle ϕ, measured from the X-axis, and an angle α measured in a plane perpendicular to the X-axis as shown in Figure 2. The directivity factor γ is then given by:

$$\gamma = \frac{4\pi}{\displaystyle\int_0^{\phi=2\pi}\int_0^{\alpha=\pi} 10^{-0,1\,[L_{rd} - L(\phi,\alpha)]}\,|\sin\phi|\,d\alpha\,d\phi} \qquad (3)$$

4.6 For a practical determination of random-incidence sensitivity level, the number of sound-incidence directions has to be limited. Sound pressure levels indicated by the sound level meter for particular directions are considered representative of directions near those selected.

4.7 Assuming the sound pressure level $L(\phi,\alpha)$ to be constant within sufficiently small increments of ϕ and α and dividing the range of angles ϕ and α into m and n equal parts such that $\Delta\phi = 2\pi/m$ and $\Delta\alpha = \pi/n$, respectively, equation (3) may be approximated by:

$$\gamma = \frac{1}{\displaystyle\sum_{i=1}^{m}\sum_{j=1}^{n} K(\phi_i,\alpha_j)\cdot 10^{-0,1\,[L_{rd} - L(\phi_i,\alpha_j)]}} \qquad (4)$$

where

$$K(\phi_i,\alpha_j) = \int_{\phi_i - \Delta\phi/2}^{\phi_i + \Delta\phi/2} \int_{\alpha_j - \Delta\alpha/2}^{\alpha_j + \Delta\alpha/2} (1/4\pi)\,|\sin\phi|\,d\alpha\,d\phi \qquad (5)$$

From equation (5), with angles ϕ, $\Delta\phi$, α and $\Delta\alpha$ in radians, follows the expression for the dimensionless adjustment factor:

$$K(\phi_i,\alpha_j) = |(\Delta\alpha/4\pi)\,[\cos(\phi_i - \Delta\phi/2) - \cos(\phi_i + \Delta\phi/2)]| \qquad (6)$$

provided that sin ϕ does not change sign over the integration range, and

$$K(\phi_i,\alpha_j) = (2\,\Delta\alpha/4\pi)\,[1 - \cos(\Delta\phi/2)] \qquad (7)$$

for $\phi_i = 0$ or $\phi_i = \pi$.

NOTE 1 For the purpose of simplification, indices i and j are omitted throughout the following text.

NOTE 2 As $K(\phi,\alpha)$ is not dependent on α, the notation for the dependency of the adjustment factors on angle α is omitted in the following text.

4.8 $K(\phi)$ are adjustment factors accounting for the weighting applied to the individual measurements. The weighting is proportional to the size of the solid angle subtended by the element of surface area on the sphere surrounding the sound level meter.

4.9 Annex A describes a practical method for determining random-incidence sensitivity level in accordance with equation (4).

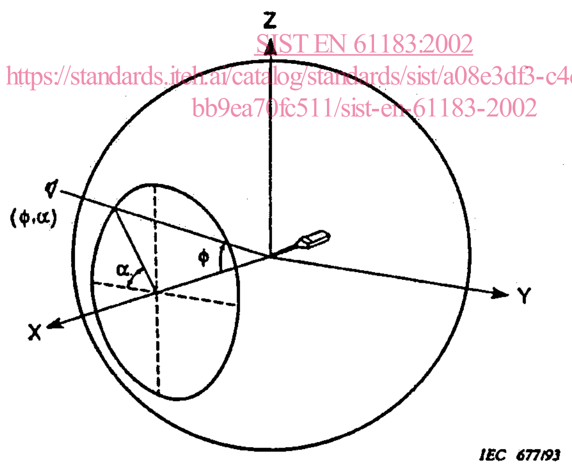

Figure 2 — Reference coordinate system for the purpose of practical measurement of random-incidence sensitivity level based on free-field measurements

4.10 Measurements of random-incidence sensitivity levels shall be carried out in an anechoic room that fulfils the requirements of ISO 3745 (Annex A). The measurements may be carried out with discrete-frequency sinusoidal sounds or random noise. Results shall be reported for preferred frequencies from ISO 266 and for bandwidths not greater than one-third octave. Bandpass filters shall meet the class 0 or class 1 requirements of IEC 1260.

4.11 To ensure consistent results when using discrete-frequency sinusoidal signals for the measurements, it may be necessary to calculate G_F as well as γ from averages of at least eight measurement results within the bandwidth of each one-third octave band over the frequency range of interest. The frequencies chosen should be equidistantly distributed on a logarithmic axis. Averaging should be performed as root-mean-square averaging.

5 Calibration method based on diffuse-field measurements

5.1 The diffuse-field calibration method is based on comparison of the diffuse-field sensitivity level of a sound level meter, with the diffuse-field sensitivity level of a reference sound level meter when the microphone of the device under test and the microphone of the reference system are placed successively at exactly the same locations in a diffuse sound field. The reference sound level meter may be calibrated by the method based on free-field measurements (see clause **4**), free-field calibrated if the directivity factors are known, or pressure calibrated if the differences between the diffuse-field and pressure sensitivity levels are known (see Annex B and Table B.1).

5.2 For each frequency band, the difference between the diffuse-field sensitivity levels, ΔG_D is given, in decibels, by:

$$\Delta G_D = L_D - L_{D,ref} \tag{8}$$

where

L_D is the sound pressure level indicated by the sound level meter under test, in decibels;

$L_{D,ref}$ is the sound pressure level indicated by the reference sound level meter, in decibels.

5.3 If the reference sound level meter is calibrated in accordance with clause **4**, the diffuse-field sensitivity level shall be calculated, in decibels, from:

$$G_D = \Delta G_D + G_{RI,ref} \tag{9}$$

where

$G_{RI,ref}$ is the random-incidence sensitivity level of the reference sound level meter, in decibels.

5.4 If the reference sound level meter is calibrated in a free sound field and the directivity factors are known (e.g. see Table B.1), the diffuse-field sensitivity level shall be calculated, in decibels, from:

$$G_D = \Delta G_D + G_{F,ref} - 10 \lg \gamma_{ref} \tag{10}$$

where

$G_{F,ref}$ is the free-field sensitivity level, in decibels, of the reference sound level meter, for the reference direction of sound incidence and equal to $L_{rd,ref} - L_o$;

γ_{ref} is the directivity factor of the reference sound level meter.

5.5 If the reference sound level meter is pressure calibrated and the differences between the diffuse-field sensitivity levels and the pressure sensitivity levels are known (e.g. see Table B.1), the diffuse-field sensitivity levels shall be calculated, in decibels, from:

$$G_D = \Delta G_D + (G_{P,ref} + \Delta_{DP}) \tag{11}$$

where

$G_{P,ref}$ is the pressure sensitivity level, in decibels, of the reference sound level meter;

Δ_{DP} is the difference between the diffuse-field sensitivity level and the pressure sensitivity level of the reference sound level meter, in decibels.

5.6 Measurements of diffuse-field sensitivity level shall be carried out in a reverberation room that fulfils the requirements of ISO 3741 (Annex A). The measurements may be carried out with broadband random noise or filtered random noise. Results shall be given for a bandwidth not greater than one-third octave. Integration times shall be of sufficient length to ensure that the standard deviation of test results, from repeated measurements under identical test conditions, is less than 0,05 dB.

5.7 Bandpass filters shall meet the class 0 or class 1 requirements of IEC 1260.

5.8 Annex B describes practical methods for determining diffuse-field sensitivity level.