IEC 60118-9

Edition 2.0 2019-09

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Electroacoustics – Hearing aids –
Part 9: Methods of measurement of the performance characteristics of bone conduction hearing aids

Électroacoustique – Appareils de correction auditive –
Partie 9: Méthodes de mesure des caractéristiques fonctionnelles des appareils de correction auditive à conduction osseuse

IEC 60118-9:2019-09(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

ICS 17.140.50

ISBN 978-2-8322-7332-6

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ELECTROACOUSTICS –
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Part 9: Methods of measurement of the performance characteristics of bone conduction hearing aids

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.
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International Standard IEC 60118-9 has been prepared by IEC technical committee 29: Electroacoustics.

This second edition cancels and replaces the first edition published in 1985. This edition constitutes a technical revision.

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

a) includes bone coupled devices measured on a skull simulator;
b) measurement frequency range increased to 8 000 Hz for bone coupled devices.

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

FDIS	Report on voting
29/1025/FDIS	29/1029/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 document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60118 series, published under the general title *Electroacoustics – Hearing aids*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://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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INTRODUCTION

IEC 60118-0 gives information on methods of measurement for air conduction hearing aids. The majority of hearing aids in use are of this type, but a small percentage use a bone vibrator instead of an earphone. The use of a bone vibrator requires a different method of measuring the output from the hearing aid and also makes it impractical to measure amplification directly in terms of acoustic gain.

Amplification in the case of an air conduction hearing aid is expressed as the difference between the output sound pressure level in an acoustic coupler or ear simulator and the input sound pressure level measured in a specified manner. However, with bone conduction hearing aids, the input is in terms of sound pressure level, but the output will be in terms of mechanical vibration measured as a vibratory force or force level.

By means of information provided in this document, the performance of hearing aids with bone vibrator outputs which do not form an integral part of the hearing aid, for example body-worn, behind-the-ear hearing aids, or bone conduction implant systems with an external bone vibrator, can be measured in a similar manner to aids with air conduction outputs as described in IEC 60118-0.

Where the bone vibrator forms an integral part of the hearing aid, or where it is attached in some fixed manner to the hearing aid, for example a bone coupled (bone anchored) hearing aid, its performance cannot be measured in the same way as for body-worn aids, due to the large dimensions of the mechanical coupler. This document recommends a pressure method of controlling the input sound pressure level to the hearing aid microphone. As an alternative to the pressure method, storage of a test enclosure frequency response correction curve can be used. This method is referred to as the "substitution method".

ELECTROACOUSTICS – HEARING AIDS –

Part 9: Methods of measurement of the performance characteristics of bone conduction hearing aids

1 Scope

This part of IEC 60118 specifies methods for the measurement of bone conduction hearing aid characteristics.

The methods described will produce a suitable basis for the exchange of information or for direct comparison of the electroacoustical characteristics of bone conduction hearing aids. These methods are chosen to be practical and reproducible and are based on selected fixed parameters.

The results obtained by the methods specified in this document express the performance under the conditions of measurement; however, the performance of the hearing aid under practical conditions of use will depend upon a number of factors (e.g. effective load impedance, environmental conditions, acoustical environment, etc.).

This document defines methods of measurement of characteristics of bone conduction hearing aids both for

- transcutaneously coupled devices measured on a mechanical coupler, meeting the requirements of IEC 60318-6, and
- bone coupled/bone anchored devices measured on a skull simulator.

NOTE 1 A skull simulator is a mechanical coupler designed to present a specific mechanical impedance to mechanically coupled vibrator.

NOTE 2 Throughout this document, all sound pressure levels specified are referred to 20 μPa. When appropriate, sound pressure level will be abbreviated to SPL.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60118-0, *Electroacoustics – Hearing aids – Part 0: Measurement of the performance characteristics of hearing aids*

IEC 60318-6, *Electroacoustics – Simulators of human head and ear – Part 6: Mechanical coupler for the measurement on bone vibrators*

ISO 3, *Preferred numbers – Series of preferred numbers*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
bone conduction hearing aid
wearable instrument intended to aid a person with impaired hearing using an electromechanical transducer intended to produce the sensation of hearing by vibrating the cranial bones

Note 1 to entry: A bone conduction hearing aid usually consists of a microphone, amplifier, signal processor, and bone vibrator, powered by a low-voltage battery, and possibly also containing an induction pick-up coil. It is fitted using audiometric and prescriptive methods.

Note 2 to entry: The bone vibrator of a hearing aid can be integrated in the same housing with the hearing aid, can be driven via a cable solution and placed in a separate housing, or can be driven via an inductive link and implanted in the skull.

Note 3 to entry: Bone conduction hearing aids can be placed on the body (body worn), behind-the-ear (BTE), or in the mastoid area (ear level).

3.2
transcutaneously coupled hearing aid
bone conduction hearing aid using a device that is coupled by an attractive or a static force to a human head

3.3
bone coupled hearing aid
device that is implanted or rigidly coupled to the skull bone, via a mechanical coupling or an abutment to the human head

Note 1 to entry: A bone coupled bone conduction hearing aid is often named a bone-anchored device.

3.4
vibratory force level
VFL
twenty times the logarithm to the base 10 of the ratio of the RMS value of the force transmitting the vibration to the reference value of 1 μN, expressed in decibels

Note 1 to entry: This note applies to the French language only.

3.5
mechanical coupler
device for measuring the vibratory force level output of a transcutaneously coupled hearing aid, where the force level is measured by a calibrated mechano-electric transducer coupled to the source

EXAMPLE As described in IEC 60318-6.

3.6
skull simulator
device for measuring the vibratory force level output of a bone coupled hearing aid, where the force level is measured by a calibrated mechano-electric transducer coupled to the source

3.7
acousto-mechanical sensitivity
quotient of the vibratory force, produced on a mechanical coupler or a skull simulator by the bone conduction hearing aid and the sound pressure at the reference point of the hearing aid

3.8
acousto-mechanical sensitivity level
AMSL
twenty times the logarithm to the base 10 of the ratio of the acousto-mechanical sensitivity to the reference sensitivity of 1 μN/20 μPa, expressed in decibels

Note 1 to entry: To calculate the acousto-mechanical sensitivity level from measurements made in this document, the following formula can be used:

$$AMSL = VFL - Input\ SPL$$

where

VFL re 1 μN is expressed in decibels.

Note 2 to entry: This note applies to the French language only.

3.9
input sound pressure level
sound pressure level at the hearing aid reference point

3.10
basic vibratory force level frequency response curve
force level frequency response curve obtained with the gain control in the reference test setting and with an input SPL of 60 dB

3.11
input-output characteristic
plot of the output force level, for a single frequency, measured on a mechanical coupler or a skull simulator on the ordinate, against the sound pressure level applied to the hearing aid on the abscissa, with equal decibel scale divisions on each axis

3.12
vertical reference
line through or on a hearing aid which is vertical when the aid is positioned as worn on a head and a torso simulator

3.13
reference point
point on the bone conduction hearing aid chosen for the purpose of defining its position

3.14
high-frequency average
HFA
average of AMSL or VFL in decibels at 1 000 Hz, 1 600 Hz and 2 500 Hz

Note 1 to entry: This note applies to the French language only.

3.15
gain control
manually or electronically operated control for the adjustment of overall output

3.16
OVFL90
output vibratory force level for 90 dB input SPL
VFL developed on a mechanical coupler or a skull simulator with an input SPL of 90 dB with the gain control of the hearing aid full-on

Note 1 to entry: It is recognized that the maximum output level may occur with more, or occasionally with less, input SPL than 90 dB. However, the differences are usually small over the frequency range of interest and the input SPL of 90 dB makes automatic recording of the OVFL90 curve very convenient.

3.17
high-frequency average of the OVFL90
high-frequency average of the output vibratory force level for an input sound pressure level of 90 dB

3.18
full-on HFA-AMSL
full-on high-frequency average acousto-mechanical sensitivity level
HFA for an input SPL of 50 dB when the gain control of a bone conduction hearing aid is at its full-on position

Note 1 to entry: The hearing aid shall be set to maximum possible gain setting. Where possible, the AGC function of AGC hearing aids shall be set to have minimum effect for all measurements.

Note 2 to entry: The manufacturer shall specify the full-on settings used for measurements by providing either a test program, a set of programmed settings or by reference to physical control settings.

Note 3 to entry: Other adaptive features, such as some directionality, noise suppression, and feedback suppression systems etc., which may affect the validity of measurements made with steady-state pure-tone signals, should be disabled. The settings used for measurements shall be specified by the manufacturer by providing either a test program, a set of programmed settings or by reference to physical control settings.

3.19
RTS
reference test setting of the gain control
setting of the gain control required to produce, for an input SPL of 60 dB, an HFA-AMSL within ±1,5 dB of the HFA-OVFL90 minus 77 dB, or, if the full-on HFA gain for an input SPL of 60 dB is less than the HFA-OVFL90 minus 77 dB, the full-on setting of the gain control

Note 1 to entry: For most hearing aids, the use of an input SPL of 60 dB and a 17 dB difference from the OVFL90 helps to ensure that, for an overall speech level of 65 dB SPL, peaks do not exceed the OVFL90.

Note 2 to entry: The manufacturer shall specify the full-on-gain settings used for measurements by providing either a test program, a set of programmed settings or by reference to physical control settings.

Note 3 to entry: Other adaptive features, such as some directionality, noise suppression, and feedback suppression systems etc., which may affect the validity of measurements made with steady-state pure-tone signals, should be disabled. The settings used for measurements shall be specified by the manufacturer by providing either a test program, a set of programmed settings or by reference to physical control settings.

Note 4 to entry: This note applies to the French language only.

3.20
RTAMSL
reference test acousto-mechanical sensitivity level
HFA-AMSL for an input SPL of 60 dB with the gain control at RTS

Note 1 to entry: This note applies to the French language only.

3.21
AGC
automatic gain control
means (other than peak clipping) by which the gain is automatically controlled as a function of the level of the signal being amplified

Note 1 to entry: This note applies to the French language only.

3.22
magneto-mechanical sensitivity
quotient of the vibratory force level in newtons (N) produced by the bone conduction hearing aid on the mechanical coupler or skull simulator and the magnetic field strength in milliamperes per metre (mA/m) at the test point, at a specified frequency and under essentially linear input/output conditions

3.23
MMSL
magneto-mechanical sensitivity level
twenty times the logarithm to the base 10 of the ratio of the magneto-mechanical sensitivity to the reference sensitivity 1 µN/(1 mA/m)

Note 1 to entry: MMSL is expressed in decibels.

Note 2 to entry: This note applies to the French language only.

3.24
VFLIV
VFL in a vertical magnetic field
VFL developed in the mechanical coupler or skull simulator with the gain control at RTS when the input is −30 dB re 1 A/m (= 31,6 mA/m) sinusoidal alternating magnetic field parallel to the vertical reference with induction pick-up coil selected

Note 1 to entry: This note applies to the French language only.

3.25
high-frequency average of the VFLIV levels
high frequency average VFL in a vertical magnetic field

4 Measurement method

4.1 General

The preferred acoustic measurement procedure, which shall be applied according to IEC 60118-0, is based on a method of measurement in which the sound pressure level at the bone conduction hearing aid reference point is kept constant to simulate free field conditions. This is accomplished in a test enclosure or acoustic test box by the use of a pressure-calibrated control microphone, on the assumption that the sound field is homogeneous around the reference point of the hearing aid.

This method is referred to as "constant entrance sound pressure method" or shortened to "pressure method" throughout this document.

As an alternative to the pressure method, storage of a test enclosure frequency response correction curve may be used. This method is referred to as the "substitution method".

4.2 Mechanical coupler

Measurements of the transcutaneously coupled bone conduction hearing aid performance characteristics are made using a mechanical coupler in accordance with IEC 60318-6.

4.3 Skull simulator

Measurements of the bone coupled hearing aid performance characteristics are made using a skull simulator which shall be specified by the manufacturer of the bone coupled hearing aid.

4.4 Measurement frequency range

All measurements of the transcutaneously coupled bone conduction hearing aid shall be made for a stated frequency range of 200 Hz to 5 000 Hz.

All measurements of the bone coupled bone conduction hearing aid shall be made for a stated frequency range of 200 Hz to 8 000 Hz.

4.5 Reporting of data

All data reported shall be clearly labelled: "According to IEC 60118-9:2019".

5 Measurement enclosure and measurement equipment

5.1 General

The conditions specified in 5.2 to 5.6 apply. Measurements shall be made at the ISO R40 preferred frequencies (1/40 decade or one-twelfth octave) as specified in ISO 3 unless otherwise stated.

5.2 Unwanted stimuli in the test enclosure

Unwanted stimuli in the test enclosure, such as ambient noise, mechanical vibrations and electrical or magnetic stray fields, shall be sufficiently low so as not to affect the test results by more than 0,5 dB. This can be verified if the output level of the hearing aid falls by at least 10 dB in each frequency analysis band, when the signal source is switched off.

5.3 Sound source

5.3.1 The sound source (pure-tone) shall be capable of producing at the measurement point the requisite sound pressure levels between 50 dB and 90 dB, with a minimum step size of 5 dB.

The level of the sound source shall be within ±1,5 dB of the indicated value over the frequency range from 200 Hz to 3 000 Hz, and within ±2,5 dB of the indicated value over the range from 3 000 Hz to 8 000 Hz.

If the calibration of the sound source depends on ambient conditions, corrections for such dependence shall be made when necessary.

5.3.2 The frequency of the sound source shall be within ±2 % of the indicated value. The frequency interval between data points in frequency response curves shall not exceed one-twelfth octave or 100 Hz, whichever is greater.

5.3.3 For frequency response and full-on gain measurements, the total harmonic distortion of the sound source shall not exceed 1 % for a sound pressure level up to and including 70 dB and 2 % for a sound pressure level greater than 70 dB and up to and including 90 dB.

For harmonic distortion measurements, the total harmonic distortion of the sound source at the frequencies of the THD measurement shall not exceed 0,5 % up to and including a sound pressure level of 70 dB and 1 % for a sound pressure level greater than 70 dB and up to and including 90 dB.

5.4 Measurement system for the measurement of the vibratory force level produced by a bone conduction hearing aid

The equipment for the measurement of the vibratory force level produced by a bone conduction hearing aid shall fulfil the following requirements:

a) the vibratory force level measurement system shall be accurate to within ±0,5 dB at the frequency of calibration;

b) the indication of vibratory force level shall be measured with an expanded uncertainty to within ±2 dB in the range from 200 Hz to 5 000 Hz and to within ±4 dB in the range from 5 000 Hz to 8 000 Hz;

If, under certain conditions, it is necessary to use a selective measuring system in order to ensure that the response of the bone conduction hearing aid to the signal can be differentiated from inherent noise in the bone conduction hearing aid, the use of the selective system shall be stated in the test report.

5.5 Direct-current measuring system

The direct-current measuring system shall have the following characteristics:

a) an acceptance limit of ±5 % at the value of current measured;

b) direct-current voltage drop across current-measuring device ≤ 50 mV;

c) an impedance not exceeding 1 Ω over the frequency range 200 Hz to 8 000 Hz.

One method of realizing 5.5 c) is to bypass the current meter with an 8 000 µF capacitor. The capacitor should not shunt the battery or the power supply.

5.6 Magnetic field source for ETLS and MMSL measurements

5.6.1 For the measurement of the equivalent test loop sensitivity (ETLS) and the magneto-mechanical sensitivity level (MMSL), the magnetic field strength produced by the magnetic loop is computed from the geometry of the loop.

5.6.2 As the material and the construction of the power source may influence the results, the actual type of source shall be stated.

NOTE 1 For example, the magnetic field strength in the centre of a square loop with a side of "a" metres and carrying a current of "i" amperes is given by:

$$H = \frac{2\sqrt{2}}{\pi}\frac{i}{a}\ \text{A/m}$$

In the centre of a circular loop with a diameter of "d" metres, carrying a current of "i" amperes, the magnetic field strength is given by:

$$H = \frac{i}{d}\ \text{A/m}$$

NOTE 2 One way to secure essentially constant current conditions is to drive the magnetic field source from a device having a constant electromotive force and an internal impedance at least 100 times greater than the magnetic field source input impedance in the frequency range 200 Hz to 8 000 Hz, which, in the case of a low impedance generator, can be accomplished by a resistor connected in series with the output of the generator.

5.6.3 The measurement space shall be outside the influence from any field-disturbing iron or other ferromagnetic material or other material in which eddy currents can be induced that could give rise to a field disturbance.

5.6.4 The magnetic field source shall be provided with a calibration expressing the relationship between the magnetic field strength in amperes per metre at the measurement point and the input current in amperes.

5.6.5 The magnetic field source shall be of such shape and dimensions that inside a sphere of diameter 10 cm, of which the centre is the measurement point, the deviation from nominal values in magnitude and direction is less than ± 5 % and ± 10°, respectively.

NOTE A square loop with a side length "a" greater than 0,5 m or a circular loop with a diameter "d" greater than 0,56 m will meet these specifications.

5.6.6 The total harmonic distortion of the magnetic field shall not exceed 1 %.

NOTE This condition will be met if the distortion of the input current is less than 1 %.