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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Electroacoustics – Measurement of real-ear acoustical performance characteristics of hearing aids

Électroacoustique – Mesure des caractéristiques de performances acoustiques des appareils de correction auditive sur une oreille réelle

IEC 61669:2015-11(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

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CONTENTS

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ELECTROACOUSTICS – MEASUREMENT OF REAL-EAR ACOUSTICAL PERFORMANCE CHARACTERISTICS OF 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 61669 has been prepared by IEC technical committee 29: Electroacoustics.

This second edition cancels and replaces the first edition of IEC 61669:2001 and the first edition of ISO 12124:2001. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to IEC 61669:2001 and ISO 12124:2001:

a) the addition of the International Speech Test Signal as a preferred speech-like stimulus;
b) definitions and test methods for the real-ear to dial difference;
c) definitions and test methods for the real-ear to coupler difference and
d) an annex dealing with issues in the measurement and application of the real-ear to coupler difference;

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

FDIS	Report on voting
29/886/FDIS	29/893/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.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website 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.

INTRODUCTION

The performance characteristics of hearing aids in actual use can differ significantly from those determined in accordance with standards such as IEC 60118-0, and IEC 60118-7, due to differing acoustic influence and coupling presented by individual ears. Measuring methods that take into account the acoustic coupling and the acoustic influence of the individual wearer on the performance of hearing aids are therefore important in the fitting of these devices. Such measuring methods have come to be known as “real-ear measurements” and are sometimes performed clinically in less than ideal acoustic environments. The accuracy and repeatability of measurements made under such conditions are complex functions of the sound field, the test environment, the nature of the test signal, the hearing aid under evaluation, the method of test signal control, the location of the sound field source, the nature of the data acquisition, analysis and presentation as well as the degree of subject movement permitted.

This standard provides definitions for terms used in the measurement of real-ear performance characteristics of hearing aids, provides procedural and reporting guidelines, and identifies essential characteristics to be reported by the manufacturer of equipment used for this purpose. Acceptable tolerances for the control and measurement of sound pressure levels are indicated. Where possible, sources of error have been identified and suggestions provided for their management.

ELECTROACOUSTICS – MEASUREMENT OF REAL-EAR ACOUSTICAL PERFORMANCE CHARACTERISTICS OF HEARING AIDS

1 Scope

This International Standard gives recommendations and requirements for the measurement and estimation of the real-ear acoustical performance characteristics of air-conduction hearing aids and for the measurement of certain acoustic properties of the ear related to the application of hearing aids.

Measurements of real-ear acoustical characteristics of hearing aids which apply non-linear or analytical processing techniques are valid only for the test signals used and conditions employed.

The purpose of this standard is to ensure that measurements of real-ear acoustical performance characteristics of a given hearing aid on a given human ear can be replicated in other locations with other test equipment.

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 60601-1, *Medical electrical equipment – Part 1: General requirements for basic safety and essential performance*

IEC 60601-1-2, *Medical electrical equipment – Part 1-2: General requirements for basic safety and essential performance – Collateral Standard: Electromagnetic disturbances – Requirements and tests*

IEC 60318-5, *Electroacoustics – Simulators of human head and ear – Part 5: 2 cm^3 coupler for the measurement of hearing aids and earphones coupled to the ear by means of ear inserts*

IEC 60942, *Electroacoustics – Sound calibrators*

IEC 61260-1, *Electroacoustics – Octave-band and fractional-octave-band filters – Part 1: Specifications*

ISO 266, *Acoustics – Preferred frequencies*

ISO 8253-2, *Acoustics – Audiometric test methods – Part 2: Sound field audiometry with pure-tone and narrow-band test signals*

ISO/TR 25417, *Acoustics – Definitions of basic quantities and terms*

3 Terms and definitions

For the purpose of this document, the terms and definitions of ISO/TR 25417 and the following apply:

3.1
test signal
acoustic signal at the field reference point

3.2
coupled sound source
earphone or hearing aid receiver and any tubing used to couple its acoustic output, without leakage, to the ear canal or the cavity of a coupler

3.3
free sound field
sound field where the boundaries of the room exert a negligible effect on the sound waves

Note 1 to entry: In practice, a free sound field is a field in which the influence of reflections at the boundaries or other disturbing objects is negligible over the frequency range of interest.

[SOURCE: ISO 8253-2:2009, 3.12, modified (addition of note to entry)]

3.4
quasi-free sound field
sound field where the boundaries of the room exert only a moderate effect on the sound waves

[SOURCE: ISO 8253-2:2009, 3.13]

3.5
subject
person in whose ear the hearing aid performance is characterized

3.6
subject reference point
point bisecting the line joining the centres of the openings of the ear canals of the subject (at the junction between concha and ear canal)

Note 1 to entry: In cases where severe head shape abnormality or asymmetry make it difficult to determine the reference point of the subject, the subject reference point used should be stated.

3.7
subject test position
position with subject seated in a reproducible upright position with the head erect and the subject reference point located on the test axis at the working distance

3.8
test axis
line through the centre of the surface from which sound exits the sound field source and in the direction of maximum acoustic radiation

SEE: Figure 1.

3.9
test point
reproducible position on the test axis at which the subject reference point is located for test purposes

SEE: Figure 1.

3.10
working distance
distance from the subject reference point to the plane of the mounting ring or protective grille of the sound field source measured along the test axis

SEE: Figure 1.

3.11
SPL
sound pressure level
ten times the logarithm to the base 10 of the ratio of the square of the sound pressure, p, to the square of a reference value, p_0

$$L_p = 10\lg(p^2/p_0{}^2)\ \text{dB}$$

where the reference value, p_0, is 20 µPa

Note 1 to entry: Sound pressure level is expressed in decibels.

Note 2 to entry: Because of practical limitations of the measuring instruments, p^2 is always understood to denote the square of a frequency-weighted, frequency-band-limited or time-weighted sound pressure.

Note 3 to entry: This note applies to the French version only.

[SOURCE: ISO/TR 25417:2007, 1.2]

3.12
BSPL
band sound pressure level
SPL for a specified frequency band

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

3.13
test signal level
SPL of the test signal at the field reference point

Note 1 to entry: For broad-band signals the bandwidth of the SPL measurement and the BSPL as a function of frequency should be specified and stated.

3.14
equalization
process of controlling the test signal level as a function of frequency such that it does not vary from the desired level

3.14.1
concurrent equalization
real time equalization
equalization performed at the time of measurement based on the monitoring of the test signal level

3.14.2
stored equalization
equalization performed at the time of measurement based on data recorded during a prior measurement of the sound field

3.15
reference microphone
controlling microphone
microphone used to measure the test signal level in the measurement process and/or to control it in the equalization process

SEE: Figure 2.

3.16
sound inlet
aperture through which sound enters a microphone and at which the microphone is calibrated

3.17
field reference point
point at which the sound inlet of the reference microphone is located during equalization and/or measurement

SEE: Figure 2.

3.18
probe microphone
microphone adapted to explore a sound field without significantly disturbing it

Note 1 to entry: If the probe microphone utilizes a probe tube, this tube is considered part of the probe microphone and its open end is the probe microphone sound inlet.

3.19
test ear
ear of the subject in which the probe microphone sound inlet is placed

3.20
measurement point
point in the ear canal of the test ear at which the probe microphone sound inlet is placed

3.21
axis of rotation
straight line about which the subject can be rotated, passing through the subject reference point and lying in the vertical plane of symmetry

SEE: Figure 1.

3.22
azimuth angle of sound incidence
angle between the plane of symmetry of the subject and the plane defined by the axis of rotation and the test axis

SEE: Figure 1.

Note 1 to entry: When the subject faces the sound field source, the azimuth angle of sound incidence is defined as 0°. When the test ear of the subject faces the sound field source, the azimuth angle is defined as 90°. When the non-test ear faces the sound field source, the angle is defined as –90°.

3.23
subject reference plane
horizontal plane that contains the subject reference point

SEE: Figure 1.

3.24
elevation angle of sound incidence
angle between the subject reference plane and the test axis

SEE: Figure 1.

Note 1 to entry: When the sound field source is directly above the subject, the elevation angle is defined as +90°. When the test axis lies in the subject reference plane, the elevation angle is defined as 0°.

3.25
test signal type
identification of the test signal in terms of its frequency spectrum and/or temporal properties

3.26
maximum length sequence
MLS
periodic pseudo-random binary sequence of length one less than an integer power of two, whose circular autocorrelation function is an impulse

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

3.27
substitution method
method of measurement using stored equalization with the reference microphone located at the subject reference point and the subject absent during the recording of the SPL at the test point

3.28
modified pressure method
method of measurement using stored or concurrent equalization with the field reference point near the surface of the head of the subject close to the test ear, but outside the acoustic influence of the pinna and the hearing aid

Note 1 to entry: The exact location of the field reference point should be specified by its perpendicular distance from the surface of the head and its distance (in millimetres) forward of and above or below the centre of the ear canal entrance.

3.29
differential comparison
measurement in which the test signal level is subtracted from the SPL at the measurement point

Note 1 to entry: When using broad-band signals, BSPL should be used.

3.30
real-ear unaided response
REUR
SPL as a function of frequency at the measurement point in the unoccluded ear canal for a specified test signal level

Note 1 to entry: When using broad-band signals, BSPL should be used.

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

3.31
real-ear unaided gain
REUG
difference, as a function of frequency, between the SPL at the measurement point in the unoccluded ear canal and the test signal level

Note 1 to entry: When using broad-band signals, BSPL should be used.

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

3.32
real-ear occluded response
REOR
SPL as a function of frequency at the measurement point for a specified test signal level, with the hearing aid in place and switched off

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

3.33
real-ear occluded gain
REOG
difference as a function of frequency, between the SPL at the measurement point and the test signal level, with the hearing aid in place and switched off

Note 1 to entry: When using broad-band signals, BSPL should be used.

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

3.34
real-ear aided response
REAR
SPL as a function of frequency at the measurement point for a specified test signal level, with the hearing aid in place and switched on

Note 1 to entry: The term Real-Ear Saturation Response (RESR) has sometimes been used for the REAR with a stimulus SPL of 85 dB or 90 dB. The use of this term is deprecated in favour of REAR85 or REAR90.

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

3.35
real-ear aided gain
REAG
difference as a function of frequency, between the SPL at the measurement point and the test signal level, with the hearing aid in place and switched on

Note 1 to entry: When using broad-band signals, BSPL should be used.

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

3.36
real-ear insertion gain
REIG
difference as a function of frequency, between aided response and unaided response (*REIG* = *REAR* – *REUR*), or between aided gain and unaided gain (*REIG* = *REAG* – *REUG*)

Note 1 to entry: It is assumed that REAR and REUR have been derived using the same test signal.

Note 2 to entry: REIG is expressed in decibels.

Note 3 to entry: This note applies to the French language only.

3.37
real-ear to coupler difference
RECD
difference as a function of frequency, between the SPL produced near the tympanic membrane in an occluded ear canal by a coupled sound source having a high acoustic impedance and that produced in the 2 cm^3 coupler specified in IEC 60318-5 by the same coupled sound source connected directly to its cavity

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

3.38
real-ear to dial difference
REDD
difference as a function of frequency, between the SPL produced near the tympanic membrane by an audiometric sound source and the hearing level indicated by the audiometer driving the sound source

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

3.39
curve
real-ear acoustical characteristic expressed and graphically displayed as a function of frequency

EXAMPLE Real-ear aided response curve.

3.40
crest factor
ratio of the peak sound pressure to the root-mean-square sound pressure of the test signal

Note 1 to entry: When expressed in decibels, crest factor is the difference between the peak and r.m.s levels of the test signal.

3.41
long term average speech spectrum
LTASS
SPL in contiguous one-third-octave bands measured over the duration of a speech sample

4 Test setup diagrams

The following two figures illustrate the relationship between the subject and the parts of the measurement system that deliver and receive sound.