

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





THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2015 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
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.

IEC Catalogue - webstore.iec.ch/catalogue

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub

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 It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

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

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in 15 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

More than 60 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) 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 IEC

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

Catalogue IEC - webstore.iec.ch/catalogue

Application autonome pour consulter tous les renseignements bibliographiques sur les Normes internationales, Spécifications techniques, Rapports techniques et autres documents de l'IEC. Disponible pour PC, Mac OS, tablettes Android et iPad.

Recherche de publications IEC - www.iec.ch/searchpub

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

Electropedia - www.electropedia.org

Le premier dictionnaire en ligne de termes électroniques et électriques. Il contient plus de 30 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans 15 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

Glossaire IEC - std.iec.ch/glossary

Plus de 60 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: csc@iec.ch.

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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 17.140.50

ISBN 978-2-8322-2994-1

**Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

CONTENTS

| | |
|----------------------------------------------------------------|----|
| FOREWORD..... | 4 |
| INTRODUCTION..... | 6 |
| 1 Scope..... | 7 |
| 2 Normative references | 7 |
| 3 Terms and definitions | 8 |
| 4 Test setup diagrams | 13 |
| 5 Limitations..... | 15 |
| 6 Test equipment..... | 16 |
| 6.1 Safety requirements..... | 16 |
| 6.2 Ambient conditions..... | 16 |
| 6.3 Test signal | 16 |
| 6.4 Sound field source | 17 |
| 6.5 Coupled sound source | 17 |
| 6.6 Test signal range | 17 |
| 6.7 Test signal level indication..... | 17 |
| 6.8 Equalization..... | 17 |
| 6.9 Frequency..... | 17 |
| 6.10 Harmonic distortion..... | 17 |
| 6.11 Probe microphone measurement..... | 17 |
| 6.12 Noise floor of probe microphone measurement..... | 17 |
| 6.13 Attenuation of probe microphone to external signals | 18 |
| 6.14 Analysis characteristics..... | 18 |
| 6.15 Output indication..... | 18 |
| 6.16 Graphical printout | 18 |
| 7 Test conditions | 19 |
| 7.1 Ambient conditions in the test space..... | 19 |
| 7.2 Background noise | 19 |
| 7.3 Acoustical properties..... | 19 |
| 7.4 Sound field characteristics | 19 |
| 7.5 Calibration..... | 19 |
| 7.6 Equalization..... | 19 |
| 7.6.1 General..... | 19 |
| 7.6.2 Substitution method..... | 19 |
| 7.6.3 Modified pressure method – Stored equalization..... | 20 |
| 7.6.4 Modified pressure method – Concurrent equalization..... | 20 |
| 7.7 Test signal level..... | 20 |
| 7.8 Location of the subject..... | 20 |
| 7.9 Location of the tester | 20 |
| 7.10 Location of the field reference point | 20 |
| 7.11 Location of the measurement point | 21 |
| 7.12 Instructions to the subject..... | 21 |
| 7.13 Location and coupling of the hearing aid..... | 21 |
| 7.14 Operating conditions for the hearing aid..... | 21 |
| 8 Measurements..... | 21 |
| 8.1 General..... | 21 |

| | | |
|------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|----|
| 8.2 | Real-ear unaided response (REUR) curve..... | 21 |
| 8.3 | Real-ear unaided gain (REUG) curve | 22 |
| 8.4 | Real-ear occluded response (REOR) curve..... | 22 |
| 8.5 | Real-ear occluded gain (REOG) curve | 22 |
| 8.6 | Real-ear aided response (REAR) curve..... | 22 |
| 8.7 | Real-ear aided gain (REAG) curve | 23 |
| 8.8 | Real-ear insertion gain (REIG) curve | 23 |
| 8.9 | Real-ear to coupler difference (RECD) curve | 23 |
| 8.10 | Real-ear to dial difference (REDD) curve | 23 |
| 9 | Measurement uncertainty for the performance requirements of Clause 6 | 24 |
| Annex A (informative) Positioning the probe microphone sound inlet at the measurement point | | |
| A.1 | General..... | 25 |
| A.2 | Visual positioning..... | 25 |
| A.3 | Acoustically-assisted positioning..... | 25 |
| A.4 | Acoustic positioning – Method 1..... | 26 |
| A.5 | Acoustic positioning – Method 2..... | 26 |
| A.6 | Geometrical positioning | 26 |
| Annex B (informative) Issues in RECD measurement and application | | |
| B.1 | General..... | 27 |
| B.2 | Influence of the coupled sound source | 27 |
| B.3 | Estimating ear canal SPL produced by a hearing aid | 30 |
| B.4 | Correcting an HL audiogram obtained with an insert earphone and a standard eartip..... | 32 |
| B.5 | Correcting an HL audiogram obtained with an insert earphone and a custom earmould..... | 32 |
| Annex C (informative) Relationship between tolerance interval, corresponding acceptance interval and the maximum permitted uncertainty of measurement..... | | |
| Bibliography..... | | 35 |
| | | |
| Figure 1 – Test set-up..... | | 14 |
| Figure 2 – Real-ear measurement arrangement | | 15 |
| Figure B.1 – Computer-simulated ECLD for an average adult ear | | 29 |
| Figure B.2 – Computer-simulated ECLD for an average 3-month old child’s ear | | 29 |
| Figure B.3 – Computer-simulated error in estimating SPL in an average adult ear | | 31 |
| Figure B.4 – Computer-simulated error in estimating SPL in an average 3-month old child’s ear..... | | 31 |
| Figure B.5 – Computer-simulated HL correction for an average 3 month old child’s ear | | 33 |
| Figure C.1 – Relationship between tolerance interval, corresponding acceptance interval and the maximum permitted uncertainty of measurement | | 34 |
| Table 1 – Tolerance limits, acceptance limits and U_{\max} for basic measurements | | 24 |

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**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.
- 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 itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 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 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 cm³ 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 226, *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*