TECHNICAL SPECIFICATION

Electroacoustics – Hearing aids – Method for measuring electroacoustic performance up to 16 kHz
CONTENTS

FOREWORD................................................................................................................... 5
INTRODUCTION .................................................................................................................. 7
  1 Scope.......................................................................................................................... 8
  2 Normative references .............................................................................................. 8
  3 Terms, definitions and abbreviated terms ............................................................. 8
    3.1 Terms and definitions ......................................................................................... 8
    3.2 Abbreviated terms .............................................................................................. 9
  4 Mechanical design of the 0,4 cm³ coupler ............................................................ 9
    4.1 General ............................................................................................................... 9
    4.2 Cavity dimensions ............................................................................................ 10
      4.2.1 Critical dimensions .................................................................................. 10
      4.2.2 Effective coupler volume ....................................................................... 10
      4.2.3 Diameter of the coupler cavity .................................................................. 11
    4.3 Verification procedure of the effective coupler volume .................................. 11
      4.3.1 General ..................................................................................................... 11
      4.3.2 Test set-up ................................................................................................. 11
      4.3.3 Effective volume of the coupler under test ............................................. 11
    4.4 Measuring microphone .................................................................................... 12
      4.4.1 General ..................................................................................................... 12
      4.4.2 Preferred microphone ............................................................................... 12
      4.4.3 Alternative microphones ......................................................................... 12
    4.5 Static pressure equalisation vent ..................................................................... 12
  5 Calibration ............................................................................................................. 12
    5.1 Reference environmental conditions ................................................................ 12
    5.2 Calibration procedure ....................................................................................... 13
  6 Coupling of receivers and hearing aids to the coupler ............................................. 13
    6.1 Coupling to a hearing aid receiver by means of tubing ................................ 13
    6.2 Coupling to a hearing aid embedded in or connected to an earmould .......... 13
    6.3 Coupling to a receiver in the canal (RIC hearing aid) ..................................... 14
    6.4 Coupling to a BTE hearing aid with 2 mm continuous internal diameter tubing ................................................................. 15
    6.5 Coupling to a BTE hearing aid with earmould simulator .............................. 16
    6.6 Coupling to a BTE hearing aid with thin tubing ............................................. 17
  7 Transfer impedance of the 0,4 cm³ coupler ............................................................... 18
  8 Comparison of the 0,4 cm³, the 2 cm³ coupler and the occluded-ear simulator ...... 19
    8.1 Sound pressure level frequency response curves ........................................... 19
    8.2 Comparison of the coupler impedance with typical source impedances ....... 20
    8.3 Influence of sound source impedance on measured level difference between
        the 0,4 cm³ coupler and the 2 cm³ coupler ...................................................... 21
  9 Maximum permitted expanded uncertainty for coupler conformance testing ....... 22
  10 Measurements using the 0,4 cm³ coupler ............................................................... 23
    10.1 General ............................................................................................................. 23
    10.2 Test enclosure and test equipment .................................................................. 23
    10.3 Extended frequency range for total harmonic distortion measurements ....... 23
    10.4 Presentation of data ....................................................................................... 24
      10.4.1 General ..................................................................................................... 24
IEC TS 62886 Ed. 1.0...

10.4.2 Presentation as 0,4 cm³ coupler data .......................................................... 24
10.4.3 Presentation as normalised to 2 cm³ coupler data ....................................... 24
10.5 Maximum permitted expanded uncertainty of measurements performed using
the 0,4 cm³ coupler ..................................................................................................... 24

Annex A (informative) Response transforms between the 0,4 cm³ coupler and the
occluded-ear simulator .............................................................................................. 26
A.1 General ............................................................................................................... 26
A.2 Simulation model of the human ear and approximation of λ/2 resonances ........ 26
A.3 Measured and simulated transform responses of a standard-fitting .................. 28
A.4 Transform curves for CIC-fitting and deep-insertion-fitting ............................. 29

Annex B (informative) Measurement and modelling of the transfer impedance of the
0,4 cm³ coupler ........................................................................................................ 33
B.1 Measurement procedure ..................................................................................... 33
B.1.1 Transfer impedance ....................................................................................... 33
B.1.2 Calibration of the volume velocity source at 250 Hz .................................... 33
B.1.3 Calibration of the volume velocity source over the frequency range from
100 Hz to 60 kHz ..................................................................................................... 34
B.1.4 Test set-up for measuring the coupler transfer impedance ......................... 34
B.2 Measurement of the coupler transfer impedance ............................................. 35
B.3 Electrical analogue representation of the coupler as a tube model .................. 38

Bibliography ............................................................................................................. 41

Figure 1 – Mechanical design of the 0,4 cm³ coupler, shown with removable coupling
plate with a nipple for the attachment of coupling tubing ................................. 10
Figure 2 – Coupling to a hearing aid receiver by means of coupling tubing .......... 13
Figure 3 – Coupling to an ITE hearing aid .............................................................. 14
Figure 4 – Coupling to a receiver in the canal (RIC hearing aid) ......................... 15
Figure 5 – Coupling to a BTE hearing aid with 2 mm continuous internal diameter
tubing ..................................................................................................................... 16
Figure 6 – Coupling to a BTE hearing aid with earmould simulator ..................... 17
Figure 7 – Coupling to a BTE hearing aid with thin coupling tubing ................... 18
Figure 8 – Magnitude frequency response of the transfer impedance × frequency and
the related equivalent volume ............................................................................... 19
Figure 9 – Comparative measurement of the 0,4 cm³ coupler, the 2 cm³ coupler and
the occluded-ear simulator frequency responses ..................................................... 20
Figure 10 – Magnitude frequency responses of acoustic impedance of the 2 cm³, the
0,4 cm³ coupler and various hearing aid types ...................................................... 21
Figure 11 – Deviation from the normalized coupler volume ratio as a function of the
effective volume of the sound source V_s ............................................................... 22
Figure A.1 – Electrical analogue model of the human ear ...................................... 27
Figure A.2 – Measured transform response of a standard-fitting ............................. 28
Figure A.3 – Comparison between the measured and the simulated standard-fitting
transform response ................................................................................................. 29
Figure A.4 – Transform responses for (a) standard-fitting, b) CIC-fitting and (c) deep-
insertion-fitting .................................................................................................... 30
Figure B.1 – Test set-up for measuring the coupler transfer impedance ................ 35
Figure B.2 – Average frequency response of 8 coupler measurements .................. 35
Figure B.3 – Average transfer impedance of the 0,4 cm³ coupler ......................... 36
Figure B.4 – Transfer impedance times frequency re 1 Pa/m³ in dB and as equivalent volume in mm³ in the frequency range 100 Hz to 60 kHz ..................................................... 36
Figure B.5 – Electrical analogue model based on a tube model ............................................. 39
Figure B.6 – Comparison between the measured (solid line) and the simulated (dashed line) transfer impedance ..................................................................................................... 39
Figure B.7 – Frequency responses of simulated 0,4 cm³ coupler input and transfer impedances ................................................................................................................ 40

Table 1 – Values of \( U_{\text{max}} \) for basic measurements .............................................................. 23
Table 2 – Distortion test frequencies and input sound pressure levels ....................................... 24
Table 3 – Values of \( U_{\text{max}} \) for basic measurements .............................................................. 25
Table A.1 – Transform data for standard-fitting (fitting at reference plane), CIC-fitting and deep-insertion-fitting ..................................................................................................... 31
Table B.1 – Transfer impedance of the 0,4 cm³ coupler in the frequency range from 100 Hz to 60 kHz ................................................................................................................ 37
INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTROACOUSTICS – HEARING AIDS –
METHOD FOR MEASURING ELECTROACOUSTIC PERFORMANCE UP TO 16 kHz

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.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a Technical Specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical Specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 62886, which is a Technical Specification, has been prepared by IEC technical committee 29: Electroacoustics.
The text of this Technical Specification is based on the following documents:

<table>
<thead>
<tr>
<th>Enquiry draft</th>
<th>Report on voting</th>
</tr>
</thead>
<tbody>
<tr>
<td>29/897/DTS</td>
<td>29/902A/RVC</td>
</tr>
</tbody>
</table>

Full information on the voting for the approval of this Technical Specification 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

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

**IMPORTANT –** The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.
INTRODUCTION

Advancement in hearing aid design makes it possible to increase the bandwidth of hearing aids up to 16 kHz. Accordingly, there is a need for an accurate and yet robust measurement method for the transducer (receiver, earphone) designer, the hearing aid designer, and the fitter of hearing aids.

The 2 cm³ coupler as described in IEC 60318-5 is only suitable for measurements up to 8 kHz. The limitation is caused by unfavourable acoustic modes of the coupler.

The occluded-ear simulator as described in IEC 60318-4 simulates the average human external ear up to 8 kHz, and can be used as a test coupler up to 16 kHz. The occluded ear-simulator is designed for a specific insertion depth of the earmould, which is associated with a half-wavelength $\lambda/2$ resonance at about 13,5 kHz. This half-wavelength resonance degrades the reproducibility of measurement results in that frequency range and harmonic distortion measurements made at corresponding multiples of the resonance frequency. Also, this resonance represents a complex load to the hearing aid transducer, which makes it more difficult to differentiate between transducer and load related effects.

The effective internal volume of the coupler described in this Technical Specification is 0,4 cm³, which is small enough not to produce any resonance in the frequency range below 16 kHz. The frequency response of the magnitude of acoustic impedance follows a pattern of a capacitive load up to about 30 kHz. With a sufficiently high source impedance and a sufficiently small coupling volume, the 0,4 cm³ coupler produces an approximately 14 dB higher output at 1 kHz in comparison to data obtained with the 2 cm³ coupler.

The coupler described in this document will allow the characterisation of hearing aids and transducers, including the verification of simulation models, up to 16 kHz.

0,4 cm³ is also approximately the residual volume of the ear canal when fitted with a CIC hearing aid (completely-in-the-canal) hearing aid, making this coupler particularly useful for this application.

In combination with an appropriate real-ear probe microphone measurement, the 0,4 cm³ coupler will enable the derivation of real-ear to coupler difference (RECD) up to 16 kHz.
1 Scope

IEC TS 62886, which is a Technical Specification, describes a coupler and measurement methods to characterise the electroacoustic performance of hearing aids and insert earphones primarily in the range of 8 kHz to 16 kHz.

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 60318-4, Electroacoustics – Simulators of human head and ear – Part 4: Occluded-ear simulator for the measurement of earphones coupled to the ear by means of ear inserts

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 61094-4, Measurement microphones – Part 4: Specifications for working standard microphones

IEC 60263, Scales and sizes for plotting frequency characteristics and polar diagrams