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

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

INTERNATIONAL
ELECTROTECHNICAL
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

FOREWORD

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- 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:

Enquiry draft	Report on voting
29/897/DTS	29/902A/RVC

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- withdrawn,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 cm^3 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 cm^3, 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 cm^3 coupler produces an approximately 14 dB higher output at 1 kHz in comparison to data obtained with the 2 cm^3 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 cm^3 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 cm^3 coupler will enable the derivation of real-ear to coupler difference (RECD) up to 16 kHz.

ELECTROACOUSTICS – HEARING AIDS – METHOD FOR MEASURING ELECTROACOUSTIC PERFORMANCE 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*

3 Terms, definitions and abbreviated terms

3.1 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

3.1.1
reference cavity
simple cylindrical cavity with the same nominal diameter and height as the coupler under test, establishing a volume that can be measured using precision dimensional metrology

Note 1 to entry: In the context of this document, the reference cavity is 400 mm^3 ± 3 mm^3, with a diameter of 9,45 mm ± 0,02 mm and a height of 5,70 mm ± 0,02 mm.

3.1.2
effective coupler volume
adjusted volume of the coupler under test that causes the measured sound pressure level in the coupler under test to equal the measured sound pressure level in the reference cavity

3.1.3
coupler volume ratio
20 times the logarithmic ratio to the base of 10 of the effective coupler volumes of a 2 cm^3 and 0,4 cm^3 coupler ($20 \lg \frac{V_{2\ cm^3}}{V_{0,4\ cm^3}}$ dB)

Note 1 to entry: The coupler volume ratio is expressed in dB.

Note 2 to entry: The coupler volume ratio can vary between 13,46 dB and 14,50 dB since the effective coupler volume of the 2 cm^3 coupler (according to IEC 60318-5) is defined as 2 000 mm^3 ± 70 mm^3 and the effective coupler volume of the 0,4 cm^3 coupler is defined as 400 mm^3 ± 10 mm^3 (see 4.2.2).

3.1.4
coupler level difference
difference between the sound pressure levels in the 0,4 cm^3 coupler and the 2 cm^3 coupler produced by the same sound source

Note 1 to entry: The coupler level difference includes the influence of the impedance of the sound source. For finite source impedance, the coupler level difference will be less than the coupler volume ratio.

3.1.5
effective length of coupling tubing
length of the acoustic coupling tubing that extends from the output of the receiver or BTE hearing aid ear hook to the coupler reference plane

Note 1 to entry: The actual length of tubing used may deviate from the effective length of coupling tubing, for example, a) the overlap resulting from the connection to the ear hook or hearing aid receiver may increase the actual length of tubing used, whereas (b) connection to the nipple of the coupling plate or earmould simulator, which is considered part of the effective length of coupling tubing, may reduce the actual length of tubing used accordingly. See Figure 2, Figure 5 and Figure 6.

3.2 Abbreviated terms

CIC	completely-in-the-canal
ITC	in-the-canal
IIC	invisible-in-the-canal
ITE	in-the-ear
BTE	behind-the-ear
RIC	receiver-in-the canal
RECD	real-ear to coupler difference
SPL	sound pressure level

4 Mechanical design of the 0,4 cm^3 coupler

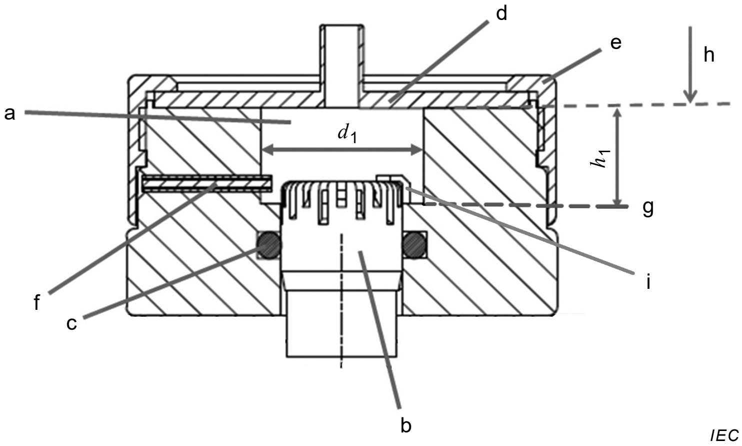
4.1 General

The coupler consists essentially of a cylindrical cavity whose effective volume is nominally 400 mm^3. The base of the cylindrical cavity contains the diaphragm of a microphone, or a microphone with an adaptor. A protection grid may or may not be fitted. The microphone measures the sound pressure level (SPL) in the coupler. The coupler shall be constructed of hard, dimensionally stable, non-porous and non-magnetic material. The general construction of the coupler and mounting of the microphone shall aim to minimise the response of the microphone to vibration (for example from an earphone) or to extraneous sound outside the cavity.

The external diameter of the coupler should be kept as small as possible in order to minimise diffraction errors which might affect the measurements when the coupler has to be placed in a sound field.

Where tolerances are specified in this document, these shall be reduced by an amount equal to the actual expanded measurement uncertainty of the test laboratory before deciding if a device conforms to the stated requirement.

Figure 1 shows the mechanical design of the coupler.



Key

d_1 Cavity diameter

h_1 Cavity height

a Cylindrical cavity

b Measuring microphone with protection grid

c O-ring or other means of airtight sealing

d Coupling plate (removable)

e Coupling plate lock bushing

f Static pressure equalization vent

g Cavity base; plane of microphone diaphragm

h Coupler reference plane

i Microphone insertion stop feature

Figure 1 – Mechanical design of the 0,4 cm^3 coupler, shown with removable coupling plate with a nipple for the attachment of coupling tubing

4.2 Cavity dimensions

4.2.1 Critical dimensions

The critical dimensions of the coupler are those which determine the shape and the volume of the cavity terminated by a measurement microphone, and the static pressure equalisation vent.

4.2.2 Effective coupler volume

The effective coupler volume shall be 400 mm^3 ± 10 mm^3.

The contribution of any front cavity and of the finite diaphragm impedance associated with the measurement microphone shall be included in the effective volume of the coupler. Therefore, the height of the cylindrical cavity should be designed such that the effective volume of the coupler conforms to the requirement for all microphone models intended for use with the coupler.

4.2.3 Diameter of the coupler cavity

The diameter d_1 of the cylindrical coupler cavity shall be 9,45 mm ± 0,05 mm.

4.3 Verification procedure of the effective coupler volume

4.3.1 General

The verification of the effective coupler volume (see 3.1.2) by acoustical means is performed by comparing the sound pressure in the coupler – which includes the coupler microphone with protection grid, the static pressure equalisation vent, microphone insertion stop if fitted and any other feature affecting the effective volume – with the sound pressure produced in a reference cavity (see 3.1.1).

4.3.2 Test set-up

The coupling plate for this test includes a source and a control microphone. This assembly can be attached to the reference cavity and the coupler under test. The control microphone measures the sound pressure in the reference cavity and in the coupler under test. The sound source input signal shall be the same for both measurements.

NOTE If both measurements are performed immediately one after another in a stable environment, effects related to heat conduction into the cavity walls will be essentially the same for both tests.

4.3.3 Effective volume of the coupler under test

During the sound pressure measurements made in the coupler under test and in the reference cavity, the effective volume of the coupler under test and the effective volume of the reference cavity will be increased by the effective volume V_s of the sound source.

Measurement in reference cavity: $p_{ref} \sim 1/(V_{ref} + V_s)$

Measurement in coupler under test: $p_{coupler} \sim 1/(V_{coupler} + V_s)$

Assuming constant air temperature and using Boyle's law:

$$p_{ref}/(V_{ref} + V_s) = p_{coupler}/(V_{coupler} + V_s)$$

$$V_{coupler} = \left(\frac{P_{ref}}{P_{coupler}}\right) V_{ref} + \left(\frac{P_{ref}}{P_{coupler}}\right) V_s - V_s$$

where

V_{ref} is the volume of reference cavity

$V_{coupler}$ is the volume of the coupler under test

V_s is the effective volume of the sound source which is the combined volumes of the sound source and control microphone

p_{ref} is the sound pressure in the reference cavity

$p_{coupler}$ is the sound pressure in the coupler under test

V_s cancels out, if $p_{coupler}$ equals p_{ref}.

Subsequently, $V_{coupler}$ equals V_{ref}.