IEC 60318-8

Edition 1.0 2022-04

INTERNATIONAL STANDARD

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Electroacoustics – Simulators of human head and ear –
Part 8: Acoustic coupler for high-frequency measurements of hearing aids and earphones coupled to the ear by means of ear inserts

Électroacoustique – Simulateurs de tête et d'oreille humaines –
Partie 8: Coupleur acoustique pour les mesurages à hautes fréquences des appareils de correction auditive et des écouteurs couplés à l'oreille par des embouts

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IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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ELECTROACOUSTICS – SIMULATORS OF HUMAN HEAD AND EAR –

Part 8: Acoustic coupler for high-frequency measurements of hearing aids and earphones coupled to the ear by means of ear inserts

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Draft	Report on voting
29/1111/FDIS	29/1117/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available

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A list of all parts in the IEC 60318 series, published under the general title *Electroacoustics – Simulators of human head and ear*, can be found on the IEC website.

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INTRODUCTION

Advancement in hearing aid design makes it possible to increase the bandwidth of hearing aids up to 16 kHz.

The 2 cm^3 coupler as described in IEC 60318-5 [1][1] is suitable for measurements up to 8 kHz. At frequencies above 8 kHz, high measurement uncertainty will occur in earphone responses, due to acoustic resonances in the coupler.

The occluded-ear simulator as described in IEC 60318-4 [2] simulates the human external ear up to 10 kHz and can be used as an acoustic coupler up to 16 kHz. It is designed with a principal cavity length which produces a half-wavelength resonance of the sound pressure at approximately 13,5 kHz. This resonance, which is also present in a person's ear canal but more controlled by the tympanic membrane, can also cause measurement uncertainty in earphone responses above 10 kHz.

Accordingly, there is a need for a well-defined and robust acoustic coupler to be used by designers of transducers (receiver, earphone), and by the designer and dispensers of hearing aids when making measurements on earphones in the frequency range 8 kHz to 16 kHz.

The sound pressure developed by an earphone is, in general, not the same in an acoustic coupler as in a person's ear. However, results obtained with an acoustic coupler can be used as a simple and ready means for the exchange of specifications and test data on hearing aids and insert earphones used in audiometry.

This document describes an acoustic coupler for loading a hearing aid or insert earphone with a specified acoustic impedance when testing acoustic performance, in the frequency range up to 16 kHz, as required in IEC 60118-0 [3].

[1] Numbers in square brackets refer to the Bibliography.

ELECTROACOUSTICS – SIMULATORS OF HUMAN HEAD AND EAR –

Part 8: Acoustic coupler for high-frequency measurements of hearing aids and earphones coupled to the ear by means of ear inserts

1 Scope

This part of IEC 60318 describes an acoustic coupler for loading a hearing aid or insert earphone with a specified acoustic impedance when testing its acoustic performance, in the frequency range up to 16 kHz. It is suitable for air-conduction hearing aids and earphones, coupled to the ear by means of ear inserts, earmoulds or similar devices.

The acoustic coupler does not simulate the human ear. However, it has an effective volume of only 0,4 cm^3, which is small enough not to produce significant resonances in the coupler in the frequency range below 16 kHz. Therefore, it will load the earphone with a known acoustic impedance, which allows repeatable measurements with low uncertainty to be obtained on earphones used in extended high-frequency audiometry.

2 Normative references

There are no normative references in this document.

3 Terms, definitions and abbreviated terms

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

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

3.1 Terms and definitions

3.1.1
acoustic coupler
device for measuring the acoustic output of sound sources where the sound pressure is measured by a calibrated microphone coupled to the source by a cavity of predetermined shape and volume which does not necessarily approximate the acoustic impedance of the normal human ear

3.1.2
earmould simulator
ear insert simulator
insert which terminates the entrance of the acoustic coupler and provides for passage of sound into the acoustic coupler through an opening on its axis

3.1.3
reference plane
plane perpendicular to the axis of the cavity of the acoustic coupler, chosen to pass through the position normally occupied by the tip of an earmould

3.1.4
acoustic transfer impedance
quotient of sound pressure at the diaphragm of the acoustic coupler's microphone by the volume velocity through the reference plane

3.1.5
reference cavity
cylindrical cavity with the same nominal diameter and volume as the acoustic coupler under test, establishing a volume that can be measured using precision dimensional measurements

3.1.6
effective coupler volume
equivalent volume of air of the acoustic compliance of the coupler formed by the cavity and the microphone at a frequency of 250 Hz

3.1.7
effective length of coupling tubing
length of the coupling tubing that extends from the output of the receiver or BTE ear hook to the coupler reference plane

Note 1 to entry: The actual length of tubing used can 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 can 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, can reduce the actual length of tubing used accordingly. See Figure 1, Figure 4 and Figure 5.

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
SPL sound pressure level

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

4.1 General

4.1.1 Overall design guidelines

The coupler consists essentially of a cylindrical cavity whose effective coupler volume is nominally 400 mm^3. A microphone with a diaphragm having high acoustic impedance is located in the base of the cylindrical cavity. A protection grid can be fitted but it is not required. The microphone measures the sound pressure level (SPL) in the coupler.

The coupler shall be made of a material that has no negative influences on its performance. For example, it should be acoustically hard and dimensionally stable. The general construction of the coupler and mounting of the microphone shall be designed to reduce the response to vibration of any earphone or to sound outside the cavity.

The external diameter of the coupler should be kept as small as possible in order to minimise diffraction errors which can affect the measurements when the coupler is placed in a sound field. See Annex C.

NOTE Due to the small effective volume, the 0,4 cm^3 coupler produces a sound pressure level output at 1 kHz that is approximately 14 dB higher than data obtained with the 2 cm^3 coupler, under the same conditions using an earphone with high source impedance and small coupling volume.

4.1.2 Acceptance limits

Acceptance limits in this document include allowances for design, manufacturing and ageing. In subsequent subclauses, acceptance limits are provided for allowable values of measured deviations from design goals. All specifications concerning conformity with the requirements of this standard are given as acceptance limits. Annex E describes example assessments of conformance to specifications of this document.

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 and cavity dimensions

The effective coupler volume shall be 400 mm^3 ± 6 mm^3.

Any contributions to the cavity volume arising from sources other than the cavity itself, such as the front cavity and impedance of the measurement microphone, the static-pressure equalisation vent and any microphone insertion stop fitted, shall be included in the effective coupler volume. Therefore, the height of the cylindrical cavity should be designed such that the effective coupler volume conforms to the requirement for all microphone models intended for use with the coupler.

The diameter d_1 of the cylindrical coupler cavity shall be 9,45 mm ± 0,04 mm.

4.3 Verification procedure of the effective coupler volume

The effective volume of the coupler shall be verified with an expanded uncertainty that is less than the maximum permitted uncertainty specified in Table 2.

One means of verifying the effective volume is given in Annex A.

4.4 Microphone

4.4.1 General

A calibrated microphone shall be fitted with the diaphragm mounted centrally in the base of the coupler. The effective volume of the coupler shall include the contribution from the microphone, and any protection grid fitted to it.

In the frequency range from 100 Hz to 16 kHz, the overall pressure sensitivity level of the microphone and associated measuring system shall be known with an uncertainty not exceeding 0,5 dB for a coverage probability of 95 %. The microphone shall be removeable for calibration.

4.4.2 Microphone type

A type WS3P microphone as specified in IEC 61094-4 [4] is preferred.

NOTE The equivalent volume of a WS3P microphone is approximately 0,25 mm^3.

Other types of microphones may be used, provided they fulfil the requirements of 4.4.1.

4.5 Static pressure equalisation vent

Any change in the static pressure within the cavity caused by coupling the hearing aid or the earphone to the coupler and microphone shall decay toward the ambient static-pressure with a time constant of less than 1,5 s. If this necessitates the introduction of a controlled leak in the coupler, it shall have the following characteristics:

a) it shall not alter the cavity volume by more than 4 mm^3,

b) it shall attenuate external sound reaching the cavity, with the coupling plate aperture sealed, by at least 16 dB at 125 Hz, increasing by 6 dB per octave for increasing frequencies up to 2 kHz.

NOTE 1 Equalisation can be realised, for example, by a capillary tube.

NOTE 2 The time constant can be measured as the time it takes for the static pressure inside the coupler to fall by 64 % after a sudden increase in static pressure inside the coupler.

4.6 Acoustic transfer impedance level

The transfer impedance level of the coupler and the associated acceptance intervals shall be as specified in Table 1.

Table 1 – The acoustic transfer impedance level modulus and the associated acceptance intervals

Nominal frequency	Acoustic transfer impedance level in dB re 1 Ns/m^5	
Hz	Level	Acceptance interval
250	167,0	±0,5
1 000	155,3	±0,7
2 000	149,2	±0,7
4 000	143,5	±1,0
8 000	138,7	±1,2
16 000	136,5	±2,5
NOTE Measurements made at intermediate frequencies, while not part of the specification, can nevertheless provide additional information.		

5 Calibration

5.1 Reference environmental conditions

The reference environmental conditions are the following:

– static pressure: 101,325 kPa

– temperature: 23 °C

– relative humidity: 50 %

5.2 Method of calibration

The manufacturer shall provide a method of calibration for the microphone system in an instruction manual.

The manufacturer shall also provide:

- The effective volume of the coupler at 250 Hz. One method for performing the measurement is given in Annex A.

- The product of the acoustic impedance and frequency, expressed as a level and as a function of frequency. One method for performing the measurement is given in Annex B.

Ideally, the calibration should be performed at the reference environmental conditions given in 5.1. If the environmental conditions are different from those given in 5.1, the actual environmental conditions at the time of test shall be stated.

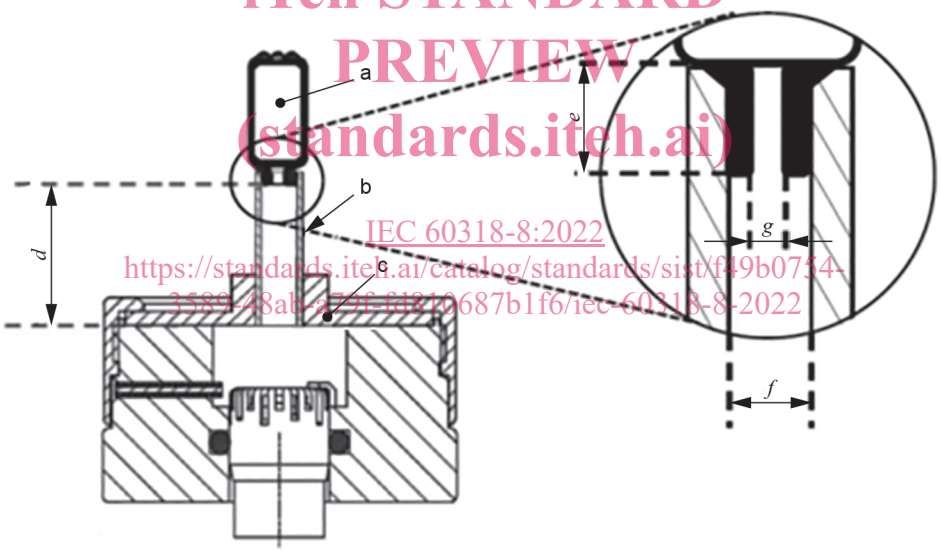
6 Coupling of receivers and hearing aids to the coupler

6.1 Coupling to a hearing aid receiver by means of tubing

Figure 1 describes the coupling to a hearing aid receiver. A bore diameter in the coupling plate, which fits the coupling tube external diameter shall be used. The tube shall be attached to the coupler in a manner that does not change the acoustic properties of the coupler. The end of the tube should be flush with the lower face of the coupling plate.

For measurements on hearing aid receivers, a tube with an internal diameter of 1 mm ± 0,06 mm and an effective length of a coupling tube of 5 mm ± 0,1 mm shall be used.

For more reliable sealing of the coupling tubing to the coupling plate, the thickness of the coupling plate may be increased in the centre portion.



Key

a Hearing aid receiver

b Coupling tubing

c Coupling plate with central bore corresponding to the external diameter of coupling tubing

d Effective length of coupling tubing

e Length of receiver connection port

f Internal diameter of coupling tubing

g Effective diameter of receiver connection port

Figure 1 – Coupling to a hearing aid receiver by means of coupling tubing

6.2 Coupling to a hearing aid embedded in or connected to an earmould

This Subclause 6.2 is applicable to any style of hearing aid embedded in or attached to an earmould.

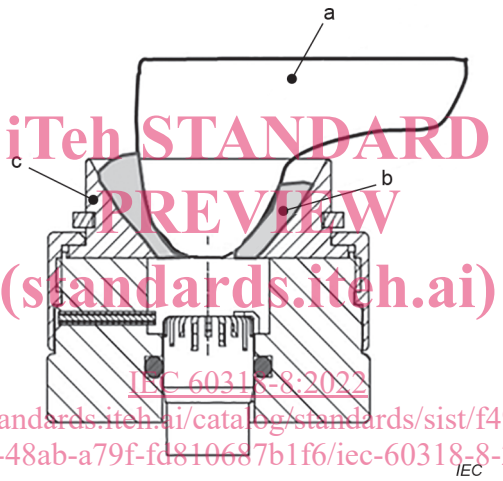
Examples of hearing aids fully embedded in the earmould are ITE (in-the-ear), ITC (in-the-canal), CIC (completely-in-the-canal), IIC (invisible-in-the-canal).

An example of a partially embedded hearing aid is the receiver-in-the-canal (RIC) hearing aid.

Examples of hearing aids attached to an earmould are behind-the-ear (BTE) hearing aids either coupled with standard coupling tubing or thin tubing.

The coupling arrangement is illustrated in Figure 2 where it is shown with an ITE. The coupling is performed by attaching the ITE by means of a sealant to the concave shaped ITE ear-mould simulator. Care shall be taken to avoid any gaps or slit leakages. Any vents in the instrument shall be sealed at the coupler side. The end of the ITE sound port shall be flush with the coupler reference plane. The coupling plate is removable from the 0,4 cm^3 coupler. This allows the inspection of the seal quality and the position of the opening of the sound port that will face the inside volume of the coupler.

NOTE Owing to the smaller volume, the 0,4 cm^3 coupler is more sensitive to gaps or slit leakages than the 2 cm^3 coupler.



Key

a ITE

b Sealant to seal ITE to mounting fixture

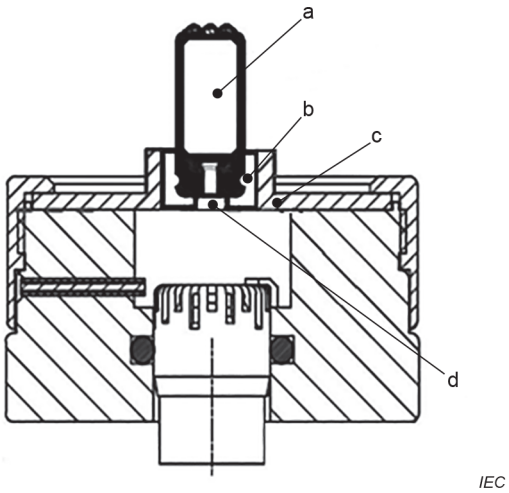
c ITE ear-mould simulator

Figure 2 – Coupling to an ITE, ITC, or CIC

6.3 Coupling to a receiver in the canal (RIC)

Figure 3 shows the coupling of a receiver-in-the-canal to the 0,4 cm^3 coupler. This may be used as an alternative to 6.2 provided that a coupling adapter is available. The coupling adapter is considered a part of the receiver system, and therefore its lower face shall be aligned to within ± 0,5 mm with the coupler reference plane.

If the receiver is attached to an earmould, then coupling as described in 6.2 and Figure 2 shall be used.



Key

a Receiver in the canal (RIC)

b RIC specific coupling adaptor

c Coupling plate

d Bore in RIC specific coupling adaptor

Figure 3 – Coupling to a receiver in the canal (RIC)

6.4 Coupling to a BTE hearing aid with 2 mm continuous internal diameter tubing

Figure 4 shows the coupling to a BTE hearing aid by means of coupling tubing with 2 mm ± 0,1 mm continuous internal diameter, which reflects the most common fitting practice. The tubing is connected to the coupling plate with a nipple of 2 mm ± 0,1 mm internal diameter.

An effective coupling tubing length of 43 mm ± 1 mm shall be used.

NOTE The 43 mm length consists of 25 mm of standard tubing length plus 18 mm for the earmould and includes the thickness of the coupling plate.