IEC 60268-7

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INTERNATIONAL STANDARD

Sound system equipment –
Part 7: Headphones and earphones

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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 60268-7 has been prepared by IEC technical committee TC 100: Audio, video and multimedia systems and equipment.

This third edition cancels and replaces the second edition published in 1996, and constitutes a technical revision. This edition contains the following changes:

- clause/subclause renumbering in accordance with ISO/IEC Directives, Part 2;
- addition of a measurement system using HATS;
- addition of details on pinna simulators for high measurement reproducibility, see Annex A.

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

FDIS	Report on voting
100/1621/FDIS	100/1641/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.

A list of all parts of IEC 60268 series, published under the general title *Sound system equipment,* can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site 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.

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

SOUND SYSTEM EQUIPMENT –

Part 7: Headphones and earphones

1 Scope

This part of IEC 60268, is applicable to headphones, headsets, earphones and earsets, intended to be used on, or in, the human ear. It also applies to equipment, such as pre-amplifiers, passive networks and power supplies which form an integral part of the headphone system.

It does not deal with:

a) safety, for which reference should be made to IEC 60065 or another appropriate standard;

b) the characteristics of microphones of headsets, for which reference should be made to IEC 60268-4;

c) earphones and other devices for hearing aids, for which reference should be made to IEC 60118-0;

d) headphones for audiometry;

e) headphones and other devices which form part of an active ear-defender system, although some of its provisions may be applicable.

This standard specifies the characteristics which should be included by the manufacturer in specifications, and relevant methods of measurement. It includes a classification of the different types of earphone, mainly characterized by the way in which the transducer is coupled acoustically to the ear, and a classification code which may also be used for marking.

2 Normative references

The following referenced documents are indispensable for the application 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 60038, *IEC standard voltages*

IEC 60050(801):1994, *International Electrotechnical Vocabulary – Chapter 801: Acoustics and electroacoustics*

IEC 60068-1, *Environmental testing – Part 1: General and guidance*

IEC 60086-1, *Primary batteries – Part 1: General*

IEC Guide 106, *Guide for specifying environmental conditions for equipment performance rating*

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

IEC 60268-1, *Sound system equipment – Part 1: General*

IEC 60268-2, *Sound system equipment – Part 2: Explanation of general terms and calculation methods*

IEC 60268-11, *Sound system equipment – Part 11: Application of connectors for the interconnection of sound system components*

IEC 60268-12, *Sound system equipment – Part 12: Application of connectors for broadcast and similar use*

IEC 60711, *Occluded-ear simulator for the measurement of earphones coupled to the ear by ear inserts*[1]

IEC TR 60959, *Provisional head and torso simulator for acoustic measurements on air conduction hearing aids*[2]

IEC 61672-1, *Electroacoustics – Sound level meters – Part 1: Specifications*

ISO 3741, *Acoustics – Determination of sound power levels of noise sources using sound pressure – Precision methods for reverberation rooms*

ISO 4869-1, *Acoustics – Hearing protectors – Part 1: Subjective method for the measurement of sound attenuation*

ISO 4869-3, *Acoustics – Hearing protectors – Part 3: Measurement of insertion loss of ear-muff type protectors using an acoustic test fixture*

ISO 7619-1, *Rubber, vulcanized and thermoplastic – Determination of indentation hardness – Part 1: Durometer method (Shore hardness)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply, see also IEC 60050-801 (IEV).

NOTE Any device defined in 3.1 to 3.15 and their connector(s) for electrical input should be regarded as part of the transducer.

3.1
earphone
electroacoustic transducer by which acoustic oscillations are obtained from electric signals and intended to be closely coupled acoustically to the ear

[IEV 801-27-18]

3.2
headphone
assembly of one or two earphones on a headband or chinband, the use of which may be optional (e.g. with intra-concha earphones)

3.3
headset
headphones equipped with a microphone

3.4
earset
earphones equipped with a microphone

1 This publication will be replaced by future IEC 60318-4 (to be published).

2 This publication is planned to be replaced by future IEC 60318-7 (under consideration).

NOTE This definition is included because the term appears in the catalogue of IEC publications.

3.5
insert earphone
small earphone that is attached directly to a connecting element, for example an earmould, inserted into the ear canal

[IEV 801-27-22, modified]

3.6
intra-concha earphone
small earphone that fits in the concha cavity, with its acoustic exit close to the entrance of the ear canal

3.7
supra-aural earphone
earphone applied externally to the outer ear and intended to rest on the pinna

[IEV 801-27-23, modified]

3.8
supra-concha earphone
earphone intended to rest on the ridges of the concha cavity

3.9
circumaural earphone
earphone having a cavity large enough to cover the region of the head including the ear

[IEV 801-27-24]

3.10
ear shell
circumaural type of earphone hanging on the ear

3.11
stethoscopic headphone
insert headphone by which the earphone(s) is/are coupled to the ears by means of a pair of rigid tubes, so that the assembly resembles a stethoscope

3.12
acoustically open earphone
earphone which intentionally provides an acoustic path between the external environment and the ear canal

3.13
acoustically closed earphone
earphone which is intended to prevent acoustic coupling between the external environment and the ear canal

3.14
closed-back earphone
earphone which does not emit significant sound radiation from the back of the transducer to the external environment

3.15
open-back earphone
earphone which emits significant sound radiation from the back of the transducer to the external environment

3.16
simulated programme signal
signal whose mean power spectral density closely resembles the average of the mean power spectral densities of a wide range of programme material, in accordance with IEC 60268-1.

NOTE This signal is called as “wide band signal” in a few standards.

4 Classification, designation and coding

The following designations and classification codes shall be used:

60268-7 - IEC - XXXX - NNRN - N

where

60268-7-IEC is the standard form of prefix.

- X (first letter) gives the principle of the transducer:
  - D - electrodynamic (moving coil);
  - E - electret (self-polarizing);
  - F - piezo-electric (polymer);
  - M - electromagnetic (moving armature or diaphragm);
  - P - piezo-electric (ceramic);
  - S - electrostatic (externally polarized).
- X (second letter) gives the type of earphone:
  - C - circumaural;
  - E - intra-concha;
  - H - earshell;
  - I - insert;
  - M - supra-concha;
  - S - supra-aural;
  - T - stethoscopic.

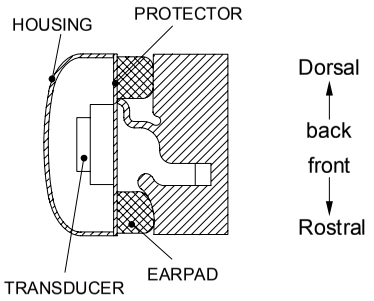
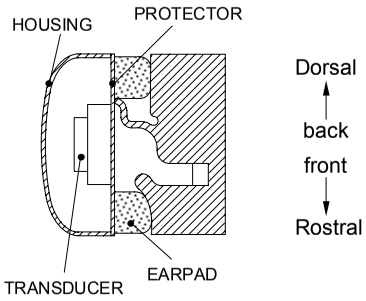
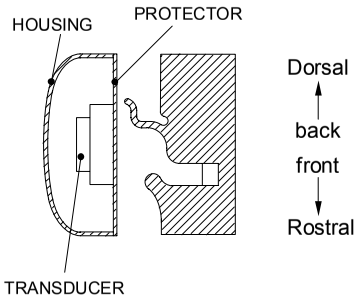
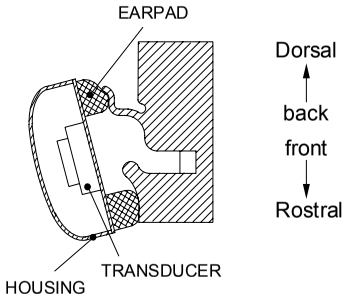
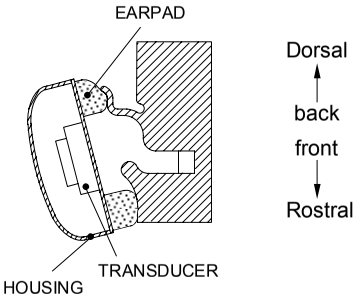
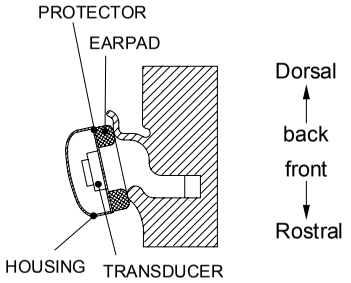
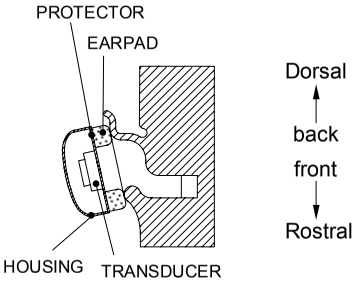
An illustration of the types, except “H”, is given in Figure 1.

- X (third letter) gives the intended nature of the acoustic coupling to the ear canal:
  - L - acoustically open (controlled leakage);
  - S - acoustically closed (minimum leakage).
- X (fourth letter) gives the intended nature of the radiation to the external environment:
  - C - closed-back (see 3.14);
  - O - open-back (see 3.15).

An illustration of the four possibilities defined in 3.12 to 3.15, and indicated by the third and fourth classification letters, is given in Figure 2:

- NNRN (first number) gives the impedance in ohms in "mantissa and exponent" form. (For example, 8 Ω as "08R0", 32 Ω as "32R0" and 600 Ω as "06R2");
- N (second number) gives the number of channels.

The code, compiled in accordance with the above rules, may be used for marking.

Type of earphone	Acoustically closed earphone (minimum leakage)	Acoustically open earphone (controlled leakage)	Ear loudspeaker
Circumaural			
Supra-aural			
Supra-concha			

NOTE The transducers shown in the schematics are not necessarily positioned in the centre of the housings or concentric to the ear canal.

Figure 1 – Diagrammatic horizontal sections showing types of earphones and their spatial relationships with the pinna and/or canal entrance

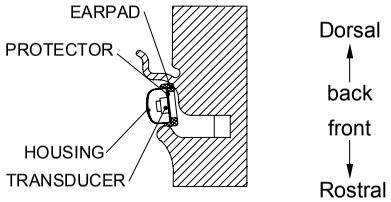
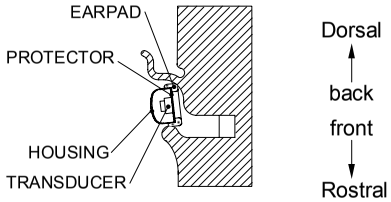
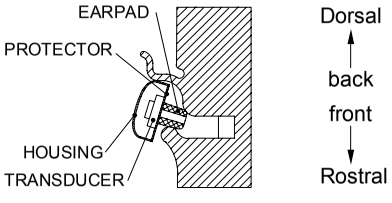
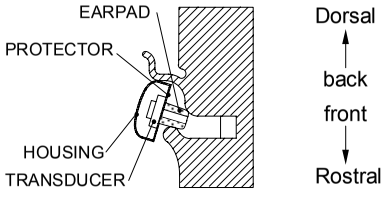
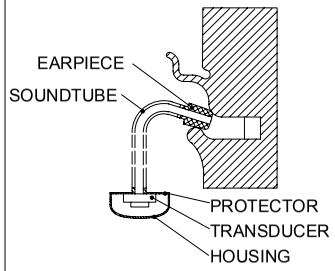
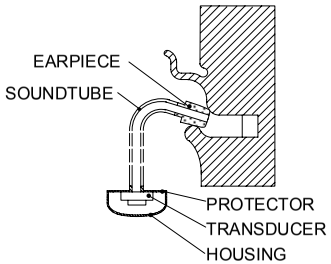
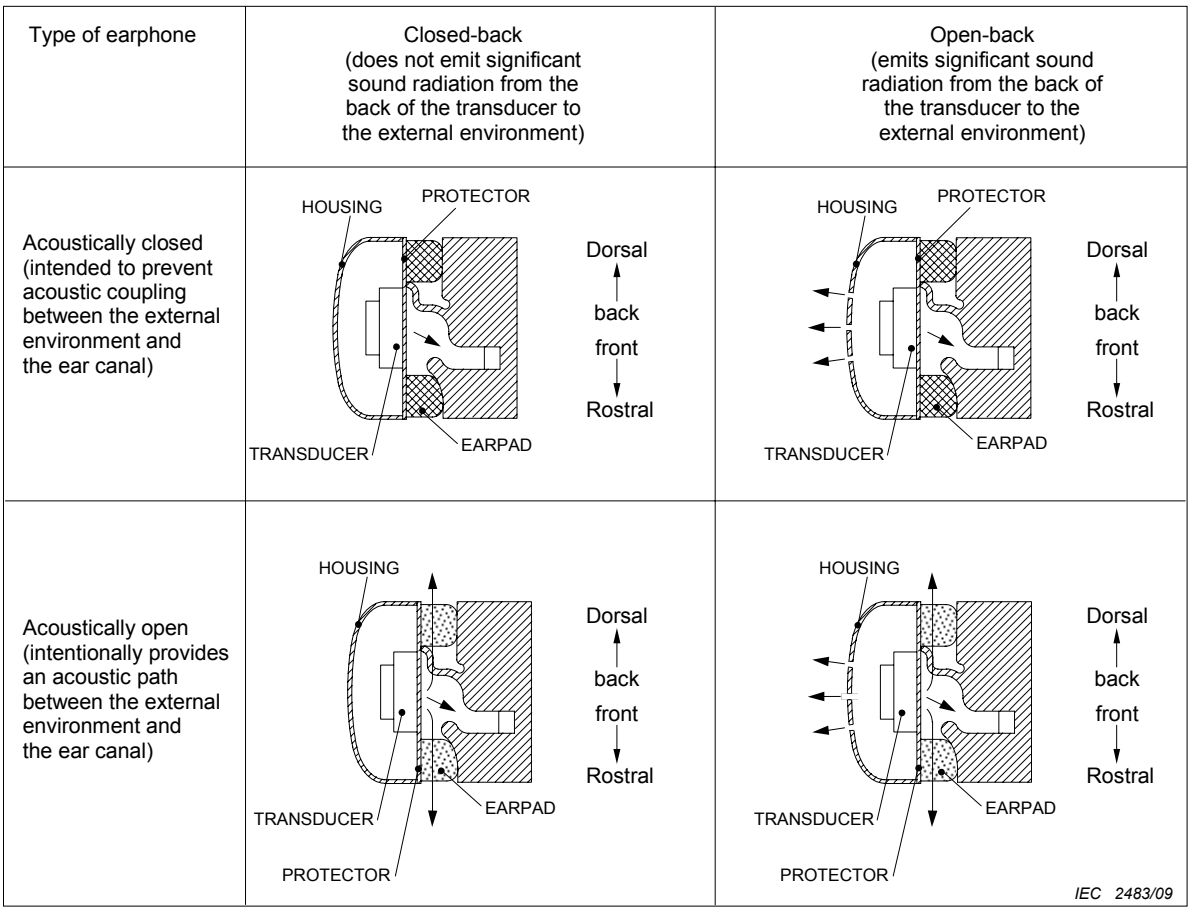
Type of earphone	Acoustically closed earphone (minimum leakage)	Acoustically open earphone (controlled leakage)	
Intra-concha			
Insert			
Insert with sound tube between transducer and earpiece (for example, stethoscopic type of earphone for hearing aid)			Key Cross hatching shows acoustically closed earpad to accomplish minimum leakage. Spotted by small circle shows porous material earpad to accomplish controlled leakage. IEC 2482/09

Figure 1 *(continued)*



NOTE 1 Arrows show sound flow or sound leakage.

NOTE 2 The transducers shown in the schematics are not necessary positioned in the centre of the housings or concentric to the ear canal.

Figure 2 – Diagrams showing the four possible construction: acoustically open or closed, and closed- or open-back

5 Marking of terminals, controls and polarity

Requirements for marking terminals and controls are given in IEC 60268-1, and for polarity in IEC 60268-2. In addition, headphones which are intended to be worn with a particular earphone on each ear shall be marked to indicate the "left" and "right" earphones. If a colour marking is used, the "right" earphone shall be indicated by a red marking. For the sake of visually-impaired persons, it is recommended to indicate the left earphone by a projection of at least 1,5 mm diameter and 0,3 to 0,5 mm height.

6 User instructions

The user instructions shall include information on:

- connector contact assignments (see IEC 60268-11);
- controls and switches (if any);
- microphone (if any);

- diagram of the interconnections of the earphones (if more than one);
- classification code (see Clause 4);
- description of the type of headphone.

Information shall also be provided on the safe use of the headphone, using wording similar to:

> "To prevent possible hearing damage, do not listen at high volume levels for long periods, do not use the headphones while driving or cycling, or in any situation where you should be able to hear other sounds. As a guide to setting the volume level, check that you can still hear your own voice, when speaking normally while listening with the headphones."

If the headphone is supplied with auxiliary equipment, information shall also be provided on:

- pre-amplifiers and/or passive networks;
- receivers (for cordless systems);
- power supplies;
- other parts, such as magnetic pick-up devices.

7 Conditions for specifications and measurements

7.1 Rated conditions

For an explanation of the meaning of "rated conditions" and "rated value of a characteristic", reference shall be made to IEC 60268-2.

The rated conditions for a headphone are:

- rated impedance;
- rated source e.m.f. (or power, see 8.4);
- rated noise e.m.f. (or power, see 8.4);
- rated source impedance (see Note);
- rated frequency range;
- rated long-term maximum input voltage (or power);
- rated maximum permanent noise source e.m.f. (or power);
- rated power supply voltage (if any);
- rated climatic conditions (temperature, humidity, air pressure);
- rated damage limited source e.m.f.;
- rated application force.

These values are taken from the manufacturer's specification, and are not subject to measurement; they constitute the basis for measuring the other characteristics.

For climatic conditions, reference is made to IEC 60268-1, and further information is given in IEC 60068-1 and IEC Guide 106.

NOTE The performance of most types of headphones depends very little on the source impedance. However, in order to allow headphones of widely different impedances to be reasonably well-matched, in terms of the sound pressure level produced, to a single headphone output on other equipment, IEC 61938 at present specifies a source impedance of 120 Ω, intermediate between the lowest and highest likely impedances of available headphones. It is thus important for the manufacturer to specify the rated source impedance, particularly if, for some reason, it is not 120 Ω.

7.2 Standard conditions for measurement

A headphone is working under standard conditions for measurement when all of the following conditions are fulfilled.

a) At least one earphone is applied to the appropriate coupler or ear simulator, with the rated application force.

b) A sinusoidal voltage at the standard measuring frequency is applied, in series with the rated source impedance. The voltage shall be such that a sound pressure level of 94 dB (reference 20 μPa) is generated in the coupler or ear simulator. Unless otherwise stated, the standard measuring frequency shall be 500 Hz. The input signal shall be applied at the point where the signal from an amplifier or other equipment is applied when the headphone is in use. This point may be the input of a piece of auxiliary equipment, such as a preamplifier.

   As an alternative, the manufacturer may specify this condition as being a signal voltage which dissipates a power of 1 mW in a pure resistance equal to the rated impedance of the earphone being measured.

   NOTE Electrostatic, piezo-electric, electret condenser and cordless headphones are within the scope of this standard. The signal may be sent to the headphone by infra-red, radio, light or magnetic induction (either directly to the transducers or to a magnetic pick-up device and amplifier). These types of headphone are more easily dealt with by specifying the sound pressure level to be generated (the input signal being applied to the transmitter unit), rather than by specifying the power in the rated impedance.

c) Unless otherwise specified by the manufacturer, volume controls are set at minimum attenuation. For headphones supplied with a preamplifier, and for cordless headphones, the manufacturer shall specify a reference position of the gain control for use in measurements. Other controls shall be set at the designated "normal" positions, or at stated positions, preferably those giving the greatest range of frequency response. Balance controls shall be set for equal voltages at the terminals of the channels. Crosstalk controls shall be set for minimum crosstalk.

d) If the headphone requires a power supply, the rated supply voltage and frequency are applied.

7.3 Couplers and ear simulators

The manufacturer should use the coupler or ear simulator which is specified in the international standard for the measurement of the headphone or earphone, for which results are to be published. The manufacturer shall state the type of the used coupler or ear simulator in the results.

NOTE Examples of the international standards specifying the couplers and ear simulators are IEC 60318-1, IEC 60318-2, IEC 60318-3, IEC 60318-5, IEC 60711, ITU-T Recommendation P.57, 4.3 and the ear part of HATS (Head and torso simulator) in IEC 60959.

For the measurement using the ear part of HATS (Head and Torso Simulator), the manufacturer should use the model specified in IEC 60959 or equivalent, see ITU Recommendation P.58. Hardness of the rubber pinna used shall be stated in the results, see ISO 7619-1 (2004).

Information for the pinna simulator suitable for measurements of headphones is given in Annex A.

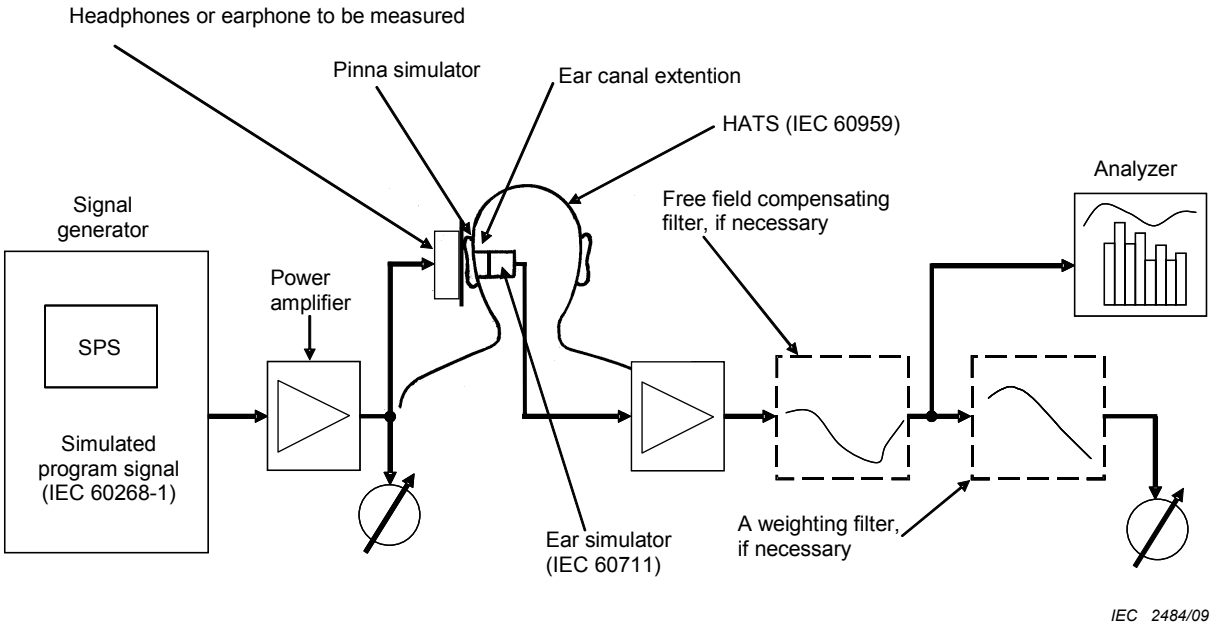
If the coupler or ear simulator except specified in the international standards was used, the manufacturer shall state its physical parameters, shape, dimension, volume of the cavity, etc., to maintain repeatability of measurement.

7.4 Measurement conditions for simulated programme signal

The conditions specified in 7.2 are applied except that the simulated programme signal specified in IEC 60268-1 shall be applied. The following filters can be used to process the output signal of the ear simulator:

- a weighting filter specified in IEC 61672-1;
- free field compensating filter, that is the filter with inverse response of the free field response of the manikin specified in IEC 60959.

Measurement diagram by the simulated program signal is illustrated in Figure 3.



NOTE The output signal correction can be done numerically without use of any filtering devices. Power summation of the 1/3-octave-analized data multiplied by filtering coefficients given by IEC 61672-1 and/or IEC 60969 gives the corrected voltage.

Figure 3 – Illustrated measurement diagram by simulated programme signal

7.5 Loudness comparison conditions

7.5.1 General

The response of a headphone to a given electrical signal may be determined by subjective comparison of the loudness of the sound from the headphone with that of a reference sound field derived from the same electrical signal. Headphones provided with earphones for both ears shall be operated with uncorrelated signals, having the same spectrum and amplitude, applied to both earphones simultaneously.

7.5.2 Free-field comparison conditions

A headphone is working under free-field comparison conditions when both of the following conditions are fulfilled:

a) the headphone is worn by a test person in accordance with the manufacturer's instructions or in the usual way for that type. It is necessary to fit the headphone in accordance with the manufacturer's instructions, so that the earphones are correctly positioned, and the application force is close to the rated value;

b) the reference sound field simulates a progressive plane wave. The acoustic signal shall have a specified bandwidth and sound pressure level at a stated reference point, in the absence of the test person.

Practical details of free-field comparison conditions are given in Annex C.

7.5.3 Diffuse-field comparison conditions

A headphone is working under diffuse-field comparison conditions when both of the following conditions are fulfilled:

a) the headphone is worn by a test person in accordance with the manufacturer's instructions or in the usual way for that type. It is necessary to fit the headphone in accordance with the manufacturer's instructions, so that the earphones are correctly positioned, and the application force is close to the rated value;

b) the reference sound field simulates a diffuse sound field, as described in ISO 3741. The acoustic signal shall have a specified bandwidth and sound pressure level at a stated reference point, in the absence of the test person.

Practical details of diffuse-field comparison conditions are given in Annex D. The use of a reverberant chamber for the generation of the diffuse field is suitable for ear canal probe measurements, but less suitable for subjective loudness level comparison, because of the long reverberation time.

7.6 Ear canal sound pressure level measurement conditions

A headphone is working under ear canal sound pressure level measurement conditions when the conditions for free-field comparison (7.5.2) or diffuse-field comparison (7.5.3) are fulfilled, in addition to the following condition. A very small microphone, in accordance with the requirements in Annex B, is positioned inside the ear canal of the test person, with its sound entrance at least 4 mm from the entrance of the canal. Practical details of these conditions are given in Annex E.

8 Characteristics to be specified and their methods of measurement

8.1 Power supply

If the headphone requires a power supply, the manufacturer shall specify:

- the type of power supply (a.c. or d.c.);
- the rated supply voltage and frequency, or their ranges (see IEC 60038) and/or type of battery (see IEC 60086-1). These are rated conditions (see 7.1);
- the maximum power drawn from the power supply.

Headphones, which require or tolerate a small direct current in addition to the signal, are not regarded as requiring a power supply. However, details of the required or maximum permissible direct current shall be given.

8.2 Electrical impedance

8.2.1 Rated impedance

NOTE This is a rated condition, see 7.1.

Characteristics to be specified:

a) the value of a pure resistance which is specified by the manufacturer for matching purposes;

b) the rated impedance shall be chosen so that the lowest value of the modulus of the actual impedance within the rated frequency range is not less than 80 % of the rated value. If the impedance at any frequency between 0 kHz and 20 kHz is less than this value, this should be stated in the specification.

8.2.2 Impedance/frequency characteristic

8.2.2.1 Characteristic to be specified

The characteristic to be specified is a representation of the modulus of the impedance as a function of frequency.

8.2.2.2 Method of measurement

The method of measurement is detailed below.

a) The headphone is brought under standard conditions for measurement.

b) The signal is changed to a sinusoidal voltage or current of variable frequency, whose amplitude is constant, and sufficiently small to ensure that the headphone operates in a linear region.

c) The modulus of the impedance shall be measured, at least over the frequency range 20 Hz to 20 kHz.

d) The results shall be presented graphically as a function of frequency. The value of signal voltage or current shall be stated.

8.2.3 Rated source impedance

NOTE 1 This is a rated condition.

The characteristic to be specified is the source impedance, specified by the manufacturer, with which the headphone is intended to operate.

NOTE 2 See Note to 7.1.

8.3 Input voltage

8.3.1 Rated source e.m.f.

NOTE 1 This is a rated condition.

Characteristics to be specified.

The maximum r.m.s. voltage (on peaks of programme signal), specified by the manufacturer, which should be applied to the headphone through the rated source impedance, during the reproduction of normal programme signals.

NOTE 2 For headphones intended to comply with the matching requirements at present in IEC 61938, the rated source e.m.f. should be 5 V. See also Clause 6 and the Note to 7.1.

NOTE 3 Attention is drawn to the need for discouraging the use of headphones at sound pressures that might cause damage to hearing. The rated input voltage should, preferably, not exceed the characteristic voltage (see 8.3.3) by more than 10 dB to 15 dB. See also Note 2 to 8.3.4.2.

8.3.2 Limiting values of input voltage

8.3.2.1 Characteristics to be specified

The characteristics to be specified are as follows:

a) the rated long-term maximum source e.m.f. (a rated condition) is the maximum voltage, applied through the rated source impedance, which the headphone can tolerate without permanent damage, when the signal is a noise signal simulating normal programme material (see IEC 60268-1), with additional clipping, and is applied for 10 periods of 60 s, separated by periods of zero signal of 120 s duration;

b) the rated maximum permanent noise source e.m.f. (a rated condition) is the maximum voltage, applied through the rated source impedance, which the headphone can tolerate without permanent damage, when the signal is a noise signal simulating normal programme material (see IEC 60268-1), with additional clipping, and is applied for a continuous period of 100 h.

8.3.2.2 Method of measurement

NOTE 1 Since these are rated conditions, they are not, strictly, subject to measurement, except by the manufacturer. The following method is standardized to encourage all manufacturers to use the same method, and it may be used by test houses for verification of manufacturers' specifications.

The method of measurement is detailed below.

a) The following equipment is required:
   - a source of the weighted noise signal, which can be switched on and off for specified short periods of time;
   - a clipping network;
   - a power amplifier;
   - any auxiliary equipment which is normally connected between the amplifier and the headphone;
   - a resistor equal to the rated source impedance, if not included in the amplifier or the auxiliary equipment;
   - the headphone under test, which should be allowed to radiate freely in an unobstructed space.

b) The clipped noise signal at the output of the amplifier shall have a frequency distribution as specified in IEC 60268-1, and a peak-to-r.m.s ratio between 1,8 and 2,2. The amplifier shall be capable of supplying an output voltage of at least twice the rated value of the long-term maximum source e.m.f., without clipping, and with a total harmonic distortion of less than 10 %.

c) To verify the rated long-term maximum source e.m.f., that e.m.f. shall be applied to the headphone through the rated source impedance, under stated climatic conditions, for 10 periods of 60 s, separated by periods of zero signal of 120 s duration. The headphone shall then be stored under similar climatic conditions for at least 4 h.

d) To verify the rated noise e.m.f., that e.m.f. shall be applied to the headphone through the rated source impedance, under static climatic conditions, for a continuous period of 100 h. The headphone shall then be stored under similar climatic conditions for at least 24 h.

e) The rated value of long-term maximum source e.m.f. or rated noise voltage has been verified if, after the storage period, there is no significant change in any of the characteristics of the headphone, so that it no longer complies with its specification.

   NOTE 2 It may be inadvisable to use the same sample headphone to verify both characteristics, since the application of both tests could be considered too severe.

8.3.3 Characteristic voltage

8.3.3.1 Characteristic to be specified

The sinusoidal source e.m.f. at 500 Hz which, when applied to the headphone through the rated source impedance, produces a sound pressure level in the coupler or ear simulator of 94 dB (reference 20 μPa).

NOTE The frequency of 500 Hz is chosen to avoid the effects of diaphragm resonance, leakage and standing waves that may occur in the coupler or ear simulator at other frequencies.

8.3.3.2 Method of measurement

The method of measurement is detailed below.

a) The headphone is brought under standard conditions for measurement.

b) The sinusoidal source e.m.f. at 500 Hz, applied through the rated source impedance, is then adjusted until a sound pressure level of 94 dB (ref. 20 μPa) is obtained in the coupler or ear simulator.

c) The source e.m.f. is then noted, and stated as the result.

8.3.4 Simulated programme signal characteristic voltage

8.3.4.1 Characteristic to be specified

The source e.m.f. of the simulated programme signal which, when applied to the headphone through the rated source impedance, produces a sound pressure level in the coupler or ear simulator of 94 dB (ref. 20 μPa), see IEC 60268-1.

8.3.4.2 Method of measurement

The method of measurement is detailed below.

a) The headphone is brought under measurement conditions for the simulated programme signal given in 7.4.

b) The source e.m.f. of the simulated programme signal specified in IEC 60268-1, applied through the rated source impedance, is then adjusted until a sound pressure level of 94 dB (ref. 20 μPa) is obtained in the coupler or ear simulator.

c) The source e.m.f. is then noted, and stated as the result.

NOTE 1 IEC 60268-1 specifies the spectrum, filtering circuit and crest factor of the simulated programme signal.

NOTE 2 The measurement should be repeated satisfactorily and then the results should be averaged, because meter indication of the random noise signal level is unstable. If automatically averaging equipment is not used, averaging of 5 to 10 measurements in every 1 s to 5 s by using the meter with *S* time weighting characteristics specified in IEC 61672 is suitable.

NOTE 3 Use of the the pinna simulator specified in Annex A is recommended for improvement of accuracy at the measurement of intra-concha and insert earphones.

8.3.5 Simulated programme signal characteristic voltage corrected by A-weighting characteristics and free-field response compensation

8.3.5.1 Characteristic to be specified

The source e.m.f. of the simulated programme signal which, when applied to the headphone through the rated source impedance, produces a sound pressure level in the coupler or ear simulator of 94 dB (ref 20 μPa), corrected by A-weighting characteristics and free-field response compensation.

8.3.5.2 Method of measurement

The method of measurement is detailed below.

a) The headphone is brought under measurement conditions for the simulated programme signal given in 7.4.

b) The ear simulator of IEC 60711 with the pinna simulator through the ear canal extension specified in Annex A shall be used.

c) The output signal of the ear simulator is processed by an A weighting filter specified in IEC 61672-1 and free field compensating filter, i.e. the filter with inverse response of the free field response of the manikin for 0° azimuth angle and ear canal sound pressure ratio of HATS specified in IEC 60959.

d) The source e.m.f. of the simulated programme signal specified in IEC 60268-1, applied through the rated source impedance, is then adjusted until a sound pressure level of 94 dB (reference 20 μPa) is obtained in the coupler or ear simulator.

e) The measured source e.m.f. is then noted.

f) The headphone is removed from HATS completely, then applied again for the measurement stated in d), and the source e.m.f. is noted.

g) The average value of source e.m.f. of 3 to 5 measurements is calculated, and stated as the result.

NOTE 1 For the simulated programme signal, see Note 1 of 8.3.4.2.

NOTE 2 For use of automatically averaging equipment, see Note 2 of 8.3.4.2.

8.3.6 Protective devices

8.3.6.1 Characteristics to be specified

The characteristics to be specified are as follows:

a) the protection voltage, which is the sinusoidal source e.m.f., applied through the rated source impedance, at which a device operates to protect the headphone from damage or the user from excessive sound pressure level. (see also Clause 6);

NOTE 1 If this voltage depends on frequency, the dependence should be presented graphically.

NOTE 2 The limitation of excessive sound pressure level ("acoustic shock") in public telephone systems occurs at a sound pressure level of 126 dB (reference 20 μPa) in some countries.

b) the effect (if any) of the operation of the device on the sound pressure produced by the headphone;

c) the effect (if any) of the operation of the device on the impedance of the headphone;

d) the damage limited source e.m.f., which is the maximum source e.m.f. that the protective device can tolerate without damage. This is a rated condition.

8.3.6.2 Method of measurement

The method of measurement is detailed below.

a) The headphone is brought under standard measuring conditions, and the signal is changed to a sinusoidal signal of variable voltage and frequency.

b) The source e.m.f., at the standard reference frequency, is increased until operation of the protective device causes a change of at least 1 dB in the sensitivity of the headphone. This voltage is noted, and measurements are then made of the impedance and sound pressure level at voltages 1 dB lower and 1 dB higher than the noted voltage.

NOTE At the 1 dB higher level, the impedance may be very high or very low, and the sound pressure may be very low.

c) The measurements are then repeated, if necessary, at other frequencies.

d) The source e.m.f. is then increased to the rated value of damage limited source e.m.f. and any damage which results in a deviation from the specification is noted.

e) The measurements are then repeated, if necessary, at other frequencies. It may be necessary to repair damage or test other samples.

f) The results of the tests may be tabulated or expressed graphically.

8.4 Input power

For headphones in which the signal from the source equipment is directly applied to the earphone(s), there is a characteristic expressed in terms of power corresponding to each of the characteristics given in 8.3:

- rated input power;
- rated long-term maximum input power;
- rated noise power;

- characteristic power;
- simulated programme signal characteristic power;
- simulated programme signal characteristic power corrected by A-weighting characteristics and free-field response compensation;
- characteristics a) and d) relating to protective devices (see 8.3.6.1).

Specifications in terms of power can be derived from the corresponding voltages (8.3) and the rated impedance.

8.5 Sound pressure (level)

8.5.1 General

Subclause 8.5 provides a specification on sound pressure (level) of headphones and earphones.

NOTE To avoid continuous repetition of "sound pressure and/or sound pressure level", the abbreviation "sound pressure (level)" is used.

8.5.2 Characteristics to be specified

The characteristics to be specified are as follows:

a) the maximum sound pressure (level), which is the sound pressure (level), produced in the coupler or ear simulator when the headphone is supplied with a sinusoidal voltage of the rated source e.m.f. at 500 Hz, in series with the rated source impedance;

b) the working sound pressure (level), which is the sound pressure (level) produced in the coupler or ear simulator, when the headphone is supplied with a sinusoidal voltage at 500 Hz, in series with the rated source impedance, of such value that 1 mW would be dissipated in a pure resistance equal to the rated impedance of the headphone, connected in place of it;

c) the simulated programme signal working sound pressure (level), which is the sound pressure (level) produced in the coupler or ear simulator, when the headphone is supplied with the simulated programme signal specified in IEC 60268-1, in series with the rated source impedance, of such value that 1 mW would be dissipated in a pure resistance equal to the rated impedance of the headphone, connected in place of it;

d) the simulated programme signal working sound pressure (level) corrected by A-weighting characteristics and free-field response, which is the sound pressure (level) produced in the coupler or ear simulator, when the headphone is supplied with the simulated programme signal specified in IEC 60268-1, in series with the rated source impedance, of such value that 1 mW would be dissipated in a pure resistance equal to the rated impedance of the headphone, connected in place of it. Output signal of the ear simulator shall be processed by an A weighting filter specified in IEC 61672-1 and a free field compencating filter, i.e. the filter with inverse response of the free field response of the manikin for 0° azimuth angle and ear canal sound pressure ratio of HATS specified in IEC 60959.

NOTE This characteristic is not relevant for headphones in which the signal from the source equipment is not directly applied to the earphone(s).

8.5.3 Method of measurement

The method of measurement is detailed below.

a) The headphone is brought under standard conditions for measurement, and an appropriate signal of the rated source e.m.f. is then applied in series with the rated source impedance. The output signal of the ear simulator shall be processed by appropriate filter(s), if necessary.

NOTE The measurement repetition requirement for noise signal is similar to Note 2 of 8.3.4.2.

b) The sound pressure (level) in the coupler or ear simulator is then noted, and stated as the result a) in 8.5.2.

c) The source e.m.f. is then adjusted so that the voltage across the input connector of the headphone is such that it would cause 1 mW to be dissipated in a pure resistance equal to the rated impedance of the headphone.

d) The sound pressure (level) in the coupler or ear simulator is then noted, and stated as the result b) in 8.5.2.

8.6 Frequency response

8.6.1 General

Frequency response of headphones or earphones shall be evaluated at least by one of the following responses:

- coupler or ear simulator (including HATS) frequency response;
- field comparison frequency response, measured by a test person.

The field comparison frequency response is preferably accompanied by the coupler or ear simulator frequency response for confirmation by comparison of them.

NOTE Two categories of methods of measuring frequency response are specified in this standard because no method has yet been developed that is universally applicable.

Coupler or ear simulator measurements, purely objective, are relatively simple and repeatability is sufficient. They are, therefore, most useful for production testing, quality control and commercial specifications.

However, subjective assessments are still useful because the objective methods whose results bear good relation to those from subjective assessments are under research stage.

The two types of subjective assessment themselves produce different results, as do the two types of ear canal sound pressure level measurement. These methods are more time-consuming than coupler measurements, and are most useful in product development and for small batch production of special products. No known objective method produces a flat frequency response characteristic from an earphone which is subjectively judged to produce wide band uncoloured reproduction.

8.6.2 Coupler or ear simulator (including HATS) frequency response

8.6.2.1 Characteristic to be specified

The variation of the sound pressure (level) in the coupler or ear simulator as a function of frequency, when a sinusoidal voltage of variable frequency, under standard measuring conditions, is applied to the headphone in series with the rated source impedance. The type of coupler or ear simulator and pinna used (see 7.3 if any) shall be stated in the results.

The value of this characteristic can also be deduced from measurements using:

- narrowband or wideband noise signals;
- impulse signals or other appropriate signals for impulse response calculation.

Especially, calculation of transfer function by Fourier transform of the impulse response is recommended because it brings not only amplitude (level) frequency response but also phase frequency response.

NOTE Information for measurements using impulse response are given in ISO 18233.

If one of these types of signal is used, it is the responsibility of the test house to show that the results are equivalent to those obtained with sinusoidal signals.

8.6.2.2 Method of measurement

The method of measurement is detailed below.

a) The headphone is brought under standard conditions for measurement, and a sinusoidal source of variable frequency, at the rated source e.m.f., is applied in series with the rated source impedance.

b) The frequency is then varied over at least the rated frequency range of the headphone (see 8.6.6), and the sound pressure (level) at each frequency is noted. This should be done automatically, using a swept- or stepped-frequency source, and a chart recorder or plotter. The chart speed and resolution, which should be stated by the manufacturer, shall be chosen so that the specified accuracy of the results is obtained.

NOTE If the direction of the frequency sweep affects the results, the results with the frequency sweeping from low to high should be used, and this should be stated in the results.

c) The results are presented graphically. If sound pressure level in decibels is plotted against frequency on a logarithmic scale, the preferred scale has the same length representing 50 dB as represents one decade of frequency (see IEC 60268-1 and IEC 60263).

8.6.3 Free-field comparison frequency response

8.6.3.1 Characteristic to be specified

The quotient, as a function of frequency, of the sound pressure of the reference-free sound field by the source e.m.f. to the headphone which is required to produce a sound subjectively equal in loudness to the free sound field. It is normally expressed in decibels referred to the value at the standard reference frequency.

8.6.3.2 Method of measurement (direct)

In order to apply this method, it is necessary for two earphones, with sufficiently similar frequency response to allow adequate accuracy of measurement, to be worn simultaneously by a test person (see Annex E).

NOTE Similarity of response within 2 dB is often sufficient.

a) The headphone is brought under free-field comparison conditions (see 7.4 and Annex C).

b) The test signals are 1/3 octave filtered bands of pink noise, covering at least the rated frequency range (see 8.6.5). For each band, the test person listens alternately to the free field, with the headphone removed, and then to the headphone, and the source e.m.f. applied to the headphone, in series with the rated source impedance, is adjusted until equal loudness is obtained. The adjustment may be performed by the test person or the test supervisor, or automatically under computer control.

c) It has proved practical to begin the test sequence with the band centred on 1 kHz, proceed higher in frequency to at least the upper limit of the rated frequency range, continue the tests with descending centre frequencies, at least to the lower limit of the rated frequency range, and then with increasing centre frequencies up to the 1 kHz band.

d) The tests shall be repeated with at least eight test persons. The individual test results differ due to differences in head and pinna shape and size (see Annex E).

e) The results for all the test persons are averaged in each $^1/_3$ octave band, and the resulting bar graph is presented as the free-field comparison frequency response of the headphone. The standard deviation of the results in each band should be indicated on the graph. The scales for the graph preferably shall be such that 50 dB is represented by the same length as one decade of frequency.

8.6.3.3 Method of measurement (by substitution)

A headphone, whose free-field comparison frequency response has been measured as described in 8.6.2.2, using a panel of at least 16 persons, may be used as a loudness comparison reference for the measurement of other headphones. The reference headphone shall be supplied with noise voltages equal to those obtained in its direct measurement. The measurement shall be carried out in a quiet room, and the results, calculated as described in 8.6.3.2, shall state that a substitution method has been used.

NOTE The accuracy of this method is greater if the characteristics of the reference headphone and the headphone being tested are similar.

8.6.4 Diffuse-field comparison frequency response

8.6.4.1 Characteristic to be specified

The quotient, as a function of frequency, of the sound pressure of the reference diffuse sound field by the source e.m.f. to the headphone required to produce a sound subjectively equal in loudness to the diffuse sound field. It is normally expressed in decibels referred to the value at the standard reference frequency.

8.6.4.2 Method of measurement (direct)

In order to apply this method, it is necessary for two earphones, with sufficiently similar frequency response to allow adequate accuracy of measurement, to be worn simultaneously by a test person (see Annex E).

NOTE Similarity of response within 2 dB is often sufficient.

a) The headphone is brought under diffuse-field comparison conditions (see 7.4 and Annex D).

b) The test signals are 1/3 octave filtered bands of pink noise, covering at least the rated frequency range (see 8.6.5). For each band, the test person listens alternately to the diffuse field, with the headphone removed, then with the headphone, and adjusts the source e.m.f. applied to the headphone, in series with the rated source impedance, until equal loudness is obtained. The adjustment may be performed by the test person or the test supervisor, or automatically under computer control.

c) It has proved practical to begin the test sequence with the band centred on 1 kHz; proceed higher in frequency to at least the upper limit of the rated frequency range, continue the tests with descending centre frequencies, at least to the lower limit of the rated frequency range, and then with increasing centre frequencies up to the 1 kHz band.

d) The tests shall be repeated with at least eight test persons. The individual test results differ due to differences in head and pinna shape and size (see Annex E).

e) The results for all the test persons are averaged in each 1/3 octave band, and the resulting bar graph is presented as the diffuse-field comparison frequency response of the headphone. The standard deviation of the results in each band shall be indicated on the graph. The scales for the graph preferably shall be such that 50 dB is represented by the same length as one decade of frequency.

8.6.4.3 Method of measurement (by substitution)

A headphone whose diffuse-field comparison frequency response has been measured as described in 8.6.3.2, using a panel of at least 16 persons, may be used as a loudness comparison reference for the measurement of other headphones. The reference headphone shall be supplied with noise voltages equal to those obtained in its direct measurement. The measurement shall be carried out in a quiet room, and the results, calculated as described in 8.6.3.2, shall state that a substitution method has been used.

NOTE See the Note to 8.6.3.3.

8.6.5 Free-field and diffuse-field ear canal sound pressure level frequency responses

8.6.5.1 Characteristics to be specified

The characteristics to be specified are as follows:

a) the free-field ear canal sound pressure level frequency response, which is the frequency response when the sound pressure level produced by the headphone is measured in the ear canal, averaged for a group of test persons, referred to the sound pressure level in the ear canal when the test person is exposed to a free sound field;

b) the diffuse-field ear canal sound pressure level frequency response, which is the frequency response when the sound pressure level produced by the earphone is measured in the ear canal, averaged for a group of test persons, referred to the sound pressure level in the ear canal when the test person is exposed to a diffuse sound field.

NOTE 1 These characteristics are not applicable for earphones whose construction prevents measurement of the sound pressure level in the ear canal.

NOTE 2 The two characteristics do not in general give the same results. At present, it is not possible to correlate the results, nor to correlate either precisely with the results of other measurements.

8.6.5.2 Method of measurement (direct)

In order to apply this method, it is not necessary for two similar earphones to be worn simultaneously by the test person.

a) The headphone is brought under free-field or diffuse-field comparison conditions (see 8.6.2.2 or 8.6.3.2 and Annex E).

b) The test signals are $^1/_3$ octave bands of pink noise, covering at least the rated frequency range (see 8.6.5). For each band, the output voltage level of a very small microphone in the ear canal of the test person is measured through a $^1/_3$ octave filter with appropriate centre frequency (see 7.5 and Annex B). The sound pressure level should not exceed 85 dB (ref. 20 micro Pa), but shall be sufficient to achieve a signal-to-noise ratio of at least 10 dB for the filtered microphone signal.

NOTE 1 It is necessary to use a meter with a sufficiently long integration time-constant to measure the output voltage from the microphone with the required accuracy, and that each test signal is applied for a time sufficient for the meter to reach its steady state reading (see Annex E).

c) The headphone is then carefully put on by the test person, and the test signal is removed from the system generating the sound field and applied to the earphone being measured. The signal level is adjusted, using the $^1/_3$ octave band of noise centred on 500 Hz, so that the filtered microphone output signal level is within 3 dB of that due to the sound field in the same frequency band, measured in item b) above. The filtered microphone output signal level is then measured for each $^1/_3$ octave band, as in item b).

d) The test person then removes the headphone and immediately replaces it. The measurement in item c) is then repeated.

e) The headphone is then removed, and the test signal restored to the sound-field generating system. The measurement in item b) is then repeated.

f) The results of the measurements in items c) and d) are then compared, and if there is a difference exceeding 2,5 dB (for example, due to differences in the way that the headphones are fitted) in any 1/3 octave band, the whole procedure is repeated.

NOTE 2 For some persons, the sound-field measurements are continually inconsistent. Such persons are unsuitable as test persons.

NOTE 3 Differences in fitting the headphones may cause differences exceeding 2,5 dB.

g) The results of the measurements in items b) and e), and those in items c) and d), are arithmetically averaged. The frequency response of the earphone, for each $^1/_3$ octave band, is given by

$$L_f = L_e - L_s - (L_e - L_s)_{500} \quad (1)$$

where

L_f is the relative frequency response, referred to the response at 500 Hz (dB);

L_e is the filtered microphone output signal voltage level due to the earphone (dB);

L_s is the filtered microphone output signal voltage level due to the sound field (dB);

$(L_e - L_s)_{500}$ is the difference between L_e and L_s for the 500 Hz band (dB).

h) The measurements are repeated with at least eight test persons. The final results are obtained by arithmetically averaging the values of L_f for each band. These results may be tabulated or presented graphically, the scales being preferably chosen so that 50 dB and one decade of frequency are represented by the same length.

NOTE 4 Instead of $^1/_3$ octave bands of noise, the test signal may be a wideband noise, if a comparison test shows that this does not introduce unacceptable inaccuracy. The use of wideband noise should be stated in the results.

NOTE 5 The results should include details of the number of test persons used, if other than eight, and the standard deviation of the results in each band.

8.6.5.3 Method of measurement (indirect)

The method of measurement is the same as given in 8.6.4.2, except that the sound field is replaced by a headphone, previously calibrated by the method of 8.6.4.2, using at least 16 test persons for increased accuracy. The use of the indirect method, and the type of calibrated headphone, shall be stated in the results.

8.6.6 Rated frequency range

NOTE 1 This is a rated condition.

Characteristic to be specified:

The range of input frequencies, specified by the manufacturer, which the headphone is intended to reproduce. The manufacturer shall state the criteria on which the selection of the limit frequencies is based.

NOTE 2 It is not at present possible to set limits for the frequency range based on deviations from a flat, or defined, frequency response, because of difficulties in correlating the results of measurements with subjective evaluations.

8.7 Amplitude non-linearity

8.7.1 General

Subclause 8.7 provides specification on amplitude non-linearity of headphones and earphones.

NOTE For a detailed explanation of different ways of measuring and expressing amplitude non-linearity, see IEC 60268-2. The basic methods of measurement for the different ways are given in IEC 60268-3.

8.7.2 Harmonic distortion

8.7.2.1 Characteristics to be specified

The characteristics to be *specified* are as follows:

a) harmonic distortion of the nth order (n = 2 or 3), which is the ratio of the output sound pressure at n times the input frequency to the total sound pressure, with the rated input voltage applied in series with the rated source impedance;

b) total harmonic distortion, which is the ratio of the r.m.s. sum of the output sound pressures at multiples of the input frequency to the total sound pressure, with the rated input voltage applied in series with the rated source impedance.

These characteristics may be specified at the standard reference frequency or, preferably, expressed graphically as a function of frequency.

8.7.2.2 Method of measurement

The method of measurement is detailed below.

a) The headphone is brought under standard conditions for measurement.

b) The input voltage is adjusted to be equal to the rated voltage, applied in series with the rated source impedance, at the standard measuring frequency.

c) The second and third harmonic distortion components of the signal from the measuring microphone system, and/or the total harmonic distortion, are measured.

NOTE It is obviously essential that the distortion in the measuring microphone system is much less than that in the headphone.

d) The measurements may be repeated at other frequencies, or a swept- or stepped-frequency measurement may be made, with automatic plotting of the results.

8.7.3 Modulation distortion

8.7.3.1 General

For a detailed explanation of modulation distortion, see IEC 60268-2.

8.7.3.2 Characteristics to be specified

The second and third order intermodulation distortions; when the signal is composed of two sinusoidal signals, at 70 Hz and 600 Hz, with amplitude ratio 4:1, and has a peak voltage equal to that of the rated input voltage.

8.7.3.3 Method of measurement

The method of measurement is detailed below.

a) The headphone is brought under standard measuring conditions, and then the signal is adjusted to the sum of two sinusoidal signals, at 70 Hz and 600 Hz, with amplitude ratio 4:1. The peak voltage of the signal shall be equal to that of the rated input voltage.

NOTE 1 The signal levels referred to the rated input voltage should be −1,9 dB at 70 Hz and −14,0 dB at 600 Hz.

b) The second and third-order modulation distortion components at the output of the measuring microphone system are measured with a wave or spectrum-analyzer. The second-order components are at 530 Hz and 670 Hz, and the third-order components are at 460 Hz and 740 Hz.

NOTE 2 It is obviously essential that the distortion in the microphone system is much lower than in the headphone.

c) The second order modulation distortion, expressed in decibels, is calculated as:

$$L_{d2} = 20 \log \{(U_{530} + U_{670})/U_{600}\} \quad (2)$$

where the suffix indicates the frequency, and the third order modulation distortion, expressed in decibels, is calculated as:

$$L_{d3} = 20 \log \{(U_{470} + U_{740})/U_{600}\} \quad (3)$$

8.7.4 Difference-frequency distortion

8.7.4.1 Characteristic to be specified

The difference-frequency distortions of the second and third orders, when the input signals are two sinusoidal signals, separated in frequency by 80 Hz, each giving half the rated input voltage (see IEC 60268-2).

8.7.4.2 Method of measurement

The method of measurement is detailed below.

a) The headphone is brought under standard measuring conditions, and then the input signal is changed to that required for the measurement (see 8.7.3.1).

b) The required difference-frequency components at the output of the measuring microphone system are measured with a wave or spectrum-analyzer. A total difference-frequency distortion meter may be used.

c) The second-order difference-frequency distortion, expressed in decibels, is calculated as:

$$L_{dd2} = 20 \log (U_{f2-f1}/2\ U_{f2}) \quad (4)$$

and the third-order difference-frequency distortion as:

$$L_{dd3} = 20 \log \{U_{2f2-f1} + U_{2f1-f2})/2\ U_{f2}\} \quad (5)$$

d) The measurements of second and third-order difference-frequency distortion may be carried out using swept- or stepped-frequency signals, and a chart-recorder or plotter, the results being presented graphically as functions of frequency.

8.8 Rated climatic conditions

NOTE These are rated conditions.

Characteristics to be specified:

a) rated temperature range;

b) rated humidity range;

c) rated air-pressure range.

These are the ranges, specified by the manufacturer, over which the headphone is intended to meet its specifications.

8.9 External electric and/or magnetic field

8.9.1 Characteristics to be specified

The characteristics to be specified are as follows:

a) the maximum direct and alternating components of the electric and/or magnetic field generated at a stated position in space relative to the headphone, when the headphone is supplied with the rated voltage at the standard reference frequency in series with the rated source impedance;

b) the maximum alternating (and direct, if any) component of the electric and/or magnetic field generated by any auxiliary equipment which forms part of the headphone system, at a stated position in space relative to the equipment, under stated conditions of supply and signal voltage and frequency.

NOTE Although the accepted safety limits are far higher than the usual values of these field strengths, it is recommended to keep these emissions as low as possible because the limits could be reduced as result of continuing research. See IEC 61786 for information of measurement.

8.9.2 Method of measurement

The method of measurement is detailed below.

a) Alternating components of the electric and/or magnetic field may be measured with a calibrated search coil (see IEC 60268-1).

b) Direct components of the electric and/or magnetic field may be measured with a suitable flux meter.

8.10 Unwanted sound radiation

8.10.1 Characteristic to be specified

For a sinusoidal input signal at rated source e.m.f., in series with the rated source impedance, and at any frequency within the rated frequency range, the sound pressure level produced in a free-field at 0,1 m from the headphone, on the axis in a direction opposite to that of the normal acoustic exit. The headphone is applied to the appropriate coupler or ear simulator.

This characteristic is normally expressed as a graph of sound pressure level against frequency on a logarithmic scale.

8.10.2 Method of measurement

The method of measurement is detailed below.

a) The headphone is brought under standard conditions for measurement in an anechoic room, and a measuring microphone is placed at 0,1 m distance, facing the back of the earphone.
b) The signal is then changed to a swept- or stepped-frequency signal, at the rated voltage, covering at least the rated frequency range, and the sound pressure level measured by the microphone is plotted against frequency.

8.11 Sound attenuation

8.11.1 Characteristic to be specified

The attenuation of an external sound field, produced by the headphone, expressed in decibels as a function of frequency.

8.11.2 Method of measurement

The measurement shall be made as specified in ISO 4869-1.

NOTE Headphones forming part of a system giving active noise compensation (e.g. active ear defenders) may require a modified procedure.

8.12 Crosstalk attenuation for multi-channel headphones

8.12.1 Characteristic to be specified

The ratio of the sound pressure produced in the coupler or ear simulator due to rated source e.m.f. applied to the channel under test to the sound pressure produced by rated source e.m.f. applied to another, stated channel. This characteristic is normally expressed as a graph of the difference of the sound pressure levels in decibels against frequency on a logarithmic scale.

8.12.2 Method of measurement

The method of measurement is detailed below.

a) The coupler frequency response curve is measured (see 8.6.1). Any crosstalk controls shall be set for minimum crosstalk.
b) The signal is then applied to another input channel, and the measurement repeated.
c) The difference in sound pressure levels is plotted against frequency.
d) The measurement may be repeated for other stated positions of crosstalk controls.

8.13 Application force

NOTE This is a rated condition.

8.13.1 Characteristic to be specified

The clamping force exerted by the headphone on a test jig simulating a human head.

8.13.2 Method of measurement

The method of measurement is detailed below.

a) The headphone is applied to a test jig as specified in ISO 4869-3.

b) The application force is measured with an electric force gauge, or other device of sufficient accuracy.

8.14 Physical characteristics, cables and connectors

8.14.1 Characteristics to be specified

The characteristics to be specified are as follows:

- the main dimensions;
- the weight of the headphone and of all auxiliary equipment;
- the length and type of cable, and, for coiled cords, the coiled length and the maximum stretched length;
- the types of connectors used for the input to the system, and within the system (see IEC 60268-11 and IEC 60268-12).

9 Classification of characteristics

Table 1 – Classification of characteristics

Clause/subclause	Characteristics	A[a]	B[b]
4	Classification code and description	R[d]	X[c]
7.3	Type of coupler or ear simulator		X
8.1	Type of power supply	X	X
	Rated supply voltage and frequency	X	X
	Maximum power drawn from the power supply	X	X
8.2.1	Rated impedance	X	X
8.2.2	Rated impedance/frequency characteristic		R
8.2.3	Rated source impedance		X
8.3.1	Rated source e.m.f.		X
8.3.2	Limiting values of input voltage		R
8.3.3	Rated characteristic voltage		X
8.3.4	Rated characteristics of protective devices		X
8.5.1	Rated maximum or working sound pressure level		X
8.6	Rated frequency response (one or more of the characteristics described in this subclause)		X
8.6.5	Rated frequency range		X
8.7.1	Rated harmonic distortion		X
8.7.2	Rated modulation distortion		R
8.7.3	Rated difference-frequency distortion		R
8.8	Rated climatic conditions		X
8.9	Rated external magnetic field		R
8.10	Rated unwanted sound radiation		R
8.11	Rated sound attenuation		R
8.12	Rated crosstalk attenuation		R
8.13	Rated application force		X
8.14	Physical characteristics, cables and connectors:		
	– dimensions		R
	– weight		X
	– length and type of cable, etc.		X
	– types of connectors		

NOTE 1 Instead of the above (8.3.1 to 8.3.4), the corresponding characteristics related to power (see 8.4) may be stated.

NOTE 2 To avoid misunderstandings or arbitrary references to national or international requirements on accuracy, it is highly recommended that all physical values in data sheets published in accordance with the table are given including guaranteed tolerances.

[a] Column A represents data marked on the headphone or auxiliary equipment.

[b] Column B represents data specified in a document available to the user before purchase.

[c] Code X represents essential data which shall be given in all cases.

[d] Code R represents other data recommended to be given.

Annex A
(normative)

Pinna simulators for measurements of headphones and earphones

The pinna simulators in IEC TR 60959 are primarily intended for hearing aid measurements, including behind-the-ear hearing aids. Therefore, these pinna simulators have extra-large ear protrusions, larger concha volumes and a simple ear canal inlet shape. This reduces their suitability for supra-aural, circumaural, supra-concha, intra-concha and insert earphone measurements.

The ear simulators used for measurements of headphones and earphones, enumerated in 7.3, may occasionally bear uncertainty of the measured data due to the difficulty of identical application of units to ear simulators. This defect is remarkable at the measurements of headphones for portable audio sets, that is intra-concha and insert earphones.

a) This annex specifies a pinna simulator to consist of an improved ear simulator for measurement of headphones and earphones, by combination of the IEC 60711 ear simulator.

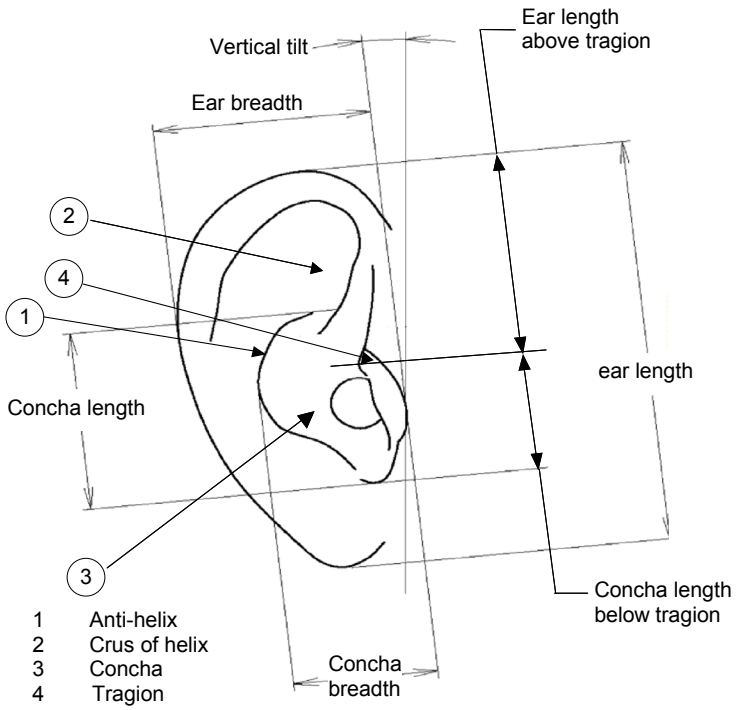
b) For the purposes of this annex, the terms and definitions in IEC TR 60959 are applied.

c) The precise shape of the recommended pinna simulator is shown in Figures A.1 and A.2. Cross-sectional shapes and dimensions are shown in Figures A.3a, A.3b and A.3c and Figures A.4a, A.4b and A.4c. Figure A.3 shows horizontal and Figure A.4 shows vertical sections, respectively. Figures A.3 to A.4 show cross-sections of the right pinna. The left pinna is determined as a mirror image of the right pinna.

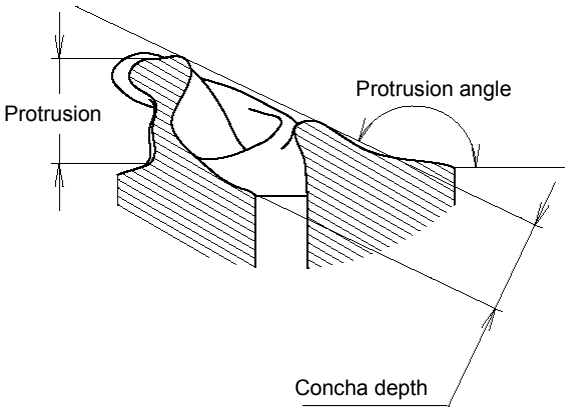
   The pinna simulator shall be made from a high-quality rubber or elastomer, the shore-A hardness of which, measured at the surface 15 mm forward to the ear canal opening should be 35. The limiting date, until which the mechanical characteristics of the pinna simulator are guaranteed, should be indicated, if necessary. See also ISO 7619-1.

d) The earphone to be measured should be applied to the ear simulator in a mechanically stable manner. The relative position of the sound outlet of the earphone and the entrance of the simulated ear canal should be checked carefully.

e) The ear simulator comprises an occluded ear simulator as described in IEC 60711, extended beyond the occluded ear simulator reference plane by an 8,8 mm long circular cylinder having a diameter of 7,5 mm ± 0,02 mm. The ear canal extension terminates at the ear simulator reference plane and is connected to the pinna as shown in Figures A.3 and A.4.



a) Side view



b) Cross-section

IEC 2485/09

Key

Ear length	58 mm
Ear length above tragion	28 mm
Ear breadth	28 mm
Ear protrusion	14 mm
Protrusion angle	155°
Vertical tilt front view	6°
Vertical tilt side view	6°
Concha length	26 mm
Concha length below tragion	19 mm
Concha breadth	18 mm
Concha breadth, tragion to helix	18 mm
Concha depth	13 mm

Figure A.1 – Shape of the recommended pinna simulator

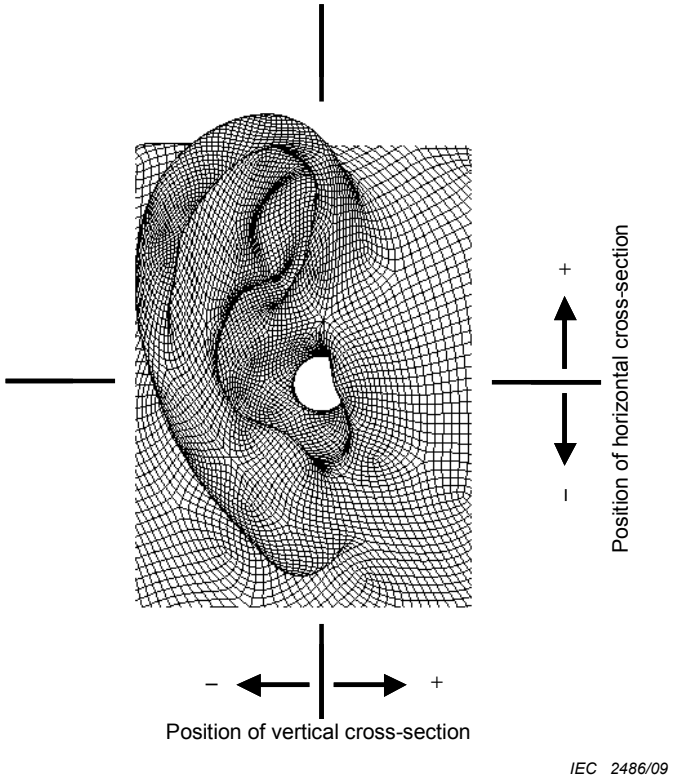
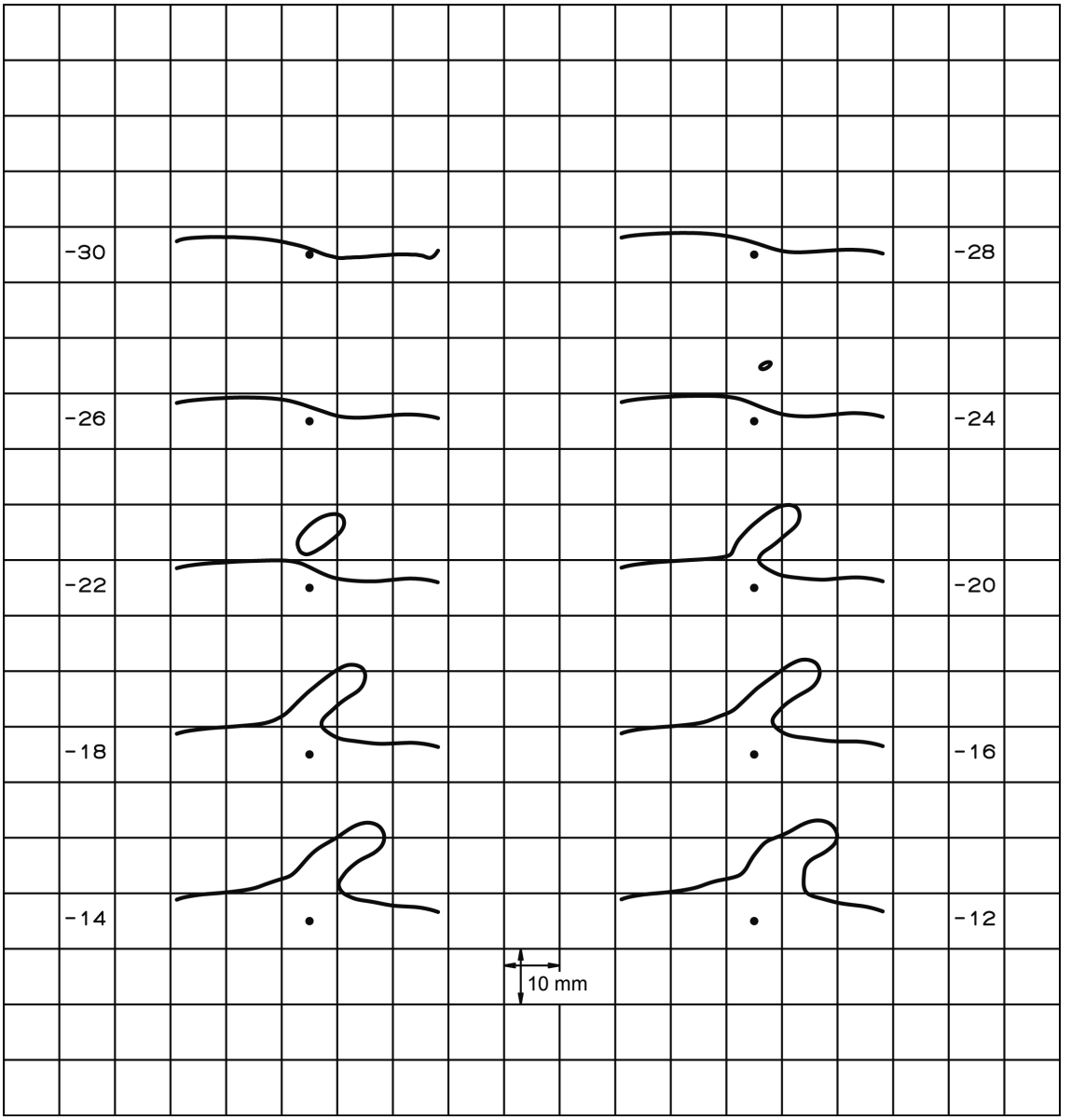
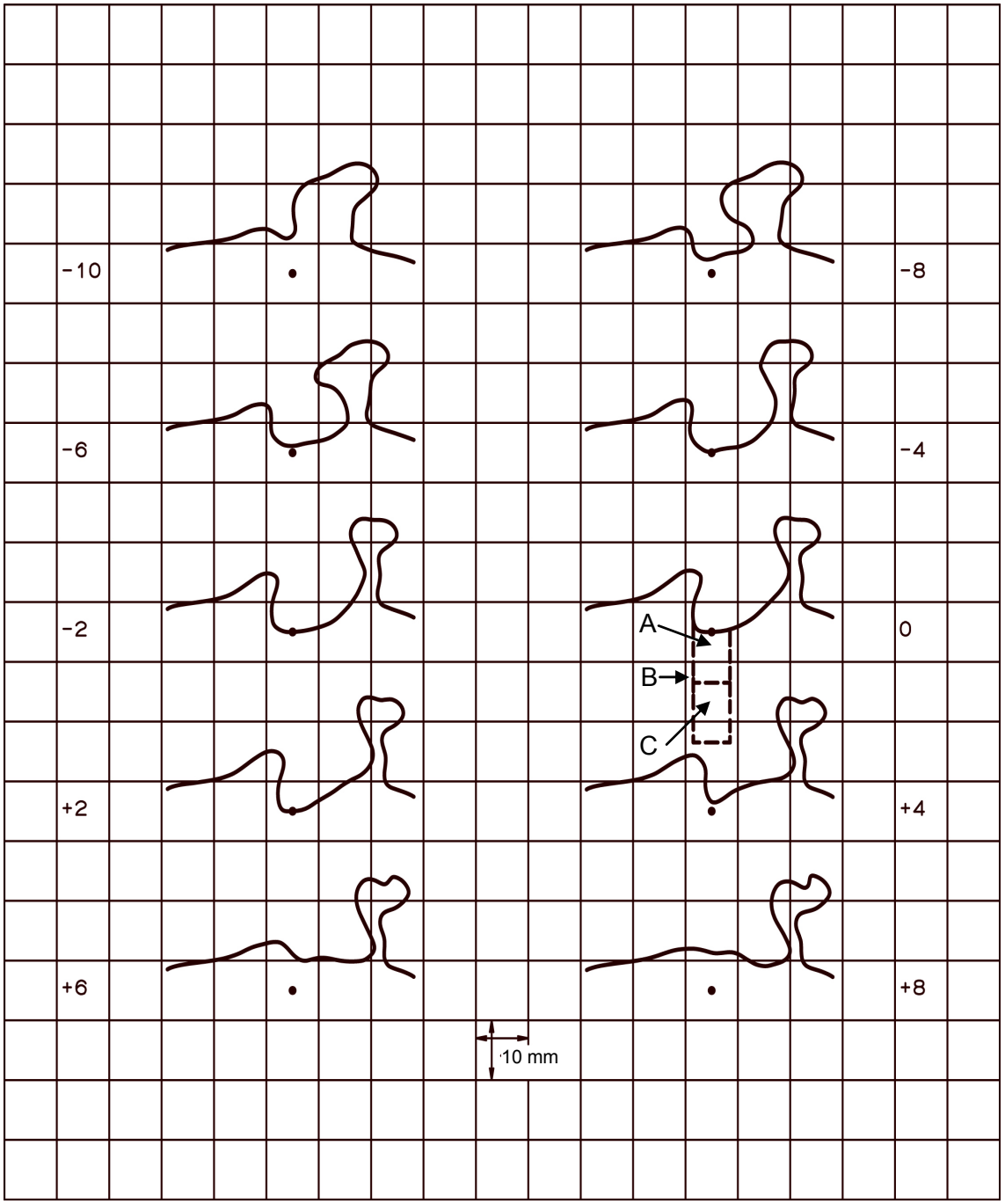


Figure A.2 – Coordinate for the recommended pinna simulator



Tolerance ±0,7 mm

Figure A.3a – −30 mm to –12 mm



Tolerance ±0,7 mm

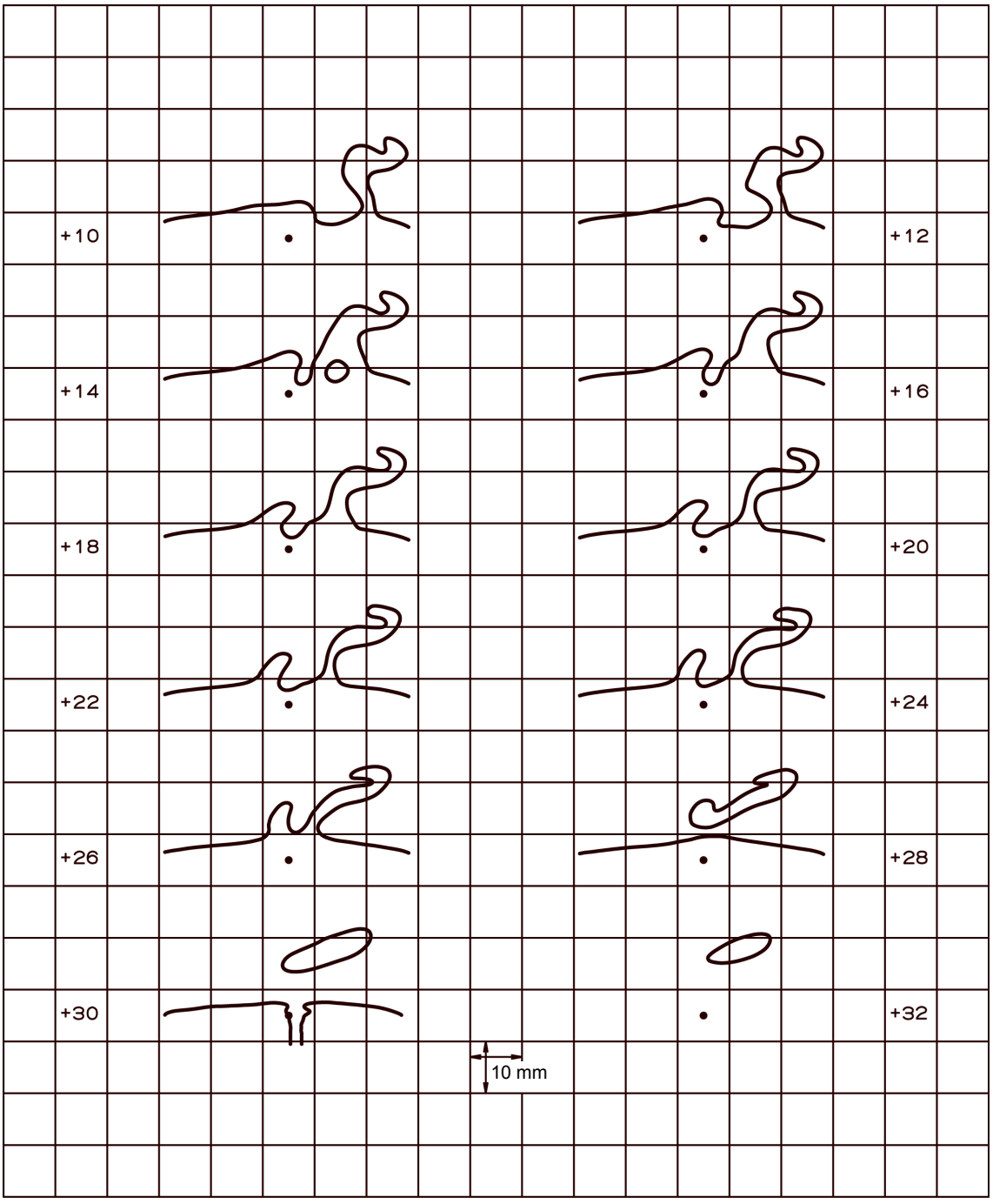
Key

A: Ear canal extension

B: Occluded ear simulator reference plane

C: Occluded ear simulator

Figure A.3b – –10 mm to +8 mm

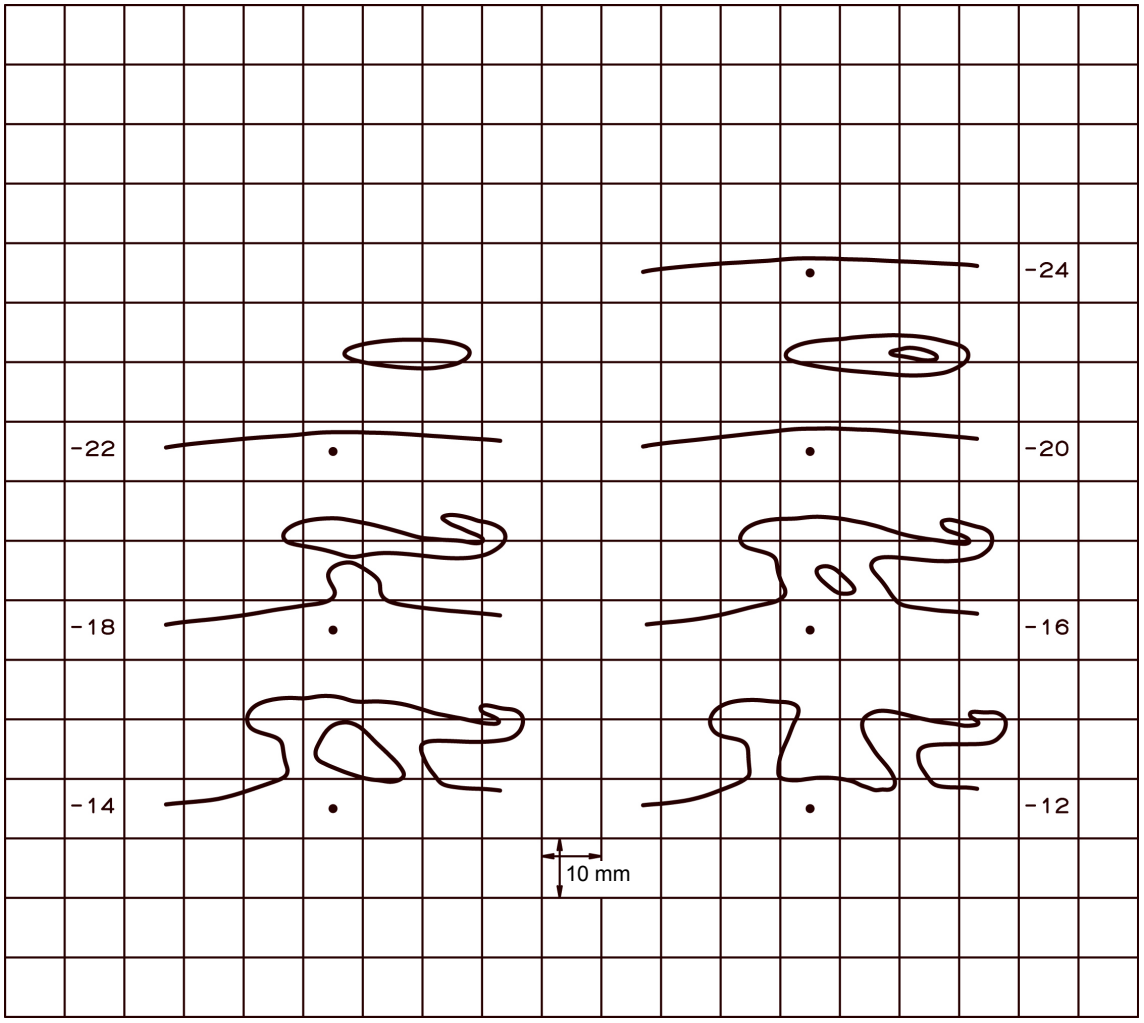


Tolerance ±0,7 mm

Figure A.3c – +10 mm to +32 mm

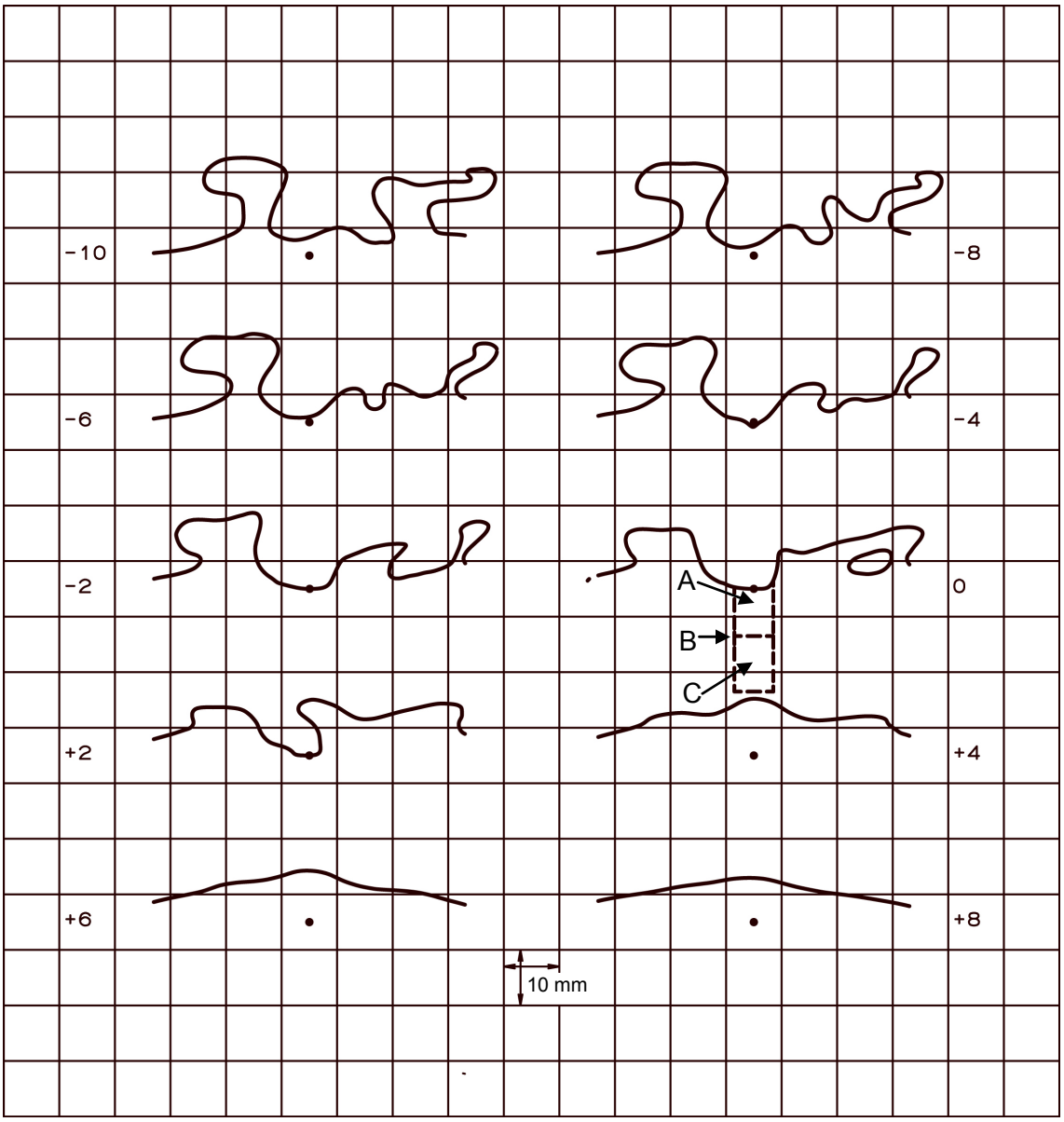
Figure A.3 – Cross-sectional shapes and dimensions of the recommended pinna simulator, horizontal section

The dots indicate the position of the pinna reference axis. The grid lines are spaced 10 mm. The orientation of the cross-section is such that the front of the head is toward the left.



Tolerance ±0,7 mm

Figure A.4a – −24 mm to −12 mm



Tolerance ±0,7 mm

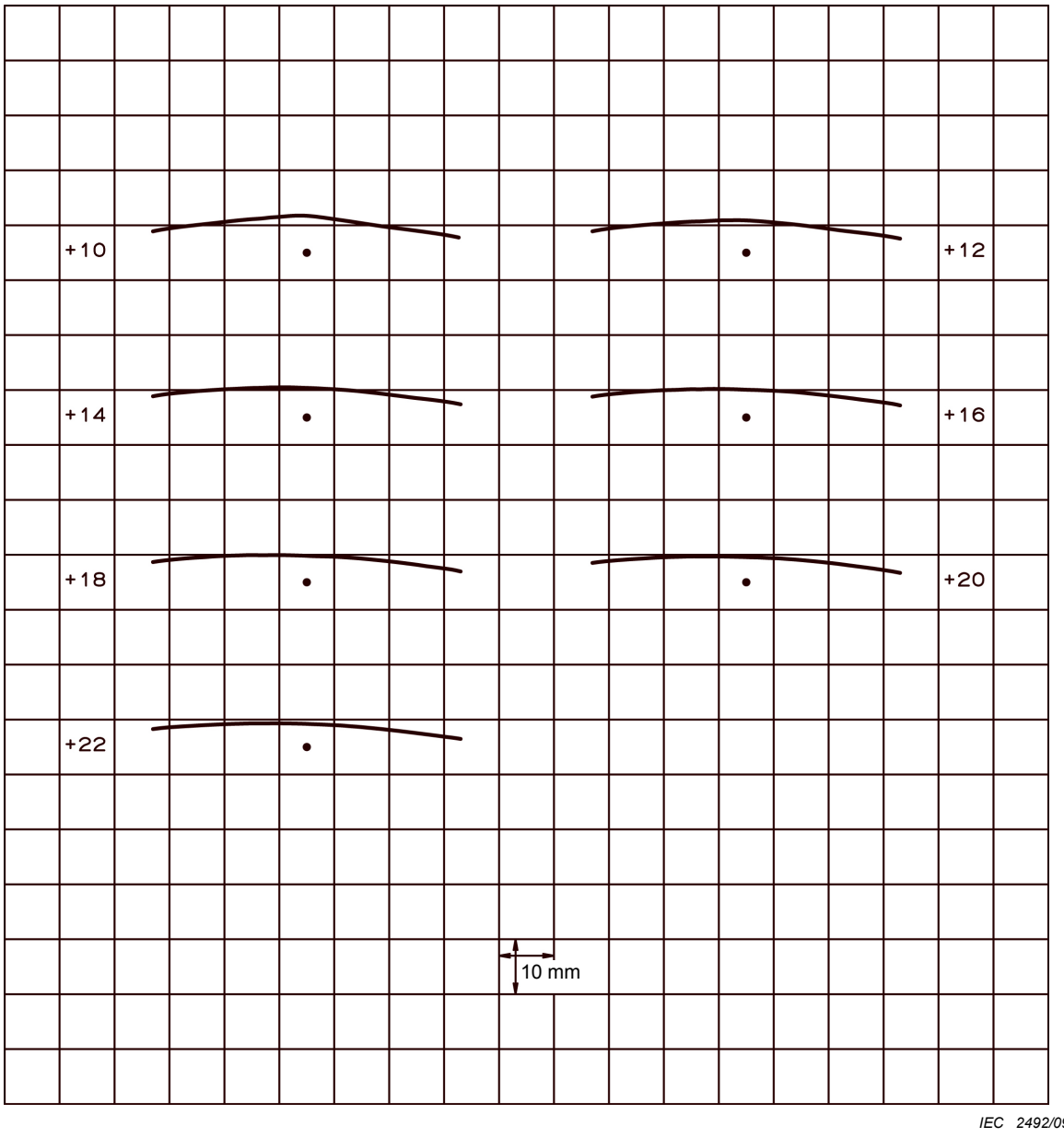
Key

A: Ear canal extension

B: Occluded ear simulator reference plane

C: Occluded ear simulator

Figure A.4b – −10 mm to +8 mm



Tolerance ±0,7 mm

Figure A.4c – +10 mm to +22 mm

The dots indicate the position of the pinna reference axis. The grid lines are spaced 10 mm. The orientation of the cross-section is such that the front of the head is toward the left.

Figure A.4 – Cross-sectional shapes and dimensions of the recommended pinna simulator, vertical section

Annex B
(normative)

Specification and conditions of use of a microphone for use inside the ear canal

The following conditions have been found necessary:

a) the microphone has a cross-sectional area of 5 mm^2 or less within the area of the concha and the first 4 mm of the ear canal;

b) in the remainder of the ear canal, the ratio of the microphone cross-sectional area to the ear canal cross-sectional area is less than 0,6. (The average ear canal area of an adult is 45 mm^2.);

c) the volume of the microphone, including mounting parts, is less than 130 mm^3;

d) the frequency response of the microphone is free of resonances which might affect the result. Usually, it is sufficient if the responses due to neighbouring $^1/_3$ octave bands of pink noise do not differ by more than 3 dB;

e) the output voltage level of the microphone, with the sound entrance sealed, is at least 15 dB below that with the entrance open, at all measuring frequencies;

f) the microphone has suspending elements which fix it in a stable position in the ear canal. The elasticity of these elements accommodates different ear canal dimensions, while allowing easy insertion and removal of the microphone;

g) the microphone has been inspected by an appropriately qualified physician, and certified, with regard to the medical aspects, for safe use.

Annex C
(informative)

Practical details of free-field comparison conditions

The following conditions have been found to give satisfactory results:

a) the loudspeaker is arranged at head height for each seated listener, the reference axis being directed through the reference point for the measurement. The distance between the reference point of the loudspeaker (IEC 60268-5) and the reference point for the measurement is at least 2 m;

NOTE 1 The reference point for the measurement is defined in ISO 4869-1 as the mid-point of a line joining the listener's ear canal openings.

b) the sound pressure level produced by the loudspeaker does not deviate within a circle of 150 mm radius, centred on the reference point for the measurement, and lying in a plane perpendicular to the reference axis of the loudspeaker, by more than ±1 dB for any of the test signals at frequencies below 4 kHz, nor by more than ±2 dB at frequencies between 4 kHz and 12,5 kHz;

c) the sound pressure level produced by the loudspeaker, within a sphere of 150 mm radius centred on the reference point for the measurement, does not vary by more than ±2,5 dB for any $^1/_3$ octave band of noise with centre frequency from 100 Hz to 12,5 kHz. The frequency response of the loudspeaker, measured with sinusoidal signals, should be free from sharp peaks and dips, so as to avoid errors due to colouration;

d) the sound pressure level produced by the loudspeaker at the reference point for the measurement is fairly constant (within ±5 dB, for example) and approximately 70 dB (ref. 20 μPa) for all frequency bands;

e) the total harmonic distortion of the signal from the loudspeaker and that of the headphone do not exceed 2 % under the conditions for measurement. The free-field comparison frequency response of the headphone has to be taken into account when calculating the distortion;

NOTE 2 The distortion at low frequencies may exceed 2 % if this can be shown not to affect the accuracy of the results.

f) Annex E also applies, with the exception of Clause E.3;

g) reference document IEC 60268-5.

Annex D
(informative)

Practical details of diffuse-field comparison conditions

The following conditions have been found to give satisfactory results:

NOTE 1 The conditions in Clauses C.2 and C.3 are taken, in part, from ISO 4869-1.

a) the test person is seated in the optimum position in the diffuse field. The distance between the reference point of the nearest loudspeaker and the reference point for the measurement is 2 m or more (see Note 3);

NOTE 2 See the Note to item a) of Annex C.

NOTE 3 The distance of 2 m may be reduced to approximately 1,3 m if this can be shown not to affect the accuracy of measurement.

b) the sound pressure level, measured with an omnidirectional microphone, does not deviate, at the six points above, below and to the right, left, front and back, on a sphere of 150 mm radius, centred on the reference point for the measurement, by more than ± 2,5 dB for any of the test signals within the range 100 Hz to 12,5 kHz. For this test, the axis of the microphone is fixed in direction. If measurements are made with both ears, the sound pressure levels at 150 mm distance to the right and left of the reference point do not differ by more than 3 dB;

c) the sound pressure level of the diffuse field at the reference point for the measurement, measured with a unidirectional microphone having a front to random sensitivity index of at least 5 dB, does not vary with the direction of the axis of the microphone by more than 5 dB for any 1/3 octave band of noise with centre frequency from 500 Hz to 12,5 kHz;

NOTE 4 The number of different directions at which the measurements should be made depends on the type of microphone and the layout of the equipment. The directions giving maximum and minimum sound pressure level should be identified for each frequency band.

NOTE 5 It may be necessary to use more than one loudspeaker, possibly fed with uncorrelated noise signals, in order to avoid wave interference effects.

d) the sound pressure level of the diffuse field at the reference point for the measurement is fairly constant (within ± 5 dB, for example) and approximately 70 dB (reference 20 μPa) for all frequency bands.

e) the total harmonic distortion of the diffuse field and that of the headphone do not exceed 2 % under the conditions for measurement. The diffuse-field comparison frequency response of the headphone has to be taken into account when calculating the distortion;

NOTE 6 See the Note 2 to item e) of Annex C.

f) Annex E also applies, with the exception of item c).

Annex E
(informative)

Practical details of the subjective comparison and ear canal sound pressure level conditions

The following conditions have been found to give satisfactory results:

a) spectacles, earrings and anything else which might influence the position of the headphone are removed or, in the case of a hair-style, re-arranged;

b) the pinna of the test person do not show any unusual characteristic and, for the subjective comparison, the test person's hearing falls within the normal range (see ISO 7029);

c) the dimensions of the ear canal(s) are compatible with safe insertion of the microphone and the maintenance of a stable microphone position;

d) for free-field measurements, the head position of the test person is fixed by means of mechanical or optical aids;

e) the headphone is worn as intended by the manufacturer, particularly regarding the application of the left and right earphones to the appropriate ears. The test persons normally put the headphones on, but the measurement operator should check and correct any obvious errors;

f) the test person listens for approximately 2,5 s to the sound of the free field, and then to the sound of the headphone for a similar period, which is followed by a silent pause of 2,5 s. The test signals are applied without clicks;

g) the test persons should receive an explanation sufficient to ensure that the procedure is correctly followed;

h) reference document ISO 7029:1984.

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