

Intended use of human head and ear simulators — Guide

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 HSE — Health and Safety Executive
 IEE — Institute of Electrical Engineers
 IOA — Institute of Acoustics
 ISVR — Institute of Sound and Vibration Research
 MRC — Medical Research Council
 MHRA — Medicines and Healthcare products Regulatory Agency
 NPL — National Physical Laboratory
 PLASA — Professional Lighting and Sound Association
 SEE — Society of Environmental Engineers
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Foreword

This Published Document has been prepared by Technical Committee EPL/29. It provides guidance for the use of ear simulators in the fields of audiology, telecommunications, audio engineering and in certain aspects of hearing protection.

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Summary of pages

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Introduction

The generic term “ear simulator” in this document describes a range of devices, namely acoustic couplers, artificial ears, mechanical couplers and head and torso simulators. The degree to which these devices reflect the true performance of a transducer on a human being varies according to the device being used. Consequently the data that is produced from measurements on ear simulators needs to be interpreted with care when estimating what will happen on humans and in particular on any individual.

Ear simulators are made to conform to a variety of IEC (International Electrotechnical Commission) standards and are used primarily in three industries, namely audiology, telecommunications and audio engineering. These industries are not normally in close contact with each other on these matters and other standardizing bodies, e.g. the International Telecommunications Union (ITU), use IEC standards as a basis for their own standards. Furthermore, standards for measuring aspects of hearing produced by the International Organization for Standardization (ISO), e.g. loudness, and by ITU for telephony directly involve the use of ear simulators.

As ear simulators are intended to measure the output from earphones and bone vibrators it is necessary to define the form of ear simulator to be used with each type of transducer. In addition the earphones being measured may have different acoustic characteristics in terms of acoustic leakage, etc. that will significantly affect the method of measurement and needs to be taken into account when describing the appropriate ear simulator to be used.

The intended use and limitations of ear simulators requires clarification as most ear simulator standards are solely descriptions of such devices and give no indication of their applications.

This document is constructed so that after general issues concerned with the use of ear simulators are discussed, each of the following application areas are dealt with independently:

- applications for audiological purposes;
- applications in telecommunications;
- applications in audio engineering;
- applications in hearing protection.

1 Scope

This Published Document describes and gives guidance on the range of currently available standardized head and torso simulators, and ear simulators in the fields of audiology, telecommunications, audio engineering and hearing protection.

This guide describes ear simulators of the following types and their applications:

- acoustic couplers;
- artificial ears/occluded ear simulators;
- head and torso simulators;
- mechanical couplers for the calibration of bone vibrators.

The guide also describes the range of earphones available and how they are to be measured on appropriate ear simulators.

The guide does not describe the effects on the measurement of performance due to using different forms of test stimuli. The guide does not indicate the performance of a transducer (earphone or bone vibrator) on any individual person or the perceptual qualities of a listener using a transducer.

NOTE All documents referred to in the text are listed in the Bibliography.

2 Glossary of terms

The following terms and definitions used in conjunction with earphones/transducers and ear simulators are taken from appropriate IEC/ISO/ITU publications. Where differing definitions are used in standards emanating from different organizations the alternatives are given.

2.1 ear simulators

2.1.1

ear simulator

device for the calibration of earphones which incorporates a calibrated microphone for the measurement of sound pressure and an acoustic coupler. The overall acoustic impedance of the simulator approximates that of the average human ear in a given frequency band
[IEC 60318-1]

or

ear simulator

device for measuring the output sound pressure of an earphone under well-defined loading conditions in a specified frequency range. It consists essentially of a principal cavity, acoustic load networks, and a calibrated microphone. The location of the microphone is chosen so that the sound pressure at the microphone corresponds approximately to the sound pressure existing at the human eardrum
[ITU-T P.57]

2.1.2

artificial ear

device for the calibration of earphones incorporating an acoustic coupler and a calibrated microphone for the measurement of sound pressure and having an overall acoustic impedance similar to that of the average human ear over a given frequency band
[ITU-T P.57]

2.1.3

acoustic coupler

cavity of predetermined shape and volume which is used for the calibration of an earphone in conjunction with a calibrated microphone to measure the sound pressure developed within the cavity
[IEC 60318-3]

2.1.4

occluded-ear simulator

device that simulates the inner part of the ear canal, from the tip of an ear insert to the ear-drum
[ITU-T P.57]

2.1.5

pinna simulator

device which has the approximate shape and dimensions of a median adult human pinna
[ITU-T P.57]

2.1.6

ear canal extension

cylindrical cavity extending the simulation of the ear canal provided by the occluded ear simulator out of the concha cavity
[ITU-T P.57]

2.1.7

ear insert simulator

ear insert simulator (e.g. earmould simulator) is an insert which terminates the entrance of the ear simulator and provides for passage of sound into the occluded ear simulator through an opening on its axis
[IEC 60711]

2.1.8

ear pip

ear tip

ready-formed plastic ear insert designed to provide a seal between an acoustic input tube and the ear canal

2.1.9

head and torso simulator (HATS)

<for telephonometry> manikin extending downward from the top of the head to the waist, designed to simulate the sound pick-up characteristics and the acoustic diffraction produced by the median human adult and to reproduce the acoustic field generated by the human mouth
[ITU-T P58]

2.1.10

mechanical coupler

device designed to present a specified mechanical impedance to a vibrator applied with a specified static force, and equipped with a mechano-electric transducer to enable the alternating force level at the surface of contact between the vibrator and the mechanical coupler to be determined
[IEC 60373]

2.2

transducers (earphones and bone vibrators)

2.2.1

earphone

electroacoustic transducer by which acoustic oscillations are obtained from electric signals and intended to be closely coupled acoustically to the ear
[IEC 50(801) 801-27-18]

2.2.2

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)
[IEC 60268-7]

2.2.3

insert earphone

small earphone that is attached directly to a connecting element, e.g. an earmould, inserted into the ear canal
[IEC 50(801) 801-27-22, modified in IEC 60268-7]

or

insert earphone

small earphone coupled to the ear canal by means of an ear insert or attached to a connecting element which is inserted into the ear canal. This ear insert may be a part of the insert earphone
[IEC 60711]

or

insert earphones

earphones which are intended to partially or completely enter the ear canal
[ITU-T P.57]

2.2.4

ear insert

device used to provide the acoustic coupling between an earphone and the ear canal (e.g. an earmould or a similar device with or without a connecting tube)
[IEC 60711]

2.2.5

supra-concha earphone

earphone intended to rest on the ridges of the concha cavity
[IEC 60268-7]

or

supra-concha earphones

earphones which are intended to rest upon the ridges of the concha cavity and have an external diameter (or maximum dimension) greater than 25 mm and less than 45 mm
[ITU-T P.57]

2.2.6

intra-concha earphone

small earphone that fits in the concha cavity, with its acoustic exit close to the entrance of the ear canal
[IEC 60268-7]

or

intra-concha earphones

earphones which are intended to rest within the concha cavity of the ear. They have an external diameter (or maximum dimension) of less than 25 mm but are not made to enter the ear canal
[ITU-T P.57]

2.2.7

supra-aural earphone

earphone applied externally to the outer ear and intended to rest on the pinna
[IEC 50(801) 801-27-23, modified in IEC 60268-7]

or

supra-aural earphone

earphone applied externally to the outer ear
[IEC 60318-1]

2.2.8

circumaural earphone

earphone having a cavity large enough to cover the region of the head including the ear
[IEC 50(801) 801-27-24]

or

circumaural earphones

earphones which enclose the pinna and seat on the surrounding surface of the head. Contact to the head is normally maintained by compliant cushions. Circumaural earphones may touch, but not significantly compress the pinna
[ITU-T P.57]

2.2.9

ear shell

circumaural type of earphone hanging on the ear
[IEC 60914]

2.2.10

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
[IEC 60268-7]

2.2.11

acoustically open earphone

earphone which intentionally provides an acoustic path between the external environment and the ear canal
[IEC 60268-7, ITU-T P.57]

2.2.12**acoustically closed earphones (nominally sealed)**

earphones which are intended to prevent any acoustic coupling between the external environment and the ear canal

[IEC 60268-7, ITU-T P.57]

2.2.13**closed-back earphone**

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

[IEC 60268-7]

2.2.14**open-back earphone**

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

[IEC 60268-7]

2.2.15**ear probe transducer**

device containing one or more transducers that are applied to the entrance of the ear canal to produce acoustic stimuli for audiological investigation.

NOTE Typical uses include admittance measurement systems and to otoacoustic emission systems.

2.2.16**reference device**

stable transducer used solely for the purpose of checking the performance of a measurement system

2.2.17**bone vibrator**

electromechanical transducer intended to produce the sensation of hearing by vibrating the cranial bones

[ISO 8253-1]

2.3**reference threshold values****2.3.1****reference equivalent threshold sound pressure level (RETSPL)**

at a specified frequency, the modal value of the equivalent threshold sound pressure levels of a sufficiently large number of ears of otologically normal persons of both sexes, aged between 18 years and 30 years inclusive, expressing the threshold of hearing in a specified acoustic coupler or artificial ear for a specified earphone

[ISO 389-1]

2.3.2**reference equivalent force level (RETFL)**

at a specified frequency, the mean value of the equivalent threshold sound force levels of a sufficiently large number of ears of otologically normal persons of both sexes, aged between 18 years and 30 years inclusive, expressing the threshold of hearing in a specified mechanical coupler for a specified configuration of bone vibrator

[ISO 389-3]

2.4**ear reference points****2.4.1****ear reference point (ERP)**

virtual point for geometric reference located at the entrance to the listener's ear, traditionally used for calculating telephonometric loudness ratings

[ITU-T P.57]

2.4.2

ear canal entrance point (EEP)

point located at the centre of the ear canal opening
[ITU-T P.57]

2.4.3

ear-drum reference point (DRP)

point located at the end of the ear canal, corresponding to the ear drum position
[ITU-T P.57]

3 Ear simulators

3.1 General

Ear simulators are devices that provide a means of making an objective measurement of the acoustic output from earphones and bone vibrators. In the case of earphones the measurement is that of sound pressure level developed in a specified type of ear simulator and for bone vibrators, force level developed in a specified mechanical coupler.

The value of the measured output is dependent on a combination of the transducer being measured and the ear simulator upon which the measurements are being made. The frequency characteristics of the ear simulator and the transducer being measured should be plotted in accordance with IEC 60263.

Ear simulators fall into the following four categories:

- a) acoustic couplers;
- b) artificial ears/occluded ear simulators;
- c) head and torso simulators (HATS);
- d) mechanical couplers for the calibration of bone vibrators.

The terms “acoustic coupler” and “artificial ear” both fall under the generic term “ear simulator”. However, the difference between acoustic couplers and artificial ears is that the latter has been designed to approximate stated acoustic characteristics of the human ear. Acoustic couplers are essentially simple cavities of defined dimensions while artificial ears have complex acoustic characteristics to provide impedances that match average human adult ears.

Each of the types of ear simulator in a) to d) should be used with the following specific types of transducer (see also Figure 1):

- 1) supra-aural earphones;
- 2) circumaural earphones;
- 3) insert earphones;
- 4) ear probe transducers;
- 5) bone vibrators.

For each type of earphone it should be specified whether it will be close coupled to the ear or of an open type. The performance of close-coupled earphones relies on having no acoustic leakage; any leakage will significantly affect low frequency performance. Earphones of the open type have low acoustic impedance and the coupling to the ear or ear simulator does not influence their performance; effectively they are small loudspeakers.

The plane of the measurement of sound pressure level is an important variable, as its value will vary considerably with the position in the ear that the ear simulator is designed to represent.

Most earphones are designed for the transmission of speech and music, however, particularly for audiological purposes, the signals may be pure tones, noise bands, clicks and tone bursts. The measured value of the output sound pressure varies according to the type of test signal used to specify the performance of the earphone. Many performance specifications are, however, stated in terms of pure tone measurement.

The design of an ear simulator should be predicated by the following factors:

- the type of earphone to be measured;
- the frequency range under consideration;
- whether the measurement is intended to replicate use on a real head, i.e. using a head and torso simulator;
- whether the earphone is close coupled or an acoustic leak is present.

3.2 Standardized ear simulators

Reference should be made to Annex A for a description of the main design features of currently standardized ear simulators.

Table 1 relates the type of earphone whose performance is to be measured to the ear simulator standards that are called up in various applications. The table does not preclude other applications, in particular those in audio engineering.

3.3 Scales and sizes for plotting frequency characteristics

In order that a proper impression may be gained from any graph in which a response is plotted as a level (in decibels) against frequency on a logarithmic scale, the proportions of the scales are standardized. Otherwise, a spectrum or response curve can be made to appear unduly flat or unduly steep by compression or expansion of one of the scales.

IEC 60263 specifies that for a graph in which the level (in decibels) is plotted against frequency on a logarithmic scale, the scale proportions are those for which the length for a 10:1 frequency ratio is equal to the length for a level difference of 10 dB, 25 dB or 50 dB on the ordinate scale.

3.4 Measurement uncertainty

The measurement uncertainty is an estimate of the likely bounds of the measured value for a given level of confidence and should always be taken into account when considering measurement results.

Measurement uncertainty is composed of several factors:

- accuracy of equipment used, such as measuring microphones, type of ear simulator etc.;
- tolerances of the coupling between the transducer and the ear simulator;
- accuracy and care of positioning the transducer on the ear simulator;
- the repeatability of the measurement;
- the level of experience in making this type of measurement.

The *Guide to the expression of uncertainty in measurement (GUM)* [1] (see also PD 6461) gives methods of calculating the level of measurement uncertainty. IEC 60645-1 specifies a value of the maximum expanded uncertainty for a coverage factor of $k = 2$, $U_{\max}$, of 0.7 dB for the measurement of sound pressure level in the frequency range 125 Hz to 4 000 Hz and 1.2 dB for frequencies above 4 000 Hz. For force levels in the frequency range 250 Hz to 4 000 Hz the value of $U_{\max}$ is 1.0 dB and 1.5 dB above 4 000 Hz. Different transducer and ear simulator combinations give different values of uncertainty.

NOTE Reference should be made to Annex B for further details regarding measurement uncertainty.

3.5 The measurement environment

3.5.1 General

The required environmental conditions, such as ambient temperature, pressure and humidity, are specified in the standards describing ear simulators (see Bibliography). However, consideration should be given to other environmental factors such as background ambient noise and electromagnetic compatibility (EMC) considerations.

3.5.2 Background noise

The presence of background noise, i.e. any acoustic source that does not constitute part of the signal to be measured, may affect the reliability of the measurement being made. Ear simulators, together with their associated microphones, may also be sensitive to noise arising from structure-borne vibration, particularly when rigidly mounted. The permitted level of background noise including that resulting from a vibrating source depends upon the measurement equipment being used and the level and characteristics of the signal being measured.

The test signal being measured should be at least 10 dB above the noise floor in all the frequency bands being used for the measurement; this may be achieved by the use of appropriate filters. For any test signal, removal of the test signal should cause the measured level to drop by at least 10 dB.

3.5.3 Electromagnetic and electrostatic interference

Ear simulators including their associated microphones provide different levels of immunity to power and radio frequency fields and to electrostatic discharge. The presence of an electromagnetic or electrostatic field may affect the reliability of measurements made when using ear simulators.

As earphones and other acoustic transducers may contain components which are themselves susceptible to electromagnetic or electrostatic fields, the presence of such fields may influence their performance and affect the characteristics of their acoustic outputs which should be taken into account when selecting earphones. The leads to the transducers may also act as an antenna for such signals. As some transducers generate low level electromagnetic or electrostatic fields their close proximity to an ear simulator may result in a field coupling effect that may also lead to measurement error. The measured test signal should be at least 10 dB above the electromagnetic background noise from whatever source.

It should be ensured that the measurement environment does not contain any electromagnetic or electrostatic interference that may influence the accuracy of measurement prior to making measurements.

4 Transducers

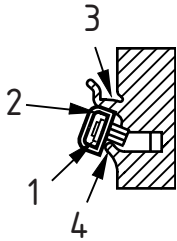
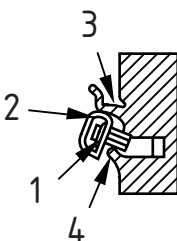
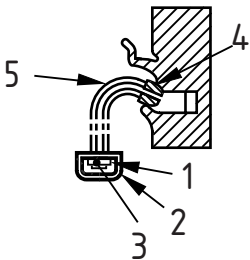
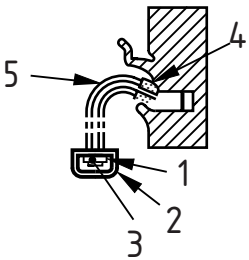
4.1 Earphones

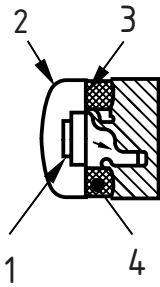
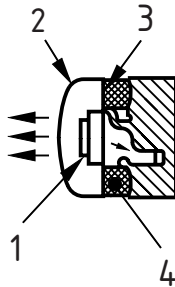
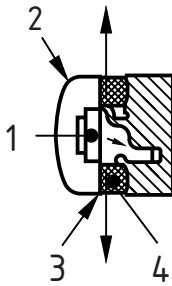
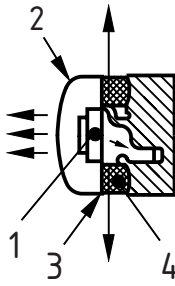
A wide range of earphones currently exists. IEC 60268-7 divides them into eight groups in which there are two subgroups:

- a) acoustically closed earphones, with minimum leakage;
- b) acoustically open earphones, with a controlled leakage.

Figure 1 from IEC 60268-7 illustrates these main types. Consideration should be given as to which ear simulator should be used to measure the performance of each type of earphone. Figure 2 illustrates the possibilities for acoustically open or closed conditions.

Type of earphone	Acoustically closed earphone (minimum leakage)	Acoustically open earphone (controlled leakage)	Ear loudspeaker
Circumaural			
Supra-aural			
Supra-concha			
Intra-concha			
1 Transducer 2 Housing 3 Protector 4 Earpad NOTE 1  Solid area shows acoustically closed earpad to accomplish minimum leakage. NOTE 2  Cross hatching shows porous material earpad to accomplish controlled leakage. Figure 1 — Diagrammatic horizontal sections showing types of earphone and their spatial relationships with the pinna and/or canal entrance			

Type of earphone	Acoustically closed earphone (minimum leakage)	Acoustically open earphone (controlled leakage)	Ear loudspeaker
Insert			
	1 Transducer 2 Housing 3 Protector 4 Earpad		
Insert with sound tube between transducer and earpiece (e.g. stethoscopic type of earphone for hearing aid)			
	1 Transducer 2 Housing 3 Protector 4 Earpiece 5 Sound tube		
NOTE 1  Solid area shows acoustically closed earpad to accomplish minimum leakage. NOTE 2  Cross hatching shows porous material earpad to accomplish controlled leakage. Figure 1 — Diagrammatic horizontal sections showing types of earphone and their spatial relationships with the pinna and/or canal entrance <i>(continued)</i>			

Type of earphone	Closed-back (does not emit significant sound radiation from the back of the transducer to the external environment)	Open-back (emits significant sound radiation from the back of the transducer to the external environment)	
Acoustically closed (intended to prevent acoustic coupling between the external environment and the ear canal)			
Acoustically open (intentionally provides an acoustic path between the external environment and the ear canal)			
1 Transducer	2 Housing	3 Protector	4 Earpad

NOTE Arrows show sound flow or sound leakage.

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

4.2 Ear probe transducers

For certain applications, particularly in audiology, signals are presented to the ear through probe tubes which are terminated with ear tips to be placed on the entrance to the ear canal, or with tubes that go into the ear canal.

4.3 Bone vibrators

Bone vibrators are mainly used for audiometric testing and as such are specified to have a plane contact tip area of 175 mm², applied with a contact force of 5.4 N (including the weight of the bone vibrator itself and any loading mechanism used) and covering the frequency range 250 Hz to 4 000 Hz. These measurements should be made on the mechanical coupler specified in IEC 60373 that in turn has been designed to provide a specific impedance to that faceplate. Consequently measurements on bone vibrators with different faceplates or force of application produce results that may vary from that with the standard faceplate.

Table 1 — Summary of the main applications of standard ear simulators

Transducer/earphone type	IEC/ITU standard. ear simulator type	Applications
Telephone receivers and headsets	IEC 60318-1 ITU-T P57 Type 1 Artificial ear	Telephonometry Measurements with no acoustic leakage
Telephone receivers and headsets	IEC 60711 ITU-T P57 Type 2 Occluded ear simulator for use sealed or with means for including acoustic leakage around the pinna	Telephonometry Measurements to be made using the IEC 60711 ear simulator without modification
Telephone receivers and headsets	IEC 60711 ITU-T P57 Type 3.1, 3.2, 3.3 and 3.4 Occluded ear simulator for use sealed or with means for including acoustic leakage around an artificial pinna	Telephonometry Type 3.1 has concha bottom simulation Type 3.2 has simplified pinna simulation Type 3.3 has more realistic pinna simulation Type 3.4 has simplified pinna simulation for measuring pressure dependant acoustic leakage effects
Supra-aural	IEC 60318-1 Artificial ear	Audiometry 125 Hz to 8 000 Hz
Supra-aural	IEC 60318-3 Acoustic coupler (6 cc)	Audiometry 125 Hz to 8 000 Hz
Circumaural	IEC 60318-2 Acoustic coupler IEC 60318-1 with adaptor plates	High frequency Audiometry 125 Hz to 16 000 Hz
Insert	IEC 60711 Occluded ear simulator	Audiometry Hearing aids Insert earphones
Insert	IEC 60126 Acoustic coupler (2 cc)	Audiometry Hearing aids Insert earphones
Bone vibrator	IEC 60318-6 Mechanical coupler	Bone conduction audiometry Hearing aids
All earphones	IEC/TR 60959 ITU-T P58 Head and torso simulator	All earphone types measured as worn on a simulation of a human head and torso
Table 1 relates the type of earphone whose performance is to be measured to the ear simulator standards that are called up in various applications. The table does not preclude other applications, in particular those in audio engineering.		

5 Applications for audiological purposes

5.1 Method of measurement of the acoustical output characteristics of supra-aural and circumaural earphones used for audiological investigations

5.1.1 General

Current published standards used in audiology employ one of three ear simulators as described in IEC 60318-1, IEC 60318-2 and IEC 60318-3 (see Annex A). These devices may be referred to by other names relating to their origins.

The device described in IEC 60318-1 may be referred to as an “artificial ear” or as a “wide band artificial ear”. This device also forms the basis of IEC 60318-2 used for measurements made in the high frequency range 8 000 Hz to 16 000 Hz.

The device described in IEC 60318-3 may also be referred to as an “acoustic coupler” or as a “6 cc coupler” making reference to its internal volume.

NOTE It is sometimes mistakenly referred to as an “artificial ear” and this should be avoided.

The term “artificial ear” reflects the fact that such devices are designed to approximate the acoustic impedance of the average human adult ear. Acoustic couplers are not designed to do this but provide a stated acoustic load for an earphone.

5.1.2 Applications

The measurements should be used for the following.

- a) Calibration of earphone systems used for the presentation of audiometric stimuli (including stimuli of short duration), masking signals and contralateral reflex stimuli used in admittance measurements: values of the reference equivalent threshold sound pressure levels (RETSPLs) for audiometric zero are given in ISO 389-1, -2 and -5.

NOTE ISO 389-4 gives values for masking signals.

- b) Other acoustical characteristics produced by earphones for the verification of equipment specification: these parameters include noise of an electrical origin, distortion, attenuator linearity, temporal and spectral characteristics of broadband audiometric and masking stimuli and stimuli of short duration.

- c) Acoustical characteristics of earphones under specified drive conditions.

5.1.3 Type of ear simulator

The type of ear simulator used is dependent upon the earphone type, the cushion used with the earphone and the frequency range in which the measurement is to be made. The ear simulator used should be in accordance with the information given in Table 2.

Table 2 — Ear simulator type to be used with specific measurement configurations
(see Annex A for details of ear simulators)

Earphone/cushion combination	Frequency measurement range	
	125 Hz–8 000 Hz	8 000 Hz–16 000 Hz
Telephonics TDH 39 ^a with MX41/AR cushion	IEC 60318-3	N/A
Telephonics TDH 39 ^a with model 51 cushion	IEC 60318-3	N/A
All other supra-aural earphones and cushion combinations (excluding those specified above)	IEC 60318-1	IEC 60318-1 up to 10 000 Hz
Circumaural earphone/cushion combinations for specified earphones	IEC 60318-2 (using appropriate adaptor plate)	IEC 60318-2 (using appropriate adaptor plate)
^a Telephonics TDH 39 is a trade mark and is an example of a suitable product available commercially. This information is given for the convenience of users of this standard and does not constitute an endorsement by BSI of this product.		

5.1.4 Measuring equipment

5.1.4.1 Appropriate ear simulator, used in conjunction with a measuring amplifier. Ensure that the measurement system has a traceable calibration identifying its measurement accuracy for the parameters to be measured, together with its uncertainties.

NOTE This traceability should be obtained by submitting the measurement system to a national accredited laboratory on a regular basis. In the UK the body responsible for assessing laboratories is the United Kingdom Accreditation Service, UKAS. At present audiometric standards give no guidance on the calibration intervals for test equipment required for audiometric calibration, however it is suggested that the re-calibration of the test equipment should take place at least once every two years or when discrepancies are found when checking with the reference devices.

5.1.4.2 Other components, necessary for the measurement of the specific parameter concerned, e.g. when measuring distortion the system should also include a distortion meter, filter set, or spectrum analyser.

5.1.5 Procedure

The following procedure should be used.

- a) Correctly identify the earphone/cushion combination so that the appropriate ear simulators can be employed for the particular measurements to be made.
- b) Connect the ear simulator to a measurement system that will enable the measurement of that specific parameter.
- c) Retain one pair of earphones as reference devices and if any discrepancy can be shown to be the result of damage or drifting affecting only one of these devices, re-calibration of the equipment may not be necessary. In this eventuality, discard the faulty reference device and make in-house measurements using a replacement to establish a new base-line for subsequent checks.
- d) Prior to any measurements being made check the calibration of the measuring system by placing a pistonphone or acoustic calibrator (see IEC 60942) on the measurement microphone of the ear simulator. Make any adjustment for changes in calibration at this time and note corrections.
- e) Examine the condition of the earphone and cushion before carrying out any measurement as any distortion in the physical shape of the cushion or deterioration in the properties of the material from which the cushion is made may influence the results.

NOTE 1 Deterioration in the cushion may lead to unwanted acoustic leakage and/or the introduction of performance changes.

- f) Couple the earphone/cushion combination to the ear simulator so that the axis of symmetry of the earphone transducer is co-incident with the axis of symmetry of the ear simulator measurement microphone.
 - g) Ensure that the position and loading of the earphone is not influenced in any way by the presence of a headband, signal lead or other associated component.
- NOTE 2 Whenever possible the earphone should be disconnected from the headband.
- h) If the earphone is normally used with a noise excluding headset, which may affect the coupling of the earphone cushion to the ear simulator, remove the headset.
 - i) Apply the earphone to the ear simulator without acoustic leakage with a force of (4.5 ± 0.5) N, not including the weight of the earphone itself.

NOTE 3 If, for a specific earphone, a different coupling force is specified this should be used.

NOTE 4 Ear simulator manufacturers might provide a mechanism for loading the transducer by the required amount. As such a mechanism can prove unreliable, it is recommended that the back of the transducer be directly loaded with the required amount. For a loading of (4.5 ± 0.5) N it is recommended that a cylindrical mass of 500 g (4.9 N) be used in order to provide the appropriate measurement conditions.

- j) With ear simulators conforming to IEC 60318-1 and -3, ensure that the earphone does not rest on the sloping side of the ear simulator but only on the upper edge (or rim). In the case of earphones with a rigid ear cap or cushion, use a thin film of sealing material or thin soft rubber ring on the lip in order to produce an effective seal between the earphone and the edge of the simulator.
- k) When conducting measurements the transducer may be rotated through, e.g. three measurement points located at 120° to each other, and the derived measurements averaged to minimize positional effects.