IEC 60318-7

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

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Electroacoustics – Simulators of human head and ear – Part 7: Head and torso simulator for the measurement of sound sources close to the ear

Électroacoustique – Simulateurs de tête et d'oreille humaines – Partie 7: Simulateur de tête et de torse pour le mesurage des sources sonores à proximité de l'oreille

IEC 60318-7:2022-06(en-fr)

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ELECTROACOUSTICS – SIMULATORS OF HUMAN HEAD AND EAR –

Part 7: Head and torso simulator for the measurement of sound sources close to the ear

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This publication contains attached files in the form of 3D PDF files. These files are intended to be used as a complement and do not form an integral part of the publication.

This edition cancels and replaces IEC TS 60318-7:2017. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to IEC TS 60318-7:2017:

a) changing the title;
b) extending the scope to sound sources close to the ear.

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The text of this International Standard is based on the following documents:

Draft	Report on voting
29/1118/FDIS	29/1121/RVD

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

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

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

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

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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ELECTROACOUSTICS – SIMULATORS OF HUMAN HEAD AND EAR –

Part 7: Head and torso simulator for the measurement of sound sources close to the ear

1 Scope

This part of IEC 60318 describes a head and torso simulator, or manikin, intended for the measurement of sound sources placed close to the ear in the frequency range from 100 Hz to 16 000 Hz.

The manikin described in this document is intended for airborne acoustic measurements only. It is not suitable for measurements which depend upon vibration transmission paths such as bone conduction, or for measurements requiring the simulation of bone or tissue.

This document specifies the manikin in terms of both its geometrical dimensions and its acoustical properties. Only manikins compliant with both sets of specifications are in conformance with this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60118-8, *Electroacoustics – Hearing aids – Part 8: Methods of measurement of performance characteristics of hearing aids under simulated in situ working conditions*

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

IEC 61260-1, *Electroacoustics – Octave-band and fractional-octave-band filters – Part 1: Specifications*

ISO 3, *Preferred numbers – Series of preferred numbers*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

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

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3.1
manikin
head and torso simulator
simulator of a median adult human head and part of the torso extending in total from the top of the head to the waist and designed to simulate the sound pick-up characteristics and acoustic diffraction

Note 1 to entry: The head and torso simulator includes two pinna simulators, and at least one occluded-ear simulator.

3.2
manikin type
designation of the manikin as either anatomical or geometrical in shape

3.3
pinna simulator
device which has the approximate shape and dimensions of a median adult human pinna

3.4
ear simulator
device for measuring the acoustic output of sound sources where the sound pressure is measured by a calibrated microphone coupled to the source so that the overall acoustic impedance of the device approximates that of the normal human ear at a given location and in a given frequency band

Note 1 to entry: In this document, an ear simulator comprises an ear canal extension and an occluded-ear simulator (see 4.2.4).

3.5
occluded-ear simulator
ear simulator which approximates the acoustic transfer impedance of the inner part of the ear canal, from the tip of an ear insert to the eardrum

Note 1 to entry: An occluded-ear simulator is standardised in IEC 60318-4.

3.6
ear canal extension
device that provides a connection between the occluded-ear simulator and the aperture of the device simulating the concha

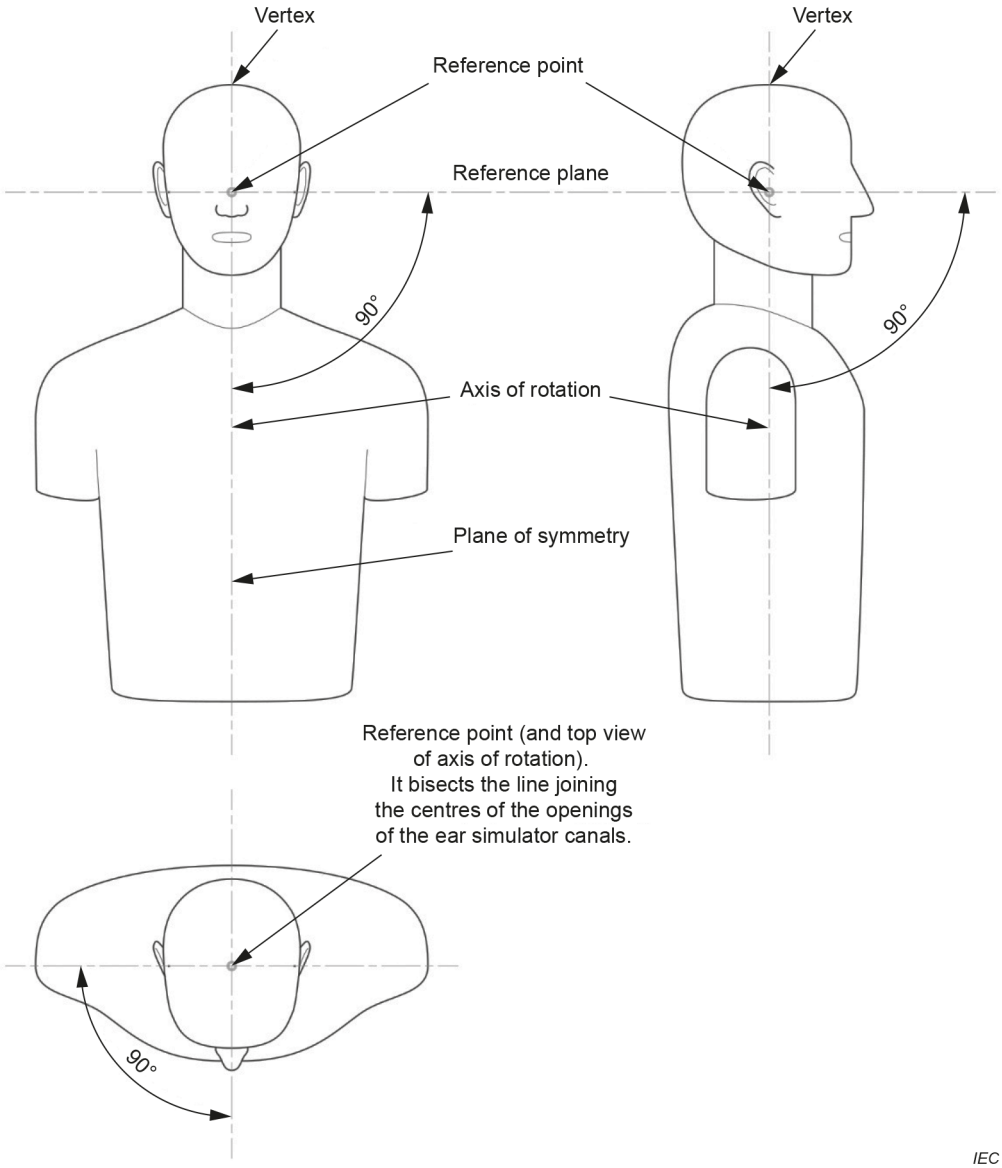
3.7
reference plane of the occluded-ear simulator
plane perpendicular to the axis of the cavity of the simulator, chosen to pass through the position normally occupied by the tip of an ear mould in a human ear canal

3.8
reference point of the manikin
point bisecting the line joining the right and left ear canal entrance points (EEP, 3.17)

3.9
plane of symmetry of the manikin
plane passing through the reference point of the manikin that divides the left and right portions of the manikin into symmetrical halves, within the allowed tolerances, where left and right is interpreted as for the human torso

Note 1 to entry: See Figure 1.

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NOTE The reference point of the manikin is situated within the head.

Figure 1 – Manikin geometrical references

3.10
axis of rotation of the manikin
straight line about which the manikin can be rotated, passing through the reference point of the manikin, lying in the plane of symmetry of the manikin, and having a direction that would be vertical if the manikin were mounted in a position corresponding to that of a standing person

SEE: Figure 1.

3.11
reference plane of the manikin
plane perpendicular to the axis of rotation that contains the reference point of the manikin

SEE: Figure 1.

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3.12
test point
reproducible position in the test space at which the sound pressure level is measured with the manikin absent and at which the reference point of the manikin is to be located for test purposes

Note 1 to entry: See Figure 2.

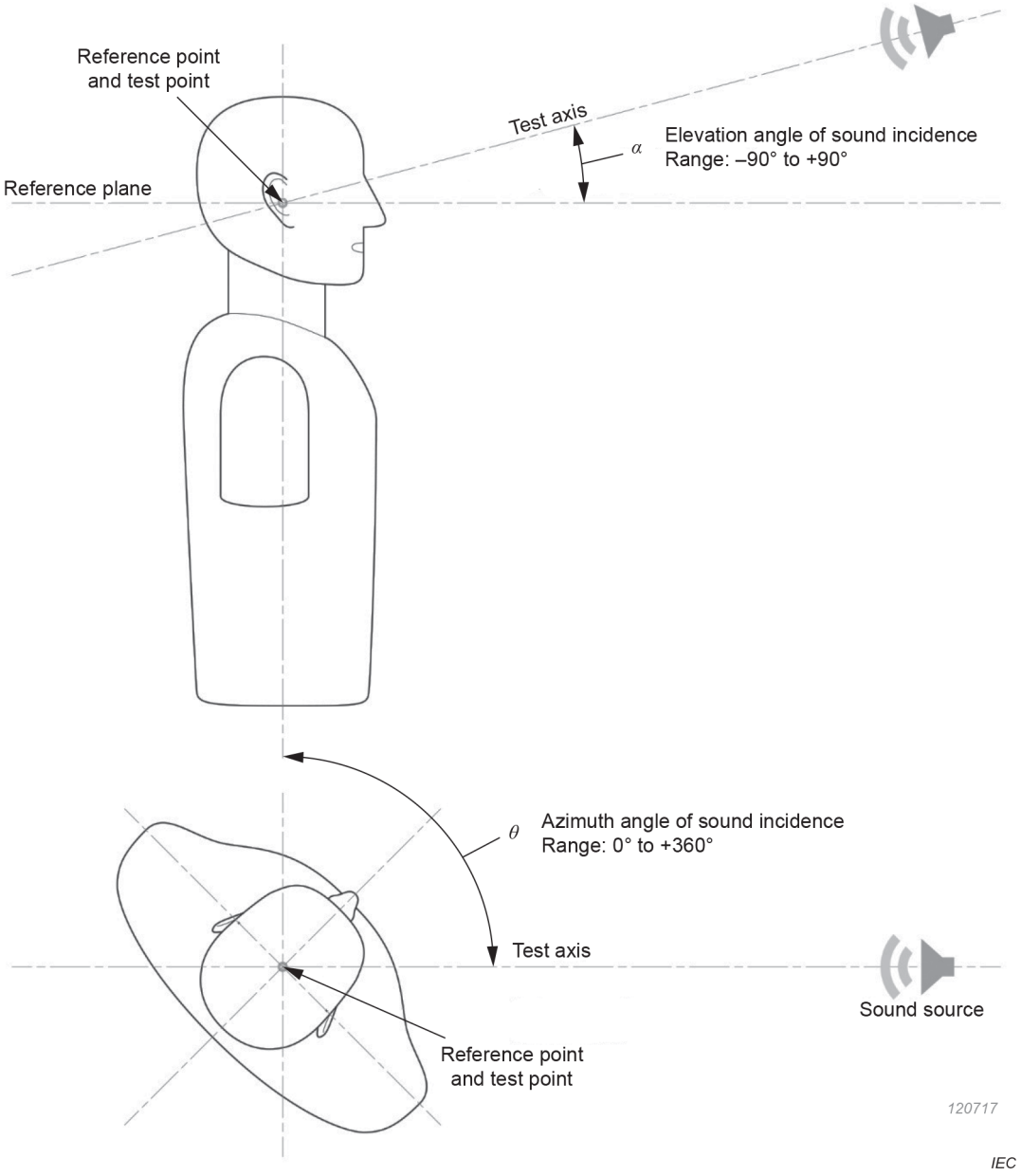


Figure 2 – Coordinate scheme for azimuth and elevation angles

3.13
test axis
line joining the test point and the acoustic centre of the sound source

SEE: Figure 2.

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3.14
test plane
plane perpendicular to the test axis and containing the test point

3.15
azimuth angle of sound incidence
angle between the plane of symmetry of the manikin and the plane defined by the axis of rotation of the manikin and the test axis

Note 1 to entry: When the manikin faces the sound source, the azimuth angle of sound incidence is defined as 0°. When the right ear of the manikin faces the sound source, the angle is defined as +90°. When the left ear of the manikin faces the sound source, the angle is defined as +270°.

SEE: Figure 2.

3.16
elevation angle of sound incidence
angle between the reference plane of the manikin and the test axis

Note 1 to entry: When the vertex points towards the sound source, the elevation angle is defined as +90°. When the test axis lies in the reference plane of the manikin, the elevation angle is defined as 0°.

SEE: Figure 2.

3.17
ear canal entrance point
EEP
point located at the centre of the manikin ear canal at the junction between concha and ear canal extension

3.18
transverse plane of the manikin
plane perpendicular to the plane of symmetry of the manikin and containing the axis of rotation

3.19
reference position of the manikin
position of the manikin in the test space where the reference point of the manikin coincides with the test point, and the azimuth and elevation angles are both equal to zero

3.20
manikin free-field frequency response
difference, as a function of frequency, between the sound pressure level at the ear simulator microphone with the reference point of the manikin at the test point within a free-field measurement environment and the sound pressure level at the test point with the manikin absent

3.21
manikin diffuse-field frequency response
difference, as a function of frequency, between the sound pressure level at the ear simulator microphone with the reference point of the manikin at the test point within a diffuse-field measurement environment and the sound pressure level at the test point with the manikin absent

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4 Construction

4.1 General

The simulator consists of a head mounted on a torso that extends to the waist. The head is equipped with simulated pinnae and one or two occluded-ear simulators formed of cavities having acoustic impedance terminations corresponding to that of a median human adult, and microphones located at positions corresponding to the eardrums. It has been designed to provide acoustic diffraction similar to that encountered around the median human head and torso. Measurement results obtained with a manikin can differ substantially from similar measurements made on an individual person, due to anatomical variations. Measurement results for a given hearing aid obtained with different models of manikin conforming to this document can also differ, depending on the type and the method of fitting the hearing aid. The same holds for measurement results obtained with the same manikin model but with different models of pinna simulators.

NOTE 1 Above 10 kHz, an occluded-ear simulator conforming to IEC 60318-4 does not simulate the acoustic impedance of the human ear and can only be used as an acoustic coupler in this frequency range.

The realization of the manikin conforming to this document can be either anatomically shaped (see Annex A) or geometrically shaped (see Annex B) and can have different anatomically shaped pinna simulators. The realization of the ear canal entrance, together with the additional ear canal extension, can be either cylindrical or tapered in shape. This enables measurements of all types of insert devices, for example behind-the-ear (BTE) and in-the-ear (ITE) hearing aid designs.

NOTE 2 Nevertheless, some specific ITE hearing aid models might not be compatible.

This document covers both the geometrical dimensions of the manikin's head, torso, pinnae and ear canals and the manikin's acoustical characteristics. As a minimum, the manikin shall be specified with cylindrical ear canal extensions and comply with the appropriate acoustical characteristics. Optionally, tapered ear canal extensions may also be specified. The model and type of the manikin used (see 3.2) and the model of the pinna simulator used shall be stated when giving results of measurements made with the manikin.

4.2 Geometrical dimensions of the manikin

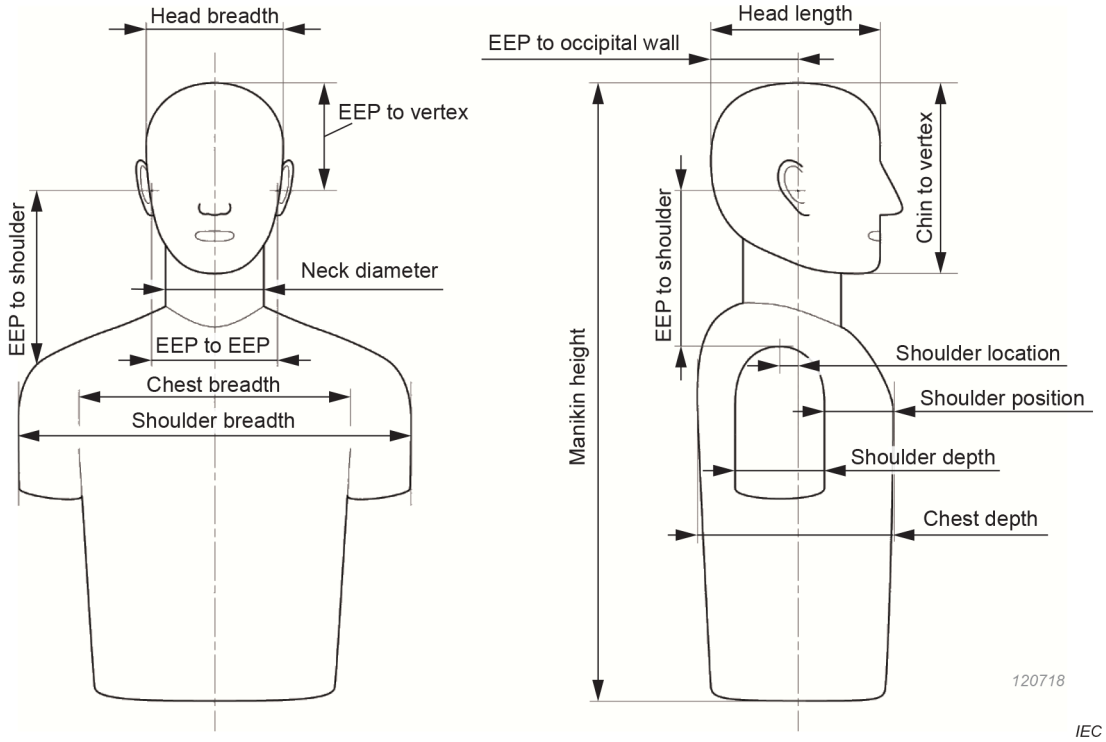
4.2.1 Head and torso

The geometrical dimensions of the head and the torso are illustrated in Figure 3, and listed in Table 1. The realization of the head (excluding the pinnae) and of the torso can be either anatomically shaped or geometrically shaped. Anatomically shaped manikins are not necessarily completely symmetrical and may be described as "quasi-symmetrical", when staying within the allowable differences from the completely symmetrical manikin. Both anatomically and geometrically shaped manikins shall conform to the specified ranges of geometrical dimensions and acoustical characteristics specified in this document.

The acceptance interval of the quasi-symmetrical left and right portion of the manikin shall be ±2 mm for the head and ±3 mm for the torso with respect to the plane of symmetry.

NOTE For measurements that include both head and torso dimensions, for example EEP to shoulder, the acceptance interval sums up to ±5 mm.

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NOTE For position of ear canal entrance point (EEP), see Figure 4.

Figure 3 – Illustration of manikin head and torso dimensions

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Table 1 – Manikin head and torso dimensions

Linear dimension of	Nominal	Minimum	Maximum	Average human data [1][1]
	mm	mm	mm	mm
Head breadth	151	148	153	151
Head length	195	190	204	188
EEP to vertex	130	128	135	130
EEP to EEP distance	132	130	134	132
EEP to occipital wall	95	93	99	95
Chin-to-vertex length	220	217	225	222
EEP to shoulder[c]	175	169	181	176
Neck diameter	113	111	115	112
Shoulder breadth	432	399	456	427
Chest breadth	282	280	284	291
Chest depth	219	180	241	–
Shoulder depth[d]	110	108	161	–
Shoulder location [b, e]	6	–4	20	–
Shoulder position [a, f]	78	76	80	–
Manikin height	–	600	–	

NOTE To be independent of the type of pinna simulator used, this document uses the ear canal entrance point (EEP) rather than the tragion as a reference point. The differences between both sets of values are chosen in conformity with [2] to be 5 mm for EEP to vertex, –11 mm for left EEP to right EEP, –3 mm for EEP to occipital wall and –5 mm for EEP to shoulder.

[a] For anatomically shaped manikin only.

[b] For geometrically shaped manikin only.

[c] Measured from the shoulder surface, 175 mm sideways from the plane of symmetry, to the reference plane of the manikin.

[d] Measured between front and back shoulder points, 175 mm sideward from the plane of symmetry of the manikin.

[e] Measured from the point of the shoulder section, 175 mm sideward from the plane of symmetry, to the transverse plane of the manikin (positive behind transverse plane).

[f] Measured between front shoulder point, 175 mm sideward from the plane of symmetry of the manikin to the front-most point on the torso.

4.2.2 Pinna simulators for hearing aid measurements

The right and left pinna simulators shall be anatomically shaped.

NOTE 1 3D representations of example pinna simulators are shown in Annex D.

For each type of manikin, only one pair of pinna simulators with cylindrical ear canal extensions and optionally only one pair of pinna simulators with the tapered ear canal extensions shall be specified. Their principal dimensions and orientation are illustrated in Figure 4 a), b) and c), and listed in Table 2 and Table 3.

The acceptance intervals of the quasi-symmetrical left and right pinna simulator of the manikin shall be ±2 mm.

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

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NOTE 2 In addition to the pinna simulators described in this document, there are many other models of pinna simulator on the market, for instance a small one used for the measurement of earphones (see IEC 60268-7). However, these pinna simulators are not intended for hearing aid measurements.

4.2.3 Ear canal extension

Only the cylindrical or tapered ear canal extensions specified in Table 3 shall be used. A cylindrical ear canal extension shall have a nominal diameter of 7,50 mm. A tapered ear canal shall have a nominal diameter of 7,50 mm where it couples to the occluded-ear simulator and a maximum diameter of 7,60 mm where it couples to the bottom of the concha of the pinna simulator.

NOTE The cylindrical ear canal extension is intended primarily for the measurement of behind-the-ear and full-concha in-the-ear hearing aids and insert earphones. The tapered ear canal extension is intended for the measurement of in-the-ear and completely-in-the-canal hearing aids and insert earphones.

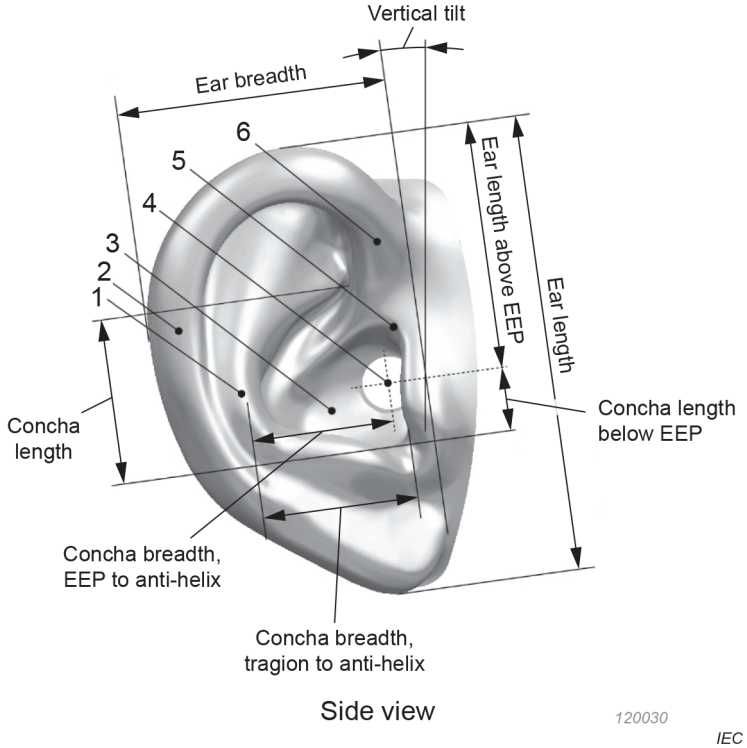


Figure 4 a) – Pinna simulator

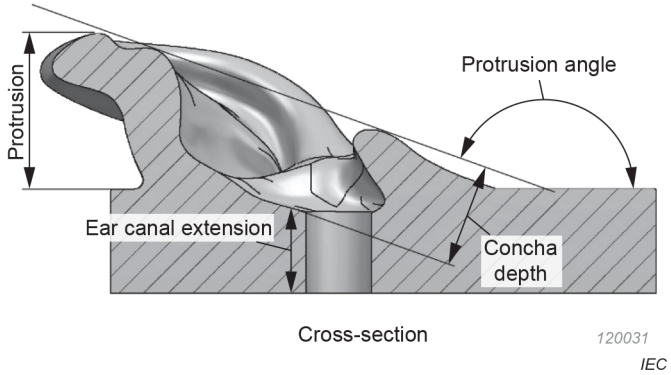


Figure 4 b) – Ear canal extension cylindrical

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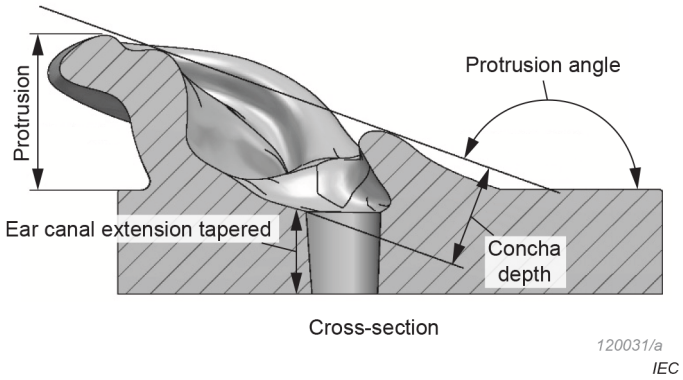


Figure 4 c) – Ear canal extension tapered

Key

1 anti-helix
2 helix
3 concha
4 EEP
5 tragion
6 crus of helix

Figure 4 – Illustration of manikin pinna simulator dimensions

Table 2 – Dimensions of the pinna simulator and the cylindrical ear canal extension of the manikin

Linear dimension of	Nominal	Minimum	Maximum
Ear length	65 mm	64 mm	67 mm
Ear length above EEP	35 mm	33 mm	38 mm
Ear breadth	37 mm	36 mm	38 mm
Ear protrusion	20 mm	18 mm	24 mm
Ear protrusion angle	160°	159,5°	160,5°
Vertical tilt front view	9°	7,5°	10,5°
Vertical tilt side view	6°	5,5°	6,5°
Concha length	24 mm	23 mm	26 mm
Concha length below EEP	10 mm	8 mm	11 mm
Concha breadth, tragion to anti-helix	23 mm	22 mm	24 mm
Concha breadth, EEP to anti-helix	17 mm	14 mm	20 mm
Concha depth	13 mm	11 mm	16 mm
Diameter of ear canal extension	7,50 mm	7,40 mm	7,60 mm
Length of ear canal extension	10 mm	9 mm	11 mm

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Table 3 – Dimensions of the pinna simulator and the tapered ear canal extension of the manikin

Linear dimension of	Nominal	Minimum	Maximum
Ear length	66 mm	65 mm	67 mm
Ear length above EEP	36 mm	35 mm	37 mm
Ear breadth	37 mm	36 mm	38 mm
Ear protrusion	23 mm	19 mm	24 mm
Ear protrusion angle	160°	159,5°	160,5°
Vertical tilt front view	10°	8°	10,5°
Vertical tilt side view	6°	5,5°	6,5°
Concha length	28 mm	24 mm	29 mm
Concha length below EEP	10 mm	9 mm	11 mm
Concha breadth, tragion to anti-helix	23 mm	22 mm	24 mm
Concha breadth, EEP to anti-helix	23 mm	19 mm	24 mm
Concha depth	15 mm	12 mm	16 mm
Diameter of ear canal extension at the reference plane of the occluded-ear simulator	7,50 mm	7,40 mm	7,60 mm
Diameter of ear canal extension at the pinna simulator	10 mm	9,5 mm	10,5 mm
Length of ear canal extension	8,8 mm	7,8 mm	10 mm

4.2.4 Ear simulator

The ear simulator shall comprise an occluded-ear simulator, for example as described in IEC 60318-4, and an ear canal extension (see 3.6).

If occluded-ear simulators differing in detail from that specified in IEC 60318-4 are used, their characteristics should be stated when giving results of measurements of hearing aids made with the manikin.

4.2.5 Materials

The manikin shall have a non-porous surface, with an acoustic impedance which is high compared to that of air, and be of a material which ensures dimensional stability.

The pinna simulators shall be made from a high-quality elastomer. The Shore-OO hardness [3] shall be in the range from 30 Shore OO to 60 Shore OO. The time interval for which the mechanical characteristics of the pinna simulators are expected to remain compliant with this document shall be indicated by means of an expiration date.

Measurement results on hearing aids obtained with the same manikin fitted with different pinna simulator models can differ by varying degrees depending on the type of hearing aid under test and the way it is fitted. The model, or similar identification, of the pinna simulators together with their Shore-OO hardness should be stated when giving results of hearing aid measurements made with the manikin.

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4.3 Acoustical characteristics of the manikin

4.3.1 Free-field frequency response

Table 4 and Table 5 specify, in one-twelfth-octave bands, the nominal free-field frequency responses of the manikin (right ear) equipped with cylindrically shaped ear canal extensions. Values are stated for 0° elevation angle and azimuth angles of 0° (frontal incidence), 90°, 180° and 270°. The values also apply for the corresponding symmetrical azimuth angles for the left pinna.

NOTE 1 Difficulties can be experienced when measuring the manikin frequency response at the azimuth angle 270° for 6,3 kHz and higher frequencies. This is due to a combination of reflections from the boundaries of the test enclosure, and the head shadow effect. Hence, these values have been omitted in Table 5.

NOTE 2 The nominal free-field frequency responses were obtained from a power average of the measured free-field frequency responses of the three manikins in Annex A and Annex B, extracted from [4]. The free field-frequency response in [4] is given in one-twelfth-octave bands, which were synthesized from high-frequency-resolution sweep measurements. The values at the ISO 3 R10 (nominal one-third-octave) frequencies were taken for the specification.

NOTE 3 The nominal one-third-octave band centre frequencies used as test frequencies in Table 4 and Table 5 correspond to the ISO 3 R10 preferred number series.

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Table 4 – Free-field frequency response of the manikin (right ear) for an azimuth angle of 0° in one-twelfth-octave bands

Mid-frequency of one-twelfth-octave band	Free-field frequency response	Acceptance interval	
Hz	dB	dB	
	Azimuth angle		
	0°		
100	0,0	+1,5	–1,5
125	0,0	+1,5	–1,5
160	0,0	+1,5	–1,5
200	0,0	+1,5	–1,5
250	0,0	+1,5	–1,5
315	1,0	+1,5	–1,5
400	2,0	+1,5	–1,5
500	2,5	+2,0	–1,5
630	3,0	+1,5	–1,5
800	4,0	+1,5	–1,5
1 000	4,0	+2,0	–2,5
1 250	3,0	+2,0	–3,5
1 600	5,0	+1,5	–2,0
2 000	12,0	+2,0	–2,5
2 500	16,5	+3,0	–3,0
3 150	17,5	+2,0	–2,5
4 000	14,0	+2,0	–3,0
5 000	11,5	+2,5	–3,0
6 300	7,0	+2,0	–2,0
8 000	2,0	+3,5	–5,5
10 000	2,0	+4,0	–4,5
12 500	9,0	+4,0	–4,5
16 000	3,0	+4,0	–6,0

NOTE 1 The free field-frequency response is given at the ISO 3 R10 frequencies, but as one-twelfth-octave bands centred at these frequencies.

NOTE 2 The values in Table 4 are valid only for pinna simulators for hearing aid measurements by means of cylindrical ear canal extensions according to Table 2.

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Table 5 – Free-field frequency responses of the manikin (right ear) for azimuth angles of 90°, 180° and 270° in one-twelfth-octave bands

Mid-frequency of one-twelfth-octave band	Free-field frequency response			Acceptance interval	
Hz	dB			dB	
	Azimuth angle				
	90°	180°	270°		
100	0,5	0,0	–0,5	+1,5	–1,5
125	0,5	0,0	–0,5	+1,5	–1,5
160	1,0	–0,5	–1,0	+1,5	–1,5
200	1,5	0,0	–1,0	+1,5	–2,0
250	2,5	0,0	–0,5	+1,5	–1,5
315	3,5	0,0	0,0	+1,5	–1,5
400	4,5	0,5	0,5	+1,5	–1,5
500	5,5	1,0	1,5	+2,0	–1,5
630	7,0	2,0	1,5	+1,5	–2,0
800	8,0	4,0	2,0	+1,5	–2,0
1 000	7,5	4,0	2,5	+1,5	–2,0
1 250	9,5	5,5	3,5	+2,5	–2,5
1 600	9,5	5,5	5,0	+2,0	–2,0
2 000	11,0	9,5	7,0	+2,5	–4,0
2 500	16,5	14,0	10,0	+2,5	–2,5
3 150	17,0	13,5	9,0	+3,0	–2,0
4 000	13,5	10,5	3,5	+5,0	–3,0
5 000	17,0	6,0	–3,5	+7,0	–8,0
6 300	17,0	2,0	---	+2,5	–5,0
8 000	16,5	3,5	---	+5,0	–10,5
10 000	10,5	–1,5	---	+6,0	–10,5
12 500	11,5	–0,5	---	+6,0	–8,5
16 000	3,5	–4,0	---	+6,0	–11,0

NOTE 1 The free field-frequency response is given at the ISO 3 R10 frequencies, but as one-twelfth-octave bands centred at these frequencies.

NOTE 2 The values in Table 5 are valid only for pinna simulators with cylindrical ear canal extensions according to Table 2.

NOTE 3 Free-field responses for 0° azimuth angle are given in Table 4.

4.3.2 Diffuse-field frequency response

Table 6 specifies, in one-third-octave bands, the diffuse-field frequency response of the manikin (right ear) equipped with a cylindrically shaped ear canal extension.

NOTE The nominal diffuse-field frequency response was obtained from a power average of the diffuse-field frequency responses of the three manikins in Annex A and Annex B, extracted from [4]. The diffuse-field frequency response is given in one-third-octave frequency bands.

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