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BSI Standards Publication

Electroacoustics – Simulators of human head and ear

Part 7: Head and torso simulator for the measurement of hearing aids

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National foreword

This Draft for Development is the UK implementation of IEC/TS 60318-7:2011.

The UK participation in its preparation was entrusted to Technical Committee EPL/29, Electroacoustics.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Compliance with a British Standard cannot confer immunity from legal obligations.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

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- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC/TS 60318-7, which is a technical specification, has been prepared by IEC technical committee 29: Electroacoustics.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
29/716/DTS	29/729A/RVC

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of 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 publication will remain unchanged until the stability 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

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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

INTRODUCTION

This technical specification describes a head and torso simulator for hearing aid measurements. It has been developed as a revision of IEC/TR 60959 (1990). The main changes, as compared to the technical report, are the insertion of maximum permitted expanded measurement uncertainties and additional references in the Bibliography. A future IEC Standard which will include additional models of head and torso simulators for hearing aid measurements is planned.

ELECTROACOUSTICS – SIMULATORS OF HUMAN HEAD AND EAR –

Part 7: Head and torso simulator for the measurement of hearing aids

1 Scope

This part of IEC 60318 describes a head and torso simulator (manikin) intended for the measurement of air-conduction hearing aids in the frequency range from 100 Hz to 10 000 Hz. The device consists of a head mounted on a torso that extends to the waist. The head is equipped with simulated pinnae and with cylindrical cavities having acoustic impedance terminations and microphones located at positions corresponding to those of the eardrums in a median human adult. It has been designed to provide acoustic diffraction similar to that encountered around the median human head and torso.

The device with its present pinna simulator, however, is not suitable for the measurement of all types of hearing aids. For example, most in-the-ear (ITE) and completely-in-the-canal (CIC) hearing aids cannot be measured correctly.

The manikin is specified in terms of both, its geometrical dimensions and its acoustical properties.

NOTE 1 Measurement results obtained with a manikin may differ substantially from similar results obtained on an individual person, due to anatomical variations.

NOTE 2 The median values of the human head and torso were drawn from the population samples described in [5][1].

NOTE 3 It is acknowledged that devices conforming to this part of IEC 60318 are also used as the basis for applications extending beyond this Scope. In such cases it is recommended that any design variations that are necessary are documented, and that a statistical analysis of the measurement data be carried out to determine the level of repeatability that can be achieved. It will also be necessary to consider the relevance of the measurements made with the head and torso simulator to the application in question.

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 60318-4, *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*

ISO/IEC Guide 98-3, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement* (GUM:1995)

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply. Reference is also made to Figure 1 and Figure 2.

———————

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

3.1
manikin
head and torso simulator extending downward from the top of the head to the waist and designed to simulate the acoustic diffraction produced by a median adult human head and torso

NOTE The head includes two pinna simulators, and contains at least one ear simulator.

3.2
pinna simulator
device which has the approximate shape and dimensions of a median adult human pinna

3.3
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 In this technical specification it comprises an ear canal extension and an occluded ear simulator.

3.4
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 An occluded ear simulator is standardised in IEC 60318-4.

3.5
ear canal extension
device that provides a connection between the ear canal of an occluded ear simulator and the aperture of a device simulating the concha

3.6
reference plane of the occluded ear simulator
plane perpendicular to the axis of the ear canal, at the junction between the occluded ear simulator and the ear canal extension

3.7
reference point of the manikin
point bisecting the line joining the centres of the openings of the ear canals (at the junction between concha and ear canal)

3.8
plane of symmetry of the manikin
virtual plane passing through the reference point of the manikin that divides the left and right portions of the manikin into symmetrical halves, left and right to be interpreted as for the human torso (see Figure 1)

NOTE No real human is perfectly symmetrical.

3.9
axis of rotation of the manikin
straight line about which the manikin can be rotated, passing through the reference point of the manikin and 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)

3.10
reference plane of the manikin
plane perpendicular to the axis of rotation that contains the reference point of the manikin

3.11
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

3.12
test axis
line joining the test point and the centre of the sound source (see Figure 2)

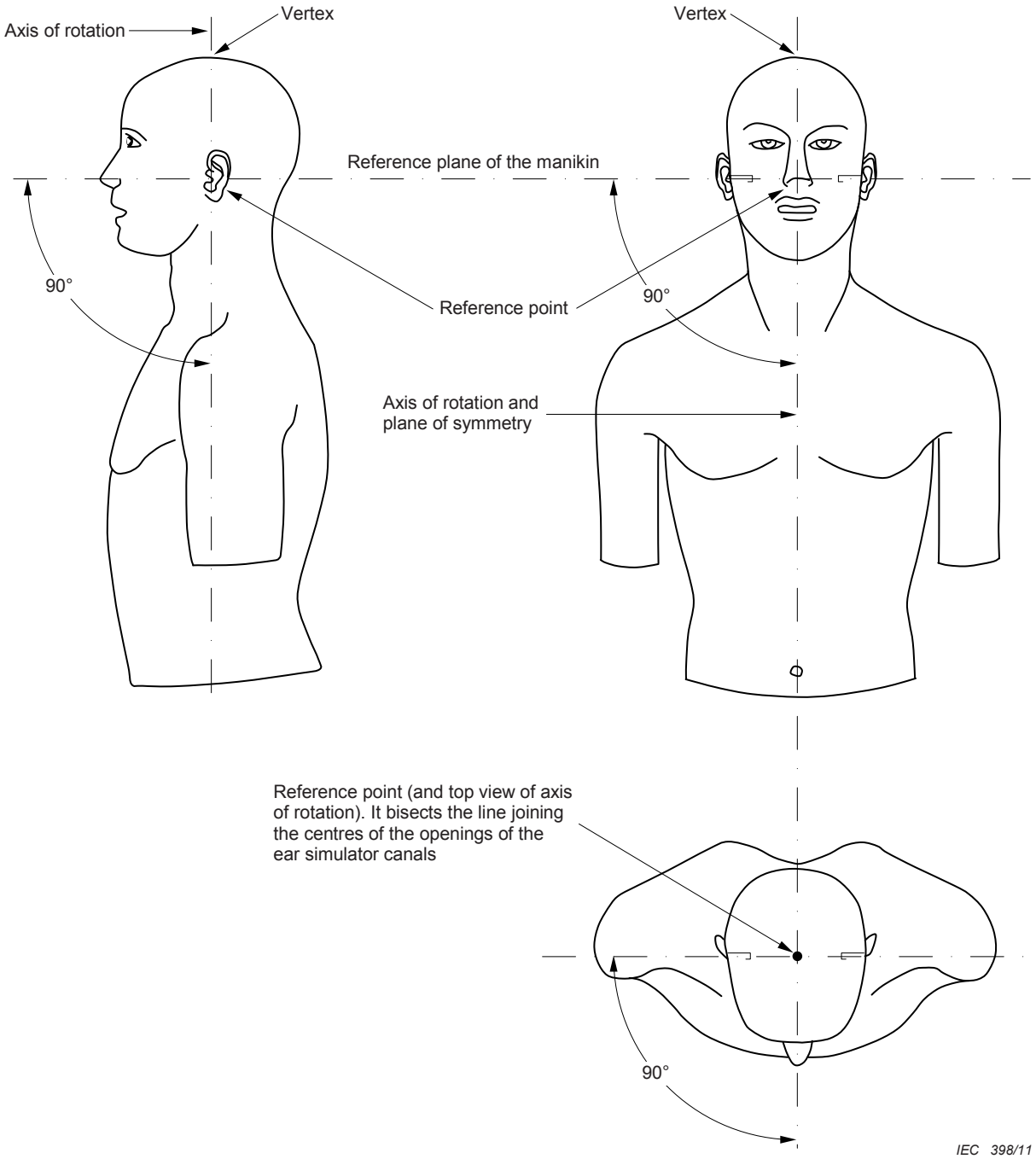
3.13
test plane
plane perpendicular to the test axis and containing the test point

3.14
azimuth angle of sound incidence
θ
angle between the plane of symmetry of the manikin (see Figure 2) and the plane defined by the axis of rotation and the test axis; when the manikin faces the sound source, the azimuth angle of sound incidence is defined as 0°

NOTE 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°.

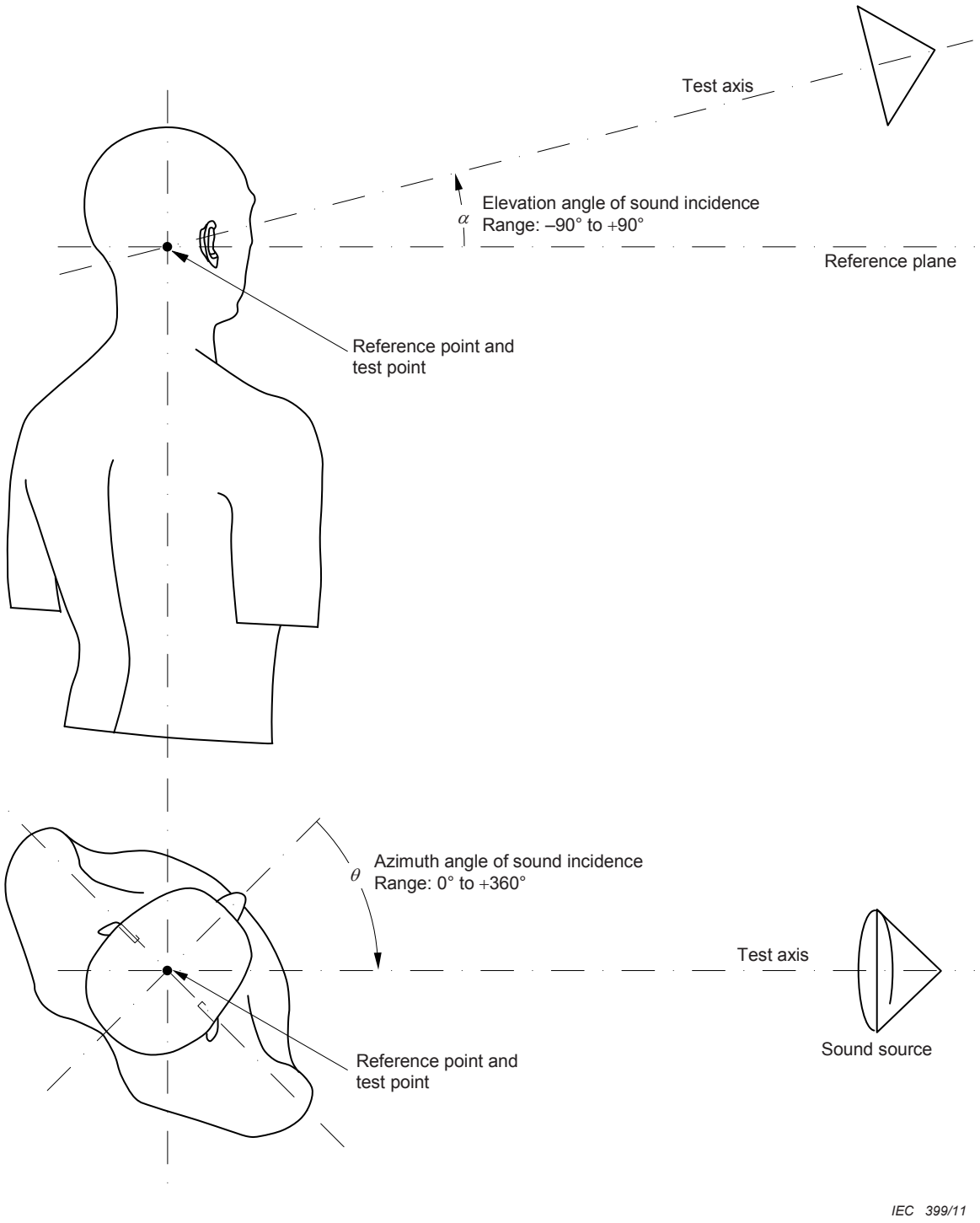
3.15
elevation angle of sound incidence
α
angle between the reference plane of the manikin and the test axis (see Figure 2); when the vertex points towards the sound source, the elevation angle is defined as +90°

NOTE When the test axis lies in the reference plane, the elevation angle is defined as 0°.



NOTE The reference point is the reference point of the manikin.

Figure 1 – Manikin geometrical references



NOTE The reference point is the reference point of the manikin.

Figure 2 – Coordinate scheme for azimuth and elevation angles

3.16
reference position of the manikin
position of the manikin in the test space that meets the following conditions:

– the reference point of the manikin coincides with the test point,

– the azimuth and elevation angles are both equal to zero

3.17
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 and the sound pressure level at the test point with the manikin absent

3.18
ear canal entrance point
EEP
point located at the centre of the manikin ear canal at the junction between concha and ear canal extension

3.19
vertical pinna reference axis
line through the EEP, and parallel to the axis of rotation of the manikin

3.20
horizontal pinna reference axis
line through the EEP, and parallel to the reference plane of the manikin with an azimuth angle of 90°

NOTE The horizontal pinna reference axis is needed for vertical cross-sections of a pinna simulator, see for instance IEC 60268-7 [1].

4 Construction

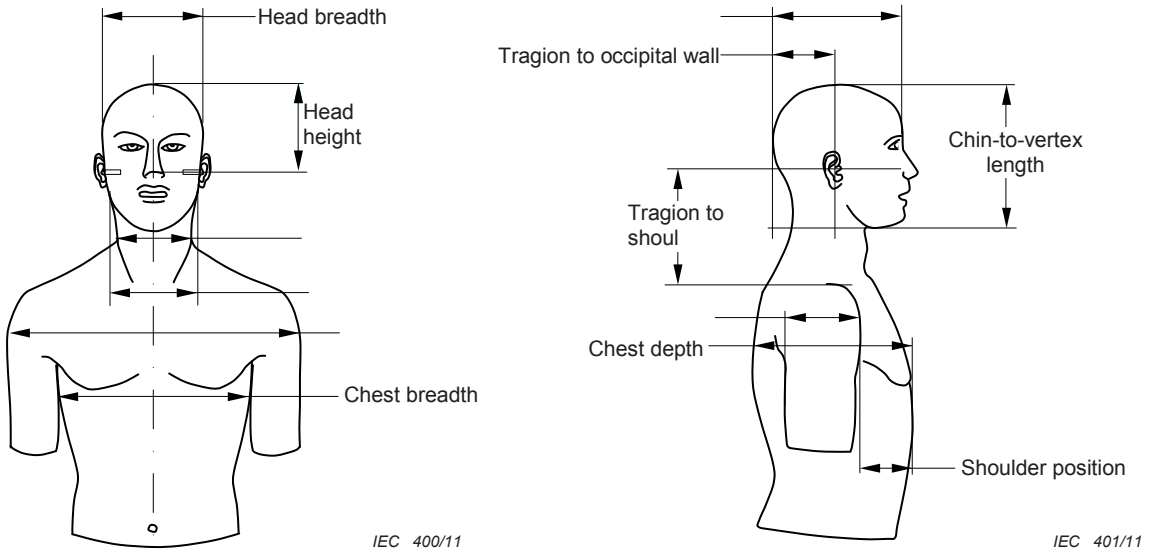
4.1 General

In the following, both the geometrical physical dimensions of the manikin's head, torso and pinnae and the manikin's acoustical characteristics are specified. Where tolerances are specified in this technical specification, these shall be reduced by an amount equal to the actual expanded measurement uncertainty of the test laboratory before deciding if a device conforms to the stated requirement.

4.2 Geometrical dimensions of the manikin

4.2.1 Torso

4.2.1.1 The principal geometrical dimensions of the manikin torso are illustrated in Figure 3, and listed in Table 1 (for information only). The realization of the torso is specified in 4.2.1.2.



a) Front view b) Side view

NOTE For position of tragion, see Figure 6.

Figure 3 – Illustration of manikin head and torso dimensions

Table 1 – Head and torso dimensions for the manikin and average human data

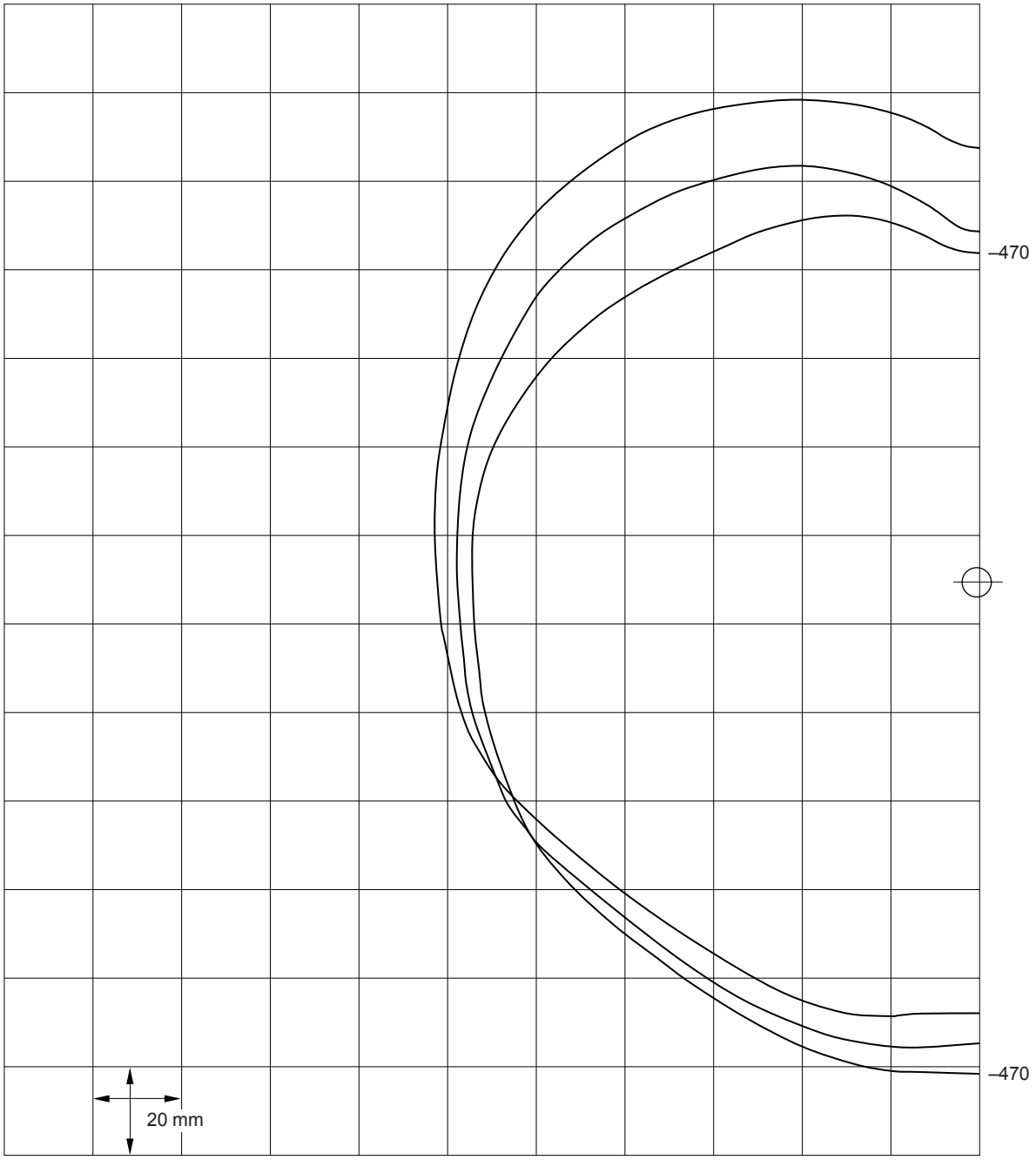
Dimension	**Manikin** (mm)	**Average human data [5]** (mm)
Head breadth	152	151
Head length	191	188
Head height (tragion to vertex)	125	130
Bitragion diameter	143	139
Tragion to occipital wall	97	98
Tragion to shoulder	175	176
Neck diameter	113	112
Shoulder breadth	440	427
Chest breadth	282	291
Chin to vertex length	224	222
Chest depth	235	--
Shoulder depth	110	--
Shoulder position	80	--

NOTE 1 The data given in Table 1 is for information only.

NOTE 2 In order to be independent of the type of pinna simulator, the tragion sometimes is replaced by the ear canal entrance point (EEP) as reference point of the manikin [5]. In this case the corresponding manikin values are: EEP to vertex 130 mm, EEP to EEP distance 132 mm, EEP to occipital wall 94 mm and EEP to shoulder 170 mm.

4.2.1.2 Cross-sections parallel to the reference plane of the manikin are given in Figures 4a) to 4e). Each cross-section is identified by the distance (in millimetres, negative towards the waist) from the reference plane of the manikin. Circles indicate the position of the axis of rotation of the manikin. Grid lines are spaced 20 mm.

NOTE The torso is symmetrical. Cross-sections are shown only for the top view of the right side. The orientation of the cross-section is such that the front of the head points downwards.

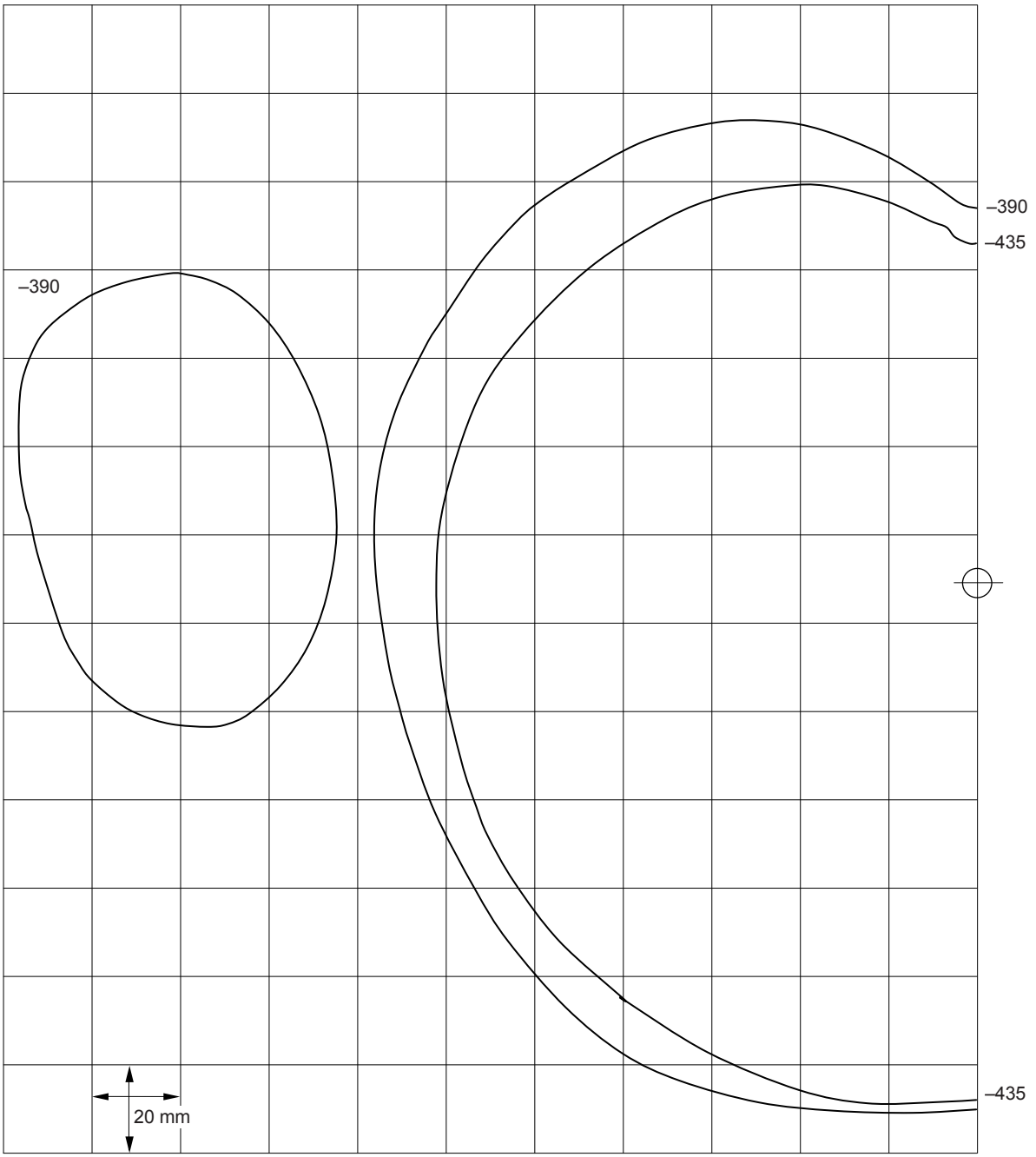


IEC 402/11

NOTE 1 Not to scale, convert grid as dimensioned.

NOTE 2 For detailed information on the graph refer to 4.2.1.2.

4a) Cross-section 1

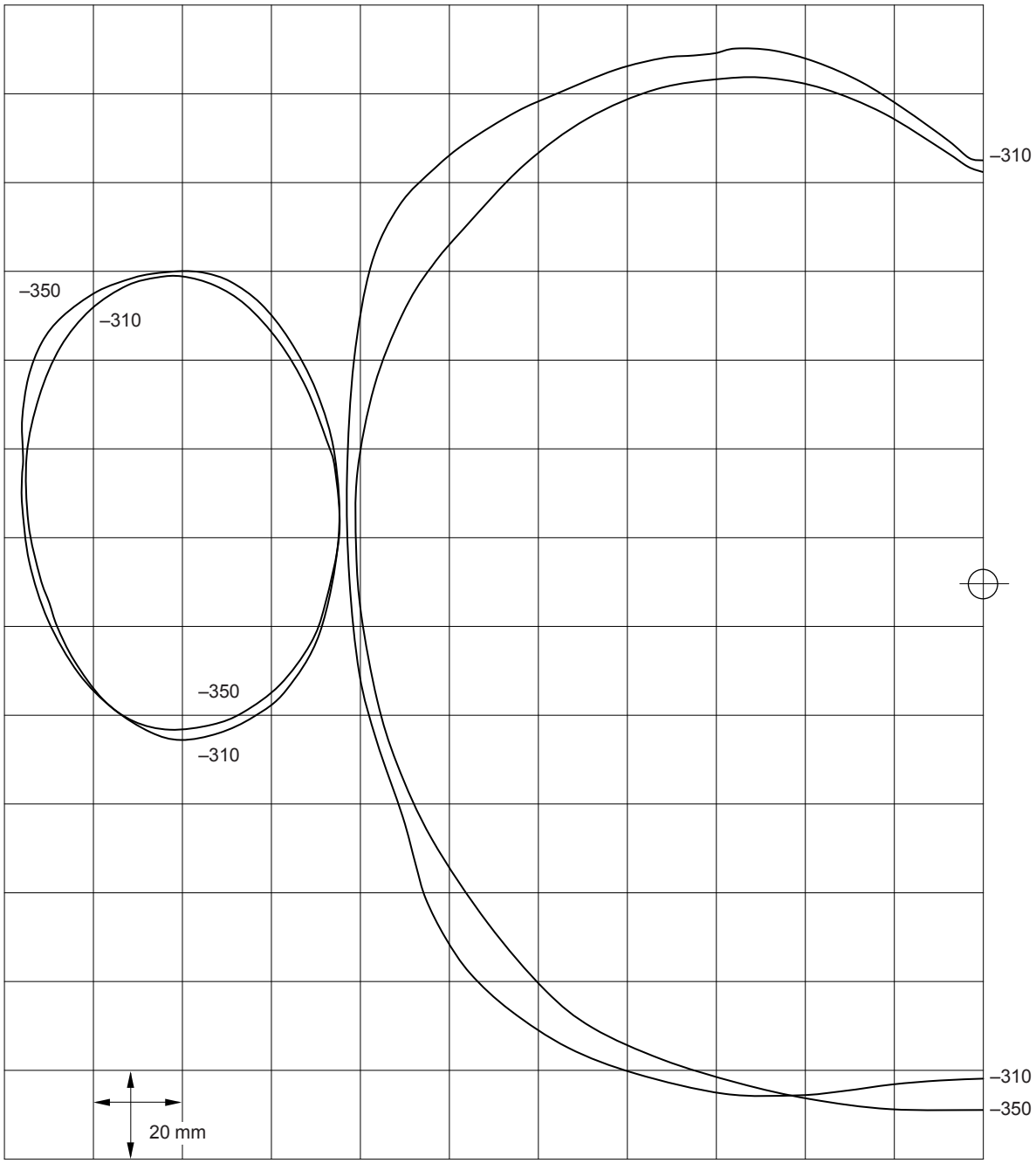


IEC 403/11

NOTE1 Not to scale, convert grid as dimensioned.

NOTE 2 For detailed information on the graph refer to 4.2.1.2.

4b) Cross-section 2

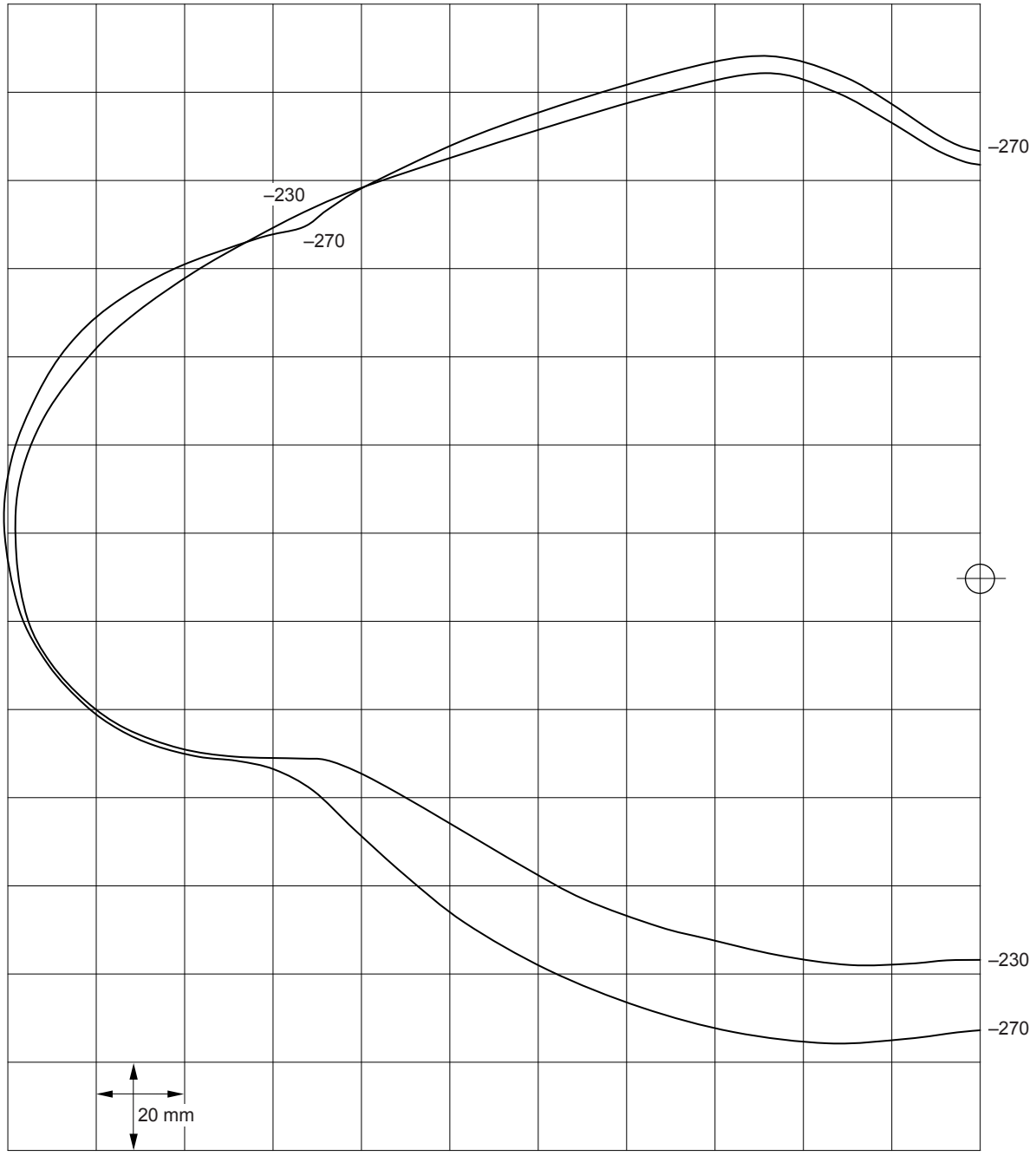


IEC 404/11

NOTE 1 Not to scale, convert grid as dimensioned.

NOTE 2 For detailed information on the graph refer to 4.2.1.2.

4c) Cross-section 3

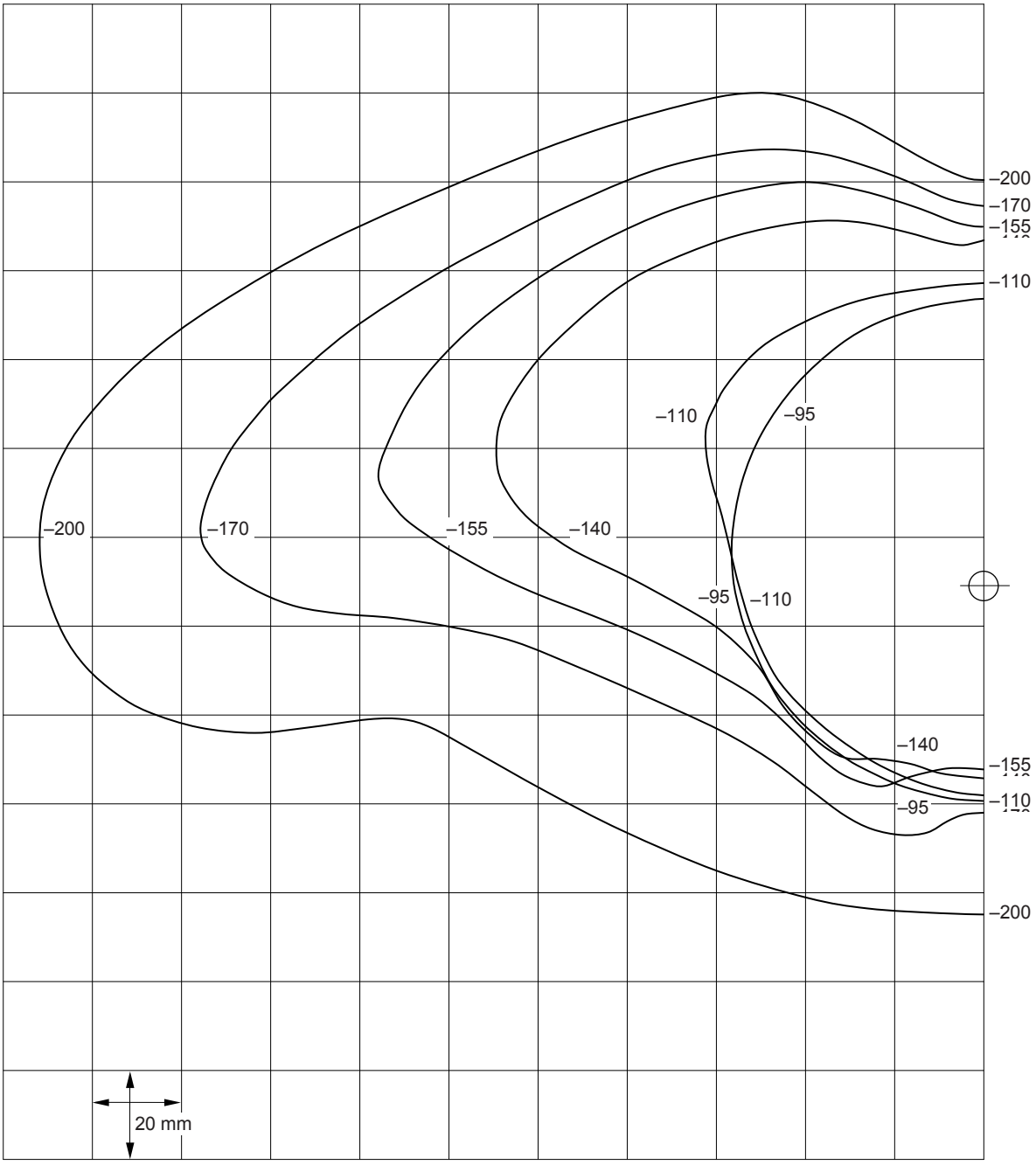


IEC 405/11

NOTE 1 Not to scale, convert grid as dimensioned.

NOTE 2 For detailed information on the graph refer to 4.2.1.2.

4d) Cross-section 4



IEC 406/11

NOTE 1 Not to scale, convert grid as dimensioned.

NOTE 2 For detailed information on the graph refer to 4.2.1.2.

4e) Cross-section 5

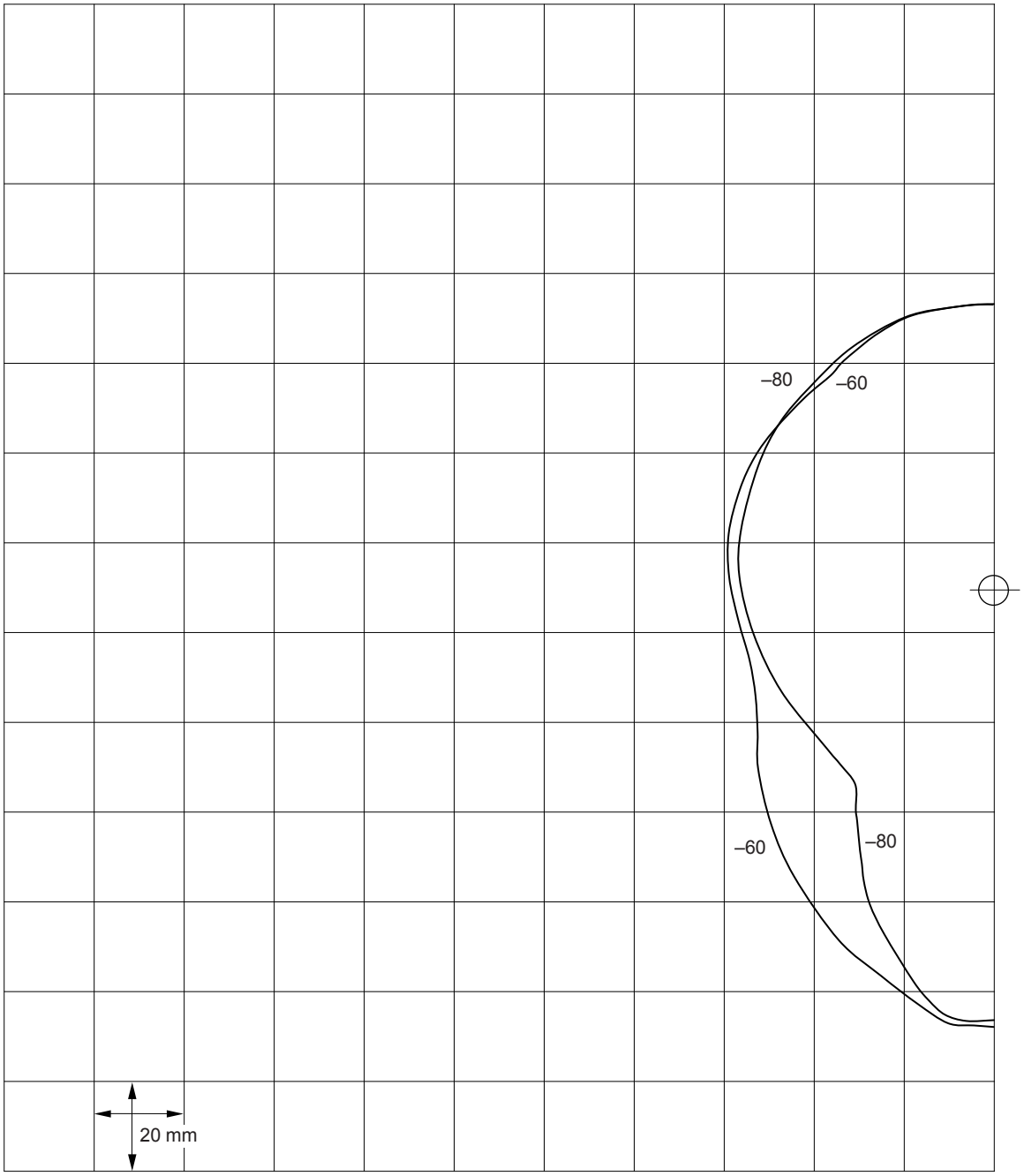
Figure 4 – Cross-sections of torso (tolerance ± 4 mm)

4.2.2 Head

4.2.2.1 The principal geometrical dimensions of the manikin head are illustrated in Figure 3, and listed in Table 1 (for information only). The realization of the head is specified in 4.2.2.2.

4.2.2.2 Cross-sections parallel to the reference plane of the manikin are given in Figures 5a) to 5e). Each cross-section is identified by the distance (in millimetres, positive towards the vertex, negative towards the waist) from the reference plane of the manikin. Circles indicate the position of the axis of rotation of the manikin. The dot in Figures 5b) to 5d) indicates the position of the ear canal entrance point (EEP). The vertical pinna reference axis is used as a reference for location of the pinna cross-sections. Grid lines are spaced 20 mm.

NOTE The head is symmetrical; cross-sections are shown only for the top view of the right side. The orientation of the cross-section is such that the front of the head points downwards.

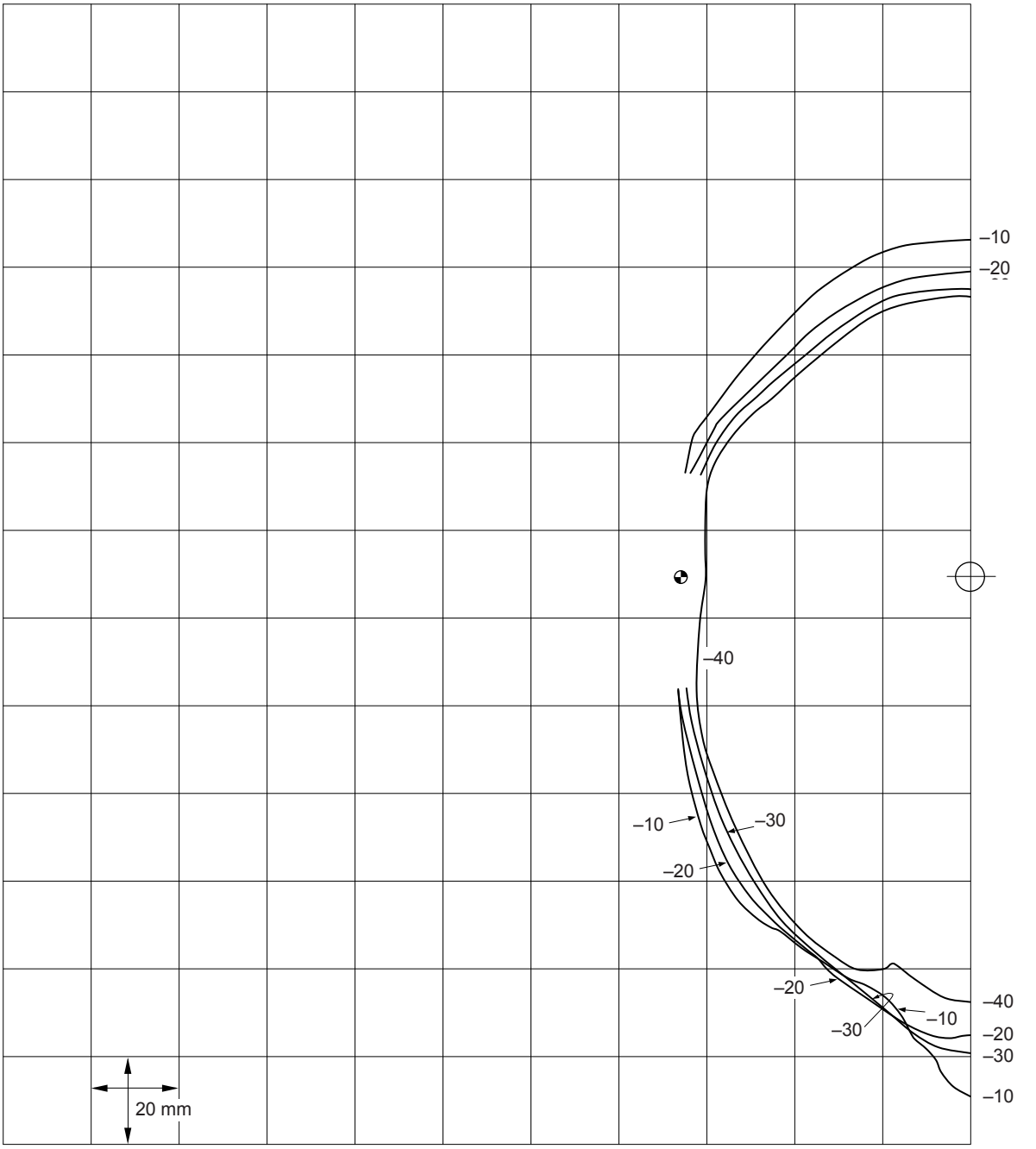


IEC 407/11

NOTE 1 Not to scale, convert grid as dimensioned.

NOTE 2 For detailed information on the graph refer to 4.2.2.2.

5a) Cross-section 1

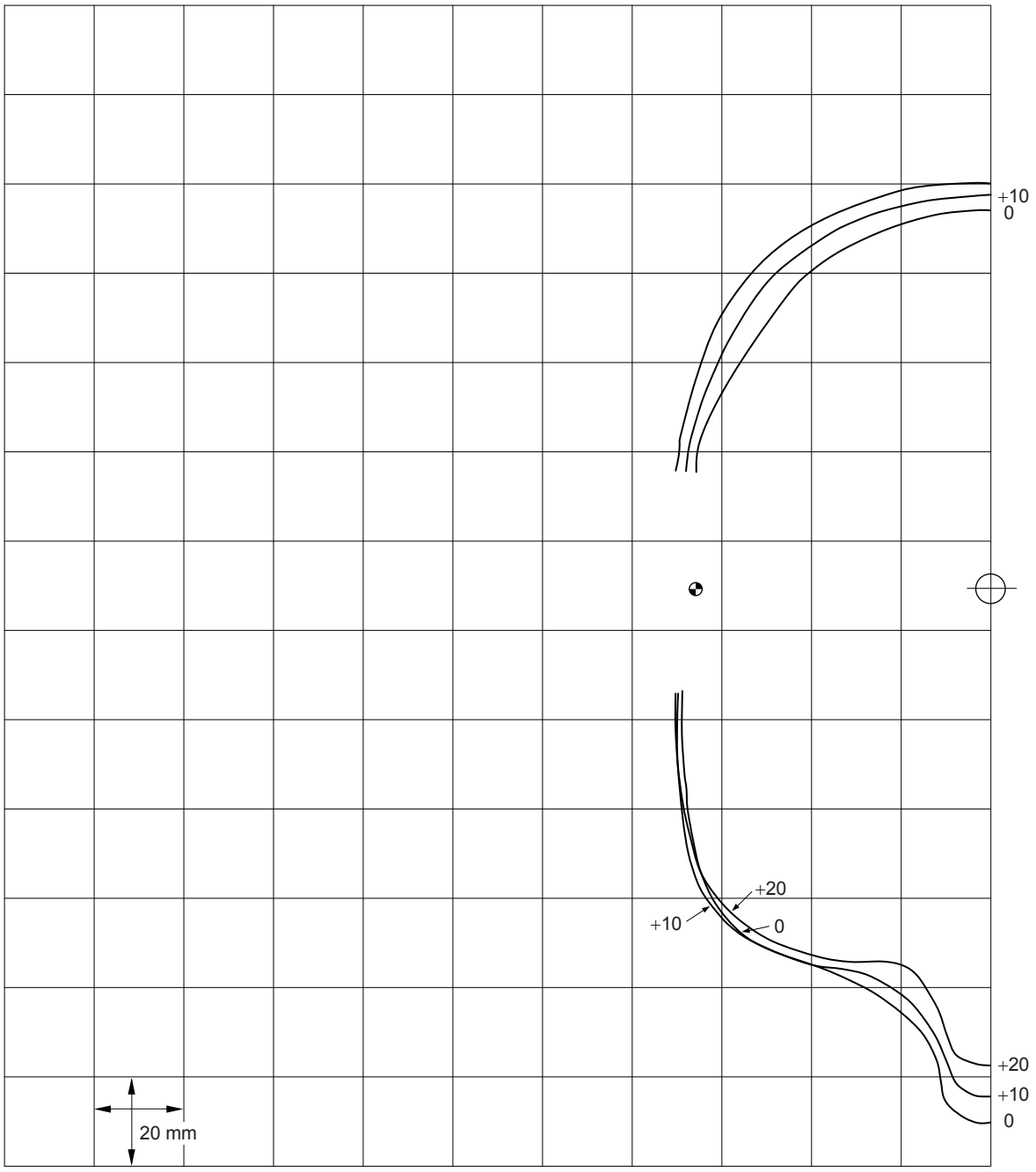


NOTE 1 Not to scale, convert grid as dimensioned.

NOTE 2 For detailed information on the graph refer to 4.2.2.2.

NOTE 3 For missing segments refer to Figures 7a) to 7c).

5b) Cross-section 2



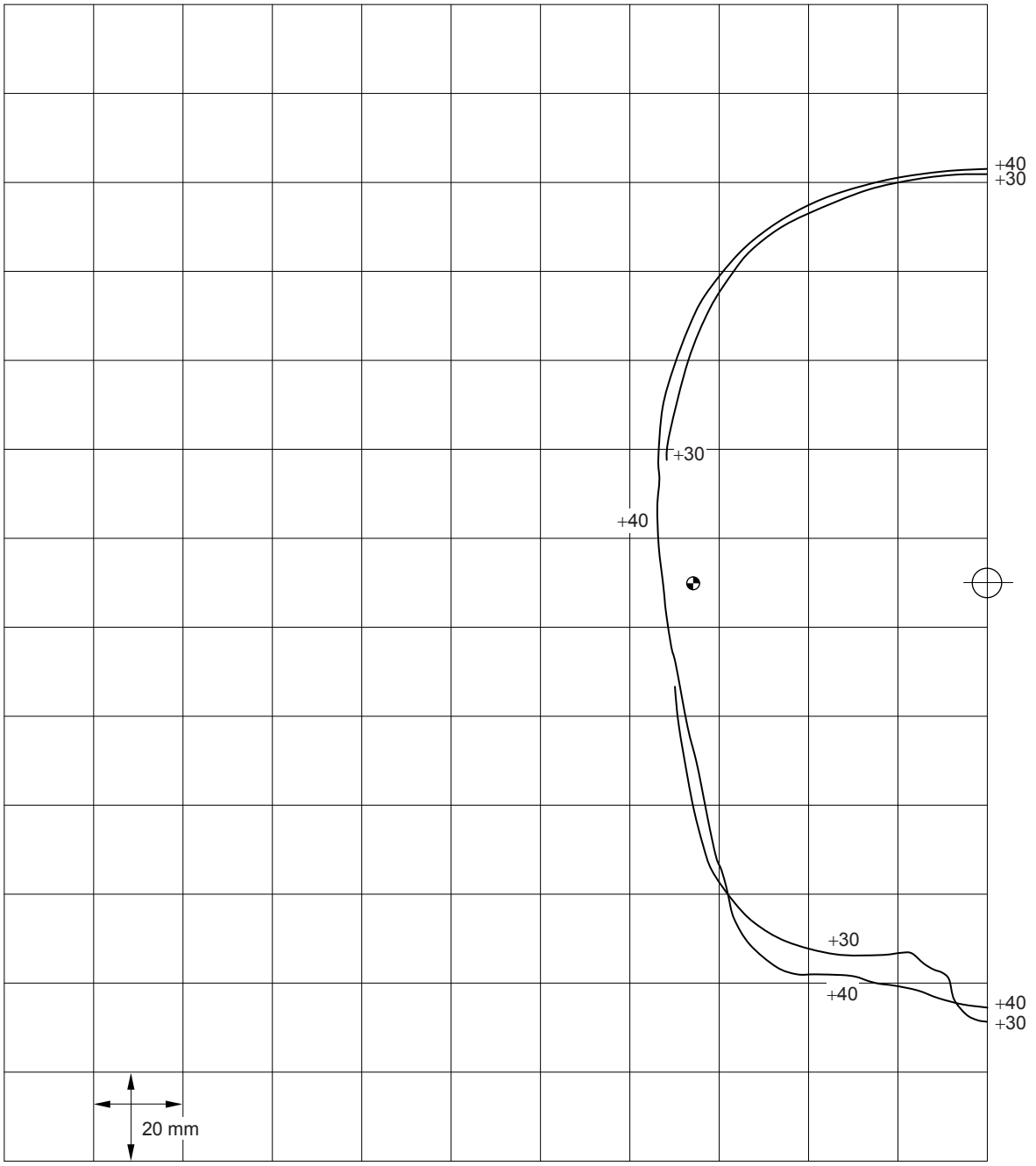
IEC 409/11

NOTE 1 Not to scale, convert grid as dimensioned.

NOTE 2 For detailed information on the graph refer to 4.2.2.2.

NOTE 3 For missing segments refer to Figures 7a) to 7c).

5c) Cross-section 3



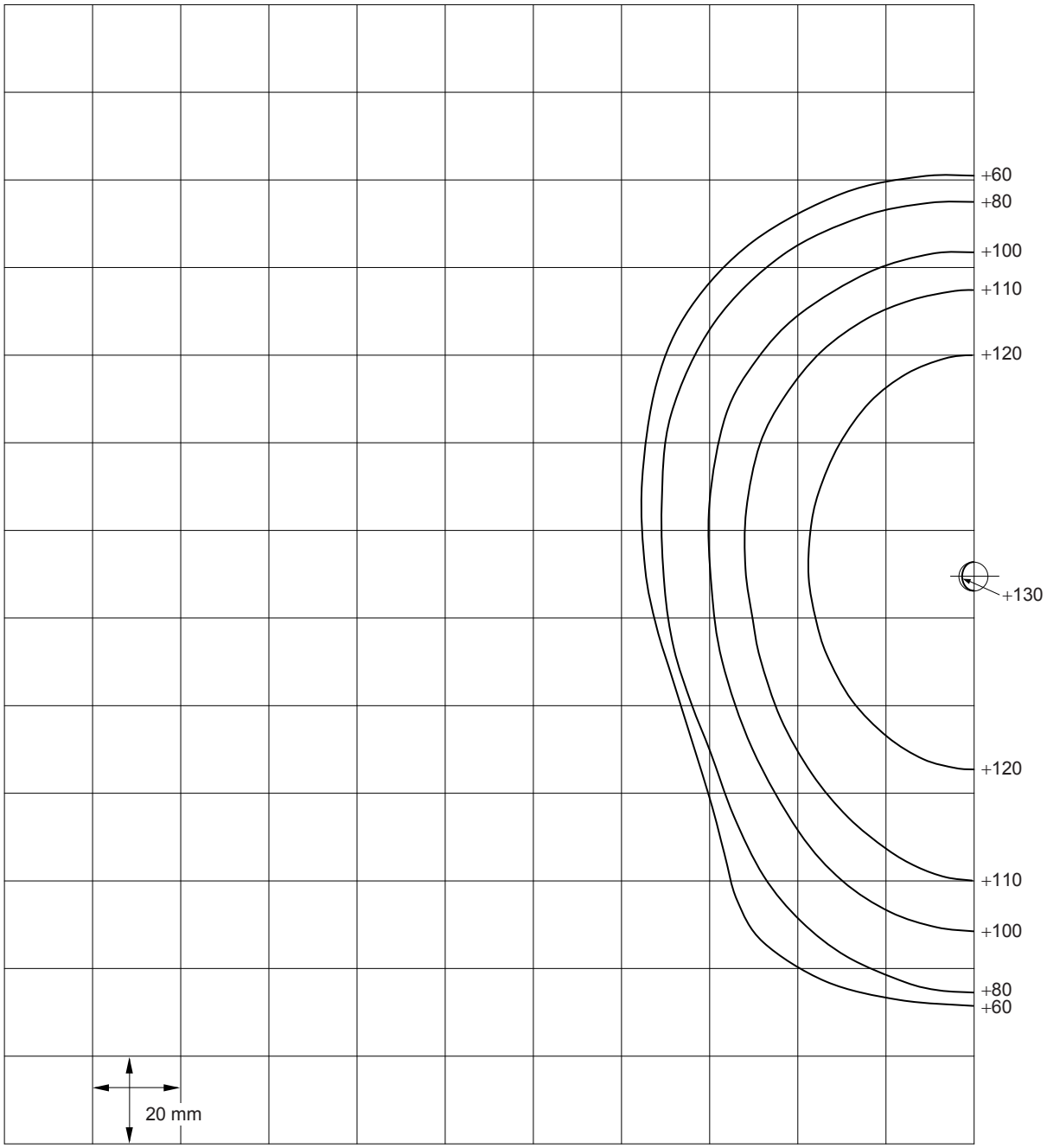
IEC 410/11

NOTE 1 Not to scale, convert grid as dimensioned.

NOTE 2 For detailed information on the graph refer to 4.2.2.2.

NOTE 3 For missing segments refer to Figures 7a) to 7c).

5d) Cross-section 4



NOTE 1 Not to scale, convert grid as dimensioned.

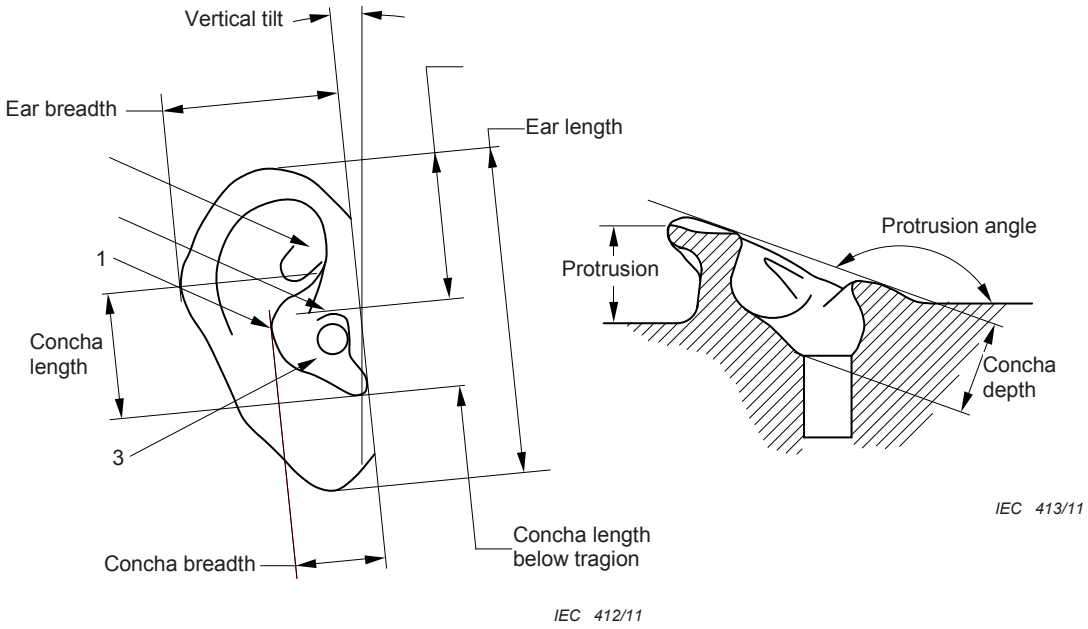
NOTE 2 For detailed information on the graph refer to 4.2.2.2.

5e) Cross-section 5

Figure 5 – Cross-sections of head (tolerance ± 2,5 mm)

4.2.3 Pinna

4.2.3.1 The principal geometrical dimensions and orientation of the simulated pinna are illustrated in Figure 6, and listed in Table 2 (for information only). The realization of the simulated pinna is specified in 4.2.3.2.



a) Side view b) Cross-section

Key

1. Anti-helix
2. Crus of helix
3. Concha
4. Tragion

Figure 6 – Illustration of manikin pinna dimensions

Table 2 – Pinna dimensions for the manikin

Dimension	Manikin (mm and °)
Ear length	66
Ear length above tragion	30
Ear breadth	37
Ear protrusion	23
Ear protrusion angle	160°
Vertical tilt front view	10°
Vertical tilt side view	6°
Concha length	28
Concha length below tragion	20
Concha breadth	23
Concha breadth, tragion to helix	23
Concha depth	15

NOTE The data given in Table 2 is for information only.

4.2.3.2 Cross-sections parallel to the reference plane of the manikin are given in Figures 7a) to 7c). Each cross-section is identified by the distance (in millimetres, positive towards the vertex, negative towards the waist) from the section plane to the reference plane of the manikin.

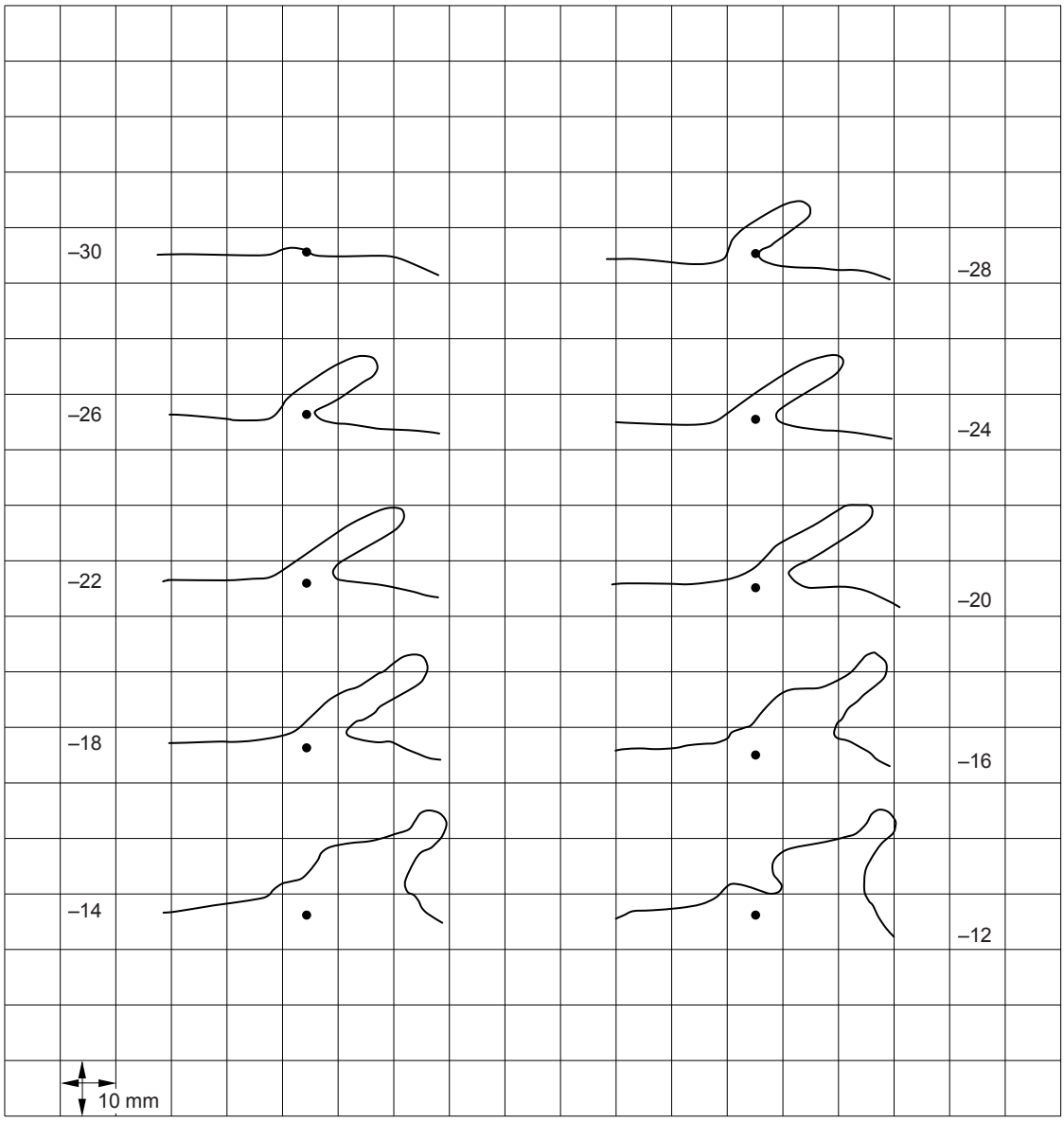
The dots indicate the position of the vertical pinna reference axis (see 4.2.2.2). The grid lines are spaced 10 mm.

NOTE 1 Figures 7a) to 7c) show cross-sections for the top view of the right pinna. The left pinna is determined as a mirror image of the right pinna.

NOTE 2 The relation between dimensional details and acoustical performance of the pinna are at present only partially understood, and minor adjustments of concha shape, anti-helix, crus of helix, and the location of pinna relative to ear canal may be necessary to conform with the acoustical specifications (see 4.3), particularly at high frequencies.

NOTE 3 The position of the ear simulator relative to the pinna is shown in Figure 7b).

NOTE 4 In addition to the pinna simulator described in this technical specification, there are other types of pinna simulator on the market. These pinna simulators, however, do not fulfill the requirements of Table 3 of this technical specification.



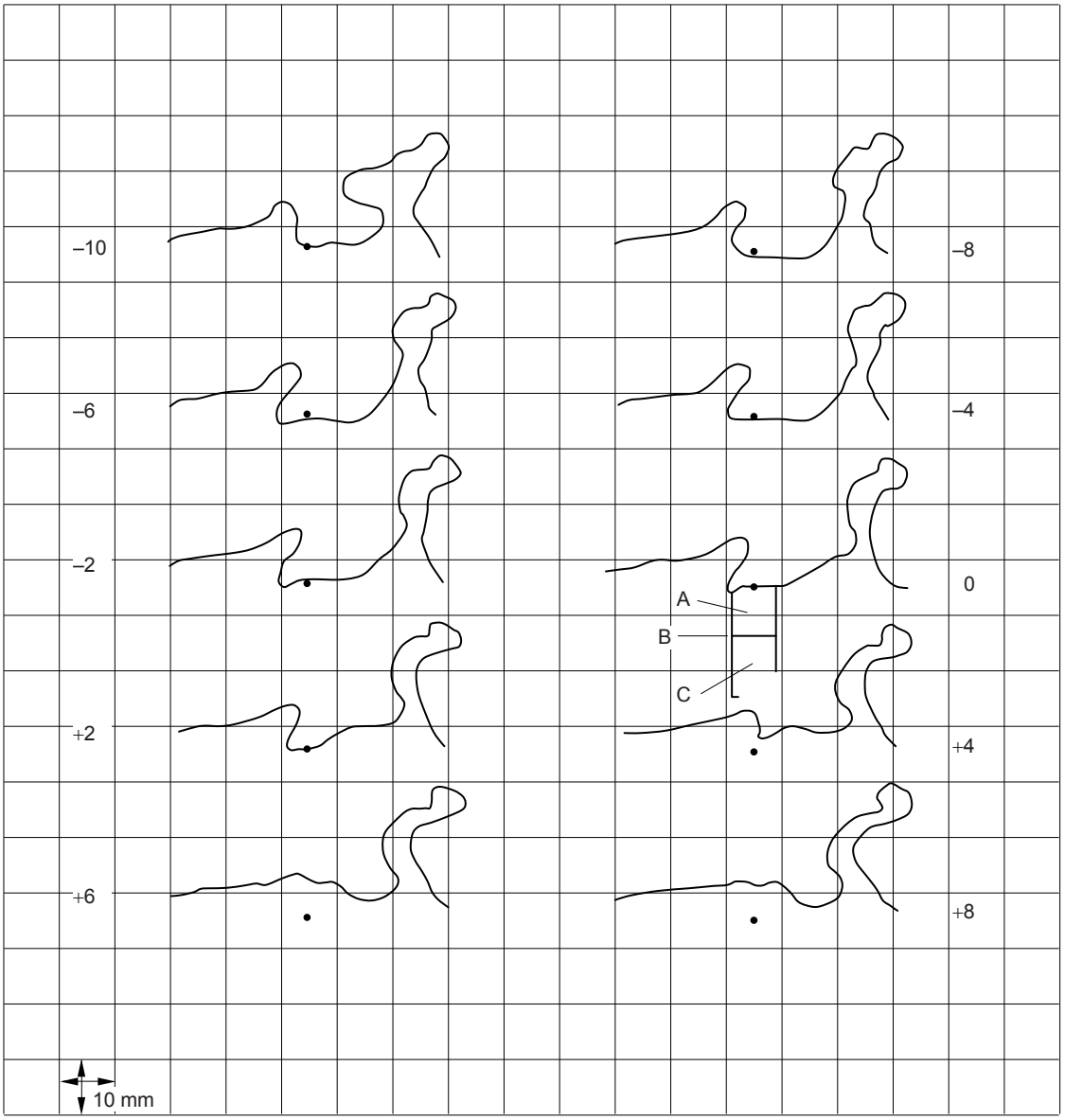
IEC 414/11

NOTE 1 Not to scale, convert grid as dimensioned.

NOTE 2 The orientation of the cross-section is such that the front of the head points leftwards.

NOTE 3 For detailed information on the graph refer to 4.2.3.2.

7a) Cross-section 1



IEC 415/11

Key

A Ear canal extension

B Occluded ear simulator reference plane

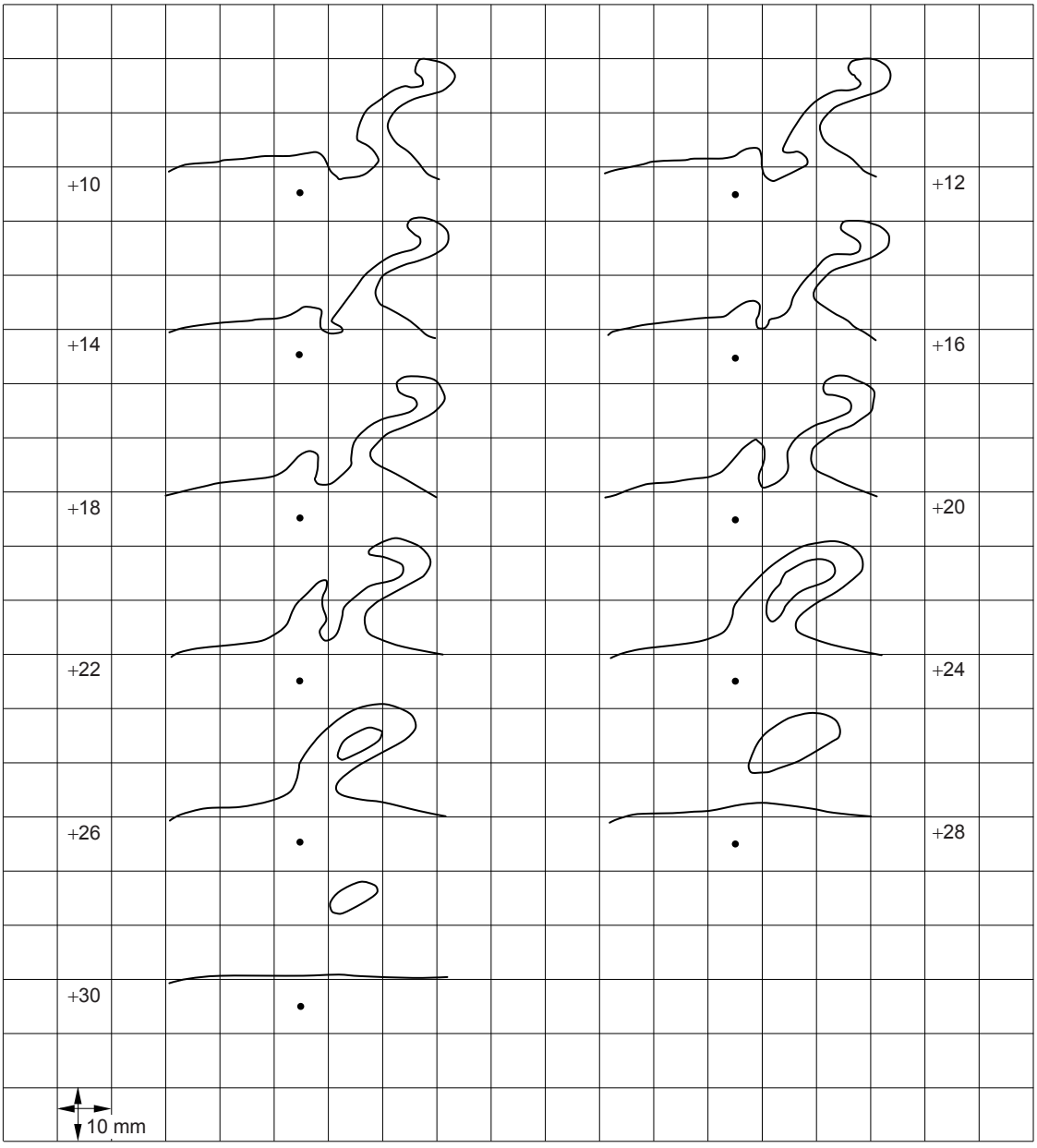
C Occluded ear simulator

NOTE 1 Not to scale, convert grid as dimensioned.

NOTE 2 The orientation of the cross-section is such that the front of the head points leftwards.

NOTE 3 For detailed information on the graph refer to 4.2.3.2.

7b) Cross-section 2



IEC 416/11

NOTE 1 Not to scale, convert grid as dimensioned.

NOTE 2 The orientation of the cross-section is such that the front of the head points leftwards.

NOTE 3 For detailed information on the graph refer to 4.2.3.2.

7c) Cross-section 3

Figure 7 – Cross-sections of right pinna (tolerance ± 1,5 mm)

4.2.4 Ear simulator

The ear simulator shall comprise an occluded ear simulator as described in IEC 60318-4, and an ear canal extension. The ear canal extension shall have a cylindrical form with the length of 8,8 mm ± 0,3 mm and diameter of 7,5 mm ± 0,3 mm. The ear canal extension terminates at the ear simulator reference plane and is connected to the pinna as shown on Figure 7b).

NOTE Occluded ear simulators differing in detail from that specified in IEC 60318-4, are in current use in some countries. If such devices are used as part of the ear simulator, their characteristics should be stated when giving results of measurements of hearing aids or other devices under test made with the head and torso simulator.

4.2.5 Materials

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

The pinna simulator shall be made from a high-quality elastomer. It is recommended that its shore-OO hardness, measured at the surface 15 mm forward to the ear opening, is 35° ± 6°, providing that it conforms with the acoustical specifications (see 4.3). Since the mechanical properties of elastomer materials are likely to change over time, a time period shall be specified for individual pinna simulators (e.g. by means of an expiration date), over which the mechanical characteristics of the material are expected to remain in compliance with this specification.

NOTE Type of pinna simulator used for the measurement of a device should be stated together with the test result.

4.2.6 Markings

4.2.6.1 To facilitate azimuth alignment, the torso shall, at the waist, be equipped with markings indicating the direction of 0° azimuth.

4.2.6.2 If the head is removable from the torso, both shall be provided with markings to ensure correct alignment.

4.2.6.3 To assist reproducible placement of hearing aids or other devices under test in and around the pinna, the head surfaces in the immediate vicinity of the pinnae may be equipped with coordinate axis markings. The coordinate axes should be parallel to the axis of rotation (*y*-axis) and the manikin reference plane (*x*-axis) respectively, and have the ear canal entrance point (EEP) as their origin. Values on the *x*-axis shall be positive towards the front of the manikin, on the *y*-axis positive towards the vertex.

4.2.7 Tolerances

The tolerance on a point of a cross-section relative to contours in the figures shall be ± 4 mm for the torso (Figures 4a) to 4e)), ± 2,5 mm for the head (Figures 5a) to 5e)) and ± 1,5 mm for the pinna (Figures 7a) to 7c)). These tolerances also apply for the distance between cross-sections and the reference plane of the manikin.

4.3 Acoustical characteristics of the manikin

4.3.1 Free field frequency response

Table 3 gives the manikin free field frequency response for pure tones at third octave intervals, in decibels relative to the free field sound pressure level. Values are stated for an elevation angle of 0°, and the azimuth angles 0°, 90°, 180° and 270° for the right ear. Corresponding symmetrical azimuth angles apply for the left ear.

NOTE 1 Difficulties may be experienced when measuring the manikin frequency response at azimuth angle 270 ° for frequencies of 4 kHz and above. 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 3.

NOTE 2 The data in Table 3 are based on the studies by Maxwell and Burkhard [10] and by Münster-Swendsen [12]. The results of two subsequent studies on the manikin are described in [13] and [17].

4.3.2 Tolerances

Tolerances on the manikin free field frequency response are stated in Table 3. The values stated include the tolerances in the calibration of the occluded ear simulator, but not in the calibration of the free field microphone.

4.3.3 Openings

Any openings for access to the interior of the manikin other than the ears shall not affect the response of the manikin as specified in 4.3.1.

NOTE A suitable test method is given in 5.2.5.

5 Calibration

5.1 Atmospheric reference conditions

Reference ambient pressure: 101,325 kPa

Reference temperature: 23 °C

Reference relative humidity: 50 %

5.2 Calibration method

5.2.1 General

Measurement of acoustical characteristics of the manikin shall be performed with equipment conforming to the following specifications.

5.2.2 Test space and measurement equipment

The test space and sound source shall provide an approximation to plane progressive waves in free field conditions in the frequency range 100 Hz to 10 000 Hz.

These conditions are deemed to exist if the sound pressure levels measured at distances of 250 mm from the test point do not deviate from the sound pressure level at the test point by more than ± 2 dB. The measurement points for testing compliances shall include two points on the test axis, respectively towards and away from the sound source. Four further measurement points in the test plane shall be included: two in the reference plane, to the left and right as viewed from the sound source; the other two on the axis of rotation, above and below the test point.

NOTE 1 Elimination of reflections in the test space may either be achieved by suitable absorbent lining of the enclosure boundaries, by temporal gating of the measured signal (impulse response technique), or by delayed frequency filtering of the measured signal (time delay spectrometry).

NOTE 2 The permitted deviation of sound pressure level relative to that at the test point includes the inverse pressure/distance law, deviations from this inverse pressure/distance law and deviations due to source directionality.

NOTE 3 For an anechoic room, compliance cannot generally be expected unless the test point is further than 1 m from the boundaries and the sound source is at least 2 m from the boundaries.

The sound source shall only contain coaxial elements or a single diaphragm, and the ratio of the maximum frontal sound source dimension to source distance shall be less than 0,25. In order to avoid reflections the frontal area of the sound source baffle may be covered by a suitable absorbing material.

The acoustic test signal shall be a sinusoid with a frequency within ± 1 % of the nominal frequency, and with harmonic distortion less than 2 %.

The test space shall be equipped with fixtures permitting an accurate and repeatable positioning of the manikin in accordance with the selected test point.

The effective sound pressure level of extraneous background noise shall be at least 10 dB less than the sound pressure level in the frequency band of the test signal.

NOTE 4 This may be achieved by suitable attenuation of extraneous signals by the test enclosure boundaries, by signal averaging, or by selective filtering.

5.2.3 Measurement of sound pressure level

The free field sensitivity level of the reference microphone used to measure the unobstructed free field sound pressure level shall be known by calibration with an expanded measurement uncertainty (95 % level of confidence) of no more than 0,8 dB for frequencies up to 5 kHz and 1,3 dB from 5 kHz to 10 kHz.

The calibration of the occluded ear simulator shall conform to the specifications in IEC 60318-4.

Harmonic distortion of the measurement system shall not exceed 2% at the frequencies and sound pressure levels encountered.

The calibration should be performed under the atmospheric reference conditions given in 5.1 with the following tolerances:

Ambient pressure: ± 3 kPa

Temperature: ± 3 °C

Relative humidity: ± 20 %

If it is not possible to fulfil these atmospheric requirements, the actual atmospheric conditions shall be stated.

5.2.4 Alignment of manikin azimuth and elevation

The azimuth and elevation angle shall be aligned with an accuracy of ± 2,5°.

NOTE If the manikin is equipped with two ear simulators, 0° or 180° azimuth alignment may be achieved by adjustment of the azimuth angle for minimum time difference between the microphone outputs from the two ear simulators. Alternatively a broadband noise may be fed to the sound source, the microphone outputs from the two ear simulators connected to the *x* and *y* grids of an oscilloscope, and the azimuth angle adjusted for minimum width of the resulting Lissajous figure.

5.2.5 Test for sound leakage

With the ear canal under test effectively sealed from external sound by the device under test at the reference plane of the occluded ear simulator and the other ear canal blocked, the measurements described in Clause 4 shall give results at least 35 dB below those with both ear canals open.

Table 3 – Free field frequency response of the manikin

Frequency	Azimuth angle				Tolerance
Hz	0°	90°	180°	270°	dB
	Free field response in dB				
100	0,0	0,0	0,0	0,0	± 2,0
125	0,0	0,5	0,0	0,0	± 2,0
160	0,0	1,0	–0,5	0,0	± 2,0
200	0,0	1,5	–0,5	0,0	± 2,0
250	0,5	2,0	0,0	0,0	± 2,0
315	1,0	3,0	0,0	0,0	± 2,0
400	1,5	4,0	1,0	0,5	± 2,5
500	2,0	5,5	1,5	1,0	± 2,5
630	2,5	7,0	2,5	2,0	± 2,5
800	3,5	7,5	4,0	2,5	± 2,5
1 000	3,5	7,5	5,0	2,5	± 2,5
1 250	3,5	8,5	6,5	3,0	± 2,5
1 600	5,0	9,5	7,0	4,5	± 3,5
2 000	12,5	12,0	10,0	6,5	± 3,5
2 500	18,5	17,0	14,0	9,0	± 3,5
3 150	15,5	17,0	13,0	7,5	± 3,5
4 000	13,0	12,5	10,5	–	± 3,5
5 000	11,0	15,5	7,0	–	± 3,5
6 300	5,0	17,0	0,5	–	± 6,5
8 000	2,0	15,0	–1,5	–	± 8,5
10 000	7,0	3,0	–6,0	–	± 8,5

6 Maximum permitted expanded uncertainty of measurements

Table 4 specifies the maximum permitted expanded uncertainty U_{max}, calculated with a coverage factor of k=2 to give a level of confidence of approximately 95 %, associated with the measurements undertaken in this part of IEC 60318, (see ISO/IEC Guide 98-3). One set of values for U_{max} is given for basic type approval measurements.

The expanded uncertainties of measurements given in Table 4 are the maximum permitted for demonstration of conformance to the requirements of this part of IEC 60318. If the actual expanded uncertainty of a measurement performed by the test laboratory exceeds the maximum permitted value in Table 4, the measurement shall not be used to demonstrate conformance to the requirements of this part of IEC 60318.

Table 4 – Values of U_{max} for basic measurements

Measured quantity	Relevant clause number	U_{max} (k=2)
Cross-section of torso	4.2.1	1 mm
Cross-section of head	4.2.2	0,5 mm
Cross-section of simulated pinna	4.2.3	0,5 mm
Diameter of ear canal extension	4.2.4	0,1 mm
Length of ear canal extension	4.2.4	0,1 mm
Free-field frequency response	4.3.1	0,5 dB
Azimuth and elevation angle	4.3.1, 5.2.4	0,5 °
Frequency of test signal	5.2.2	0,1 %
Harmonic distortion	5.2.2, 5.2.3	0,2 %
Microphone free field sensitivity level	5.2.3	0,3 dB
Ambient pressure	5.2.3	0,1 kPa
Temperature	5.2.3	0,5 °C
Relative humidity	5.2.3	5 %

Annex A
(informative)

Ear canal sound pressure ratio

The ear canal sound pressure ratio is the difference (in dB) between the sound pressure level at the microphone of the occluded ear simulator and the sound pressure level at the ear canal entrance point (EEP).

This quantity may be useful in certain applications and the specific level differences are given in Table A.1.

Table A.1 – Ear canal sound pressure ratio

Frequency Hz	Sound pressure ratio dB
100 125 160	0 0 0
200 250 315	0,2 0,4 0,6
400 500 630	0,6 0,8 1,2
800 1 000 1 250	1,6 1,8 2,4
1 600 2 000 2 500	3,2 4,6 6,6
3 150 4 000 5 000	9,4 9,0 6,0
6 300 8 000 10 000	2,0 1,6 6,2

Bibliography

[1] IEC 60268-7, *Sound system equipment – Part 7: Headphones and earphones*

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

[3] ISO 11904-2, Acoustics – *Determination of sound immission from sound sources placed close to the ear* – Part 2: *Technique using a manikin*

[4] BLAUERT, J. *Sound localization in the median plane*, Acustica 22, 205-213 (1969/70)

[5] BURKHARD, M.D. and SACHS, R.M. *Anthropometric manikin for acoustic research*, J. Acous. Soc. Am. 58, 214-222 (1975)

[6] BURKHARD, M.D., editor, *Manikin Measurements*, Industrial Research Products, Inc., Elk Grove Village, Illinois, U.S.A. (1978)

[7] ITU-T Recommendation P.57 (2005): *Terminals and subjective and objective assessment methods – Artificial ears*

[8] ITU-T Recommendation P.58 (1996): *Terminals and subjective and objective assessment methods – Head and torso simulator for telephonometry*

[9] KUHN, G.F. *Interaural time difference in the azimuth plane*, Proceedings 9th ICA, Madrid (1977), paper H45

[10] MAXWELL, R.J. and BURKHARD, M.D. *Larger ear replica for the KEMAR manikin*, J. Acous. Soc. Am. 65, 1055-1058 (1979)

[11] MELLERT, V. *Construction of a dummy head after new measurement of thresholds of hearing*, J. Acous. Soc. Am. 51, 1359-1361 (1972)

[12] MÜNSTER-SWENDSEN, J. *Measurements of Kemar open-ear-gain*, Oticon internal report No 9-8-6, Oticon Research Unit, Snekkersten, Denmark (1981)

[13] RICHTER, U. and FEDTKE, T. *Determination of noise immissions from headphones and earphones by means of different head and torso simulators*, Proceedings 6th ICSV, Copenhagen (1999), 1019 - 1026

[14] SHAW, E.A.G. *The external ear*, in Handbook of Sensory Physiology, edited by W.D. Keidel and W.D. Neff, (Springer-Verlag 1974), V.1, 457

[15] SHAW, E.A.G. *Transformation of sound pressure from the free field to the eardrum in the horizontal plane*, J. Acous. Soc. Am. 56, 1848-61 (1974)

[16] TORICK, E.L. et. al. *An electric dummy for acoustical testing*, J. Audio Eng. Soc. 16 4 (1968)

[17] VORLÄNDER, M. *Free-field and Diffuse-field responses of Human Heads and of Head and Torso Simulators*, ACUSTICA Vol.74 (1991), 192 – 200, (in German language)

[18] ASTM D2240-05, *Standard test method for rubber property – Durometer Hardness*

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