International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

P.58

(06/2021)

SERIES P: TELEPHONE TRANSMISSION QUALITY, TELEPHONE INSTALLATIONS, LOCAL LINE NETWORKS

Objective measuring apparatus

Head and torso simulator for telephonometry

Recommendation ITU-T P.58

ITU-T P-SERIES RECOMMENDATIONS

TELEPHONE TRANSMISSION QUALITY, TELEPHONE INSTALLATIONS, LOCAL LINE NETWORKS

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Recommendation ITU-T P.58

Head and torso simulator for telephonometry

Summary

Recommendation ITU-T P.58 specifies the electroacoustic characteristics of the head and torso simulator (HATS) to be used for telephonometric measurements. Both the sound generation and sound pick-up characteristics of this device are specified.

The artificial ears described in this Recommendation support narrowband, wideband, super-wideband, as well as full-band applications.

The artificial mouth described in this Recommendation supports narrowband, wideband and super-wideband applications. However, it should be noted that the directionality of the artificial mouth is limited in its ability to simulate the human mouth in the super-wideband frequency range.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T P.58	1993-03-12	XII	11.1002/1000/1748
2.0	ITU-T P.58	1996-08-30	12	11.1002/1000/3637
3.0	ITU-T P.58	2011-12-14	12	11.1002/1000/11458
4.0	ITU-T P.58	2013-05-14	12	11.1002/1000/11932
5.0	ITU-T P.58	2021-02-13	12	11.1002/1000/14600
6.0	ITU-T P.58	2021-06-13	12	11.1002/1000/14663

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

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Recommendation ITU-T P.58

Head and torso simulator for telephonometry

1 Scope

This Recommendation specifies the electroacoustic characteristics of the head and torso simulator (HATS) for telephonometric use. Both sound emissions and sound pick-up characteristics are specified; the free-field acoustic diffraction is also specified.

The device is intended for airborne acoustic measurements, and is not suitable for measurements that depend on vibration conduction paths, such as bone conduction. The HATS is intended to provide acoustic diffraction similar to that encountered around the median human head and torso, and to generate an acoustic field similar to that generated by the human mouth, both in proximity and in the far field.

The methods of use of the HATS in telephonometry lie outside the scope of this Recommendation. However, the sound pick-up and diffraction characteristics specified by this Recommendation resemble those recommended by the International Electrotechnical Commission (IEC) for the measurement of hearing aids. The electroacoustic measurement methodologies for assessing the performance of hearing aids in their telecommunication applications are then, to the extent applicable, specified by the relevant IEC publications.

The characteristics of the device are fully specified for narrowband and wideband speech measurements. Some of its characteristics are described for an enlarged frequency range enabling measurements to be performed for super-wideband speech. Regarding sound pickup, some characteristics are specified up to 20 kHz, thus enabling measurements to be performed for fullband speech as well. Regarding ear simulator acoustic impedance, characteristics are described in [IEC 60318-4] and [ITU-T P.57].

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T O.131] Recommendation ITU-T O.131 (1988), *Quantizing distortion measuring equipment using a pseudo-random noise test signal*.

[ITU-T P.50] Recommendation ITU-T P.50 (1999), *Artificial voices*.

[ITU-T P.51] Recommendation ITU-T P.51 (1996), *Artificial mouth*.

[ITU-T P.57] Recommendation ITU-T P.57 (2021), *Artificial ears*.

[IEC 60318-4] IEC 60318-4:2010, *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 TS 60318-7] Technical Specification IEC TS 60318-7:2017, *Electroacoustics – Simulators of human head and ear – Part 7: Head and torso simulator for the measurement of air-conduction hearing aids*.

[ISO 4869-1]	ISO 4869-1:2018, *Acoustics – Hearing protectors – Part 1: Subjective method for the measurement of sound attenuation*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 ear canal entrance point (EEP) [b-ITU-T P.10]: A point located at the centre of the ear canal opening.

3.1.2 ear canal extension [b-ITU-T P.10]: Cylindrical cavity, extending the simulation of the ear canal provided by the occluded-ear simulator out to the concha cavity.

3.1.3 eardrum reference point (DRP) [b-ITU-T P.10]: A point located at the end of the ear canal, corresponding to the eardrum position.

3.1.4 ear reference point (ERP) [b-ITU-T P.10]: A virtual point for geometric reference located at the entrance to the listener's ear, traditionally used for calculating telephonometric loudness ratings.

3.1.5 ear simulator [b-ITU-T P.10]: 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.

3.1.6 head and torso simulator (HATS) [b-ITU-T P.10]: 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 a median human adult and to reproduce the acoustic field generated by the human mouth.

3.1.7 occluded-ear simulator [b-ITU-T P.10]: Ear simulator which simulates the inner part of the ear canal, from the tip of an ear insert to the eardrum.

3.1.8 pinna simulator [b-ITU-T P.10]: A device which has the approximate shape and dimensions of a median adult human pinna.

3.1.9 reference position of HATS [b-ITU-T P.10]: The reference position of the HATS in the test space is intended to simulate a person in the upright position. The HATS is in the reference position when the following conditions are met:

– the reference point coincides with the test point;

– the HATS reference plane is horizontal.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 artificial ear: A device for the calibration of earphones incorporating an acoustic coupler and a calibrated microphone for the measurement of the sound pressure and having an overall acoustic impedance similar to that of the median adult human ear over a given frequency band.

NOTE – Based on [b-ITU-T P.10].

3.2.2 axis of rotation: A straight line about which the head and torso simulator (HATS) can be rotated, passing through the HATS reference point, vertical to the horizontal plane and lying in the vertical plane. It is vertically oriented when the HATS is in the reference position.

3.2.3 azimuth angle of sound incidence: The angle between the vertical plane of the head and torso simulator (HATS) and the plane defined by the axis of rotation and the test axis. When the

HATS faces the sound source, the azimuth angle of sound incidence is defined as 0°. When the right ear of the HATS faces the sound source, the angle is defined as +90°. When the left ear of the HATS faces the sound source, the angle is defined as +270°.

3.2.4 diffuse field diffraction at mouth reference point: Difference, in decibels, between the third octave spectrum level of the acoustic pressure at the mouth reference point and the third octave spectrum level of the acoustic pressure at the same point in a diffuse sound field with the head and torso simulator absent.

3.2.5 diffuse field frequency response of head and torso simulator (sound pick-up): Difference, in decibels, between the third octave spectrum level of the acoustic pressure at the eardrum reference point and the third octave spectrum level of the acoustic pressure at the head and torso simulator (HATS) reference point in a diffuse sound field with the HATS absent.

3.2.6 elevation angle of sound incidence: The angle between the reference plane and the test axis. When the vertex points towards the sound source, the elevation angle is defined as +90°. When the test axis lies in the reference plane, the elevation angle is defined as 0°.

3.2.7 free-field frequency response of head and torso simulator (sound pick-up): Difference, in decibels, between the third octave spectrum level of the acoustic pressure at the eardrum reference point and the third octave spectrum level of the acoustic pressure at the head and torso simulator (HATS) reference point in a free sound field with the HATS absent (test point).

3.2.8 free-field plane wave diffraction at mouth reference point: Difference, in decibels, between the third octave spectrum level of the acoustic pressure at the mouth reference point and the third octave spectrum level of the acoustic pressure at the same point in a free sound field with the head and torso simulator absent. The characteristic is measured for a frontal sound incidence, with a propagation direction parallel to the reference axis.

3.2.9 head and torso simulator reference plane: A plane parallel to the horizontal plane, containing the head and torso simulator reference point.

3.2.10 head and torso simulator reference point (HRP): The point bisecting the line joining the ear canal entrance points.

3.2.11 horizontal plane of head and torso simulator: The plane containing the reference axis, perpendicular to the vertical plane. It is horizontally oriented when the head and torso simulator is in the reference position.

3.2.12 lip plane: Outer plane of the lip ring. The lip plane of the head and torso simulator (HATS) is normally different from the plane of the mouth simulator orifice. The lip plane is vertically oriented when the HATS is in the reference position.

NOTE – Based on [b-ITU-T P.10].

3.2.13 lip ring: Circular ring of thin rigid rod, having a diameter of 25 mm and less than 2 mm thick. It shall be constructed of non-magnetic material and be solidly fixable to the head and torso simulator. The lip ring defines both the reference axis of the mouth and the mouth reference point.

NOTE – Based on [b-ITU-T P.10].

3.2.14 monaural free-field frequency response of head and torso simulator (sound pick-up): The difference, in decibels, between the third octave spectrum level of the acoustic pressure at the eardrum reference point (DRP) for a given angle of sound incidence and the third octave spectrum level of the acoustic pressure at the DRP for front (0°) sound incidence.

3.2.15 mouth reference point (MRP): The point on the reference axis, 25 mm in front of the lip plane.

NOTE – Based on [b-ITU-T P.10].

3.2.16 mouth-ear reference plane: Plane containing the ear canal entrance points of both ears and the centre of the lip ring on the lip plane.

3.2.17 normalized free-field response (sound generation): Difference, in decibels, between the third octave spectrum level of the signal delivered by the head and torso simulator mouth at a given point in the free field and the third octave spectrum level of the signal delivered simultaneously at the mouth reference point. The characteristic is measured by generating the artificial voice (see [ITU-T P.50]), a speech shaped random noise, a pink noise or other adequate wideband signals.

3.2.18 normalized obstacle diffraction: Difference, in decibels, between the third octave spectrum level of the acoustic pressure delivered by the head and torso simulator (HATS) mouth simulator at the surface of the reference obstacle and the third octave spectrum level of the pressure simultaneously delivered at the point on the reference axis, 500 mm in front of the lip plane. The characteristic is defined for positions of the reference obstacle in front of the HATS mouth, with the disc axis coinciding with the reference axis, and is measured by generating the artificial voice (see [ITU-T P.50]), a speech shaped random noise, a pink noise or other adequate wideband signals.

3.2.19 reference axis: The line perpendicular to the lip plane containing the centre of the lip ring.

NOTE – Based on [b-ITU-T P.10].

3.2.20 reference obstacle: Disc constructed of hard, stable and non-magnetic material, such as brass, having a diameter of 63 mm and thickness 5 mm. In order to measure the normalized obstacle diffraction of the mouth simulator, it shall be fitted with a ¼ inch pressure microphone, mounted at the centre with the diaphragm flush with the disc surface facing the head and torso simulator.

3.2.21 test axis: The line through the test point, parallel to the propagation direction of externally applied plane progressive waves in a free sound field.

3.2.22 test plane for measurement of the uniformity of the free field wavefront: A plane perpendicular to the test axis and containing the test point.

3.2.23 test point: A reproducible position in the test space at which the sound pressure level is measured with the head and torso simulator (HATS) absent and at which the HATS reference point has to be located for test purposes.

3.2.24 transverse plane: A plane perpendicular to the reference axis and containing the head and torso simulator reference point.

3.2.25 vertical plane (plane of symmetry of the head and torso simulator): A plane containing the reference axis that divides the head and torso simulator (HATS) into symmetrical halves. It is vertically oriented when the HATS is in the reference position.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AC Alternating Current

DC Direct Current

DRP eardrum Reference Point

EEP Ear canal Entrance Point

ERP Ear Reference Point

HATS Head And Torso Simulator

HRP HATS Reference Point

MRP Mouth Reference Point

5 Conventions

None.

6 Description of the object

The HATS is a device that accurately reproduces the sound transmission and pick-up characteristics of the median head and torso of adult humans. Only the sound emission and pick-up characteristics affecting the electroacoustic measurements of telephone sets, headsets and hands-free telecommunication devices are considered.

The HATS consists of a head mounted on a torso that extends to the waist. The head is equipped with one or two artificial ears, and a mouth simulator. The HATS is specified physically and acoustically, as well as corresponding requirements.

7 Physical dimensions of the head and torso simulator

The HATS geometric references are illustrated in Figure 1. The coordinate scheme for azimuth and elevation angles of the sound source is illustrated in Figure 2.

7.1 Torso

The principal dimensions of the torso are illustrated in Figure 3 and ranges are listed in Table 1. The realization of the torso shall conform to the given dimensional ranges and guarantee conformity to the electroacoustic performance specified in this Recommendation.

NOTE – For the relevant dimensions, reference is made to the EEP position of the ears.

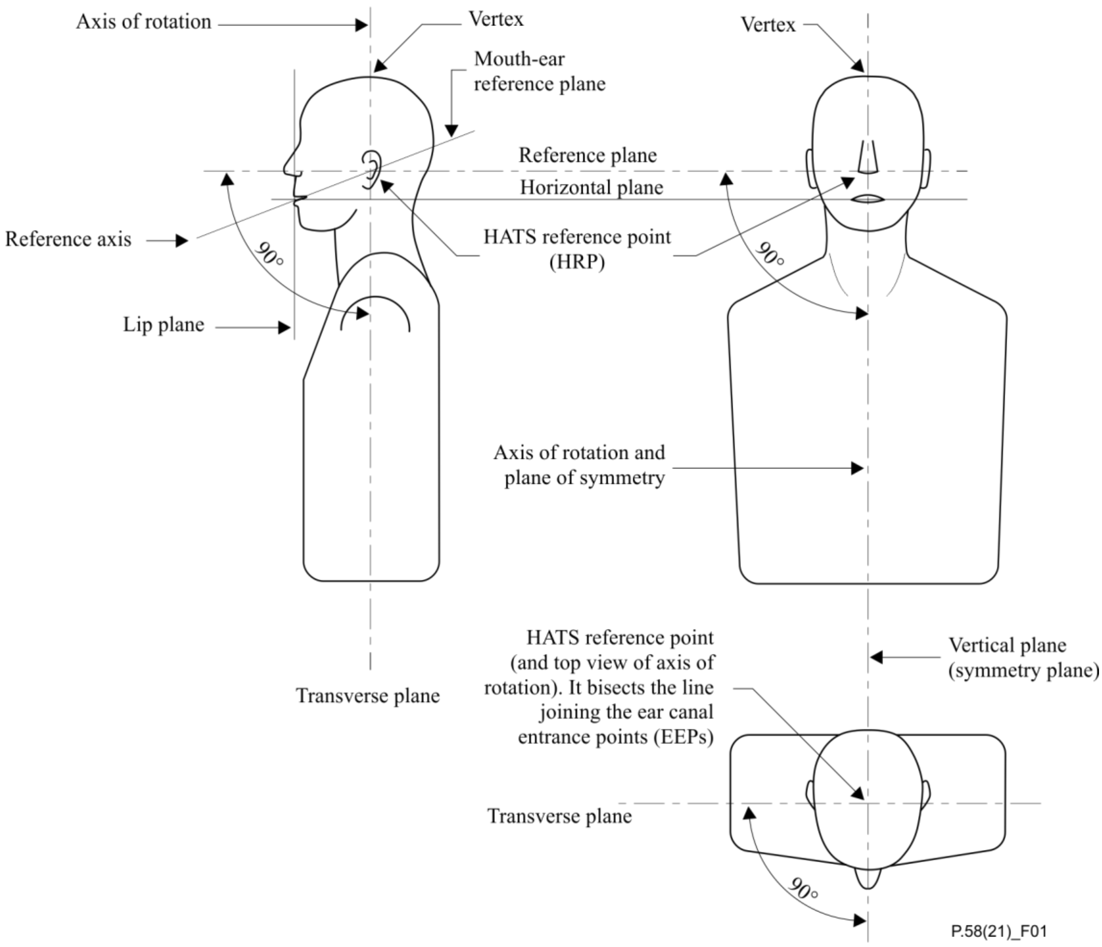


Figure 1 – HATS geometric references

7.2 Head

The principal dimensions of the head of the HATS are listed in Table 1. The realization of the head shall conform to the given dimensional ranges and guarantee conformity to the electroacoustic performance specified in this Recommendation.

NOTE – For the relevant dimensions, reference is made to the EEP position of the ears.

The cross-sections of the head surface, excluding pinnae, shall conform to the templates reported in Figures 4, 5, 6, and 7. In order to comply with this Recommendation, the HATS shall comply both with the dimensions in Table 1 and with the cross-section templates shown in Figures 4, 5, 6, and 7.

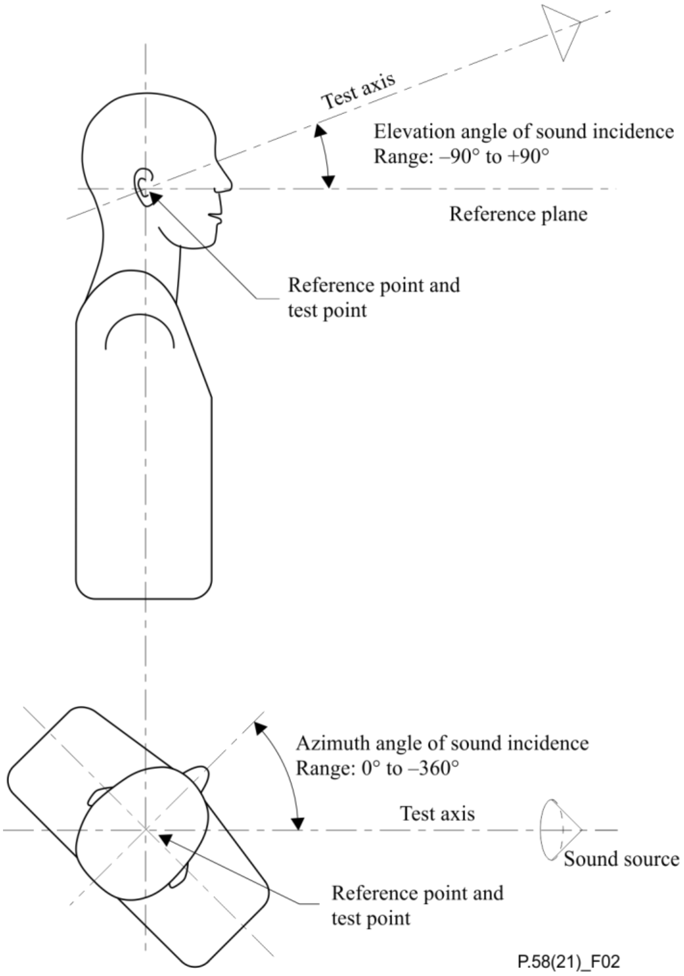


Figure 2 – Coordinate scheme for azimuth and elevation angles of the sound source

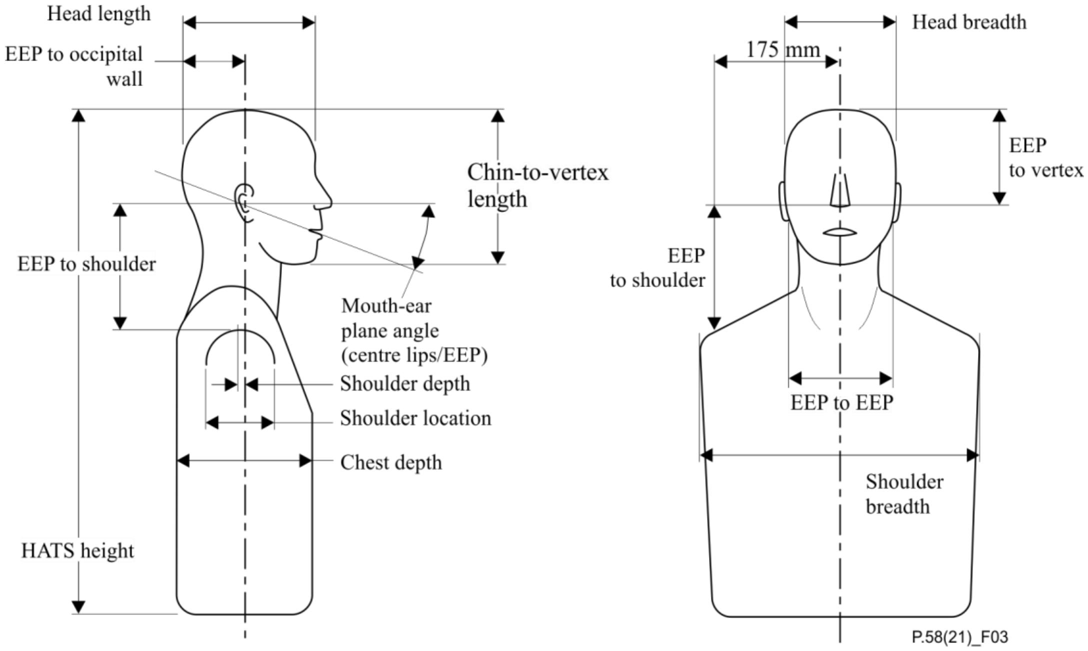


Figure 3 – HATS torso dimensions

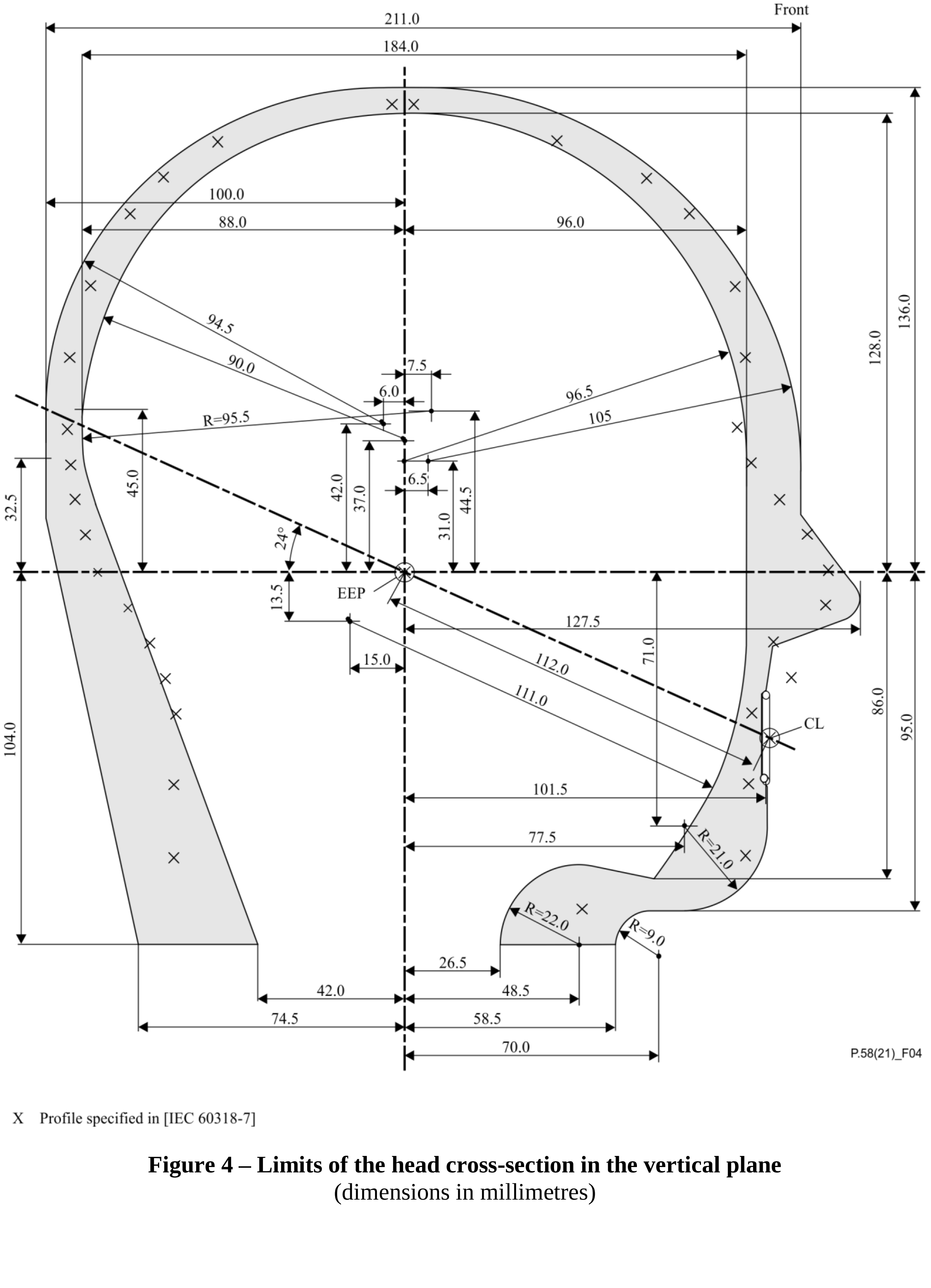
Table 1 – Head and torso dimensions

Dimension	**Nominal** (mm)	**Minimum** (mm)	**Maximum** (mm)
Head breadth	152	147	154
Head length	191	190	205
EEP to vertex	130	128	136
EEP to EEP distance	132	130	133
EEP to occipital wall	94	92	100
EEP to shoulder [a] EEP to centre lips	170 130	167 128	181 131
Chin-to-vertex length	224	216	225
Mouth-ear plane angle	24°	21.5°	25.5°
Shoulder breadth	420	400	455
Chest depth	235	178	272
Shoulder depth [b]	110	108	161
Shoulder location [c]	10	–4	46
HATS height		600	

[a] Measured from the shoulder surface, 175 mm sideways from the vertical plane, to the HATS reference plane.

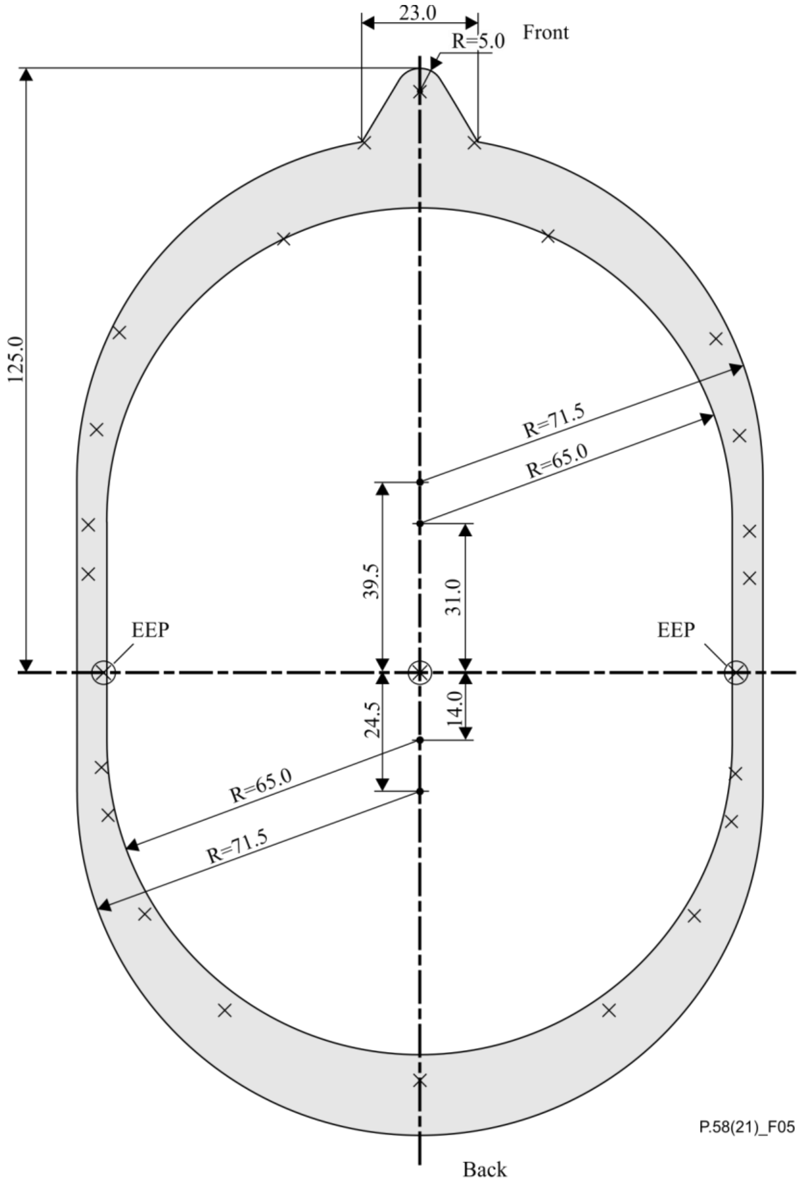
[b] Measured between front and back shoulder points, 175 mm sideways from the vertical plane.

[c] Measured from the point of the shoulder section, 175 mm sideways from the vertical plane, to the HATS transverse plane (positive behind transverse plane).



X Profile specified in [IEC 60318-7]

Figure 4 – Limits of the head cross-section in the vertical plane
(dimensions in millimetres)



X Profile specified in [IEC 60318-7]

Figure 5 – Limits of the head cross-section in the reference plane
(dimensions in millimetres)

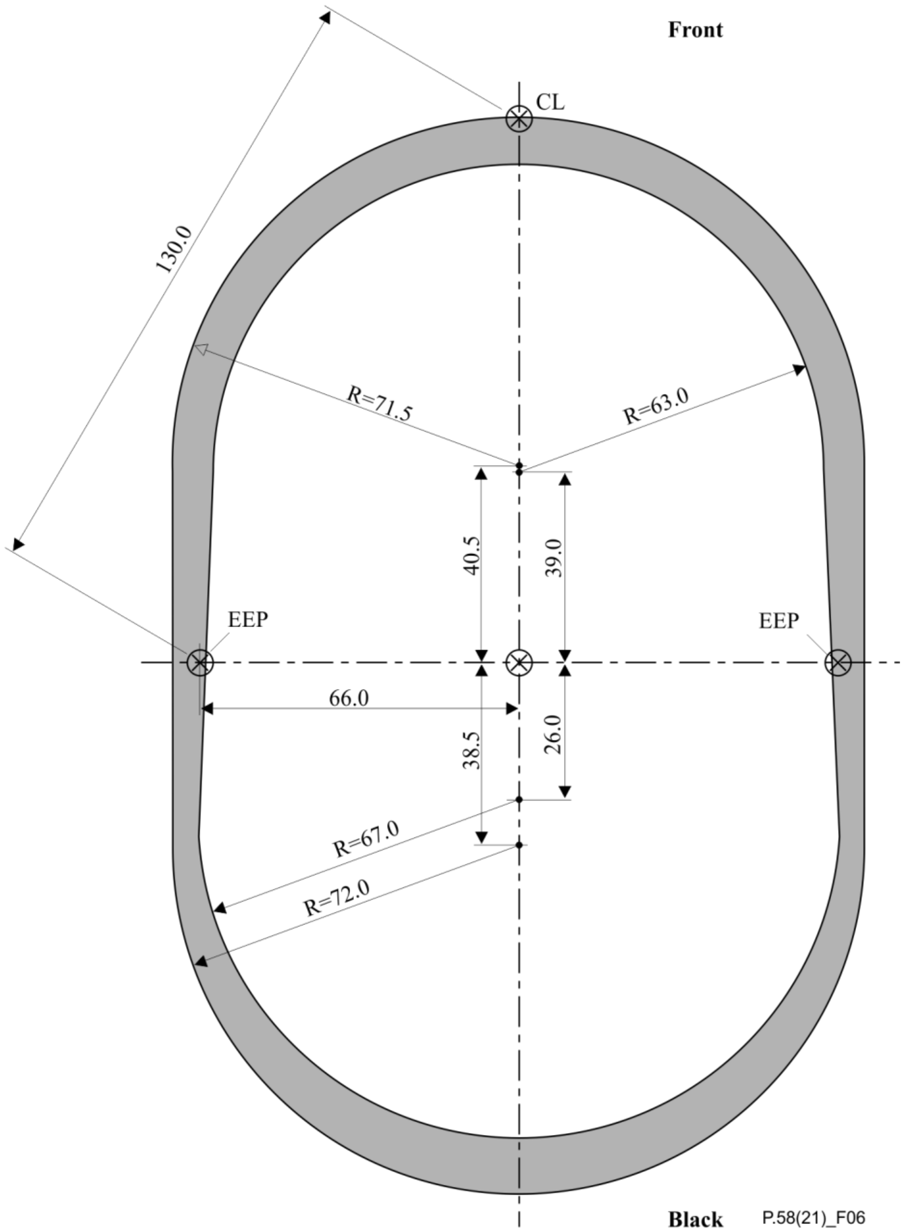


Figure 6 – Limits of the head cross-section in the mouth-ear reference plane
(dimensions in millimetres)

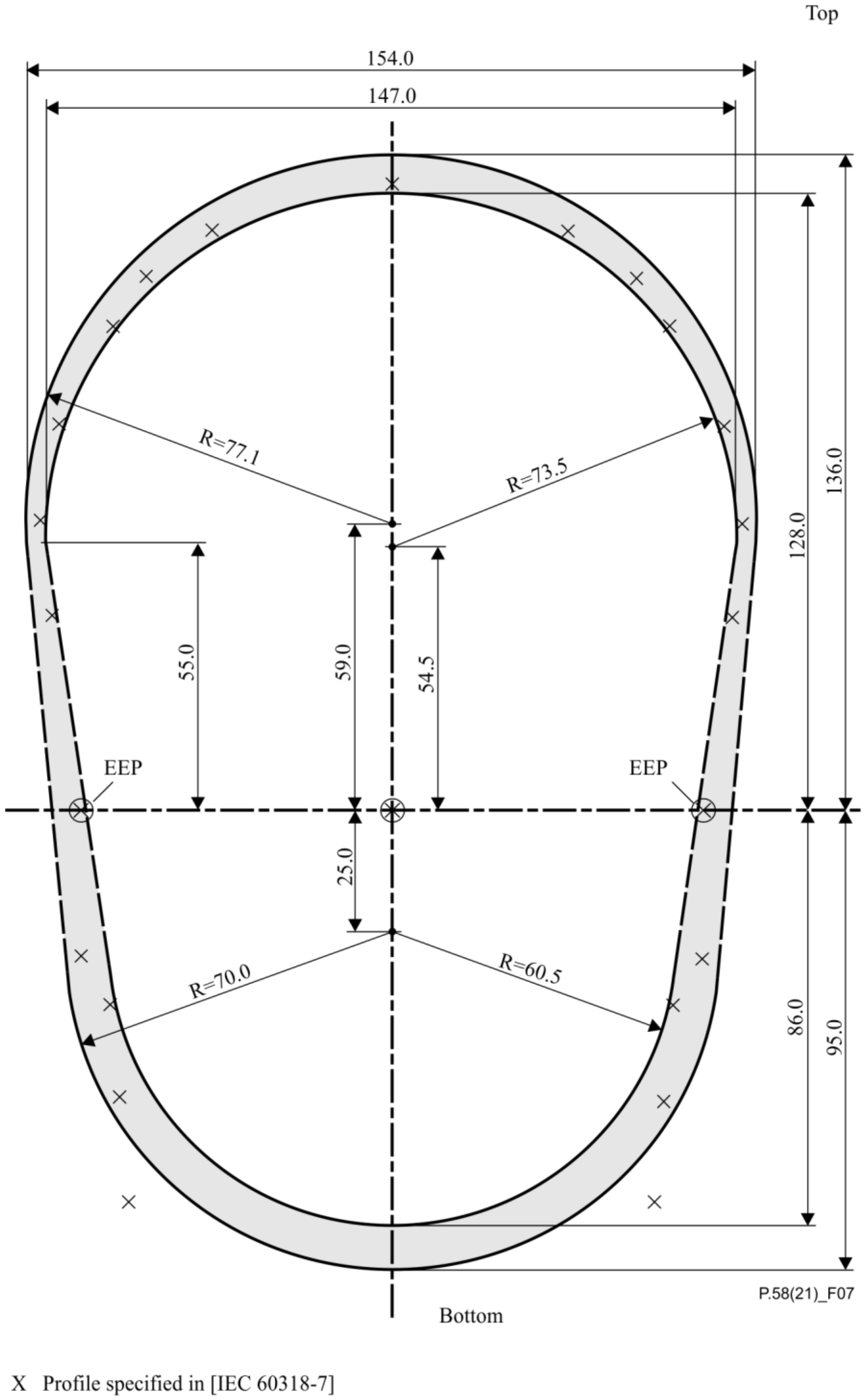


Figure 7 – Limits of the head cross-section in the transverse plane
(dimensions in millimetres)

7.3 Pinna

The dimensions of the pinna are as specified for the type 3.3 artificial ear in [ITU-T P.57]. The pinna shall be positioned on the HATS in order to meet the following requirements:

– the EEP of Figure 7-c of [ITU-T P.57] (0 mm) shall correspond to the EEP of Figure 5;

– the vertical axis through the dots in Figures 7-b, 7-c and 7-d of [ITU-T P.57] is perpendicular to the HATS reference plane;

– the cross-sections reported in Figures 7-b, 7-c and 7-d of [ITU-T P.57] are referred to planes parallel to the HATS reference plane;

– the baselines on Figures 7-b, 7-c and 7-d of [ITU-T P.57] (horizontal with dot) shall be parallel to the HATS vertical plane.

The dimensions of the simplified pinna are as specified for the type 3.4 artificial ear in [ITU-T P.57]. The pinna shall be positioned on the HATS in order to meet the following requirements:

– the EEP of Figure 8 of [ITU-T P.57] shall correspond to the EEP of Figure 5;

– the vertical axis through the axis of rotation (reference plane) in Figure 8 of [ITU-T P.57] is perpendicular to the HATS reference plane;

– the cross-section A-A reported in Figure 8 of [ITU-T P.57] is referred to the HATS transverse plane and indicates a tilting of 1.3° downwards of the ear;

– the cross-section B-B reported in Figure 8 of [ITU-T P.57] is referred to the transverse plane containing the EEP.

The dimensions of the pinna are as specified for the type 4.3 artificial ear in [ITU-T P.57]. The pinna shall be positioned on the HATS in order to meet the following requirements:

– the EEP of Figure 10 of [ITU-T P.57] shall correspond to the EEP of Figure 5;

– for more information, please see clause 6.4.3 of [ITU-T P.57].

The dimensions of the pinna are as specified for the type 4.4 artificial ear in [ITU-T P.57]. The pinna shall be positioned on the HATS in order to meet the following requirements:

– the EEP of Figure 15 of [ITU-T P.57] shall correspond to the EEP of Figure 5;

– for more information, please see clause 6.4.4 of [ITU-T P.57].

8 Acoustic characteristics

Please note that all tolerances in this Recommendation have been provided without taking into consideration the actual measurement uncertainty of the individual measurements.

8.1 Sound pick-up

The HATS shall be equipped with one or two artificial ears. Regardless of whether one or two ears are installed, the HATS shall always be equipped with two artificial pinnae.

8.1.1 Measurement conditions

Measurement of sound pick-up characteristics of the HATS shall be performed with equipment conforming to the specifications in clauses 8.1.1.1 to 8.1.1.4.

8.1.1.1 Test space and measurement equipment

The sound pressure level of extraneous background noise, in each measurement frequency band, shall be at least 15 dB less than the sound pressure level in the same band of the test signal.

– *Free-field measurements*

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

  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 up to 300 Hz and ±1 dB above 300 Hz. The measurement points for testing compliance shall include two points on the test axis, towards and away, respectively, from the sound source. Four additional 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; two on the axis of rotation, above and below the test point.

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

The test 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 shall be covered by a suitable absorbing material.

– *Diffuse-field measurements*

Please see [ISO 4869-1].

8.1.1.2 Measurement of sound pressure level

The free-field calibration of the reference microphone used to measure the unobstructed free-field sound pressure level shall be accurate within: ±0.5 dB for frequencies up to 5 kHz; and ±1.0 dB from 5 kHz to 10 kHz.

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

8.1.1.3 Positioning of the HATS in the test space

The test space shall be equipped with fixtures permitting an accurate and repeatable positioning of the HATS in the reference position.

The horizontal positioning of the HATS reference plane shall be guaranteed within ±2°.

8.1.1.4 Sound source positioning

The azimuth and elevation angles of the sound source shall be aligned with an accuracy of ±2° relative to the vertical and reference planes of the HATS.

8.1.2 Free-field frequency response

Table 2 gives the HATS free-field frequency response, in decibels relative to the free-field sound pressure level. Values are stated for elevation and azimuth angles of 0° (frontal incidence).

8.1.2.1 Tolerances

Tolerances on the HATS free-field frequency response are listed in Table 2. The values stated include the tolerances in the calibration of the occluded-ear simulator, but not the free-field calibration microphone.

Table 2 – Sound pick-up free field frequency response of HATS

Frequency (Hz)	Free-field response (dB)	Tolerance (dB)		
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	0.5	+1.5		–2.0
315	1.0	+1.5		–2.0
400	1.5	+1.5		–2.0
500	2.0	+2.0		–1.5
630	2.5	+2.0		–1.5

Table 2 – Sound pick-up free field frequency response of HATS

Frequency (Hz)	Free-field response (dB)	Tolerance (dB)		
800	3.5	+3.0		–1.5
1 000	3.5	+3.5		–2.0
1 250	3.5	+3.0		–3.0
1 600	5.0	+2.5		–3.5
2 000	12.5	+1.5		–4.0
2 500	18.5	+1.5		–4.5
3 150	15.5	+5.5		–2.5
4 000	13.0	+5.0		–2.5
5 000	11.0	+5.0		–3.5
6 300	5.0	+8.5		–3.0
8 000	2.0	+9.0		–5.0
10 000	7.0	+3.5		–7.5
12 500	9.0	+5.0		–6.0
16 000	5.5	+8.0		–5.0
20 000	–3.0	+12.5		–5.5

8.1.3 Diffuse-field frequency response

Table 3 gives the diffuse-field frequency response of the HATS in third octave bands. Annex A provides an interpolated 12th octave representation of the diffuse-field response.

8.1.3.1 Tolerances

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

Table 3 – Sound pick-up diffuse field frequency response of the HATS

Frequency (Hz)	Diffuse-field response (dB)	Tolerance (dB)		
100	0.0	+1.0		–1.5
125	0.0	+1.0		–1.5
160	0.0	+1.0		–1.5
200	0.0	+1.0		–1.5
250	0.5	+1.0		–1.5
315	0.5	+1.5		–1.0
400	1.0	+1.5		–1.0
500	1.5	+1.5		–1.5
630	2.0	+2.0		–1.5
800	4.0	+2.0		–2.0
1 000	5.0	+2.0		–2.5

Table 3 – Sound pick-up diffuse field frequency response of the HATS

Frequency (Hz)	Diffuse-field response (dB)	Tolerance (dB)		
1 250	6.5	+1.5		–3.0
1 600	8.0	+1.5		–2.5
2 000	10.5	+2.0		–2.5
2 500	14.0	+2.0		–3.0
3 150	12.0	+6.0		–1.0
4 000	11.5	+6.0		–2.0
5 000	11.0	+5.0		–2.0
6 300	8.0	+6.5		–4.0
8 000	6.5	+8.0		–4.0
10 000	10.5	+2.0		–10.0
12 500	4.0	+6.5		–3.0
16 000	1.0	+8.5		–4.0
20 000	–3.0	+9.5		–5.0

8.1.4 Monaural frequency response of the HATS

Table 4 gives the HATS monaural frequency response. Values are stated for an elevation angle of 0° and azimuth angles of 90°, 180° and 270° for the right ear. Corresponding symmetrical azimuth angles apply for the left ear.

In addition to complying with the sound pick-up requirements in this Recommendation, the HATS manufacturer shall supply a HATS-model typical sound pick-up curve in 12th octave bands, extending from 20 Hz to 20 kHz, for 0° incidence and 0° elevation. Any HATS of the model in question shall perform within ±2 dB from this typical curve, for the frequency range from 20 Hz to 10 kHz and within ±4 dB from this typical curve, for the frequency range from 10 kHz to 20 kHz.

8.1.4.1 Tolerances

Tolerances on the HATS monaural frequency response are listed in Table 4.

8.1.5 Sound leakage

With the ear canal under test effectively sealed from external sound at the reference plane of the occluded-ear simulator and the other ear canal blocked, the measurement of the free-field frequency response of the HATS shall give results at least 35 dB below those obtained with the ear canal open.

NOTE – Suitable plugs or equivalent arrangements for checking the conformity to this requirement without dismantling the HATS external ear shall be provided by the manufacturer.

Table 4 – Monaural frequency response (dB) of the HATS – Right ear

Frequency (Hz)	Azimuth angle			Tolerance (dB)	
	90°	180°	270°	upper	lower
100	0.0	0.0	0.0	+1.5	–1.5
125	0.5	0.0	0.0	+1.5	–1.5
160	1.0	–0.5	0.0	+1.5	–1.5
200	1.5	–0.5	–1.0	+2.5	–1.5
250	1.5	–0.5	–1.0	+2.5	–1.5
315	2.0	–0.7	–1.0	+1.5	–1.5
400	2.5	–1.0	–1.0	+2.0	–2.0
500	3.5	–1.0	–1.0	+2.0	–2.0
630	4.5	0.0	–0.5	+2.0	–3.0
800	4.0	0.5	–1.0	+2.0	–3.0
1 000	4.5	1.5	–1.0	+2.0	–4.0
1 250	5.8	2.5	–0.5	+4.5	–2.5
1 600	5.0	1.0	–0.5	+4.0	–2.0
2 000	–0.5	–2.0	–4.0	+3.5	–3.0
2 500	0.0	–2.5	–6.0	+3.0	–3.0
3 150	1.5	–3.0	–8.0	+3.0	–3.0
4 000	1.5	–3.0	–	+2.0	–2.0
5 000	3.5	–4.0	–	+5.0	–4.5
6 300	12.0	–1.0	–	+4.5	–7.5
8 000	12.0	3.5	–	+6.5	–7.0
(10 000)	6.0	–3.0	–		

8.2 Sound generation

8.2.1 Normalized free-field response

The normalized free-field response is specified at 23 points: 11 in the near field and 12 in the far field. Near-field points are listed in Table 5, while far-field points are listed in Table 6-a and b.

NOTE 1 – Azimuth and elevation angles given in Table 6-a and b are relative to the vertical and the horizontal planes and are computed for the line joining the measurement points to the centre of the lip ring. The same sign conventions of the angles defined for sound incidence apply.

Table 5-a – Coordinates of points in the near field

Measurement point	On axis displacement from the lip plane (mm)	Off axis, perpendicular displacement (mm)
1	12.5	0
2	50	0
3	100	0
4	140	0
5	0	20 horizontal
6	0	40 horizontal
7	25	20 horizontal
8	25	40 horizontal
9	25	20 vertical (down)
10	25	40 vertical

Table 5-b – Coordinates of the boom microphone position (BMP)

Measurement point # 21	
On axis[a] displacement[b]	–6 mm (backwards)
Off axis[a] horizontal displacement	42 mm (right)
Off axis[a] vertical displacement	–9 mm (down)

[a] Reference axis
[b] Distance from the lip plane

Table 6-a – Coordinates of far-field front points

Measurement point	Distance from the lip plane (mm)	Azimuth angle (horizontal) (°)	Elevation angle (vertical) (°)
11	500	0	0
12	500	0	+15 (up)
13	500	0	+30 (up)
14	500	0	–15 (down)
15	500	0	–30 (down)
16	500	15	0
17	500	30	0

Table 6-b – Coordinates of points in the far-field behind and above the speaker

Measurement point	Distance from the centre of the lip ring (mm)	Azimuth angle (horizontal) (°)	Elevation angle (vertical) (°)
22	500	90	0
23	500	135	0
24	500	180	0
25	500	180	45 (up)
26	500	0	90 (up)
NOTE – It shall be noticed that points in Table 6-a lie on a plane while points in Table 6-b lie on the surface of a sphere.			

Table 7 provides the normalized free-field response of the HATS mouth, together with tolerances, for the bandwidth between 100 Hz and 8 kHz. The requirements at each point not lying in the vertical plane shall also be met by the corresponding point in the symmetrical half-space.

NOTE 2 – The normalized response at off-axis points in the near field are given in Table 7-b and c. Points in Table 7-b are not significantly affected by the body reflection and approximately the same tolerance set applies as in [ITU-T P.51] (Artificial mouth). Points in Table 7-c are affected by body reflection and different tolerances apply with respect to [ITU-T P.51].

The normalized free-field response shall be checked by using appropriate microphones, as specified in Table 8. Pressure microphones shall be oriented with their axis perpendicular to the sound direction, while free-field microphones shall be oriented with their axis parallel to the direction of sound.

NOTE 3 – If a compressor microphone is normally used in the HATS, it (or an equivalent dummy) shall be left in place while checking the normalized free-field response.

Table 7-a – Normalized free-field response at points on-axis in the near field

Frequency (Hz)	Measurement point				Tolerance (dB)
	1 (dB)	2 (dB)	3 (dB)	4 (dB)	
100	4.2	–5.0	–11.0	–13.6	+2/–1.5
125	4.2	–5.0	–10.9	–13.6	+2/–1.5
160	4.2	–5.0	–10.7	–13.6	+2/–1.5
200	4.0	–5.0	–10.7	–13.3	+2/–1.5
250	4.0	–5.0	–10.6	–13.2	+2/–1.5
315	4.0	–5.0	–10.6	–13.2	+2/–1.5
400	4.0	–5.0	–10.6	–13.2	+2/–1.5
500	4.1	–5.0	–10.6	–13.2	+2/–1.5
630	4.2	–4.9	–11.3	–14.2	+1/–1.5
800	4.2	–4.8	–11.9	–15.1	+1/–2.0
1 000	4.1	–4.8	–11.4	–14.6	+1/–2.0
1 250	3.9	–4.8	–10.2	–13.8	+1/–1.5
1 600	3.8	–4.8	–10.0	–12.7	+1/–1.5
2 000	3.6	–4.7	–10.0	–12.7	+1/–1.5
2 500	3.5	–4.6	–9.4	–13.3	+1/–1.5

Table 7-a – Normalized free-field response at points on-axis in the near field

Frequency (Hz)	Measurement point				Tolerance (dB)
	1 (dB)	2 (dB)	3 (dB)	4 (dB)	
3 150	3.6	–4.6	–9.4	–12.0	+1/–1.5
4 000	3.7	–4.6	–9.7	–12.3	±1.5
5 000	3.7	–4.5	–9.7	–12.6	±1.5
6 300	3.8	–4.5	–9.7	–12.6	±1.5
8 000	3.8	–4.9	–10.0	–12.7	±1.5

Table 7-b – Normalized free-field response at points off-axis in the near field

Frequency (Hz)	Measurement point				Tolerance (dB)
	5[a] (dB)	7 (dB)	8 (dB)	9 (dB)	
100	5.2	–1.4	–4.0	–1.6	±1.5
125	5.2	–1.3	–3.8	–1.5	±1.5
160	5.2	–1.2	–3.8	–1.5	±1.5
200	5.2	–1.2	–3.8	–1.5	±1.5
250	5.2	–1.3	–3.8	–1.4	±1.5
315	5.1	–1.3	–3.8	–1.3	±1.0
400	5.1	–1.3	–3.8	–1.3	±1.0
500	5.0	–1.3	–3.8	–1.3	±1.0
630	5.0	–1.3	–3.8	–1.3	±1.0
800	5.0	–1.3	–3.8	–1.3	±1.0
1 000	4.8	–1.3	–3.9	–1.3	±1.0
1 250	4.8	–1.4	–4.0	–1.3	±1.0
1 600	4.7	–1.4	–3.8	–1.3	±1.0
2 000	4.7	–1.2	–3.7	–1.3	±1.0
2 500	4.7	–1.0	–3.6	–1.1	±1.0
3 150	4.7	–1.1	–3.5	–1.2	±1.0
4 000	4.5	–1.5	–4.1	–1.3	±1.5
5 000	3.8	–1.5	–4.8	–1.3	±1.5
6 300	3.2	–1.8	–5.2	–1.7	±2.0
8 000	2.5	–2.0	–6.1	–1.8[b]	±3.0

[a] The measurements on the human mouth at point 5 are quite scattered, so the response at this point is only indicatively provided and no tolerances apply.

[b] Slight difference from the artificial mouth requirement ([ITU-T P.51]) due to the nose diffraction.

Table 7-c – Normalized free-field response at points off-axis in the near field

Frequency (Hz)	Measurement point			Tolerance (dB)
	6 (dB)	10 (dB)	21 (dB)	
100	–1.7	–4.2	–3	±1.5
125	–1.7	–4.2	–3	±1.5
160	–1.7	–4.2	–3	±1.5
200	–1.7	–4.2	–3	±1.5
250	–1.8	–4.2	–3	±1.5
315	–1.8	–4.2	–3	+1.0/–1.5
400	–1.8	–4.0	–3	+1.0/–1.5
500	–1.6	–3.9	–3	+1.0/–1.5
630	–1.6	–3.9	–3	+1.0/–1.5
800	–1.6	–4.0	–3	+1.0/–1.5
1 000	–1.7	–4.1	–3	+1.0/–2.0
1 250	–1.8	–4.3	–3	+1.0/–2.0
1 600	–1.8	–4.0	–3	+1.0/–2.5
2 000	–1.8	–3.6	–3	+1.0/–2.5
2 500	–1.9	–3.5	–3	+1.0/–2.5
3 150	–2.1	–3.4	–3	+1.0/–2.5
4 000	–2.9	–3.0	–4	+1.0/–2.5
5 000	–3.6	–3.7	–5	+1.0/–3.0
6 300	–5.0	–3.7	–6	+1.5/–4.0
8 000	–5.2	–4.2	–7	+3.0/–7.5

Table 7-d – Normalized free-field response in the far field in front of the speaker

Frequency (Hz)	Measurement point							Tolerance (dB)
	11 (dB)	12 (dB)	13 (dB)	14 (dB)	15 (dB)	16 (dB)	17 (dB)	
100	–24	–24	–25	–24	–25	–24	–25	+3/–4
125	–24	–24	–25	–24	–25	–24	–25	+3/–4
160	–24	–24	–25	–24	–25	–24	–25	+3/–4
200	–24	–24	–25	–24	–25	–24	–25	+3/–4
250	–24	–24	–24	–24	–24	–24	–24	±3
315	–24	–24	–24	–24	–24	–24	–24	±3
400	–24	–24	–24	–24	–24	–24	–24	±3
500	–24	–24	–24	–24	–24	–24	–24	±3
630	–25.5	–25.5	–25.5	–24	–23	–25.5	–25.5	+3/–4
800	–27	–27	–27	–25.5	–23	–27	–27	+3/–4

Table 7-d – Normalized free-field response in the far field in front of the speaker

Frequency (Hz)	Measurement point							Tolerance (dB)
	11 (dB)	12 (dB)	13 (dB)	14 (dB)	15 (dB)	16 (dB)	17 (dB)	
1 000	–25.5	–25.5	–25.5	–27	–25.5	–27	–27	+3/–4
1 250	–24	–24	–24	–25.5	–27	–25,5	–25.5	+3/–4
1 600	–24	–24	–24	–24	–27	–24	–24	+3/–4
2 000	–24	–24	–24	–24	–25.5	–24	–24	±3
2 500	–24	–24	–24	–24	–23	–24	–24	±3
3 150	–24	–24	–24	–24	–23	–24	–24	±3
4 000	–24	–24	–24	–24	–24	–24	–24	±3
5 000	–24	–24	–24	–24	–24	–24	–24	±3
6 300	–24	–24	–24	–24	–24	–24	–24	±3
8 000	–24	–24	–24	–24	–24	–24	–24	±3

Table 7-e – Normalized free-field response in the far field behind and above the speaker

Frequency (Hz)	Measurement point					Tolerance (dB)
	22 (dB)	23 (dB)	24 (dB)	25 (dB)	26 (dB)	
100	–24.5	–24.5	–25.0	–25.0	–24	+3/–5
125	–24.5	–25.1	–25.7	–25.0	–24	+3/–5
160	–24.5	–25.7	–26.4	–25.0	–24	+3/–5
200	–24.5	–26.3	–27.1	–25.0	–24	+3/–4
250	–24.5	–26.9	–27.8	–25.0	–24	+3/–4
315	–24.5	–27.5	–28.5	–25.0	–24	+3/–4
400	–24.5	–28.1	–29.2	–25.0	–24.5	+3/–4
500	–24.5	–28.7	–29.9	–25.8	–25.2	+3/–5
630	–25.1	–29.3	–30.6	–26.6	–26.5	+3/–5
800	–25.7	–29.9	–31.3	–27.4	–26.5	+3/–5
1 000	–26.3	–30.5	–32.0	–28.2	–26.5	+3/–5
1 250	–26.9	–30.5	–33.5	–29.0	–26.5	+3/–5
1 600	–27.5	–30.5	–35.0	–29.8	–26.5	+3/–5
2 000	–27.5	–30.5	–36.5[a]	–30.6	–26.5	+3/–5
2 500	–27.5	–32.1	–38.0[a]	–31.4	–26.5	+3/–5
3 150	–27.5	–33.7	–39.5[a]	–32.2	–26.5	+3/–5
4 000	–27.5	–35.3	–41.0[a]	–33.0	–26.5	+3/–5
5 000	–29.0	–36.9	–42.5[a]	–34.5	–26.5	+3/–5
6 300	–31.5	–38.5	–44.0[a]	–36.0	–27.5	+3/–5
8 000	–32.0	–40.0	–45.5[a]	–37.5	–28.5	+3/–5
[a] Shadow zone: tolerances not applicable						

Table 8 – Recommended microphone types for free-field sound emission characterization of the HATS

Measurement point	Microphone size	Microphone equalization
1, 2, 5, 6, 7, 8, 9, 10, 21	¼ inch	Pressure
3, 4	½ inch	Pressure
11, 12, 13, 14, 15, 16, 17, 22, 23, 24, 25, 26	1 inch	Free field
MRP	¼ inch	Pressure

8.2.2 Normalized obstacle diffraction

The normalized obstacle diffraction of the HATS mouth is defined at three points on the reference axis, as specified in Table 9.

NOTE – If a compressor microphone is normally used in the HATS, it (or an equivalent simulator) shall be left in place while checking the normalized obstacle diffraction.

Table 9 – Normalized obstacle diffraction

Frequency (Hz)	Measurement point			Tolerance (dB)
	18 (12.5 mm) (dB)	19 (25 mm) (dB)	20 (50 mm) (dB)	
100	34.2	28.5	23.2	+3.0/–2.0
125	34.0	28.5	22.9	+3.0/–2.0
160	34.0	28.8	22.9	+3.0/–2.0
200	33.2	28.0	22.1	+3.0/–2.0
250	33.2	28.0	22.0	±2.0
315	33.9	28.5	22.5	±1.5
400	33.8	28.5	22.4	±1.5
500	33.3	27.9	21.9	±1.5
630	33.0	27.5	21.5	+3.0/–1.5
800	36.1	30.6	24.9	+3.0/–1.5
1 000	35.3	29.9	24.3	+3.0/–1.5
1 250	32.0	26.8	21.3	+3.0/–1.5
1 600	30.9	26.0	21.1	+2.5/–1.5
2 000	30.6	26.7	22.0	+2.5/–1.5
2 500	31.0	27.8	24.7	+2.5/–1.5
3 150	31.0	28.0	23.3	+2.5/–1.5
4 000	31.6	28.8	24.3	(Note)
5 000	33.2	28.4	23.9	(Note)
6 300	33.7	27.5	24.0	(Note)
8 000	32.0	24.5	19.5	(Note)
NOTE – Only indicative values – Tolerances not specified.				

8.2.3 Maximum deliverable sound pressure level

The HATS mouth shall be able steadily to deliver the acoustic artificial voice at sound pressure levels up to at least +6 dB (reference 1 Pa) at the MRP.

8.2.4 Distortion

8.2.4.1 Harmonic distortion

When delivering sine tones, with amplitudes up to 0 dBPa at the MRP, the harmonic distortion of the acoustic signal (delivered at the MRP) shall lie below the curve drawn with the straight lines between the breaking points in Table 10 on a logarithmic (frequency) – logarithmic (% distortion) scale.

Table 10 – Maximum harmonic distortion of the HATS mouth

Frequency	Second harmonic (%)	Third harmonic (%)
100 Hz	14	14
300 Hz	1	1
10 kHz	1	1

In addition to the requirement of Table 10, when delivering sine tones with frequencies between 1 004 Hz and 1 025 Hz with a level up to 10 dBPa, the total harmonic distortion (second and third harmonics) of the HATS mouth measured at the MRP shall not exceed 1.5%.

8.2.4.2 Total distortion

When delivering noise signals (according to [ITU-T O.131]) with levels up to +5 dBPa at the MRP, the total distortion of the HATS mouth measured at the MRP shall not exceed 1.5%.

8.2.5 Linearity

Positive or negative level variations of 6 dB of the feeding electrical signal shall produce corresponding variations of 6 dB ± 0.5 dB at the MRP for output pressures in the range from −14 dBPa to +6 dBPa. This requirement shall be met both for complex excitations, such as the artificial voice, and for sinusoidal excitations in the range from 100 Hz to 8 kHz.

NOTE – Better and less temperature-dependent linearity performances can be achieved by controlling the electrical excitation current instead of the feeding voltage. For applications requiring better performance than specified here, and extended dynamic ranges, it is recommended to individually calibrate the HATS mouth used, and to compensate the measured data by taking into account the calibration results. An effective alternative technique also consists of monitoring the generated acoustic pressure by means of a measurement microphone placed at the acoustic outlet of the HATS mouth.

8.3 Composite characteristics

8.3.1 Free-field plane wave diffraction at the MRP

The free-field diffraction at the MRP is given in Table 11.

Table 11 – Free-field diffraction at the MRP

Frequency (Hz)	Diffraction 0° (dB)	Diffraction 90° (dB)	Diffraction 180° (dB)	Tolerance (dB)
100	1.0	–0.5	–1.0	±2.0
125	0.5	–0.5	–1.0	±2.0
160	1.5	–0.5	–1.0	±2.0
200	1.5	–0.5	–1.5	±2.0
250	3.0	0.0	–1.5	±2.0
315	4.0	0.0	–1.5	±1.5
400	4.5	0.0	–2.5	±1.5
500	4.0	0.5	–3.0	±1.5
630	3.0	0.5	–2.5	±1.5
800	–0.5	1.5	–2.0	±2.0
1 000	–0.5	2.5	–2.5	±2.0
1 250	3.5	2.5	–3.0	±1.5
1 600	5.0	1.5	–4.0	±1.5
2 000	1.0	1.5	–3.0	±1.5
2 500	–5.0	–1.0	–5.0	±2.0
3 150	–1.5	–1.0	–5.5	±2.0
4 000	–0.5	0.5	–6.0	±2.0
5 000	3.0	3.5	–8.5[a]	±2.0
6 300	3.5	1.0	–11.0[a]	±2.0
8 000	–4.5	–2.0	–12.0[a]	±2.0

[a] Shadow zone: tolerances not applicable

8.3.2 Diffuse-field diffraction at the MRP

The diffuse-field diffraction at the MRP is given in Table 12.

Table 12 – Diffuse-field diffraction at the MRP

Frequency (Hz)	Diffraction (dB)	Tolerance (dB)
100	1.0	±2.0
125	1.0	±2.0
160	1.0	±2.0
200	0.0	±2.0
250	0.0	±2.0
315	0.5	±1.5
400	1.0	±1.5
500	1.0	±1.5
630	1.0	±1.5

Table 12 – Diffuse-field diffraction at the MRP

Frequency (Hz)	Diffraction (dB)	Tolerance (dB)
800	1.0	±1.5
1 000	1.0	±1.5
1 250	1.0	±1.5
1 600	1.0	±1.5
2 000	0.5	±1.5
2 500	–0.5	±1.5
3 150	–1.5	± 1.5
4 000	–1.0	±2.0
5 000	–1.0	±3.0
6 300	–0.5	±3.0
8 000	–0.5	±3.0

8.3.3 Mouth to ear crosstalk

8.3.3.1 Closed ears

The MRP to eardrum sound attenuation with closed ears shall be more than 40 dB in the third octave bands between 100 Hz and 1 kHz and more than 50 dB in the third octave bands between 1 250 Hz and 8 kHz (see Note to clause 8.1.5).

8.3.3.2 Open ears

The MRP to eardrum sound attenuation with open ears shall be as specified in Table 13.

Table 13 – MRP to DRP transfer function (open ear)

Frequency (Hz)	Transfer function (dB)	Tolerance (dB)
100	–18.0	±2
125	–18.0	±2
160	–18.0	±2
200	–18.0	±2
250	–18.0	±2
315	–18.0	±1.5
400	–17.5	±1.5
500	–17.5	±1.5
630	–17.0	±1.5
800	–17.0	±1.5
1 000	–17.0	±2
1 250	–17.0	±2
1 600	–15.5	±2
2 000	–12.5	±2
2 500	–9.0	±2

Table 13 – MRP to DRP transfer function (open ear)

Frequency (Hz)	Transfer function (dB)	Tolerance (dB)
3 150	–10.5	±2
4 000	–15.5	±4/–2
5 000	–20.5	±4/–2
6 300	–32.5	±4/–2
8 000	–31.5	±4/–2

9 Miscellaneous

9.1 Calibration of the artificial ears

The calibration at any frequency of type 3.3 artificial ears installed on the HATS is defined as the pressure sensitivity of the respective occluded-ear simulators at that frequency.

NOTE 1 – Performance testing and calibration of the occluded-ear simulator are specified in [IEC 60318-4].

NOTE 2 – Manufacturers are encouraged to provide suitable means for calibrating the occluded-ear simulator without dismantling the HATS.

9.2 DRP-ERP transfer function

The sound pressure measured by the type 3.3 artificial ear is referred to the DRP. The correction function given in Table 14-a and b shall be used for converting data to the ERP, when it is required to calculate loudness ratings or compare results with specifications based on measurements referred to it. Table 14-a applies to third octave measurements, while Table 14-b applies to 12th octave and sine measurements.

The sound pressure measured by the type 4.3 and type 4.4 artificial ear is referred to the DRP. The correction function given in Tables 5-a and 5-b of [ITU-T P.57] shall be used for converting data to the ERP, when it is required to calculate loudness ratings or compare results with specifications based on measurements referred to it. Table 5-a of [ITU-T P.57] applies to third octave measurements, while Table 5-b of [ITU-T P.57] applies to 12th octave and sine measurements.

Table 14-a – S_{DE}: Third octave measurements

Frequency (Hz)	S_{DE} (dB)
100	0.0
125	0.0
160	0.0
200	0.0
250	–0.3
315	–0.2
400	–0.5
500	–0.6
630	–0.7
800	–1.1

Table 14-a – S_{DE}: Third octave measurements

Frequency (Hz)	**S_{DE} (dB)**
1 000	–1.7
1 250	–2.6
1 600	–4.2
2 000	–6.5
2 500	–9.4
3 150	–10.3
4 000	–6.6
5 000	–3.2
6 300	–3.3
8 000	–16.0
(10 000)	(–14.4)
S_{DE}: Transfer function DRP to ERP $S_{DE} = 20\log_{10}(p_E/p_D)$ where p_E: Sound pressure at the ERP p_D: Sound pressure at the DRP	

Table 14-b – S_{DE}: 12th-octave measurements

Frequency (Hz)	**S_{DE}** (dB)	**Frequency** (Hz)	**S_{DE}** (dB)	**Frequency** (Hz)	**S_{DE}** (dB)	**Frequency** (Hz)	**S_{DE}** (dB)
92	0.1	290	–0.3	917	–1.3	2 901	–11.0
97	0.0	307	–0.2	972	–1.4	3 073	–10.5
103	0.0	325	–0.2	1 029	–1.8	3 255	–10.2
109	0.0	345	–0.2	1 090	–2.0	3 447	–9.1
115	0.0	365	–0.4	1 155	–2.3	3 652	–8.0
122	0.0	387	–0.5	1 223	–2.4	3 868	–6.9
130	0.0	410	–0.4	1 296	–2.6	4 097	–5.8
137	0.0	434	–0.6	1 372	–3.1	4 340	–5.0
145	0.0	460	–0.3	1 454	–3.3	4 597	–4.2
154	0.0	487	–0.7	1 540	–3.9	4 870	–3.3
163	0.0	516	–0.6	1 631	–4.4	5 158	–2.7
173	–0.1	546	–0.6	1 728	–4.8	5 464	–2.4
183	–0.1	579	–0.6	1 830	–5.3	5 788	–2.4
193	0.0	613	–0.6	1 939	–6.0	6 131	–2.5
205	0.1	649	–0.8	2 053	–6.9	6 494	–3.3
218	0.0	688	–0.8	2 175	–7.5	6 879	–4.5
230	–0.1	729	–1.0	2 304	–8.1	7 286	–5.9

Table 14-b – S_{DE}: 12th-octave measurements

Frequency (Hz)	S_{DE} (dB)	Frequency (Hz)	S_{DE} (dB)	Frequency (Hz)	S_{DE} (dB)	Frequency (Hz)	S_{DE} (dB)
244	–0.2	772	–1.1	2 441	–9.1	7 718	–9.0
259	–0.3	818	–1.1	2 585	–9.5	8 175	–14.2
274	–0.3	866	–1.2	2 738	–10.4	8 659	–20.7

9.3 Stray magnetic field

Neither the direct current (DC) nor the alternating current (AC) magnetic stray fields generated by the HATS mouth shall influence the signal transduced by microphones, receivers or other electroacoustic devices (e.g., hearing aids) under test.

It is recommended that the AC stray field produced at the MRP should lie below the curve formed by the coordinates listed in Table 15.

Table 15 – Coordinates of the magnetic output at MRP against frequency curve

Frequency (Hz)	Magnetic output at MRP (dB A m^{-1} Pa^{-1})
200	–10
1 000	–40
10 000	–40

It is also recommended that the DC stray field at the MRP and at the ear cap position be lower than 400 A/m.

NOTE – The recommended DC stray-field limit of 400 A/m at the MRP applies specifically to mouths intended for measuring electromagnetic microphones. For measuring other kinds of microphones (e.g., electret), a higher limit of 1 200 A/m at the MRP is acceptable.

9.4 Atmospheric reference conditions

The range of the ambient conditions where the HATS characteristics shall comply with this Recommendation are:

– static pressure: 101.3 ± 3.0 kPa
– temperature: 23 ± 3°C
– relative humidity: 60 ± 20%

9.5 Markings and calibration fixtures

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

If the head is not solidly connected to the torso, both must be provided with markings to ensure correct alignment.

To assist reproducible placement of transducers on 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 HATS reference plane (x-axis) respectively, and could have the centre of the ear canal at the concha as their origin. Values on the x-axis shall be positive towards the front of the HATS, on the y-axis positive towards the vertex.

The HATS shall be provided by the manufacturer with the mechanical fixtures required to place a ¼ inch (6.350 0 mm) calibration microphone at the MRP.

NOTE – Manufacturers are encouraged to provide means for easily checking the correct vertical positioning of the HATS.

9.6 Delivery conditions

Each HATS shall be delivered with calibration documentation specifying the acoustical characteristics as defined in this Recommendation.

NOTE – Manufacturers are encouraged to provide supplementary information about the acoustical characteristics of the HATS (e.g., 12th octave frequency characteristics), for better supporting research applications of the HATS.

9.7 Materials

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

9.8 Stability

The HATS shall be stable and reproducible. The stability of the HATS shall be periodically controlled by recalibration.

Annex A

Interpolated 12th octave diffuse-field response

(This annex forms an integral part of this Recommendation.)

Frequency [Hz]	**Diffuse-field response** [dB]	**Frequency** [Hz] **CONTINUED**	**Diffuse-field response** [dB]	**Frequency** [Hz] **CONTINUED**	**Diffuse-field response** [dB]
97	0.0	613	1.9	3 868	11.6
103	0.0	649	2.2	4 097	11.5
109	0.0	688	2.7	4 340	11.3
115	0.0	729	3.2	4 597	11.2
122	0.0	772	3.7	4 870	11.1
130	0.0	818	4.1	5 158	10.6
137	0.0	866	4.3	5 464	9.9
145	0.0	917	4.6	5 788	9.2
154	0.0	972	4.9	6 131	8.4
163	0.0	1 029	5.2	6 494	7.8
173	0.0	1 090	5.5	6 879	7.5
183	0.0	1 155	5.9	7 286	7.1
194	0.0	1 223	6.3	7 718	6.7
205	0.1	1 296	6.7	8 175	6.9
218	0.2	1 372	7.0	8 660	7.8
230	0.3	1 454	7.4	9 173	8.8
244	0.4	1 540	7.7	9 716	9.9
259	0.5	1 631	8.2	10 292	9.7
274	0.5	1 728	8.8	10 902	8.2
290	0.5	1 830	9.4	11 548	6.5
307	0.5	1 939	10.1	12 232	4.7
325	0.6	2 054	10.9	12 957	3.6
345	0.7	2 175	11.7	13 725	3.0
365	0.8	2 304	12.6	14 538	2.3
387	0.9	2 441	13.6	15 399	1.5
410	1.1	2 585	13.7	16 312	0.7
434	1.2	2 738	13.3	17 278	−0.1
460	1.3	2 901	12.8	18 302	−1.0
487	1.4	3 073	12.2	19 387	−1.9
516	1.6	3 255	11.9	20 535	−2.9
546	1.7	3 447	11.8	21 752	−3.9
579	1.8	3 652	11.7		

Bibliography

[b-ITU-T P.10] Recommendation ITU-T P.10/G.100 (2017), *Vocabulary for performance, quality of service and quality of experience*.

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Printed in Switzerland
Geneva, 2021