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# ITU-T

TELECOMMUNICATION  
STANDARDIZATION SECTOR  
OF ITU

# P.57

(12/2011)

SERIES P: TERMINALS AND SUBJECTIVE AND  
OBJECTIVE ASSESSMENT METHODS

Objective measuring apparatus

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## Artificial ears

Recommendation ITU-T P.57



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### TERMINALS AND SUBJECTIVE AND OBJECTIVE ASSESSMENT METHODS

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# Recommendation ITU-T P.57

## Artificial ears

### Summary

Recommendation ITU-T P.57 specifies the electro-acoustical characteristics of artificial ears to be used for telephonometric measurements. Three devices are specified: a telephone band type for measurements on traditional telephone sets, an insert earphone type and a type faithfully reproducing the characteristics of the human ear.

The latter type (type 3) is specified in four configurations. The requirements of the third one (type 3.3 – Pinna simulator) have been slightly modified in this revision of Recommendation ITU-T P.57 by specifying its construction by a softer elastomer.

Besides this, the description of the applicability of all couplers has been changed, now allowing for an overlap in their usability according to the receiver type under test.

### History

| Edition | Recommendation           | Approval   | Study Group |
|---------|--------------------------|------------|-------------|
| 1.0     | ITU-T P.57               | 1993-03-12 | XII         |
| 2.0     | ITU-T P.57               | 1996-08-30 | 12          |
| 3.0     | ITU-T P.57               | 2002-07-14 | 12          |
| 3.1     | ITU-T P.57 (2002) Cor. 1 | 2005-01-27 | 12          |
| 4.0     | ITU-T P.57               | 2005-11-29 | 12          |
| 5.0     | ITU-T P.57               | 2009-04-29 | 12          |
| 6.0     | ITU-T P.57               | 2011-12-14 | 12          |

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

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In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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# Recommendation ITU-T P.57

## Artificial ears

### 1 Scope and object

#### 1.1 Scope

This Recommendation specifies the artificial ears for telephonometric use. Three types are recommended, covering the different transducers, types, sizes and technologies.

The methods of use of the artificial ears are outside the scope of this Recommendation; however, some general rules are provided about the application force and the positioning of transducers.

#### 1.2 Object

Three types of artificial ears are defined:

- 1) a telephone-band type for measurements on traditional telephone sets;
- 2) a type for measuring insert earphones;
- 3) a type which faithfully reproduces the characteristics of the median human ear.

### 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 P.79] Recommendation ITU-T P.79 (2007), *Calculation of loudness ratings for telephone sets*.
- [ITU-T P.380] Recommendation ITU-T P.380 (2003), *Electro-acoustic measurements on headsets*.
- [IEC 60318-1] IEC 60318-1 (2009), *Electroacoustics – Simulators of human head and ear – Part 1: Ear simulator for the measurement of supra-aural and circumaural earphones*.  
<[http://webstore.iec.ch/webstore/webstore.nsf/ArtNum\\_PK/43309?OpenDocument](http://webstore.iec.ch/webstore/webstore.nsf/ArtNum_PK/43309?OpenDocument)>
- [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*.  
<[http://webstore.iec.ch/webstore/webstore.nsf/ArtNum\\_PK/43703?OpenDocument](http://webstore.iec.ch/webstore/webstore.nsf/ArtNum_PK/43703?OpenDocument)>
- [IEC 61260] IEC 61260 (1995), *Electroacoustics – Octave-band and fractional-octave-band filters*.  
<[http://webstore.iec.ch/webstore/webstore.nsf/ArtNum\\_PK/19426?OpenDocument](http://webstore.iec.ch/webstore/webstore.nsf/ArtNum_PK/19426?OpenDocument)>

### 3 Definitions

#### 3.1 Terms defined elsewhere

None.

## 3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

**3.2.1 acoustically closed earphones (nominally sealed):** Earphones which are intended to prevent any acoustic coupling between the external environment and the ear canal.

**3.2.2 acoustically open earphones (nominally unsealed):** Earphones which intentionally provide an acoustic path between the external environment and the ear canal.

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

**3.2.4 circum-aural earphones:** Earphones which enclose the pinna and seat on the surrounding surface of the head. Contact to the head is normally maintained by compliant cushions. Circum-aural earphones may touch but not significantly compress the pinna (see Figure 1).

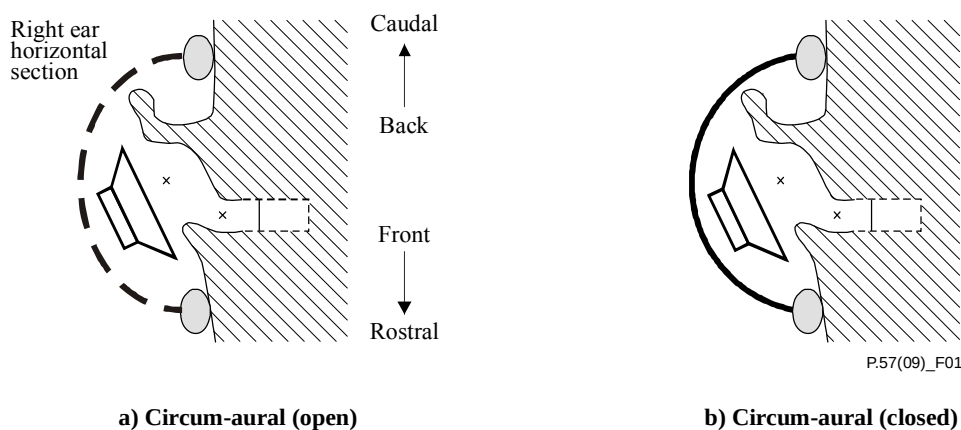


**Figure 1 – Circum-aural earphones**

**3.2.5 ear canal entrance point (EEP):** A point located at the centre of the ear canal opening.

**3.2.6 ear canal extension:** Cylindrical cavity extending the simulation of the ear canal provided by the occluded-ear simulator out of the concha cavity.

**3.2.7 ear reference point (ERP):** A virtual point for geometric reference located at the entrance to the listener's ear, traditionally used for calculating telephonometric loudness ratings.

**3.2.8 ear simulator:** Device for measuring the output sound pressure of an earphone under well-defined loading conditions in a specified frequency range. It consists essentially of a principal cavity, acoustic load networks and a calibrated microphone. The location of the microphone is chosen so that the sound pressure at the microphone corresponds approximately to the sound pressure existing at the human ear-drum.

**3.2.9 ear-drum reference point (DRP):** A point located at the end of the ear canal, corresponding to the ear-drum position.

**3.2.10 insert earphones:** Earphones which are intended to partially or completely enter the ear canal (see Figure 2).

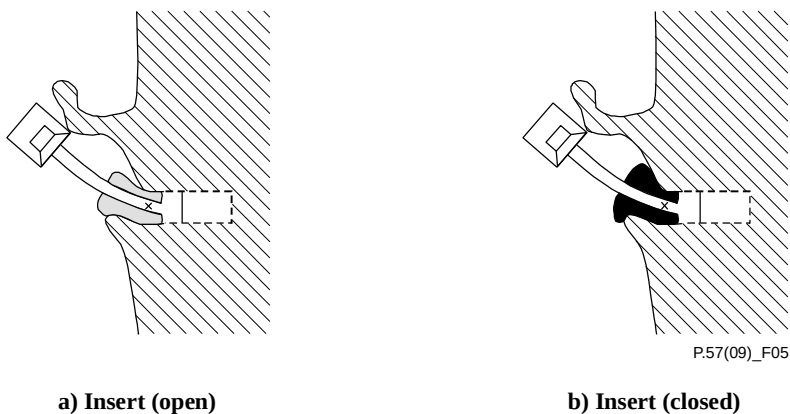


**Figure 2 – Insert earphones**

**3.2.11 intra-concha earphones:** Earphones which are intended to rest within the concha cavity of the ear. They have an external diameter (or maximum dimension) of less than 25 mm but are not made to enter the ear canal (see Figure 3).

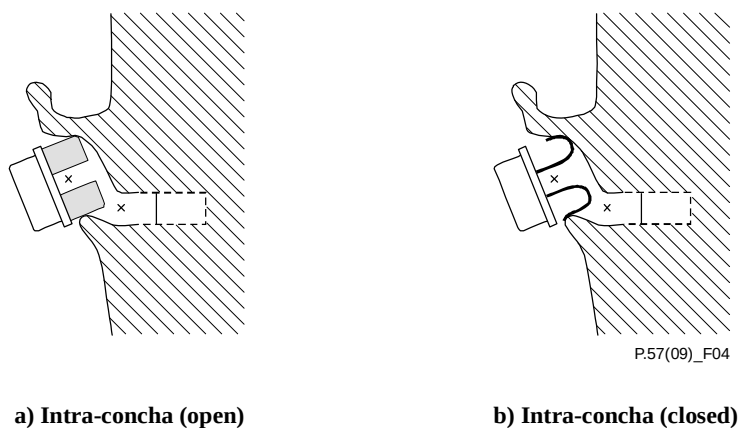


**Figure 3 – Intra-concha earphones**

**3.2.12 occluded-ear simulator:** Ear simulator which simulates the inner part of the ear canal, from the tip of an ear insert to the ear-drum.

**3.2.13 pinna simulator:** A device which has the approximate shape or dimensions of a median adult human pinna.

**3.2.14 supra-aural earphones:** Earphones which rest upon the pinna and have an external diameter (or maximum dimension) of at least 45 mm (see Figure 4).

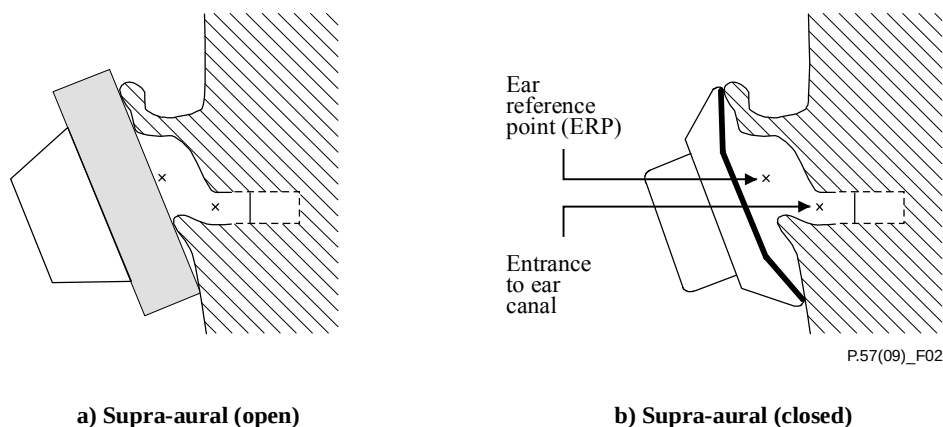


**Figure 4 – Supra-aural earphones**

**3.2.15 supra-concha earphones:** Earphones which are intended to rest upon the ridges of the concha cavity and have an external diameter (or maximum dimension) greater than 25 mm and less than 45 mm (see Figure 5).

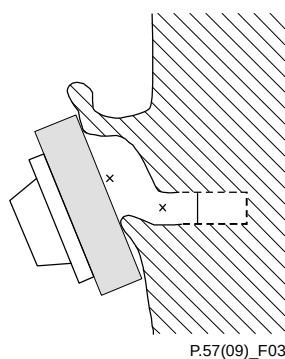


**Figure 5 – Supra-concha (open) earphones**

## 4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

|       |                                     |
|-------|-------------------------------------|
| ANOVA | ANALYSIS OF VARIANCE                |
| DRP   | ear-Drum Reference Point            |
| EEP   | Ear canal Entrance Point            |
| ERP   | Ear Reference Point                 |
| HATS  | Head And Torso Simulator            |
| LRGP  | Loudness Rating Guard-ring Position |

## 5 Artificial ear types

The fundamental purpose of an artificial ear is to test a receiver under conditions that most closely approximate actual use by real persons. The recommendations that follow are based upon the manner in which the receivers are intended to be used. Modifications to an artificial ear or test procedure shall not be made. To avoid alteration of the specified concha volume and/or leak, flexible sealing material, such as putty, shall not be used.

Of the artificial ears defined below, those with a flexible pinna are intended to most closely resemble the manner in which the receivers are intended to be used.

In the narrow-band (100 Hz to 4 kHz), the type 3.3 artificial ear resembles the human ear most closely and is the preferred choice, irrespective of the device to be tested.

Use of artificial ears type 1 and 3.2 is limited to their scope of usability, described below.

Comparative acoustic impedance measurements of the artificial ear types and human ears were conducted on a large scale and are shown in Appendix I.

For wider-band applications, further study is still needed.

## 5.1 Type 1 artificial ear

The type 1 artificial ear is specified in [IEC 60318-1].

It is recommended that the type 1 artificial ear should only be used as a legacy ear simulator for measurements on large, supra-aural or supra-concha, hard-cap, conically symmetrical receivers, which naturally seal to the simulator rim, intended for narrow-band telephony applications (100 Hz to 4 kHz). The type 1 artificial ear should not be used for receivers that do not meet these specifications.

The acoustic input impedance and the frequency sensitivity response of the type 1 artificial ear are determined with reference to the ERP as specified in clause 5.4. The nominal modulus of the impedance curve and the corresponding tolerance limits are given in Table 1.

**Table 1 – Acoustical impedance for type 1 artificial ear (IEC 60318)**

| Frequency<br>(Hz) | Acoustical imp.<br>(dB re 1 Pa s/m <sup>3</sup> ) | Tolerance<br>(± dB) | Frequency<br>(Hz) | Acoustical imp.<br>(dB re 1 Pa s/m <sup>3</sup> ) | Tolerance<br>(± dB) |
|-------------------|---------------------------------------------------|---------------------|-------------------|---------------------------------------------------|---------------------|
| 100               | 145.6                                             | 1                   | 950               | 134.5                                             | 1                   |
| 106               | 145.3                                             | 1                   | 1000              | 134.0                                             | 1                   |
| 112               | 145.0                                             | 1                   | 1060              | 133.4                                             | 1                   |
| 118               | 144.6                                             | 1                   | 1120              | 132.8                                             | 1                   |
| 125               | 144.3                                             | 1                   | 1180              | 132.2                                             | 1                   |
| 132               | 144.0                                             | 1                   | 1250              | 131.7                                             | 1                   |
| 140               | 143.7                                             | 1                   | 1320              | 131.1                                             | 1                   |
| 150               | 143.4                                             | 1                   | 1400              | 130.6                                             | 1                   |
| 160               | 143.2                                             | 1                   | 1500              | 130.1                                             | 1                   |
| 170               | 143.0                                             | 1                   | 1600              | 129.6                                             | 1                   |
| 180               | 143.0                                             | 1                   | 1700              | 129.4                                             | 1                   |
| 190               | 142.9                                             | 1                   | 1800              | 129.2                                             | 1                   |
| 200               | 142.8                                             | 1                   | 1900              | 129.2                                             | 1                   |
| 212               | 142.9                                             | 1                   | 2000              | 129.3                                             | 1                   |
| 224               | 142.9                                             | 1                   | 2120              | 129.5                                             | 1                   |
| 236               | 143.1                                             | 1                   | 2240              | 129.7                                             | 1                   |
| 250               | 143.2                                             | 1                   | 2360              | 129.8                                             | 1                   |
| 265               | 143.4                                             | 1                   | 2500              | 129.8                                             | 1                   |
| 280               | 143.5                                             | 1                   | 2650              | 129.6                                             | 1                   |
| 300               | 143.7                                             | 1                   | 2800              | 129.2                                             | 1                   |
| 315               | 143.6                                             | 1                   | 3000              | 128.6                                             | 1                   |
| 335               | 143.7                                             | 1                   | 3150              | 127.9                                             | 1                   |

**Table 1 – Acoustical impedance for type 1 artificial ear (IEC 60318)**

| Frequency (Hz) | Acoustical imp. (dB re 1 Pa s/m <sup>3</sup> ) | Tolerance (± dB) | Frequency (Hz) | Acoustical imp. (dB re 1 Pa s/m <sup>3</sup> ) | Tolerance (± dB) |
|----------------|------------------------------------------------|------------------|----------------|------------------------------------------------|------------------|
| 355            | 143.6                                          | 1                | 3350           | 127.0                                          | 1                |
| 375            | 143.3                                          | 1                | 3550           | 125.9                                          | 1                |
| 400            | 143.0                                          | 1                | 3750           | 124.8                                          | 1                |
| 425            | 142.7                                          | 1                | 4000           | 123.2                                          | 1                |
| 450            | 142.2                                          | 1                | 4250           | 121.5                                          | 1                |
| 475            | 141.7                                          | 1                | 4500           | 119.5                                          | 1                |
| 500            | 141.3                                          | 1                | 4750           | 117.1                                          | 1                |
| 530            | 140.7                                          | 1                | 5000           | 114.2                                          | 1                |
| 560            | 140.1                                          | 1                | 5300           | 109.6                                          | 1                |
| 600            | 139.4                                          | 1                | 5600           | 104.7                                          | 1                |
| 630            | 138.9                                          | 1                | 6000           | 109.6                                          | 1                |
| 670            | 138.3                                          | 1                | 6300           | 113.6                                          | 1                |
| 710            | 137.6                                          | 1                | 6700           | 117.0                                          | 1                |
| 750            | 137.1                                          | 1                | 7100           | 119.5                                          | 1                |
| 800            | 136.4                                          | 1                | 7500           | 121.3                                          | 1                |
| 850            | 135.7                                          | 1                | 8000           | 123.2                                          | 1                |
| 900            | 135.1                                          | 1                |                |                                                |                  |

NOTE 1 – The type 1 artificial ear is not suitable for measuring low acoustic-impedance earphones.

NOTE 2 – The type 1 artificial ear is defined for simulating the acoustic load of the human ear under no leakage conditions. For receive loudness rating calculations according to [ITU-T P.79], it is recommended that measured data be corrected using the real ear loss correction  $L_E$  provided in Table 2 of [ITU-T P.79].

NOTE 3 – It is recommended to use an application force between 5 N and 10 N for placing ear-caps against type 1 artificial ears. The force applied in measurements shall always be reported.

## 5.2 Type 2 artificial ear

The type 2 artificial ear is specified in [IEC 60318-4].

It is recommended that the type 2 artificial ear should be used for measurements on insert earphones, both sealed and unsealed.

The sound pressure measured by the type 2 artificial ear is referred to the ear-drum reference point (DRP). The correction function given in Tables 2-a (1/3 octave band measurements) and 2-b (1/12 octave band and sine measurements) shall be used for converting data to the ear reference point (ERP) when it is required to calculate loudness ratings or check results against specifications based on measurements referring to the ERP.

NOTE – For receive loudness rating calculations according to [ITU-T P.79], the real ear loss correction  $L_E$  should be as specified in [ITU-T P.380].

**Table 2-a – S<sub>DE</sub> – Third octave measurements**

| Frequency<br>(Hz)                                                                                                                                                                                                                                                                                                        | S <sub>DE</sub><br>(dB) | Frequency<br>(Hz) | S <sub>DE</sub><br>(dB) |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-------------------|-------------------------|
| 100                                                                                                                                                                                                                                                                                                                      | 0.0                     | 1000              | −1.7                    |
| 125                                                                                                                                                                                                                                                                                                                      | 0.0                     | 1250              | −2.6                    |
| 160                                                                                                                                                                                                                                                                                                                      | 0.0                     | 1600              | −4.2                    |
| 200                                                                                                                                                                                                                                                                                                                      | 0.0                     | 2000              | −6.5                    |
| 250                                                                                                                                                                                                                                                                                                                      | −0.3                    | 2500              | −9.4                    |
| 315                                                                                                                                                                                                                                                                                                                      | −0.2                    | 3150              | −10.3                   |
| 400                                                                                                                                                                                                                                                                                                                      | −0.5                    | 4000              | −6.6                    |
| 500                                                                                                                                                                                                                                                                                                                      | −0.6                    | 5000              | −3.2                    |
| 630                                                                                                                                                                                                                                                                                                                      | −0.7                    | 6300              | −3.3                    |
| 800                                                                                                                                                                                                                                                                                                                      | −1.1                    | 8000              | −16.0                   |
|                                                                                                                                                                                                                                                                                                                          |                         | (10 000)          | (−14.4)                 |
| <p>S<sub>DE</sub> The transfer function DRP to ERP<br/> <math>S_{DE} = 20 \log_{10} (P_E/P_D)</math><br/>           where: P<sub>E</sub> Sound pressure at the ERP<br/>           P<sub>D</sub> Sound pressure at the DRP<br/>           NOTE – The values in this table apply to 1/3 octave band measurements only.</p> |                         |                   |                         |

**Table 2-b – S<sub>DE</sub> – Twelfth octave measurements**

| Frequency<br>(Hz) | S <sub>DE</sub><br>(dB) | Frequency<br>(Hz) | S <sub>DE</sub><br>(dB) | Frequency<br>(Hz) | S <sub>DE</sub><br>(dB) | Frequency<br>(Hz) | S <sub>DE</sub><br>(dB) |
|-------------------|-------------------------|-------------------|-------------------------|-------------------|-------------------------|-------------------|-------------------------|
| 92                | 0.1                     | 290               | −0.3                    | 917               | −1.3                    | 2901              | −11.0                   |
| 97                | 0.0                     | 307               | −0.2                    | 972               | −1.4                    | 3073              | −10.5                   |
| 103               | 0.0                     | 325               | −0.2                    | 1029              | −1.8                    | 3255              | −10.2                   |
| 109               | 0.0                     | 345               | −0.2                    | 1090              | −2.0                    | 3447              | −9.1                    |
| 115               | 0.0                     | 365               | −0.4                    | 1155              | −2.3                    | 3652              | −8.0                    |
| 122               | 0.0                     | 387               | −0.5                    | 1223              | −2.4                    | 3868              | −6.9                    |
| 130               | 0.0                     | 410               | −0.4                    | 1296              | −2.6                    | 4097              | −5.8                    |
| 137               | 0.0                     | 434               | −0.6                    | 1372              | −3.1                    | 4340              | −5.0                    |
| 145               | 0.0                     | 460               | −0.3                    | 1454              | −3.3                    | 4597              | −4.2                    |
| 154               | 0.0                     | 487               | −0.7                    | 1540              | −3.9                    | 4870              | −3.3                    |
| 163               | 0.0                     | 516               | −0.6                    | 1631              | −4.4                    | 5158              | −2.7                    |
| 173               | −0.1                    | 546               | −0.6                    | 1728              | −4.8                    | 5464              | −2.4                    |
| 183               | −0.1                    | 579               | −0.6                    | 1830              | −5.3                    | 5788              | −2.4                    |
| 193               | 0.0                     | 613               | −0.6                    | 1939              | −6.0                    | 6131              | −2.5                    |
| 205               | 0.1                     | 649               | −0.8                    | 2053              | −6.9                    | 6494              | −3.3                    |
| 218               | 0.0                     | 688               | −0.8                    | 2175              | −7.5                    | 6879              | −4.5                    |
| 230               | −0.1                    | 729               | −1.0                    | 2304              | −8.1                    | 7286              | −5.9                    |

**Table 2-b –  $S_{DE}$  – Twelfth octave measurements**

| Frequency<br>(Hz) | $S_{DE}$<br>(dB) | Frequency<br>(Hz) | $S_{DE}$<br>(dB) | Frequency<br>(Hz) | $S_{DE}$<br>(dB) | Frequency<br>(Hz) | $S_{DE}$<br>(dB) |
|-------------------|------------------|-------------------|------------------|-------------------|------------------|-------------------|------------------|
| 244               | −0.2             | 772               | −1.1             | 2441              | −9.1             | 7718              | −9.0             |
| 259               | −0.3             | 818               | −1.1             | 2585              | −9.5             | 8175              | −14.2            |
| 274               | −0.3             | 866               | −1.2             | 2738              | −10.4            | 8659              | −20.7            |

NOTE – The frequencies listed are the 1/12 octave centre frequencies specified in [IEC 61260]. The values apply to 1/12 octave band measurements as well as sine-based measurements.  $S_{DE}$  may be determined for immediate frequencies by interpolation on a (log f) versus (lin dB) basis.

### 5.3 Type 3

The type 3 artificial ear consists of the IEC 60318-4 occluded-ear simulator, to which is added an ear canal extension terminated with a pinna simulation device. Three pinna simulators are recommended, providing the suitable coupling arrangements for measuring different transducer types. The type 3 artificial ear configurations are classified as follows:

Type 3.1 Concha bottom simulator.

Type 3.2 Simplified pinna simulator.

Type 3.3 Pinna simulator (anatomically shaped).

Type 3.4 Pinna simulator (simplified).

NOTE – Acoustically, open earphones equipped with soft cushions should be positioned against the type 3 artificial ear with the same force as applied in normal use. The force applied in measurements shall always be reported.

#### 5.3.1 Type 3.1 – Concha bottom simulator

The concha bottom simulation is realized in the type 3.1 artificial ear by a flat plate termination of the 10.0 mm ear canal extension.

It is recommended that the type 3.1 artificial ear should be used for measurements on intra-concha earphones, designed for sitting on the bottom of the concha cavity.

The sound pressure measured by the type 3.1 artificial ear is referred to the ear-drum reference point (DRP). The correction function given in Tables 2-a (1/3 octave band measurements) and 2-b (1/12 octave band and sine measurements) shall be used for converting data to the ear reference point (ERP) when it is required to calculate loudness ratings or check results against specifications based on measurements referred to the ERP.

NOTE – For receive loudness rating calculations according to [ITU-T P.79], the real ear loss correction  $L_E$  should be set to zero.

#### 5.3.2 Type 3.2 – Simplified pinna simulator

The pinna simulation is realized in the type 3.2 artificial ear by a cavity terminating the 10.0 mm ear canal extension. A well-defined leak from the cavity to the exterior simulates the average human ear loss for telephone handsets which are held either firmly (low leak version) or loosely (high leak version) against the human ear. The construction of the leak may differ depending on the specific application of the type 3.2 artificial ear (see Figure 6 and Tables 3-a and 3-b).

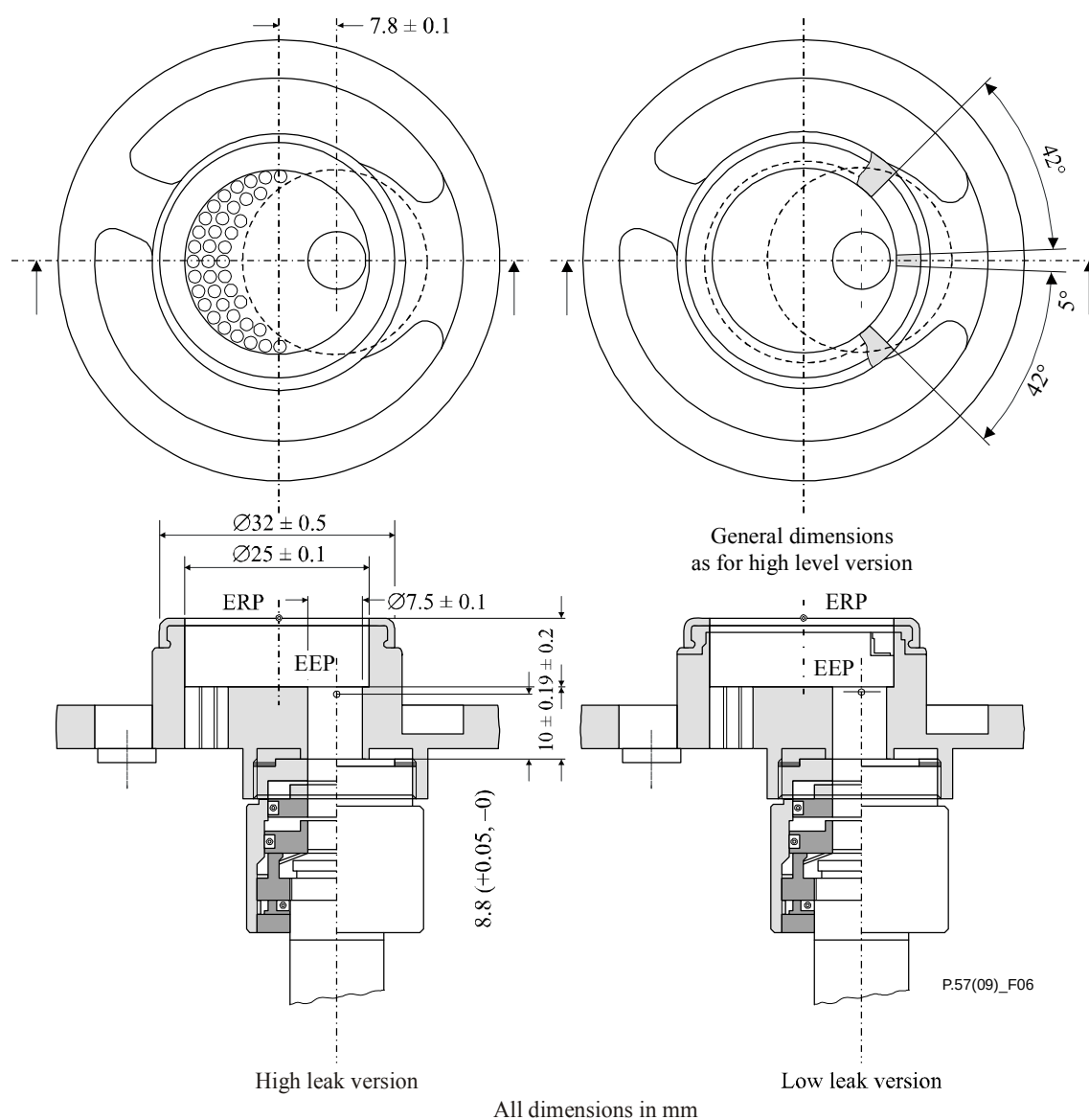


**Figure 6 – Example of high leak and low leak simplified pinna simulators for use in an LRGP test head**

**Table 3-a – Leakage simulation, realized using a slit (type 3.2 artificial ear)**

| Leakage grade | Use       | Slit depth (mm) | Slit height (mm)     | Opening angle (degrees) |
|---------------|-----------|-----------------|----------------------|-------------------------|
| Low           | LRGP/HATS | $2.8 \pm 0.2$   | $0.26 \pm 0.01$      | $84 \pm 1$              |
| High          | HATS      | $1.9 \pm 0.2$   | $0.50 + 0.01 - 0.03$ | $240 \pm 1$             |

**Table 3-b – Leakage simulation, realized using cylindrical holes  
(type 3.2 artificial ear)**

| Leakage grade | Use  | Number of holes | Diameter (mm) | Depth (mm)    |
|---------------|------|-----------------|---------------|---------------|
| High          | LRGP | 33              | 1.7           | $8.5 \pm 0.2$ |
|               |      | 6               | 1.8           | $8.5 \pm 0.2$ |

It is recommended that the type 3.2 artificial ear with a high- or low-grade leak should be used for measurements on supra-aural or supra-concha, hard-cap receivers, which naturally seal to the simulator rim, intended for both narrow-band and wideband telephony applications (100 Hz to 8 kHz). It is also recommended for measurements on low acoustic impedance receivers.

The acoustic input impedance and the frequency sensitivity response of the type 3.2 artificial ear are determined with reference to the ERP as specified in clause 5.4. The nominal modulus of the impedance curve and the corresponding tolerance limits are given in Tables 4-a, 4-b and 4-c.

NOTE 1 – The leakage grade ("high" or "low") adopted in measurements shall be reported. The low-grade leak intends to simulate real ear loss for a receiver pressed firmly to the ear, while the high-grade leak intends to simulate real ear loss for a loosely coupled receiver.

NOTE 2 – The type 3.2 artificial ear emulates the human ear canal, with the microphone diaphragm at the eardrum position. Hence, in addition to the particular microphone characteristics, the frequency sensitivity response of the artificial ear includes an individual ERP to DRP transfer function. It is essential, therefore, that measurement values are corrected for the frequency sensitivity response calibration data (open ear condition) provided with the particular artificial ear used.

NOTE 3 – For receive loudness rating calculations according to [ITU-T P.79], the real ear loss correction  $L_E$  should be set to zero.

NOTE 4 – The ERP to DRP transfer function depends significantly on the acoustic loading of the ear. For diagnostic purposes (e.g., to interpret differences to measurements made using the type 1 artificial ear), the type 3.2 artificial ear may be supplied with calibration data recorded under closed-ear conditions or other well-defined acoustical terminations.

NOTE 5 – The flat plate termination of the ear canal extension provided by the type 3.2 artificial ear is a possible implementation of the type 3.1 artificial ear.

NOTE 6 – The type 3.2 artificial ear is only intended for use with earphones designed to operate in close contact with the real pinna.

NOTE 7 – All dimensions determining the acoustic leak are for guidance only. They may be modified slightly for different commercial designs in order to obtain the nominal acoustic input impedance.

NOTE 8 – It is recommended to use an application force between 5 N and 10 N for placing hard ear-caps against the type 3.2 artificial ear. The force applied in the measurements shall always be reported.

NOTE 9 – For receivers that do not naturally seal to the simulator rim, an adaptor may be created for the specific geometry of the receiver. This adaptor may be machined or injection moulded and shall not alter the specified concha volume or leak. The adaptor shall be made from a material which cannot be altered, shaped or modified by the person performing the testing.

All leakage-related dimensions are for guidance only – see also Figure 6. Practical implementation must always be optimized with respect to the acoustical specifications.

**Table 4-a – Acoustical impedance, resonance, and Q-factors  
(type 3.2 – low and high leak)**

|               | <b>Q-factor</b> | <b>Resonance<br/>(Hz)</b> | <b>Magnitude<br/>(dB)</b> |
|---------------|-----------------|---------------------------|---------------------------|
| Low leak      | 1.81            | 713.8                     | 140.4                     |
| Tolerance (±) | 0.18            | 25.0                      | 1.0                       |
| High leak     | 3.5             | 1570.0                    | 138.8                     |
| Tolerance (±) | 0.35            | 50.0                      | 1.5                       |

**Table 4-b – Acoustical impedance (type 3.2 – low leak)**

| <b>Frequency<br/>(Hz)</b> | <b>Acoustical imp.<br/>(dB re 1 Pa s/m<sup>3</sup>)</b> | <b>Tolerance<br/>(± dB)</b> | <b>Frequency<br/>(Hz)</b> | <b>Acoustical imp.<br/>(dB re 1 Pa s/m<sup>3</sup>)</b> | <b>Tolerance<br/>(± dB)</b> |
|---------------------------|---------------------------------------------------------|-----------------------------|---------------------------|---------------------------------------------------------|-----------------------------|
| 100                       | 125.77                                                  | 4.00                        | 950                       | 137.18                                                  | 1.00                        |
| 106                       | 126.07                                                  | 4.00                        | 1000                      | 136.33                                                  | 1.00                        |
| 112                       | 126.18                                                  | 4.00                        | 1060                      | 135.34                                                  | 1.00                        |
| 118                       | 126.28                                                  | 4.00                        | 1120                      | 134.40                                                  | 1.00                        |
| 125                       | 126.44                                                  | 4.00                        | 1180                      | 133.48                                                  | 1.00                        |
| 132                       | 126.60                                                  | 4.00                        | 1250                      | 132.46                                                  | 1.00                        |
| 140                       | 126.74                                                  | 4.00                        | 1320                      | 131.48                                                  | 1.00                        |
| 150                       | 127.26                                                  | 4.00                        | 1400                      | 130.40                                                  | 1.00                        |
| 160                       | 127.27                                                  | 4.00                        | 1500                      | 129.10                                                  | 1.00                        |
| 170                       | 127.42                                                  | 3.73                        | 1600                      | 127.85                                                  | 1.00                        |
| 180                       | 127.79                                                  | 3.47                        | 1700                      | 126.69                                                  | 1.00                        |
| 190                       | 127.89                                                  | 3.23                        | 1800                      | 125.58                                                  | 1.00                        |
| 200                       | 128.10                                                  | 3.00                        | 1900                      | 124.46                                                  | 1.00                        |
| 212                       | 128.44                                                  | 3.00                        | 2000                      | 123.45                                                  | 1.00                        |
| 224                       | 128.71                                                  | 3.00                        | 2120                      | 122.38                                                  | 1.26                        |
| 236                       | 129.01                                                  | 3.00                        | 2240                      | 121.22                                                  | 1.51                        |
| 250                       | 129.31                                                  | 3.00                        | 2360                      | 119.99                                                  | 1.74                        |
| 265                       | 129.66                                                  | 2.75                        | 2500                      | 118.69                                                  | 2.00                        |
| 280                       | 130.08                                                  | 2.51                        | 2650                      | 117.60                                                  | 2.00                        |
| 300                       | 130.46                                                  | 2.21                        | 2800                      | 116.99                                                  | 2.00                        |
| 315                       | 130.92                                                  | 2.00                        | 3000                      | 117.47                                                  | 2.00                        |
| 335                       | 131.50                                                  | 2.00                        | 3150                      | 117.91                                                  | 2.00                        |
| 355                       | 132.02                                                  | 2.00                        | 3350                      | 118.74                                                  | 2.00                        |
| 375                       | 132.52                                                  | 2.00                        | 3550                      | 119.23                                                  | 2.00                        |
| 400                       | 133.23                                                  | 2.00                        | 3750                      | 118.77                                                  | 2.00                        |
| 425                       | 133.95                                                  | 1.73                        | 4000                      | 116.22                                                  | 2.00                        |
| 450                       | 134.72                                                  | 1.47                        | 4250                      | 111.62                                                  | 2.27                        |
| 475                       | 135.32                                                  | 1.23                        | 4500                      | 108.19                                                  | 2.53                        |