INTERNATIONAL TELECOMMUNICATION UNION

# ITU-T

# P.57

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

(03/93)

## TELEPHONE TRANSMISSION QUALITY
## OBJECTIVE MEASURING APPARATUS

# ARTIFICIAL EARS

## ITU-T Recommendation P.57

(Previously "CCITT Recommendation")

# FOREWORD

The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the International Telecommunication Union. The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, established the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

ITU-T Recommendation P.57 was prepared by the ITU-T Study Group XII (1988-1993) and was approved by the WTSC (Helsinki, March 1-12, 1993).

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NOTES

1 As a consequence of a reform process within the International Telecommunication Union (ITU), the CCITT ceased to exist as of 28 February 1993. In its place, the ITU Telecommunication Standardization Sector (ITU-T) was created as of 1 March 1993. Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.

In order not to delay publication of this Recommendation, no change has been made in the text to references containing the acronyms "CCITT, CCIR or IFRB" or their associated entities such as Plenary Assembly, Secretariat, etc. Future editions of this Recommendation will contain the proper terminology related to the new ITU structure.

2 In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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# ARTIFICIAL EARS

*(Helsinki, 1993)*

## 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.

## 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.

## 3 Definitions

For the purposes of this Recommendation, the following definitions apply:

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

**3.2 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.

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

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

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

**3.6 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.

**3.7 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.

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

**3.9 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).

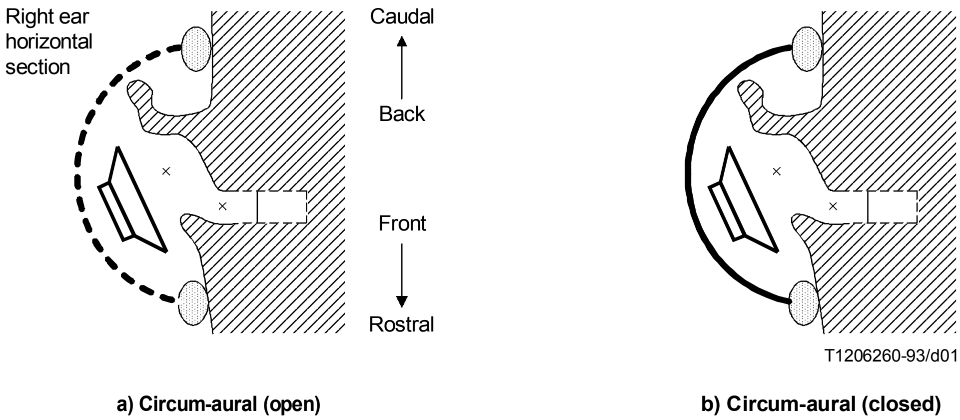


FIGURE 1/P.57

**3.10** **supra-aural earphones**: Earphones which rest upon the pinna and have an external diameter (or maximum dimension) of at least 45 mm (see Figure 2).

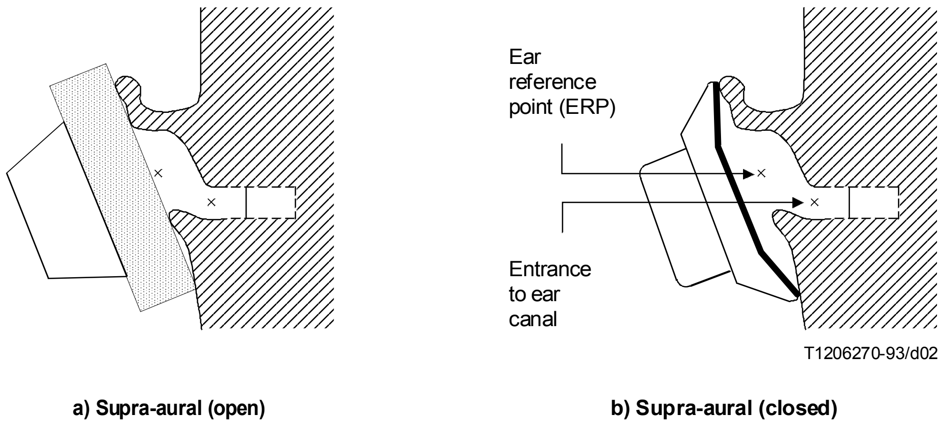


FIGURE 2/P.57

**3.11** **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 3).

**3.12** **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 4).

**3.13** **insert earphones**: Earphones which are intended to partially or completely enter the ear canal (see Figure 5).

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

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

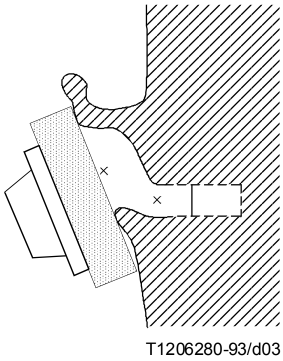


FIGURE 3/P.57

**Supra-concha (open)**

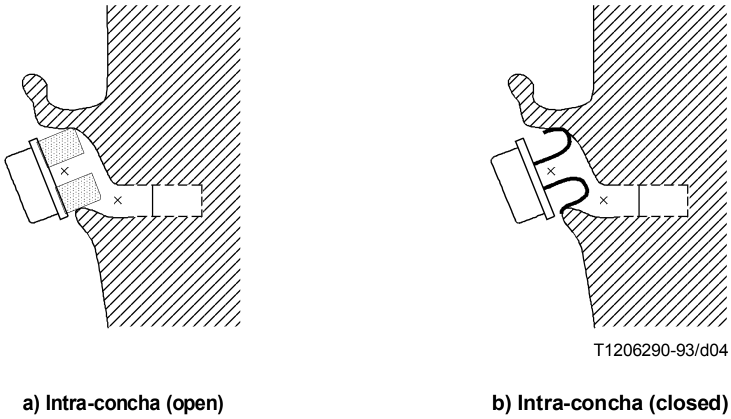


FIGURE 4/P.57

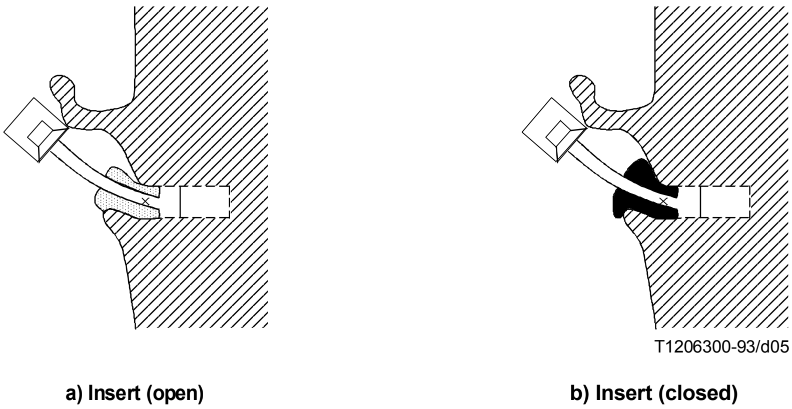


FIGURE 5/P.57

# 4 Artificial Ear types

## 4.1 Type 1 – IEC 318

The Type 1 Artificial Ear is specified in IEC Publication 318 [1].

It is recommended that the Type 1 Artificial Ear should be used for measurements on supra-aural and supra-concha earphones, intended for telephone bandwidth applications.

NOTES

1 The Type 1 Artificial Ear is not suitable for measuring low acoustic impedance earphones.

2 The IEC 318 Artificial Ear is defined for simulating the acoustic load of the human ear under no leakage conditions.

3 It is recommended to use an application force between 8N and 10N for placing earcaps against Type 1 Artificial Ear.

## 4.2 Type 2 – IEC 711

The Type 2 Artificial Ear is specified in IEC Publication 711 [2].

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 1a and 1b shall be used for converting data to the ear reference point (ERP) when it is required to calculate loudness ratings or compare results with specifications based on measurements referred to ERP. Table 1a applies to third octave measurements, while Table 1b applies to twelfth octave and sine measurements.

## 4.3 Type 3

The Type 3 Artificial Ear consists in the IEC 711 occluded-ear simulator, to which is added the 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)

### 4.3.1 Type 3.1 – Concha bottom simulator

The concha bottom simulation is realized in Type 3.1 Artificial Ear by a flat plate termination of the ear canal extension, the length of which is increased by 2.2 mm.

It is recommended that the Type 3.1 Artificial Ear be used for measurements on intra-concha earphones, designed for sitting on the bottom of the concha cavity.

### 4.3.2 Type 3.2 – Simplified pinna simulator

The pinna simulation is realized in Type 3.2 Artificial Ear by a cavity terminating the ear canal extension, the length of which is increased by 2.2 mm (see Figure 6).

It is recommended that the Type 3.2 Artificial Ear be used for measurements on supra-aural and supra-concha earphones, both sealed and unsealed, intended for wideband telephony applications (≤ 8 kHz). It is also recommended for measurements on low acoustic impedance earphones.

TABLE 1a/P.57

**$S_{DE}$ – 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 |
| 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) |

$S_{DE}$ The 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 1b/P.57

**$S_{DE}$ – Twelfth 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 | 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 |
| 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 |

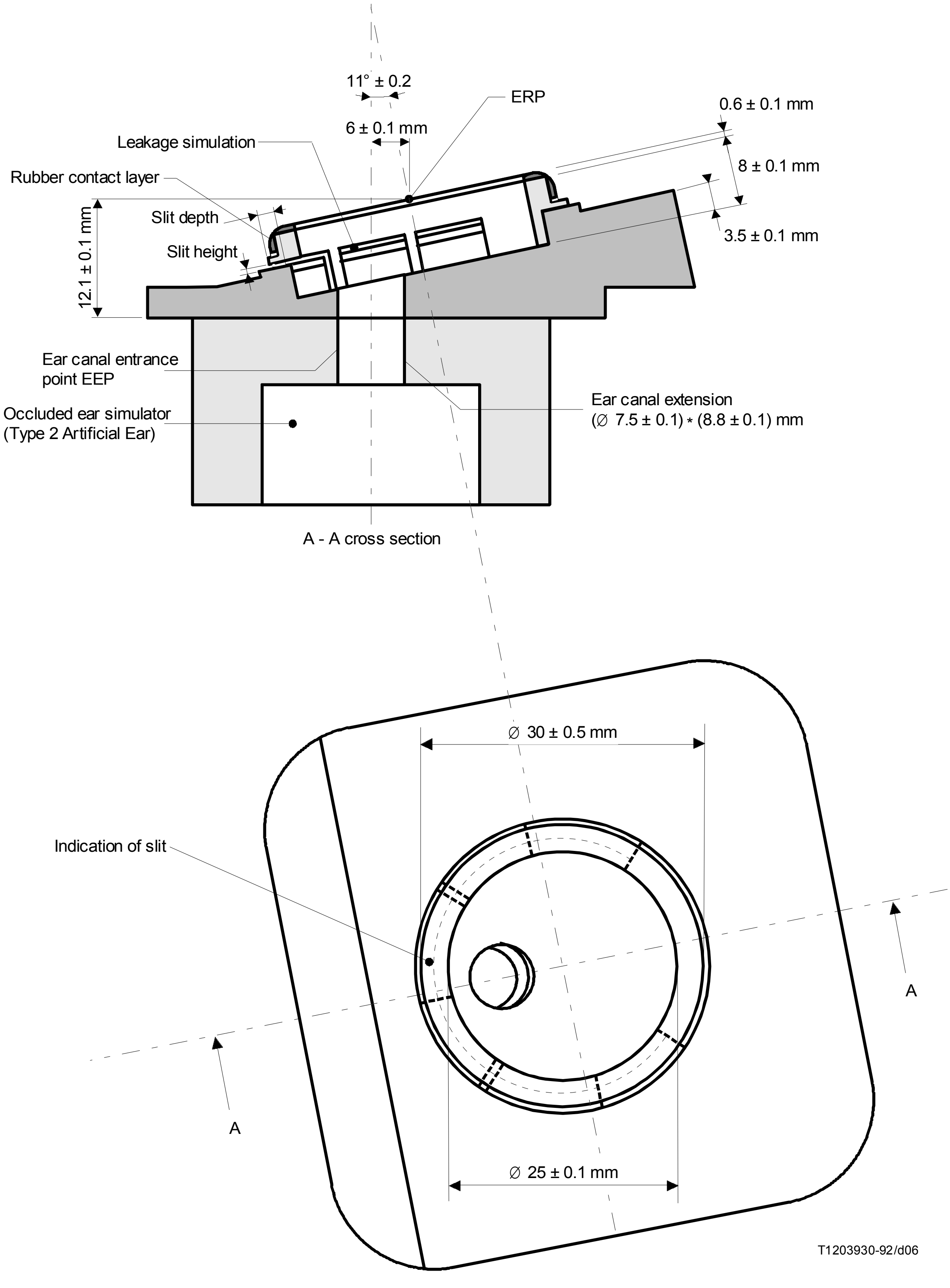


FIGURE 6/P.57

**Simplified pinna simulator (High leak version: 6 slits, 40° each)**
**Section through the symmetry plane of the simulator and top view**

NOTES

1 The Type 3.2 Artificial Ear provides two grades of leakage, respectively intended to reproduce the normal use conditions of telephone handsets loosely held and firmly held against the ear. The leak slit dimensions are reported in Table 2. The leakage grade adopted in measurements should be specified.

2 The modulus of the nominal acoustic input impedance of Type 3.2 Artificial Ear is reported in Table 3. It shall be measured with an IEC LS2P 1/2″ condenser microphone, with its protection grid mounted, acting as the acoustic source, mounted in a flat surface and concentric with the area being driven. The input pressure to the concha shall be measured using a probe microphone with the pick-up point being concentric and in front of the driver microphone at a maximum distance of 1 mm from its protection grid.

3 The flat plate termination of the ear canal extension provided by the Type 3.2 Artificial Ear is a possible implementation of Type 3.1 Artificial Ear.

4 For the time being the Simplified Pinna Simulator is only intended for use with earphones designed to operate in close contact with the real pinna. For applications with devices not touching the pinna, another Simplified Pinna Simulator is under study.

TABLE 2/P.57

**Leakage simulation (Type 3.2 Artificial Ear)**

| Leakage grade | Slit depth (mm) | Slit height (mm) | Effective opening angle |
|---|---|---|---|
| High leak | 1.9 ± 0.2 | $0.50^{+0.01}_{-0.03}$ | 240° ± 1 |
| Low leak | 2.1 ± 0.2 | $0.30^{+0.01}_{-0.03}$ | 84° ± 1 |

TABLE 3/P.57

**Acoustic impedance (Type 3.2 Artificial Ear)**

| Frequency (Hz) | Acoustic impedance [dB (reference 1 Pa · s/m$^3$)] | | |
|---|---|---|---|
| | High leak | Low leak | Tolerance (dB) |
| 100 | 106.0 a) | 121.5 a) | ± 2 |
| 125 | 108.0 a) | 123.5 a) | |
| 160 | 110.0 a) | 125.5 a) | |
| 200 | 112.0 a) | 127.5 a) | |
| 250 | 114.0 a) | 129.5 a) | |
| 315 | 116.0 a) | 131.5 | |
| 400 | 118.0 a) | 133.5 | |
| 500 | 120.0 a) | 136.0 | ± 1 |
| 630 | 122.5 | 140.0 b) | |
| 800 | 124.0 | 139.5 b) | |
| 1 000 | 127.5 | 136.0 | |
| 1 250 | 131.5 | 131.0 | |
| 1 600 | 137.5 b) | 126.5 | |
| 2 000 | 131.5 | 123.0 | |
| 2 500 | 122.5 | 118.0 | ± 2 |
| 3 150 | 120.0 | 117.0 | |
| 4 000 | 120.5 | 116.0 | |
| 5 000 | 108.5 | 107.5 | ± 3 |
| 6 300 | 114.5 | 114.0 | |
| 8 000 | 121.5 | 122.0 | |

a) Only indicative values, tolerances not applicable.

b) Impedance peaks: tolerance ± 2 dB.

#### 4.3.3 Type 3.3 – Pinna simulator

The Type 3.3 Artificial Ear is realized by terminating the ear canal extension with the pinna simulator described in IEC Publication 959 (see Figure 7a to Figure 7d). The dots in Figure 7b are located on a vertical axis through the ear canal entrance point. The pinna simulator shall be made by a high quality elastomer, the shore-A hardness of which, measured at the surface 15 mm forward to the ear canal opening, should be 25 ± 3 at 20 °C ± 2 °C (see ISO 868).

It is recommended that the Type 3.3 Artificial Ear be used for measurements on supra-concha earphones which, due to their peculiar shape, do not fit the circular rims of Type 1 or Type 3.2 Artificial Ears, whichever is applicable. Type 3.3 Artificial Ear should also be used for measuring intra-concha earphones not intended for sitting on the bottom of the concha cavity.

#### 4.3.4 General requirements

The metallic parts composing the Type 3 Artificial Ears shall be made of non-magnetic material.

#### 4.3.5 Calibration of the Artificial Ear

The calibration at any frequency of Type 3 Artificial Ear is defined as the pressure sensitivity of the occluded-ear simulator at that frequency.

NOTE – Performance testing and calibration of the occluded-ear simulator are specified in IEC Publication 711.

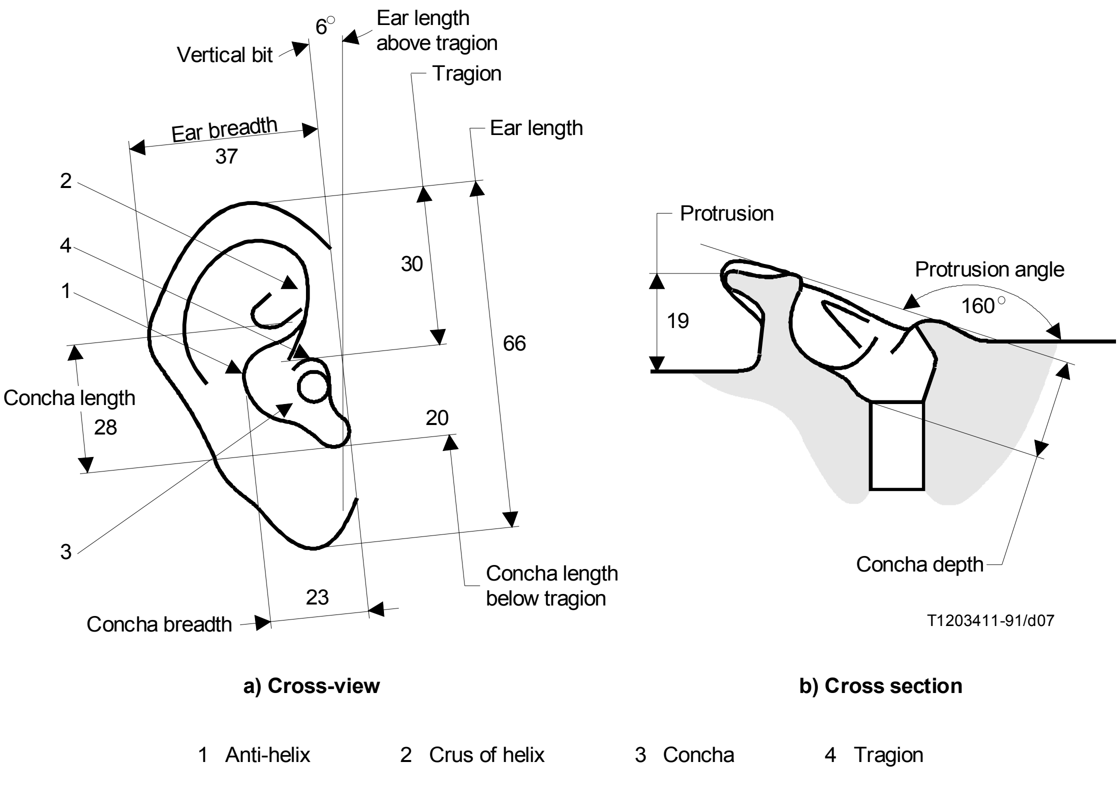


FIGURE 7a/P.57

**Anatomically shaped pinna simulator**
**(not to scale, units in mm)**

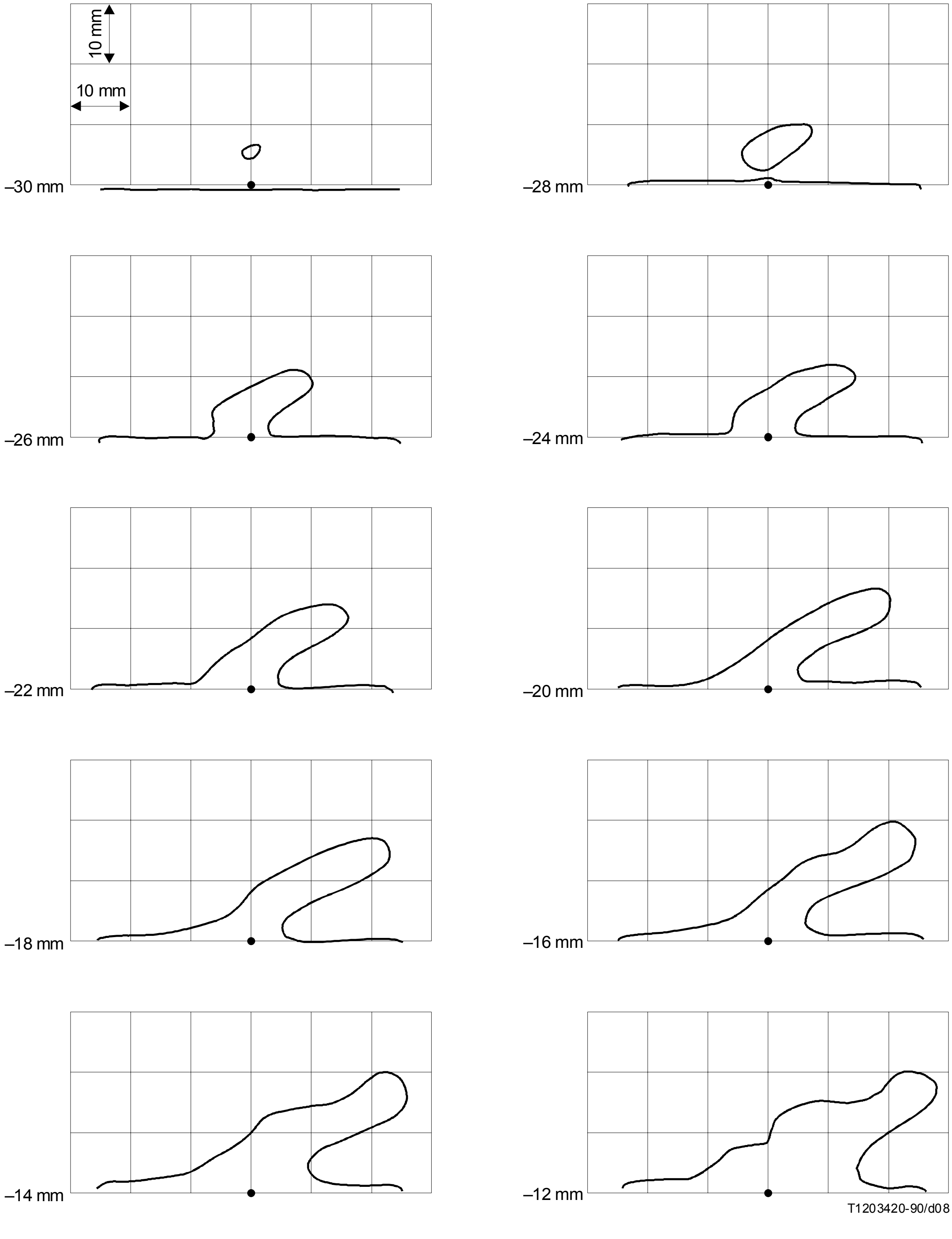


FIGURE 7b/P.57

**Pinna simulator cross sections**

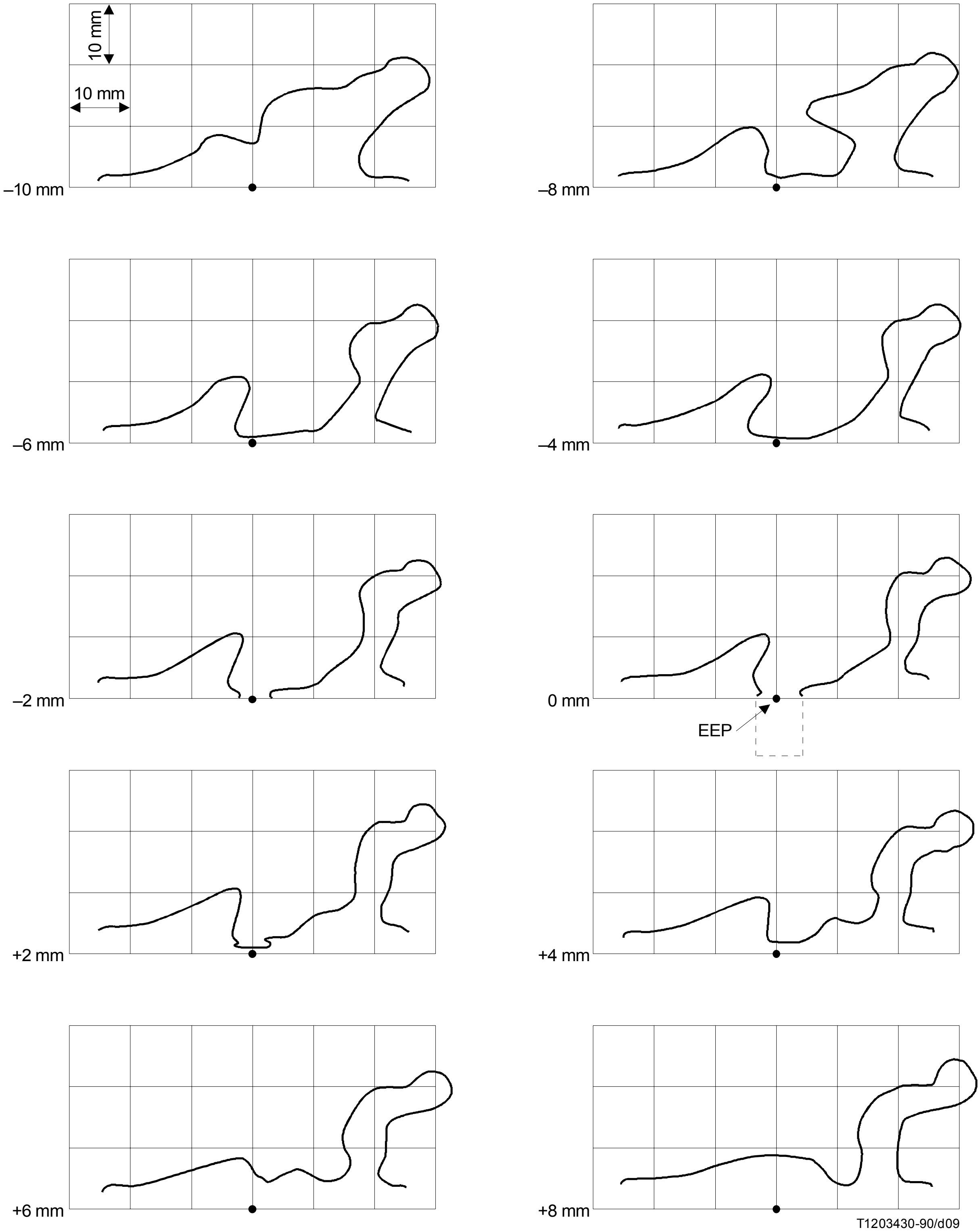


FIGURE 7c/P.57

**Pinna simulator cross sections**

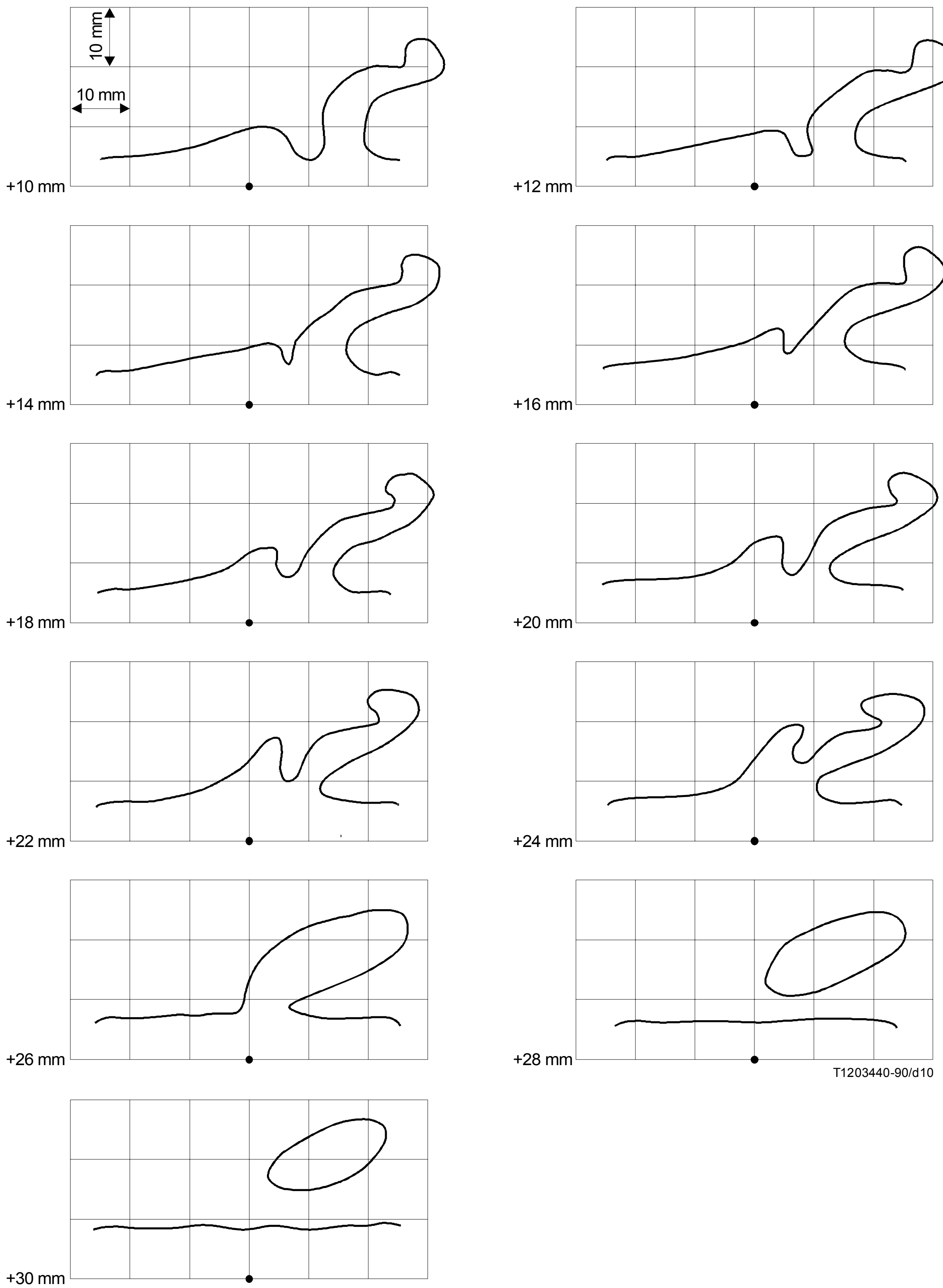


FIGURE 7d/P.57

**Pinna simulator cross sections**

#### 4.3.6 Atmospheric reference conditions

The range of the ambient conditions is the same as for the occluded-ear simulator used in Type 3 Artificial Ear:

| | |
|---|---|
| Static pressure: | 101.3 ± 3.0 kPa |
| Temperature: | 23 °C ± 3 °C |
| Relative humidity: | 60 ± 20% |

#### 4.3.7 Earphone placement

Acoustically open earphones equipped with soft cushions should be positioned against Type 3 Artificial Ear with the same force applied in normal use.

The application force of hard earcaps against Type 3.3 pinna simulator should exceed by a factor of 10 the application force occurring in actual use. An application force in the range between 10 N and 20 N is recommended.

Hard earcaps must be applied against Type 3.2 Artificial Ear with an application force between 8 N and 10 N.

The force applied in the measurements shall always be reported.

#### 4.3.8 DRP-ERP transfer function

The sound pressure measured by the Type 3 Artificial Ear is referred to the ear-drum reference point (DRP). The correction function given in Table 1 shall be used for converting data to the ear reference point (ERP) when it is required to calculate loudness ratings or compare results with specifications based on measurements referred to ERP.

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