

# Electroacoustics — Audiometric equipment

## Part 5: Instruments for the measurement of aural acoustic impedance/admittance

The European Standard EN 60645-5:2005 has the status of a  
British Standard

ICS 17.140.50

# National foreword

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## Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, the foreword page, pages 3 to 29 and a back cover.

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## Amendments issued since publication

| Amd. No. | Date | Comments |
|----------|------|----------|
|          |      |          |
|          |      |          |
|          |      |          |
|          |      |          |
|          |      |          |

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ISBN 0 580 45430 4

English version

**Electroacoustics –  
Audiometric equipment  
Part 5: Instruments for the measurement  
of aural acoustic impedance/admittance  
(IEC 60645-5:2004)**

Electroacoustique –  
Appareillage audiométrique  
Partie 5: Instruments pour la mesure  
de l'impédance ou de l'admittance aurale  
(impédancemètres ou admittancemètres)  
(CEI 60645-5:2004)

Akustik –  
Audiometer  
Teil 5: Geräte zur Messung der  
akustischen Impedanzen/Admittanzen  
des Gehörs  
(IEC 60645-5:2004)

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**CENELEC**

European Committee for Electrotechnical Standardization  
Comité Européen de Normalisation Electrotechnique  
Europäisches Komitee für Elektrotechnische Normung

**Central Secretariat: rue de Stassart 35, B - 1050 Brussels**

## Foreword

The text of document 29/563/FDIS, future edition 1 of IEC 60645-5, prepared by IEC TC 29, Electroacoustics, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60645-5 on 2004-12-01.

This European Standard supersedes EN 61027:1993.

The following dates were fixed:

- |                                                                                                                                          |       |            |
|------------------------------------------------------------------------------------------------------------------------------------------|-------|------------|
| – latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement | (dop) | 2005-09-01 |
| – latest date by which the national standards conflicting with the EN have to be withdrawn                                               | (dow) | 2007-12-01 |

Annex ZA has been added by CENELEC.

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## Endorsement notice

The text of the International Standard IEC 60645-5:2004 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

|           |      |                                                 |
|-----------|------|-------------------------------------------------|
| ISO 389-1 | NOTE | Harmonized as EN ISO 389-1:2000 (not modified). |
| ISO 389-2 | NOTE | Harmonized as EN ISO 389-2:1996 (not modified). |

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## **INTRODUCTION**

Developments in the field of diagnostic hearing measurement have resulted in a number of instruments designed to evaluate the acoustic impedance/admittance of the human ear by means of acoustic probe signals having different frequencies and temporal characteristics. The practical use of such instruments concerns to a large extent the measurement of changes in acoustic impedance/admittance caused either by varying the air pressure in the external acoustic meatus or by activating the middle ear muscle reflex.

## ELECTROACOUSTICS – AUDIOMETRIC EQUIPMENT –

### Part 5: Instruments for the measurement of aural acoustic impedance/admittance

#### 1 Scope

This part of IEC 60645 applies to instruments designed primarily for the measurement of acoustic impedance/admittance in the human external acoustic meatus using a stated probe tone. It is recognized that other probe signals may also be used. The standard defines the characteristics to be specified by the manufacturer, lays down performance specifications for three types of instruments and specifies the facilities to be provided on these types. This standard describes methods of test to be used for approval testing and guidance on methods for undertaking routine calibration.

The purpose of this standard is to ensure that measurements made under comparable test conditions with different instruments complying with the standard will be consistent. The standard is not intended to restrict development or incorporation of new features, nor to discourage innovative approaches.

#### 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60126, *IEC reference coupler for the measurement of hearing aids using earphones coupled to the ear by means of ear inserts*<sup>1</sup>

IEC 60601-1, *Medical electrical equipment – Part 1: General requirements for safety*

IEC 60601-1-2, *Medical electrical equipment – Part 1-2: General requirements for safety – Collateral standard: Electromagnetic compatibility – Requirements and tests*

IEC 60601-1-4, *Medical electrical equipment – Part 1: General requirements for safety – Collateral standard: Programmable electrical medical systems*

IEC 60645-1:2001, *Electroacoustics – Audiological equipment – Part 1: Pure-tone audiometers*

BIPM/IEC/IFCC/ISO/IUPAC/IUPAP/OIML, *Guide to the expression of uncertainty in measurement (GUM)*

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<sup>1</sup> To be revised as IEC 60318-5.

### 3 Terms and definitions

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

NOTE The units in this standard conform to the International System of Units (SI). However, for audiological measurements test results have traditionally often been reported in other units. To provide information on the conversion from such units to SI units, Annex B has been compiled.

#### 3.1

##### **aural impedance/admittance**

general term covering all aspects of acoustic impedance/admittance of the ear

NOTE Throughout this standard the term aural impedance/admittance will be employed as a general term covering all aspects of acoustic impedance/admittance of the ear, except where reference is made to specific derivatives.

#### 3.2

##### **acoustic impedance**

at a specified surface, quotient of sound pressure by volume velocity through the surface

NOTE 1 The symbol is  $Z_a$  and the unit is the pascal second per metre to the third power ( $\text{Pa}\cdot\text{s}/\text{m}^3$ )

NOTE 2 The quantity usually measured is the modulus.

#### 3.3

##### **acoustic resistance**

real component of complex acoustic impedance

NOTE The symbol is  $R_a$  and the unit is the pascal second per metre to the third power ( $\text{Pa}\cdot\text{s}/\text{m}^3$ ).

#### 3.4

##### **acoustic reactance**

imaginary component of complex acoustic impedance

NOTE The symbol is  $X_a$  and the unit is the pascal second per metre to the third power ( $\text{Pa}\cdot\text{s}/\text{m}^3$ ).

#### 3.5

##### **acoustic admittance**

at a given surface, the reciprocal of acoustic impedance at the same surface

NOTE 1 The symbol is  $Y_a$  and the unit is the metre to the third power per pascal second ( $\text{m}^3/\text{Pa}\cdot\text{s}$ ).

NOTE 2 Thus, the acoustic admittance at a given surface is the complex ratio of the volume velocity through the surface of the sound pressure averaged over the surface. The quantity usually measured is the modulus.

#### 3.6

##### **acoustic conductance**

real component of complex acoustic admittance

NOTE The symbol is  $G_a$  and the unit is the metre to the third power per pascal second ( $\text{m}^3/\text{Pa}\cdot\text{s}$ ).

#### 3.7

##### **acoustic susceptance**

imaginary component of complex acoustic admittance

NOTE The symbol is  $B_a$  and the unit is the metre to the third power per pascal second ( $\text{m}^3/\text{Pa}\cdot\text{s}$ ).

#### 3.8

##### **acoustic inertance**

ratio of the driving sound pressure to the resulting rate of change in volume velocity

NOTE The symbol is  $M_a$  and the unit is the pascal second to the second power per metre to the third power ( $\text{Pa}\cdot\text{s}^2/\text{m}^3$ ).

### 3.9

#### **acoustic compliance**

ratio of volume displacement to sound pressure

NOTE The symbol is  $C_a$  and the unit is the metre to third power per pascal ( $\text{m}^3/\text{Pa}$ ).

### 3.10

#### **equivalent volume**

volume of an air-filled hard-walled cylindrical cavity that offers the equivalent acoustic impedance/admittance

NOTE 1 The volume is given by the formula:

$$V_e = \gamma \cdot p_s \cdot C_a = \rho \cdot c^2 \cdot C_a$$

where

$V_e$  is the equivalent volume in  $\text{m}^3$ ;

$\gamma$  is the ratio of specific heat for air at constant pressure to that at constant volume (approximately 1,40);

$p_s$  is the barometric air pressure in Pa;

$\rho$  is the ambient density of air in  $\text{kg}/\text{m}^3$ , at the temperature and pressure of the measurement;

$c$  is the speed of sound in m/s at the temperature and pressure of the measurement;

$C_a$  is the acoustic compliance in  $\text{m}^3/\text{Pa}$ .

NOTE 2 It has been practice to refer to aural impedance/admittance at the probe tone frequency of 226 Hz as an equivalent volume of air.

NOTE 3 For a probe tone frequency of 226 Hz, the equivalent volume of air is equal to its physical volume provided the latter does not exceed  $5 \text{ cm}^3$ .

### 3.11

#### **relative pressure in the external acoustic meatus**

difference between the pressure in the external acoustic meatus and the ambient barometric pressure in daPa

### 3.12

#### **probe**

coupling device that is inserted into the external acoustic meatus to connect the instrument to the ear

### 3.13

#### **ear tip**

device used to provide a seal between the probe and the external acoustic meatus

### 3.14

#### **probe signal**

acoustic signal that is emitted into the external auditory meatus by means of a probe

NOTE The signal is used to measure acoustic impedance/admittance.

### 3.15

#### **probe ear**

ear into which the probe is inserted

### 3.16

#### **measurement plane**

plane located at the frontal surface of the probe perpendicular to the volume velocity vector

**3.17****tympanometry**

measurement of change of aural impedance/admittance as a function of air pressure in the external acoustic meatus

NOTE The measured acoustic impedance/admittance values may depend on rate and direction of change of air pressure as well as time spent with a certain constant air pressure in the external acoustic meatus.

**3.17.1****measurement plane tympanometry**

measurement of change of the aural impedance/admittance at the measurement plane, comprising the combined impedance/admittance of the middle ear and part of the external acoustic meatus

**3.17.2****meatus-compensated tympanometry**

measurement of the vector difference between the aural impedance/admittance obtained at the test pressure and that obtained at a specific reference pressure in the external acoustic meatus for a given fitting of the probe

NOTE 1 The reference pressure should be such as to effectively eliminate the influence of the middle ear.

NOTE 2 The reference pressure will normally be 200 daPa different from the indicated pressure, which gives maximum admittance or minimum impedance indication, or fixed at 200 daPa relative to ambient pressure.

**3.18****tympanogram**

graphical display of some quantity related to aural impedance/admittance as a function of air pressure in the external acoustic meatus

**3.19****middle-ear muscle reflex**

change in tonus of muscles of the middle ear in response to stimulation

NOTE The change may be measured as a variation in the acoustic impedance/admittance within the external auditory meatus

**3.19.1****acoustic reflex**

middle-ear muscle reflex elicited by an acoustic stimulus

**3.19.2****non-acoustic reflex**

middle-ear muscle reflex elicited by a non-acoustic stimulus

**3.20****acoustic reflex activating stimulus**

acoustic stimulus that is used to elicit an acoustic reflex

**3.21****stimulus ear**

ear to which a reflex activating stimulus is presented in order to elicit a middle ear muscle reflex

**3.22****ipsilateral reflex**

middle ear muscle reflex elicited in the stimulus ear