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Respiratory protective devices — Human factors —

Part 7: Hearing and speech

Appareils de protection respiratoire — Facteurs humains — Partie 7: Discours et audition

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 94, *Personal safety — Personal protective equipment*, Subcommittee SC 15, *Respiratory protective devices*.

This second edition cancels and replaces the first edition (ISO/TS 16976-7:2013), which has been technically revised. The main changes compared to the previous edition are as follows:

— new definitions were added;

— introduction of references to IEC-standards;

— reference to B-weighting was removed;

— a number of references in Bibliography were removed.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

For an appropriate design, selection and use of respiratory protective devices, basic physiological demands of the user should be considered. The function of a respiratory protective device, the way it is designed and used and the properties of its material can affect communications: either speech or hearing or both.

This document belongs to a series of documents providing basic physiological and anthropometric data on humans. It contains information about hearing and speech associated with wearing respiratory protective devices.

Respiratory protective devices — Human factors —

Part 7: Hearing and speech

1 Scope

This document contains information related to the interaction between respiratory protective devices and the human body functions of hearing and speech.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

ISO 1999, *Acoustics — Estimation of noise-induced hearing loss*

ISO 16972, *Respiratory protective devices — Terms, definitions, graphical symbols and units of measurement*

IEC 61672, *Electroacoustics — Sound Level Meters*

3 Terms and definitions, and abbreviated terms

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1999, ISO 16972 and the following apply.

3.1.1
hearing
manner in which the brain and central nervous system recognizes and interprets sounds

3.1.2
ototoxicity
damage to hearing from overexposure to drugs or toxic substances

3.1.3
noise
unwanted sound

3.1.4
presbycusis
gradual sensorineural hearing loss due to natural ageing

3.1.5
sound
form of energy that moves through media in waves of pressure

3.1.6
sound pressure
local pressure deviation from the ambient atmospheric pressure caused by a sound wave

Note 1 to entry: Measured in pascals (Pa).

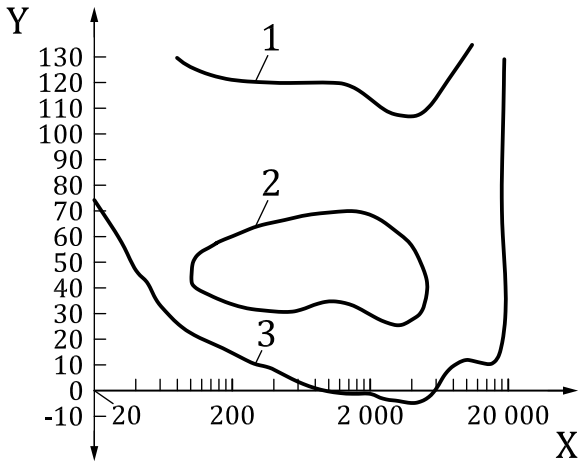
3.1.7
RMS sound pressure
deviation from the ambient atmospheric pressure caused by a sound wave at an instant in time over a given period of time

3.2 Abbreviated terms

SPL	sound pressure level
NIHL	noise induced hearing loss
TWA	time-weighted average
STI	speech transmission index
SII	speech intelligibility index
RMS	root mean square

4 Range of hearing and speech

Humans with normal hearing can usually hear sound pressure waves in a frequency range of about 20 Hz to 20 000 Hz, but the ear is most sensitive to frequencies from 500 Hz to around 4 000 Hz and declines dramatically in sensitivity as frequencies drop below 500 Hz. Figure 1 depicts the frequency response and sound pressure level response of human hearing and speech. The frequency range is affected by ageing as explained further in 7.3.



Key

X logarithmic sale of frequency (Hz)
Y sound pressure level (dB)
1 pain threshold
2 range of speech
3 hearing threshold

Figure 1 — Range of human hearing and speech

5 Measurement of sound pressure

The measurement of sound pressure is carried out using a sound level meter which shall meet the requirements of IEC 61672.

The sound pressure level (SPL) is the logarithmic ratio of the sound pressure to a reference sound pressure and is expressed in decibels (dB) by Formula (1)

$$L_p = 20 \log_{10} \left(\frac{p_{\mathrm{RMS}}}{p_0} \right) \tag{1}$$

where

L_p is the sound pressure level, in dB,

p_{RMS} is the root mean square (RMS) sound pressure, in Pa,

p_0 is the sound reference pressure, in Pa.

In air, the reference sound pressure is 20 µPa. That reference is based on the average human threshold of hearing at a frequency of 1 000 Hz.

When measuring sound pressure level as it relates to human perception, weighting factors, as given in IEC 61672, are used to represent human loudness perception at different frequencies. The most common is the A weighted sound measurement which approximates the human loudness perception at phon (40 dB at 1 000 Hz) and is expressed as dBA. Examples of some typical sound levels are:

Library	40 dBA
Normal conversation	60 dBA
Traffic noise	80 dBA
Metal shop	100 dBA
Siren	120 dBA
Jet engine	140 dBA

A perceived difference in sound level occurs at approximately 3 dB, and a perceived doubling of sound volume occurs with a 10 dB increase in sound pressure level.

Another sound weighting is the C-weighting, which approximates the human loudness perception at 100 phon.

6 Physiology of the ear

6.1 General

The human ear is the sense organ that detects sounds and changes the pressure waves into a signal of nerve impulses that is sent to the brain. The ear not only receives and converts sound but also plays a major role in the sense of balance and body position.

As shown in Figure 2, the ear is usually described in three sections: the outer ear (key 1), middle ear (key 2) and inner ear (key 3).