FINAL
DRAFT

INTERNATIONAL STANDARD

ISO/FDIS
11904-2

Acoustics — Determination of sound immission from sound sources placed close to the ear —

Part 2:
Technique using a manikin

Acoustique — Détermination de l'exposition sonore due à des sources placées à proximité de l'oreille —

Partie 2: Technique utilisant un mannequin

IMPORTANT — Please use this updated version dated 2020-11-05, and discard any previous version of this FDIS. The ballot dates have been modified.

ISO/CEN PARALLEL PROCESSING

Reference number
ISO/FDIS 11904-2:2020(E)

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ISO/FDIS 11904-2
https://standards.iteh.ai/catalog/standards/sist/ab5a4e13-c7cc-4b42-93d1-
8575400d443f/iso-fdis-11904-2

Contents

Foreword

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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).

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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 43, *Acoustics* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 211, *Acoustics*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 11904-2:2004), of which it constitutes a minor revision. The changes compared to the previous edition are editorial.

A list of all parts in the ISO 11904 series can be found on the ISO website.

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

ISO 11904 is a series of standards which specify methods for the determination of sound immissions from sources located close to the ear in which situations the sound pressure level measured at the position of the exposed person (but with the person absent) does not adequately represent the sound exposure.

In order to make it possible to assess the exposure by means of well-established criteria, the exposure of the ear is measured and subsequently converted into a corresponding free-field or diffuse-field level. The result is given as a free-field related or diffuse-field related equivalent continuous A-weighted sound pressure level, $L_{FF,H,Aeq}$ or $L_{DF,H,Aeq}$ when ISO 11904-1 is used, or $L_{FF,M,Aeq}$ or $L_{DF,M,Aeq}$ when ISO 11904-2 is used.

ISO 11904-1 describes measurements carried out using miniature or probe microphones inserted in the ears of human subjects (microphones in real ear, MIRE technique). ISO 11904-2 describes measurements carried out using a manikin equipped with ear simulators including microphones (manikin technique).

ISO 11904 may, for instance, be applied to equipment tests and the determination of noise exposure at the workplace where, in the case of exposure from sources close to the ears, the sound pressure level measured at the position of the exposed person (but with the person absent) does not adequately represent the sound exposure. Examples of applications are head- and earphones used to reproduce music or speech, whether at the workplace or during leisure, nail guns used close to the head, and combined exposure from a close-to-ear sound source and an external sound field.

When specific types of equipment are to be tested (e.g. portable cassette players or hearing protectors provided with radio receivers), test signals suitable for this particular type of equipment have to be used. Neither such test signals nor the operating conditions of the equipment are included in ISO 11904 but might be specified in other standards.

When workplace situations are measured, the various noise sources contributing to the immission should be identified. Operating conditions for machinery and equipment used might be specified in other standards.

Both parts of ISO 11904 strive for the same result: a mean value for a population of the free-field or the diffuse-field related level. ISO 11904-1 does this by specifying the mean of measurements on a number of human subjects; ISO 11904-2 does this by using a manikin, which aims at reproducing the acoustical effects on an average human adult. However, the two methods yield different measurement uncertainties which can influence the choice of method. Only the method described in ISO 11904-1 gives results which indicate the variance in a human population. Information on the uncertainties is given in Annexes A and B.

When using the MIRE technique for measurement of sound from earphones of insert and stethoscopic types, practical problems can occur with the positioning of microphones in the ear canal. When using the manikin technique, the headphone or earphone is coupled to the pinna simulator and ear canal extension as closely as possible to the way it is coupled to the human ear. In cases where headphones, earphones, or other objects touch the pinna, a possible deviation in stiffness or shape of the artificial pinna from human pinnae has a significant impact on the result and can even make the results invalid.

An overview of the differences between the two parts of ISO 11904 is given in Table 0.1.

Table 0.1 — Overview of differences between MIRE and manikin techniques

Parameter	ISO 11904-1	ISO 11904-2
Type of method	Microphone in real ear technique	Manikin technique
Limitation of the method	With earphones of insert and stethoscopic type, practical problems can occur with positioning of microphones in the ear canal.	Proper coupling may not always be obtained if the artificial pinna deviates from human pinnae in stiffness or shape. In some cases the exposed person cannot be replaced by a manikin, e.g., if the person has to operate equipment.
Main issues affecting accuracy	Number of subjects When tabulated values are used for $\Delta L_{FF,H}$ or $\Delta L_{DF,H}$: — calibration of ear canal microphone — accuracy in positioning of microphones in the ear canal When individual values are used for $\Delta L_{FF,H}$ or $\Delta L_{DF,H}$: — quality of reference sound field — stability of sensitivity and frequency response as well as position of ear canal microphone	Similarity of manikin to humans Calibration of manikin
Frequency range	20 Hz to 16 kHz	20 Hz to 10 kHz

Acoustics — Determination of sound immission from sound sources placed close to the ear —

Part 2:
Technique using a manikin

1 Scope

This document specifies basic framework measurement methods for sound immission from sound sources placed close to the ear. These measurements are carried out with a manikin, equipped with ear simulators including microphones. The measured values are subsequently converted into corresponding free-field or diffuse-field levels. The results are given as free-field related or diffuse-field related equivalent continuous A-weighted sound pressure levels. The technique is denoted the manikin technique.

This document is applicable to exposure to sound from sources close to the ear, for example during equipment tests or at the workplace to sound from earphones or hearing protectors with audio communication facilities.

This document is applicable in the frequency range from 20 Hz to 10 kHz. For frequencies above 10 kHz, ISO 11904-1 can be used.

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.

IEC 61260, *Electroacoustics — Octave-band and fractional-octave-band filters*

IEC 61672-1, *Electroacoustics — Sound level meters — Part 1: Specifications*

ITU-T P.58:2013, *Head and torso simulator for telephonometry*

3 Terms and definitions

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

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

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

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

3.1
manikin sound pressure level
$L_{M,exp,f}$
equivalent continuous sound pressure level in one-third-octave frequency bands with nominal midband frequency f, measured with the microphone of an ear simulator integrated in a manikin when the manikin is exposed to the sound under test

3.2
free-field frequency response for use with manikins

$\Delta L_{FF,M,f}$

average human free-field frequency response for use with manikins, corrected for the difference between the sound transmission inside the average human ear canal and the corresponding transmission of the manikin ear simulator

Note 1 to entry: For applicability with manikins, the eardrum reference is replaced by the output of the manikin ear simulator in tabulated values of $\Delta L_{FF,M,f}$.

Note 2 to entry: The free-field frequency response for use with manikins is identical to the amplitude of the head-related transfer function (HRTF) for frontal sound incidence.

Note 3 to entry: The human free-field frequency response is defined in ISO 11904-1.

3.3
diffuse-field frequency response for use with manikins

$\Delta L_{DF,M,f}$

average human diffuse-field frequency response for use with manikins, corrected for the difference between the sound transmission inside the average human ear canal and the corresponding transmission of the manikin ear simulator

Note 1 to entry: For applicability with manikins, the eardrum reference is replaced by the output of the manikin ear simulator in tabulated values of $\Delta L_{DF,M,f}$.

Note 2 to entry: The human diffuse-field frequency response is defined in ISO 11904-1.

3.4
free-field related sound pressure level determined with a manikin

$L_{FF,M}$

free-field sound pressure level determined with the method using a manikin

Note 1 to entry: The definition may be applied to specific frequencies or frequency bands, weighted or unweighted levels, specific time weightings, etc., for instance "free-field related equivalent continuous A-weighted sound pressure level" (free-field related $L_{M,Aeq}$, also denoted $L_{FF,M,Aeq}$).

Note 2 to entry: The method is aimed at the mean free-field related sound pressure level that would be obtained with a large human population.

Note 3 to entry: The free-field related sound pressure level for a human subject is defined in ISO 11904-1.

3.5
diffuse-field related sound pressure level determined with a manikin

$L_{DF,M}$

diffuse-field sound pressure level determined with the method using a manikin

Note 1 to entry: The definition may be applied to specific frequencies or frequency bands, weighted or unweighted levels, specific time weightings, etc., for instance "diffuse-field related equivalent continuous A-weighted sound pressure level" (diffuse-field related $L_{M,Aeq}$, also denoted $L_{DF,M,Aeq}$).

Note 2 to entry: The method is aimed at the mean diffuse-field related sound pressure level that would be obtained with a large human population.

Note 3 to entry: The diffuse-field related sound pressure level for a human subject is defined in ISO 11904-1.

4   Measurement principle

A manikin (head and torso simulator) is exposed to the sound source(s) in question and, for each of the ear simulators integrated in the manikin, the sound pressure level is measured in one-third-octave frequency bands, $L_{M,exp,f}$.

Each of the one-third-octave-band levels is adjusted with the free-field or diffuse-field frequency response for the manikin, $\Delta L_{\text{FF,M},f}$ or $\Delta L_{\text{DF,M},f}$, in order to obtain the corresponding free-field related or diffuse-field related one-third-octave-band sound pressure levels. These one-third-octave-band levels are adjusted using A-weighting constants, and subsequently combined to obtain the free-field related or diffuse-field related equivalent continuous A-weighted sound pressure level, $L_{\text{FF,M,Aeq}}$ or $L_{\text{DF,M,Aeq}}$.

The measurements may be carried out for one or both ears, as appropriate. The free-field or diffuse-field frequency response for use with manikins is taken from Table 1.

5   Instrumentation

5.1   Manikin (head and torso simulator)

The manikin used shall satisfy the requirements of ITU-T P.58:2013, 5.3 (first paragraph), 6.1 and 7.1, for the ear simulator and the acoustic characteristics of the manikin respectively.

The manikin used should be checked regularly for compliance with the requirements of ITU-T P.58:2013, 5.3 (first paragraph), 6.1 and 7.1.

In cases where sound sources touch the pinna (such as earphones or hearing protectors with communication facilities), they shall be coupled to the pinna simulator and ear canal extension in a way that represents as closely as possible the way they are coupled to the human ear.

NOTE   In cases where head- or earphones or other objects touch the pinna, the deviation in stiffness or shape of the artificial pinna from human pinnae has a significant impact on the result and may even make the results invalid.

5.2   Check of calibration

The calibration of the microphones and the measuring equipment shall be checked as follows.

For checking the calibration of the measurement system together with the occluded ear simulator, an acoustic calibrator (class 1 according to IEC 60942) shall be coupled to the occluded ear simulator. The sound pressure level shall, in this case, be measured without any frequency weighting.

NOTE   Calibration of the manikin is usually performed using an adapter for the acoustic calibrator. The presence of the adapter changes the effective output level of the calibrator. Check the manikin user manual for the corrected acoustic calibrator output level with the adapter.

The frequency response of the measuring system without the occluded ear simulator may be measured using suitable electrical input signals.

5.3   Filters

Signals shall be analysed with one-third-octave-band filters complying with the requirements for class 1 of IEC 61260.

6   Determination of free-field or diffuse-field related equivalent continuous A-weighted sound pressure level

6.1   Measurement of manikin sound pressure level

With the manikin exposed to the sound under test, the equivalent continuous sound pressure levels for each one-third-octave frequency band should be measured with each ear simulator. The frequency range shall cover all frequencies of significance for the test purposes, and a signal-to-noise ratio of at least 10 dB shall be guaranteed in each one-third-octave frequency band. If only one ear simulator is used, this shall be stated.

The measurement period shall be chosen to give a proper representation of the exposure. For the one-third-octave frequency band with centre frequency f, the measurement period t shall be as follows:

    – for $f \leq 2\,000\,\text{Hz}$:

$$t \geq \frac{5\,000}{f}$$

    – and for $f > 2\,000\,\text{Hz}$:

$$t \geq 2,5\,\text{s}$$

NOTE 1   The specifications given refer to random noise; the period for other test signals can be different, provided the measurement uncertainty is not increased.

The level in each one-third-octave frequency band shall be corrected for the pressure frequency response of the microphone of the ear simulator.

NOTE 2   The pressure frequency response of the microphone can be obtained from the manufacturer's calibration data.

The result, the manikin one-third-octave-band sound pressure level during exposure to the sound under test, is denoted $L_{\text{M,exp},f}$.

If only sounds from sources coupled directly to the ears are to be taken into account, only the head of the manikin (without torso) is required for the measurements.

6.2   Conversion to free-field or diffuse-field related sound pressure level

To obtain the free-field or diffuse-field related one-third-octave band sound pressure level, $L_{\text{FF,M},f}$ or $L_{\text{DF,M},f}$, the free-field or diffuse-field frequency response for use with manikin, $\Delta L_{\text{FF,M},f}$ or $\Delta L_{\text{DF,M},f}$, shall be subtracted from the manikin sound pressure level, $L_{\text{M,exp},f}$:

$$L_{\text{FF,M},f} = L_{\text{M,exp},f} - \Delta L_{\text{FF,M},f} \tag{1}$$

$$L_{\text{DF,M},f} = L_{\text{M,exp},f} - \Delta L_{\text{DF,M},f} \tag{2}$$

$\Delta L_{\text{FF,M},f}$ or $\Delta L_{\text{DF,M},f}$ shall be taken from [Table 1](#).

Table 1 — Free-field and diffuse-field frequency response for use with manikins

One-third-octave band centre frequency Hz	Free-field frequency response $\Delta L_{\text{FF,M,}f}$ dB	Diffuse-field frequency response $\Delta L_{\text{DF,M,}f}$ dB
≤100	0	0
125	0,4	0,3
160	0,8	0,6
200	1,2	0,9
250	1,5	1,2
315	1,5	1,4
400	1,7	1,8
500	2,1	2,3
630	2,5	3,2
800	2,2	4,0
1 000	1,7	4,6
1 250	3,8	6,0
1 600	8,4	8,1
2 000	12,9	11,4
2 500	15,6	15,0
3 150	15,6	14,2
4 000	14,2	11,9
5 000	10,6	9,8
6 300	4,0	8,5
8 000	2,0	11,0
10 000	−0,3	7,1

NOTE 1   Data have been taken from Reference [11].

NOTE 2   The mean human blocked-entrance data from Reference [12] have been transferred to the "manikin eardrum" using the blocked entrance to the "manikin eardrum" transfer function for ear simulators according to IEC 60318-4 (see Reference [11]). Systematic deviations are found for exposure to sound sources placed close to the ear measured with manikins, compared to MIRE measurements using human subjects. For compensation, the frequency responses listed in this table differ from frequency responses of manikins specified in ITU-T P.58 or IEC 60318-7.