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Acoustics — Noise from shooting ranges —

Part 6:
Sound exposure at close range of the sound source

Acoustique — Bruit des stands de tir —

Partie 6: L´exposition au bruit à proximité de la source sonore

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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 on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

A list of all parts in the ISO 17201 series can be found on the ISO website.

Introduction

Parts 1 to 5 of the Standard series ISO 17201 ([2] to [5]) relate to the determination or prediction of environmentally relevant exposure to sound at receiving points outside shooting ranges.

In several countries however also the need exists for knowledge about exposure to sound within a shooting range at short distance from the sound source, for instance for prediction, evaluation, control or comparison purposes.

For such assessment various measures are in use, which all can be derived from the time history of sound pressure at the locations of interest. Close to the muzzle blast or blast of an explosion the measurement of sound pressure has particular features to be dealt with.

This Part 6 of the Standard series ISO 17201 therefore defines how the time histories of the sound pressure at locations of interest within a shooting range can be reliably obtained.

Acoustics — Noise from shooting ranges —

Part 6:
Sound exposure at close range of the sound source

1 Scope

This document specifies methods for recording the time history of the sound pressure produced by shooting with calibres of less than 20 mm or by detonation of explosive charges of less than 50 g TNT equivalent in locations within the shooting range. The location of the measurement can be the position of the shooter or any person in the shooting range. The time history of the sound pressure can be the basis for further analyses of exposure of persons to these kinds of sounds.

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 60942, *Electroacoustics — Sound calibrators*

IEC 61094-6:2004, *Measurement microphones — Part 6: Electrostatic actuators for determination of frequency response*

IEC 61672-1:2013, *Electroacoustics — Sound level meters — Part 1: Specifications*

ISO 17201-1:2018, *Acoustics — Noise from shooting ranges — Part 1: Determination of muzzle blast by measurement*

ISO 80000-8, *Quantities and units — Part 8: Acoustics*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 80000-8 and the following 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
discrete-time sound pressure series
sound pressure history with values given for discrete times

Note 1 to entry: In general, this time-series is the result of sampling the recorded sound pressure time-history.

Note 2 to entry: In all applications in this document, equal time spacing is assumed.

3.2
sampling
reduction of a continuous-time signal to a discrete-time signal series

3.3
sample
value at a point in time in a discrete-time signal series

Note 1 to entry: Samples can be in various number formats, typically Integer or Real.

Note 2 to entry: Calibration information is needed to convert from a sample value to a sound pressure.

3.4
sampling interval
T_s
time between two adjacent values in a discrete-time signal series

Note 1 to entry: The sampling interval T_s is expressed in seconds.

Note 2 to entry: $f_s = \frac{1}{T_s}$.

3.5
sampling rate
f_s
number of samples per second

Note 1 to entry: The sampling rate f_s is expressed in hertz.

4 Measurement system requirements

4.1 General

This clause specifies instrumentation for measuring impulsive sounds in the audible frequency range from 20 Hz to 20 kHz. The purpose is to enable the reliable and accurate measurement of sound pressure histories which can be used as input to various methods for describing impulsive sound characteristics such as sound exposure level, peak sound pressure level, A-duration etc. as for example defined in ISO 10843[1].

Impulsive sound signals may contain significant contributions in the frequency range outside the audible range from 20 Hz to 20 kHz, and impulsive sound quantifiers will therefore depend on the frequency range of the instrumentation used for the measurements, and can therefore not be directly compared for measurements where these parameters are not the same. As this clause specifies the frequency range and other system requirements, data obtained within the given specifications can be compared to other measurements obtained using this method.

4.2 Ranges of sound pressure levels

The peak sound pressure level depends – among other things – on the source energy of the blast and the distance to it. At close distances, the peak sound pressure may be above 1 kPa, corresponding to a level above 154 dB. The other parts of the standard series ISO 17201 limit its use for measurements with peak sound pressure levels below 154 dB, since these parts are concerned with sound propagation. This document is focused on the measurement of the time history of the sound pressure, therefore no limit on the peak sound pressure level is set.

4.3 Overall system description

The measurements system shall consist of at least a microphone with a preamplifier and a digital data acquisition system capable of storing digital signals for later retrieval and processing.

The measurement system shall be class 1 according to IEC 61672-1 using Z-weighting.

4.4 Microphone and preamplifier requirements

The measurements shall be performed with a pressure type microphone meeting the requirements for a WS3-P or WS2-P microphone as defined in IEC 61094-4. The use of a WS3-P microphone is preferred, since the influence of the angle of incidence within the frequency range of interest is smaller compared to a WS2-P microphone.

The microphone shall be connected to a cylindrical preamplifier with a diameter not larger than that of the microphone. The microphone and preamplifier combination shall have the capability to measure peak sound pressure levels in the appropriate range, with

$$L_{p,\max} \leq L_{p,\mathrm{OL}} - 5\,\mathrm{dB} \tag{1}$$

where

$L_{p,\max}$ is the peak sound pressure level to be measured; expressed in decibel;

$L_{p,\mathrm{OL}}$ is the maximum peak sound pressure level at which the microphone and preamplifier combination is not overloaded; expressed in decibel.

$$L_{p,\mathrm{nf}} \leq L_{p,\max} - 60\,\mathrm{dB} \tag{2}$$

where

$L_{p,\max}$ is the peak sound pressure level to be measured; expressed in decibel;

$L_{p,\mathrm{nf}}$ is the A-weighted noise floor of the microphone and preamplifier combination; expressed in decibel.

NOTE 1 The A-weighted noise floor is used because this value is typically specified in microphone and preamplifier data sheets.

A microphone and preamplifier combination capable of measuring peak sound pressure levels of at least 165 dB is recommended.

The dynamic range of the microphone and preamplifier combination shall be at least 100 dB. The dynamic range is the range from the highest peak sound pressure level capacity of the microphone to the A-weighted noise floor level of the microphone and preamplifier combination.

The frequency response of the microphone and preamplifier shall be calibrated with an electrostatic actuator according to IEC 61094-6 in the frequency range from 250 Hz to 20 kHz. This calibration shall be performed less than 365 days before the measurements.

NOTE 2 The calibration according to IEC 61094-6 is usually performed by the microphone manufacturer or a calibration laboratory.

4.5 Fixture

A fixture shall be used for the preamplifier and microphone that reduces influences of the fixture on the measured sound field.

4.6 Cable length

The microphone and preamplifier shall be capable of handling the occurring signal rise times. The signal rise time handling capacity is often determined by the preamplifier and the capacity of the cable between the preamplifier and data acquisition system. If the cable length is increased, the cable capacity will increase and the signal rise time handling capacity of the system will decrease. It is therefore important to ensure that the signal rise time handling capacity is determined for the actual

cable length used in the setup. For more information about slew rate limitations and signal rise time handling capacity see Annex A.

NOTE In many microphone and preamplifier combinations, the limiting factor for the high peak sound pressure handling capacity will be the preamplifier rather than the microphone.

4.7 Data acquisition system

The data acquisition system shall have a sample rate of at least 96 000 samples per second and shall be able to store at least 10 s of continuous data. The resolution of the data acquisition system shall be at least 24 bit.

The data acquisition system shall be equipped with an anti-aliasing filter attenuating all signal component above the frequency f_{AA}, with

$$\frac{f_s}{2{,}5} \leq f_{AA} \leq \frac{f_s}{2} \tag{3}$$

where

f_{AA} is the cut-off frequency of the anti-aliasing filter; expressed in hertz;

f_s is the sampling rate, expressed in hertz.

NOTE 1 $f_s/2$ is the Nyquist-frequency.

NOTE 2 For a sampling rate of 96 000 samples per second, the cut-off of the anti-aliasing filter should therefore be between 38,4 kHz and 48,0 kHz.

The anti-aliasing filter shall have a roll-off rate of not less than 36 dB/octave.

4.8 Data storage

The recorded sound pressure time-series shall be stored in a digital uncompressed file format. It can be stored directly as a sound pressure time-series, or as a sampled data time-series. In the latter case calibration and offset information shall be provided additionally. In both cases, timing information shall be provided to link each sample or data point to time.

If sampled data time-series are stored, the WAV-Format may be used for example.

Timing information shall be provided either by giving the time for each data point or by giving the sampling rate and the starting time of the recording.

4.9 Frequency-weighting

All data shall be recorded within the range of the Z-weighting given in IEC 61672-1.

4.10 Calibration

The system calibration shall include the response of the microphone, preamplifier, all cables and data acquisition system. The calibration shall be performed at either 250 Hz or 1 kHz, at a minimum sound pressure level of 114 dB, using a sound calibrator Class 1 as defined in IEC 60942. The calibration shall be performed on the same day before the measurements, and again after the measurements on the same day.

The calibration shall be documented, and this documentation shall be included with the measurement documentation.

5 Measurement setup

5.1 General considerations

The measured time history of the sound pressure from a specific weapon or explosive charge is influenced by the acoustical environment within the specific shooting range. Any reflections from the ground, walls or other obstacles will be included in the measurement. Also, the result will depend on the directivity of the sound radiation from the weapon and the location and posture of the shooter and bystanders.

As the result may be different for different shooter locations and postures as well as bystander positions, the measurements should either be performed in designated typical locations or in all individual shooting and bystander positions and postures of interest.

If a person of interest were present, measured values may be influenced by slight variations in head position. Also, differences between the sound levels at the left and right hand side of the head can be different for other orientations of the head. To reduce these influences the measurements are therefore carried out without the presence of the person of interest.

5.2 Measurement location

5.2.1 General

To determine the exposure to sound of a person

— within a specific shooting range;

— in a specific location and in a specific body posture;

— for a specific shooting situation;

measurements are performed with that person being absent, and the microphone placed in the position where the head of the person would be.

All effects of a specific ground, reflections on walls, and the effects due to the presence of other persons, are included in the measurement.

5.2.2 Special case: Shooter firing a gun

To determine the exposure to sound at the location of a shooter firing a gun, the person is removed, and the weapon is placed in a fixture and operated remotely. The microphone is placed in the position where the head of the shooter would be.

Only in this special case the measurement of shooting sound shall be performed in the absence of the shooter.

As there is not a universal applicable weapons fixture, it is mandatory that the used fixture is extensively documented. It should be constructed to minimize reflections.

Since the presence of the shooter can influence the exposure to sound of other persons in the shooting range, such as for instance an instructor or bystanders, the measurements for the assessment of the exposure to shooting sound at the location of these persons is to be performed with the shooter present. The persons of interest shall not be present during the measurements.

5.3 Microphone orientation

The microphone shall be mounted vertically, with the diaphragm facing upwards.

Note 1 to entry In terms of IEC 61672-1, the reference direction is vertical.