FINAL
DRAFT

INTERNATIONAL
STANDARD

**ISO/FDIS
17201-6**

ISO/TC **43**/SC **1**

Secretariat: DIN

Voting begins on:
2021-04-06

Voting terminates on:
2021-06-01

Acoustics — Noise from shooting ranges —

Part 6: Sound pressure measurements close to the source for determining exposure to sound

Acoustique — Bruit des stands de tir —
Partie 6: Mesurages de la pression sonore près de la source pour déterminer l'exposition au son

Reference number
ISO/FDIS 17201-6:2021(E)

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Published in Switzerland

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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 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*, Subcommittee SC 1, *Noise*.

A list of all parts in the ISO 17201 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 17201-1 to ISO 17201-5 (see Clause 2 and References [2] to [5]) relate to the determination or prediction of environmentally relevant sound immission at receiving locations outside shooting ranges.

There are countries, where the need exists also for knowledge about exposure to sound within a shooting range at short distances from the sound source, for instance for prediction, evaluation, assessment, control or comparison purposes.

Various methods and metrics are in use for the determination of exposure to impulsive sounds, and these can be derived from the measurement and analysis of 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 considered. This document can be applied to both indoor and outdoor shooting ranges that can contain different elements or usage situations. The method is applicable for locations where persons may be present at the shooting range, including the shooter and other persons (such as an instructor, supervisor, bystander or observer). The locations of interest include the position of the shooter (and posture and orientation) and the position of other persons within the shooting range.

This document defines how the time history of the sound pressure at locations of interest within a shooting range, regarding the exposure to impulsive sound of a person, can be reliably obtained.

Acoustics — Noise from shooting ranges —

Part 6: Sound pressure measurements close to the source for determining exposure to sound

1 Scope

This document specifies methods for recording the time history of the sound pressure produced either by shooting with calibres of less than 20 mm, or by detonation of explosive charges of less than 50 g TNT equivalent, within the shooting range at locations of interest, regarding the exposure to sound of the shooter, or any other person within the shooting range. The time history of the sound pressure can be the basis for further analyses of this type of sound at the locations of interest.

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 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*

IEC 60942, *Electroacoustics — Sound calibrators*

IEC 61094-4, *Measurement microphones — Part 4: Specifications for working standard microphones*

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*

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 https://www.electropedia.or

3.1
discrete-time sound pressure signal 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 series to a discrete-time signal series

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

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

Note 2 to entry: Scaling and offset information is needed if samples are not stored as sound pressure values.

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.

3.5
sampling rate
f_s
number of *samples* (3.3) per second

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

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

4 Measurement system requirements

4.1 General

This clause specifies instrumentation for measuring impulsive sounds from the sources specified in the scope. 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].

As this clause specifies the frequency range and other system requirements, data obtained within the given specifications can be compared to other measurement results 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 to the source, the peak sound pressure can be above 1 kPa, corresponding to a level above 154 dB. The other parts of ISO 17201 series can only be used for 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 including the digital data acquisition system shall meet the requirements for the limits on frequency response for Class 1 according to IEC 61672-1:2013, 5.5 using Z-weighting.

NOTE For the calculation of quantities specified in IEC 61672-1, also see Annex B.

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.

NOTE 1 A microphone of type WS3-P is often named ¼ inch working standard pressure microphone and WS2-P a ½ inch working standard pressure 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 decibels;

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

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

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

NOTE 2 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. This is defined in IEC 61094-4:2004, Figure 2 and Table 2.

NOTE 3 The calibration according to IEC 61094-6 is usually performed by the microphone manufacturer or a calibration laboratory.

4.5 Microphone fixture

A fixture with small influences on the measured sound field shall be used for the preamplifier and microphone to reduce 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 increases and the signal rise time handling capacity of the system decreases. 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 is the preamplifier, rather than the microphone.

4.7 Wind screens

It is recommended to perform measurements without a windscreen, because windscreens will change the high frequency content of the signal and may affect the measured peak values.

However, even moderate wind speeds may cause significant wind induced noise signals from the microphone and it is therefore recommended to check the residual noise during the measurements. If the difference between the peak C-weighted sound pressure level during the 3 s before the impulsive sound event and the measured C-weighted peak sound pressure value during the impulsive sound event is less than 60 dB, the use of a windscreen is recommended. For series of measurements of impulsive sound events with less than 3 s in between, the level of the residual background noise only needs to be measured once.

4.8 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 20 bit.

The data acquisition system shall be equipped with an anti-aliasing filter attenuating all signal components above the Nyquist-frequency $f_s/2$.

For frequencies from $f_s/2$ and higher, the attenuation shall be at least 10 dB.

The attenuation of the anti-aliasing filter shall be verified either by measurement or by using the technical specifications provided by the manufacturer.

4.9 Data storage

The recorded discrete-time sound pressure signal series shall be stored in a digital file format, uncompressed or with lossless compression. It can be stored directly as a discrete-time sound pressure signal series, or as a sampled data time-series. In the latter case, calibration factor 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 time of the first sample.

4.10 Frequency-weighting

All data shall be recorded and stored with Z-weighting given in IEC 61672-1.

4.11 Field calibration

The field calibration of the system shall include the response of the microphone, preamplifier, all cables and the 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 before the measurements and again after the measurements, not earlier than two hours before the measurements and not later than two hours after the measurements.

The calibration before the measurement may include an adjustment of sensitivity parameters. The calibration after the measurement is a verification of calibration conformance.

The calibration, including differences between first and second 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 and scattering from the ground, walls or other obstacles as well as effects due to the presence of persons are included in the measurement. For a specific weapon the result may also depend on the directivity of the sound radiation from the weapon and the location and posture of the shooter.

The sound pressure at the ears of a person at a location of interest can be very different for the left and right ear, and is influenced by specific details such as different head shapes and the exact orientation of the head. Measurement setups that take all these influences into account typically provide results for very individual events.

To enable generic and reproducible measurement results, the measurements are therefore carried out without the presence of the person at the location at which the exposure to sound is to be determined, and the microphone is placed where the centre of the head of that person would be.

5.2 Measurement location

To determine the exposure to sound at a location of interest

— within a specific shooting range,

— for a specific body posture, and

— for a specific source (firearm or explosive charge),

measurements are performed with a person at that location being absent, and the microphone placed where the centre of the head would be.

5.3 Special case: Weapons fixture

To determine the exposure to sound at the location of a shooter discharging a firearm, the shooter is absent, and the weapon is placed in a fixture and operated remotely. Only in this special case the measurement of shooting sound shall be performed in the absence of the shooter. The microphone is placed in the position where the centre of the head of the shooter would be.

The weapons fixture shall be constructed in such a way that the sound reflected by the fixture does not contribute significantly to the recorded discrete-time sound pressure signal series.

5.4 Persons in the shooting range

The presence of persons in the shooting range can influence the exposure to sound at the location of interest. As an example, if the location of interest is behind the shooter, the head and body of the shooter is expected to significantly influence the exposure to sound at that location. Another example would be a person between the blast source and the location of interest.

If the presence of persons in the shooting range is deemed to influence the exposure to sound at the location of interest, the measurements shall be performed with these persons present. Therefore, if measurements are performed in regard to a firearm, the shooter is always present if the location of interest is not the location of the shooter itself.