# INTERNATIONAL STANDARD

# ISO 17201-2

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## Acoustics — Noise from shooting ranges —

## Part 2:
## Estimation of muzzle blast and projectile sound by calculation

*Acoustique — Bruit des stands de tir —*

*Partie 2: Estimation de la détonation à la bouche et du bruit du projectile par calcul*



Reference number
ISO 17201-2:2006(E)

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 17201-2 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

ISO 17201 consists of the following parts, under the general title *Acoustics — Noise from shooting ranges*:



— *Part 1: Determination of muzzle blast by measurement*

— *Part 2: Estimation of muzzle blast and projectile sound by calculation*

— *Part 4: Prediction of projectile sound*



The following parts are under preparation:

— *Part 3: Guidelines for sound propagation calculations*

— *Part 5: Noise management*

The initiative to prepare a standard on impulse noise from shooting ranges was taken by AFEMS, the Association of European Manufacturers of Sporting Ammunition, in April 1996, by the submission of a formal proposal to CEN. After consultation in CEN in 1998, CEN/TC 211, *Acoustics*, asked ISO/TC 43/SC 1, *Noise*, to prepare the ISO 17201 series.

## Introduction

Two basic sources dominate the shooting sound from firearms: the muzzle blast and the projectile sound. These two sources are basically different. The explosion blast from devices can be treated as muzzle blast.

The muzzle blast is caused by the expanding gases of the propellant at the muzzle. The muzzle blast can be modelled based on essentially less spherical volume of these gases at that moment when the expansion speed becomes subsonic.

The projectile sound is caused by the supersonic flight of the projectile along the trajectory from the muzzle to the target or to a point on the trajectory where the projectile speed becomes subsonic. The projectile sound stems from a section of the trajectory that coherently radiates a shock wave into a certain direction.

In general, the procedures for estimating the source energy depends on the estimation of energies that are involved in related processes. The procedures give estimates for the fraction of these energies that transforms into acoustic energy. The result of the estimation is a set of acoustical source data with respect to energy, direction and frequency content.



# Acoustics — Noise from shooting ranges —

# Part 2:
**Estimation of muzzle blast and projectile sound by calculation**

## 1 Scope

This part of ISO 17201 specifies methods for estimating the acoustic source data of muzzle blast and explosions and the source data of projectile sound on the basis of non-acoustic data for firearms with calibres less than 20 mm and explosions less than 50 g TNT equivalent.

This part of ISO 17201 addresses those cases where no source measurements exist or where the data necessary to calculate projectile sound according to ISO 17201-4 are unknown. An example of this situation would be measuring projectile sound from shot guns pellets. This part of ISO 17201 can also be used as an interpolation method between measurements of muzzle blast.



Source data are given in terms of spectral angular source energy covering the frequency range from 12,5 Hz to 10 kHz and can be used as data input for sound propagation calculation.



This part of ISO 17201 is not applicable to the prediction of sound levels for the assessment of hearing damage and cannot be used to predict sound pressure levels or sound exposure levels below a specific distance where linear acoustics does not apply.



## 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.

ISO 17201-1:2005, *Acoustics — Noise from shooting ranges — Part 1: Determination of muzzle blast by measurement*

ISO 17201-4, *Acoustics — Noise from shooting ranges — Part 4: Prediction of projectile sound*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 17201-1 and the following apply.

### 3.1 General

**3.1.1**
**air density**
$\rho$
density of air for the estimation conditions

NOTE The air density is expressed in kilograms per cubic metre (kg/m$^3$).

**3.1.2**
**angular frequency**
$\omega$
frequency multiplied by $2\pi$

NOTE The angular frequency is expressed in radians per second (rad/s) in all formulae.

**3.1.3**
**coordinate system ($x$, $y$)**
plane coordinate system describing geometry, where the $x$-axis denotes the line of fire with $x$ = 0 at the muzzle, and the $y$-axis measures the perpendicular distance from the line of fire in any plane around the line of fire

NOTE 1 The sound field of projectile sound is rotational symmetric around the line of fire.

NOTE 2 The coordinates are given in metres (m).

**3.1.4**
**cosine-coefficients**
$c_{1,2\ldots N}$
coefficients of the cosine-transform used to describe the directivity of the angular source energy

**3.1.5**
**deceleration angle**
$\varepsilon$
difference between the radiation angle at the beginning and end of a part of the trajectory



NOTE The deceleration angle is expressed in radians (rad) in all formulae.

**3.1.6**
**specific chemical energy**
$u$
specific chemical energy content of the propellant



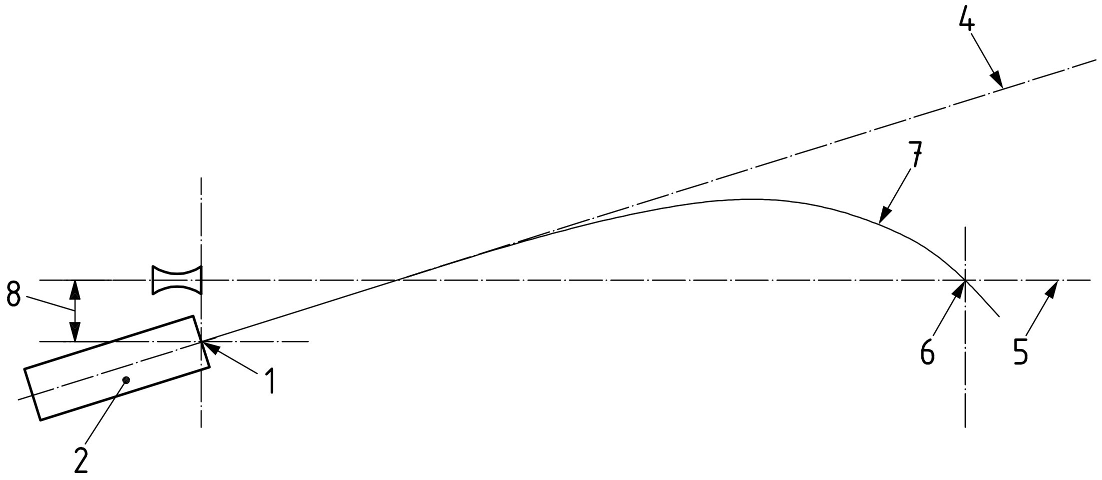
NOTE The specific chemical energy is usually expressed in joules per kilogram (J/kg)

**3.1.7**
**line of fire**
continuation of the axis of the barrel

See Figure 1.

NOTE Ballistic trajectories can be described as a sequence of straight lines. Then the methods apply to each segment. Corrections of the aiming device are ignored.




a) Side or elevation view




b) Top or plan view



**Key**

1 muzzle
2 barrel
3 sight
4 line of fire
5 line of sight
6 target
7 trajectory
8 height of sight

**Figure 1 — Line of fire and line of sight**

**3.1.8**
**projectile sound source energy**
$Q_p$
acoustic energy from a trajectory length of one metre

NOTE 1 The projectile sound source energy is expressed in joules (J).

NOTE 2 See also 3.3.6.

**3.1.9**
**propellant mass**
$m_c$
mass of the propellant

NOTE The propellant mass is expressed in kilograms (kg).

**3.1.10**
**radiation angle**
$\xi$
angle between the line of fire and the wave number vector describing the local direction of the propagation of the projectile sound

NOTE 1 The radiation angle is expressed in radians (rad) in all formulae.

NOTE 2 $\xi$ is the 90° complement of the Mach angle.

**3.1.11**
**angle alpha**
$\alpha$
angle between the line of fire and a line from the muzzle to the receiver

NOTE 1 See ISO 17201-1:2005, Figure 3.

NOTE 2 The angle alpha is expressed in radians (rad) in all formulae.

**3.1.12**
**sound exposure**
$E$
time integral of frequency-weighted squared instantaneous sound pressure over the event duration time

$$E = \int_T p^2(t)\, \mathrm{d}t$$



NOTE The sound exposure is expressed in pascal-squared seconds ($\mathrm{Pa}^2 \cdot \mathrm{s}$).



**3.1.13**
**sound exposure level**
$L_E$
ten times the logarithm to the base 10 of the ratio of the sound exposure to a reference value

NOTE 1 The sound exposure level is expressed in decibels.

NOTE 2 See also ISO 1996-1.

NOTE 3 The sound exposure level of a single burst of sound or transient sound with duration time is given by the formula

$$L_E = 10 \lg \left[ \int_T \frac{p^2(t)}{p_0^2 T_0} \mathrm{d}t \right] \mathrm{dB}$$

where

$p(t)$ is the instantaneous sound pressure as a function of time;

$p_0^2 T_0$ is the reference value [(20 μPa)$^2$ × 1 s].

**3.1.14**
**speed of sound in air**
$c$
speed of sound for the estimation condition

NOTE The speed of sound in air is expressed in metres per second (m/s).

**3.1.15**
**divergent area**
$S_S$
size of the area at a certain distance from the trajectory through which the sound radiated from the respective path of the trajectory is propagating

NOTE The divergent area is expressed in square metres ($m^2$).

**3.1.16**
**propagation distance**
$r_S$
distance between the source point of projectile sound, $P_S$, and the receiver point, $P_R$,

NOTE The propagation distance is expressed in metres (m).

**3.1.17**
**Weber radius**
$R_W$
radius of an equivalent radiating sphere of the "simple model of explosion"

NOTE The Weber radius is expressed in metres (m).

**3.1.18**
**Weber pressure**
$p_W$
sound pressure at the surface of the Weber sphere



NOTE The Weber pressure is expressed in pascals (Pa).

## 3.2 Directivity



**3.2.1**
**correction factor due to source directivity**
$c_S$
correction taking into account that different orders of Fourier functions contribute differently to the energy

**3.2.2**
**directivity factor**
$Y(\alpha)$
directivity function in the direction of $\alpha$

## 3.3 Energy

**3.3.1**
**effective angular source energy distribution**
$Q_Y(\alpha)$
effective energy radiated into the direction $\alpha$, weighted by directivity

NOTE The effective angular source energy distribution is expressed in joules per steradian (J/sr).

**3.3.2**
**total acoustic source energy**
$Q_e$
total acoustic energy after integration of $Q_Y(\alpha)$ over the whole sphere

NOTE The total acoustic energy is expressed in joules (J).

**3.3.3**
**energy in the propellant gas**
$Q_g$
energy in the gaseous efflux of the propellant at the muzzle

NOTE The energy in the propellant gas is expressed in joules (J).

**3.3.4**
**kinetic energy loss**
$Q_l$
difference in projectile energy of the translatory motion on a part of the trajectory of 1 m length due to air drag

NOTE The kinetic energy loss is expressed in joules (J).

**3.3.5**
**muzzle source energy**
$Q_m$
total acoustic energy of the muzzle blast

NOTE The muzzle source energy is expressed in joules (J).

**3.3.6**
**projectile sound source energy**
$Q_p$
product of the kinetic energy loss, $Q_l$, and the acoustical efficiency, $\sigma_{ac}$



NOTE 1 The projectile sound source energy is expressed in joules (J).

NOTE 2 See also 3.1.8.



**3.3.7**
**projectile muzzle kinetic energy**
$Q_{p0}$
kinetic energy of the projectile at the muzzle

NOTE The projectile muzzle kinetic energy is expressed in joules (J).

**3.3.8**
**propellant energy**
$Q_c$
total chemical energy of the propellant

NOTE The propellant energy is expressed in joules (J).

**3.3.9**
**Weber energy density**
$Q_W$
energy density of a Weber source with a Weber radius of 1 m

NOTE The Weber energy is expressed in joules per cubic metre (J/m$^3$).

**3.3.10**
**reference Weber energy**
$Q_{W,1}$
Weber energy for a mass of propellant having a Weber radius of 1 m

NOTE The reference Weber energy is expressed in joules (J).