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Part 2:
Calculation of muzzle blast

Acoustique — Bruit des stands de tir —

Partie 2: Calcul de la détonation à la bouche

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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 document 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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This document was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*, 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 17201-2:2006), which has been technically revised.

The main changes are as follows:

— deletion of former Clauses 5 and 6, and Annex D which were moved to ISO 17201-4;

— revision of former Clause 7 (now Clause 5) and Annex C;

— addition of a new Clause 6;

— editorial revision of the document.

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

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.

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

There are two basic sources that 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. This document describes the calculation of muzzle blast. The calculation of projectile sound is described in ISO 17201-4.

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

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

Acoustics — Noise from shooting ranges —

Part 2: Calculation of muzzle blast

1 Scope

This document specifies a computational method (in line with ISO 17201-4) for estimating the acoustic source data of muzzle blast and explosions on the basis of non-acoustic data for firearms with calibres less than 20 mm and explosions less than 50 g TNT equivalent.

This document addresses those cases where no source measurements exist. This document 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 document does not apply to the prediction of sound levels for the assessment of hearing damage; nor can it be used to predict sound pressure levels or sound exposure levels at distances where linear acoustics do not apply.

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

3 Terms and definitions

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

ISO and IEC maintain terminology 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.org/

3.1 General

3.1.1
air density
ρ
density of air for the estimation conditions

Note 1 to entry: The air density is expressed in kilograms per cubic metre (kg/m^3).

3.1.2
angular frequency
ω
frequency multiplied by 2π

Note 1 to entry: The angular frequency is expressed in radians per second (rad/s) in all formulae.

3.1.3
cosine coefficients
$c_{1,2...N}$
coefficients of the cosine-transform used to describe the directivity of the angular source energy

3.1.4
specific chemical energy
u
specific chemical energy content of the propellant

Note 1 to entry: The specific chemical energy is usually expressed in joules per kilogram (J/kg).

3.1.5
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 1 to entry: The sound exposure is expressed in pascal-squared seconds ($\mathrm{Pa}^2 \cdot \mathrm{s}$).

3.1.6
sound exposure level
L_E
ten times the logarithm to the base 10 of the ratio of the sound exposure, E, to the reference sound exposure

Note 1 to entry: The sound exposure level is expressed in decibels.

Note 2 to entry: See also ISO 1996-1[1].

Note 3 to entry: The sound exposure level of a single burst of sound or transient sound with duration time T is given by the formula

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

where

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

$p_0{}^2T_0$ is the reference value [$(20\ \mu\mathrm{Pa})^2 \times 1\ \mathrm{s}$].

3.1.7
speed of sound
c
<in air> speed of sound for the estimation condition

Note 1 to entry: The speed of sound in air is expressed in metres per second (m/s).

3.1.8
Weber radius
R_W
radius of an equivalent radiating sphere of the "simple model of explosion"

Note 1 to entry: The Weber radius is expressed in metres (m).

3.1.9
Weber pressure
p_W
sound pressure at the surface of the Weber sphere

Note 1 to entry: 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
$Y(\alpha)$
factor that specifies how many times higher the source energy is in direction α, compared with omnidirectional radiation and the same source energy

3.3 Energy

3.3.1
effective angular source energy
Q_Y
energy of an equivalent Weber source with a uniform energy density having the same energy density at direction α of the muzzle blast under consideration

Note 1 to entry: The effective angular source energy is expressed in joules (J).

3.3.2
total acoustic source energy
Q_e
total acoustic energy after integration of Q_Y over the whole sphere

Note 1 to entry: 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 1 to entry: The energy in the propellant gas is expressed in joules (J).

3.3.4
muzzle source energy
Q_m
total acoustic energy of the muzzle blast

Note 1 to entry: The muzzle source energy is expressed in joules (J).

3.3.5
kinetic energy of the projectile
Q_{p0}
translational kinetic energy of the projectile at the muzzle

Note 1 to entry: The projectile muzzle translational kinetic energy is expressed in joules (J).

3.3.6
propellant energy
Q_c
total chemical energy of the propellant

Note 1 to entry: The propellant energy is expressed in joules (J).

3.3.7
reference length
r_0
$r_0 = 1$ m

3.3.8
reference Weber energy
$Q_{W,1}$
Weber energy for a mass of propellant having a Weber radius of $r_0 = 1$ m

Note 1 to entry: The reference Weber energy is expressed in joules (J).

3.3.9
angular source energy distribution
$S_q(\alpha)$
acoustic energy radiated from the source into the far field per unit solid angle

Note 1 to entry: The acoustic energy radiated by the source within a narrow cone centred around the direction α is

$$S_q(\alpha) = \frac{\mathrm{d}Q}{\mathrm{d}\Omega}$$

where Ω is the solid angle in steradian (sr).

Note 2 to entry: The angular source energy distribution is expressed in joules per steradian (J/sr).

3.4 Fraction

3.4.1
projectile kinetic fraction
σ_{cp}
<projectile> fraction of the projectile kinetic energy, Q_p, relative to chemical energy, Q_c

Note 1 to entry: The efficiency is the kinetic fraction, expressed as percentage.

3.4.2
gas kinetic fraction
σ_{cg}
<gas> fraction of the chemical energy, Q_c, relative to propellant gas energy, Q_g

3.4.3
acoustical efficiency
σ_{ac}
fraction of an energy that converts into acoustic energy