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Environmental noise reduction means of weapons

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The structure and mechanics of gun silencers have not changed significantly. One novel aspect in noise attenuation is the use of an active noise cancelling system at shooting ranges and in hearing protectors. Attenuating the bullet flight noise is only possible by decreasing the velocity. Silencers that attenuate noise to the sides and back have a significant effect, whereas the noise to the front is not significantly affected because of the bullet noise. It is also possible to gain an attenuation of a few decibels from the maximum level of the muzzle blast by using ANC headsets. The most important aspect in the use of weapons is to get the bullets or shots to depart from the weapon in the most controllable manner, which means that the use of subsonic cartridges, smaller charges of gunpowder or modifications that attenuate noise are not at the top of the list of product development. However, shotguns are the most significant source of environmental noise at many shooting ranges, which are often situated very near houses or residential areas. The noise from shooting ranges disturbs and causes annoyance for those living nearby. Therefore, good practices are needed in environmental noise control at shooting ranges.

1 Introduction

The noise from hand-held weapons is generated by the muzzle blast, the noise of the bullet in flight and the impact, of which the muzzle blast is the most notable. The flight noise of the bullet can be as strong as that of the muzzle blast when heard from the front side relative to the shooting direction. The sound of a bullet's impact is usually a much weaker source of environmental noise than either flight noise or muzzle blast. Noise generating components in the weapon include the detonator, gunpowder and bullets (shots), the lock and barrel of the gun and any accessories (flash suppressor, muzzle brake, silencer or blank bullet amplifier). The detonation of gunpowder generates enormous pressure in the lock area, which accelerates the bullet at the start, which continues all through its trajectory both in the barrel and outside it. Figure 1 presents some average directions in which noise of handguns can disperse (1,7). In addition to the environmental noise presented in the figure, the muzzle blast of almost all powder guns exceeds 140 dB near the ear of the shooter, which is considered the top level over which any noise will generate a risk of hearing defects.

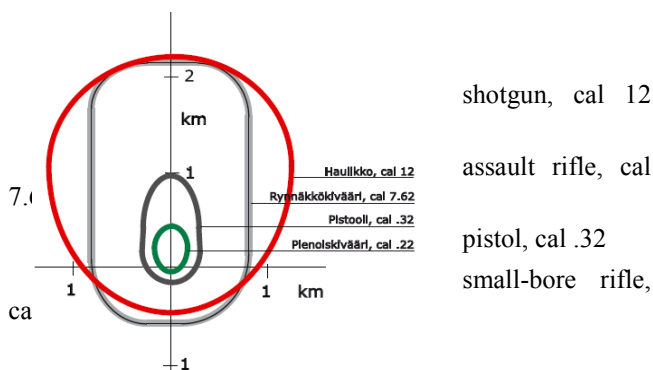


Fig. 1. Dispersion of noise generated by guns. Curves depict the maximum sound level of 65 dB.

The most significant source of environmental noise to the side, obliquely backward and backward of the shooting direction is the sound of the muzzle blast. The noise of the bullet in flight and on impact can usually be disregarded. The noise from the muzzle blast spreads evenly into all directions unless it is controlled by a muzzle brake, flash suppressor or other control unit (4). The function of the muzzle brake is to decrease recoil, but at the same time it forces the sound sideways and backwards (5).

Physically speaking, the silencer does not attenuate much noise, but the energy of the pressure is distributed over a longer period of time. In a typical case, the peak pressure measured in decibels at the maximum sound level is attenuated by 10–30 dB using a silencer. Even though the total energy of the pressure is not necessarily attenuated in a similar way, from a health point of view, the maximum level is the most significant factor in creating acute hearing damage. There are other things to take into account in addition to noise attenuation when considering the use of silencers (5): the gun's centre of gravity shifts; the silencer decreases the gun's recoil; and the aiming point of the gun is changed. In addition, silencers may increase the risk of accidents by jamming, making the gun or silencer blow up. The rules of sport shooting do not allow the use of a silencer. However, the use of silencers in practice shooting and hunting is slowly becoming more common due to their ability to decrease recoil and the risk of hearing damage (Figure 2).



Figure 2. Example of rifles at shooting range in Finland 2007. More than half of the weapons are equipped with suppressors.

The idea of active noise cancellation (ANC) is to send a pressure impulse of a reversed waveform to the gun's muzzle blast to the desired target, resulting in the attenuation of the pressure impulse according to the principle of acoustic interference. So far, the application of active noise control in weapons has been limited by the slowness of the electronic systems: the sharp pressure

impulse of the gun contains much higher frequencies (over 1 kHz) than active noise control can handle well at this time. One obvious method going forward is to combine the techniques of active noise control and passive attenuation. Thus far, there are no known incidences of attempts to apply active noise control to silencers because this technique would call for an extremely strong source of noise, which would significantly decrease the usability of the gun. On the other hand, it would be possible to construct a casing in front of the gun's muzzle at a shooting range in which active noise control could be applied. A research group in Finland has considered applying active noise control at a shooting range. They were able to create an attenuation of 3-6 dB from the peak level of an object observed in a restricted area (2). ANC headsets have recently been developed by Silenta Ltd. in collaboration with the Tampere University of Technology (3).

The purpose of this study is to review the current situation of shooting noise and shooting range control in Finland.

2 Materials and methods

The data has been collected at different shooting ranges in Finland. The weapons under study were assault rifles (e.g. 762RK62, Kalashnikov type) and hunting rifles (e.g. calibre .308). There were three types of suppressors analysed for the assault rifles and two types for the hunting rifles. Both front and reflection suppressors were used. The noise levels were measured using condenser microphones B&K 4136, B&K 4147, B&K 4133, B&K 4138 and B&K 4135. The signal was amplified by precision sound level meters B&K 2209, B&K 2221 or B&K 2260, and tape-recorded by Sony TCD D8 digital tape-recorders. The recorded samples were analysed in a laboratory using an FFT analyser (Advantest R9211B). On the whole, the frequency response of the complete measurement and analysing chain was 25-10,000 Hz. From the analysed results, peak sound pressure levels and 1-s equivalent levels were calculated, and the attenuation values of the suppressors were calculated using the insertion loss method. In addition, noise dose meters, CEL 460, with mode 1-s time logging of impulse-weighted SPL were used at a greater distance from the shooting site. All of the presented values represent an average of at least five similar shots. The statistical standard deviation for the shot series was typically less than 1.0 dB.

3 Results

Attenuating the bullet flight noise is only possible by decreasing the velocity of the bullet. An experimental measuring result is presented in Figure 3, where the velocity of one bullet was increased by increasing the amount of gunpowder. Changing the shape of the bullet has a rather small impact. It would, however, be possible to attenuate the sound of the impact created by the bullet in sport shooting: the bullet trap that has been used lately to gather lead generates a louder noise than that used previously. Figure 4 presents the calculated results of the noise levels of bullet and muzzle blast measured from an oblique front angle from the shooting direction with a high maximum sound level (L_{Amax}).

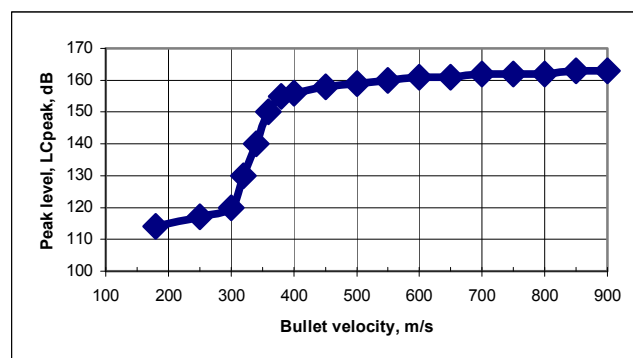


Fig. 3. Bullet flight noise as velocity increases. Bullet flight noise, .308 rifle, microphone 0,65 m from the bullet trajectory. C-weighted peak sound pressure, LC_{peak} , dB. Bullet velocity in m/s.

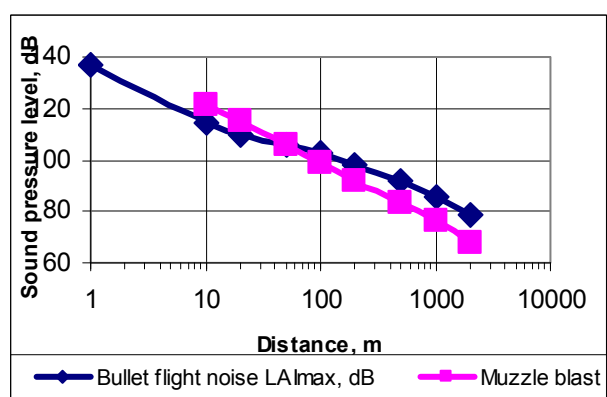


Fig. 4. Calculated comparison of bullet noise and muzzle blast obliquely forward from shooting direction. Calculated comparison of bullet noise and muzzle blast. Noise level, dB. Distance, m. Bullet noise, L_{Amax} dB. Muzzle blast to the side, dB.

Silencers are important in decreasing the exposure to noise of the shooter, a group of shooters and the audience (Figure 5). Silencers that attenuate noise to the sides and back have a significant effect, whereas the noise to the front is not significantly attenuated because of the bullet noise.

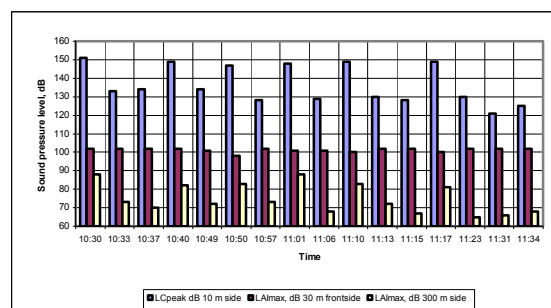


Fig. 5. Effect of silencers around the gun. Several rifle calibres without and with a suppressor. 30 m towards the front side, the bullet noise determines the environmental noise. To the side, the suppressor has some effect.

It is also possible to gain an attenuation of a few decibels from the maximum level of the muzzle blast with ANC headsets. One experiment used the Sennheizer HME200 ANC headset to reach a maximum sound level of a .12 calibre shotgun or a .308 calibre rifle 3 dB lower at the mouth of the outer auditory canal compared to a respective passive headset.

4 Discussion

The attenuation of weapons still leans greatly on traditional techniques of attenuation that are summarized in Table 1. It is hoped that new techniques will create novel approaches to the data presented. The techniques that concern attenuation of weapons are a marginal area in the development of technology and practice because their use is primarily in hunting and sport shooting. There is little being done, especially in the area of environmental noise in the shooting direction or from in front of the shooting direction. There is also no change to be seen in the amount of noise weapons create. The most important aspect in the use of weapons is to get the bullets or shots to depart the weapon in the most controllable manner, which means that the use of subsonic cartridges, smaller charges of gunpowder or modifications that attenuate noise are not at the top of the list of product development.

However, the noise created by shotguns is the most significant source of environmental noise at many shooting ranges. In addition, shotguns are used to fire into sectors rather than set directions, which reduces the possibilities for using technical attenuation procedures. The flight of the shots is supersonic only within tens of metres of the muzzle of the shotgun in the shooting direction. The blast of the shotgun is of a lower frequency than that of rifles and pistols, which makes noise prevention even more difficult in the case of shotguns than for other handguns. Because of these concerns, it is particularly important to find new ideas and innovations in noise prevention at shotgun ranges. Shooting ranges are often situated very near houses or residential areas. The noise from shooting ranges disturbs and causes annoyance for those living nearby. Therefore, good practices in environmental noise control are needed at shooting ranges

TABLE 1. Possibilities for noise attenuation at shooting ranges

	Effect from side 20 m, dB	Effect on gun in back 20 m, dB	Effect 1 km away, dB	Notes
Preventing noise from creating				
Choice of weapon	10	10	10	Seldom possible
Choice of cartridges	2-4	2-3	2-3	Seldom possible
Choice of shooting direction	10-20	10-20	5-7	Important in the planning process
Choice of	3-6	10-20	5	Sometimes

silencer				possible
Preventing noise from spreading				
Shelter for shooting	3-8	5-15	0-4	Also protection for bad weather
Noise barrier	5-10	5-10	0-7	Also a safety factor
Absorption of shooting shelter	0-3	0-2	0-1	Mainly for shooters
Exposure				
Time of shooting			0-2	Night, Sunday mornings
Licensing policies			0-	Encourages noise protection and safety zones

References

- [1] Asikainen, S., Halonen, T., Krootila, I., Pyy, O., Pääkkönen, R., Riissanen, J., Sillanpää, J., Tuunanen, P. & [2] Aarrekivi, R.: Ampumarataopas. Opetusministeriö, Liikuntapaikkajulkaisu 87. Suomen ampumaurheiluliitto. Rakennustieto Oy, Helsinki 2005. 184 s [Shooting range guidebook. Ministry of Education. Publication 87. Finnish Shooting Association].
- [3] Kuisma, M., Pennanen, J., Silventoinen, P., Kuronen, J. and Kuronen, T.: The test setup for Active Noise Control at Shooting Range. Euronoise 2006, 30 May-1 June, Tampere, Finland.
- [4] Oinonen, M.: Development of active noise control and voice communication systems for personal hearing protectors. Dissertation, Publication 608. Tampere University of Technology. Tampere 2006. 58 s. + articles.
- [5] Pääkkönen, R. & Kyttälä, I.: Attenuation of rifle and pistol noise with the use of suppressors and subsonic bullets. Acta acustica 2(1994): 2, 29-36.
- [6] Pääkkönen, R. & Kyttälä, I.: Effects of rifle-calibre muzzle brakes and suppressors on noise exposure, recoil and accuracy. Acta acustica 2(1994): 4, 143-148.
- [7] Suomen Ympäristö 38/2006: Puolustusvoimien ampumatoiminta maankäytön suunnittelussa ja ympäristölupamenettelyssä. Ampumaratatyöryhmän mietintö, Ympäristöministeriö 2006. [Shooting activities in planning of land use and environmental licences for Finnish Defence Forces. Summary of the shooting range working group. Ministry of environment].
- [8] Pääkkönen, R.: Low frequency high level noise impulses near weapons and explosions. Journal of low frequency noise & vibration 7(1988): 2, 42-49.