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Sound Level Suppressors for the Reduction of Firearm Noise: Implications for Hearing Conservation

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Several years ago, our research team at the Callier Center for Communication Disorders became interested in the challenges of hearing conservation for shooters, which broadly includes hunters, target shooters, law enforcement officers, and soldiers. For some of these groups, shooting is a recreational activity, and for others, there is a requirement to engage in weapons training annually, or perhaps even more frequently. Our initial interests and activities were stimulated by a query from Officer Ryan Scott, who was at that time a member of the High Springs Police Department, in High Springs, Florida. Officer Scott communicated concern over a national trend of deploying Armalite Rifle model 15, commonly referred to as the AR-15 rifles, among law enforcement officers in the United States and in particular, the use of short-barreled AR-15 rifles to increase maneuverability during indoor engagements and in urban settings. During our initial efforts to assess sound level as a function of barrel length, we made significant efforts to identify appropriate measurement strategies. This required careful selection of measurement location, appropriate microphones and pressure probes, and recording equipment with a sufficiently high sampling rate.

These issues have been identified and discussed in detail by other,[1–5] but relatively recent examples

of sound level meters (SLMs) being used to measure the sound levels associated with firearm discharges can still be found.[6,7]

We provided a short overview of these issues when we discovered differences of at least 6 dB, and often as much as 12 dB or more, when comparing peak level measurements collected simultaneously via a Larson-Davis model 831 SLM set for impulse noise to those collected using a Pulse spectrum analyzer (3052-A-030, Brüel and Kjær) with a 256-kHz sampling rate.[8] In every case, the SLM underestimated the peak SPL relative to the levels measured using the spectrum analyzer. Using the appropriate technical equipment, peak sound levels measured at the position of the shooters ears during discharge of a 10.5-inch short-barreled rifle were found to be approximately 170 dB SPL, and with the addition of various muzzle brakes, commonly used to control recoil from short rifles, peak sound levels were as high as 180–185 dB SPL.[9]

Given the dangerously high levels measured, the selection of hearing protection devices (HPDs) would logically include recommendations for dual protection using both earplugs and earmuffs. The specific selection of HPD's is compromised, however, by the way in which HPD attenuation is calculated and reported. In the United States (US), through the Noise Control Act of 1972, Congress gave regulatory authority to the US Environmental Protection Agency (EPA) to rate equipment and devices that either produce noise, or claim to reduce noise. This was accomplished in 1978, when the promulgation of 40 CFR 211 put into place a new regulatory framework for product noise labelling. The Noise Reduction Rating (NRR) specifically created a single "consumer-friendly" number that would provide guidance to consumers regarding the amount of sound attenuation provided by an HPD – at least in a controlled laboratory setting.

A well-known shortcoming of the NRR is the extent to which real-world use of HPDs fails to achieve the level of attenuation accomplished in the controlled laboratory setting.[10,11] A second major issue, however, is the shortcoming of the NRR in predicting attenuation of high-level, short-duration, impulse noise. Two of the strategies that have emerged are impulse peak insertion loss (IPIL), which is specifically described in ANSI/ASA S12.42-2010, and impulsive spectral insertion loss (ISIL).[12–14] A complete technical explanation of IPIL and ISIL strategies is beyond the scope of this article, and readers who are interested in more specific technical information should review the recent report by Fackler et al. who describe IPIL and ISIL in detail.[14]

In brief, IPIL measurement results in a single number representing dB reduction in SPL in the HPD-occluded ear relative to the unoccluded ear, based on data collected using an acoustic test fixture and an acoustic test signal that meet highly specific criteria. In contrast to the single dB value generated as an IPIL measurement, the outcome of the ISIL analysis is a curve illustrating the frequency dependence of the attenuation properties. As noted by Fackler et al.,[14] for IPIL values generated per ANSI/ASA S12.42-2010 protocols to be relevant to firearm discharges, modifications to the standard are needed; S12.42-2010 specifies the use of acoustic test signals with A durations of at least 0.5 ms and not more than 2 ms, whereas AR-15 rifle discharge produces impulses with A durations of less than 0.5 ms.

For those not familiar with impulse noise, the A-duration is defined as the time from the onset of the impulse to the first zero pressure level crossing.[15] Consumers would perhaps be better able to select appropriate HPDs for use during firearm discharges if an IPIL or ISIL like rating scheme was implemented; however, changes to the regulatory framework for HPDs in the US seem relatively unlikely at this time, as the EPA Office of Noise Abatement and Control was defunded in 1981.

A second strategy for reducing the dangerously high sound levels produced by firearms that could be used in combination with HPDs is the use of a suppressor or as often referred to *erroneously*, a "silencer." We assessed a variety of suppressors as a means to reduce the hazardous sound levels produced by derivatives of the AR-15. This rifle is a common and immensely popular firearm in both Canada and the US for both law enforcement and recreational purposes. We found that overall suppression ranged from 7–32 dB across conditions (with variables including ear, ammunition, weapon, etc.), and with the exception of a subset of conditions in which subsonic ammunition was used, discharge levels routinely exceeded 140 dB SPL despite the use of a suppressor.[9] As suppressors are considered for potential adoption not only by recreational shooters but also by government and law enforcement agencies, additional evidence related to achieved suppression and sound level at the shooters ears will need to be carefully considered as part of an overall hearing loss prevention program that will likely continues to require HPD use. In a recent Request for Information (RFI) issued by the Marine Corps Systems Command, suppressors that can attenuate discharge levels to not more 139 dB at the shooters ears are sought, with a variety of additional requirements related to weight, length, detachment/attachment, dispersion of shots, etc.[16,17]

Use of 139-dB SPL at the shooters ears would comply with guidance from the Occupational Safety and Health Administration (OSHA), which states that, "Exposure to impulsive or impact noise should not exceed 140-dB peak sound pressure level."[18] The 1998 Criterion Document published by the National Institute for Occupational Safety and Health (NIOSH) explains the history of the 140-dB SPL limit, which is largely based on inferences drawn from animal literature and they generally support this limit.[10] Their specific guidance is that, "Exposure to continuous, varying, intermittent, or impulsive noise shall not exceed 140 dBA"[10]; this ceiling limit of 140-dB A-weighted SPL is potentially higher than that of OSHA in that the allowance for A-weighting allows energy below 1000 Hz to be discounted during the sound level measurement.

Because discharge levels routinely exceeded 140 dB SPL despite the use of a suppressor (with the

previously noted exception of conditions in which subsonic ammunition was used),[9] the use of a suppressor device did not make AR-15 discharges “hearing safe” in the absence of HPDs. To be clear, the combination of a suppressor and HPDs will be safer than the use of HPDs alone, but the use of a suppressor alone is not adequate for hearing loss prevention purposes when using an AR-15 or similar rifle. This important message has been brought forward to the law enforcement community by Officer Scott, who is now a deputy sheriff with the Alachua County Sheriff’s Office in Florida. In his educational workshop, “Firearms Training and Hearing Loss,” he advocates for the use of suppressors in combination with technological solutions and devices that integrate hearing protection with radio communication systems, so that situational awareness is preserved for those whose hearing is critical to job performance and safety. Officer Scott received a 2017 Safe-in-Sound Excellence in Hearing Loss Prevention Award from the National Institute for Occupational Safety and Health (NIOSH) and the National Hearing Conservation Association (NHCA) for his efforts to bring solutions to the law enforcement community (https://www.cdc.gov/niosh/updates/upd-02-23-17.html). A recent NHCA guidance document, prepared by the NHCA Task Force on Prevention of Noise-Induced Hearing Loss from Firearm Noise, provides guidance on both suppressors and electronic HPD options for recreational firearm users, noting the potential reluctance of many hunters to wear HPDs while hunting.[19]

In the US, suppressors have received increasing attention over the past year due to recent legislative efforts intended to make the acquisition of suppressors easier, and less expensive, for those that wish to acquire them. In Europe suppressor laws vary, some countries such as Norway have no regulations whereas others such as Germany and the UK, have much tighter regulations and a “good cause” is required. Recently in the US, H.R. 367 (the “Hearing Protection Act of 2015” previously released as H.R. 3799) was introduced in the House of Representatives in January 2017. As per the on-line summary of the bill, “This bill amends the Internal Revenue Code to: (1) eliminate the $200 transfer tax on firearm silencers, and (2) treat any person who acquires or possesses a firearm silencer as meeting any registration or licensing requirements of the National Firearms Act with respect to such silencer. Any person who pays a transfer tax on a silencer after October 22, 2015, may receive a refund of such tax. The bill amends the federal criminal code to preempt state or local laws that tax or regulate firearm silencers.” (https://www.congress.gov/bill/115th-congress/house-bill/367). In effect, passage of this bill would replace the months-long approval process with an instant background check (as required for the initial firearm purchase), eliminate the $200 tax for transferring the device registration, and eliminate federal registration of the device. Succinctly, any person who can legally own a firearm would be eligible to legally own a suppressor without additional fees or waiting periods. A useful summary of the arguments for, and against, this bill was provided in a “fact-checking” article in the *Washington Post.*[20] After reviewing various claims, they conclude the bill might be more appropriately named “The Paperwork Reduction Act” as the devices do not mitigate the need for hearing protection, and the main impact of the bill is to loosen restrictions on the purchase of suppressors.

I fully agree with the conclusion by Kessler that suppressors in combination with HPDs will work better than HPDs or suppressors alone, and also share the sentiment that the naming of the bill may be misleading. There is reason to be concerned that by naming the bill “The Hearing Protection Act,” some consumers might assume a suppressed weapon will be “hearing safe.” The development of explicit testing and reporting requirements for sound level reductions accomplished via the use of a given make and model of suppressor would be a significant advance in consumer protection. Ideally, manufacturer product safety data would be required to report sound level attenuation in standardized conditions, with ammunition, bullet weight, muzzle

velocity, propellant charge, and the location where measurements were made (i.e., at the location of a shooter's ears, or a fixed position relative to the muzzle), all required to be constant across tests as all of these variables can affect measured levels. Armed with consistent information for both suppressors and HPDs, shooters could make informed decisions about the selection of both suppressor devices and HPDs to bring sound levels well below the 140-dB SPL limit. Shooters should be reminded that 140-dB SPL is the sound level *a single shot* should not exceed. The more shooting an individual does (or, the more shooting activity on the range near the shooter), the more attenuation is needed, as risk for hearing loss is dictated by both the sound level of the impulses and the number of impulses. We know that the distribution of impulses over time also influences the risk of hearing loss,[21] but incorporating such data into a risk assessment is a challenge that may only be fully resolved with the development of some real-time dosimeter for shooters to use for monitoring their individual exposure. Interestingly, efforts to develop such a device for use by military personnel in hazardous settings are ongoing.[22]

Conclusions

Firearm noise is dangerously loud, and those who engage in hunting or other shooting activities should be concerned and counselled about the urgent need to protect their hearing. Suppressors reduce but do not eliminate hazardous noise exposure, especially for AR-15 or similar semiautomatic rifles. Many of the bolt action rifles and handguns that may potentially be used by recreational shooters have lower discharge levels,[23] and suppressors are more effective in reducing sound levels for at least some of these platforms (unpublished observations), but peer-reviewed presentations of the complete data sets are necessary before evidence-based guidance can be generated. At this time, the best advice is dual use of both HPDs and suppressors, particularly for those shooting AR-15 weapons which produce dangerously high sound levels. For shooters that are reluctant to use HPDs, electronic HPDs should be considered as an option. Those interested in more information should review the position paper of the NHCA, and other literature cited above for specific details and information.

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