NRR or IPIL for Gunshot Noise Hearing Protection Selection?

Scott Lake
DefendEar: Manager of Engineering and Technical Sales
July 10, 2013

Westone®

Westone Laboratories, Inc. • 2235 Executive Circle, Colorado Springs , CO 80906 • www.westone.com

Background

In the United States, hearing protection is sold with a Noise reduction Rating (NRR) that is required by the U.S. Environmental Protection Agency[i]. The purpose of the NRR is to inform consumers about the potential to reduce hazardous sounds to a level which is safe for the ear of the person using the protection. The input data to calculate the NRR requires that hearing protection is tested via a method designed to assess the attenuation in the presence of continuous noise. Subjects are tested with their ears open and with the protectors covering the ears or inserted into the ear canal. When sounds of different frequencies are presented, the subject must respond to the lowest level sound to determine the hearing thresholds for each frequency. Because the maximum attenuation possible by tightly sealing a person's ears is only about 50 to 60 decibels (the difference between a really quiet room and a conversation in a quiet room), the performance of the protector is measured in the linear acoustic regime. That is, sound is attenuated by the protector and the attenuation doesn't change appreciably for quiet, moderate or even loud sounds. For most of the noises that one might experience in the workplace or working with tools around the home or at activities like sporting events and concerts, the protectors will provide the same amount of attenuation. However, when one experiences exposures to extremely loud sounds like gunshots, fireworks and even some pneumatic tools (e.g. nail guns or powder-actuated tools), the attenuation provided by the hearing protector is no longer constant.

Technically speaking, this test method does not use any kind of sound that is similar to what is experienced during gunshot and other loud, impulsive noise events. The test to determine the input data to calculate NRR uses pulsed, 1/3 octave band-limited noises for test signals[ii]– presented to test subjects without hearing protection in place and with hearing protection in place. The task for the subject is to indicate when they hear the test signals. Without hearing protection in place, the test signals are very quiet. With hearing protection in place the test signals can be the same level and up to around 50 or 60 dB higher than the levels present without hearing protection in place. However, even with the potential of 50 to 60 dB increased level, these levels do not come close to what happens during a gunshot, which has peak levels of roughly 115 dB and higher.

The attenuation of a typical earplug, ear muff or canal cap will not be the same for low-level noise as for high-level impulse interaction with the protector. Response will vary from nearly linear to highly non-linear response depending on the type of protector[iii]. Thus, the attenuation reported as the NRR and quantified with the method currently required by the EPA will not describe how well the protector performs to attenuate high-level impulsive sounds such as gunshot sounds.

In 2009, the EPA proposed to change the way that hearing protection is measured and reported to the consumer[iv]. For hearing protectors designed to provide little attenuation at low levels and higher attenuation at high-levels, the EPA developed an IMPULSE rating to describe the change in the peak impulse level over a range of 130 to 170 decibels. Recreational shooters and law enforcement personnel are exposed to impulses from their weapons at the higher end of the range,150 to 170 dB[v]. The proposed ruling has not yet gone

into effect, so there is still no requirement to label hearing protectors with an IMPULSE rating.

So, is hearing protection performance testing and rating at high levels important or not? Because attenuation tends to increase as the impulse level increases, the constant value derived from the NRR measurement method will likely understate the amount of protection that one may receive when wearing the protection properly.

Development of a new Test Method: ANSI S12.42-2010

From the earliest studies of hearing loss due to impulse noise, experts have been seeking a method to describe the performance of hearing protection for high-level exposures. In the early 1990s the French German Research Institute in Saint Louis, France (ISL) developed an acoustic test fixture that allowed hearing protection to be tested and permitted estimation of the exposure levels at the eardrum. The American National Standards Institute (ANSI) developed a new standard for use with an acoustic test fixture like the one ISL developed. The new ANSI S12.42 standard was approved and published in 2010 and has been used in several studies conducted by the National Institute for Occupational Safety and Health to provide support for the EPA's proposed revision of the hearing protector labeling regulation.

To quantify the attenuation of this non-linear behavior, ANSI S12.42-2010 uses three levels of impulsive noises, with peak values at nominally 132, 150 and 168 dB SPL, that are representative of peak exposures commonly present at the ear for different types of firearms. Three levels are used instead of a single level, because the attenuation properties are non-linear, meaning that attenuation will be different, dependent on the level of the peak noise exposure. The amount of attenuation that is present for these different exposure levels is referred to as the Impulsive Peak Insertion Loss, abbreviated as IPIL. Insertion Loss is the terminology given to a certain type of attenuation that is characterized by measuring noise levels with and without some type of barrier in place with the difference of the noise levels with and without the barrier forming the basis for the Insertion Loss metric. IPIL[vi] is very similar to the EPA's proposed IMPULSE rating.[vii]

DefendEar IPIL Results

Westone has tested both their DefendEar Hunter Passive product, as well as their DefendEar Digital product line for IPIL, according to ANSI S12.42-2010, at Michael & Associates, an independent NVLAP accredited testing facility.

Westone IPIL results are as follows:

	Impulsive Peak Insertion Loss (IPIL) in dB	
Peak Exposure Level, dB	DefendEar Hunter Passive	DefendEar Digital series
132	15.1	37.3
150	22.8	44
168	26.7	42

Use of IPIL or NRR for Gunshot Noise Hearing Protection Estimation: Which?

The EPA has not issued a final regulation that requires provision of an IMPULSE NRR for hearing protector performance in impulse noise. Regardless of whether EPA finalizes the proposed regulation, the hearing protector consumer should understand the distinctions between IPIL and NRR and how IPIL may be applied to estimate one's exposure. It behooves the user of hearing protection to understand how to interpret use of IPIL as it pertains to estimating the hearing protection received when selecting and using hearing protection products for protecting against firearm noise exposure.

Let us look at the NRR and IPIL for the Westone DefendEar Hunter Passive as an example. The design goal for the DefendEar Hunter Passive was to provide as little attenuation of sounds of interest to hunting enthusiasts, such as the sounds of game or tracking dogs in the surroundings, while providing as much IPIL as possible at the same time, with a passive (non-electronic) means of protection. The DefendEar Hunter Passive uses a Y-bore configuration and a small filter is placed in each of the two branches of the Y-bore and the base of the Y leads to the ear canal. The dual filter design allows for minimal attenuation of surrounding low-level sounds that operate within linear acoustic behavior, while the small orifices provide the non-linear attenuation properties for the impulsive noise. The NRR of the DefendEar Hunter Passive is only 4. However, as shown in the table above the IPIL ranges from 15.1 dB to 26.7 dB, depending on the peak exposure.

If the peak impulse levels were 130, 150 or 170 dB and the NRR (4 dB) were used, then the exposures would be 126, 146 and 166 dB respectively. However if the IPIL were used, then the estimated protected exposure levels would be dramatically different: 130 –15.1 = 114.9 dB; 150 – 22.8 = 127.2 dB; and 170 – 26.7 = 143.3 dB. In the case of the DefendEar Digital series of products, use of the DefendEar Digital NRR of 26 instead of IPIL would yield under estimate the attenuation by 11.3 dB on the low side of the test data (IPIL of 37.3 – NRR of 26), and underestimate attenuation by 16 dB on the upper end of the test data (IPIL of 42 – NRR of 26). Take note that there is really no known relationship between the NRR results, generated at linear acoustics levels, and the IPIL results generated at gunshot-like, non-linear acoustics levels. This makes the NRR on the product label, somewhat irrelevant to understanding the attenuation potential for gunshot sounds. No matter if one pays attention to NRR or IPIL, the hearing protection device user should exercise great care to fit the hearing protector according to the manufacturer's instructions.

Bottom Line

NIOSH has recommended that hunters and shooters wear dual protection, earmuffs and plugs, when engaging in target practice and recreational shooting. The levels at the eardrum when using a single protector are close to the recommended maximum exposure limit of 140 dB peak sound pressure level. When hunting in the field, electronic protectors will provide adequate protection against a limited number of impulses. Electronic protectors will affect one's ability to localize sound compared to wearing no hearing protection whatsoever, but

they can also enhance the ability to hear faint sounds outdoors that may compensate for the change in localization capability. The shooting enthusiast should pay attention to the protection performance as expressed by both the NRR and the IPIL. With non-electronic devices, a low NRR means that one will be able to hear faint sounds, while a high-level IPIL indicates the protection from the impulse noise exposures. Electronic devices with higher NRR allow the user to hear low-level sounds through amplification, while limiting amplifying gunshot sounds.

Hunters and shooters are recommended to follow NIOSH recommendations to wear deeply seated earplugs with earmuffs over the top for the ultimate in hearing protection if several shots are expected to be fired (e.g. hunting waterfowl in groups or target shooting). It is understood that following this recommendation may cause issues for enjoyment of shooting sports, either through interference of earcups with shoulder-mounted firearms, or by limiting ability to hear ambient sounds. Should shooting sports enthusiasts choose not to follow NIOSH guidelines it is recommended that the enthusiast know what type of peak sound pressure level their firearm(s) produce, and to select shooting sports specific hearing protection based on IPIL values, not NRR for the reasons of understanding estimation of attenuation.

---

[i] US 40 CFR 211, Subpart B
[ii] ANSI S3.19-1974, section 3.1.1.2
[iii] International Journal of Occupational Safety and Ergonomics (JOSE) 2009, Vol. 15, No. 2, 227–240, section 4
[iv] Federal Register vol. 74, No. 149, August 5, 2009, Proposed Rules pages 39149-39196
[v] "Bystander Impulse Noise Exposure from Small-Caliber Weapons: How Close is Too Close?", Authors: Murphy, Flamme, Zechmann, Dektas, Meinke, Stewart, Lankford, Finan, Collins, CAOHC Update Spring 2013 Vol. 25, Issue 1.
[vi] ANSI S12.42-2010 section 11.3
[vii] Federal Register vol. 74, No. 149, August 5, 2009, pages 39193-39194, section 211.207-4