INSERTION LOSS OF HEARING PROTECTION DEVICES FOR MILITARY IMPULSE NOISE

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1 Introduction

Military operators are exposed to a broad range of complex noises from various types of equipment. In particular, impulse noise from different weapons can vary greatly in terms of level, temporal and spectral characteristics. The American National Standards Institute/Acoustical Society of America (ANSI/ASA) S12.42 describes methods for measuring the impulse peak insertion loss (IPIL) of hearing protection devices (HPDs) [1]. The IPIL is a single number that gives the overall reduction of the peak sound pressure level that is provided by a HPD. However, the measurement methods in the standard are difficult to achieve in practice, and it is unknown if the results can be applied to non-idealized impulse noise sources and realistic operational conditions [1]. In addition, recent studies have shown that the IPIL does not completely describe the performance of HPDs, and that the frequency-domain impulse spectral insertion loss (ISIL) must be considered [2]. In a previous study, IPIL measurements for different types of HPDs for one type of noise source were reported [3]. The current paper presents insertion loss measurements using different HPDs with several different weapons used as noise sources.

2 Method

Three types of Canadian Armed Forces (CAF) weapons were used as noise sources for the HPD insertion loss (IL) measurements: a 5.56 mm semi-automatic rifle, a 7.62 mm medium machine gun and a 12.7 mm heavy machine gun. IL data were acquired using a GRAS 45 CB acoustic test fixture (ATF), a 67S blast probe and a Sinus Soundbook data acquisition system with Samurai software (204.8 kHz sampling rate), or a HBM Genesis high-speed transient recorder and data acquisition system (1 MHz sampling rate). Two types of Israel Defense Forces (IDF) weapons were used as noise sources: a grenade launcher and a mortar. Data were acquired using an ATF produced by the French-German Institute of Saint-Louis (ISL) and a Soundbook with Samurai software. The equipment met ANSI/ASA S12.42 requirements for measuring IPIL, but the noise sources were not ideal. Since our objective was to study HPDs for specific weapons, we accepted this limitation and refer to our results as IL and ISIL rather than IPIL. Several types of earplugs and earmuffs were used, alone and in combination.

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The results shown here will be limited to two passive earplugs and one electronic earmuff: 3M EAR Classic (level-independent passive earplug), Etymotic ETY Plug (linear attenuation passive earplug), 3M Peltor Tactical 6-S (electronic level-dependent earmuff) and the EAR Classic in combination with the Peltor earmuff.

3 Results

The pressure-time signals of the CAF rifle and machine guns are shown in Fig. 1. The rifle noise was measured with the blast probe in front of the weapon to reduce reflections. The shockwave seen in Fig. 1 (top) was removed for the analysis. The peak level of the 5.56 mm muzzle blast was 153 dB SPL. The 7.62 mm and 12.7 mm machine gun signals in the middle and bottom of Fig. 1 were measured at the blast probe 0.5 m behind and to the left of the gunner. The peak levels were 154 and 152 dB SPL, respectively.

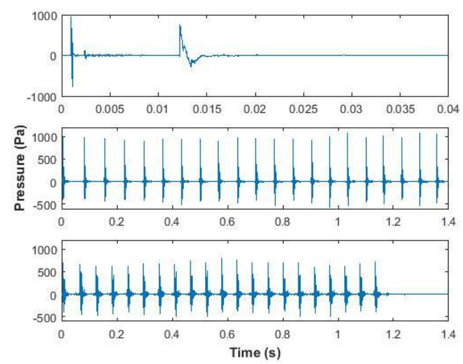

Figure 1: Time signal of a 5.56 mm rifle (top) and 21-round bursts from 7.62 mm (middle) and 12.7 mm (bottom) machine guns.

The pressure-time signals of the IDF grenade launcher and mortar, measured in-ear with the ATF, are shown in Fig. 2. The ATF was placed 0.5 m to the right of the gunner for the grenade launcher, and 0.5 m behind the mortar. These signals have been modified by the ear transfer function, but they clearly have different temporal characteristics than those shown in Fig. 1. The in-ear peak levels were 175 and 173 dB SPL for the grenade launcher and mortar, respectively. Free-field levels can be estimated at 8 to 12 dB lower than the in-ear levels [4].

For the 12.7 mm heavy machine gun, the overall peak IL results were 20.0 dB (Peltor Tactical 6-S), 41.7 dB (EAR Classic), 49.2 (ETY plugs) and 54.7 dB (EAR Classic earplug with Peltor earmuff). The 1/3 octave band ISIL for are shown in Fig. 3. The Peltor muff provided the least overall insertion loss. For the earplugs, bone conduction limits were exceeded in several frequency bands.

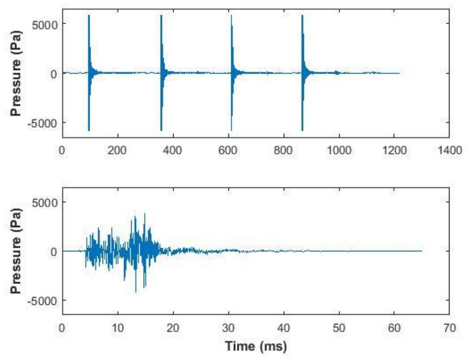

Figure 2: Time signals of the grenade launcher (top) and mortar (bottom) measured inside the ear of the ATF.

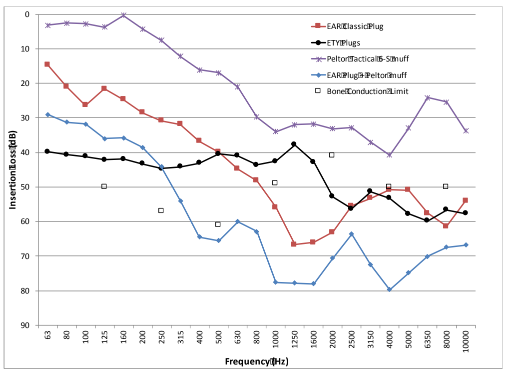

Figure 3: Insertion loss of passive earplugs and electronic earmuff for the 12.7 mm machine gun noise.

The ISIL for the EAR classic earplug are shown in Fig. 4 for the five weapon noise sources, as well as continuous pink noise. The earplug was least protective for the mortar and most protective for the 7.62 mm medium machine gun. Bone conduction limits were exceeded at frequencies from 1000 Hz and higher for several of the weapons and the pink noise.

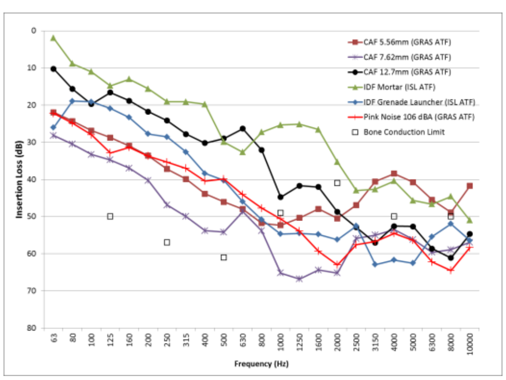

Figure 4: Impulse spectral insertion loss of EAR Classic plug for different noise sources.

4 Discussion and conclusions

The weapon noise signatures shown in Figs. 1 and 2 do not meet the ANSI/ASA standard for measuring IPIL. The A-duration, or duration of the impulse from its initial sharp increase in positive sound pressure to the time when the pressure becomes negative, is required to be between 0.5 and 2.0 ms [1]. The A-duration can only be clearly identified for the 5.56 mm rifle, and it is shorter than 0.5 ms. Although, we have not strictly followed the standard, it is important to know which HPDs work best for each weapon. The EAR classic is a very well-known example of a passive level-independent HPD. However, with different noise sources with free-field peak levels ranging from about 152 to 165 dB, different ISIL results are clearly shown in Fig. 4. In general, less protection was obtained for the heavier weapons (12.7 mm and mortar), particularly at low frequencies. This could be a concern because the noise from large calibre weapons has more energy at low frequencies [5]. However, the passive linear-attenuation earplug (ETY Plugs) provided good insertion loss for the 12.7 mm at low frequencies (Fig. 3).

An additional advantage of looking at the ISIL rather than the IPIL is that bone conduction exceedances can be seen. As shown in Figs. 3 and 4, bone conduction limits were exceeded for earplugs and double protection at frequencies of 1000 Hz and above. The IPIL can overestimate the amount of protection because bone conduction corrections are not part of the calculations [2].

It was recommended previously that the IPIL could be used account for HPDs in the assessment of noise exposure for small calibre weapons, but not large calibre weapons and blasts [6]. The current data show the importance of measuring ISIL for specific noise sources, rather than relying on IPIL data which are measured with an idealized source. We will continue collecting data for different types of weapons in order to provide better recommendations for HPD use. Additional results for more weapon types and HPDs will be presented in a follow-up paper.

References

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