

IMPULSE NOISE EXPOSURE DURING PERSONAL WEAPONS TESTING ON AN OUTDOOR SHOOTING RANGE

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1. INTRODUCTION

High-level impulse noise from firearms and blasts are a concern in military operations. Although the auditory hazard due to impulse noise exposure has been investigated extensively by many research groups, there are still differences between the criteria listed by different governing bodies. The Occupational Health and Safety Administration (OSHA) states that impulsive or impact noise exposure shall not exceed 140 dB peak sound pressure level. Other standards use the 8-hour integrated average of the A-weighted sound pressure level, $Leq8$, which is applied the same way for continuous and impulsive noise (e.g. ISO 1999). The Canada Labour Code limit for $Leq8$ is 87 dBA (MOL, 1991). There has been considerable research on temporary hearing threshold shift (TTS) immediately after exposure to a noise impulse or a series of impulses. Exposure limits based on the TTS have also been proposed (NATO, 2003). It is often not practical to take these measurements in practice, because it would require unoccluded exposures to high noise levels.

Canadian Forces (CF) army members, or any CF personnel who are being deployed overseas, are required to complete weapons qualifications, called Personal Weapons Tests (PWT). The noise exposure will be different for the shooters, the personnel in the butts (the shielded area from which the targets are raised and lowered), and the Range Safety Officer (RSO). It was of interest to measure the noise levels on the range at the firing line and in the butts to estimate the exposure levels for all range personnel.

2. METHOD

2.1 Description of the Personal Weapons Tests

Measurements were taken on two occasions over three days of personal weapons testing at Canadian Forces Base Borden (CFB Borden) in May 2007. The shooters performed PWT 1 and 2 using the C7 service rifle and 9 mm service pistol. PWT 1 for the rifle involves shooting at a target in the prone, kneeling, sitting and standing positions at a distance of 100m. In PWT 2, rapid and snap shooting (target exposure is time-limited) are tested at 200m. For the pistol, PWT 1 tests shooting from 15m in the standing position, and PWT 2 tests shooting from 15, 20 and 25m in the standing, kneeling and sitting positions. To pass the tests, shooters must achieve a minimum grouping on the target (pattern created by firing numerous bullets at the same point of aim on a target).

2.2 Measurement Procedure

Measurements were taken using a Larson Davis LxT sound level meter with a high pressure microphone at the firing line, and a Quest 1900 sound level meter in the butts. Digital recordings were also made with Sony PCM-M1 portable digital audio tape (DAT) recorders. Separate recordings were taken for each application of each test. The length of time required for each application was generally between 60 and 90 seconds for the rifle and between 30 and 60 seconds for the pistol. Between each application, there were less noisy periods while the butts personnel scored the groupings and the shooters received their instructions.

On the first day of testing, measurements were taken of one group of five shooters who performed PWT 1 and 2 for both the C7 rifle, and six shooters for the 9 mm pistol. The measurements were taken a few meters behind the shooters on the firing line (where the RSO stands), and in the butts. The tests took approximately 4.5 hours in total to complete. On the third day of testing, measurements were taken of one group of four and one group of five shooters who performed PWT 1 and 2 for the rifle only; this took approximately 3 hours. Measurements were taken approximately 30 cm from the ear of one of the shooters, and in the butts. Because the shooters wore the provided earplugs, it was not possible to take in-ear measurements.

3. RESULTS

Sample C7 rifle data for one of the PWT 1 applications are shown in Table 1 for the shooter, RSO, and butts. During this application, each of the five shooters fired five rounds in the standing position at a distance of 100m from the target. For the "Shooter" data, the microphone was held approximately 30 cm from the head of the shooter. The exposure time during this application was approximately one minute. In all cases, the peak levels exceeded the 140 dB OSHA limit for unprotected exposure to impulses. The time signal and 1/3 octave band spectrum for this application are shown in Figures 1 and 2, respectively.

Table 1. Sample data for the C7 rifle during a PWT 1 application (five rounds fired from 100 m)

	Leq (dBA)	Lpeak (dB SPL)
RSO	104.2	148.3
Shooter	112.9	154.7
Butts	90.2	140.8

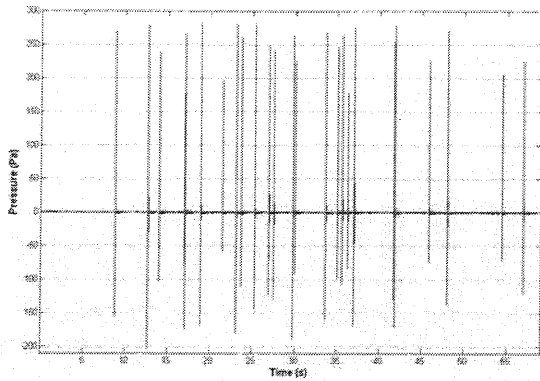


Figure 1. Time signal of a PWT 1 application using the C7 rifle.

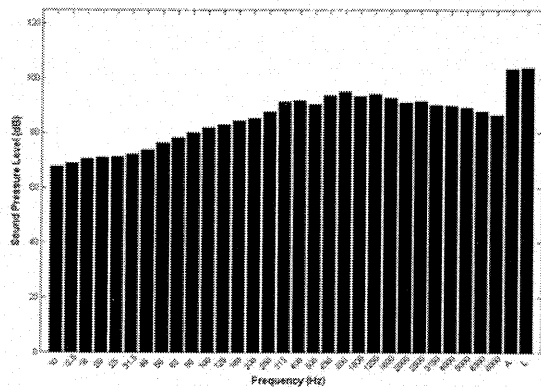


Figure 2. 1/3 octave band spectrum of a PWT 1 application using the C7 rifle.

Sample data for the 9 mm pistol during a PWT 1 application (six shooters), in which 10 rounds were fired from a distance of 15 m from the target, are shown in Table 2. The exposure time for this application was approximately 45 seconds. The peak levels for the RSO and shooter were similar to those of the rifle, and exceeded the 140 dB OSHA limit. The peak level in the butts was below the limit at 134.5 dB.

Table 2. Sample data for the 9 mm pistol during a PWT 1 application (10 rounds fired from 15 m)

	Leq (dBA)	Lpeak (dB SPL)
RSO	101.0	148.4
Shooter	111.5	155.6
Butts	96.1	134.5

Of the 4.5 hours of testing that were observed on the first day, there was approximately 37 min of shooting. The Leq for the RSO during that 37 min was 106 dBA, or approximately 97 dBA over 4.5 hours. For the shooters on the third day of testing, the Leq for the 26 min of shooting was 113 dBA, or 104 dBA over 3 hours. In the butts, the Leq for the shooting time was 94 dBA, or 85 dBA over 3

hours. The exposures for the RSO and the shooters were well above the Leq8 limit of 87 dBA using the 3 dB exchange rate.

4. DISCUSSION

It is difficult to assess the noise hazard on a live fire range without disturbing operations. In particular, it was not possible to take TTS measurements immediately after each application, nor was it possible to take in-ear noise measurements underneath the earplugs that were provided to the range personnel. Noise dosimeters do not have the capability to capture impulse noise, and thus will tend to underestimate the noise exposure. Since the RSO, shooters and butts personnel were all exposed to noise impulses in excess of 140 dB, hearing protection would have been required according to the OSHA standard. However, according to the Canada Labour Code limit of 87 dBA for Leq8, and using the 3 dB exchange rate, hearing protection would not have been required for the butts personnel.

It was observed that some of the range personnel inserted their earplugs improperly due to lack of training, or intentionally so that they can better hear the RSO. The reduced attenuation due to improper insertion may not be sufficient to reduce the noise exposure to safe levels (Abel et al, 1982). One possible solution is to use non-linear earplugs which allow natural listening for non-hazardous noises (i.e., speech), but provide attenuation for high-level impulses.

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