**OSHA** Compliance **Issues**

# Airborne **Lead and Noise Exposures During Police Firearms Qualification**

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### Introduction

Most Oregon **state** police agencies use outdoor firing ranges for practice. The evaluation conducted by the Oregon Occupational Safety and Health Administration (OSHA) Consultative Service assessed shooter and instructor exposures to airborne lead and noise at the Oregon police academy's open-air, outdoor range. During the course of the study information was also gathered on recent changes to the academy's firearms training methods. The evaluation specifically did the following:

- determined if totally metal-jacketed (TMJ) ammunition containing either lead styphnate primer or lead-free primer produced lower instructor and shooter exposures to airborne lead;
- estimated personal noise doses;
- identified alternative training methods to reduce lead and noise exposures.

### Initial Evaluation

#### *Methods*

Two firearms were used-a service revolver and a semiautomatic pistol. Each firearm fired two ammunition types (Table 1). For each firearm and ammunition type, instructor and shooter exposures were evaluated while firing 250 rounds or 5 courses of fire, representing a typical exposure day. Table 2 provides the course of fire followed during the evaluation. Figures 1 and 2 illustrate typical instructor and shooter positions during the study.

Personal breathing zone samples for airborne lead and copper were taken:

Filter: 37-mm mixed cellulose ester membrane, 0.8-$\mu$m pore size, closed face
Position: Right collar of shooter and left collar of instructor for first half (or 125 rounds) of 250-round cycle; then instructor and shooter switched roles, thus changing position to left collar for shooter and right collar for instructor during the second half of the 250-round cycle. All shooters were right handed.
Rate: 3.6 to 3.9 L/min; rate increased from recommended 0.5 to 2.0 L/min to increase sample volume.
Analysis: Atomic absorption graphite furnace, 0.30-$\mu$g limit of detection.

Personal hearing zone samples were taken for noise:

Instrument: Metrosonics dB-307 noise dosimeter
Position: The opposite collar from where the filter cassette was placed; see above
Data recorded: Average level (&A), duration (minutes), dose-5 dB exchange rate (%), maximum level (dBA), peak level (dB-peak)

The weather conditions were moderate: fair, 68° to 73°F, relative humidity 45 to 64 percent, average wind speed 5 to 6 miles per hour (mph) with gusts up to 11 mph, and wind direction from the north perpendicular to the direction of fire.

#### *Lead Results*

Airborne lead was not detected in 11 of the 12 breathing zone samples taken when firing the service revolver (loaded with TMJ ammunition containing lead-free primer) or when firing the semiautomatic pistol (loaded with TMJ ammunition containing either lead styphnate or lead-free primer). The limit of detection ranged from 3.5 to 4.8 $\mu g/m^3$. The detectable TMJ sample (4.3 $\mu g/m^3$) was just above the limit of detection.

Airborne lead was detected in three of the four samples taken in the breathing zones of the shooter and instructor when firing the service revolver loaded with unjacketed, round-nose (RN) ammunition containing lead styphnate primer. The lead concentrations in the three detectable RN samples ranged from 11 to 61 $\mu g/m^3$.

The shooter's and instructor's 8-hour time-weighted average exposures for the RN ammunition were estimated to be 11 and 1 percent of the OSHA-permissible exposure limit (PEL), respectively. Airborne lead (48 $\mu g/m^3$) was also detected in the shooter's breathing zone when cleaning the service revolver, immediately after firing the unjacketed, RN ammunition. Airborne copper levels (n = 20) ranged from not detected to 0.007 $mg/m^3$.

#### *Discussion*

When firing a handgun with a load containing an unjacketed lead bullet or a jacketed bullet with the lead core exposed at the rear, the greatest fraction (about 80%) of airborne lead emitted comes from the bullet being ejected, rather than from the primer.[1,2] Hot gases act on the bullet passing through the barrel to produce lead fumes, which are forcibly exhausted into the air during the muzzle blast. Service revolvers introduce these particles closer to the shooter's breathing zone than semiautomatic pistols because some of the particles exit at right angles through the revolver's barrel/cylinder gap in addition to through

**TABLE 1. Firearms and Ammunition Types**

1. Smith and Wesson, model 66, 4-inch barrel, .357 magnum, service revolver
   a. CCI Blazer Lead Free, 38 Special+P, 158 grain TMJ, 250 rounds
   b. CCI Blazer, 38 Special, 158 grain RN, 250 rounds
2. Glock, model 17, 9mm semiautomatic pistol
   a. CCI Blazer Lead Free, 9mm Luger, 124 grain TMJ, 250 rounds
   b. CCI Blazer, 9mm Luger, 115 grain TMJ, 250 rounds

### Noise Results

Shooter 8-hour noise doses (n = 4) ranged from 88 to 152 percent; instructor 8-hour noise doses (n = 4) ranged from 53 to 79 percent (Table 3). Both shooters and instructors should be included in a hearing conservation program. The dosimeters we used also measured peak sound levels. However, we couldn't get a specific peak sound level because the instruments can only record levels up to 148 dB; the actual peak levels were above that.

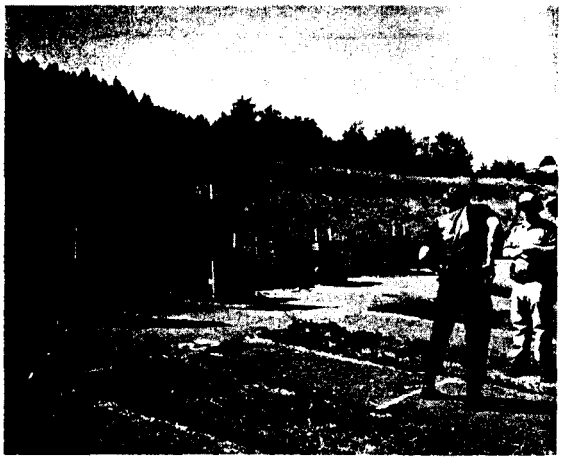

**FIGURE** 2. Typical shooter and instructor positions.

### Discussion

The sound from a single gunshot in the open air is called impulse noise because it is a distinct noise of short duration in which the sound level rises very rapidly to a high peak level before falling off to below background levels. This impulse noise can produce both temporary and permanent hearing loss like the losses produced by continuous noise.

A gunshot's peak sound level, the shot's duration, the number of repeated shots in a daily exposure, the intervals between shots, the individual's susceptibility to noise, and a hearing protector's effectiveness all contribute to the shooter's and instructor's hearing loss potential.

The American Conference of Governmental Industrial Hygienists (ACGIH) has a recommended threshold limit value (TLV) for impulse noise.(') It is based on both the peak sound level and the number of impulses in a day. The TLV doesn't allow unprotected employee peak sound levels above 140 dB, and permits 100 impulses per day at 140 dB, 1000 impulses at 130 dB, and 10,000 impulses at 120 dB.

Based on measurements taken at the police academy's range and by others, peak sound levels in the hearing zones of shooters and instructors will probably be above 140 dB. The TLV assumes that each impulse will be separated by at least 1 second. In a timed course of tire and with more than one shooter firing at the same time, the separation between shots can easily be less than 1 second. Therefore, the best approach to evaluate the noise hazard for shooters and instructors is to apply the OSHA requirements and the ACGIH recommendations together.

A hearing conservation program that includes noise measurement and monitoring, hearing protection, hearing testing, and information and training is necessary to prevent and detect hearing losses by shooters and instructors.

The first element of the program is to evaluate workplace noise exposures for employees. The methods used should be consistent with those described above. The key is to evaluate representative exposures.

The next element is to have the affected employees' hearing tested. This audiometric testing needs to be done initially to establish a baseline hearing level and repeated at least annually to detect hearing losses over time. Los Alamos National Laboratory provides audiometric testing for their firearms instructors a few times per year, 1 week to 10 days after a qualification cycle is completed.@

Providing hearing protection and ensuring that employees wear this protection is the third element of a hearing conservation program. Choose hearing protectors, such as earmuffs, which have a high noise reduction rating and are also acceptable to the users. Comfort and the ability to hear and give commands are design features to consider. Active (electronic) and passive muffs are available which allow verbal communication in between firing, yet shut out the sound during firing. Before purchasing these kinds of protectors, confirm their ability to effectively respond to and shut out the impulse noise.

The final element is employee training, which ties the program together. Annual training needs to be done for all employees included in the hearing conservation program. The training includes the effects of noise on hearing; the purpose, advantages, disadvantages, and noise reduction of hearing protectors;

**TABLE 3. Noise Evaluation Results**

1. Smith and Wesson, model 66, 4-inch barrel, .357 magnum, service revolver
   a. CCI Blazer Lead Free .38 Special+P, 158 grain TMJ, 250 rounds
      Instructor: 71% dose,[A] or 88 dBA[B] TWA[C]
      Shooter: 135% dose, or 92 dBA TWA
   b. CCI Blazer .38 Special, 158 grain RN, 250 rounds
      Instructor: 53% dose, or 86 dBA TWA
      Shooter: 88% dose, or 89 dBA TWA
2. Glock, model 17, 9mm semiautomatic pistol
   a. CCI Blazer Lead Free, 9mm Luger, 124 grain TMJ, 250 rounds
      Instructor: 79% dose, or 88 dBA TWA
      Shooter: 152% dose, or 93 dBA TWA
   b. CCI Blazer, 9mm Luger, 115 grain TMJ, 250 rounds
      Instructor: 67% dose, or 87 dBA TWA
      Shooter: 136% dose, or 92 dBA TWA

[A]Action level is 50%, PEL is 100%.
[B]Decibels on the A-scale measured at slow response.
[C]8-hour time-weighted average sound level.

**TABLE 2. Course of Fire Follwed During Evaluation**

1. 25-yard line8 rounds
   a. From low cover positions, student draws and fires (two-hand sighted fire):
      1. Two rounds from the strong side
      2. Two rounds over the top
      3. Two rounds from the support side
      4. Reload with two rounds from the ground and fire two rounds from any of the above positions.
   b. Time limit: 50 seconds
2. 15-yard line-6 rounds
   a. Student draws and fires two rounds, two-hand sighted fire.
   b. Time limit: 5 seconds
   c. Repeat for a total of 6 rounds.
3. lo-yard line-12 rounds
   a. Student draws and fires six rounds, reloads and fires six rounds, two-hand sighted fire.
   b. Time limit: 25 seconds
4. 5-yard line-12 rounds
   a. Student draws and fires three rounds, two-hand sighted fire
   b. Time limit: 5 seconds
   c. Repeat for a total of 12 rounds.
5. 3-yard line-6 rounds
   a. Student draws and fires three rounds, strong-hand only, at eye level. Student transfers the weapon to the support hand and fires three rounds. Both tasks must be performed with one hand only.
   b. Time limit: 25 seconds
6. 2-yard line-6 rounds
   a. Student draws and fires three rounds, close-quarters unsighted fire (one hand only).
   b. Student will start from the FI position (hands encumbered).
   c. Time limit: 5 seconds
   d. Repeat for a total of six rounds.

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| Target: | BPST combat silhouette (cardboard) |
| Weapon: | The officer's primary duty weapon, revolver or semiautomatic, caliber .38 Special/9mm P or larger |
| Scoring: | Total the value of all hits in the 3, 4, and 5 scoring zones. Multiply this sum by 0.4 to determine the percentage score. Hits on the line will count the value of the higher zone. Hits on the head portion are counted as zero. (50 rounds total, 250 points possible) |

Qualification: Minimum qualifying score is 80% for police and corrections.

**FIGURE 1.** Typical shooter position

the muzzle. In general, larger ammunition produces greater amounts of lead fume, with shotgun ammunition producing the most.

A TMJ bullet eliminates a major source of airborne lead because the rear of the bullet core is protected from the burning propellant. Several studies have compared airborne lead exposures using various jacketed ammunition (including nylon-clad bullets) with lead exposures using conventional lead reloads.[2–6] In each case, the totally jacketed ammunition reduced airborne lead exposures to a fraction of the conventional lead reload exposures. However, because the jacketed ammunition still has lead styphnate primer, shooter and/or instructor air exposures could still be above the OSHA PEL and/or action level in poor ventilation, heavy-use, and long-duration exposure situations. TMJ ammunition with lead-free primer is available.

The City of Los Angeles police recruit range substituted their conventional ammunition with copper-jacketed, lead-free primer ammunition in March 1988.[4] The substitution resulted in lower airborne lead concentrations and lower lead absorption for their range instructors. The range is outdoors, uncovered, and surrounded by 8-ft walls or embankments.

How do the costs of TMJ ammunition compare with conventional lead reloads? Lead reloads for Blazer .38 Special is about $75 per 1000 rounds, while conventional Blazer (TMJ with lead styphnate primer) is about $125 per 1000, and lead-free Blazer (TMJ with lead-free primer) is about $150 per 1000. To get a realistic cost-benefit estimate, compare the direct costs of this ammunition with the indirect costs of managing a lead control program if instructor and/or shooter airborne lead exposures are above the PEL and/or the action level. These indirect costs might include engineering and work practice controls, training, and medical surveillance.

Employee lead exposures at outdoor ranges are influenced by the weather and air flow conditions at the time of firing. For example, airborne lead exposures should be lower on days when the wind is blowing the smoke downrange (away from the shooters' and instructors' breathing zones) than on days when the air is still or when the wind is blowing the smoke uprange.

**TABLE 4. Revised Practical Qualification Course**

25 rounds
100% hits in 4 and 5 zone required to qualify.
1. lo-yard line--3 rounds
   a. On the signal, the student draws and fires from low cover one round strong side, one round over the top, and one round support side.
   b. Time limit: 10 seconds
   c. Strong hand is allowed for all positions.
2. J-yard line-6 rounds
   a. On the signal, the student draws and fires two rounds, two-hand sighted fire.
   b. Time limit: 4 seconds
   c. Repeat for a total of 6 rounds.
3. 5-yard line--8 rounds
   a. On the signal, the student draws and fires two rounds, two-hand sighted fire.
   b. Student reloads from lock-back and fires six rounds.
   c. Time limit: 12 seconds/semiautomatic or 18 seconds revolver
4. 3-yard line-6 rounds
   a. Student draws and tires three rounds strong hand only.
b. Student transfers the weapon to the support hand and fires three rounds with the support hand only.
   c. Time limit: 10 seconds
5. 2-yard line-2 rounds
   a. Student draws and fires two rounds, close quarters, unsighted fire.
   b. Student starts with hands encumbered.
   c. Time limit: 3 seconds

Target: BPSST combat silhouette
Weapon: Officer's primary duty handgun
Scoring: Hits in the 4 and 5 zones only. Hits on the line will count the higher value. Hits on the head count zero.
Qualification: All 25 rounds must hit in the 4 or 5 zone. Any round hitting outside the 4 zone fails qualification.

and the purpose of audiometric testing and an explanation of test procedures.

A strong hearing conservation program can help detect and prevent hearing losses. In addition, it is helpful to look at engineering and work practice controls, such as alternative firearms training methods, which could reduce shooter and instructor noise exposures.

### *Limitations*

The survey represented a one-to-one shooter-to-instructor ratio with one shooter firing, which may or may not be typical of a police agency's exposure pattern. If more than one shooter is firing at a time, each shooter's overall lead and noise exposures may be higher, and the instructor's exposures could be higher depending on the distance from the shooters.

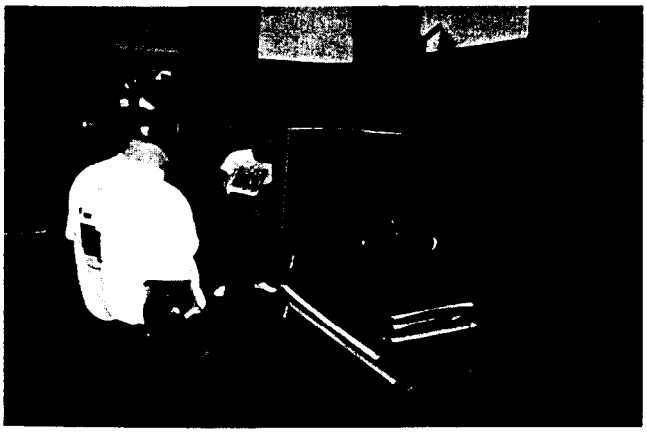

**FIGURE 3.** Students interact with threat.

### Recent Changes in Training Methods

Since the initial evaluation, several changes have occurred at the Oregon police academy related to firearms training. First, the range allows only TMJ ammunition. Also, they decreased student time on range from 32 to 18 hours and changed the course of fire from 50 rounds to 25 rounds (Table 4).

This change was coincidental to our evaluation. The academy did a survey of Oregon police departments to identify the factors related to officer-involved shootings. They found that most shootings occurred at close range, at less than 10 yards. Therefore, 25-yard marksmanship was less important than other skills such as defensive tactics and use of force. As a result, they changed the range course of fire and reduced range training time and added confrontational simulation and electronic simulation training.

### Confrontational Simulation

Confrontational simulation provides a realistic, interactive, hostile environment that requires the student to successfully integrate and apply use of force options, use of available cover, effective verbalization, effective gun handling, safety, and marksmanship (Figures 3 and 4). Standard ammunition is replaced by special effects marking cartridges that do not contain lead and are quieter than regular ammunition. The cartridges cost $700 per 2000-round case. The training occurs over a l-day period and about 150 rounds are used for a class of 50 students.

#### *Electronic simulation*

The firearms training system (FATS) is an electronic simulator. It provides scenarios that require the student to successfully integrate and apply use of available cover, effective verbalization, effective gun handling, and marksmanship. FATS uses a handgun with laser. The projection screen senses where the laser hits and a scenario evolves accordingly. No ammunition is used and the sound levels are controlled through audio speakers (Figures 5 and 6). The initial cost of the FATS system is $60,000. The academy uses it an average of 500 student hours per month.

FIGURE 4. Instructor reviews actions with students.

FIGURE 5. Projection equipment.

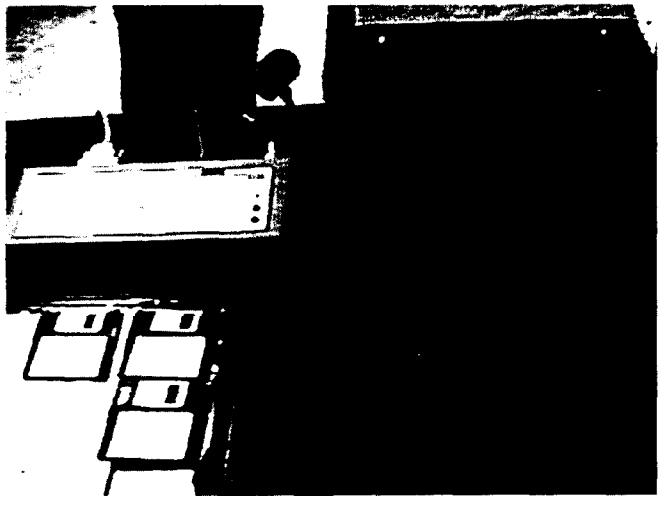

FIGURE 6. Software, controls, and firearm.

## Conclusions

TMJ ammunition reduces lead exposures for shooters and instructors. Range noise exposures are significant for shooters and instructors. Both lead and noise exposure can be reduced by integrating alternative training methods such as confrontational simulation and electronic simulation.

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The opinions and findings expressed in this article are those of the authors and do not necessarily reflect the views of the Oregon State Consultative Services or the U.S. Department *of* Labor, Occupational Safety and Health Administration.