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Dartmouth Police Department
Dartmouth, Massachusetts

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PREFACE

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ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by David C. Sylvain, M.S., CIH, of the Hazard Evaluations and Technical Assistance Branch, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Desktop publishing by Pat Lovell.

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Health Hazard Evaluation Report 96-0107-2613
Dartmouth Police Department
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SUMMARY

In March 1996, the National Institute for Occupational Safety and Health (NIOSH) received a Health Hazard Evaluation (HHE) request from the Dartmouth Chief of Police to evaluate lead exposure during firearms training. Although no adverse health effects had been reported, some of the officers were concerned about potential lead exposure in the indoor range.

Police from Dartmouth, New Bedford, and nearby towns, conduct firearms training at an outdoor range that is owned and operated by the New Bedford Police Department. Within the past year, an indoor facility was added to the range for providing instruction in night firing and fire/no-fire decision making. The facility is located in an old, unrenovated office trailer which was moved onto the site. Inside the trailer, audiovisual equipment is used to project a variety of scenarios that could be encountered by police officers. During training, officers fire at the video images, and the bullets pass through the end of the trailer and into a dirt berm.

A site visit was conducted on June 24, 1996, which included air sampling for lead during an in-service firearms training session. A walk-through inspection of the facility was also conducted at this time.

The results of air sampling conducted on this date indicate that airborne lead concentrations were below the minimum quantifiable concentration (MQC). The average MQC for personal samples collected on officers was 43 micrograms of lead per cubic meter of air ($\mu g/m^3$) based upon an average sample volume of 27.6 liters (range 30 - 84 $\mu g/m^3$). The MQC for the sample collected on the instructor during the training session was 4.4 $\mu g/m^3$. The MQC for an area sample was 4.1 $\mu g/m^3$. Wipe samples from surfaces inside the trailer revealed lead concentrations ranging from 6.6 to 31.6 $\mu g/100\ cm^2$. Use of lead-containing ammunition is the likely source of the surface contamination.

Ventilation inside the trailer was provided by two 14-inch axial fans located in the sidewalls of the trailer, approximately 60 inches from the floor at either side of the target area. Makeup air enters through a doorway at the back of the room. The airflow was neither well-distributed, nor adequate to ensure the removal of airborne lead that is generated by the firing of lead-primer ammunition.

The firing of copper-jacketed lead-free primer ammunition in the trailer did not present a health hazard to officers-in-training or the range instructor. However, continued use of lead-primer ammunition by other police departments may expose those officers to lead, and result in further surface contamination inside the trailer. The two axial fans, which provide ventilation in the trailer, did not provide an adequate, evenly-distributed airflow which would be needed to control lead exposure during the firing of lead-primer ammunition.

Keywords: SIC 9221 (police protection), indoor firing ranges, lead

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INTRODUCTION

In March 1996, the National Institute for Occupational Safety and Health (NIOSH) received a Health Hazard Evaluation (HHE) request from the Chief of Police in Dartmouth, Massachusetts, to evaluate lead exposure during firearms training in an indoor facility. Although no adverse health effects had been reported, some of the officers were concerned about potential lead exposure in the indoor range.

A site visit was conducted on June 24, 1996, which included air sampling for lead during an in-service firearms training session. A walk-through inspection of the facility was also conducted at this time.

BACKGROUND

Police officers from Dartmouth, New Bedford, and nearby towns, conduct firearms training at an outdoor range that is owned and operated by the New Bedford Police Department. Within the past year, an indoor facility was added to the range for providing instruction in night firing and fire/no-fire decision making. The facility is located in an old, unrenovated office trailer which was moved onto the site. Inside the trailer, audiovisual equipment is used to project a variety of scenarios that could be encountered by the officers. During training, officers fire at the video images, and the bullets pass through the end of the trailer and into a dirt berm.

The interior dimensions of the trailer are 41' x 9.33' x 7' (ceiling height). An unused lavatory area divides the trailer into two rooms. The larger room, where firing occurs is 27' in length. Ventilation is provided by two 14-inch axial fans located in the sidewalls of the trailer, approximately 60 inches from the floor at either side of the target area. Makeup air enters through a doorway at the back of the room.

During in-service training conducted by the Dartmouth Police Department earlier this year, three officers entered the trailer along with a range officer (instructor). Each officer fired approximately 18 rounds using a .40 caliber Glock handgun during an estimated one to ten minute period. The range officer remained in the trailer throughout a subsequent session where approximately 70 officers received training. Other phases of firearms training were conducted outdoors.

During the initial training session conducted in the trailer, Dartmouth officers fired ammunition which utilized a lead-containing cartridge primer ("conventional" ammunition); however, copper-jacketed, lead-free primer ammunition was used during the second in-service session. The types of weapons, and training format used by other police departments is not known; however, it was reported that these departments use conventional ammunition inside the trailer.

METHODS

On June 24, 1996, personal breathing zone (PBZ) air samples were collected on ten officers and the range instructor during firearms training inside the trailer located at New Bedford Police Department's Woodcock Road range. On this date, each officer entered the trailer individually, and fired 12 rounds at video images that were projected onto the end of the trailer. The range officer remained in the trailer while each officer-in-training fired. When finished, the officer (trainee) left the trailer, and the next officer entered the trailer to fire 12 rounds. The officers were firing .40 caliber Glock handguns loaded with copper-jacketed, nonleaded primer ammunition.

In addition to PBZ samples, an area air sample was collected above the bench at the rear of the firing area throughout the entire training period. Upon completing the training session, the area sample was removed from the trailer, and the instructor fired 12 rounds of conventional .40 caliber ammunition.

Each sample was collected using a battery-powered sampling pump to draw air through a 37-millimeter (mm) diameter, 0.8 micrometer (µm) pore-size mixed cellulose esters membrane filter mounted in a closed-face cassette. The pumps were operated at a nominal flow rate of 2.9 liters per minute (lpm), and were calibrated before and after sampling to ensure that the desired flow rate was maintained throughout the sampling period. Air samples were analyzed for lead using an inductively coupled plasma (ICP) emission spectrometer according to NIOSH Method 7300 (modified).

Wash 'n Dri™ wipes were used to collect five surface wipe samples from locations throughout the trailer for lead analysis according to NIOSH Method 9100. Each wipe sample was collected from a 100 cm^2 area using a 10 cm by 10 cm plastic template. Using a new pair of disposable latex gloves for each sample, a wipe was removed from its protective package, and the area within the template was wiped with firm pressure, using three or four vertical S-strokes. The exposed area of the pad was folded in, and the area was wiped using three or four horizontal strokes. The pad was folded once more, and the area was wiped with three or four vertical strokes. The folded pad was then placed in a disposable scintillation vial. A clean template and new pair of gloves was used for each sample. Care was taken to use the same technique and wiping pressure for each sample to reduce variation in collection efficiency.

Ventilation inside the trailer was evaluated using a Model 8360 VelociCalc® Plus Air Velocity Meter, and ventilation smoke tubes.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a preexisting medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs)[1], (2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs™)[2] and (3) the U.S. Department of Labor, OSHA Permissible Exposure Limits (PELs)[3]. In July 1992, the 11th Circuit Court of Appeals vacated the 1989 OSHA PEL Air Contaminants Standard. OSHA is currently enforcing the 1971 standards; however, some states operating their own OSHA approved job safety and health programs continue to enforce the 1989 limits. NIOSH encourages employers to follow the 1989 OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever is the more protective criterion. The OSHA PELs reflect the feasibility of controlling exposures in various industries where the agents are used, whereas NIOSH RELs are based primarily on concerns relating to the prevention of occupational disease. It should be noted when reviewing this report that employers are legally required to meet those levels specified by an OSHA standard and that the OSHA PELs included in this report reflect the 1971 values.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8-to-10-hour workday. Some substances have recommended short-term exposure limits (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

Lead

Lead is ubiquitous in U.S. urban environments due to the widespread use of lead compounds in industry, gasoline, and paints during the past century. Exposure to lead occurs via inhalation of dust and fume, and ingestion through contact with lead-contaminated hands, food, cigarettes, and clothing. Absorbed lead accumulates in the body in the soft tissues and bones. Lead is stored in bones for decades, and may cause health effects long after exposure as it is slowly released in the body.

Symptoms of lead exposure include weakness, excessive tiredness, irritability, constipation, anorexia, abdominal discomfort (colic), fine tremors, and "wrist drop."[4, 5, 6] Overexposure to lead may also result in damage to the kidneys, anemia, high blood pressure, infertility and reduced sex drive in both sexes, and impotence. An individual's blood lead level (BLL) is a good indication of recent exposure to, and current absorption of lead.[7] The frequency and severity of symptoms associated with lead exposure generally increase with the BLL.

The overall geometric mean BLL for the U.S. adult population (ages 20-74 yrs) declined significantly between 1976 and 1991, from 13.1 to 3.0 micrograms per deciliter of blood (µg/dL)--this decline is most likely due primarily to the reduction of lead in gasoline. More than 90% of adults now have a BLL of <10 µg/dL, and more than 98% have a BLL <15 µg/dL.[8]

Under the OSHA general industry lead standard (29 CFR 1910.1025), the PEL for airborne exposure to lead is 50 µg/m^3 (8-hour TWA).[3] The standard requires lowering the PEL for shifts exceeding 8 hours, medical monitoring for employees exposed to airborne lead at or above the action level of 30 µg/m^3 (8-hour TWA), medical removal of employees whose average BLL is 50 µg/dL or greater, and economic protection for medically removed workers. Medically removed workers cannot return to jobs involving lead exposure until their BLL is below 40 µg/dL. The OSHA interim final rule for lead in the construction industry (29 CFR 1926.62) provides an equivalent level of protection to construction workers. ACGIH has adopted a TLV for lead of 50 µg/m^3 (8-hour TWA), with worker BLLs to be controlled to at or below 30 µg/dL, and designation of lead as an animal carcinogen.[2] The U.S. Public Health Service has established a goal, by the year 2000, to eliminate all occupational exposures that result in BLLs greater than 25 µg/dL.[9]

The occupational exposure criteria (above) are not protective for all the known health effects of lead. For example, studies have found neurological symptoms in workers with BLLs of 40 to 60 µg/dL, and decreased fertility in men at BLLs as low as 40 µg/dL. BLLs are associated with increases in blood pressure, with no apparent threshold through less than 10 µg/dL. Fetal exposure to lead is associated with reduced gestational age, birth weight, and early mental development with maternal BLLs as low as 10 to 15 µg/dL.[10] Men and women who are planning on having children should limit their exposure to lead.

The BLL of law enforcement trainees using a poorly ventilated firing range for an average of 7.2 hours during their first month of training rose from a mean of 6 µg/dL to 51 µg/dL (range 31-73 µg/dL).[11] Assuming a linear relationship between hours of exposure and BLL, employees using or working at this firing range more than 3.6 hours per month were found to be at risk for BLL rising above 40 µg/dL.

Range masters or instructors should have their BLL checked at least every six months. Law enforcement trainees should be checked approximately three weeks after training begins. Individuals using or working at the range for more than 3 hours per month, should have their BLL checked.

In homes with a family member occupationally exposed to lead, care must be taken to prevent lead from being carried into the home on clothing, skin, and hair, and in vehicles. High BLLs in resident children, and elevated concentrations of lead in house dust, have been found in homes of workers employed in industries associated with high lead exposure.[12] Particular effort should be made to ensure that children of persons who work in areas of high lead exposure receive a BLL test.

RESULTS

The results of air sampling indicate that airborne lead concentrations were below the minimum quantifiable concentration (MQC). The MQC is the minimum concentration that can be measured, based upon sample volume and analytical sensitivity. The average MQC for personal samples collected on officers-in-training was 43 µg/m^3 based upon an average sample volume of 27.6 liters (range 30 - 84 µg/m^3). The MQC for the sample collected on the instructor during the training session was 4.4 µg/m^3. The MQC for the area sample was 4.1 µg/m^3.

The average sampling time for each officer was 9.6 minutes (range 5 - 14 minutes). The sampling period for the instructor was 99 minutes. The area sample was collected at the bench at the rear of the firing area for 102 minutes.

An 8-minute PBZ sample was collected while the instructor fired 12 rounds of conventional .40 caliber ammunition. This ammunition had a lead-containing primer, as did the ammunition which was used during prior training in the trailer. No lead was quantified in this sample; however it should be noted that, due to the minimal sampling time and subsequent low sample volume, the MQC was 54 µg/m^3.

The results of wipe sampling are presented in table 1. Wipe samples revealed lead concentrations ranging from 6.6 to 31.6 µg/100 cm^2 (an area of approximately 16 square inches).

When interior and exterior trailer doors were open, air velocity at the firing line ranged from 16 feet per minute (fpm) along the left wall, to 130 fpm along the opposite wall where air enters through a pocket door. Air velocity at the center of the trailer was 16 fpm. With the doors closed, as is the case when officers are firing, the air velocity ranged from zero to 50 fpm. Air velocity at the center of the trailer when doors were closed was 35 fpm. Use of ventilation smoke tubes to visualize airflow revealed considerable turbulence within the trailer, especially when the doors were closed. When doors were closed, smoke near the ceiling flowed toward the rear of the firing area where it accumulated in a corner above the bench.

DISCUSSION

Air sampling indicates that the 8-hour TWA lead exposures on the sampling date were below the MQC and, therefore, were well-below the OSHA PEL during the firing of copper-jacketed, lead-free primer ammunition. When expressed as an 8-hour TWA concentration, the MQC of 43 µg/m^3 during a 9.6-minute sampling period is equivalent to an average concentration of 0.86 µg/m^3; the MQC of 4.4 µg/m^3 during the 99-minute sample collected on the range officer is equivalent to 0.91 µg/m^3. (Since sampling results indicated concentrations below the MQC, the actual concentrations to which officers were exposed were below these levels.) It should be noted that these results do not represent the exposure of officers when firing non-jacketed, lead-primer ammunition inside the trailer. Use of lead-containing ammunition can result in significant airborne lead exposure in indoor firing ranges, especially in ranges with poor ventilation.[13]

The two wall-mounted fans in the trailer do not provide adequate ventilation for removing airborne lead during the firing of conventional ammunition. Ventilation in an indoor firing range, where conventional ammunition is used, should provide a smooth, evenly-distributed airflow of 75 fpm across the firing line.[14] The airflow in the trailer was neither well-distributed, nor adequate to ensure the removal of airborne lead during the firing of conventional ammunition. However, as demonstrated during this HHE, use of lead-free primer ammunition eliminates the source of much of the lead that would otherwise be released inside the trailer.

It is likely that surface lead contamination detected during this site visit resulted from the firing of conventional ammunition. The continued use of conventional ammunition by other departments can be expected to result in further contamination inside the trailer.

The axial fans were not provided with guards to prevent accidental contact with the moving blades. Guards should be installed which have openings no greater than one-half inch in width. The use of concentric rings with spacing between them not exceeding one-half inch is acceptable provided that sufficient radial spokes and firm mountings are used to make the guard rigid enough to prevent it from being pushed into the fan blade during normal use.

CONCLUSIONS

The firing of copper-jacketed lead-free primer ammunition in the trailer did not present a health hazard to the officers or the range instructor. However, continued use of lead-primer ammunition by other police departments may expose those officers to lead. The two axial fans that provide ventilation in the trailer, did not provide an adequate, evenly-distributed airflow which would be needed to control lead exposure during the firing of lead-primer ammunition.

RECOMMENDATIONS

1. Only jacketed, lead-free primer ammunition should be used in the trailer. The use of "lead-free" ammunition greatly reduces the potential for exposure to lead in the air and on surfaces, inside the trailer.

2. Users of the range should be instructed to wash after shooting. Although "lead-free" ammunition was used by the Dartmouth Police Department, surfaces within the trailer are contaminated with lead from the use of conventional ammunition by officers from other agencies. Shoes worn inside the trailer can become contaminated with lead, and should not be worn home.

3. Surface dust should be cleaned using wet-methods or a vacuum cleaner equipped with a high-efficiency particulate air (HEPA) filter. Dry-sweeping of the floor and surfaces inside the trailer should be prohibited.

4. Range masters or instructors should have their BLL checked at least every six months. Individuals who use or work in the trailer for more than 3 hours per month, should have their BLL checked.

5. Guards should be installed on the fans to prevent injury from accidental contact with moving fan blades. Fan blade guards should have openings no greater than one-half inch in width, and should be sufficiently rigid to prevent the guards from being pushed into the fan blades.

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Table 1. Wipe Samples, New Bedford Police Firing Range, June 24, 1996.

Sample	Location	Lead† ($\mu g/100\ cm^2$)
W-1	Bench top at rear of firing area	31.6
W-2	Floor where trainee stands	24.5
W-3	Top of VCR cabinet	6.6
W-4	Seat of folding chair	12.2
W-5	Floor, in front of bench	14.8

† micrograms of lead per 100 square centimeters of surface area (An area measuring approximately 4 inches by 4 inches).