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SAINT BERNARD POLICE DEPARTMENT
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I. SUMMARY

On October 23, 1991, the National Institute for Occupational Safety and Health (NIOSH) received a request to conduct a health hazard evaluation (HHE) at the Saint Bernard Police Department located in Saint Bernard, Ohio. The request was initiated by the management which was concerned about police officers' exposures to lead fumes generated during monthly hand gun firing exercises. In response to the request, on January 17, 1992, NIOSH investigators conducted environmental monitoring to assess potential occupational exposures to airborne lead and hazardous noise levels generated at the facility during the hand gun firing exercises.

For three police officers present during the firing exercises, personal breathing-zone (PBZ) measurements ranged from 36 to 48 micrograms of lead per cubic meter ($\mu g/M^3$), based on the actual sampling time (an average of 72 minutes). PBZ measurements for the three officers, calculated as an 8-hour time-weighted average (TWA), ranged from 5 to 7 $\mu g/M^3$. The 8-hour TWA calculation assumes that police officers received no additional exposure to lead before or after leaving the firing range. All PBZ sampling results revealed lead concentrations that were below the Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) of 50 $\mu g/M^3$ calculated as an 8-hour TWA and the NIOSH Recommended Exposure Limit (REL) of less than 100 $\mu g/M^3$ as a 10-hour TWA. Thirteen general area (GA) air samples ranged from none-detected to 845 $\mu g/M^3$, based on the actual sampling time (an average of 72 minutes). The highest airborne lead concentrations were measured at the bullet trap of the firing range.

Peak sound pressure levels measured within the firing range were as high as 160 decibels (dB), which exceeded the OSHA peak exposure criteria of 140 dB. Approximately 180 rounds of Blazer® and/or Hydra Shok® 9 millimeter (mm) 115 grain lead ammunition were fired during the exercise.

NIOSH environmental results revealed that there were no overexposures to airborne lead on the day of the evaluation. GA measurements showed that elevated levels of airborne lead are generated at the bullet trap in the firing range. If police officers spend more time in the firing range during firing exercises, the likelihood of increased exposure to airborne lead will increase. Recommendations are provided in section VII of this report to: (1) establish improved personal hygiene practices, (2) properly clean the firing range, and (3) maintain hearing protection devices (HPDs).

KEYWORDS: SIC 9221 (Police Protection), lead, firing range, noise, ventilation.

II. INTRODUCTION

On October 23, 1991, the National Institute for Occupational Safety and Health (NIOSH) received a request to conduct a health hazard evaluation (HHE) at the Saint Bernard Police Department located in Saint Bernard, Ohio. The request was initiated by management which was concerned of police officers' exposures to lead fumes generated during monthly firing exercises. On November 27, 1991, NIOSH conducted an initial meeting with the management and employee representatives of the police department, which included a discussion of range procedures and a walk-through inspection of the firing range. On January 17, 1992, NIOSH investigators returned to the firing range to conduct an environmental evaluation. An interim report dated August 4, 1992, presented the preliminary results of the environmental evaluation.

III. BACKGROUND

A. Facility and Firing Range Descriptions

The Saint Bernard Police Department employs a staff of approximately 17 police officers. Each month the firing range is utilized by four or five police officers for a period of 1 to 2 hours, who fire their service revolvers for practice or for an annual small arms qualification requirement of the police department. During each monthly firing exercise, each police officer fires approximately 60 rounds of 9 millimeter (mm) 115 grain lead ammunition (Blazer® and/or Hydra Shok®). On the day of the NIOSH evaluation, three police officers participated in the qualification exercise, with one of the officers also serving as the range officer.

In 1978, the firing range was built on the lower level of the Saint Bernard Police Department Headquarters. The firing range occupies 2500 square feet (ft^2) (125 ft x 20 ft) of the lower level of the building. The range is comprised of four shooting booths, each booth being 3 feet wide and 7½ ft high. Located at the rear of the range is a glass-fronted control booth, a firearms cleaning room, and an exercise room. The control booth has a raised platform that enables the range officer to view the range while operating the controls. The floor of the control booth area, including the platform, is carpeted. Located approximately 70 feet down range from the shooting booths is a "V" shaped bullet trap, constructed of overlapping, angled metal plates.

Other areas on the lower level of the building include storage rooms, mechanical rooms, and a locker room. These areas usually are not occupied for extended periods of time by the occupants of the building.

B. Heating, Ventilating, and Air-Conditioning (HVAC) Description

The firing range is served by a dedicated, variable air volume (VAV) heating, ventilating, and air-conditioning (HVAC) system. Ventilation is provided by air handling unit (AHU) #1 which distributes supply air (SA) to the control booth through two 24 inch x 24 inch, 4-way, louvered ceiling diffusers. The design SA flow for the control booth is 790 cubic feet per minute (cfm), distributed to the range via linear diffusers located in the ceiling about one foot from the wall

separating the control booth and the range. These diffusers run the full width of the range. The designed SA flow for the range is 9,230 cfm. Air exhausted or recirculated from the range is first passed through a high efficiency particulate air (HEPA) filter. An inline exhaust fan is located downstream of the HEPA filter. A discharge damper, located downstream of the HEPA filter, regulates the amount of air either recirculated or exhausted directly to the outdoors. Located upstream of the AHU, is a SA damper that regulates the amount of outside air (OA) provided to the range area. Both dampers are controlled by a timer switch that is located in the control booth.

Exhaust air is discharged at three locations. Located approximately 12 feet downrange from the shooting booths (between the bullet deflectors near the ceiling) are two 26 inch x 18 inch exhaust grills. These grills are designed to exhaust air from the range at a volumetric flowrate of 1595 cfm. A third exhaust diffuser (66 inch x 42 inch), designed to exhaust 7980 cfm from the range, is located on the left wall above the bullet trap.

The range is heated by electric heating coils located downstream of the mixed air plenum. The range is cooled by water chilled cooling coils located upstream of the mixed-air plenum, which is the room that houses the AHU.

The ventilation system has two operational modes: a recirculation mode and an exhaust mode. When the range is not being utilized, the ventilation system is operated in the recirculation mode. During firing exercises, the ventilation system is operated in the exhaust mode. In the recirculation mode, OA air is neither supplied to nor exhausted from the range (to the outdoors). In the exhaust mode, 100% OA is brought into the range, and 100% of the range air is exhausted directly to the outdoors.

C. Previous Evaluation

In November 1979 and January 1980, NIOSH conducted a HHE of the Saint Bernard Police indoor firing range. The evaluation was prompted by concerns that smoke filled the control booth during firing exercises. During that evaluation, police officers fired approximately 60 rounds using .38 special, 148 grain Wadcutter ammunition. 8-hour TWA PBZ measurements showed that police officers' lead exposures ranged from 170 to 32,500 $\mu g/M^3$, with a mean of 9,700 $\mu g/M^3$. Many of the lead concentrations measured exceeded the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) of 50 $\mu g/M^3$ as an 8-hour time-weighed average (TWA). It was concluded that a hazard from exposure to lead existed at the firing range, and that a serious health hazard could result if the range was used more frequently or for prolonged periods of time. Recommendations were provided to reduce lead exposures by improving the ventilation in the range.

IV. ENVIRONMENTAL EVALUATION AND METHODS

On January 17, 1992, 16 air samples were collected during the qualification period on mixed cellulose ester (MCE) filters, using battery-powered air sampling pumps operated at a flowrate of 2 liters per minute. Three personal breathing-zone (PBZ)

samples were collected to assess police officers' exposures to airborne lead. Thirteen general area (GA) air samples were taken during the firing exercise for the purpose of assessing lead concentrations within the firing range and in adjacent areas. Air samples were analyzed according to NIOSH Method 7082, using a Perkin-Elmer Model 5000 flame atomic absorption (AA) spectrometer.[1]

Area noise measurements were made in the firing range with a Larson-Davis Laboratories Model 800B Precision Integrating Sound Level Meter (SLM) fitted with a Model 2530 1/4" microphone. Unweighted measurements of weapon noise were made with the SLM in the integration mode, using a 3 decibel (dB) integration equation (L_{eq}). The SLM was mounted on a tripod located 5 feet behind the shooting line with the microphone at ear level near the range officer. One additional measurement was made in the control booth. The SLM was calibrated with an acoustical reference tone both before and after the measurement period.

A Rosco Fog Machine (Model Number 8560) was used to visualize the air flow patterns in the range with a non-hazardous artificial smoke generated by boiling a mixture of three glycols and distilled water. The smoke machine was placed on the shelf and on the floor beneath the shelf in each shooting booth. This test checked the backward flow of air from downrange. In addition, the smoke machine was placed about 4 feet off the floor in the center of the range about 10 feet downrange from the booths.

V. 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 from eight to ten hours a day, forty hours a week, for a working lifetime without experiencing adverse health effects. However, it is important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substance 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 to the level set by the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, thus potentially increasing 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 Criteria Documents and Recommended Exposure Limits (RELs), 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs), and 3) the US Department of Labor OSHA PELs.[2-4] In evaluating the exposure levels and the recommendations for reducing those levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA PEL.

A TWA exposure level refers to the average airborne concentration of a substance during a normal eight to ten 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 brief high exposures.

A. Lead

Inhalation (breathing) of dust and fume, and ingestion (swallowing) resulting from hand-to-mouth contact with lead-contaminated food, cigarettes, clothing, or other objects are the major routes of worker exposure to lead. Once absorbed, lead accumulates in the soft tissues and bones, with the highest accumulation initially in the liver and kidneys.[5] Lead is stored in the bones for decades, and may cause toxic effects as it is slowly released over time. Overexposure to lead results in damage to the kidneys, gastrointestinal tract, peripheral and central nervous systems, and the blood-forming organs (bone marrow).

The frequency and severity of symptoms associated with lead exposure increase with increasing blood lead levels (BLLs). Signs or symptoms of acute lead intoxication include weakness, excessive tiredness, irritability, constipation, anorexia, abdominal discomfort, colic, anemia, high blood pressure, irritability or anxiety, fine tremors, pigmentation of the gums ("lead line"), and "wrist drop."[6-8]

Overt symptoms of lead poisoning in adults generally begin at BLLs between 60 and 120 µg/dl. Neurologic, hematologic, and reproductive effects, however, may be detectable at much lower levels, and the World Health Organization (WHO) has recommended an upper limit of 40 µg/dl for occupationally exposed adult males.[9] The mean serum lead level for U.S. men from 1976-1980 was 16 µg/dl.[10,11] However, with the implementation of lead-free gasoline and reduced lead in food, the 1991 average serum lead level of U.S. men will probably drop below 9 µg/dl.[12]

An increase in an individual worker's BLL can mean that the worker is being overexposed to lead. While the BLL is a good indication of recent exposure to, and current absorption of lead, it is not a reliable indication of the total body burden of lead.[13] Lead can accumulate in the body over time and produce health effects long after exposure has stopped. Long-term overexposure to lead may cause infertility in both sexes, fetal damage, chronic kidney disease (nephropathy), and anemia.

Under the OSHA standard regulating occupational exposure to inorganic lead in general industry, the PEL is 50 $\mu g/m^3$ as an 8-hour TWA.[14] The standard requires semi-annual monitoring of BLL for employees exposed to airborne lead at or above the Action Level of 30 $\mu g/m^3$ (8-hour TWA), specifies medical removal of employees whose average BLL is 50 µg/dl or greater, and provides economic protection for medically removed workers. The NIOSH REL for lead is less than 100 $\mu g/m^3$ as a TWA for up to 10 hours. This REL is an air concentration to be maintained so that worker blood lead levels remain below 60 µg/100 grams of whole blood. NIOSH is presently reviewing literature on the health effects of lead to re-evaluate its REL. The OSHA PEL for general industry is currently recommended by NIOSH investigators as a more protective criteria.

Recent studies suggest that there are adverse health effects at BLLs below the current evaluation criteria for occupational exposure. A number of studies have found neurological symptoms in workers with BLLs of 40 to 60 µg/dl. Male BLLs are associated with increases in blood pressure, with no apparent threshold through less than 10 µg/dl. Studies have suggested decreased fertility in men at BLLs as low as 40 µg/dl. Prenatal exposure to lead is associated with reduced gestational age, low birthweight, and early mental development at prenatal maternal BLLs as low as 10 to 15 µg/dl.[15]

In recognition of the health risks associated with exposure to lead, a goal for reducing occupational exposure was specified in *Healthy People 2000*, a recent statement of national consensus and U.S. Public Health Service policy for health promotion and disease prevention. The goal is to eliminate, by the year 2000, all workplace exposures that result in BLLs greater than 25 µg/dl.[16]

Lead dust may be carried home on clothing, skin, and hair, and in vehicles. High BLLs in resident children, and elevated concentrations of lead in the house dust, have been found in the homes of workers employed in industries associated with high lead exposure.[17] Particular efforts should be made to ensure that children of workers with lead poisoning, or who work in areas of high lead exposure, are tested for lead exposure (BLL) by a qualified health-care provider.

B. Noise

Occupational deafness was first documented among metalworkers in the sixteenth century.[18] Since then, it has been shown that workers have experienced excessive hearing loss in many occupations associated with noise. Noise-induced loss of hearing is an irreversible, sensorineural condition that progresses with exposure. Although hearing ability declines with age (presbycusis) in all populations, exposure to noise produces hearing loss greater than that resulting from the natural aging process. This noise-induced loss is caused by damage to nerve cells of the inner ear (cochlea) and, unlike some conductive hearing disorders, cannot be treated medically.[19]

While loss of hearing may result from a single exposure to a very brief impulse noise or explosion, such traumatic losses are rare. In most cases, noise-induced hearing loss is insidious. Typically, it begins to develop at 4000 or 6000 Hz (the hearing range is 20 Hz to 20000 Hz) and spreads to lower and higher frequencies. Often, material impairment has occurred before the condition is clearly recognized. Such impairment is usually severe enough to permanently affect a person's ability to hear and understand speech under everyday conditions. Although the primary frequencies of human speech range from 200 Hz to 2000 Hz, research has shown that the consonant sounds, which enable people to distinguish words such as "fish" from "fist," have still higher frequency components.[20]

The OSHA standard for occupational exposure to noise (29 CFR 1910.95)[21] specifies a maximum PEL of 90 dB(A)-slow response for a duration of 8 hours per day. The regulation, in calculating the PEL, uses a 5 dB time/intensity trading relationship. This means that in order for a person to be exposed to noise levels of 95 dB(A), the amount of time allowed at this exposure level must be cut in half in order to be within OSHA's PEL. Conversely, a person exposed to 85 dB(A) is

allowed twice as much time at this level (16 hours) and is within his daily PEL. Both NIOSH, in its Criteria for a Recommended Standard,[22] and the ACGIH, in their TLVs,[23] propose an exposure limit of 85 dB(A) for 8 hours, 5 dB less than the OSHA standard. Both of these latter two criteria also use a 5 dB time/intensity trading relationship in calculating exposure limits.

TWA noise limits as a function of exposure duration are shown as follows:

Duration of Exposure Hours/day	Sound Level (dB[A])	
	ACGIH/NIOSH	OSHA
16	80	85
8	85	90
4	90	95
2	95	100
1	100	105
½	105	110
¼	110	115*
C	115*	---**

* No exposure to continuous or intermittent noise in excess of 115 dB(A).

** Exposure to impulsive or impact noise should not exceed 140 dB(A) peak sound pressure level.

The OSHA regulation has an additional action level (AL) of 85 dB(A) which stipulates that an employer shall administer a continuing, effective hearing conservation program when the TWA value exceeds the AL. The program must include monitoring, employee notification, observation, an audiometric testing program, hearing protectors, training programs, and recordkeeping requirements. All of these stipulations are included in 29 CFR 1910.95, paragraphs (c) through (o).

The OSHA noise standard also states that when workers are exposed to noise levels in excess of the OSHA PEL of 90 dB(A), feasible engineering or administrative controls shall be implemented to reduce the workers' exposure levels. Also, a continuing, effective hearing conservation program shall be implemented.

VI. RESULTS

A. Air Sampling for Lead

Results of the PBZ and GA air sampling for lead are presented in Table 1. Based on the actual sampling time (an average of 72 minutes), PBZ lead concentrations ranged from 36 to 48 $\mu g/M^3$ for the three police officers present during the firing exercise. The calculated 8-hour TWAs for PBZ concentrations of airborne lead ranged from 5 to 6 $\mu g/M^3$, well below the OSHA PEL of 50 $\mu g/M^3$. The 8-hour TWA calculation assumes that police officers received no additional exposure to lead before or after leaving the firing range. Lead concentrations determined from

the GA air samples ranged from none-detected to 845 $\mu g/M^3$, with the highest lead concentrations (438 $\mu g/M^3$ to 845 $\mu g/M^3$) measured at the bullet trap of the firing range. The remaining GA air samples revealed lead concentrations at or below 30 $\mu g/M^3$.

B. Noise Measurements

Because of the explosive nature of gunfire, only the peak sound pressure levels from the weapons were recorded. Noise measurements were made when either one, two, or all three officers were firing their weapons. The number of shooters did not appear to have a large effect on the noise levels recorded on the stationary SLM. When all three officers were firing, the peak sound pressure level was 160 dB. Two shooters were exposed to 157 dB peak levels and one officer firing on the range was also measured at 157 dB. The noise in the range control room was

Table 1

PBZ and Area Air Sampling Results\Data for Lead
January 17, 1992

St. Bernard Police Department
St. Bernard, Ohio

Job Title/Location	Sampling Period		Time (min)[1]	Lead Conc. (µg/M^3)	
	Begin	End		TWA[2]	8-hr TWA
Personal Sampling					
Range Officer	3:06	4:16	70	36	5
Shooter #1	3:05	4:11	66	44	6
Shooter #2	3:08	4:14	67	48	7
Area Sampling					
Booth #1	3:08	4:19	73	13	---
Booth #2	3:10	4:24	75	20	---
Booth #3	3:08	4:19	72	20	---
Booth #4	3:09	4:21	73	21	---
Bullet trap (R)	3:10	4:21	73	438	---
Bullet trap (L)	3:09	4:22	71	845	---
Range Desk	3:08	4:18	71	7	---
Table behind booths (L)	3:10	4:23	74	30	---
Table behind booths (R)	3:10	4:23	74	20	---
Control room table	3:09	4:17	70	ND	---
Cleaning room	3:10	4:23	73	ND	---
Hallway	3:12	4:18	71	ND	---
Outdoors	3:13	4:18	77	ND	---
OSHA PEL				50 µg/M^3	
NIOSH REL				100 µg/M^3	
ACGIH TLV				150 µg/M^3	

[1]Total number of minutes sampled.
[2]TWA for sampling time.
[3]µg/M^3 micrograms per cubic meter.

(R) = right side
(L) = left side
ND = None detected below the minimum detectable concentration of 0.007 µg based on a sampling volume of 150 liters.

measured at 134 dB peak levels; 13-16 dB less than the noise levels measured in the range.

One type of ear muffs worn by the officers during qualification was determined to be less than optimal for attenuating the high peak levels of noise that they were exposed to during shooting. Due to the age of the MSA ear muffs, the cushions on the edge of the ear cups lost their pliancy. The cushions need to be replaced

periodically to maintain the muffs' maximal attenuation characteristics. The E-A-R ear muffs (Cabot Corporation) have an orifice in the ear cup which covers the ear. At noise levels below a critical sound level (the transition level), sound can enter the ear cups through orifice openings, allowing conversations and other low level sounds to be better heard when the ambient noise levels are low. However, above the transition level, the air turbulence created by the high noise levels restricts the passage of sound through the opening. The transition sound level for these ear muffs is 120 dB, making them appropriate for isolated impulses such as gunfire. However, cushions on these muffs also must be changed periodically to assure maximal attenuation from the product.

C. Ventilation

The information presented below discusses the findings of the smoke machine assessment of airflow patterns at each firing booth and down range of the firing booths. The firing booths are referred to by number starting from left to right while facing downrange.

1. **Firing Booth 1:** Smoke released at both the shelf and at the floor levels backflowed immediately to the area uprange of the booth.

2. **Firing Booth 2:** Smoke released at the shelf level did not backflow uprange of the firing booths. Smoke released at floor backflowed intermittently uprange of the booth.

3. **Firing Booth 3:** Smoke released at the shelf level backflowed uprange of the booth, but the amount of smoke that backflowed through booth 3 appeared to be less than and more intermittent than that noted in booth 1. Smoke released at the floor level did not move uprange.

4. **Firing Booth 4:** Smoke released at shelf level in booth 4 did not backflow through the booth. Smoke released at floor level backflowed through the booth.

5. **Smoke testing downrange of the booths** (near the bullet trap): the test showed that air from downrange backflowed uprange toward the booths. This smoke flowed from the ceiling space through the exhaust grille uprange of the booths, and through cracks in the suspended ceiling and around light fixtures. The exhaust grill system appeared to have minimal effect on the smoke.

In all cases, smoke that backflowed uprange of the booths flowed to the control booth area, flowed up the wall, and mixed with air flowing from the linear diffusers. The smoke was then blown through the booths with the supply air. Smoke released in any booth tended to spread throughout the area uprange of the booths. Smoke uprange of the booths dissipated slowly--smoke was still visible after ten minutes after the Rosco machine had been stop.

VII. DISCUSSION

It was estimated by the management that the range officer spends approximately 24 hours per year in the firing range. Considering the short time spent in the firing range, and low personal lead exposures, overexposure to lead is not likely to occur under these circumstances and ventilation conditions. However, if the firing range is used more frequently or for more prolonged periods of time, airborne lead exposures are likely to increase.

Four or five police officers generally use the firing range during the qualification period. However, only three police officers fired on the day of the NIOSH evaluation. Consequently, airborne lead concentrations may be higher on days when more than three officers participate.

Although PBZ lead concentrations were relatively low, there is a potential for carrying lead dust away from the firing range on contaminated clothing and shoes. This could lead to lead dust exposure to other people such as co-workers and family members.

The smoke machine results illustrate that shooters standing in booths 1 and 3 can be directly exposed to lead-contaminated air originating downrange of the shooting booths. Booths 2 and 4 also demonstrated this backflow of air but because air flow was in the lower part of the booth, shooters in these booths may not inhale lead-contaminated air unless they shoot from the prone position. Shooters in all of the booths, as well as anyone uprange of the booths, are potentially exposed to lead-contaminated air that was shown to backflow from down range.

The backflow of air at the firing booths is caused by the way air is supplied to the range. Linear diffusers across the ceiling supply air to the range in a high velocity jet. Surrounding air is pulled into the jet of air because of the turbulence between the jet boundary and surrounding air, thus creating a siphoning effect.

Openings were observed around the sanitary pipes which enter from the floor above the range through the ceiling. Under certain conditions, lead contaminated air could enter these openings.

VIII. RECOMMENDATIONS

The following recommendations are offered to further reduce the lead exposures, and to protect the officers from hazards to their hearing from gunfire noise:

1. Establish and enforce personal hygiene practices designed to prevent the ingestion of lead dust by police officers, and contaminating areas outside the firing range with lead.

    a. Eating, drinking, or smoking inside the range should be prohibited to eliminate possible hand to mouth ingestion.

    b. After using the range, individuals should shower and change clothes before eating, drinking, and using tobacco products. Range officers should be

provided with two lockers to allow them to separate street clothes from lead contaminated work clothes.

2. A schedule should be established to perform routine cleaning and maintenance of the range. The following provides information about proper cleaning of the range:

   a. Lead dust that accumulates in the bullet trap should be removed. The Environmental Protection Agency (EPA) classifies lead as a hazardous material, and requires disposal in accordance with environmental regulations.[24]

   b. Because of the presence of unburnt gun powder, cleaning the range floor and bullet trap should include the use of an explosion-proof HEPA vacuum, or one which utilizes a wet dust collector. Because sweeping with brooms will disperse lead dust into the air, they should be avoided when cleaning the range. In addition, assessable surfaces (e.g., floors, table tops, and bullet traps) in the range should be cleaned routinely with a high phosphorous detergent, such as trisodium phosphate (TSP) or Spic and Span®. All cleaning in the range should be performed with the ventilation system running in the exhaust mode.

   c. Spent cartridges should not be picked up by hand to avoid dermal contact with lead from the bullets and from the floor. Instead, they should be collected using a HEPA vacuum.

3. A respiratory protection program should be established for personnel assigned to cleaning the range, and removing lead dust from the bullet trap. The program should be established in accordance with OSHA regulation 29 CFR 1910.134.[4]

4. Sampling results show elevated lead concentrations measured at the bullet trap area of the range. Following firing exercises, police officers were observed walking downrange toward the bullet trap. To prevent further lead exposures, only authorized personnel (range officers or maintenance personnel) should be permitted to go downrange of the firing line. Personnel who walk downrange should wear disposable clothing to cover portions of the body that will come in contact with surfaces covered with lead.

5. Carpet that is located in the control booth area of the range acts as a reservoir for lead dust and gun powder. The carpet in that area should be removed to reduce a potential fire hazard posed by unburnt gun powder and to minimize lead exposures. The carpet should be replaced with a seamless, rubberized surface. This would provide sound absorption as well as reducing lead hazards and making clean-up easier.

6. The use of low-lead ammunition should be considered. Substituting copper jacketed, nylon jacketed, or zinc slugs has been shown to reduce lead emission significantly.[25]

7. To prevent lead contaminated air from entering areas on the first floor of the building, the sanitary pipes (as discussed in section VII of this report) leading to the first floor should be sealed.

8. Because the officers are subject to peak noises levels up to 160 dB during periods of gunfire, all personnel must wear hearing protection while on the range. This should include officers firing their weapons, range instructors, and anyone else who is on the range, in the range control room, or in the rooms which are accessed from the control room. A warning light should be placed in the hallway outside of the range to warn people in the hall that weapon firing is taking place and that they must have hearing protection in place before entering the range area.

9. Hearing protection must be supplied to all personnel who may enter the firing range area. If ear muffs are the device of choice, then a periodic maintenance program must be instituted. The maintenance program must check to see that the headbands of the muffs have not been sprung which will result in not enough pressure being applied to the side of the person's head to adequately block out noise from entering the ear through a pathway between the ear cup and the head. The cushions should be replaced every six months to assure that they are pliant. Ear plugs should be available for those people who are unable to wear ear muffs because of facial deformities or glasses that break the seal between the head and ear muff.

10. Annual audiometric examinations should be instituted to check officers' hearing because of the potential for exposure to damaging noise. If an officer shows a reduction in high frequency hearing from one year to the next in spite of the use of hearing protection, the officer can be refit with another type of hearing protection device or instructed to use both ear plugs and ear muffs while on the range. The annual audiometric test will identify potentially serious hearing problems in officers before they become excessive.

IX. REFERENCES

1. NIOSH [1984]. Manual of Analytical Methods, Third Edition. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 84-100.

2. CDC [1988]. NIOSH recommendations for occupational safety and health standards 1988. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control; National Institute for Occupational Safety and Health. MMWR 37 (supp. S-7).

3. ACGIH [1990]. Threshold limit values and biological exposure indices for 1990-1991. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

4. Code of Federal Regulations [1989]. 29 CFR 1910.1000. Washington, DC: U.S. Government Printing Office, Federal Register.

5. NIOSH [1981]. Occupational health guidelines for chemical hazards. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 81-123, and supplements 88-118, 89-104.

6. Hernberg S, et al. [1988]. Lead and its compounds. In: Occupational medicine. 2nd ed. Chicago, IL: Year Book Medical Publishers.

7. Landrigan PJ, et al. [1985]. Body lead burden: Summary of epidemiological data on its relation to environmental sources and toxic effects. In: Dietary and environmental lead: Human health effects. Amsterdam: Elsevier Science Publishers.

8. Proctor NH, Hughes JP, Fischman ML [1988]. Lead. In: Chemical hazards of the workplace. 2nd ed. Philadelphia, PA: J.B. Lippincott Company, Philadelphia, pp 294-298.

9. World Health Organization [1980]. Recommended health-based limits in occupational exposure to heavy metals. Geneva: Technical Report Series 647.

10. Muhaffey K, Annest J, Roberts J, Murphy R [1982]. National estimates of blood lead levels. United States, 1976-1980. New Engl J Med 307:373-9.

11. Annest J, Dirkle J, Makuc C, Nesse J, Bayse D, Kovar M [1983]. Chronological trends in blood lead levels between 1976 and 1980. New Engl J Med 308:1373-7.

12. CDC [1991]. Strategic plan for the elimination of childhood lead poisoning. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control.

13. NIOSH [1978]. Occupational exposure to inorganic lead. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 78-158.

14. Code of Federal Regulations [1989]. OSHA lead standard. 29 CFR, Part 1910.1025. Washington, DC: U.S. Government Printing Office, Federal Register.

15. ATSDR [1990]. Toxicological profile for lead. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry. DHHS (ATSDR) Publication No. TP-88/17.

16. DHHS [1990]. Healthy people 2000: National health promotion and disease objectives. Washington, DC: U.S. Department of Health and Human Services, Public Health Service, DHHS Publication No. (PHS) 91-50212.

17. Grandjean, P and Bach, E [1986]. Indirect exposures: The significance of bystanders at work and at home. Am Ind Hyg Assoc J 47(12):819-824.

18. Alberti [1591 (1970)], cited by Bunch, C.C. Traumatic deafness. In E.P. Fowler, Jr. (Editor), Medicine of the ear, chapter X. Reprinted Translations of the Beltone Institute for Hearing Research, No. 23.

19. Ward WD [1986]. Anatomy & physiology of the ear: normal and damaged hearing. Chapter 5. In: Berger EH, Ward WD, Morrill JC, Royster LH, eds. Noise & hearing conservation manual. 4th ed. Akron, OH: American Industrial Hygiene Association, pp. 177-195.

20. Ward WD, Fleer RE, Glorig A [1961]. Characteristics of hearing loss produced by gunfire and by steady noise. Journal of Auditory Research, 1:325-356.

21. Code of Federal Regulations [1989]. OSHA. 29 CFR 1910.95. Washington, DC: U.S. Government Printing Office, Federal Register.

22. NIOSH [1972]. Criteria for a recommended standard: occupational exposure to noise. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Health Services and Mental Health Administration, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 73-11001.

23. ACGIH [1990]. 1990-1991 threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists.

24. Code of Federal Regulations [1992]. EPA. 40 CFR 261. Washington, DC: U.S. Government Printing Office, Federal Register.

25. NIOSH [1978]. Hazard evaluation and technical assistance report: Kansas City Federal Reserve Bank, Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, NIOSH Report No. HETA 81-019-846.

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