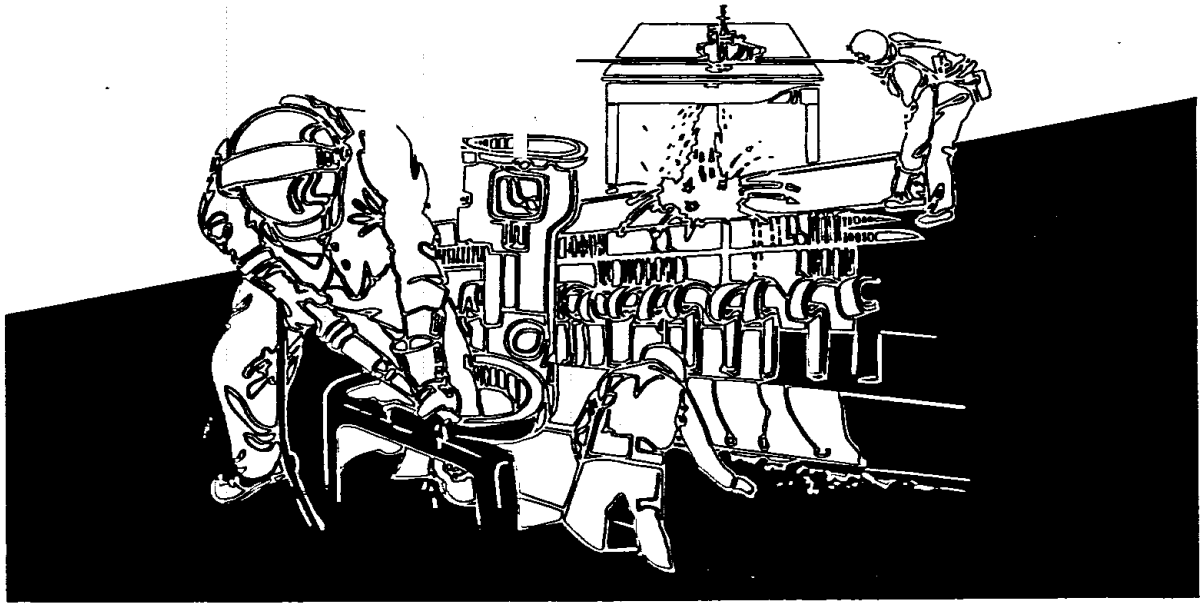
HEALTH HAZARD EVALUATION REPORT

HETA 91-161-2225
DENVER POLICE DEPARTMENT
DENVER, COLORADO



U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
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HETA 91-161-2225
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I. SUMMARY

In March 1991, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Denver Police Department for a health hazard evaluation of lead exposure in the indoor firing range during the firing of .45 caliber pistols. Police officers are required to qualify every 3 months with their service side-arm. The weapons most commonly carried are .38 caliber revolvers, .45 caliber pistols, and 9 mm pistols. The range was closed from 1985 - 1987 because of excessive lead exposure.

A NIOSH study conducted in 1988 found a mean air lead exposure of 10 micrograms per cubic meter (ug/m^3) among 15 police officers while firing .38 Special revolvers and 9 mm pistols with cartridges consisting of copper-jacketed bullets and non-lead primers. This data indicated that exposure could be kept below the OSHA permissible exposure limit for airborne lead of 50 ug/m^3 by using the modified ammunition.

Non-lead primers are not yet available for .45 caliber cartridges, therefore, further air sampling was requested from NIOSH. On March 25, 1991, NIOSH investigators measured ventilation rates and collected personal breathing-zone air samples on 10 officers during the firing of .45 caliber pistols. The rangemaster normally stays in an isolated control room outside the firing range during shooting.

Air lead exposures ranged from 1.0 to 16 ug/m^3 with a mean of 5.4 ug/m^3 during the 1991 NIOSH visit. There was a slight improvement in ventilation since the previous NIOSH study due to the removal of a 3-foot high partition along the floor on the firing line. However, there was still turbulent air flow across the entire firing line and backflow in some of the shooting booths.

Based on the results of this investigation, there was no health hazard from overexposure to lead at the time of the NIOSH visit. However, jacketed bullets, non-lead primers (when available), and administrative controls should continue to be used to minimize lead exposure until the ventilation system is substantially improved.

Keywords: SLC 9221 (police protection) indoor firing ranges, inorganic lead, ammunition, ventilation, followback.

II. INTRODUCTION

In March 1991, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Denver Police Department for a health hazard evaluation (HHE) of lead exposure in the indoor firing range during the firing of .45 caliber pistols using copper-jacketed bullets with conventional lead primers. A previous NIOSH HHE (HETA 88-029) conducted in 1988, showed that lead exposures could be kept below the OSHA Permissible Exposure Limit (PEL) by using jacketed bullets and non-lead primers in .38 and 9mm cartridges.[1] The police department requested that NIOSH conduct a followup assessment of lead exposure during the use of the different ammunition.

On March 25, 1991, NIOSH conducted air sampling and ventilation measurements during the required quarterly qualification course using .45 caliber pistols.

The air lead sample results and recommendations were provided to the police department in an interim report on April 8, 1991.

III. BACKGROUND

The firing range was closed from 1985 to 1987 because of excessive lead exposures during its use. Since the city planned to permanently close the facility, no funds were available for extensive improvements of the ventilation system. However, the Department speculated that the range could be used, if limited to non-lead ammunition. NIOSH has conducted studies[2] in several firing ranges where lead emissions from firing zinc bullets, copper-jacketed bullets, and nylon-jacketed bullets were compared with lead emissions from firing standard lead bullets. It was found that lead exposures could be greatly reduced by eliminating or isolating the major source of emission -- the lead bullet. The other source of lead in those studies was the cartridge primer, which contains lead styphnate.

Until recently there were no commercially available lead-free primers, thus, even when using jacketed or non-lead bullets it was possible for overexposures to occur in poorly ventilated firing ranges. In 1987, Fiocchi Corporation began marketing lead-free primers for small pistol cartridges, such as .38 Special and 9mm. However, non-lead primers are not yet commercially available for use in .45 caliber cartridges.

In 1988 NIOSH conducted a health hazard evaluation at the Denver Police Department indoor firing range and found numerous deficiencies in the ventilation system. However, it was concluded that lead exposures could be kept below the OSHA PEL by using jacketed bullets and non-lead primers. Eight-hour time-weighted average lead exposures among 15 officers ranged from 3 to 18 ug/m^3 with a mean of 10 ug/m^3. The NIOSH investigator concluded that the persistent emission of airborne lead, despite the use of non-lead ammunition, was most likely due to previous lead contamination of the weapons. Also, it was possible that lead from contaminated surfaces in the shooting booths could have become airborne from the muzzle blasts of the firearms.[1]

The firing range is about 80 feet long and 50 feet wide, and has 15 shooting booths. Air is supplied to the range through grills near the ceiling about 6 feet behind the firing line. Air is exhausted at the bullet trap and through ceiling grills about 10 feet in front of the firing line.

IV. METHODS

On March 25, 1991, NIOSH investigators obtained ventilation measurements and collected personal breathing-zone samples on 10 officers during 10 minutes of firing .45 caliber pistols. The rangemaster stayed in the isolated control room outside of the firing range during shooting. The officers completed the standard qualification course which consists of the timed firing of 42 rounds of ammunition. Officers are required to re-qualify every 3 months. Air samples were collected on AA filters at a flow rate of 2 liters per minute and analyzed for lead using atomic absorption spectroscopy according to NIOSH Method 7105.[3] Air velocities at the firing line were measured with a Kurz Mini Anemometer Model 490.

V. EVALUATION CRITERIA

Environmental

As a guide to the evaluation of the hazard posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for 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 form 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 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 evaluation 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 Criteria Documents and recommended exposure limits (RELs), 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs), and 3) the U.S. Department of Labor (OSHA) occupational health standards. The OSHA standards may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH RELs, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA standard.

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 (STELs) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures. A brief discussion of the toxicity and evaluation criteria for inorganic lead follows:

1. Inorganic Lead

Inhalation (breathing) of lead dust and fume is the major route of lead exposure in the industrial setting. A secondary source of exposure maybe from ingestion

(swallowing) of lead dust deposited on food, cigarettes, or other objects. Once absorbed, lead is excreted from the body very slowly. Absorbed lead can damage the peripheral and central nervous systems, gastrointestinal system, kidneys, reproductive system, hematopoietic system (blood forming organs), and virtually all other systems of the body.[4] The acute effects may manifest as weakness, tiredness, irritability, reduced intelligence, slowed reaction times, abdominal pain, or high blood pressure.[5] Chronic lead exposure can cause infertility, kidney damage, and, in pregnant women, fetal damage manifested as prematurity, reduced birth weight, reduced red blood cell production, and reduced intelligence.[6-10] The blood lead test is one measure of the amount of lead in the body and is the best available measure of recent lead absorption. The mean serum lead level for US men between 1976 and 1980 was 16 ug/dl;[11-12] however, with the implementation of lead-free gasoline and reduced lead in food, the 1991 average serum lead level of US men will probably drop below 9 ug/dl.[4] A summary of the lowest observable effect levels of lead are listed in Table 1.

2. Medical Surveillance

Even with adequate worker education on the adverse health effects of lead and appropriate training in work practices, personal hygiene, and other control measures, the physician has an important responsibility for evaluating and treating individuals with lead poisoning. Early detection of lead poisoning is critical to prevent its toxic effects, some of which are irreversible. Potential lead poisoning can be assessed with a careful medical history, work history, physical examination, and laboratory testing. Lead can be measured in the blood and the health effects of various blood lead levels (BLL) has been elucidated. BLL, therefore, can serve as a valuable screening test for individuals at risk for lead poisoning. Adverse health effects have been associated with BLL above 40 ug/dl in adults, and OSHA requires subsequent BLL monitoring of these individuals.[13]

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 ug/dl to 51 ug/dl (range 31-73).[14] 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 ug/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. According to the OSHA lead standard, if an employee's BLL is $\geq$40 ug/dl, the employee must have his blood lead checked every 2 months. If an employee's BLL averages 50 ug/dl or more, they must be removed from areas containing more than 30 ug/M^3 airborne lead, and have monthly BLL. For employees removed from lead exposure, the OSHA lead standard requires the employer to maintain the earnings, seniority, and other employment rights and benefits of an employee as though the employee had not been removed. For an employee to return to work in the area with excessive lead exposure, their BLL must be below 40 ug/dl on two consecutive tests if the original BLL was between 50-60, or drop at least 20 ug/dl on two consecutive tests if the original BLL was greater than 60. The blood samples must be analyzed by a laboratory that has been approved by OSHA.[15]

3. Occupational Exposure Criteria

The current OSHA PEL for airborne lead is 50 ug/m^3 calculated as an 8-hour TWA for daily exposure.[13] In addition, the OSHA lead standard establishes an "action level" of 30 ug/m^3 TWA which initiates several requirements of the standard, including periodic exposure monitoring, medical surveillance, and training and education. If the initial determination shows that any employee's 8-hr TWA PBZ results are above 30 ug/m^3, air monitoring must be performed every six months until the results show two consecutive levels of less than 30 ug/m^3. (measured at least seven days apart).[13] NIOSH is currently evaluating the health effects of lead exposure to determine if new exposure recommendations are needed to protect workers' health.

VI. RESULTS AND DISCUSSION

Lead Exposure

Eight-hour time-weighted average air lead exposures ranged from 1.0 to 16 ug/m^3 with a mean of 5.4 ug/m^3 on the day of our visit (Table 2). The OSHA PEL is 50 ug/m^3. These results

indicate that the range may be used for officers qualifying with .45 caliber ammunition containing jacketed bullets and lead primers. However, firing range officials should continue to limit their firing range exposure by using the enclosed control room as much as possible during firing.

Ventilation

Ventilation measurements showed that air velocities across the firing line ranged up to 200 feet per minute. Smoke tube observations revealed excessive turbulence in all of the shooting booths and back flow in some of the booths. There was less turbulence in the air flow after tearing down a 3-feet high partition along the floor on the firing line. However, backflows still existed in Shooting Booth numbers 2, 10, and 13. Therefore, these booths should not be used until further improvements in the ventilation are completed.

VII. CONCLUSION

There was no health hazard from overexposure to lead at the time of the NIOSH visit. However, jacketed bullets, non-lead primers, and administrative controls should continue to be used to keep lead exposure as low as possible.

VIII. RECOMMENDATIONS

Ventilation

The location and shape of the air inlet is crucial to the efficient functioning of the ventilation system.[16] The problem with many inlet designs is that the resulting air flow pattern in the IFR contains one or more air jets (column of rapidly moving air) extending from the inlet to a position downrange of the firing line. Because the jet entrains air from the surrounding atmosphere, a negative pressure region forms beside this jet. This low pressure zone usually pulls down-range air back to the inlet, mixes the down-range air with the clean air, and results in contaminated air at all points in the IFR. Slot or rectangular inlets, for example, located in the back wall of the IFR, which occupy significantly less than the full cross-sectional area of the wall, will probably always lead to adverse formation of air jets. Even air inlets covering the whole back wall may have flow nonuniformities which result in jet formation.[16]

A double open pegboard inlet has been shown to produce an air flow pattern free of backflow. The double open pegboard is installed as the outlet to a plenum extending over the entire cross-section of the IFR (Figure 1).[16] The double panels most commonly used are standard 1/4 inch-thick perforated hardboard. Other panels with at least as much flow resistance should also be acceptable. The separation of the panels should be large enough that the jets produced by adjacent holes in the first panel merge before the second panel is reached (at least 5 inches for 1/4 inch pegboard). Two or more jets produced by adjacent holes having a diameter "D" and a separation between hole edges of "3D" will be essentially merged at a distance of "20D" from their point of origin. The panels should be supported in such a way that air is free to move laterally between the panels. Installation of the panels on a stud wall with offset studs is one acceptable approach. The panels can be made of transparent material in locations where visibility is necessary. Also, a perforated door can be installed in an otherwise conventional manner with no significant degradation of its performance. A double door is not necessary.[16]

Access should be provided for maintenance, cleaning, inspection, etc., inside the plenum. A plenum depth of 18 inches provides for adequate air flow. The air inlet(s) to the plenum should be distributed for highest reliability. For example, a slot extending the width of the plenum works well. Individual inlets located in the plenum's ceiling or back wall and spaced at 4 foot intervals or less should also work well. The plenum and its associated supply duct work should be sealed so that leaks from these sources do not adversely affect the air flow pattern at critical points in the IFR.[16]

Hygiene Practices

Food, beverages, or tobacco products should not be used or stored in or near the indoor firing range. These items can become contaminated with lead and cause subsequent absorption of lead through inhalation or ingestion during eating, drinking, or smoking. All workers exposed to lead should wash their hands and faces before eating, drinking, or smoking. Also, users of the range should be instructed to wash after shooting, after handling fired cartridge cases, and after cleaning weapons.

IX. REFERENCES

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3. NIOSH Regional Offices/Divisions
4. Denver County Health Department

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TABLE 1
Summary of Lowest Observed Effect Levels for
Key Lead-Induced Health Effects in Adults and Children[@]

BLL[*] (ug/dl)		HEALTH EFFECT
>100	Adults:	Encephopathic signs and symptoms
>80	Adults:	Anemia
	Children:	Encephopathic signs and symptoms Chronic nephropathy (aminoaciduria, etc)
>70	Adults:	Clinically evident peripheral neuropathy
	Children:	Colic and other Gastro-Intestinal (GI) symptoms
>60	Adults:	Female reproductive effects CNS symptoms: sleep disturbances, mood changes, memory and concentration problems, headache.
>50	Adults:	Decrease hemoglobin production Decreased performance on neurobehavioral tests Altered testicular function GI symptoms: abdominal pain, constipation, diarrhea, nausea, anorexia.
	Children:	Peripheral neuropathy
>40	Adults:	Decrease peripheral nerve conduction Elevated blood pressure (white males, 40-59 years old) Chronic nephropathy
	Children:	Reduced hemoglobin synthesis
>25	Adults:	Elevated erythrocyte protoporphyrin levels in males
15-25	Adults:	Elevated erythrocyte protoporphyrin levels in females
	Children:	Decreased IQ and Growth
>10[**]	Fetus:	Pre-term Delivery Impaired Learning Reduced Birth Weight Impaired Mental Ability

[@]Adopted from ATSDR[6].
[*]Blood Lead Level (BLL) in micrograms per deciliter (ug/dl)
[**]Current research has not defined a "safe" level for fetuses.

TABLE 2
Air Lead Exposure (ug/m^3)
Denver Police Department
Denver, Colorado
HETA 91-161
March 25, 1991

Shooting Booth #	Sampling Time	Lead Concentration	Lead 8-hour TWA Concentration
3	0939 - 0949	500	10
4	0939 - 0949	320	6.7
5	0939 - 0949	215	4.5
6	0939 - 0949	750	16
7	0939 - 0949	285	5.9
8	0939 - 0949	150	3.1
9	0939 - 0949	150	3.1
11	0939 - 0949	50	1.0
12	0939 - 0949	150	3.1
14	0939 - 0949	50	1.0
Evaluation Criterion			50

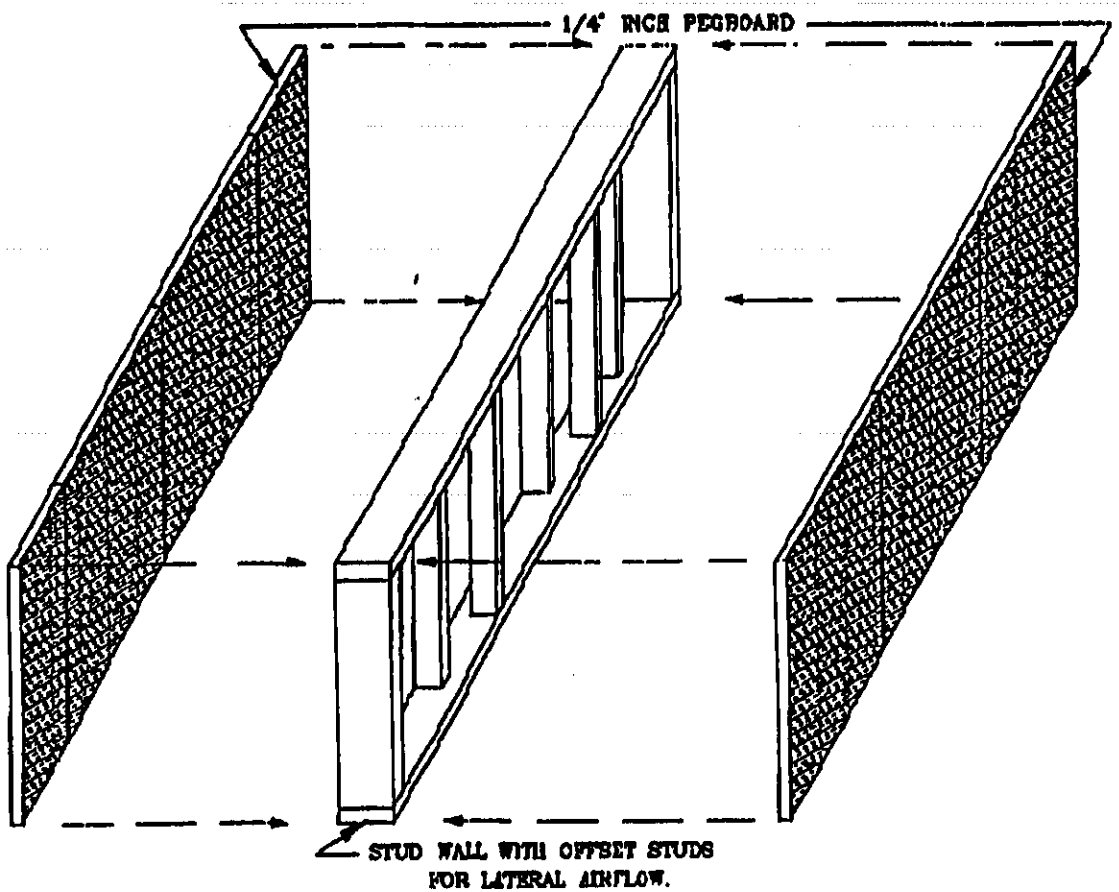

Figure 1. Double open pegboard inlet construction details.