REGION-2

PB82-188962

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

HAZARD EVALUATION AND TECHNICAL ASSISTANCE
REPORT NO. TA 78-48

PLAINFIELD POLICE DIVISION FIRING RANGE
200 East 4th Street
PLAINFIELD, NEW JERSEY 07060

JANUARY 1979

Study Requested By:
Chief, Police Division
Plainfield, New Jersey

Report Written by:
William A. Evans
Industrial Hygienist
Industrial Hygiene Section
Hazard Evaluation and Technical Assistance Branch
NIOSH, Cincinnati, Ohio

Study Dates August 10-11, 1978

50272-101

NIOSH 00114544

REPORT DOCUMENTATION PAGE	1. REPORT NO. TA-78-48	2. NA	3. Recipient's Accession No.

4. Title and Subtitle
Technical Assistance Report No. TA-78-48, Plainsfield Police Division Firing Range, Plainsfield, New Jersey

5. Report Date
January 1979

6. NA

7. Author(s)
Evans, W. A.

8. Performing Organization Rept. No.
NA

9. Performing Organization Name and Address
Hazard Evaluation and Technical Assistance Branch, Division of Surveillance, Hazard Evaluations, and Field Studies, NIOSH, Cincinnati, Ohio

10. Project/Task/Work Unit No.
NA

11. Contract(C) or Grant(G) No.
(C)
(G)

12. Sponsoring Organization Name and Address
Same as Above

13. Type of Report & Period Covered
Technical Assistance
August 1978

14. NA

15. Supplementary Notes
NA

16. Abstract (Limit: 200 words)

Environmental and personal air samples were analyzed and ventilation was measured at the indoor firing range of the Plainfield, New Jersey, Police Division headquarters (SIC-9221) on August 10 and 11, 1978, to determine exposures to lead (7439921) during firing and to evaluate the range design. The evaluation was requested by the Chief of Police on behalf of about 120 Division officers and 8 or 9 range officers. Personal samples for shooters contained 1,000 to 6,400 micrograms per cubic meter (micrograms/cu m) of lead during firing. Personal samples for range officers contained 560 to 3,000 micrograms/cu m of lead during combat firing and 600 micrograms/cu m during bullseye firing. Area air samples ranged from 400 to 37,000 micrograms/cu m of lead during firing and from 100 to 2,000 micrograms/cu m during the first half hour after firing ceased. Average air velocity across shooting positions ranged from 20 to 50 feet per minute, for an air supply of 1,200 cubic feet per minute (cfm) to the firing line and air exhaust of 3800cfm from the range. The investigators note that the OSHA standard for inorganic lead is an 8 hour time weighted average concentration of 200 micrograms/cu m. They concluded that range officers were exposed to excessive lead concentrations. They recommend changes in design considerations and work practices to reduce lead concentrations in indoor firing ranges.

17. Document Analysis a. Descriptors

Hazards-confirmed, Air-sampling, Heavy-metals, Health-surveys, Explosives, Air-contaminants

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement
Available to Public

19. Security Class (This Report) NA

20. Security Class (This Page)

21. No. of Pages 1

22. Price

(ANSI-239.18) See Instructions on Reverse OPTIONAL FORM 272 (4

I. SUMMARY

On August 10-11, 1978, an industrial hygiene survey was conducted at the indoor firing range at the Plainfield, New Jersey, Police Division headquarters. The study was conducted by the Industrial Hygiene Section of the Hazard Evaluations and Technical Assistance Branch of the Division of Surveillance, Hazard Evaluations, and Field Studies of the National Institute for Occupational Safety and Health (NIOSH). The purpose of the survey was to evaluate the extent of exposure of shooters to inorganic lead generated during firing, and to evaluate the design of the range.

A total of forty-one air samples were collected for inorganic lead, fourteen of which were personal samples and twenty-seven of which were area samples. Personal samples of shooters ranged from a low of 1,000 micrograms of lead per cubic meter of air (ug/M^3) to a high of 6400 ug/M^3. The range officer was exposed to concentrations of 560 and 3,000 ug/M^3 during combat firing and 600 ug/M^3 during bullseye firing. Since the NIOSH recommended environmental criteria is 100 ug/M^3, it can be concluded that range officers are being overexposed to lead. A well designed range should keep lead levels below this criteria at all times.

Average air velocity measurments across the shooting positions ranged from 20-50 feet per minute (fpm). At least 50 fpm is needed to keep lead concentrations at acceptable levels. With the current air flow, approximately 1200 cubic feet per minute (cfm) is being supplied to the entire firing line and 3800 cfm is being exhausted from the range. Based on 50 fpm distributed evenly across the firing line, 8400 cfm should be supplied to the range and 9200 cfm should be exhausted.

Only a few recommendations from the publication HEW (NIOSH) No. 76-130, Lead Exposure and Design Considerations for Indoor Firing Ranges, are currently being followed. These recommendations and others can be found in the body of this report.

I. INTRODUCTION AND PURPOSE

On August 10-11, 1978, at the request of the Chief, Police Division, Plainfield, New Jersey, an industrial hygiene survey was conducted at the Division's indoor firing range. The purpose of the survey was to evaluate the extent of exposure of shooters to inorganic lead during firing, and to evaluate the design of the range.

III. EVALUATION

A. DESCRIPTION OF FACILITY

The firing range is housed in the basement of the Police Division in Plainfield, New Jersey. The range facility occupies a room measuring 85 feet long by 21 feet wide; the range is approximately 7 1/2 feet high from the firing booths to the rear wall, and nine feet high from the booths to the bullet backstop. The actual firing range is 75 feet long, 21 feet wide, and 9 feet high.

There are five firing booths with each booth approximately four feet wide, 7 1/2 feet high, and 2 feet long. The booths are located approximately ten feet from the rear wall and air supply inlets. The air inlets are in the ceiling. Exhaust ducts are located approximately one foot downrange from the booths and approximately midrange on the left hand side wall. Each booth is equipped with an automatically controlled target setter. The range is equipped with a metal backstop with a sand bottom.

This indoor firing range is used by approximately 120 officers of the Division who are required to qualify semi-annually with a service revolver. There is a total of 8-9 range officers, one who must be present in the range during each qualification. This tactical revolver course (or combat course) usually involves two officers and one range officer, the former firing 50 rounds of .38 special 148 grain midrange wadcutter ammunition. Each qualifying session takes approximately 1/2 hour, with officers firing at various positions between the booths and backstop.

The police pistol league also uses the range once or twice per week with all five shooting positions occupied. The competition may take approximately one hour with each member firing 30 rounds at bullseye targets from the booths. The assigned range officer may spend a total of two hours in the range at this time.

B. ENVIRONMENTAL STUDY PROCEDURES AND INSTRUMENTATION

Atmospheric samples for lead were collected on mixed cellulose ester filters with 0.8 micron pore size. The filters were encased in plastic three-piece field monitor cassettes with face caps on and small plugs removed. The personal samples were taken in the shooter's breathing zone using battery powered pumps operating at flow rates of 1.5 liters per minute. The pumps and samples were worn by the shooters. Area samples were taken using the same pumps, using the same type of filter and operating at the same flow rate. The samples were analyzed using atomic absorption spectrophotometry.

Ventilation measurements were taken using a thermoanemometer and smoke tubes.

C. TOXICOLOGY AND EVALUATION CRITERIA

Lead poisoning may occur through the inhalation and/or ingestion of lead fumes or dust. This results in the disposition of lead in the bones and tissues of the body and alterations in normal physiological functions.

No single sign or symptom may be considered diagnostic of lead poisoning. Lead poisoning may present such symptoms as a metallic taste in the mouth, loss of appetite, indigestion, nausea, vomiting, constipation, abdominal cramps, nervousness, and insomnia.

Repeated exposure to lead can result in accumulation in the amount of lead stored in the body. Continued chronic exposures to high levels of lead, even intermittent, can cause death or permanent damage to the nervous system, serious damage to the kidneys and impairment of red blood cell production. Once the kidneys are damaged by lead, the ability of the body to excrete lead through the kidneys is impaired, thus making lead in urine a poor screening test for lead absorption.

Workers exposed to excessive levels of lead may feel weak, tired, and irritable. They may experience trembling, severe colic and digestive disturbances, and convulsions. A characteristic sign of severe lead poisoning is "wrist drop", caused by damage to the nerves controlling the extensor muscles of the forearm, wrist and fingers.

Of considerable concern are the effects resulting from long-term lead exposure. There is evidence that prolonged exposure can increase the risk of nephritis, mental deficiency premature aging, and high blood pressure.

Another category of adverse effects includes the so-called "subclinical" changes produced by lower exposures to lead. These changes are generally measured only by laboratory tests and would not necessarily be evident by routine physical examination. The workers may have early damage to the nervous system, muscular weakness, behavorial disturbances, and interference with red blood cell production. The use of the term "subclinical", however, does not mean that these changes are without significance from a health point of view. Many of the sources of lead poisoning are industrial, but man also absorbs lead in small amounts not normally leading to poisoning from his food and water, and from the air. These sources lead to the "normal" body burden of lead. Goldwater and Hoover have reported a worldwide blood lead mean of 17 micrograms of lead per 100 milliliters of whole blood (ug/100 ml)*. Thus, the lead absorbed in the course of occupational exposure is superimposed on lead absorbed from other sources. Lead poisoning is preceded by a stage of lead absorption, but lead absorption is not always followed by lead poisoning.

Airborne exposure limits for inorganic lead have been recommended or promulgated by several sources. For this study the criteria used to assess the degree of health hazards were collected from three sources:

1. NIOSH: Revised Criteria for a Recommended Standard ... Occupational Exposure to Inorganic Lead, 1978.

2. Threshold Limit Values (TLV): Guidelines for airborne exposures recommended by the American Conference of Governmental Industrial Hygienists (ACGIH) for 1977.

3. OSHA Standard: The air contaminant standard for inorganic lead enforced by the Occupational Safety and Health Administration (OSHA) of the U.S. Department of Labor and found in the Federal Register - CFR 1910.1000 (b) (Table Z-2), and 1975 proposal.

Source	8-Hour Time Weighted Average Concentration (TWA)[1]	Acceptable Ceiling Concentration[2]
NIOSH Revised Criteria Document - 1978	100 ug/M^3 3	----
OSHA Standard Present	200 ug/M^3	----
OSHA Standard Proposed - 1975	100 ug/M^3	----
1978 TLV	150	450 ug/M^3

1 - USDOL employee exposure standards are based on a computed time weighted average exposure during any eight-hour work shift or a 40-hour work week. The standard represents conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse effects.

2 - This value should never be exceeded during a commonly used 15 minute sampling period.

3 - ug/M^3 = micrograms of lead per cubic meter of air (1 ug = 0.001 milligrams).

*Goldwater, I.M. and Hoover, A.W.: An international study of "normal" levels of lead in blood and urine. Arch. Environ. Health, 15: 60-63, 1967.

IV. DISCUSSION OF RESULTS

A. VENTILATION

The ventilation system for the range did not contain an air supply fan, only exhaust fans. In the range design, air is "supposed" to enter the range through three ceiling inlets near the rear wall, from duct-work which leads to the hallway outside the range. The inlets are approximately ten feet behind the firing line and measure 24 inches by 25 inches. A total of five ventilation measurements were taken of each inlet and an average taken of these readings.

The exhaust air system consisted of five grills (10 inch by 10 inch) located in the ceiling approximately one foot downrange of the firing booths, and one exhaust grill (2 feet by 2 feet) on the left side wall approximately five feet beyond midrange. A total of five ventilation measurements were taken of each ceiling exhaust grill, and nine measurements of the side exhaust grill. An average reading was determined for each grill.

A total of nine ventilation measurements were taken at each booth in the four foot space above the table top (at breathing zone height and two feet above and below it). This was done to determine the average air flow across each booth.

Table 1 illustrates the results of ventilation measurements. The calculated total air supply from the inlets behind the firing line was approximately 1200 cubic feet of air per minute (CFM). The calculated total exhaust air was approximately 3800 CFM (50% from each exhaust location).

Based on a design air flow of 50 feet of air per minute (fpm) across the firing line, 8400 CFM should be supplied into the range and 9200 CFM should be exhausted from the range. These calculations are based on the assumption that the entire cross sectional area of the firing booths is available for air movement (approximately 168 square feet). None of these criteria are being met.

Additionally, average air velocity measurements across the shooting booths ranged from 20-50 fpm. A uniform air velocity ranging from 50-75 fpm is needed to keep lead concentrations at acceptable levels. As a consequence of turbulence, it was frequently possible to observe smoke generated during firing travel backwards into the breathing zone of shooters. Velocity measurements taken in between the booths and trap, where most of the qualifications occur, ranged from only 5 - 20 fpm.

The exhaust fans are not capable of bringing in supply air to the range from areas outside the range. This "negative pressure" condition increases the static pressure which the exhaust fans must try to overcome. The range should have a mechanical supply air system separate from the exhaust system.

B. ENVIRONMENTAL SAMPLING

The results of personal and area air sampling for inorganic lead are illustrated in Tables 2 and 3, respectively. A total of 41 air samples were collected, 14 of which were personal samples and 27 of which were area samples. Shooters were exposed to concentrations ranging from 1,000 micrograms of lead per cubic meter of air (ug/M^3) to 6400 ug/M^3, while the range instructor was exposed to concentrations of 560 and 3,000 ug/M^3 during qualifications of two police officers, and 600 ug/M^3 during bullseye shooting with five officers. This difference is probably due to the fact that the range officer during qualifications spends much time downrange where the air movement is almost non-existant. A well designed range should keep lead concentrations below the NIOSH recommended standard of 100 ug/M^3 at all times. In fact, the range officer during the first qualification was exposed to a calculated 8 hour time weighted average concentration of 170 ug/M^3, a value exceeding the criteria.

Area air samples ranged from 400 - 3700 ug/M^3 of lead in the range during qualifications firing. Samples taken after firing had ceased, to determine the purging effect of the ventilation system, ranged from 100 - 2200 ug/M^3. This range indicates that lead was still present in the range at least 30 minutes after firing had ceased. Area samples collected during bullseye firing, when all shooters were at the firing line, were similar to the qualifications firing. They ranged from 200 - 2400 ug/M^3 during firing and 100 - 300 ug/M^3 during the half hour period after firing had ceased. Thus, tripling the total number of rounds fired, did not seem to affect the concentration of lead.

V. RECOMMENDATIONS

It is recommended that the cabinet section below each firing booth be removed to allow air movement through the entire cross sectional area of the firing line. If this is not done and the supply air increased to 50-75 fpm with the present configuration, the air velocity through the larger cross sectional area downrange would still not be sufficient to convey lead particles.

All of the recommendations listed in HEW Publication No. (NIOSH) 76-130, Lead Exposure and Design Considerations for Indoor Firing Ranges, are presented here.

To reduce and/or eliminate the health hazards associated with indoor firing ranges the following design considerations and work practices are recommended.

A. Design Considerations

1. An optimum air supply would be 75 fpm at the firing line. The minimum air supply must be 50 fpm at the firing line.

2. Filtered and conditioned air should be introduced behind the firing line to guarantee an evenly distributed flow of air through the shooting positions.

3. Supplied air inlets should be placed approximately 15 feet behind the shooter's position.

4. The entire range facility should be maintained at a slightly negative pressure with respect to adjacent areas to prevent the escape of contaminants. This criteria suggests that exhaust air should exceed supplied air by 10 percent.

5. For maximum efficiency exhaust ducts should be located behind and at the apex of the bullet trap. An alternative location is to place the exhaust ducts on the side walls slightly in front of the apex of the bullet trap.

6. A minimum downrange conveying velocity of 35 fpm must be maintained.

7. When the 75 fpm rate is used a minimum of 25% of the air should be exhausted 15-20 feet downrange of shooting position and remaining 75 percent at the bullet trap.

8. When the 50 fpm rate is used, 100 percent of the air should be exhausted downrange at the bullet trap.

9. A range should have its own ventilation system to prevent the circulation of contaminated air to other areas of the building.

10. The supply and exhaust systems must be electrically interlocked, thereby eliminating an error in turning one system on and not the other. The system should operate on one fan speed only and not on variable speed fans.

11. Each range should be equipped with a floor drain and trap to facilitate cleaning by wet methods. The drain location should be approximately 20 feet downrange of the firing line. The floor should slope 2-3 inches toward the drain.

12. To minimize the effect of peak sound pressure levels on individuals in the indoor range all reflecting walls should be covered with high efficiency sound absorbing material such as fiberglass insulation covered with perforated aluminum or steel sheets with openings equivalent to 10-15 percent of the area to permit sound absorption. The coverings should be designed to permit easy access to the acoustical material for periodic replacement. The floors directly behind the shooting booths should be covered with acoustical flooring (carpet that has good acoustical absorption characteristics).

13. Range officer quarters should be acoustically treated to reduce noise levels.

14. The bullet trap or back stop should never be anchored or attached to any structural support for the building. The energy of the bullet striking the trap can be transmitted as noise and vibration through-out the building.

15. The walls and surroundings should be painted in soft, contrasting pastel colors to reduce the dungeon-like effect.

16. The range should be equipped with range officers quarters, areas for cleaning of weapons and storing materials, and with toilet and washing facilities.

17. All air being exhausted from the range should be filtered using a High Efficiency Particulate Filter (HEPA) or equivalent.

B. Work Practices

1. The ventilation system should be in operation at all times while the range is in use and during clean up.

2. Sweeping the range should be accomplished by vacuum cleaning or wet methods. Use of a hand broom, even with dust suppression compounds, should be prohibited.

3. At all times while cleaning, repairing, or reclaiming lead in the bullet trap, a NIOSH approved respirator for the removal of lead dust and fumes must be worn.

4. Proper ear protection should be provided for and worn by all individuals inside the firing area. The ear protectors should be selected on the basis on offering maximum protection.

5. Ear plugs when worn must be properly fitted.

6. In case of extremely loud weapons, both plugs and muffs should be worn simultaneously.

7. A hearing conservation program should be instituted and yearly audiometric examinations given.

8. A rotation system should be instituted for the range officer position. It is suggested that one month of duty be followed by three months of alternate activity. This change is suggested not only to alleviate any possible lead absorption and prevent its accumulation, since this should be minimal following the engineering changes, but to prevent undue psychological stresses associated with the position.

9. Eating, drinking, and smoking in the range should be prohibited.

10. A specific schedule must be established to perform maintenance and repair work to keep the range facilities operational and free of hazardous conditions.

C. Medical

Employees should have at least an annual blood lead determination. NIOSH recommends a blood level of 60 ug/100 g whole blood or lower as a safe level.

VI. ACKNOWLEDGEMENTS

Study Conducted By:

Mr. William Evans
Industrial Hygienist
Mr. Richard Duncan
Co-op Student
Industrial Hygiene Section
Hazard Evaluations and
Technical Assistance Branch
Cincinnati, Ohio

Report Typed By:

Dorothy Marshall
Linda Morris
Clerk-Typists
Industrial Hygiene Section
Hazard Evaluations and
Technical Assistance Branch
Cincinnati, Ohio

Table 1

POLICE DIVISION
PLAINFIELD, NEW JERSEY

Indoor Firing Range

August 10, 1978

VENTILATION MEASUREMENTS

- SUPPLY AIR -

LOCATION	CALCULATED: CFM[1]
Ceiling Inlet #1	450
" " #2	270
" " #3	480
TOTAL CALCULATED CFM:	1200
TOTAL REQUIRED CFM:[2]	8400

- EXHAUST AIR -

LOCATION	CALCULATED CFM
Ceiling Grill #1	710
" " #2	480
" " #3	320
" " #4	180
" " #5	120
Side Wall Grill	2040
TOTAL CALCULATED CFM:	3850
TOTAL REQUIRED CFM:	9240

- AIR FLOW ACROSS FIRING BOOTHS -

LOCATION	MEASURED FPM[3]	CALCULATED CFM
Booth 1	34	540
2	27	430
3	33	530
4	36	580
5	46	740
TOTAL MEASURED CFM:		2820

1 - CFM = cubic feet of air per minute.
2 - Required CFM based on 50 fpm at firing line.
3 - FPM = feet of air per minute.

Table 2

POLICE DIVISION
PLAINFIELD, NEW JERSEY

Indoor Firing Range

August 11, 1978

PERSONAL SAMPLE RESULTS FOR INORGANIC LEAD

BOOTH NUMBER	NO. ROUNDS FIRED	SAMPLE NUMBER	SAMPLING TIME	LEAD CONCE (ug/M^3)*
Range Officer	--	6	9:43a - 10:10a	3000
Police Officer	50	4	"	4400
Police Officer	50	7	"	6400
Range Officer	--	11	10:10a - 11:20a	560
Police Officer	50	12	10:10a - 10:50a	-- **
Police Officer	50	13	10:10a - 10:50a	1000
Police Officer	50	23	10:50a - 11:20a	1400
Police Officer	50	24	10:50a - 11:20a	1300
Range Officer	--	38	12:05p - 12:45p	600
Police Officer (Booth 1)	60	29	12:05p - 12:36p	2000
" " (" 2)	60	30	"	3900
" " (" 3)	60	37	"	2800
" " (" 4)	60	32	"	1400
" " (" 5)	60	33	"	1200

HYGIENIC CRITERIA NIOSH AND OSHA - 100 ug/M^3 TLV - 150 ug/M^3

* ug/M^3 = MICROGRAMS of lead per cubic meter of air

** SAMPLE LOST

Table 3

POLICE DIVISION
PLAINFIELD, NEW JERSEY

Indoor Firing Range

August 11, 1978

AREA AIR SAMPLES FOR INORGANIC LEAD

LOCATION	NO. ROUNDS FIRED	SAMPLE NUMBER	SAMPLING TIME	LEAD CONCE (ug/M^3)*
AREA 1:				
Near 20 yard mark on right side of range	100	3	9:43am-9:55am	3700
AREA 2:				
Near yellow 15 yard mark about 6 feet high at range center	100	2	" "	1500
AREA 3:				
About 14 feet from sand trap on left side of range	100	1	" "	2200
AREA 1	0	10	9:55am-10:10am	2200
" 2	0	8	" "	950
" 3	0	9	" "	1700
AREA 1	100	16	10:10a-10:25a	1700
" 2	100	15	" "	700
" 3	100	14	" "	2000
AREA 1	0	20	10:25a-10:50a	800
" 2	0	22	" "	100
" 3	0	21	" "	400
AREA 1	100	17	10:50a-11:05a	1200
" 2	100	18	" "	500
" 3	100	19	" "	2500
BOOTH 3	100	5	10:50a-11:20a	400
AREA 1	0	25	11:05a-11:35a	700
" 2	0	26	" "	100
" 3	0	27	" "	300
BOOTH 2	300	36	12:05p-12:35p	2400
" 4	300	34	" "	1500
Podium behind firing line on side	300	35	" "	200
Rear table behind firing line	300	31	" "	600
BOOTH 2	0	39	12:35p-1:05p	300
BOOTH 4	0	44	" "	200
Podium behind firing line on side	0	47	" "	200
Rear table behind firing line	0	43	" "	100

Hygienic Criteria NIOSH and OSHA - 100 ug/M^3 TLV - 150 ug/M^3

*ug/M^3 = Micrograms of lead per cubic meter of air