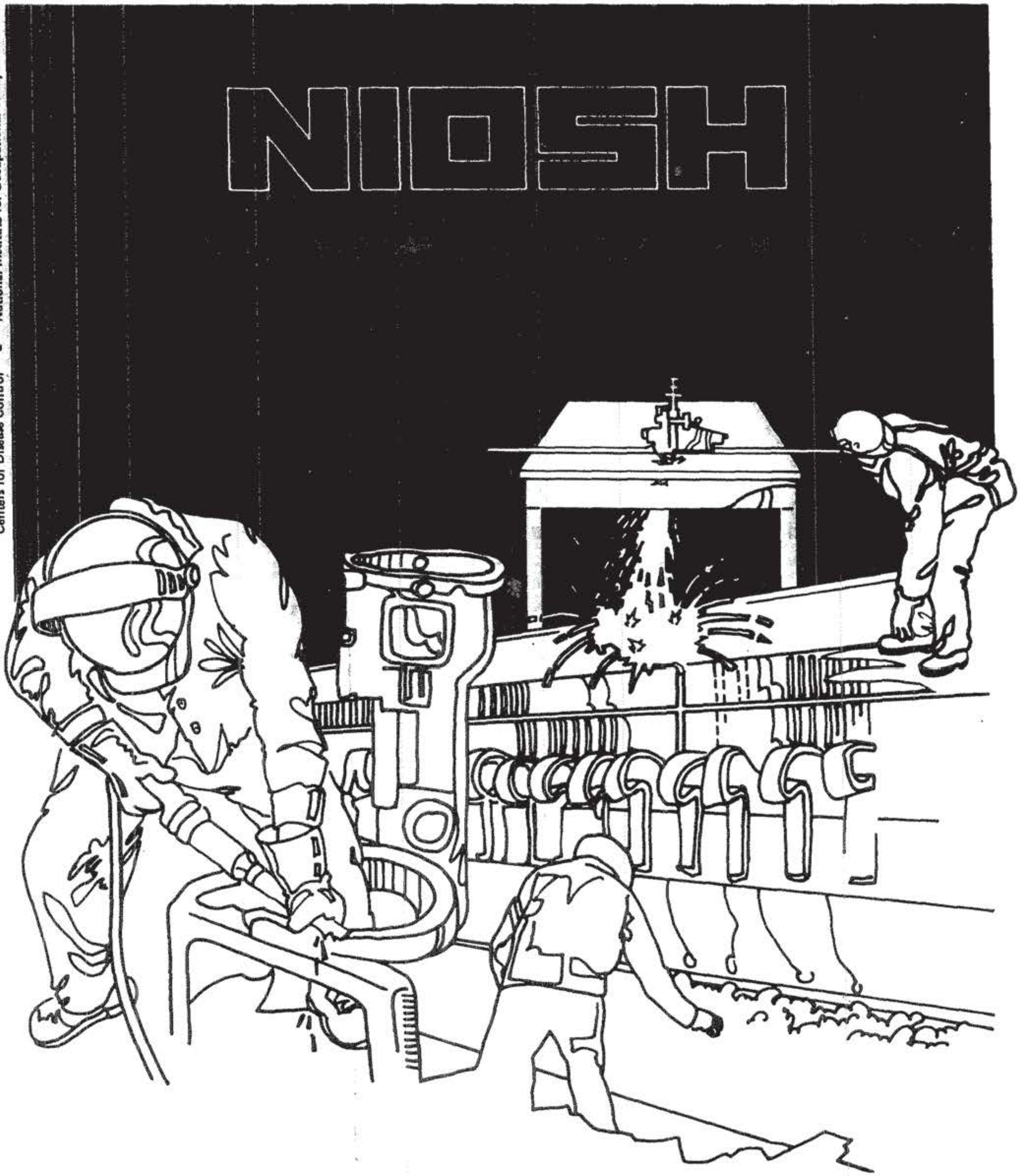
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HETA 81-470-1040
FEDERAL RESERVE BANK
CINCINNATI, OHIO

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

HETA 81-470-1040
FEBRUARY 1982
FEDERAL RESERVE BANK
CINCINNATI, OHIO

NIOSH INVESTIGATOR:
Steven A. Lee, I.H.

I. SUMMARY

In September 1981, the National Institute for Occupational Safety and Health (NIOSH) received a request from the management of the Cincinnati Branch of the Federal Reserve Bank to evaluate lead exposure among bank guards during indoor shooting practice and qualification exercises. NIOSH conducted an environmental survey on October 6, 1981. Seven personal breathing zone air samples were taken on guards while they were firing .38-special zinc wadcutter ammunition. Ventilation measurements were also taken to evaluate the design of the indoor range.

One shooter was exposed to lead at an 8-hour time-weighted average (TWA) concentration of 4.0 micrograms per cubic meter (ug/m^3) and five shooters were exposed to levels that were below the analytical limits of detection (about 3.0 ug/m^3). Shooters were exposed to zinc at TWA concentrations ranging from 3.0 to 20 ug/m^3. The rangemaster was exposed to TWA concentrations of lead at 3.0 ug/m^3 and zinc at 10 ug/m^3. The OSHA standards for inorganic lead and zinc oxide are 50 ug/m^3 and 5000 ug/m^3, respectively.

The ventilation system was found to be imbalanced as there was a much greater volume of air being supplied to the range [7000 cubic feet per minute (cfm)] versus what was being properly exhausted (520 cfm). Airflow at the firing line was erratic and turbulent.

This study provided a valuable comparison of lead emissions from lead versus zinc bullet ammunition. NIOSH studies of the same range in 1975 and in 1980 when typical lead target bullets were in use under similar range conditions showed that shooters were exposed at that time to an average TWA lead concentration of 170 ug/m^3. Average lead concentrations have since been reduced to less than 4.0 ug/m^3 with the introduction of zinc bullets.

NIOSH has determined that a hazard from overexposure to lead and zinc did not exist at the Federal Reserve Bank's Indoor Firing Range at the time of this investigation.

Recommendations for improving ventilation are included in Section VIII.

KEYWORDS: SIC 6011 (Federal Reserve Banks), inorganic lead, indoor firing range, pistol range, indoor target ammunition.

II. INTRODUCTION

In September 1981, NIOSH received a request from the Cincinnati Branch of the Federal Reserve Bank for an airborne lead determination in their indoor firing range in Cincinnati, Ohio. The request was prompted by the management's concerns about possible health hazards from airborne lead being generated during use of the firing range by bank guards. Air samples and ventilation measurements were taken by NIOSH while guards fired typical practice and qualification courses using .38-special service revolvers and zinc wadcutter ammunition. Since the new zinc bullets had replaced lead bullets at this range via a previous NIOSH recommendation (HETA 81-019-846), the requestor also wanted to know how this substitution had affected airborne lead concentrations.

III. BACKGROUND

The firing range is located in the Cincinnati Branch of the Federal Reserve Bank of Cleveland Building. The range is housed in a room about 93 feet long, 19 feet wide, and 9 feet high at the highest ceiling height. The actual firing range is 75 feet long, 19 feet wide, and 8 feet high.

There are five shooting booths, with each booth being about 3-1/2 feet wide, 6 feet long, and 6-1/2 feet high. Air is supplied into the range through a grill at the top of the back wall, about 18 feet behind the shooting positions. The grill is about 7 inches wide and 14-3/4 feet long. Two exhaust grills are located on the ceiling about 4 feet downrange of the shooting positions. Exhaust openings are also located behind the bullet trap, which essentially causes the bullet trap to act as a series of 1-1/2 inch wide exhaust slots spanning the entire back wall.

The range is used by about 25 security guards who are required to qualify quarterly in small arms proficiency. As an administrative action for reducing lead exposure, range officers are rotated such that chronic exposures would not be expected to differ much from that of the shooters. During qualifications, each guard fires 30 rounds of .38-special, 100-grain zinc wadcutter ammunition. Each qualifying round requires 5 to 10 minutes to complete.

NIOSH had conducted similar evaluations of this range in December 1975 and December 1980. In 1975, shooters firing 60 rounds each in 20 to 25 minutes were exposed to airborne lead concentrations ranging from 1500 to 6960 micrograms per cubic meter (ug/m^3). Corresponding 8-hour TWA concentrations ranged from 60 to 350 ug/m^3, with a mean of 170 ug/m^3. The total air supply was 6300 cubic feet per minute (cfm) and total exhaust was 3850 cfm.

In 1980, shooters firing 60 rounds each in 7 to 10 minutes were exposed to airborne lead concentrations ranging from 3400 to 12000 ug/m^3.

Corresponding 8-hour TWA concentrations ranged from 50 to 250 ug/m^3 with a mean of 160 ug/m^3. The total air supply was 2050 cfm and total exhaust was 2250 cfm.

After the 1980 study, the primary recommendation by NIOSH was to replace lead bullets with jacketed or non-lead bullets as a means of reducing lead exposures.

IV. EVALUATION DESIGN AND METHODS

Six personal breathing-zone samples were taken on the guards for the duration of their shooting time (5 to 10 minutes). One personal breathing-zone sample was taken from the rangemaster for 30 minutes. Each shooter fired 30 rounds of 100-grain zinc "Indoor Target" full wadcutter rounds manufactured by 3-D Police Ammunition Company. Area samples were taken on the firing line after shooting for the purpose of determining clearance rates of airborne contaminants from the range.

All samples were collected on mixed cellulose ester filters using battery-powered sampling pumps operated at 2.0 liters per minute. Lead and zinc were analyzed by atomic absorption spectroscopy according to NIOSH Analytical Method P&CAM 173.

Ventilation measurements were taken using a Kurz Air Velocity Meter, Model 441. A series of linear air velocity measurements were taken of each supply and exhaust source. These readings were averaged and total air volumes in cubic feet per minute were computed. Measurements were also taken to check linear air velocities at the firing line and to check the downrange conveying velocity. Smoke tubes were used for delineating airflow patterns.

V. EVALUATION CRITERIA

LEAD

Toxicological

Inhalation of lead dust and fume is the major route of lead exposure in industry. A secondary source of exposure may be from ingestion 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 kidneys, peripheral and central nervous systems, and the blood forming organs (bone marrow). These effects may be felt as weakness, tiredness, irritability, digestive disturbances, high blood pressure, kidney damage, mental deficiency, or slowed reaction times. Chronic lead exposure is associated with infertility and with fetal damage in pregnant women.

Blood lead levels below 40 ug/deciliter whole blood are considered to be normal levels which may result from daily environmental exposure.[1] However, fetal damage in pregnant women may occur at blood lead levels as low as 30 ug/deciliter. Lead levels between 40 to 60 ug/deciliter in lead-exposed workers indicate excessive absorption of lead and may result in some adverse health effects. Levels of 60 to 100 ug/deciliter represent unacceptable elevations which may cause serious adverse health effects. Levels over 100 ug/deciliter are considered dangerous and often require hospitalization and medical treatment.

The new Occupational Safety and Health Administration (OSHA) standard for lead in air is 50 ug/m^3 calculated as an 8-hour time-weighted average for daily exposure.[1] The standard also dictates that workers with blood lead levels greater than 60 ug/deciliter must be immediately removed from further lead exposure and, in some circumstances, workers with lead levels of less than 60 ug/deciliter must also be removed. Removed workers have protection for wage, benefits, and seniority for up to 18 months until their blood levels decline to below 50 ug/deciliter and they can return to lead exposure areas.

Chronic Toxicity

Lead has been shown in previous studies[2] to cause chronic kidney disease (nephropathy) in persons with long-time occupational exposure. The process is gradual and dose related. Persons who experience the greatest lifetime risk of manifesting lead-induced kidney disease are those who have experienced the most lead absorption over their working career. The initial signs of lead nephropathy are subtle. Affected workers will usually have no symptoms in the early stages. Their renal function test values may still be within the broad range of normal, although their test results will tend over time to move toward the high end of the normal range.

Because the kidney has an enormous reserve capacity, results of the usual renal function tests--blood urea nitrogen (BUN), serum creatinine, and serum uric acid--will not become frankly abnormal until one-third to one-half of kidney function has been destroyed.[3] For that reason, more sensitive screening tests of renal function have been sought. These include serum measurement of 1,25-dihydroxy vitamin D, which may be decreased in persons with kidney damage caused by lead.[4] Other abnormalities which may also be noted in chronic lead nephropathy include aminoaciduria, renal glycosuria, and hypercalcuria. Gout is a particularly noteworthy manifestation of lead nephropathy;[5] the elevated serum uric acid concentrations which may occur in lead nephropathy have been associated with the development of gouty arthritis.

When one or more of the standard kidney function tests is in the abnormal range in a worker exposed to lead, or even when two or more of the test results are in the high normal range, there exists the possibility of kidney damage. In that circumstance, more complete evaluation of the individual worker by a kidney disease specialist is required.

Reports of lead poisoning among firing range workers are not uncommon. In 1977, for example, an investigation of adverse neurological and gastrointestinal symptoms among firearms instructors was conducted. A high prevalence of lead-induced biochemical abnormalities was found.[6]

VI. RESULTS

Five shooters were exposed to airborne lead at concentrations that were below the limit of detection (about 200 ug/m^3 for a 10-minute sample). One shooter was exposed to 400 ug/m^3 of lead during shooting (Table I). The corresponding 8-hour TWA concentration was 4 ug/m^3. The rangemaster was exposed to 50 ug/m^3 of lead for 30 minutes which equals 3 ug/m^3 for an 8-hour TWA. Zinc concentrations ranged from 200 to 1500 ug/m^3 during shooting with 8-hour TWA levels ranging from 3 to 20 ug/m^3. The duration of exposure during this survey was typical of the time spent during routine target practice sessions.

Ten-minute area samples taken 5 minutes after shooting stopped showed that zinc was still present in the air at levels of 50 and 100 ug/m^3.

The air supply was found to be about 7000 cfm on the day of the survey. The firing line ceiling grills were exhausting 420 cfm and 100 cfm was being exhausted at the bullet trap. The total exhaust volume was 520 cfm. Airflow at the firing line was very erratic with velocities ranging from 20 to 400 fpm. Smoke tube observations showed the air to be turbulent with swirls of smoke often traveling backwards towards the shooter. There was no measurable downrange conveying air flow.

VII. CONCLUSION

Bullet substitution has clearly lowered airborne lead concentrations significantly at this firing range. TWA concentrations were reduced from an average of 170 ug/m^3 to less than 4 ug/m^3. Zinc concentrations were also well below the OSHA standard.

VIII. RECOMMENDATION

The ventilation system should be balanced to avoid the possibility of firing range contaminants from spreading and gradually accumulating in the range and in other parts of the building. On the day of the NIOSH study, the total exhaust volume was much too low. In order to maintain a slight negative pressure inside the range, the exhaust air volume should be roughly 10% greater (about 8000 cfm) than the air supply volume. At least 75% of this volume should be exhausted at the bullet trap. The imbalanced airflow may also account for much of the firing line turbulence that was noted during the study, and thus, the observed lingering existence of airborne contaminants after shooting.

IX. REFERENCES

1. Occupational Safety and Health Administration. Occupational exposure to lead--final standard. Federal Register 1978 Nov 14:53007.

2. Wedeen RP, Maesaica JK, Weiner B, et al. Occupational lead nephropathy. Am J Med 1975;59:630.

3. Page LB, Culver PJ. A syllabus of laboratory examinations in clinical diagnosis. Cambridge: Harvard University Press, 1962.

4. Rosen JF, Chesney R, Hamstra A, et al. Reduction in 1,25-dihydroxy vitamin D in children with increased lead absorption. N Engl J Med 1980;302:128-31.

5. Ball GV, Sorensen LB. Pathogenesis of hyperuricemia in saturnine gout. N Engl J Med 1969;280:119.

6. Anderson KE, Fischbein A, Kestenbaum D, et al. "Plumbism from airborne lead in a firing range: an unusual exposure to a toxic heavy metal." Am J Med 1977;63:305-312.

X. AUTHORSHIP/ACKNOWLEDGEMENTS

Report Prepared By:	Steven A. Lee Industrial Hygienist Industrial Hygiene Section
Field Assistance:	Mark Nutter Industrial Hygiene Student Industrial Hygiene Section
Originating Office:	Hazard Evaluations and Technical Assistance Branch Division of Surveillance, Hazard Evaluations and Field Studies
Report Typed By:	Debra A. McDonald Clerk-Typist Industrial Hygiene Section

XI. DISTRIBUTION AND AVAILABILITY

Copies of this report are currently available upon request from NIOSH, Division of Standard Development and Technology Transfer, 4676 Columbia

Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH, Publication Office at the Cincinnati address.

Copies of this report have been sent to:

1. Federal Reserve Bank, Cincinnati Branch
2. OSHA, Region V
3. NIOSH, Region V

TABLE I

SAMPLING RESULTS FOR INORGANIC LEAD AND ZINC
FEDERAL RESERVE BANK INDOOR FIRING RANGE
CINCINNATI, OHIO
HETA 81-470
OCTOBER 6, 1981

LOCATION	SAMPLE TYPE	SAMPLING TIME	LEAD CONCENTRATION IN ug/M^3 (& 8-HR TWA)	ZINC CONCENTRATION IN ug/M^3 (& 8-HR TWA)
Booth 2	Guard BZ*	10:01-10:10 AM	N.D.**	300 (6)
Booth 4	Guard BZ	10:13-10:21 AM	N.D.	200 (3)
Booth 2	Guard BZ	10:20-10:30 AM	N.D.	1500 (10)
Booth 4	Guard BZ	10:30-10:30 AM	N.D.	200 (4)
Booth 2	Guard BZ	10:40-10:45 AM	400 (4)	1500 (20)
Booth 4	Guard BZ	10:40-10:45 AM	N.D.	300 (3)
Booth 2	Area Sample	10:50-11:00 AM	N.D.	100
Booth 4	Area Sample	10:50-11:00 AM	N.D.	5
Desk	Rangemaster BZ	10:20-10:50 AM	50 (3)	200 (10)
OSHA Standard (8-hour TWA)			50	5000

*BZ = Personal breathing zone sample
**N.D. = non-detectable (about 200 ug/M^3 for a 10-minute sample)