HETA 86-269-1812
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FEDERAL RESERVE BANK
CINCINNATI, OHIO

NIOSH INVESTIGATORS:
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I. SUMMARY

In April 1986, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Federal Reserve Bank, Cincinnati, Ohio, for an evaluation of airborne lead exposure during use of their indoor firing range. A comparison of airborne lead levels emitted by two types of ammunition was also requested.

NIOSH investigators collected four breathing-zone air samples in May 1986, during the firing of standard lead target bullets. Air sampling was repeated in April 1987, using ammunition with copper dip-plated lead target bullets.

Mean 8-hour time-weighted average lead exposures were 89 ug/m^3 while shooting the standard lead bullets and 79 ug/m^3 while shooting the copper-coated lead bullets. The OSHA permissible exposure limit (PEL) for lead is 50 ug/m^3. It was concluded that there was little or no difference between air lead emissions from the two bullet types. It appeared likely that the copper-coating was too thin to effectively isolate the lead portion of the bullet from the firing process. Previous NIOSH studies of this and other firing ranges had shown that airborne lead exposures could be reduced to less than 4 ug/m^3 when jacketed lead bullets or zinc bullets were used. The disadvantages were the greater expense of the jacketed bullets and the tendency for the harder zinc bullets to cause damage to the range.

An evaluation of airflow patterns revealed that insufficient bullet-trap exhaust caused the unbalanced ventilation system to deliver turbulent airflow at the firing line.

The NIOSH investigator determined that a hazard from overexposure to lead existed at the Federal Reserve Bank's Indoor Firing Range at the time of this investigation. He recommended that jacketed bullets be used until the ventilation system can be repaired.

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

II. INTRODUCTION

In April 1986, NIOSH received a request from the Cincinnati Branch of the Federal Reserve Bank for an evaluation of airborne lead exposure during use of their indoor firing range.

On May 21, 1986, air sampling was conducted during the firing of standard lead target bullets and the sampling results and recommendations were sent to the Federal Reserve Bank in July 1986.

Following procurement of an alternate type of target ammunition that was hoped to reduce lead exposures, the Federal Reserve Bank (FRB) requested further air sampling, which was conducted by NIOSH investigators on April 1, 1987.

III. BACKGROUND

The firing range is 75 feet long, 19 feet wide, and 8 feet high. There are five shooting booths, each 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 6 inches wide and 15 feet long. There are two exhaust grills on the ceiling about 4 feet downrange of the shooting positions. Exhaust openings are also located behind the bullet trap.

The range is used by about 20 bank 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 qualification, each guard fires 60 rounds of .38 special ammunition in about 15 minutes.

NIOSH conducted similiar evaluations of this range in December 1980,[1] and October 1981.[2] In 1980, shooters firing 60 rounds in 7 to 10 minutes were exposed to airborne lead levels ranging from 3400 to 12000 ug/m^3. Corresponding 8-hour TWA exposures ranged from 50 to 250 ug/m^3 with a mean of 160 ug/m^3.

After the 1980 study, the primary recommendation by the NIOSH investigator was to replace the standard lead bullets with jacketed lead bullets or non-lead bullets as a means of reducing lead exposures. This recommendation was developed from NIOSH studies in several firing ranges where lead emissions from firing zinc bullets, copper-jacketed bullets, and nylon-jacketed bullets were compared with lead emissions from 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 is the cartridge primer, which contains lead styphnate.

The FRB decided to adopt the use of zinc bullets after testing to make sure that the much harder bullets would be safely handled by their bullet trap. In October 1981, NIOSH air sampling during routine qualification shooting using zinc bullets showed that one shooter was exposed to an 8-hour TWA lead exposure of 4 ug/m^3 and five shooters were exposed to levels that were below the sampling and analytical limits of detection (<3 ug/m^3).

After several years, however, it became evident that excessive damage to the floor, ceiling, and target holders was being caused by the harder zinc bullets. In April 1986, the FRB notified NIOSH of their decision to return to using lead bullets and they requested further air sampling. After excessive lead exposures were found, NIOSH recommended that the FRB use jacketed bullets to control lead exposures. Lead bullets that are jacketed such that the lead portion of the bullet is isolated from hot propellant gases and barrel rifling, are just as effective as non-lead bullets in reducing lead exposures during shooting.[3]

Due to the high cost of jacketed bullets, however, the FRB and NIOSH decided to test another type of bullet for possible indoor target use. This consisted of a standard inexpensive lead target bullet with a thin copper plating. These differ greatly from copper-jacketed service bullets whose copper-steel alloy jackets are manufactured first, then molten lead is poured into the jacket to form the rest of the bullet. This results in a much harder and thicker envelope than a copper coating that is simply deposited on the lead target bullets by dipping them in a plating solution. The copper on these bullets can easily be scraped off with a fingernail.

IV. METHODS

In May 1986, four breathing-zone air samples were collected during the firing of standard target ammunition (100 grain double-end lead wadcutter loaded to 800 feet per second). Air sampling was repeated in April 1987, during the firing of ammunition that was identical to that used in the previous evaluation except for the copper coating on the bullets.

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

Ventilation measurements were taken on each visit using a Kurz Air Velocity Meter, Model 441. Smoke tubes were used for observing airflow patterns in each of the shooting booths.

V. EVALUATION CRITERIA

A. Environmental Criteria

As a guide to the evaluation of the hazards 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 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 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 recommendations, 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. Often, the NIOSH recommendations and ACGIH TLVs are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLVs usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels 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 or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

B. LEAD

Inhalation (breathing) of lead dust and fume is the major route of lead exposure in industry. A secondary source of exposure may be 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 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[(4)]. However, fetal damage in pregnant women may occur at blood lead levels as low as 30 ug/deciliter. Lead levels between 40-60 ug/deciliter in lead-exposed workers indicate excessive absorption of lead and may result in some adverse health effects. Levels of 60-l00 ug/deciliter represent unacceptable elevations which may cause serious adverse health effects. Levels over l00 ug/deciliter are considered dangerous and often require hospitalization and medical treatment.

The 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[(4)]. The standard also dictates that workers with blood lead levels greater than 50 ug/deciliter must be immediately removed from further lead exposure and, in some circumstances, workers with lead levels of less than 50 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 40 ug/deciliter and they can return to lead exposure areas.

VI. RESULTS AND DISCUSSSION

Three shooters were exposed to 8-hour TWA lead concentrations ranging from 23 to 160 ug/m^3 with a mean of 89 ug/m^3 while shooting the5standard lead bullets (Table I). While shooting the copper plated lead bullets, three shooters were exposed to 8-hour TWA lead levels ranging from 50 to 120 ug/m^3 with a mean of 79 ug/m^3 (Table II).

The ventilation system was performing poorly on both visits. Air flow across the firing line was erratic and turbulent to the extent that much of the air was actually flowing backwards. The air supplied to the range increased from 1800 cubic feet per minute (cfm) on the first visit to about 4000 cfm on the second visit. Due to inadequate bullet trap exhaust, however, it does not matter how much air is supplied to the range since it does not have anywhere to go. This is the main cause of the turbulent, backward-flowing air at the firing line.

Little, if any, reduction in air lead emissions appears to be offered by the copper dip-plated lead target bullets. The copper coating is probably too thin to effectively isolate the lead from the firing process.

Ventilation in the range will not be effective until the bullet trap exhaust is repaired. Based on the dimensions of the range, total exhaust ventilation should be 10,000 cfm and the air supplied should be 9100 cfm. If evenly distributed and exhausted, this will provide a linear air velocity of 75 feet per minute at the firing line. Then, "fine-tuning" the ventilation should be performed by adjusting air supply grills, louvers or plenums (if necessary) until smoke generating devices at the firing line show that the air is being smoothly and evenly swept downrange.

Until the ventilation is repaired, jacketed bullets should be used.

VIII. REFERENCES

1. Lee, SA. Health Hazard Evaluation – Cincinnati, Ohio. Report No. HETA 81-019-846. Cincinnati, Ohio: NIOSH, 1981.

2. Lee, SA. Health Hazard Evaluation – Cincinnati, Ohio. Report No. HETA 81-470-1040. Cincinnati, Ohio: NIOSH, 1981.

3. Lee, SA. Reducing airborne lead exposures in indoor firing ranges. FBI Law Enforcement Bulletin. 55:2, 15-18, 1986.

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

IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

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

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

TABLE I

Air Lead Concentrations (ug/m^3)
Standard Lead Wad Cutter Bullets

Federal Reserve Bank Indoor Firing Range
Cincinnati, Ohio

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May 21, 1986

LOCATION	SAMPLE TYPE	SAMPLING TIME	LEAD CONCENTRATION	8-hr. TWA
Booth 1	Guard BZ*	1010-1025	5000	160
Booth 3	Guard BZ	1010-1025	2700	84
Booth 5	Guard BZ	1010-1025	730	23
Desk	Rangemaster BZ	1010-1028	300	11
Desk	Area	1010-1034	290	-
Desk	Area	1010-1034	250	-
Booth 1	Area (after shooting)	1025-1035	350	-
Booth 3	Area (after shooting)	1025-1035	250	-
OSHA Permissible Exposure Limit			50	

*BZ = Personal breathing-zone sample

TABLE II

Air Lead and Copper Concentrations (ug/m^3)
Copper Flash-Coated Lead Bullets

Federal Reserve Bank Indoor Firing Range
Cincinnati, Ohio

HETA 86-269
April 2, 1987

SAMPLE LOCATION	SAMPLE TYPE	TIME	LEAD	COPPER	LEAD 8-hr.TWA	COPPER 8-hr.TWA
Booth 1	Guard BZ	955-1010	3700	220	120	6.9
Booth 3	Guard BZ	955-1010	1600	100	50	3.1
Booth 5	Guard BZ	955-1010	2100	120	66	3.8
Desk	Area	955-1015	750	55	--	--
Desk	Area	955-1015	875	58	--	--
Evaluation Criteria			50	200		