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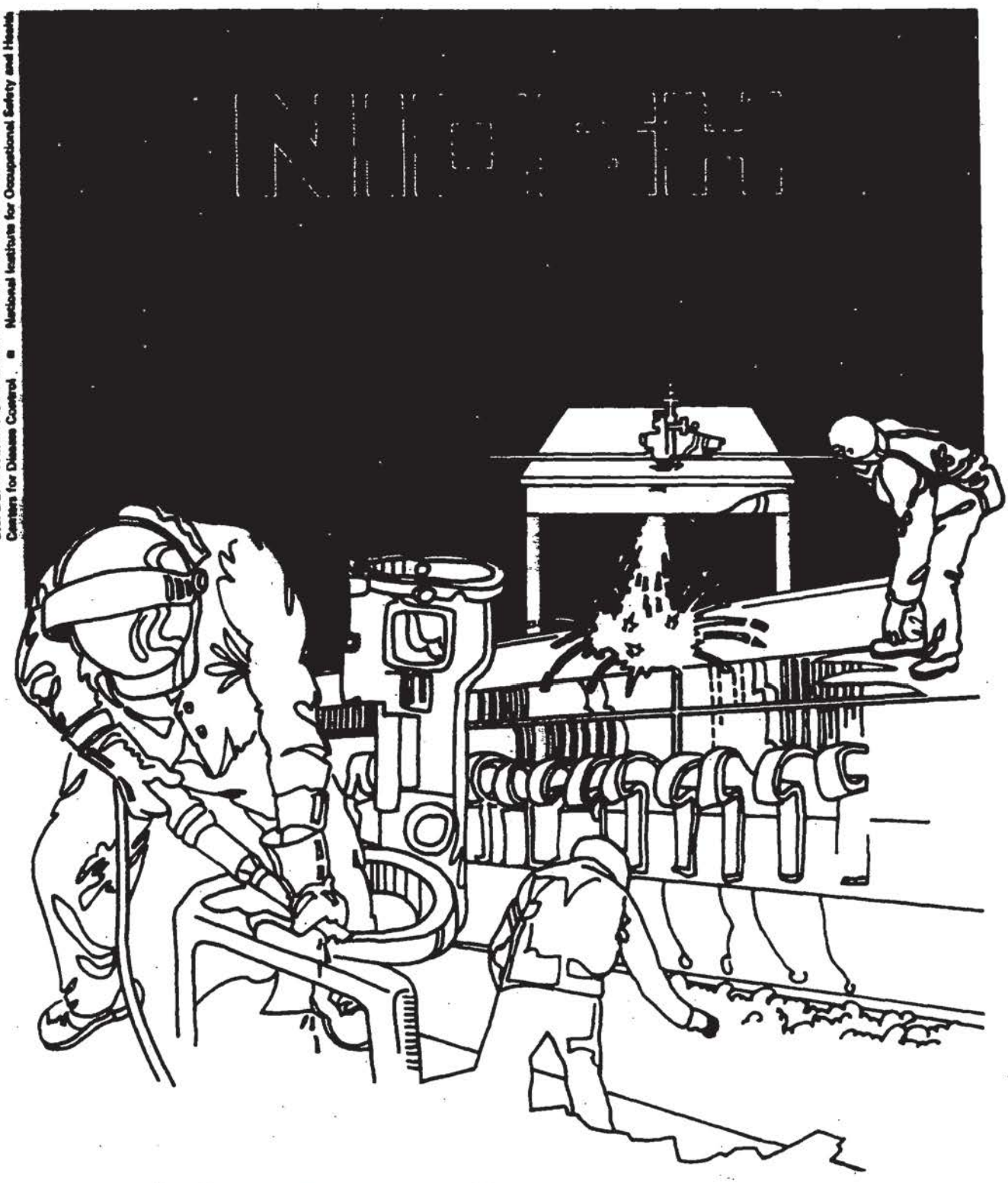

Health Hazard Evaluation Report

HETA 83-088-1324
MOLINE POLICE DEPT.
INDOOR RANGE
MOLINE, ILLINOIS

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.

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

HETA 83-088-1324
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MOLINE POLICE DEPT. INDOOR RANGE
MOLINE, ILLINOIS

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I. SUMMARY

On December 23, 1982, the National Institute for Occupational Safety and Health (NIOSH) was requested to evaluate the exposure of law enforcement officers to firearms smoke at the Moline, Illinois Police Department Indoor Firing Range.

On February 15 & 16, 1983, NIOSH investigators conducted an initial and environmental survey, during which personal breathing zone and general area air samples were collected for measurement of exposures to inorganic lead. Samples were collected while police officers were firing weapons; each officer firing 54 rounds of ammunition during the sampling period. The ventilation system was examined and airflow measurements were taken. Police officers were interviewed and procedures for use of the range were discussed.

In their personal breathing zone samples collected, time weighted average (TWA) exposures to inorganic lead ranged from 2,760 to 17,500 micrograms per cubic meter of air (ug/M^3), with an average of 10,900 ug/M^3. The calculated 8-hour TWA concentrations (assuming no other lead exposure during the 8-hour period) ranged from 40 to 333 ug/M^3, with an average of 219 ug/M^3. All the measured exposures exceeded the American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value for short term exposure limit (TLV-STEL) of 450 ug/M^3. Thirteen of the fourteen measured exposures also exceeded the Occupational Safety and Health Administration (OSHA) standard for lead of 50 ug/M^3 calculated as an 8-hour time-weighted average for 13 of the 14 officers.

The ventilation system was totally ineffective in preventing lead exposure to the shooter. A potentially more serious problem exists with the introduction of lead from the firing range into the building's ventilation system and subsequent recirculation throughout the Emergency Center.

On the basis of the information obtained in this investigation, NIOSH has determined that the police officers' were exposed to hazardous concentrations of inorganic lead. Measurements taken at the time of the survey indicate improper and insufficient ventilation exists to properly remove the lead from the range (as well as the building itself) and thereby reduce the exposures to within acceptable levels. Recommendations to reduce exposures are included in the full body of the report.

KEY WORDS: SIC 8081, Lead, Indoor firing ranges.

II. INTRODUCTION

On December 23, 1982, the National Institute for Occupational Safety and Health (NIOSH) received a request for technical assistance in assessing potential health hazards at the Moline Police Department Indoor Firing Range. The request concerned the exposure of law enforcement officers to firearms smoke in the range located at the basement level of the City Emergency Center.

Initial contact with NIOSH was made in May 1982; however, due to repair work scheduled on the air conditioning system serving the range, it was decided to postpone an investigation until this was completed.

On February 15 and 16, 1983, NIOSH investigators conducted an initial and environmental survey. During the survey, personal breathing zone and general area air samples were collected for measurement of exposures to inorganic lead. The ventilation system was examined and airflow measurements were taken. Officers were interviewed at random and the procedures for use of the range were discussed.

III. BACKGROUND

The City of Moline, Illinois constructed the Emergency Center more than 10 years ago to house the police and fire departments. The Center serves as the main offices for the cities police and fire departments. The indoor firing range was added in the basement of the Center after completion of the building. The 8 position, commercially manufactured range, is located in an area approximately 50 feet by 33.5 feet, with an 8 foot ceiling. Each shooting booth averages approximately 45 inches in width. A glass-fronted range office and adjacent firearms cleaning and maintenance room are located at the rear of the range, in an enclosed room.

The range is utilized by the law enforcement agencies of Moline, Geneseo, Rock Island, and East Moline, Illinois; Bentendorf, Iowa; and the local Federal Bureau of Investigation. The range is available for practice by the officers and they must qualify every 2 months. Qualification requires firing 54 rounds of ammunition with the officer's service revolver. Should the officer carry another gun while off duty, he/she is required to also qualify that weapon. No competitive shooting has been held in the range in the last two years. A log of range utilization is maintained.

Air is supplied to the range through two, ceiling mounted, duct systems extending across the width of the range, one behind the shooting booths and the other directly in front of the shooting booths. The ducts have eight supply grills each, in line with a shooting position and facing downrange. The major return air (exhaust) duct is located 4 feet in front of the target trap and also has 8 openings which face downward, correspnding to the shooting positions. Two return air grills (one partially obstructed) are located in the side wall a short distant downrange from the shooting stands. The range ventilation system is part of the central heating/cooling system for the Emergency Center which utilizes approximately 100% recirculated air, therefore when the range is in use, lead laden air is introduced into the system and distributed throughout the building.

IV. MATERIALS AND METHODS

An environmental survey was conducted at the Moline Police Department Indoor Firing Range on February 16, 1983. A shooting session was scheduled and conducted in accordance with established procedures for officer firearms qualification, namely 54 rounds per officer (12 rounds in 30 seconds-near target and 42 rounds in 4 minutes-far target). All rounds may not have been fired by each officer in the time period alloted. Fourteen officers participated in the exercise, with one officer also serving as the range officer (no full-time range officer is currently employed). Four shooting sessions (sampling periods) were conducted, two with three officers firing and two with four firing. Personal and general area air samples were collected for measurement of the officers' exposures to inorganic lead.

Personal samples were taken near the breathing zones of the officers and general area samples were collected on a table approximately 6 feet behind the shooting booths and also inside of the main return (exhaust) air duct using battery-powered sampling pumps operating at approximately 1.5 liters of air per minute (lpm) attached via TYGON® tubing to a filter unit, consisting of a mixed cellulose ester membrane filter (37-mm diameter, 0.8 micrometer pore size) and a 3-piece cassette filter holder. The samples were analyzed for inorganic lead using an atomic absorption spectrophotometer in accordance with NIOSH P&CAM No. S341.[1] The duration, location, and other information pertinent to sample collection is presented in Table 1.

Ventilation measurements were made using a Kurz™ Model 441, portable air velocity meter to determine the airflow into and out of the range. Smoke tubes were also used to study the airflow patterns within the range, as well as airflow into or out of doorways.

V. EVALUATION 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 (TLV's), and 3) the U.S. Department of Labor Occupational Safety and Health Administration (OSHA) occupational health standards. Often, the NIOSH recommendation and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's 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 solely 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 only those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refer to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommmended 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.

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 adsorbed, lead is excreted from the body very slowly. Adsorbed lead can damage the kidneys, peripheral and central nervous systems, and the blood forming organs. 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. The new OSHA standard for lead in air is 50 micrograms of lead per cubic meter of air (ug/M^3) calculated as an 8-hour time-weighted average for daily exposure. 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.[2] NIOSH supports the OSHA recommendations.

ACGIH recommends a Threshold Limit Value-Time Weighted Average (TLV-TWA) for lead (inorganic, dusts & fumes, as Lead) of 150 ug/M^3. The ACGIH also recommends a Threshold Limit Value-Short Term Exposure Limit (TLV-STEL) for lead of 450 ug/M^3.[4]

VI. RESULTS

Complete results of the personal samples are provided in Table 1. The concentration of lead in personal breathing zone air samples ranged from 2,760 to 17,500 (average 10,900) ug/M^3 for all officers using the range, with calculated 8-hour TWAs ranging from 40 to 333 (average 219) ug/M^3. The general area air sample collected at the rear of the range during the period of range use (78 minutes) indicated a concentration of 5040 ug of lead/M^3. Approximately 3500 ug of lead/M^3 was detected in the return (exhaust) air duct during a 100 minute sampling period.

Considerable turbulence existed at the shooter's position in all of the booths, with very little of the air flowing in a downrange direction. Smoke tube tests revealed air patterns within the shooting booths exhibited an eddy motion, with downward flow at head level and backward/upward flow at knee level. Cursory air flow measurements indicated that approximately 3900 cubic feet of air per minute (cfm) was being exhausted from the range (approximately 3300 cfm above the bullet trap and 600 cfm at the side wall), with approximately 5600 cfm of air being supplied (3300 cfm behind the firing line and 2300 cfm in front of the firing line).

VII. DISCUSSION

The results of the personal breathing zone samples (Table 1) indicate that all officers' exposures to airborne concentrations of inorganic lead were substantially above the ACGIH, TLV-STEL (450 ug/M^3), and all but one officers' calculated 8-hour TWA exceeded the current OSHA standard (50 ug/M^3), including the range officer.

There was no evidence of contaminant buildup during the shooting session as exposures remained relatively constant throughout the sessions. Table 2 graphically demonstrates the relationship between airflow and exposures. The lead levels in booths where there was more air flowing from the supply grill behind the shooter are correspondingly lower in value. This situation should be greatly enhanced if the air supply in front of the shooters is eliminated and the air supply behind the shooters is increased and properly focused, along with increasing the exhaust volume.

The required air supply behind the shooters is the larger of 20 times the total cross-sectional area of the range at the firing line or 50 times the open cross-sectional, where part of the cross-sectional area is blocked off.[5] For this range, as it currently exists, the amount of supplied air which must be supplied behind the shooters to control lead fumes and dust is 11,950 cfm. The total measured supply air volume to the range was approximately 5,600 cfm; however, only 3,300 cfm was being introduced behind the firing line, with an additional 2,300 cfm being supplied in front of the firing line. The latter air supply is ineffective and simply acts as a short circuit for the exhaust system. The amount of air supplied means very little if the ventilation system is not balanced and the air flow is not evenly distributed across the shooter.

The measured volume of exhaust air was approximately 3,900 cfm downrange from the firing line, 3,300 cfm above the bullet trap and 600 at the sidewall. The recommended exhaust volume for this range would be approximately 10% greater than the supplied air volume or 13,145 cfm. At least four deficiencies exist with the ventilation system in this range, 1) insufficient and turbulent airflow at the shooters' booths, 2) insufficient total air volume supplied and exhausted, 3) short circuiting of air past the shooter due to the introduction of supplied air in front of the firing line, and 4) lead contaminated air being recirculated to other parts of the building (3,470ug of lead/M^3 of air was measured in the duct leading to the central air conditioning and distribution system).

VIII. RECOMMENDATIONS

Although the exposures to individual officers are infrequent and no range master is employed, due to the fact that standard and recommended lead exposure values have been exceeded and lead contaminated air is recirculated throughout the buildings ventilation system, thereby posing a serious hazard to other occupants of Center, the following design considerations and work practices are recommended in order to reduce and/or eliminate the health hazards associated with the indoor firing range.[5,6]

1. The range should have its own ventilation system to prevent the circulation of contaminated air to other areas of the building. 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%.

2. An evenly-distributed, non-turbulent make-up air flow pattern is necessary. Filtered and conditioned air must be introduced behind the firing line to guarantee an evenly distributed flow of air through the shooting positions, with perforated rear wall or ceiling plenum systems preferred. The air supply located in front of the firing line should be eliminated, with all air being introduced behind the shooters.

3. Supplied air inlets should be placed approximately 15 feet behind the shooter's position; however, due to dimensional restriction, the existing air supply grills should be located on the underside of the duct and enlarged if possible, and the airflow directed downward and toward the firing line to avoid a situation where air flows rapidly downrange at ceiling height and at decreased velocities closer to the floor, or where a turbulent pattern of airflow is created. Every effort must be made to ensure a uniform airflow across the back of the firing line. The terminal velocity near the firing line should be 50 fpm, with the air exhausted downrange at the bullet trap.

4. If the quantity of supplied air is inadequate, according to the preceding criteria, some benefit may be gained by blocking off the lower panels in the shooting booths, hinging one or two panels so that it is possible to pass through when the panel is swung aside for access downrange. This could basically reduce the required air supply and exhaust by one-half. If prone shooting is also required, in order to minimize the quantity of required air supply and still maintain minimum transport velocities, the panels could be arranged so that they would be closed at the lower levels when shooting standing up and conversely would be closed at the upper levels when shooting in the prone position If the design airflow is based on this system, then it must be operated so that only one-half of the panels are open at a given time. If both sets are opened simultaneously, then the velocities would fall below minimum requirements.

5. For maximum efficiency, exhaust ducts should be located behind and at the apex of the bullet trap. The existing location could be sufficient if additional air volume is provided.

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

7. The supply and exhaust systems should 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.

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

9. 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.

10. 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.

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

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

13. The use of non-lead or copper jacketed bullets should also be considered.

IX. REFERENCES

1. Manual of Analytical Methods, Volume 3, National Institute for Occupational Safety and Health, DHEW(NIOSH) Publication No. 77-157-C, April 1977.

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

3. Criteria for a Recommended Standard....Occupational Exposure to Inorganic Lead, Revised Criteria - 1978, National Institute for Occupational Safety and Health, DHEW(NIOSH) Publication No. 78-158, May 1978.

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5. Industrial Ventilation - A Manual of Recommended Practice, American Conference of Governmental Industrial Hygienists, Committee on Industrial Ventilation, 16th edition, 1980.

6. Lead Exposure and Design Considerations for Indoor Firing Ranges, National Institute for Occupational Safety and Health, DHEW(NIOSH) Publication No. 76-130, December 1975.

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XI. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Services (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH publications office at the Cincinnati address. Copies of this report have been sent to the following:

1. City of Moline Police Department
2. Fraternal Order of Police, Lodge #77
3. U.S. Department of Labor, OSHA - Region V
4. NIOSH Regional Offices/Divisions

For the purposes of informing the affected employees, copies of the report should be posted in a prominent place accessible to the employees, for a period of 30 calendar days.

TABLE 1
Results of Personal Breathing Zone Samples
Inorganic Lead -February 16, 1983
Moline Police Department Indoor Firing Range
Moline, Illinois

Shooting Booth Number	Shooters' Sampling Period	Sample Duration (minutes)	Lead Concentration ug/M^3	Calculated 8-hour TWA ug/M^3
1	2nd	9	6,740	126
1	3rd	7	2,760	40
3	1st	11	16,000	333
3	2nd	9	15,500	292
3	4th	16	7,080	236
4	1st	9	8,150	153
4	3&4	30	4,670	292
5	1st	11	10,300	236
5	2nd	8	10,800	180
6	1st	15	12,700	264
6	3rd	8	17,500	292
7	2nd	8	17,500	292
7	3rd	7	16,190	236
7*	4th	28	6,670	333

The level of analytical detection of was 3.0 micrograms of lead per sample.

* - Served as range officer prior to shooting.

Table 2
Airflow versus Lead Concentration

Moline Police Department Indoor Firing Range

Moline, Illinois

	Booth Number							
	1	2	3	4	5	6	7	8
600								x
500	x			x				
400					x		x	
300		x	x					
200			o			x o	o	
100	o			o	o			
-0-								

x - Approximate air volume (cfm) entering range behind each shooting booth.

o - Approximate average concentration of lead (ug) deposited on filter sample.