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I. SUMMARY

On February 20, 1991, the National Institute for Occupational Safety and Health (**NIOSH**) received a request from the United States Park Police to evaluate a new indoor range facility at the U.S. Park Police building in Washington, D.C. On April 23-25, 1991, NIOSH investigators conducted an initial survey at the U.S. Park Police indoor firing range in Washington, D.C. Two NIOSH investigators returned on August 6, 1991, to further evaluate the performance of the ventilation system, and again on November 21, 1991, to provide recommendations to modify the ventilation system to improve its performance.

Air sampling results revealed that for students using the range on April 24, 1991, 8-hour Time-Weighted Average (**TWA**) exposures ranged from 4.4 $\mu g/m^3$ to 116.4 $\mu g/m^3$ of airborne lead, with a mean of 32.5 $\mu g/m^3$. Eight-hour TWA results for area samples on April 24, 1991, ranged from 0.15 to 2291.1 $\mu g/m^3$. The 8-hour TWA results for range officers on that day ranged from 0.15 to 52.6 $\mu g/m^3$, with a mean of 16.1 $\mu g/m^3$. This represents the results of sampling conducted during transition training with Heckler and Koch P7M8 9 millimeter (**mm**) automatic pistols. Range officers reported that 3,200 rounds of 115 grain, 9 mm ball, fully copper jacketed ammunition (Israel Military Industries) were fired.

Sampling was conducted again on April 25, 1991, during qualification shooting, when 115 grain hollow point, jacketed ammunition (Federal) was used. Eight-hour TWA exposures for students ranged from 1.0 to 103.8 $\mu g/m^3$, with a mean of 26.3 $\mu g/m^3$. Range officers' 8-hour TWA exposures ranged from 9.7 to 39.8 $\mu g/m^3$, with a mean of 18.0 $\mu g/m^3$. Area samples ranged from 0.19 to 2450.1 $\mu g/m^3$. Smoke tests demonstrated that contaminated air could be pulled from downrange to behind the shooting line.

Air sampling results revealed that overexposure to lead occurred during the use of this firing range. Tests with a smoke machine indicated that these overexposures were due to deficiencies in the range ventilation system. Recommendations were provided which should reduce the potential for exposure to airborne lead.

Keywords: SIC 9221 (Police Protection), lead, firing range, ventilation

II. INTRODUCTION

On April 23-25, 1991, NIOSH investigators conducted an initial survey at the U.S. Park Police indoor firing range in Washington, D.C. This survey was conducted in response to an employer request for a health hazard evaluation concerning exposure to lead, carbon monoxide, and oxides of nitrogen, and a request to evaluate the ventilation system at the firing range. A NIOSH letter dated June 25, 1991, provided the results of the lead exposure monitoring, initial recommendations, and discussed future plans. Two NIOSH investigators returned on August 6, 1991, to further evaluate the performance of the ventilation system, and again on November 21, 1991, to provide recommendations to modify the ventilation system to improve its performance.

III. BACKGROUND

On February 20, 1991, NIOSH received a request from the United States Park Police to evaluate a new indoor range facility at the U.S. Park Police building in Washington, D.C. It was apparent that considerable efforts were expended to make this a safe and healthy workplace. The range facility includes an anteroom, control booth, and the firing range. The anteroom is located at the end of the range where the shooters' booths are located. The control booth is located in the middle of the wall separating the anteroom and range and partially projects into the range. Access to the control booth is only from the anteroom. Two doors on each side of the control booth are the only entrances to the range. Both doors have magnetic/rubber seals around the periphery. The anteroom contains chairs and an area for cleaning weapons.

There are 14 booths in the range. Booth width is about 3 1/2 feet. The floor area behind the shooting line is carpeted. The booth floor area is covered with a rubber mat which prevents damage to cartridges dropped on the floor during shooting, and provides a resilient surface for the shooters to stand on.

The air handlers for the range ventilation system are located above the anteroom and range. A ceiling made of Tectum™, an acoustic ceiling material composed of wood fibers, separates the range from the air handler area. The air handler area is accessed through a door located in the anteroom. A series of catwalks permit access to the air handlers and filters.

Air is supplied to the range behind the shooters and is exhausted at two locations downstream of the shooters' booths. The wall between the anteroom and the range is the plenum for the supply air. Air is supplied to the range through perforated metal panels on the upper half of the wall, excluding the doors, and viewing and control booth windows. Air is supplied through panels above the doors, the viewing windows, and the control booth, except for the angled panels above the control booth. A shelf is located immediately below the perforated metal panels. The remaining lower part of the wall is covered with carpeting.

The perforated metal covering the upper four feet of the wall is corrugated, resembling material sometimes used for covering the soffit area on houses. Hole area as a percentage of total panel area is 12.4%.

The rear of the booths is about ten feet from the face of the air wall. The booth walls are approximately five feet long. One exception is Booth 14. A closet places the air wall closer to the back of this booth.

Two air handlers remove 23% of the supply air from the range through four 18-inch x 24-inch registers located approximately ten to fifteen feet downrange. The registers are located in the ceiling of the range and are protected from bullets. Air collected by these two air handlers (exhaust air) is filtered and exhausted from the range through an outside wall which runs parallel to the range.

Five additional air handlers remove the balance of the air from the range through five 24-inch x 30-inch registers located above the bullet trap. Air collected by each air handler (recirculation air) is filtered and recirculated through separate ducts to a header above the air wall.

Two other air handlers provide outside makeup air to the range. These air handlers pull air in through the two walls running parallel with the range. The outside air is filtered and supplied to the header above the air wall through separate ducts. The quantity of outside air is about 30% less than the quantity of exhaust air to keep the range under negative pressure.

Air from the units supplying air to the range is supplied to a header above the air wall plenum. Fourteen evenly-spaced duct drops supply air from the header to the plenum. Air to the header can be adjusted using volume dampers in the ducts supplying air to the header.

A separate air handler supplies air to the anteroom and control booth through three 24-inch x 24-inch louvered diffusers. This air handling unit recirculates a portion of the air from the anteroom. Outside air is pulled into the unit through one of the walls which is parallel to the range. Excess air is exhausted from the anteroom through the range.

Filtration for the five recirculating and two exhaust air handling units serving the range consists of three stages. First stage prefilters have an efficiency of 30 to 35% according to the American Society of Heating, Refrigerating and Air-Conditioning Engineers (**ASHRAE**) Dust Spot Test.[1] Second stage prefilters are rated at 90 to 95% efficiency. Final filters are 99.97% efficient High Efficiency Particulate Air (**HEPA**) filters. Originally, these units had prefilters and electrostatic precipitator filters; but, these filters were changed to the three-stage filters because of concern that the original filters could fail and contaminate the ductwork.

A contract HVAC firm changes the filters. Initially, filters were changed on an as-needed basis based on the manufacturer's recommended pressure drop across the filters. In general, changing the first stage prefilters was all that was needed to have the pressure drop return to the original pressure drop. Over time, the range has collected enough data to dictate that the first stage filters be put on a monthly changeout schedule.

All five of the filter systems for the recirculating air handling units and the filter system for one of the exhaust air handling units are monitored for pressure drop. Typically, the pressure drop across the filter system is monitored instead of across each filter in the system. Gauges in the control booth show the pressure drop and also have pre-alarm and final alarm indicators. Pre-alarm indication is through an amber light indicating that filters are approaching a need to be changed. Final alarm is shown by a red light indicating that the filters need to be changed. Final alarm also shuts down all of the air handling units.

Another control system monitors the pressure differential between the range and the control booth. An indicator lights if the pressure between the range and the control booth becomes positive.

The anteroom air handling unit can heat and cool air. The air handling units for the outside air can only heat the air, while recirculation air handlers neither heat nor cool the air.

The bullet trap on the range is equipped with a system to automatically remove spent bullets from behind the trap. Spent bullets fall on a vibratory conveyor behind the trap. The conveyor moves the bullets outside the building and dumps them into a covered drum. The conveyor is actuated with a button in the control booth and runs for a preset time. When partially full, the drum is manually moved and covered with a locking lid.

Shower and locker facilities are located next to the range. Access to the facility is from the same hall into which the anteroom doors open.

IV. MATERIALS AND METHODS

Seventy-two personal breathing zone and 14 general area, lead-in-air samples were collected at the firing range during transition training, qualification, and range clean-up. These samples were collected on 37 millimeter (**mm**), 0.8 micron (**µm**) pore-size mixed cellulose ester filters in three piece cassettes, using battery-powered sampling pumps calibrated at a flow rate of 2.0 liters per minute (**L/min**). The samples were analyzed for lead by atomic absorption spectroscopy (**AA**) according to NIOSH methods 7082 and 7105 (flame AA and graphite furnace AA).[2] Samples analyzed by flame AA which resulted in lead concentrations below the limit of detection (**LOD**) for the method (3 µg/filter) were subsequently analyzed by graphite furnace AA (LOD: 0.005 µg/filter).

A smoke machine (Model 1500, Rosco Laboratories, Port Chester, New York) was used to generate a non-toxic smoke in the range. Smoke was released from the fold-down shelf in each shooter's booth and at several positions behind the firing line to visualize the air flow patterns in this portion of the firing range. Smoke was also released downrange from several booths to visualize smoke patterns in that portion of the range.

V. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the 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 from eight to ten hours a day, forty hours a week, for a working lifetime without experiencing adverse health effects. However, it is 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 substance 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 to the level set by the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, thus potentially increasing 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 work place 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 US Department of Labor (**OSHA**) Permissible Exposure Limits (**PELs**).[3-5] In evaluating the exposure levels and the recommendations for reducing those levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA PEL.

A time-weighted average exposure level (**TWA**) refers to the average airborne concentration of a substance during a normal eight to ten hour workday. Some substances have recommended short-term exposure limits (**STEL**) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from brief high exposures.

A. <u>Lead</u>

Inhalation (breathing) of dust and fume, and ingestion (swallowing) resulting from hand-to-mouth contact with lead-contaminated food, cigarettes, clothing, or other objects are the major routes of worker exposure to lead. Once absorbed, lead accumulates in the soft tissues and bones, with the highest accumulation in the liver and kidneys.[6] It is stored in the bones for decades, and may cause toxic effects as it is slowly released over time. Overexposure to lead results in damage to the kidneys, gastrointestinal tract, peripheral and central nervous systems, and the blood-forming organs (bone marrow).

The frequency and severity of symptoms associated with lead exposure increase with increasing blood lead levels (BLLs). Signs or symptoms of lead intoxication include weakness, excessive tiredness, irritability, constipation, anorexia, abdominal discomfort, colic, anemia, high blood pressure, irritability or anxiety, fine tremors, and "wrist drop."[7-9]

Overt symptoms of lead poisoning in adults generally begin at BLLs between 60 and 120 µg/dl.[10] Neurologic, hematologic, and reproductive effects, however, may be detectable at much lower levels, and the World Health Organization (WHO) has recommended an upper limit of 40 µg/dl for occupationally exposed adult males.[11] The mean serum lead level for U.S. men 1976-1980 was 16 µg/dl; however, with the implementation of lead-free gasoline and reduced lead in food, the 1991 average serum lead level of U.S. men will probably drop below 9 µg/dl.[12-14]

An increase in an individual worker's BLL can mean that the worker is being overexposed to lead, and that engineering controls, respiratory protection, or work practices are inadequate. While the BLL is a good indication of recent exposure to, and current absorption of lead, it is not a reliable indication of the total body burden of lead.[15] Lead can accumulate in the body over time and produce health effects long after exposure has stopped. Long-term overexposure to lead may cause infertility in both sexes, fetal damage, chronic kidney disease (nephropathy), and anemia.

The workplace is not the only source of exposure; lead is a trace element in foods and beverages and may be a contaminant in drinking water, ambient air, soil, and street or house dust. Adults consume approximately 300 µg of lead each day, of which only approximately 10% is absorbed. The average daily respiratory intake for adults living in the United States is 20 µg.[16,17] In non-industrial environments, the greatest single source of lead in air has typically been automobile exhaust, but this source has been greatly reduced in the United States.

The OSHA lead standard for general industry specifies a PEL of 50 µg/m^3 as an 8-hour TWA for daily exposure to (airborne) lead. The standard requires semi-annual monitoring of BLL for employees exposed to airborne lead at or above the Action Level of 30 µg/m^3 (8-hour TWA), and specifies medical removal of employees whose average blood lead is 50 µg/dl or greater. Provision for economic protection of medically removed workers is included in the standard.[18]

The NIOSH REL for lead exposure is less than 100 µg/m^3 as a TWA up to 10 hours, in order that the worker's BLLs remain below 60 µg/dl. NIOSH is presently reviewing current literature on the health effects of lead exposure to re-evaluate its REL.

Recent studies suggest that there are adverse health effects at BLLs below the current acceptable levels for persons with occupational exposure. A number of studies have found neurological symptoms in workers with BLLs of 40 to 60 µg/dl. Male BLLs are associated with increases in blood pressure, with no apparent lower threshold of effect. Studies have suggested decreased fertility in men at BLLs as low as 40 µg/dl. Prenatal exposure to lead is associated with reduced gestational age and birthweight, and delayed early mental development at prenatal maternal BLLs as low as 10 to 15 µg/dl.[19]

In recognition of the health risks associated with exposure to lead, goals for reducing occupational exposure were specified in *Healthy People 2000*, a recent statement of national consensus and U.S. Public Health Service policy for health promotion and disease prevention. The goal for workers exposed to lead is to eliminate, by the year 2000, all exposures that result in BLLs greater than 25 µg/dl.[20]

VI. RESULTS

The results of the lead sampling are presented in Tables 1, 2 and 3. For U.S. Park Police students using the range on April 24, 1991, 8-hour TWA results ranged from 4.4 $\mu g/m^3$ to 116.4 $\mu g/m^3$ of airborne lead, with a mean of 32.5 $\mu g/m^3$. Eight-hour TWA results for area samples on April 24, 1991 ranged from 0.15 to 2291.1 $\mu g/m^3$. The 8-hour TWA results for range officers on that day ranged from 0.15 to 52.6 $\mu g/m^3$, with a mean of 16.1 $\mu g/m^3$. This represents the exposures during transition training with Heckler and Koch P7M8 9 millimeter (**mm**) automatic pistols, when range officers reported that 3,200 rounds of 115 grain, 9 mm ball, fully copper jacketed ammunition (Israel Military Industries) were fired.

The student using Booth 7 moved to Booth 14 at 12:34 p.m., after using Booth 7 for 31 minutes following the beginning of the afternoon sampling, and remained there until the end of sampling at 1:03 p.m. The eight-hour time-weighted average was calculated as if that student had remained at Booth 7 for the duration of shooting. That student's exposure may be an underestimate of the true exposure of a student who remains in Booth 7 throughout the day's shooting.

Sampling was conducted again on April 25, 1991, during qualification shooting, when 115 grain hollow point, jacketed ammunition (Federal) was used. Eight-hour TWA exposures for students ranged from 1.0 to 103.8 $\mu g/m^3$, with a mean of 26.3 $\mu g/m^3$. Range officers' 8-hour TWA exposures ranged from 9.7 to 39.8 $\mu g/m^3$, with a mean of 18.0 $\mu g/m^3$. Area samples ranged from 0.19 to 2450.1 $\mu g/m^3$. On April 25, 1991, the student using Booth 2 left after using the booth for 111 minutes in the morning, and the student using Booth 7 moved to Booth 2 at 12:25 p.m., and remained there until the end of shooting. However, the TWA for this student was calculated as if the student had remained at Booth 7. Again, the true exposure for an individual using Booth 7 was probably underestimated as a result.

Most of the smoke released at the shooter's position in the booths flowed downrange. However, in Booths 1, 2, 7, 8, and 11 through 14, some of the smoke was carried back uprange through the booths. This phenomenon appeared to be the worst in Booth 14 because of a wake formed in front of the lower, covered portion of the wall behind this booth. This wake extended into Booth 14 causing smoke released above the shelf to be pulled into the lower part of the booth and into the wake. Some of the smoke carried back through this booth was drawn into the air flowing through Booth 13.

Smoke released on the shelf below the perforated panel and midway between the wall and the rear of the booths, showed that the air coming from the wall and the air traveling to the booths had varying patterns. In general, the air exiting the air wall flowed toward the ceiling or the floor. The cause of this air flow pattern could not be determined, but may be due to the angle of the holes in the perforated metal or some other effect occurring in the plenum area of the wall. Air enters the booths with a rolling movement. Little of the air appeared to flow through the lower part of the booth. Air entering Booths 1 and 2 tended to fall from the ceiling as the air approached the booth and spread across the booth faces. The doors and the control booth, which projects into the range, impacted the direction of the air as it travelled to the firing booths, causing the air to move toward the area in front of the doors.

Airborne lead concentrations were affected by air flow patterns in Booths 5, 6, and 7. Results for these booths were substantially higher on both days of sampling than for other booths. Furthermore, sample results for the range officer who stood behind these booths were elevated despite the fact that this officer stood near the control booth during shooting. Subsequent evaluation with the smoke machine showed that air downrange of the firing line was being recycled through the lower portion of Booths 5, 6, and 7. This air traveled behind the booths to the control booth wall area where the air was pulled toward the ceiling by a jet along the ceiling. This jet appears to be the reason for the movement of contaminated air from downrange back through the booths.

VII. CONCLUSIONS

Air sampling results indicate that the potential exists for overexposure to lead for students using the booths directly in front of the control room (5, 6, and 7), and for range officers who remain in this area. Smoke tests demonstrate that contaminated air could be pulled from downrange to behind the shooting line. This movement of air that has been contaminated appears to be the reason for the high exposures for Booths 5, 6, and 7 and for the range officer standing behind these booths. Furthermore, contaminated air, both from the major movement of air back through these booths and more localized air currents in individual booths, appears to be the reason for quantifiable lead-in-air results for other shooters and range officers. A jet along the ceiling above the control booth wall appears to be the cause of this air flow pattern.

VIII. RECOMMENDATIONS

A. Ventilation

1. Do not use Booths 5, 6, and 7 until changes are made to the ventilation system. The following recommendations are based upon research conducted at NIOSH, and may correct the deficiencies in the ventilation system.[21]
   a. The current perforated panel wall should be replaced with a wall which uses double perforated panels, one panel on the plenum side of the wall and one on the range side of the wall. Perforated panels should have 1/4" holes on 1" centers. Holes in the panels should be misaligned if possible. The perforated panels should extend from the floor to the ceiling, requiring the removal of the carpet and dry wall covering the lower part of the wall. The distance between the range-side and plenum-side panels should be at least 5". Supply air should be able to move through the areas between the support studs. This can be achieved by constructing a wall with offset studs, or by adding 1 1/2" horizontal standoffs to the front or back of the current studs. Figures 1 and 2 illustrate these construction techniques. The current shelves can be replaced on the new air wall.
   b. Perforated panel doors should be added to the range side of the wall in front of the existing doors. These doors can be made by attaching perforated panels to the front and back faces of the stiles on doors from which the solid panels have been removed. The holes in the perforated panels should be misaligned to limit jet effects. Linear diffusers with dampers should be mounted on the two vertical faces of each doorway to connect the area between the new and existing doors, and the plenum behind the air wall.

The diffusers should be as wide as allowed by the construction of the doorway and the dampers should be used to balance the air flow from the plenum into the area between the doors. The new doors should be equipped with air-tight seals, similar to the current doors, and with automatic door closers to keep the doors shut.

c. The areas above and below the control booth on the range side should be rebuilt to present a flat face above and below the control booth that is parallel with the air wall. The faces of the boxed out area parallel with the air wall should be made of double perforated panels similar to the changed main air wall. The area behind the perforated panels of the boxed out area should be connected to the plenum area of the rest of the air wall.

d. Cooling capacity should be added to the current ventilation system. Controls on the supply air should be able to limit the temperature to between 70 and 80 °F. The temperature of the air should not be allowed to fall below 65 °F because of the potential for the air to drop as it exits the air wall. The supply air dropping as it exits the wall would flow under the warmer air in the range and cause a large recirculating eddy. In turn, this could lead to contaminated air downrange of the booths being drawn uprange of the booths.

B. <u>Lead</u>

1. Establish and enforce personal hygiene practices designed to prevent the ingestion of lead and the contamination of areas outside the firing range with lead:

   a. Range officers should be provided with two lockers to allow them to separate street clothes from lead contaminated work clothes. Continue to pursue the contract for commercial laundering of work clothes.

   b. Range officers should shower at the end of the work day.

   c. Range officers and students should wash-up before eating, drinking, using tobacco products, or applying cosmetics.

2. Establish a medical surveillance program for range officers which addresses occupational exposure to lead.

3. Establish a respiratory protection program in accordance with OSHA regulation 29 CFR 1910.134 for the range officer who wears a respirator while HEPA vacuuming the range. When range officers are required to perform maintenance on the range, they must be provided with respirators and protective clothing selected based upon the anticipated hazard.

4. Place a lead work area warning sign on exterior of the lead conveyor clean-out door. Continue with plans to interlock this door with a warning light to prevent use of the range when this area is occupied. Signs should be posted

on or near entrances to the range warning of potential lead hazards in the range, and stating the precautions and hygiene practices required of range users.

5. Remove the carpeting from the firing range using dust suppression techniques. Replace the carpeting with a non-porous resilient matting to prevent fatigue associated with prolonged standing on a hard surface.

6. Use tacky-surfaced doormats to remove lead dust from the bottom of shoes as people exit the range.

7. HEPA vacuuming did not appear to remove all of the lead dust from the range floor. If a means can be found to dispose of the wash water in accordance with environmental regulations, the range should be wet mopped with a high phosphorous detergent. Range personnel reported that dust collected in the HEPA vacuum was highly flammable due to the presence of unburnt gun powder. The use of an explosion-proof HEPA vacuum or one which utilizes a wet dust collector would reduce the hazards associated with this material.

8. Shooters should use construction paper placed under body parts contacting the floor in either kneeling or prone shooting. This construction paper should be removed and disposed of as soon after shooting as possible.

C. Noise

1. The compressed air nozzle used at the gun cleaning station should be replaced with a quieter model. These nozzles are available commercially.

2. Noise monitoring should be conducted to determine whether hearing protection should be worn in the anteroom. Plaques and photographs should not be hung on the walls in this room as they interfere with the noise attenuating properties of the wall covering by preventing sound waves from reaching it.

3. Earplugs should be obtained in packages of two rather than packages of twenty five for sanitary reasons.

4. Do not fire shotguns on the indoor range. Previous NIOSH investigations have found that even with the use ear plugs and muffs, shotgun users are exposed to sound pressure levels in excess of 120 dB(A).[22]

5. Train shooters in the proper use of hearing protection as part of their introduction to the range.

D. Safety

1. Move the fire extinguisher from the gun cleaning counter to the wall to assure that it is accessible in the event of a fire on the counter.

2. Instruct range users to wear clothing that is snug at the collar to prevent discharged cartridges from entering their clothing and burning exposed skin.

3. The material safety data sheet for REM OIL gun oil (enclosed) recommends the use of impermeable gloves to prevent skin irritation. Obtain material safety data sheets for hazardous substances used at the firing range and establish a hazard communication program in accordance with OSHA regulation 29 CFR 1910.1200.

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Copies of this report have been sent to:

1. Range Officer, United States Park Police
2. Commander, Technical Services, United States Park Police
3. Commander, Training Branch, United States Park Police
4. Force Safety Officer, United States Park Police
5. OSHA, Region III
6. NIOSH

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 1
Results of Personal Air Sampling for Lead for Students, by Firing Booth
U.S. Park Police Firing Range
Washington, D.C.
April 24 and 25, 1991
HETA 91-124

Booth	1	2	3	4	5	6	7	8	9	10	11	12	13	14
April 24, 1991 8-hour TWA lead, ($\mu g/m^3$)	(5.7)	29.	37.8	24.6	62.4	116.4	71.3	22.7	(10.7)	(12.9)	(8.6)	15.8	4.4	
April 25, 1991 8-hour TWA lead, ($\mu g/m^3$)	(7.3)	1.0	16.4	22.8	59.9	103.8	60.3	18.7	(9.4)	(6.3)	17.7	(8.3)	(10.3)	
April 24, 1991 Actual TWA lead, ($\mu g/m^3$)	(10.3)	54.5	72.8	44.7	116	210.8	129.7	41.7	(19.3)	(23.0)	(16.5)	29.5	7.8	
Sample Duration (minutes)	267	256	249	264	258	265	264	261	266	269	251	256	268	
April 25, 1991 Actual TWA lead ($\mu g/m^3$)	(14.3)	4.5	32.3	45.9	130.7	208.5	128.0	38.4	(20.8)	(13.0)	38.2	(17.2)	(20.6)	
Sample Duration (minutes)	244	111	243	239	220	239	226	234	216	230	222	232	240	

Note: Values in ( ) represent quantities of lead between the limit of detection [3 μg/filter] and the limit of quantitation [8.4 μg/filter] for flame atomic absorption spectroscopy, and should be considered trace concentrations with limited confidence in their accuracy. Values reported less than those in ( ) indicate that lead concentrations for these samples were less than the limit of detection for flame AA and that these samples were subsequently analyzed by graphite furnace AA. The OSHA Permissible Exposure Limit for lead is 50 $\mu g/m^3$, as an 8-hour TWA.

TWA: time weighted average
$\mu g/m^3$ micrograms per cubic meter

Table 2
Results of Personal Air Sampling for Lead, Range Officers
U.S. Park Police Firing Range
Washington, D.C.
April 23-25, 1991
HETA 91-124

Sample Description	8-Hour TWA Lead Concentration ($\mu g/m^3$)	Sample Duration (minutes)	Actual Time-Weighted Average Concentration ($\mu g/m^3$)
	April 23, 1991		
Vacuuming Range	(2.1)	19	(52.2)
	April 24, 1991		
Range Officer	(5.7)	188	(14.6)
Range Officer	12.6	232	26.1
Range Officer	15.1	193	37.6
Range Officer	52.6	190	132.9
Range Officer	30.3	245	59.4
Range Officer	4.1	221	8.9
Range Officer	(8.3)	46	(86.2)
Vacuuming Range	.15	19	3.7
	April 25, 1991		
Range Officer	39.8	213	89.7
Range Officer	13.2	227	28.0
Range Officer	(9.7)	228	(20.3)
Range Officer	(11.3)	214	(25.4)
Range Officer	16.1	137	56.6

Note: Values in ( ) represent quantities of lead between the limit of detection [3 μg/filter] and the limit of quantitation [8.4 μg/filter] for flame atomic absorption spectroscopy, and should be considered trace concentrations with limited confidence in their accuracy. Values reported less than those in ( ) indicate that lead concentrations for these samples were less than the limit of detection for flame AA and that these samples were subsequently analyzed by graphite furnace AA. The OSHA Permissible Exposure Limit for lead is 50 $\mu g/m^3$ as an 8-hour TWA. TWA: time weighted average. $\mu g/m^3$: micrograms per cubic meter

Table 3
Results of Area Sampling for Lead
U.S Park Police Firing Range, Washington, D.C
April 24 and 25, 1991, HETA 91-124

Sample Description	8-Hour TWA Lead Concentration ($\mu g/m^3$)	Sample Duration (minutes)	Actual Time-Weighted Average Concentration ($\mu g/m^3$)
	April 24, 1991		
Behind Booths, Right Side of Range	.15	334	.21
Behind Booths, Left Side of Range	(2.6)	335	(3.7)
Bullet Trap	2291.1	335	3282.8
Behind Booths, Over Control Booth	47.4	334	68.1
In Control Booth	.44	323	.65
Gun Cleaning	.23	43	2.6
	April 25, 1991		
Bullet Trap	2450.1	359	3275.9
Behind Booths, Over Control Booth	13.8	358	18.5
Ready Room, Window Ledge, Right Side	.54	355	.73
Ready Room, Window Ledge, Left Side	(3.5)	352	(4.8)
Locker Room	.19	347	.27
At Intake, On Roof	.29	341	.40
Gun Cleaning	(4.7)	113	(19.9)

Note: Values in ( ) represent quantities of lead between the limit of detection [3 μg/filter] and the limit of quantitation [8.4 μg/filter] for flame atomic absorption spectroscopy, and should be considered trace concentrations with limited confidence in their accuracy. Values reported less than those in ( ) indicate that lead concentrations for these samples were less than the limit of detection for flame AA and that these samples were subsequently analyzed by graphite furnace AA. The OSHA Permissible Exposure Limit for lead is 50 micrograms per cubic meter ($\mu g/m^3$) as an 8-hour time-weighted average (TWA).

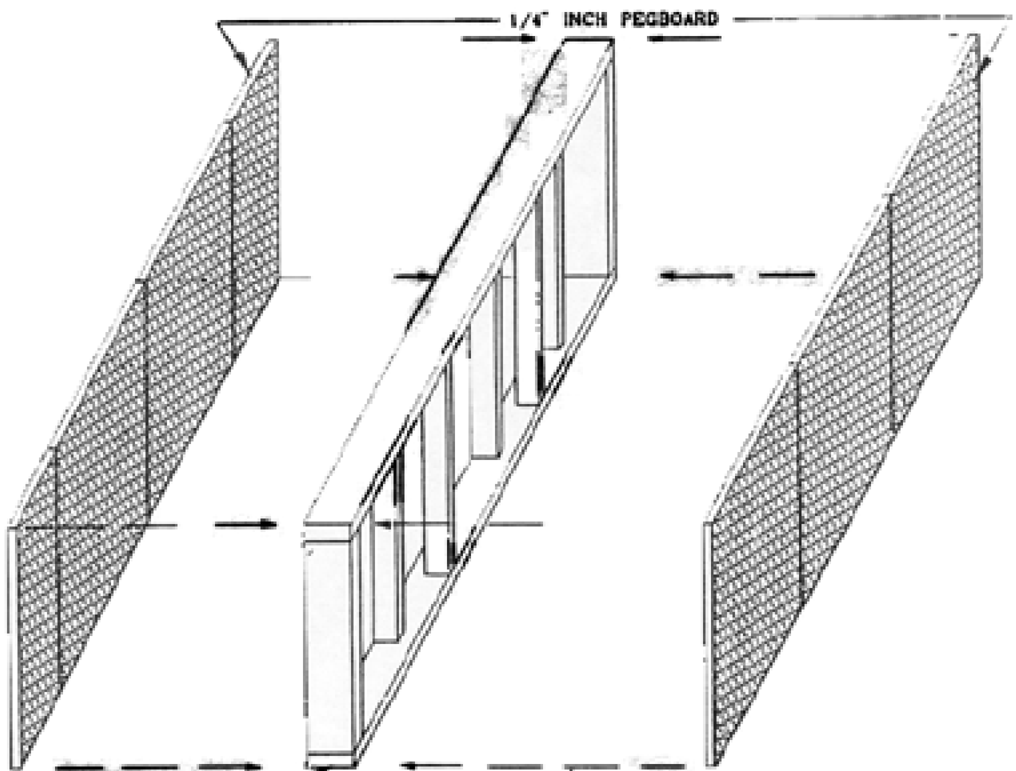

Figure 1
Construction Detail, Double Open Pegboard Inlet
U.S. Park Police Firing Range
Washington, D.C.
April 24 and 25, 1991
HETA 91-124

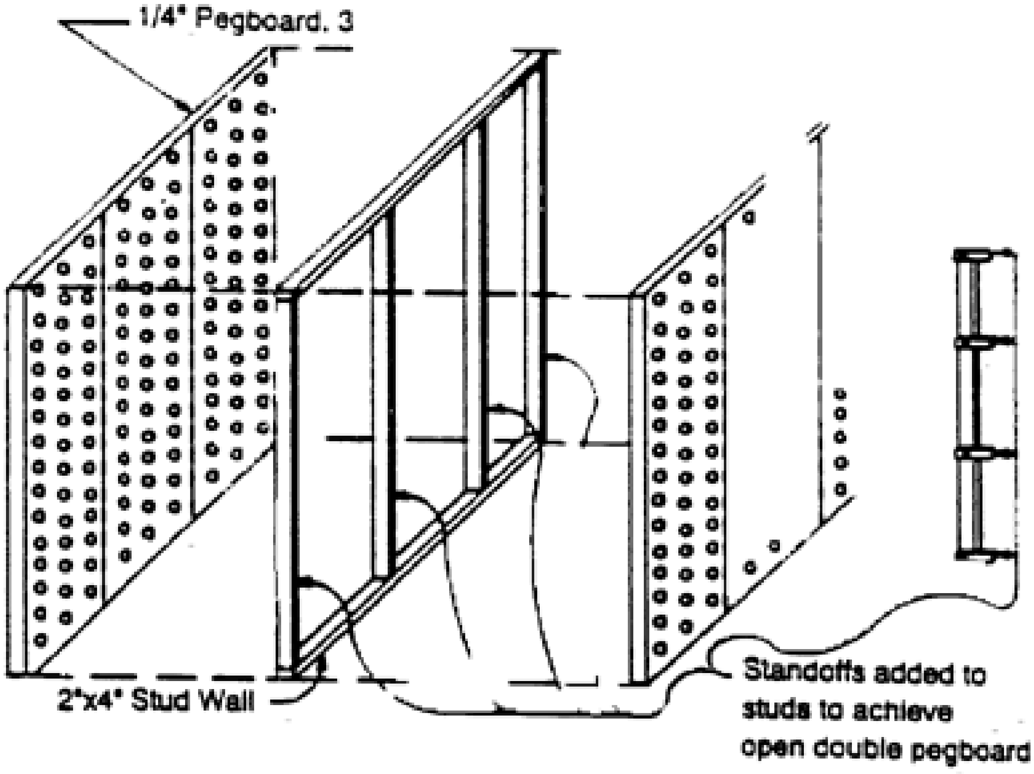

Figure 2
Construction Detail, Double Open Pegboard Inlet
Using Standoffs Added to Existing Studs
U.S. Park Police Firing Range
Washington, D.C.
April 24 and 25, 1991
HETA 91-124