syndrome (SBS) symptoms, such as headaches and irritation of the eyes, nose, throat, and skin.

In the buildings studied, respiratory illnesses varied by a factor of 1.2 to 2.0 as a result of building characteristics, including outdoor air ventilation rate, type of ventilation system, and occupant density. The researchers then correlated the symptom prevalence with statistical data on health care costs.

They estimate that the health care costs from acute respiratory infection are about $30 billion annually. They then calculate that these infections result in approximately $35 billion in sick leave and restricted activity at work. For asthma, they calculate the sick leave costs and productivity decreases at $13 billion. SBS costs, while less certain, come in at around $50 billion.

Fisk says the difficult part of the analysis was in determining the percentage of productivity improvements that would come from improving IEQ. They base these, in part, on the strength of associations between building conditions and symptoms, and the practicality of making the improvements.

From these calculations, they estimate the potential decrease in adverse health effects to be 10%-30% for infectious respiratory disease, allergy, and asthma, and 20%-50% for SBS symptoms. They estimate the potential increase in workers' performance to be between 0.5% and 5%. They calculate the health care savings plus productivity gains for US workers to be $6-$19 billion from reduced respiratory disease, $1-$4 billion from reduced allergies and asthma, $10-$20 billion from reduced SBS symptoms, and $12-$125 billion from direct improvements in worker performance unrelated to health.

They then estimate the cost of making necessary improvements — increasing ventilation and improving air filtration — and determine the benefit-to-cost ratio. These, they find, are very high: 50:1 for increased ventilation and 20:1 for improved filtration.

While more research is needed on the link between productivity and building conditions, Fisk estimates that a five-year research project could answer many questions. He estimates that $10 million a year for the five years would cover the cost. This represents less than 0.2% of the most conservative estimate of productivity gains.

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CASE STUDY

[In each issue, **IEQS** *presents a case study on an indoor air investigation in a particular building. The information in the cases comes from various sources, including published material, reports in the public record, and, in some cases, reports supplied by the consultants involved in the case.* **IEQS** *presents a variety of approaches to investigation and mitigation implemented by consultants with a broad range of experience, philosophies, and expertise. Inclusion of a particular case study in the newsletter does not imply* **IEQS***'s endorsement of the investigative procedures, analysis, or mitigation techniques employed in the case.* **IEQS** *invites readers to submit comments, suggestions, and questions concerning any case. At the discretion of the editor, correspondence may be presented in a future issue.]*

NIOSH Studies FBI Academy for Possible Lead Contamination

Concerned over possible lead exposure to students and staff at its firearms training facility at the US Federal Bureau of Investigation (FBI) Training Academy (Quantico, Virginia), the Bureau asked the US National Institute for Occupational Safety and Health (NIOSH) to conduct a health hazard evaluation. The investigators studied the potential for airborne lead contamination, blood lead levels (BLLs), "take-home" lead contamination of vehicles and homes, and exposure to families.

NIOSH conducted the survey in 1991 at the FBI facility, but released the health hazard evaluation report — prepared by Michael E. Barsan and Aubrey Miller, M.D. — only last year. The report is designated HETA 91-0346-2572.

The firearms training facility is under the control of the FBI's Firearms Training Unit (FTU), which provides training for both FBI and Drug Enforcement Agency (DEA) personnel. The academy has one indoor firing range for training, one indoor range for gun testing, and seven outdoor firing ranges.

Building and HVAC Description

The two indoor ranges have common supply and exhaust fans, which provide the facility with 100% outside air (O/A) that is exhausted after one pass. The supply fan and air intake are adjacent to the left wall of the training/ student range.

Supply air is prefiltered by a one-inch-thick filter, and then enters a plenum, which is in the same room as the supply fan. The plenum has a roll filter and heating coils, but contains no provisions for cooling the air. Investigators estimated both the prefilter and the roll filter to have an efficiency of less than 20%.

The exhaust fan system, separate from the supply fans, is located in a room adjacent to the right side of the student range. The system did not filter air either before it entered the exhaust fan room or before it was exhausted outside.

The indoor ranges are located on the first floor of a two-story, multiuse concrete block building. The student range consists of 23 booths. Trainees, gunsmiths, instructors, and other FBI agents use the range. The gun testing range, located adjacent to the student range, can accommodate one person at a time.

The student range is approximately 100 feet by 100 feet. Structural columns interrupt the room and, because of this, there are gaps between booths 6 and 7, 13 and 14, and 20 and 21. There is another gap between booth 1 and the left wall. Between the uprange wall (the area toward the shooting end of the range) and the firing line, the ceiling is 7 feet. For the next 10 feet the ceiling is 8 feet, and for the rest of the range it is 12 feet, with bullet deflectors hung from the ceiling to protect lights and ducts.

Supply air enters the range through a perforated metal wall with a pattern of $\frac{1}{4}$-inch holes on $\frac{1}{2}$-inch vertical and horizontal centers. The air wall is about three feet from the end wall, creating a plenum in the space between the two walls. Air enters the plenum from 23 ceiling ducts, which come from a common main duct. Each duct opening contains turning vanes just upstream of the plenum.

The design airflow for the student range is 43,900 cubic feet per minute (cfm), with an average velocity of 55 feet per minute. Two exhausts serve the range, one at midrange with a design capacity of 8,000 cfm, and one at the bullet trap with a design capacity of 40,000 cfm.

The gun testing range is 8 feet wide, 8 feet high, and 60 feet long, and instead of a shooting booth, contains a desk at which the gunsmith sits when firing the weapon.

Air enters the gunsmiths' range through four inline ceiling-mounted registers near the uprange wall. All of the registers have opposed-blade dampers and all but one have adjustable louvers.

The design airflow for the range is 4,050, and exhaust is provided by a single midrange exhaust and a single trap exhaust, similar to those in the student range. The investigators report that the airflow distribution for the range wasn't available.

Lead Exposure Program

The FBI conducts blood lead testing every six months on all instructors, technicians, and gunsmiths. Custodians who clean the firing ranges are tested annually, a program that started in 1991.

All instructors wear uniforms while working, but aren't required to wear protective clothing. Gunsmiths have protective aprons to use in the indoor firing ranges. Custodians wear Tyvek suits with respiratory protection when cleaning the ranges. Cleaning took place about twice a week, and consisted of using a dry broom to sweep the lead dust and other debris into piles, which was then collected with HEPA vacuums. The custodians also vacuumed the carpets uprange of the firing line.

Investigative Strategy

The investigation consisted of several components, including medical tests and interviews, environmental monitoring for lead contamination, airflow evaluation, and surface samples in dormitory rooms.

The investigators conducted private medical interviews with 13 randomly selected workers. These included six instructors, two range technicians, two gunsmiths, and three custodians. The interviewers gathered information about possible health problems, symptoms, work practices, and use of personal protective equipment.

The investigators also examined the BLL levels for the previous three years for the 41 current instructors, range technicians, gunsmiths, and custodians in an effort to determine trends.

Environmental monitoring consisted of collecting personal breathing zone (PBZ) and area air samples to test for lead concentrations. In the indoor ranges these came from throughout the range and the ventilation system. First, the investigators took air samples while the system was running, but the range was not in use. Then, they took samples from the same locations with the system running while the range was in use for a firearms session. Because the session was a qualifying session, the investigators didn't ask the shooters to wear PBZ samplers.

Later, they collected PBZ air samples from a shooter who used the indoor range for one and a half hours. They also collected samples from three custodians during short-term cleaning, and collected PBZ samples from gunsmiths and range technicians each day during the study.

The investigators used artificial smoke to evaluate airflow patterns in the indoor firing range. They released the smoke in each of the 23 booths, as well as at the floor level in the gaps between booths. They then observed the smoke to see whether the airflowed downrange.

To test for take-home lead in dormitory rooms, the investigators collected carpet dust samples in 14 student dormitory rooms and 14 non-student rooms. They took two carpet samples in each room, one two feet inside the room and one adjacent to the center of the bathroom door.

Results

The medical interview turned up no symptom complaints, except for complaints of "occasional" headaches reported by two instructors when firing guns on the indoor range. None of the persons interviewed reported any symptoms that could be associated with elevated BLLs.

The average reported potential exposure to lead differed among the workgroups as follows:

- Instructors and gunsmiths — 22 hours per week;
- Range technicians — 16 hours per week; and
- Custodians — 6 hours per week.

Of the 13 persons interviewed, 4 reported eating or drinking in areas with possible contamination, 2 reported smoking in those areas, and 10 reported that they consistently washed their hands after lead exposure. Two persons reported showering at work prior to going home.

All the instructors said they wore uniforms between work and home, and laundered the uniforms at home. Gunsmiths and technicians said they wore aprons or coveralls at work, but washed these at home. Custodians reported wearing Tyvek suits at work and disposing of these before leaving the area.

Ventilation System

Observations using the smoke generator indicated a horizontal air movement with no backflow in some of the booths, while other booths had an irregular air movement, which could result in breathing zone contamination under certain conditions.

The tests revealed that air exiting the air wall moved toward the right instead of downrange, creating an eddy behind the firing line. Investigators theorized that this may have resulted from the fact that the plenum behind the air wall was used for storage, with some boxes stacked within six inches of the plenum wall. Also, one of the plenum supply ducts didn't have turning vanes, which could have affected airflow. Other deficiencies noted by the investigators included misdirected louvers and material stored uprange of the firing line.

In the gunsmiths' range, the investigation revealed significant backflowing that could contaminate the breathing zone. Also, the room was under negative pressure, but design drawings showed equal supply and exhaust.

The exhaust fan room was found to be inefficient due to leaks that affected pressurization. Also, because all surfaces in the room were covered with lead dust, inadvertent positive pressurization of the room could spread lead throughout the rest of the facility.

Exposure Monitoring

The BLL tests revealed that all measurements fell within acceptable guidelines, which range from an OSHA guideline of 50 micrograms per deciliter (μg/dl) of blood to a US Public Health Service Goal (for the year 2000) of 25 μg/dl. However, the investigators noted in their report

Table 1 — Blood Lead Level Testing Results

Group (number of workers)	Year	Number of workers tested	Mean BLL (range)
Instructors (16)	1989	7	14.6 μg/dl (5-21)
	1990	7	13.7μg/dl (6-27)
	1991	14	7.6 μg/dl (<4-12)
Gunsmiths (13)	1989	5	12.2 μg/dl (8-15)
	1990	5	11.0 μg/dl (5-18)
	1991	11	12.1 μg/dl (<4-24)
Range Technicians (6)	1989	5	16.2 μg/dl (10-24)
	1990	5	10.4 μg/dl (6-14)
	1991	5	13.6 μg/dl (8-28)
Custodians (6)	1989	0	–
	1990	0	–
	1991	6	<4.0 μg/dl

that some studies have noted increases in adverse reactions at much lower levels, as low as 10 μg/dl. Table 1 shows the BLL of workers tested.

Air monitoring in the indoor ranges indicated that the ventilation works as designed, because no airborne lead was detected at the points behind the firing line. As the level of detection was 5 $\mu g/m^3$, this means that the airborne concentrations were well below the OSHA permissible exposure limit of 50 $\mu g/m^3$ and the OSHA action level of 30 $\mu g/m^3$.

PBZ sampling showed that range technicians were also exposed to very low concentrations, less than 2.7 $\mu g/m^3$. Gunsmith sampling indicated exposures less than 4.5 $\mu g/m^3$.

Dust samples from the dormitory indicated that student rooms had significantly higher lead concentrations than nonstudent rooms. Levels ranged from 116 μg/g to 546 μg/g for student rooms, and from 50 μg/g to 188 μg/g for nonstudent rooms. The mean concentrations were 214 μg/g and 65 μg/g respectively. Table 2 shows the results from the dormitory room sampling.

Recommendations

As a result of the investigation, the NIOSH team made numerous recommendations to correct deficiencies and reduce the opportunity for lead exposure. Among these are:

- Refrain from eating, drinking, or smoking in areas where lead exposure may occur.
- All personnel should wash their hands after lead exposure.
- Individuals should shower and change clothes before leaving the facility.
- Shooters using a kneeling or prone position should place a protective sheet on the ground beneath them to avoid coming in contact with settled lead dust.
- The facility should use nonlead jacketed bullets, with nonlead primers if possible.
- The firing range ventilation system should be in operation at all times when the range is in use.
- After each use, the range should be cleaned with a HEPA vacuum, and dry-sweeping should never be used to clean the range.
- Indoor surfaces should be routinely cleaned with a high-phosphate detergent.
- Carpeting should not be used anywhere in the range because it becomes a lead dust reservoir.
- Missing turning vanes should be replaced.
- Nothing should be stored in the air wall plenum and obstructions to the airflow should be minimized.
- The gunsmiths' shooting desk should be replaced to prevent backflow.
- All leaks should be repaired.
- A new exhaust/air filter plenum should be constructed to properly filter and exhaust lead-contaminated air.
- Current exhaust ducts should be replaced with new ducts to prevent settling of lead dust.
- All components should be decontaminated before renovations take place.

Table 2 — Dust Lead Concentration in Dormitory Rooms

Student Rooms		Nonstudent Rooms	
Room Number	Concentration	Room Number	Concentration
101	169	201	52
102	174	202	188
103	141	203	51
104	393	204	117
105	168	205	53
106	116	206	66
107	352	207	71
108	356	208	51
109	207	209	48
110	546	210	47
111	227	211	58
112	161	212	75
113	179	213	72
114	143	214	50
Geometric Mean	214		65
Standard Deviation	1.58		1.48

Source: NIOSH

For More Information

For more information on the NIOSH Health Hazard Evaluation Program or to obtain a copy of this report, contact: NIOSH, Hazard Evaluation and Technical Assistance Branch, 4676 Columbia Parkway, Cincinnati, OH 45226; (800) 356-4674.

NEWS AND ANALYSIS

Did the Tobacco Industry Sabotage the Standard 62 Revision?

The proposed revision to ASHRAE Standard 62-89, *Ventilation for Acceptable Indoor Air Quality*, to all appearances is a dead issue and will at best resurface only as a "guideline," while the current operative version remains, subject to "continuous maintenance" or periodic addenda (see ***IEQS***, August 1997). The document's ultimate fate, however, remains a matter for speculation, as even ASHRAE is unsure how things will proceed, although the future course might become a little clearer after a series of meetings over the next few weeks.

How the process derailed is an even more intriguing question than what the change in process means, but while observers with whom ***IEQS*** has spoken do not have a smoking gun, they do suspect a political maneuver, most likely by the tobacco industry or a closely allied group.

If this is true, it would explain the industry's relative silence during the public review of the standard last fall. ***IEQS*** had speculated that the tobacco industry might try a repeat of its performance during the public review on the IAQ rule proposed by the US Occupational Safety and Health Administration (OSHA). At that time, tobacco firms and lobbyists — both through extensive comments and a letter-writing campaign — flooded OSHA with tens of thousands of replies, almost bringing the process to its knees.

Steve Taylor, chairperson of the ASHRAE revision committee, had predicted a vigorous tobacco industry response. While Taylor blamed the revision's demise on "naysayers," we asked him if tobacco lobbyists could have been at work. "I suppose so," he responded, "I think that's a lot of what's behind it."

The official response is that the move to place the current standard on continuous maintenance and incorporate it as part of a multidisciplinary standard plan is in response to objections from "rank and file" members, who felt