CDC Workplace Safety and Health

Evaluation of Exposures in Sculpture Studios at a College Art Department

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Health Hazard Evaluation Report
HETA 2007–0167–3078
Brooklyn College
Brooklyn, New York
February 2009

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
NIOSH *National Institute for Occupational Safety and Health*

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Abbreviations

ACGIH®	American Conference of Governmental Industrial Hygienists
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
BEI®	Biological exposure index
cc/min	Cubic centimeters per minute
cfm	Cubic feet per minute
CFR	Code of Federal Regulations
ft^2	Square foot
GFCI	Ground fault circuit interrupter
HEPA	High-efficiency particulate air
HHE	Health hazard evaluation
LEV	Local exhaust ventilation
Lpm	Liters per minute
MDC	Minimum detectable concentration
MQC	Minimum quantifiable concentration
mg/m^3	Milligrams per cubic meter
MSDS	Material safety data sheet
NAICS	North American Industry Classification System
NIOSH	National Institute for Occupational Safety and Health
OEL	Occupational exposure limit
OSHA	Occupational Safety and Health Administration
PBZ	Personal breathing zone
PEL	Permissible exposure limit
PPE	Personal protective equipment
ppm	Parts per million
REL	Recommended exposure limit
STEL	Short term exposure limit
TD	Thermal desorption
TIG	Tungsten inert gas
TLV®	Threshold limit value
TWA	Time-weighted average
UV	Ultraviolet
VOC	Volatile organic compound
WEEL	Workplace environmental exposure limit
$\mu g/m^3$	Micrograms per cubic meter

Highlights of the NIOSH Health Hazard Evaluation

The National Institute for Occupational Safety and Health (NIOSH) received a confidential request for a health hazard evaluation (HHE) at Brooklyn College in Brooklyn, New York. The request concerned inadequate tool spacing, problems with exhaust ventilation, unsafe work areas, and exposures in the sculpture studios, and their relationship with lung cancer, degenerative nerve damage, sinus problems, allergies, and headaches among employees. Investigations were conducted on October 22–24, 2007, and March 28, 2008.

What NIOSH Did

- We looked at electrical and physical safety concerns in the studios.
- We measured the ventilation exhaust airflow rates and observed air movement in the studios.
- We collected air samples for volatile organic compounds (VOCs) in the woodworking studio during class.
- We collected air samples for welding fumes in the metalworking studio during class.
- We talked to sculpture studio employees about their health.
- We reviewed health and safety documents, training programs, and personal protective equipment (PPE) use.

What NIOSH Found

- The studios had inadequate electrical grounding, machine guarding, and spacing around power tools and machines.
- The ventilation system was not supplying outdoor or make-up air to the sculpture studios.
- The metalworking studio's exhaust airflow rate did not meet guidelines.
- Employees were not always using the available ventilation controls or appropriate PPE to reduce exposures.
- Potential human carcinogens, such as methylene chloride and welding fumes, were present in the air of the sculpture studios.
- The air concentrations of VOCs in the woodworking studio were very low.
- The air concentrations of metals and minerals in welding fumes were very low.
- All five sculpture studio employees who were interviewed reported concerns about safety issues in the sculpture studios.
- Some employees reported intermittent nose and throat irritation and breathing problems. These symptoms were consistent with work-related chemical and/or dust exposures.
- The reports of neurological disorders and lung cancer in retired studio employees could not be properly assessed because medical records and historical exposure records were not available for review, and there were very few cases.

- Cleaning and janitorial practices were inadequate.
- The material safety data sheets (MSDSs) were out-of-date.
- Safety and hazard communication training and PPE training were inadequate for sculpture studio employees.

What Managers Can Do

- Correct the safety hazards in the studios.
- Substitute a less toxic plastics adhesive for methylene chloride.
- Provide adequate outdoor and make-up air to the sculpture studios.
- Install local exhaust ventilation in the metalworking studio to reduce exposure to welding fumes.
- Strictly enforce studio safety and housekeeping rules.
- Improve safety and hazard communication and PPE training for sculpture studio employees.
- Update MSDSs according to OSHA's Hazard Communication Standard 29 CFR 1910.1200, Appendix D.
- Encourage studio employees to report work-related symptoms to supervisors, department heads, or the safety and health manager.

What Employees Can Do

- Follow all health and safety rules.
- Avoid the use of methylene chloride once an appropriate substitute becomes available.
- Use ventilation controls. Window exhaust fans should be used when working with chemicals. Dust collectors should be used when performing dust-generating tasks.
- Use appropriate PPE when welding or using machines and tools that pose a hazard.
- Report work-related health symptoms to supervisors, department heads, or the safety and health manager.
- Participate in health and safety training.
- Report cleaning and janitorial concerns to supervisors, department heads, or the safety and health manager.

Summary

NIOSH received a confidential employee request for an HHE at Brooklyn College in Brooklyn, New York. The request was to investigate health and safety concerns in the sculpture studios, including the ceramic, woodworking, and metalworking studios. Employees were concerned that degenerative nerve damage, lung cancer, sinus problems, allergies, and headaches were possibly related to work exposures.

NIOSH investigators evaluated Brooklyn College sculpture studios due to employees' health and safety concerns. We found inadequacies in electrical grounding, machine guarding, spacing between machines, ventilation, housekeeping, MSDS management, employee training, and PPE use. We also found that methylene chloride, a potential carcinogen, was being used by employees and students. Recommendations include correcting safety hazards, enforcing studio rules, improving ventilation, improving housekeeping, providing employee training, managing MSDSs, and using PPE.

On October 22–24, 2007, NIOSH investigators conducted an initial evaluation that included an opening conference, a tour of the three sculpture studios, observations of work activities, and a review of relevant health and safety documents. We evaluated the ventilation in the studios, collected area and PBZ air samples for VOCs in the woodworking studio, and interviewed employees about their health. On October 24, we held a closing conference to provide preliminary recommendations. On March 28, 2008, we returned to collect area and PBZ welding fume air samples during a metalworking class.

We observed inadequate electrical grounding, machine guarding, and spacing around power tools and machines; and poor housekeeping practices. Eating and drinking were allowed in the studios during classes, eye protection was not always used, and respirators were used improperly. Many of the existing health and safety rules and guidelines of the studios were not being enforced. The ventilation system did not mechanically provide supply air to the sculpture studios.

PBZ air samples collected for VOCs showed that xylene (0.23 ppm) and toluene (0.04 ppm) were the only compounds measured at quantifiable levels, and their concentrations were well below the NIOSH REL (100 ppm for both xylene and toluene), the OSHA PEL (xylene: 100 ppm; toluene: 200 ppm), and the ACGIH TLV (xylene: 100 ppm; toluene: 20 ppm). All other VOCs were found at trace levels or were not detected. Of the 31 airborne metals and minerals analyzed from welding fumes, most were either not detected or were present at trace concentrations. Six elements were measured in quantifiable concentrations in at least three locations. Zinc was measured in the highest concentration on a PBZ sample of 150 $\mu g/m^3$. This concentration was well below the NIOSH REL (5000 $\mu g/m^3$) and the ACGIH TLV (2000 $\mu g/m^3$) for zinc.

All interviewed employees reported concerns about safety issues in the studios. Employees reported past exposures including cadmium, lead, and asbestos exposure in the metalworking studio in the 1980s and unventilated kiln exhaust in the ceramics studio 10 to 12 years ago. Employees reported current use of glues, including methylene chloride, in the woodworking studio. Most studio employees reported intermittent nose and throat irritation, and one reported intermittent headaches at work. Employees also reported concerns about dust exposure, inadequate ventilation, and high noise levels, particularly in the woodworking and metalworking studios. Some employees were also concerned about the risk of developing lung cancer and nervous system disorders from past and current work exposures and reported previous cases in retired faculty.

Based on our findings, we conclude that employee reports of nose and throat irritation during work are consistent with particulate and/or irritant exposures. Although the VOCs and solvent levels we measured were below relevant OELs, some employees may still experience symptoms below the OELs. We determined that the neurological disorders and lung cancer in retired studio employees could not be properly assessed due to lack of historical records of exposure, inability to recreate past exposures, and small numbers of cases, making analysis not meaningful.

Management should address the sculpture studios' safety issues and improve the ventilation system. The ventilation system should supply adequate outdoor air and provide sufficient make-up air when the hoods and kilns are in use. Although welding fume concentrations were below relevant OELs for specific constituents, NIOSH considers welding fumes a potential human carcinogen and recommends reducing exposures to the lowest feasible level. Management can reduce welding fume exposures by installing adjustable LEV that removes contaminants from the point of generation. Also, ventilation fans and dust collectors that were previously installed to help collect and reduce airborne contaminants should be used when welding or performing dust-generating tasks. We also recommend that management enforce safety rules and improve housekeeping practices.

Keywords: NAICS 611310 (Colleges, Universities, and Professional Schools), university art studios, welding, VOCs, woodworking, sculpture, safety, ventilation, dust collectors, respirators, upper respiratory irritation, degenerative nerve damage, metalworking, ceramics

Introduction

On March 23, 2007, NIOSH received a confidential HHE request from employees of the Art Department of Brooklyn College in Brooklyn, New York. The request concerned inadequate tool spacing, problems with exhaust ventilation, and unsafe work facilities in the sculpture studios possibly causing a variety of health problems including lung cancer, degenerative nerve damage, sinus problems, allergies, and headaches. The sculpture studios included one ceramic, one metalworking, and one woodworking studio.

On October 22–24, 2007, NIOSH investigators made an initial site visit, which included an opening conference with Brooklyn College and City University of New York management representatives, union representatives from the Professional Staff Congress, Art Department administrative personnel, and employees working in the sculpture studios. We toured the three sculpture studios to observe work activities. We also evaluated studio ventilation, collected area and PBZ air samples in the woodworking studio, interviewed employees, and obtained relevant health and safety documents concerning the sculpture studios. On October 24, we held a closing conference to provide preliminary recommendations. An interim letter was sent in January 2008 to summarize our activities and preliminary recommendations from this visit.

On March 28, 2008, we made a second site visit to collect area and PBZ welding fume samples during the metalworking class, and noted changes that management had made based on our preliminary recommendations. This final report includes information and results from the October and March evaluations and presents our final recommendations.

Background

The sculpture studios, which include the woodworking, ceramic, and metalworking studios, are located in Whitehead Hall, separate from the rest of the Art Department. Whitehead Hall, built in 1968, is a five-story brick building consisting mostly of classrooms and offices. These studios are located in one wing of the first floor. Each studio ranges from approximately 900 to 1,000 ft^2 and is adjacent to a storage closet, restrooms, and office space.

Depending on the semester, instructors teach a variety of classes (metal sculpture, ceramics, 3-dimensional design, etc.) that last about 3 to 4 hours and are offered several times a week. A full-time studio technician spends at least 40 hours per week in the studios. Classes range in size from about 16 to 18 students.

Introduction (continued)

Due to the variety of art classes offered, a large array of tools and materials are used in these studios. The woodworking studio contains power tools such as table saws, band saws, and sanders. Students in multimedia sculpture use wood, plexiglass, adhesives, plasters, and a variety of other materials.

The ceramic studio contains potter's wheels and two kilns that were not used during our evaluation. Activities in the ceramic studio include pottery making and firing. No mixing of raw, dry materials for clay or glazes is performed. The employees expressed some concern about exposure to dried clay dust.

The metalworking studio contains seven work stations. One station has an overhead canopy hood that is manually switched on when in use and is designed to exhaust 1,800 cfm of air. Welding and aerosol paint spraying also occur under the canopy hood. Welding typically occurs on mild steel and scrap brass, using filler metals and welding rods that contain iron oxide, manganese, silicon oxide, aluminum, copper, and molybdenum. Processes that shape metals, such as bending, shearing, and filing also take place in this studio. Cadmium was reportedly used until the 1990s.

Each studio has two exhaust grilles. Each exhaust grille is designed to exhaust 500 cfm of air. In addition to the exhaust grilles, the woodworking and metalworking studios each have a 20-inch exhaust fan that exhausts air directly from the studios to the outdoors and is designed to remove approximately 3,600 cfm of air. These fans are manually switched on and off by the instructors. The studios have no mechanical air supply. Make-up air is pulled into the studios from the hall or the outdoors (from outside-facing windows and doors).

Eye protection, aprons, and dust masks (not NIOSH-certified respirators) were available in the woodworking studio. Ear muffs (for hearing protection), aprons, and NIOSH-certified elastomeric half-mask respirators with P100 particulate filter and chemical combination cartridges (Survivair Premier Plus, Santa Ana, CA) were available in the metalworking studio. Dust masks were available for use during cleaning activities.

Assessment

On October 22–24, 2007, we toured the three sculpture studios, observed classroom activities, and interviewed five of the six studio employees who worked exclusively in the sculpture studios (one was unavailable) and one other Art Department employee who asked to be interviewed. We obtained the following information for review: MSDSs of materials used in the woodworking and metalworking sculpture studios, the written Brooklyn College

Hazard Communication Program, copies of the State of New York Department of Labor Log of Work-Related Injuries and Illnesses (Form SH-900) from years 2004 through 2006, and letters and reports about the sculpture facilities from Brooklyn College Art Department administrators and employees.

We have summarized the sampling methodology below. Additional details of the sampling and analytical methods can be found in Appendix A.

On October 22–24, 2007, we collected four area and four PBZ air samples for VOCs in the woodworking studio during teaching activities when adhesives were used. Area air samples for VOCs were collected on TD tubes, which were used to identify individual compounds found at higher-than-background levels. PBZ air samples were collected on the charcoal tubes worn by employees. The PBZ charcoal tube air samples were used to quantify the concentrations of the VOCs identified from the TD tubes.

During this initial site visit, ventilation characteristics were evaluated in each studio, and an air velocity meter (TSI VelociCalc, Model 8386A, Shoreview, Minnesota) was used to measure airflow at the exhaust grilles. Smoke tubes were used to visualize air movement in each studio, in the restrooms, and in the corridor.

On March 28, 2008, we made a second site visit to sample for welding fumes during the metalworking class. We collected nine area air samples and one PBZ air sample for welding fumes in the metalworking studio during class while acetylene and TIG welding were being performed. In addition, we visually inspected the bag collectors for the band and disc sander. We also observed changes management had made in response to the preliminary recommendations from our initial site visit.

Results

Sampling Results

During the October 2007 site visit, three area air samples were taken for VOCs while students worked with various materials, and a control air sample was taken in an unused studio. Results from the area air samples identified five compounds that had concentrations above those in the control air sample: n-butyl acetate, toluene, trichloroethylene, xylene, and methyl methacrylate. When the corresponding PBZ air samples collected on charcoal tubes were analyzed to quantify those VOCs, most were found at or below the MDC. Xylene and toluene were the only quantifiable compounds found and were measured on the same air sample. Toluene was measured at 0.04 ppm and xylene at 0.23 ppm, which were well below the NIOSH REL (100 ppm for both xylene and toluene), the OSHA PEL (xylene: 100 ppm; toluene: 200 ppm), and ACGIH TLV (xylene: 100 ppm; toluene: 20 ppm).

The area air sampling results for elements (metals and minerals) that were quantifiable from welding fumes collected on March 28, 2008, are listed in Table 1. Our analysis looked for the presence of 31 different elements, and results indicated that all detectable elements were present below relevant OELs. Zinc and lead were found in the highest concentrations and were detected in all locations sampled. The highest concentration of zinc was measured on the professor's PBZ air sample (150 µg/m^3), which was still below the NIOSH REL (5,000 µg/m^3), the OSHA PEL (5,000 µg/m^3), and ACGIH TLV (2,000 µg/m^3). The highest lead concentration was measured on a welding booth area air sample (70 µg/m^3). All other airborne elements were present at concentrations below 5 µg/m^3. Although cadmium was reportedly no longer used for welding, it was detected in trace concentrations in five of eight air samples analyzed.

Table 1. Area air concentrations for selected welding fume components collected on March 28, 2008

	Time (min)	Barium	Copper	Iron	Manganese	Strontium	Zinc
				Concentration (µg/m^3)			
PBZ sample – professor	202	0.17	0.85	9.3	trace	trace	150
Under window fan	209	0.63	2.0	36	0.61	0.10	16
Between hood and sink	209	0.36	1.1	16	0.31	trace	4.3
Welding table by window	202	0.75	2.1	33	0.50	0.13	33
Area by door	200	0.28	0.76	14	trace	trace	3.3
Metalworking table – middle of studio	200	0.25	3.5	13	trace	trace	2.8
Welding booth area	195	1.6	2.4	70	0.88	0.28	8.3
Back of studio on shelf	195	trace	ND	5.4	trace	trace	2.5
MDC*	—	0.05	0.15	0.75	0.08	0.02	0.08
MQC*	—	0.16	0.53	2.8	0.28	0.08	0.28
NIOSH REL (TWA)	—	500	100†	5000	1000	NA	5000
OSHA PEL (TWA)	—	500	100†	10000	5000‡	NA	5000
ACGIH TLV (TWA)	—	500	200†	5000	200	NA	2000

Aluminum, antimony, arsenic, beryllium, cadmium, chromium, cobalt, lanthanum, lead, lithium, magnesium, molybdenum, nickel, phosphorus, potassium, selenium, silver, tellurium, thallium, tin, titanium, vanadium, and zirconium were found in trace amounts or below the MDC.
NA = no OEL
* Based on a volume of 400 liters
† As copper fume
‡ Ceiling limit
ND = Not detected (below the MDC)
Trace = Values between the MDC and MQC

Ventilation and Airflow Observations

Smoke tubes were used to observe air movement throughout the facility during various activities. We observed that air movement was greatly reduced, and large areas of the studio had stagnant pockets of air when window exhaust fans were turned off.

The woodworking studio was observed to be under negative pressure; in other words, air flowed from the hallway into the studio. The metalworking studio was under negative pressure to the hall (regardless of whether the fan and hood were off or on). Smoke test observations of air movement when both the fume hood and window exhaust fans were on showed that several welding stations were located downwind of other stations. The smoke tube observations also showed that the exhaust duct in the metalworking studio above the sink was not exhausting properly and was actually allowing air from the exhaust duct to drift into the studio.

In addition to the entry door from the hall into the ceramic studio, this studio had an exit door leading directly outside. Air was observed to enter the ceramic studio from the outdoors through windows and this exit door, into the studio, then into the hall. When the outside door was propped open, air movement fluctuated. Both exhaust grilles in this studio appeared to be functioning properly, although a portion of one of the exhaust grilles had hardened material between the fins, obstructing the grille opening.

Air from the studios was exhausted directly to the outdoors through the roof. The airflow rate at the exhaust grilles was measured, and total exhaust flow rate (cfm) was calculated for each studio. We then divided the exhaust flow rate by the area of each studio to compare measured flow rate with ASHRAE recommendations. The exhaust flow rate in the ceramic studio was 1.9 cfm/ft^2 and 1.2 cfm/ft^2 in the woodworking studio. The exhaust rate in the metalworking studio at the time of our evaluation was 0.6 cfm/ft^2.

At the time of our investigation, both restrooms located in the same wing as the art studios were under positive pressure, indicating that air was flowing from the restrooms into the corridor. We also observed aerosol paint spraying taking place under the canopy hood in the metalworking studio after class hours. After spraying occurred, we noticed a strong paint smell in the hallway outside the sculpture studios, especially near the closet containing the canopy hood fan.

Interviews

Interviews revealed that the five sculpture studio employees (including adjunct, assistant, full professors, and technicians) worked from 16 hours to more than 40 hours per week in the studios. Reported work exposures depended on the studio and the materials used. Employees reported that silver solder and cast iron were also sometimes used in the metalworking studio.

Employees reported that black rubber chemical-resistant gloves were available in the woodworking studio in addition to PPE already mentioned. Respirators were reportedly used during grinding or arc welding activities.

Employees reported concerns that sculpture studio exposures may have been causing health problems. Three of the five interviewed studio employees reported various intermittent health symptoms including sore throat/throat irritation, cough, shortness of breath, and dizziness. One of the three employees also reported intermittent wheezing, nosebleeds, and flu-like symptoms (not related to welding), and felt that symptoms were worse in winter months when windows were closed. Another employee also reported intermittent headaches at work and decreased lung capacity on pulmonary function testing. No medical records were released for review.

Employees reported historical exposure issues; for example, the potential for cadmium, lead, and asbestos exposure in the metalworking studio in the 1980s and the ceramics studio's kiln that exhausted into the studio instead of outdoors about 10–12 years ago. Employees reported current use of glues, including methylene chloride, in the woodworking studio.

One current studio employee reported neurological symptoms. We received anecdotal reports of health problems in retired studio faculty members including a variety of neurological symptoms and lung cancer. Medical records for retirees were not available for review.

All five interviewed studio employees reported concerns about safety issues in the studios such as lack of space between power tools and machinery, trip hazards, insufficient machine and tool guarding, lack of electrical grounding, and insufficient training of instructors and students on workshop safety. Most studio employees reported concerns about dust exposure, inadequate ventilation, and high noise levels, particularly in the woodworking and metalworking sculpture studios. Additionally, employees reported that the Health and Safety Committee did not meet in 2007, and that changes in sculpture studio responsibilities some years ago had caused confusion over who was accountable for different tasks, such as ventilation maintenance, housekeeping, tool and machine maintenance, MSDS management, and other safety responsibilities.

Staff reported difficulty in using the existing window fan and dust collectors because the amount of noise generated made communication with students difficult. This discouraged them from activating ventilation controls.

Document reviews

Many of the MSDSs were out of date. Telling which products were being used and which were no longer being used was difficult because all MSDSs were kept in the same binder. There was a formal written respiratory protection program; however, none of the sculpture studio employees were included in the program.

The hazard communication training program did not include specific hazardous materials used in the sculpture studios (e.g., methylene chloride). Employee and student training did not include operating instructions for power tools, machinery, hand tools, ventilation fans, exhaust hoods, fire blankets, or eyewash stations. Instructions on PPE use were also insufficient (i.e., when to use a respirator, what type of respirator, where respirators were kept, instructions on PPE maintenance, and need for fit testing).

The State of New York Department of Labor Logs of Work-Related Injuries and Illnesses, Form SH-900 were reviewed for years 2004, 2005, and 2006. In 2004, three entries were logged that occurred at Whitehead Hall, two from lacerations to fingers and one allergic reaction to a cleaning agent. One of the finger laceration entries was a fingertip amputation that occurred when an employee was using the wood router in the woodworking studio. In 2005, five entries occurred at Whitehead Hall: three slips and/or falls, one back strain, and one foot injury from a falling object. In 2006, one slip and fall entry occurred at Whitehead Hall.

Other Observations

We observed that electrical outlets in the studios were not equipped with GFCIs. We also noticed that certain areas of the studio seemed crowded when power tools and machines were in use and during the welding class. Also, we observed that all machines did not have adequate guards to prevent body parts or loose clothing from tangling with moving parts.

A housekeeping service removed trash, but most studio clean-up duties, such as mopping and dusting, were performed by work-study students and studio staff members. We observed students wearing dust masks when cleaning the studios outside of class time. When vacuuming, dust was re-entrained into the air in a visible dust cloud. Some employees were observed using high pressure air hoses to blow dust off their clothing.

Eyewash stations were not present in any of the sculpture studios. We noticed that a few persons observing materials being machined were not wearing eye protection. During oxyacetylene welding activities, we observed persons using face shields to protect from flying debris; however, the face shields did not appear to be shaded. We observed one shaded screen in use separating people performing TIG welding from the rest of the class and were told that goggles and face shields used for welding had a #6 shade rating. Hearing protection was not used when loud machinery was running. Hearing protection was not required by management, although some ear muffs were available in some studios.

We observed methylene chloride being used as an adhesive for plexiglass bonding and being applied using a 4-ounce squeeze bottle. We observed the instructor wearing gloves while using methylene chloride, but not safety glasses.

The canopy hood in the metalworking studio was designed so that the fan, located next to the metalworking studio in a maintenance closet, exhausted air from the metalworking studio to the building's roof. After detecting the smell of paint in the hallway outside the maintenance closet after aerosol paint spraying occurred, management discovered that the fan casing was loose, allowing air being exhausted from the canopy hood to leak into the surrounding areas.

At the time of our investigation, a dust collector was being installed in the corner of the woodworking studio to collect dust from the band saws. One belt and disc sander contained a built-in dust collector. We were told that some employees were concerned that the dust collector would create more dust than it would capture. This concern was based on reports that the dust collection system of the belt and disc sander created clouds of dust whenever the machine was used. It was thought that the collection system was not functioning properly. After reviewing the operating manual, we observed that the lever diverting the dust collection vacuum needed to be adjusted depending on which device (belt sander or disc sander) was used. This had not been done and may have contributed to the dust cloud.

Changes

We were informed of the following changes (or planned changes) that had been made in the sculpture studio based on our recommendations from the initial site visit in October 2007. NIOSH investigators did not verify these changes.

- Guards were installed over the machines, and all the large machines were bolted securely to the floor in the woodworking and metalworking studios.
- GFCIs were installed in the ceramic studio, and the outlets located in the middle of the studio on the floor were raised to a height of 2 feet to reduce the trip hazard.
- The exhaust duct in the metalworking studio was investigated by management, who stated that the duct had been blocked. Once the blockage was cleared, management reported that the duct was exhausting properly. Management also reported that both restroom exhaust fans had been fixed.
- The casing of the canopy hood exhaust fan located in the maintenance closet was fixed so that air no longer leaked back into the building.
- Employees were no longer allowed to use compressed air to blow dust off their clothing or off the machines. Instead, a vacuum with a HEPA filter was purchased to clean dust from machines, and two more vacuums with HEPA filters will reportedly be purchased to provide one for each studio.
- Class procedures were revised to allow students time to clean their work areas before class ended.
- The Health and Safety Committee had reconvened and meets every few weeks during each semester.
- A dust collector was installed in the woodworking studio with bags of higher efficiency. An enclosure was built around the dust collector to reduce noise.
- Management had purchased and planned to install eyewash stations (hand-held drench hose with dual heads) in each studio.

DISCUSSION

Artists face many different types of hazards due to the variety of materials they handle and the methods used to construct art pieces. For example, a variety of physical hazards were present in the sculpture studios including electrical, mechanical, and safety (flammability) hazards; ergonomic hazards; UV radiation (from welding); and noise.

Our observations of the limited amount of classroom space (due to the number of people using the space during class, amount of equipment, and limited storage space), lack of adequate guarding on all power tools, and presence of electrical hazards were concerns. Providing adequate space and marking aisles between machines and power tools can help reduce unintentional events, such as bumping into a working artist or having materials caught in moving machine parts. Machine guarding may be an effective engineering solution to prevent items or body parts from getting caught in moving machine parts. Advantages and limitations of machine guarding are discussed on OSHA's eTools website: [www.osha.gov/SLTC/etools/machineguarding/index.html]. Due to the use of large power tools and the presence of water in proximity to electrical devices (such as the ceramic studio), electrical shock is a potential hazard. GFCIs prevent electrocution by constantly monitoring electricity flowing in a circuit to sense any loss of current. If a loss of current does occur, the device quickly switches off power to that circuit to prevent electrocution.

Although the HHE request did not list noise exposure as a concern, we observed activities (e.g., grinding and cutting) that may produce excessive noise exposure. Excessive noise exposure can cause cumulative damage to the ears resulting in temporary or permanent ringing in the ears and hearing loss. Although hearing muffs were present in some studios, we did not see them being used. Management stated that they are planning to take sound level measurements to evaluate noise levels.

Multimedia sculpture classes in the woodworking studio included cutting, sawing, and sanding plexiglass, cardboard, wood, and other materials and using adhesives on these materials to join them together. Dusts and solvent vapors are created in this process. We observed methylene chloride being used as an adhesive for joining plexiglass. Methylene chloride use should be avoided because it is considered a potential carcinogen by NIOSH and OSHA. See additional information on OELs and health effects in Appendix B.

We noticed potential hazards to eye safety during our evaluation. Employees without eye protection would observe activities by standing close to working machines and power tools. Cutting, shaping, grinding, and polishing metals, wood, and other materials may produce flying particles that penetrate clothes, skin, and eyes. Employees and students need to be aware of this danger whenever using or observing these machines in use and wear appropriate eye protection and clothing. Another hazard to the eye can occur during welding, where UV light causes burns and retinal damage during the welding process. Welding, especially TIG welding, produces an intense visible, UV, and infrared light that can cause retinal damage and may also cause first and second degree burns on unprotected areas of the skin [Weiss and Lesser 1997].

Welding activities in the metalworking sculpture classes produced fumes and gases from heating metals to very high temperatures. High concentrations of welding fumes, and zinc fumes in particular, can cause metal fume fever. Although individual metal constituents from the welding fumes were below relevant OELs, NIOSH considers welding fumes a potential human carcinogen. Therefore, exposures should be limited to lowest feasible concentrations [NIOSH 2005a]. (For more information on welding hazards and health effects, see Appendix B.) A canopy hood, like the one in the metalworking studio, is not a recommended type of LEV to control for welding fumes because it draws contaminated air through the user's breathing zone. Installing a portable LEV system would increase user flexibility and employee protection as it can be moved to a variety of workstations.

Good industrial hygiene practice requires using engineering controls where feasible to reduce workplace concentrations of hazardous materials. Adequately designed studio ventilation is essential for reducing exposures from contaminants released during the art-making process. The ventilation systems at Whitehead Hall did not mechanically supply air to the sculpture studios. Air entering directly from the outdoors was not filtered or conditioned. Providing adequate supply air in accordance with appropriate codes, standards, and best practice recommendations is important to dilute contaminants and odors. A ventilation system filters particles from outdoor air and recirculated air and can supply air at the appropriate temperature and humidity. The ventilation system should also provide make-up air to replace the air removed by window exhaust fans and during kiln firing. The ASHRAE standard for Acceptable Indoor Air Quality 62.1-2007 has been used as the basis for many building codes and provides minimum outdoor air intake flow rates [ASHRAE 2007].

Adequate exhausting of air removes indoor air pollutants generated by the building occupants and other contaminant sources. ASHRAE standard 62.1-2007 recommends a minimum exhaust rate of 0.70 cfm/ft^2 for art classrooms [ASHRAE 2007]. Based on our measurements, the minimum exhaust rate was exceeded in the ceramic (1.9 cfm/ft^2) and woodworking (1.2 cfm/ft^2) studios. Because one of the exhaust grilles was not exhausting properly in the metalworking studio at the time of our evaluation, the ASHRAE recommendation for the minimum exhaust rate was not met; the exhaust airflow rate was measured at 0.6 cfm/ft^2.

CONCLUSIONS

A safety hazard existed at Brooklyn College due to inadequate spacing, machine guarding, and electrical grounding of machinery. In addition, ventilation improvements were identified that could reduce employee and student exposures to air contaminants. Specific information about the sculpture studios was not covered in the employee safety and hazard communication training. Employee reports of nose and throat irritation during work are consistent with particulate and/or irritant exposures. Although the VOCs and solvent levels we measured were below relevant OELs during the days of our evaluation, levels at other times may have been higher depending on varying conditions, such as activities performed or materials used. In addition, some employees may still experience symptoms when compounds are present at levels below the OELs. Welding fume concentrations were measured at levels below relevant OELs for specific constituents; however, NIOSH considers welding fumes a potential human carcinogen and recommends reducing exposures to the lowest feasible level. We determined that the reports of neurological disorders and lung cancer in retired studio employees could not be properly assessed due to lack of historical records of exposure, inability to recreate past exposures, and small numbers of cases, making analysis not meaningful.

RECOMMENDATIONS

Based on our findings, we recommend the actions listed below to create a more healthful workplace. We encourage Brooklyn College to use these recommendations to develop an action plan based, if possible, on the hierarchy of controls approach (refer to Appendix B: Occupational Exposure Limits and Health Effects). This approach groups actions by their likely effectiveness in reducing or removing hazards. In most cases, the preferred approach is to eliminate hazardous materials or processes and install engineering controls to reduce exposure or shield employees. Until such controls are in place, or if they are not effective or feasible, administrative measures and/or PPE may be needed.

1. Improve the safety of the sculpture studios.
   - Ground all machinery and power tools.
   - Install GFCIs in all the studios.
   - Inspect, maintain, and replace fraying or deteriorating electric cords.
   - Make sure that machines have an easily accessible stop switch.
   - Provide adequate clearance around power tools and machines by delineating well-defined aisles.
   - Install eyewash stations in each studio that allow a 15-minute rinse.

- Measure sound levels during noise-generating activities such as grinding and sawing. Depending on the intensity and duration of exposure, management may need to establish a hearing conservation program, including requiring employees to wear hearing protection.
- Enforce studio health and safety rules and guidelines including the following:
  - Always use eye protection when in the proximity of power tools to protect the eyes from flying dust and chips, even if just observing tasks.
  - Provide and encourage use of glasses, goggles, or masks with filter lenses that have a shade number appropriate for the work being performed for protection from injurious light radiation. More specific information on the minimum protective shade requirements for various welding operations is available in the OSHA standard 1910.133 for eye and face protection [29 CFR 1910.133].

2. Avoid the use of methylene chloride. If possible, substitute a less toxic adhesive for this compound.

3. Improve ventilation in the sculpture studios.
   - Provide the recommended amount of outdoor air to the sculpture studios. The ASHRAE standard for Acceptable Indoor Air Quality 62.1-2007 recommends providing a minimum combined outdoor air rate of 19 cfm/person in art classrooms [ASHRAE 2007].
   - Keep studios under negative pressure to prevent air contaminants from migrating to other parts of the building. Although the metalworking and sculpture studios were under negative pressure, the air from the ceramic studio was observed to move into the hallway.
   - Install a portable LEV system to reduce welding fume exposure. LEV would be more effective than general dilution ventilation because fumes would be exhausted at the source of generation instead of mixing with air in the room. Installing a portable LEV system would increase user flexibility because it can be moved to a variety of work stations. NIOSH considers welding fumes a potential human carcinogen and recommends reducing exposures to the lowest feasible level.
     - A canopy hood is not an appropriate type of LEV system to control welding fumes because it can move gases and fumes from the work station into the user's breathing zone.
   - Measure the exhaust airflow in the studios periodically to ensure that the ventilation system is working properly.

- o Use ventilation controls (e.g., window exhaust fans, LEV) and air cleaning equipment (dust collectors) when performing dust-generating activities.

4. If employers allow voluntary respirator use for employees performing dust-generating activities (i.e., cutting acrylic sheets, wood, or other art materials, and general cleaning) or welding activities, management must implement limited provisions of OSHA's respiratory protection standard 1910.134 [29 CFR 1910.134].
    - o If a filtering-facepiece respirator is provided for voluntary use, the employer must provide a copy of *Information for Employees Using Respirators When not Required Under Standard 1910.134 Appendix D* [29 CFR 1910.134] to the employee. In addition, management must train employees on how to maintain and store respirators.
    - o For respirators other than filtering facepieces (e.g., elastomeric respirators), management must also provide medical evaluations and have a written respiratory protection program, in addition to providing employees with Appendix D and proper training.
    - o Choose respiratory protection appropriate for the activity being performed. For example, dust masks are not considered respirators and do not provide sufficient protection from silica (when cleaning dried clay), fine particulates (when cleaning saws, sanders, and other tools), gases, or welding fumes. For additional information on the selection and use of respirators, consult the latest edition of the NIOSH Respirator Selection Logic [www.cdc.gov/niosh/docs/2005-100/default.html] [NIOSH 2005b]. Another resource for selecting respiratory protection can be found on OSHA's eTools website at: [www.osha.gov/SLTC/etools/respiratory/].

5. Maintain good housekeeping practices that decrease the amount of dust that becomes airborne and potentially inhaled.
    - o Clean and dust surfaces and equipment, including the exhaust grilles, regularly using the vacuum cleaners equipped with HEPA filters or dust suppression techniques, such as wiping areas with a damp cloth or mop.
    - o Remove the clay and dust from the exhaust fins in the ceramic studio.

6. Improve communication between the Brooklyn College Sculpture Art Department employees and Brooklyn College administration by facilitating the exchange of information and health and safety concerns about the sculpture studios.

Recommendations (continued)

- o Include employee and management representation in the studio Health and Safety Committee.
- o Maintain regularly scheduled meetings of the sculpture studio Health and Safety Committee.
- o Provide an explanation for decisions made to address identified problems.
- o Provide safety and hazard communication training for sculpture studio employees and include hazards specific to the studios.
- o Update the sculpture studio MSDSs to reflect the materials currently being used.
- o Designate one person to be responsible for health and safety of employees working in the sculpture studios and provide adequate work time for this person to devote to these duties.

7. Encourage sculpture studio employees to report work-related health concerns to the appropriate Brooklyn College personnel. Employees with these concerns should be evaluated by a physician knowledgeable in occupational medicine.

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Volatile Organic Compounds

To screen for VOCs, NIOSH investigators collected area air samples using TD tubes attached by Tygon® tubing to SKC® Pocket Pumps® (SKC, Eighty Four, Pennsylvania) calibrated at a flow rate of 0.05 Lpm. The TD tubes contain three beds of sorbent material. The first section contains Carbopack Y (90 mg), the second section contains Carbopack B (115 mg), and the last section contains Carboxen 1003 (150 mg). Sample tubes were purged with helium at 100 cc/min for 30 minutes prior to analysis to remove moisture. Analysis was done by gas chromatography-mass spectrometry according to NIOSH Method 2549 [NIOSH 2007]. At the same time the area air sampling was taking place, PBZ air samples for VOCs were being collected on charcoal tubes for analysis of specific VOCs identified in the screening samples, using gas chromatography according to NIOSH Methods 1022, 1500, and 1501 [NIOSH 2007].

Elements (Metals and Minerals)

Area and PBZ air samples for 31 elements were collected during the metalworking class where welding was performed. Classes lasted 4 hours and took place once a week. Samplers were placed in various areas around the studio and on the class professor. Sampling for airborne elements was conducted using 37-millimeter mixed-cellulose ester filters (0.8-micrometer pore size) in three-piece plastic filter cassettes. These sampling trains were calibrated at a flow rate of 2 Lpm. Filters were digested in concentrated nitric acid and analyzed per NIOSH Method 7303 [NIOSH 2007]. Samples were analyzed using a Perkin Elmer Optima 3200XL (Perkin Elmer, Waltham, Massachusetts), inductively coupled plasma atomic emission spectrometer.

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Appendix B: Occupational Exposure Limits & Health Effects

In evaluating the hazards posed by workplace exposures, NIOSH investigators use both mandatory (legally enforceable) and recommended OELs for chemical, physical, and biological agents as a guide for making recommendations. OELs have been developed by federal agencies and safety and health organizations to prevent the occurrence of adverse health effects from workplace exposures. Generally, OELs 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. However, not all workers will be protected from adverse health effects even 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 exposure limit. Also, some substances can be absorbed by direct contact with the skin and mucous membranes in addition to being inhaled, which contributes to the individual's overall exposure.

Most OELs are expressed as a TWA exposure. A TWA refers to the average exposure during a normal 8- to 10-hour workday. Some chemical substances and physical agents have recommended STEL or ceiling values where health effects are caused by exposures over a short period. Unless otherwise noted, the STEL is a 15-minute TWA exposure that should not be exceeded at any time during a workday, and the ceiling limit is an exposure that should not be exceeded at any time.

In the U.S., OELs have been established by federal agencies, professional organizations, state and local governments, and other entities. Some OELs are legally enforceable limits, while others are recommendations. The U.S. Department of Labor OSHA PELs (29 CFR 1910 [general industry], 29 CFR 1926 [construction industry], and 29 CFR 1917 [maritime industry]) are legal limits enforceable in workplaces covered under the Occupational Safety and Health Act. NIOSH RELs are recommendations based on a critical review of the scientific and technical information available on a given hazard and the adequacy of methods to identify and control the hazard. NIOSH RELs can be found in the *NIOSH Pocket Guide to Chemical Hazards* [NIOSH 2005]. NIOSH also recommends different types of risk management practices (e.g., engineering controls, safe work practices, worker education/training, personal protective equipment, and exposure and medical monitoring) to minimize the risk of exposure and adverse health effects from these hazards. Other OELs that are commonly used and cited in the U.S. include the TLVs recommended by ACGIH, a professional organization, and the WEELs recommended by the American Industrial Hygiene Association, another professional organization. The TLVs and WEELs are developed by committee members of these associations from a review of the published, peer-reviewed literature. They are not consensus standards. ACGIH TLVs are considered voluntary exposure guidelines for use by industrial hygienists and others trained in this discipline "to assist in the control of health hazards" [ACGIH 2008]. WEELs have been established for some chemicals "when no other legal or authoritative limits exist" [AIHA 2008].

Outside the U.S., OELs have been established by various agencies and organizations and include both legal and recommended limits. Since 2006, the Berufsgenossenschaftliches Institut für Arbeitsschutz (German Institute for Occupational Safety and Health) has maintained a database of international OELs from European Union member states, Canada (Québec), Japan, Switzerland, and the U.S. [www.hvbg.de/e/bia/gestis/limit_values/index.html]. The database contains international limits for over 1250 hazardous substances and is updated annually.

Employers should understand that not all hazardous chemicals have specific OSHA PELs, and for some agents the legally enforceable and recommended limits may not reflect current health-based information. However, an employer is still required by OSHA to protect its employees from hazards even in the absence of a specific OSHA PEL. OSHA requires an employer to furnish employees a place of employment free from recognized hazards that cause or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970 (Public Law 91–596, sec. 5(a)(1))]. Thus, NIOSH investigators encourage employers to make use of other OELs when making risk assessment and risk management decisions to best protect the health of their employees. NIOSH investigators also encourage the use of the traditional hierarchy of controls approach to eliminate or minimize identified workplace hazards. This includes, in order of preference, the use of: (1) substitution or elimination of the hazardous agent, (2) engineering controls (e.g., local exhaust ventilation, process enclosure, dilution ventilation), (3) administrative controls (e.g., limiting time of exposure, employee training, work practice changes, medical surveillance), and (4) personal protective equipment (e.g., respiratory protection, gloves, eye protection, hearing protection). Control banding, a qualitative risk assessment and risk management tool, is a complementary approach to protecting worker health that focuses resources on exposure controls by describing how a risk needs to be managed [www.cdc.gov/niosh/topics/ctrlbanding/]. This approach can be applied in situations where OELs have not been established or can be used to supplement the OELs, when available.

Volatile Organic Compounds

This is a large class of organic chemicals (i.e., containing carbon) that have a sufficiently high vapor pressure to allow some of the compound to exist in the gaseous state at room temperature. VOCs are emitted in varying concentrations from numerous indoor sources including carpeting, fabrics, adhesives, resins, solvents, paints, cleaners, waxes, cigarettes, and combustion sources.

Indoor environmental quality studies have measured wide ranges of VOC concentrations in indoor air as well as differences in the mixtures of chemicals which are present. Research also suggests that the irritant potency of these VOC mixtures can vary. Some researchers have compared levels of VOCs with human responses (such as headache and irritative symptoms of the eyes, nose, and throat). However, neither NIOSH nor OSHA currently have specific exposure criteria for VOC mixtures in the non-industrial environment.

Methylene Chloride

Methylene chloride, also called dichloromethane, is a volatile, colorless liquid with a chloroform-like odor. Methylene chloride is used in various industrial settings, such as paint stripping, pharmaceutical manufacturing, paint remover manufacturing, and metal cleaning and degreasing. It is also used to chemically weld certain plastics [OSHA 2007].

The most common means of exposure to methylene chloride is inhalation and skin exposure. Methylene chloride is metabolized by the body to carbon monoxide and, with high exposures, can lead to carbon monoxide poisoning [Fagin et al. 1980]. Exposure to methylene chloride may cause symptoms of eye and skin irritation; weakness, exhaustion, drowsiness, dizziness; numbness and tingling of limbs; and nausea. [NIOSH 1996, 2005] Prolonged skin contact can result in skin irritation or chemical burns [Wells and Waldron 1984].

OSHA and NIOSH consider methylene chloride to be a potential occupational carcinogen as it has been linked to cancer of the lung, liver, and pancreas in laboratory animals [ATSDR 2000; NIOSH 2005; OSHA 2007]. NIOSH does not have an established OEL for methylene chloride. OSHA has established an STEL of 125 ppm and a PEL of 25 ppm for methylene chloride [OSHA 2007].

Elements (Metals and Minerals)

The effect of elements from welding fumes on an individual's health can vary depending on the length and intensity of the exposure and the specific elements involved. Of particular concern are welding processes involving stainless steel, cadmium or lead-coated steel, and metals such as nickel, chrome, zinc, and copper. Fumes from these metals are considerably more toxic than those encountered when welding iron or mild steel. Epidemiologic studies of workers exposed to welding emissions have shown an excessive incidence of acute and chronic respiratory diseases [NIOSH 1988]. These illnesses include metal fume fever (an acute illness with symptoms similar to the flu including fever, chills, nausea, fatigue, weakness, and body aches), an increased susceptibility to pulmonary infections, pneumonitis, pulmonary edema, pulmonary fibrosis, and an elevated incidence of lung cancer among welders [Antonini et al. 2003].

Numerous studies indicate that welders may be at increased risk of neurological and neurobehavioral health effects when exposed to metals such as lead, iron and manganese. Carbon monoxide, heat, and stress can also contribute to neurological impairments in welders. Most welding fumes contain a small percentage of manganese. The exposure can vary considerably depending on the amount of manganese in the welding wire, rods, flux, and base metal. There is a concern by workers, employers, and health professionals about potential neurological effects associated with exposure to manganese in welding fumes. NIOSH has been conducting research and reviewing the published scientific literature to assess this problem. Prolonged exposure to high manganese concentrations (>1 mg/m^3) in air may lead to a Parkinsonian syndrome known as "manganism." Parkinson-like symptoms may include tremors, slowness of movement, muscle rigidity, and poor balance. Occupations with high manganese exposures include mining, ore-crushing, and metallurgical operations for iron, steel, ferrous and nonferrous alloys. The NIOSH REL for manganese is 1 mg/m^3 for an 8-hour TWA exposure, with a STEL of 3 mg/m^3 [NIOSH 2008]. The OSHA ceiling limit for manganese is 5 mg/m^3 [29 CFR 1910.1000]. The ACGIH TWA TLV for manganese is 0.2 mg/m^3 [ACGIH 2008].

A recent review publication found that welders generally have lower manganese exposures than miners and smelter workers, and, while manganism was observed in highly exposed workers, there is not enough evidence to associate welding with clinical neurotoxicity [Santamaria et al. 2007]. Recent studies indicate neurological and neurobehavioral deficits may occur when workers are exposed to low levels of manganese (< 0.2 mg/m^3) in welding fumes. These effects include changes in mood and short-term memory, altered reaction time, and reduced hand-eye coordination. It is not known if these findings have clinical significance. Art studio employees likely have even lower exposures than welders in these studies because they do not weld daily. NIOSH is currently reviewing its REL for manganese. A comprehensive review of the available scientific literature is in development and is expected to be made available by NIOSH for public review by early 2009.

NIOSH has concluded that it is not possible to establish an exposure limit for total welding emissions because the composition of welding fumes and gases varies greatly, and the welding constituents may interact to produce adverse health effects. Therefore, NIOSH recommends controlling total welding fume to the lowest feasible concentration and meeting the exposure limit for each welding fume constituent [NIOSH 2005]. NIOSH considers welding fumes to be potential occupational carcinogens [NIOSH 2005]. OSHA does not currently regulate welding fumes; however, PELs have been set for many individual welding fume constituents [29 CFR 1910.1000]. In addition to welding fumes, many other potential health hazards exist for welders. Welders can also be exposed to hazardous levels of ultraviolet radiation from the welding arc if welding screens or other precautions are not used. Because artists who weld face similar hazards as welders, they should take the same precautions to reduce their exposures.

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Acknowledgments and Availability of Report

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This report was prepared by Lilia Chen and Loren Tapp of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Health communication assistance was provided by Stefanie Evans. Editorial assistance was provided by Ellen Galloway. Desktop publishing was performed by Robin Smith.

Below is a recommended citation for this report:
NIOSH [2009]. Hazard evaluation and technical assistance report: evaluation of exposures in sculpture studios at a college art department, Brooklyn, New York. By Chen L, Tapp L. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH HETA Report No. 2007-0167-3078

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