NIOSH HEALTH HAZARD EVALUATION REPORT

HETA #2001-0326-2999
Dixie Cultured Marble
Birmingham, Alabama

May 2006

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

PREFACE

The Hazard Evaluation and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (NIOSH) conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health (OSHA) Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employers or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

HETAB also provides, upon request, technical and consultative assistance to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Robert E. McCleery, Angela Warren, and Randy L. Tubbs of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Analytical support was provided by Ardith Grote and Joseph Fernback of the Division of Applied Research and Technology (DART) and Data Chem Laboratories Incorporated, Salt Lake City, Utah. Desktop publishing was performed by Robin Smith. Editorial assistance was provided by Ellen Galloway.

Copies of this report have been sent to employee and management representatives at Dixie Cultured Marble (DCM) and the OSHA Regional Office. This report is not copyrighted and may be freely reproduced. The report may be viewed and printed from the following internet address: http://www.cdc.gov/niosh/hhe. Copies may be purchased from the National Technical Information Service (NTIS) at 5825 Port Royal Road, Springfield, Virginia 22161.

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.

Highlights of the NIOSH Health Hazard Evaluation

In May 2001, NIOSH received a confidential employee request for a HHE at Dixie Cultured Marble in Birmingham, Alabama. The request indicated concerns about exposures to chemicals present in the production of cultured marble vanities, bath tubs, and shower walls and floors. Symptoms reported by employees included: itchy skin, breathing problems, and headaches. In response, NIOSH investigators evaluated employee concerns during an initial facility site visit on December 9-10, 2004 and a follow-up site visit on June 21-22, 2005.

What NIOSH Did

- We took area and personal breathing zone (PBZ) air samples to look for volatile organic compounds, styrene, α-methyl styrene, methyl methacrylate, and dust.
- We evaluated employee noise exposure levels.
- We took tape samples from employees' arms to look for fiberglass.
- We talked to employees about job duties, work locations, and possible work-related symptoms.

What NIOSH Found

- Concentrations of styrene in the marble casting area and dust in the grinding area were above occupational exposure limits. Other PBZ air sample concentrations were below occupational exposure limits.
- Noise levels in the grinding area and the casting area vibrating tables were high.
- Most of the workers we talked to reported that they had no work-related health symptoms. A few workers, however, reported skin and breathing problems.

What Dixie Cultured Marble Managers Can Do

- Improve ventilation and work practices in the grinding booth.
- Develop a written respirator and hearing loss prevention program and ensure all requirements are being followed.
- Train employees to wear personal protective equipment the correct way.
- Place hearing and respiratory protection signs in areas where required.

What the Dixie Cultured Marble Employees Can Do

- Wear ear plugs and respirators the correct way.
- Make sure you do not have any facial hair if you wear a respirator.
- Report any health problems that you think may be work-related to the facility manager.

What To Do For More Information:
We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513-841-4252 and ask for HETA Report #2001-0326-2999

Health Hazard Evaluation Report 2001-0326-2999
Dixie Cultured Marble
Birmingham, Alabama
May 2006

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SUMMARY

In May 2001, NIOSH received a confidential employee request for a Health Hazard Evaluation at Dixie Cultured Marble (DCM) in Birmingham, Alabama. Employees were concerned with exposures to PVC glue, fiberglass, acetone, organic peroxide, and unsaturated polyester resins in the production of cultured marble vanities, bath tubs, and shower walls and floors. Employees reported symptoms that included itchy skin, breathing problems, and headaches. In response to employee concerns, NIOSH investigators conducted an initial site visit on December 9-10, 2004 and a follow-up site visit on June 21-22, 2005.

During the initial site visit, NIOSH investigators collected general area (GA) and personal breathing zone (PBZ) air samples for volatile organic compounds, collected tape samples from consenting employees' arms and a bulk sample of cultured marble dust to be analyzed for fiberglass and identified areas within the facility where they perceived elevated noise levels. They also interviewed DCM employees to gather information on demographics, health problems (work-related and non-work related), work practices, and workplace personal hygiene. During the follow-up site visit, PBZ air samples were collected for total and respirable particulate, styrene, α-methyl styrene, and methyl methacrylate. Noise dosimeters were placed on selected workers.

Respirable particulate, α-methyl styrene, and methyl methacrylate air sample concentrations were all below relevant evaluation criteria. The product grinder's total particulate exposure exceeded the Occupational Safety and Health Administration (OSHA) and American Conference of Governmental Industrial Hygienists (ACGIH), 8-hr time-weighted average (TWA) exposure limits. Styrene concentrations for two employees casting cultured marble exceeded the ACGIH 8-hr TWA of 20 parts per million (ppm). Noise monitoring data indicated that the daily noise doses of the product grinder and a product buffer exceeded the OSHA permissible exposure limit, and 10 of 11 evaluated employees exceeded the NIOSH-recommended daily allowable noise dose. Twelve of 15 employees were interviewed. Four of 12 employees reported respiratory problems and skin irritation.

Based on personal air sampling, noise monitoring, and employee interviews, NIOSH investigators conclude that a health hazard exists from exposure to total particulate, styrene, and noise. Recommendations to minimize exposures include improving existing ventilation systems, creating respiratory and hearing loss prevention programs, using improved hearing protection devices, and ensuring consistent use of respiratory protection.

Keywords: NAICS 326191 (Plastics Plumbing Fixture Manufacturing), cultured marble, bath tubs, vanities, PVC glue, fiberglass, total particulate, respirable particulate, styrene, α-methyl styrene, methyl methacrylate, organic peroxide, unsaturated polyester resin, noise, itchy skin, respiratory problems, headaches, respiratory protection, hearing protection, and ventilation

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INTRODUCTION

In May 2001, the National Institute for Occupational Safety and Health (NIOSH) received a confidential employee request for a Health Hazard Evaluation at Dixie Cultured Marble (DCM), in Birmingham, Alabama. Employees were concerned with exposures to polyvinyl chloride (PVC) glue, fiberglass, acetone, organic peroxide, and unsaturated polyester resins in the production of cultured marble vanities, bath tubs, and shower walls and floors. Employees reported symptoms that included itchy skin, breathing problems, and headaches. In response to employee concerns, NIOSH investigators conducted an initial site visit on December 9-10, 2004 and a follow-up site visit on June 21-22, 2005. The extended NIOSH response time was due to NIOSH investigators' roles in the emergency response events of 2001 and 2002, scheduling conflicts between NIOSH investigators and DCM management, and extended illness of key DCM personnel.

On December 9, 2004, the initial site visit began with an opening conference and facility tour. The environmental evaluation on December 10, 2004, consisted of general area (GA) and personal breathing zone (PBZ) air sample collection for volatile organic compounds. The medical evaluation included confidential employee interviews, review of Occupational Safety and Health Administration (OSHA) injury and illness logs and workers' compensation records, and collection of skin tape samples to be analyzed for the presence of fiberglass. During this site visit, NIOSH investigators identified areas within the facility where they perceived elevated noise levels. On June 21-22, 2005, the follow-up site visit involved an environmental evaluation consisting of PBZ air sampling for total particulate, respirable particulate, styrene, α-methyl styrene, and methyl methacrylate. Additionally, personal noise dosimeters were placed on specific employees to evaluate their exposure to noise sources in the facility.

BACKGROUND

DCM manufactures products that resemble true quarried marble, but are man-made by combining a number of chemical compounds. There are 15-20 employees producing cultured marble pieces. On an average day the company produces three showers, three whirlpool tubs, and 15-20 vanities. The facility is composed of two areas: (1) production of raw cultured marble products and (2) product finishing.

The process of producing cultured marble products begins with the preparation of molds (vanity sinks, whirlpool bathtubs, shower walls and floors, accent pieces, and other pieces) to be filled with the cultured marble material. Mold preparation includes (1) deciding whether a standard size mold can be used or whether modifying a current mold is necessary, (2) placing masking tape on the mold edges to reduce excess cultured marble on the finished product, and (3) placing a wax layer on the mold (wax acts like a releasing agent for the cultured marble piece). A gel coat is then sprayed on the mold in a ventilated spray booth. The gel coat is used to bind to the cultured marble material and is buffed to a shine in the final process step. The mold is then placed in an 85 degree Fahrenheit (ºF) oven for 10 minutes (both temperature and time are approximations). The gel coat is tacky at this point and allows for binding with the cultured marble material. After the oven step, the finished molds are placed on a vibration table for cultured marble casting (process of placing cultured marble material into a mold to form a specific shape that is then removed to produce the product of choice). The casting employees prepare a batch of cultured marble consisting of an unsaturated polyester resin in styrene, calcium and magnesium carbonate, coloring, and small amounts of other ingredients in a large, rotating mixing bowl. Using large putty knives, the employees quickly scoop the cultured marble mixture and place it into the mold. Midway through the casting process, the vibrating tables are activated to force any air pockets in the mixture to rise to the surface. In 20-30 minutes, the mixture hardens to a point of becoming too difficult to manipulate.

After the cultured marble piece has hardened it is released from its mold and begins the finishing process. The piece is moved into a ventilated booth where an employee grinds rough edges, uneven areas, and small air pockets until they are smooth. The piece is then taken to an area where employees buff the exterior to a shine with a buffing compound. The piece is stored in the facility until installers picked it up. Certain pieces may have additional steps in the finishing process. For example, before a shower floor hardens, the drain area is lowered by placing weight on the area to ensure suitable water drainage when assembled in a home or building.

The gel coat application area and the grinding areas both have approximately 13,000 cubic feet per minute (cfm) ventilation booths. Make-up air enters the facility through wall vents next to the booths and an open forklift door in each side of the facility. The production and finishing areas have two wall exhaust fans each, although the finishing side's fans are not typically operating. A ceiling exhaust fan is located above the dry material hopper in the casting area.

METHODS

Initial Site Visit

Industrial Hygiene

Volatile Organic Compounds

During the initial site visit, five thermal desorption tube area air samples were collected for qualitative analysis of volatile organic compounds in accordance with NIOSH Manual of Analytical Method (NMAM) Method 2549.[1] Samples were collected on three beds of sorbent material enclosed in a stainless steel tube using personal sampling pumps at a calibrated flow rate of 0.05 liters per minute (Lpm). The thermal desorption tubes were purged with helium to remove any water and then analyzed using a thermal unit interfaced directly to a gas chromatograph with a mass selective detector (TD-GC-MSD). A 30-meter DB-1 fused silica capillary column was used for analyses.

A bulk sample of grinding operation-generated cultured marble particulate was collected for fiber characterization, specifically fiberglass. This sample was prepared and analyzed according to NIOSH Method 9002 (Asbestos [Bulk] by PLM [polarized light microscopy]).[1]

Medical

Of the 15 employees present on the day of the survey, 12 were interviewed. During the confidential interview, the participant was asked basic demographics such as age, race, tenure, and health problems (work related and non-work related). They were also asked about their work practices (such as wearing personal protective equipment) and personal hygiene (such as washing hands and arms). Company OSHA logs were reviewed for incidents of injury or illness related to the exposures stated in the HHE request.

Tape samples were collected from an arm of consenting employees to determine whether fiberglass was present and the size of those fibers. A piece of transparent cellophane adhesive was placed on an employee's forearm, removed, and placed on a glass microscope slide. These samples and a bulk sample of cultured marble dust were prepared and analyzed according to NIOSH Method 9002.[1]

Follow-up Site Visit

Industrial Hygiene

Total Particulate

Nine PBZ air samples for total particulate were collected on tared 37-millimeter (mm) diameter, 0.8-micrometer (µm) pore size poly-vinyl chloride (PVC) filters, at a calibrated flow rate of 1.0 Lpm. The filters were gravimetrically analyzed (filter weight) for total particulate according to NIOSH Method 0500.[1] The analytical limit of detection (LOD) for

total particulate on the PVC filters was 0.02 milligrams (mg), which equates to a minimum detectable concentration (MDC) of 0.04 milligrams per cubic meter of air (mg/m^3), assuming a sample volume of 500 liters.

Respirable Particulate

Eight PBZ air samples for respirable particulate were collected on tared 37-mm diameter, 0.8-µm pore size PVC filters with a cyclone pre-selector, at a calibrated flow rate of 1.7 Lpm. The filters were gravimetrically analyzed for respirable particulate according to NIOSH Method 0600.[1] The LOD for respirable particulate on the PVC filters was 0.02 mg, which equates to a MDC of 0.03 mg/m^3, assuming a sample volume of 800 liters.

Styrene/α-Methyl Styrene

Ten PBZ air samples were collected for styrene and α-methyl styrene on solid sorbent tubes containing coconut shell charcoal (100/50 mg) at a calibrated flow rate of 0.05 Lpm, and analyzed by gas chromatography in accordance with NIOSH Method 1550.[1] Each sample was analyzed for both styrene and α-methyl styrene. The analytical LOD for styrene was 0.001 mg/sample, which is equivalent to a MDC of 0.017 parts per million (ppm), assuming a sample volume of 14 liters. The limit of quantitation (LOQ) for styrene was 0.004 mg/sample, which is equivalent to a minimum quantifiable concentration (MQC) of 0.067 ppm, assuming a sample volume of 14 liters. The analytical LOD for α-methyl styrene was 0.0006 mg/sample, which is equivalent to a MDC of 0.009 ppm, assuming a sample volume of 14 liters. The LOQ for α-methyl styrene was 0.002 mg/sample, which is equivalent to a MQC of 0.03 ppm, assuming a sample volume of 14 liters.

Methyl Methacrylate

Twelve PBZ air samples were collected for methyl methacrylate on solid sorbent tubes containing XAD-2 resin (400/200 mg) at a calibrated flow rate of 0.05 Lpm, and analyzed by gas chromatography in accordance with NIOSH Method 2537.[1] The analytical LOD for methyl methacrylate was 0.0009 mg/sample, which is equivalent to a MDC of 0.01 ppm, assuming a sample volume of 15 liters. The LOQ for methyl methacrylate was 0.003 mg/sample, which is equivalent to a MQC of 0.05 ppm, assuming a sample volume of 15 liters.

Noise

Because of the layout of the facility, with one side devoted to mold set-up and casting and the other side for cast removal and grinding and buffing of the finished product, employees were selected from each of the different manufacturing areas on one of the two sampling days. Each of the processes were evaluated for employee noise exposures over one full shift.

Quest® Electronics Model Q-300 Noise Dosimeters were used to collect the daily noise exposure measurements from the employees who volunteered for the NIOSH evaluation. The dosimeters were secured on the workers' belts and the dosimeter microphones attached to their shirts, halfway between the collar and the point of the shoulder. A windscreen provided by the dosimeter manufacturer was placed over the microphone during recordings. The dosimeters were worn for the entire work shift, but with the exception of one individual, were removed during the lunch break and allowed to run in a quiet location. The noise information was downloaded to a personal computer for interpretation with QuestSuite® Professional computer software and the dosimeters reset for the next day. The dosimeters were calibrated before and after the work shift according to the manufacturer's instructions.

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 up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though 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 criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increases the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs),[2] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[3] and (3) the U.S. Department of Labor, OSHA Permissible Exposure Limits (PELs).[4] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criteria.

OSHA requires an employer to furnish employees a place of employment that is free from recognized hazards that are causing 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, employers should understand that not all hazardous chemicals have specific OSHA exposure limits such as PELs and short-term exposure limits (STELs). An employer is still required by OSHA to protect their employees from hazards, even in the absence of a specific OSHA PEL.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended STEL or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

Nuisance Dust

A nuisance dust is typically characterized as an organic, inorganic, or mineral dust that does not have its own specific occupational health exposure criterion. Nuisance dusts have generally been described as "inert" or not producing a toxic effect or disease. However, there is the potential for respiratory tract, eye, and skin irritation depending upon the individual, dust characteristics (particle size, composition, etc.), and concentration.

The OSHA PELs for nuisance dust or particulates not otherwise regulated (PNORs), defined as total and respirable particulate in this report, are 15 mg/m^3 and 5 mg/m^3, respectively.[4]

Although no NIOSH REL for particulates has been established, after reviewing available published literature, NIOSH provided comments to OSHA on August 1, 1988, regarding the "Proposed Rule on Air Contaminants" (29 CFR 1910, Docket No. H-020). In these comments, NIOSH questioned whether the proposed OSHA PEL (as an 8-hour TWA) of 10 mg/m^3 for PNORs was adequate to protect workers from recognized health hazards.[2]

The ACGIH TLV for particles (insoluble or poorly soluble) not otherwise specified (PNOS) is 10 mg/m^3 for inhalable particles (hazardous when deposited anywhere in the respiratory tract) and 3 mg/m^3 for respirable particles (hazardous when deposited in the gas-exchange region).[3] Although PNOS is listed as a TLV, ACGIH states that it should be considered a guideline rather than a true TLV (see Appendix

B in the TLV/Biological Exposure Indices [BEI] booklet for details).[3]

Styrene

Styrene is a volatile, colorless to yellow, oily liquid with a sweet, floral odor.[5] The use of styrene in industry includes synthetic rubber and resins, a chemical intermediate, and polymerized synthetic plastics.[6] Exposure to styrene has been reported to cause eye and respiratory irritation in addition to central nervous system effects.[6] Humans have reported symptoms such as headaches, dizziness, fatigue, and nausea when exposed to styrene concentrations at approximately 100 ppm and above.[6,7]

The OSHA PEL for styrene is 100 ppm for an 8-hour TWA exposure.[4] OSHA provides a ceiling concentration for some substances that should not be exceeded at any time during an employee's 8-hour workday. However, styrene (plus a few other substances) has a ceiling concentration that can be exceeded only for a defined time period and at a specific maximum peak concentration during that 8-hour workday. Styrene's ceiling concentration is 200 ppm with a 5-minute maximum peak concentration of 600 ppm in any 3-hour period.

The NIOSH REL for styrene is 50 ppm for an 8-hour TWA exposure and 100 ppm for a STEL.[2] ACGIH recommends an 8-hour TWA TLV of 20 ppm, a STEL of 40 ppm, and assigns it an A4 designation (not classifiable as a human carcinogen).[3]

α-Methyl Styrene

α-Methyl styrene is a colorless liquid used in the production of polymers and resins.[8] Exposure to α-methyl styrene has been reported to cause eye, skin, and upper respiratory tract irritation and has the potential for central nervous system effects.[7,8]

The OSHA PEL for α-methyl styrene is 100 ppm for an 8-hour TWA exposure.[4] The NIOSH REL for α-methyl styrene is 50 ppm for an 8-hour TWA exposure and 100 ppm for a STEL.[2] ACGIH recommends an 8-hour TWA TLV of 50 ppm and a STEL of 100 ppm for α-methyl styrene.[3]

Methyl Methacrylate

Methyl methacrylate is a colorless liquid with a strong fruity odor. Methyl methacrylate is used in production of acrylic products, printing inks, and in dentistry. Methyl methacrylate has the potential to cause eye, skin, and respiratory tract irritation.[7,8] Allergic dermatitis and sensitization resulting from exposure to methyl methacrylate has been identified in occupational settings.[7]

The OSHA PEL for methyl methacrylate is 100 ppm for an 8-hour TWA exposure.[4] The NIOSH REL for methyl methacrylate is 100 ppm for an 8-hour TWA exposure.[2] ACGIH recommends an 8-hour TWA TLV of 50 ppm and a STEL of 100 ppm. ACGIH also considers methyl methacrylate a potential sensitizer and assigns it an A4 designation (not classifiable as a human carcinogen).[3]

Noise

Noise-induced loss of hearing is an irreversible, sensorineural condition that progresses with exposure. Although hearing ability declines with age (presbycusis) in all populations, exposure to noise produces hearing loss greater than that resulting from the natural aging process. This noise-induced loss is caused by damage to nerve cells of the inner ear (cochlea) and, unlike some conductive hearing disorders, cannot be treated medically.[9] While loss of hearing may result from a single exposure to a very brief impulse noise or explosion, such traumatic losses are rare. In most cases, noise-induced hearing loss is insidious. Typically, it begins to develop at 4000 or 6000 Hertz (Hz) (the hearing range is 20 Hz to 20000 Hz) and spreads to lower and higher frequencies. Often, material impairment has occurred before the condition is clearly recognized. Such impairment is usually severe enough to permanently affect a person's ability to hear and understand speech under everyday conditions. Although the primary frequencies of human speech range from 200 Hz to 2000 Hz,

research has shown that the consonant sounds, which enable people to distinguish words such as "fish" from "fist," have still higher frequency components.[10]

The A-weighted decibel [dBA] is the preferred unit for measuring sound levels to assess worker noise exposures. The dBA scale is weighted to approximate the sensory response of the human ear to sound frequencies near the threshold of hearing. The decibel unit is dimensionless, and represents the logarithmic relationship of the measured sound pressure level to an arbitrary reference sound pressure (20 micropascals, the normal threshold of human hearing at a frequency of 1000 Hz). Decibel units are used because of the very large range of sound pressure levels audible to the human ear. Because the dBA scale is logarithmic, increases of 3 dBA, 10 dBA, and 20 dBA represent a doubling, tenfold increase, and hundredfold increase of sound energy, respectively. It should be noted that noise exposures expressed in decibels cannot be averaged by taking the simple arithmetic mean.

The OSHA standard for occupational exposure to noise (29 CFR 1910.95)[11] specifies a maximum PEL of 90 dBA for a duration of 8 hours per day. The regulation, in calculating the PEL, uses a 5 dB time/intensity trading relationship, or exchange rate. This means that a person may be exposed to noise levels of 95 dBA for no more than 4 hours, to 100 dBA for 2 hours, etc. Conversely, up to 16 hours' exposure to 85 dBA is allowed by this exchange rate. The duration and sound level intensities can be combined in order to calculate a worker's daily noise dose according to the formula:

$$\text{Dose} = 100 \times (C_1/T_1 + C_2/T_2 + \ldots + C_n/T_n),$$

where C_n indicates the total time of exposure at a specific noise level and T_n indicates the reference duration for that level as given in Table G-16a of the OSHA noise regulation. During any 24-hour period, a worker is allowed up to 100% of his daily noise dose. Doses greater than 100% exceed the OSHA PEL.

The OSHA regulation has an additional action level (AL) of 85 dBA; an employer shall administer a continuing, effective hearing conservation program when the 8-hour TWA value exceeds the AL. The program must include monitoring, employee notification, observation, audiometric testing, hearing protectors, training, and record keeping. All of these requirements are included in 29 CFR 1910.95, paragraphs (c) through (o). Finally, the OSHA noise standard states that when workers are exposed to noise levels that exceed the OSHA PEL of 90 dBA, feasible engineering or administrative controls shall be implemented to reduce the workers' exposure levels.

NIOSH, in its Criteria for a Recommended Standard,[12] and the ACGIH[3] propose exposure criteria of 85 dBA as a TWA for 8 hours, 5 dB less than the OSHA standard. The criteria also use a more conservative 3 dB time/intensity trading relationship in calculating exposure limits. Thus, a worker can be exposed to 85 dBA for 8 hours, but to no more than 88 dBA for 4 hours or 91 dBA for 2 hours. The NIOSH REL for 12-hour exposure is 83 dBA or less.

RESULTS

Initial Site Visit

Industrial Hygiene

Volatile Organic Compounds

The volatile organic compound air sampling results are presented in Table 1. Major compounds detected were styrene, methyl methacrylate, methyl acrylate, and α-methyl styrene. One sample, A03393 (GA air sample at the entrance to the office area), had various aliphatic hydrocarbons, limonene, dimethyl glutarate, dimethyl succinate, and dimethyl adipate.

Medical

The tape sampling results are presented in Table 2. Skin tape samples were collected from

all production employees present during the first survey (N=15). Twelve of 15 employees (80%) were interviewed. Three employees did not speak English well enough to be interviewed.

The average age of participants was 34.0 years (Range 20-45). The average tenure was 3.5 years (Range 11 months-12 years). All workers reported washing their arms and hands before leaving work. Half reported minor skin irritation after taking a hot shower at the end of the workday. Eighty percent of employees had fiberglass on their skin by tape sample. Eight employees reported wearing "dust masks" at least occasionally or when dust exposure is especially evident. Only two employees reported wearing gloves on a regular basis. One employee reported wearing a back brace regularly. Two employees reported respiratory problems that improved after being away from work. One of these employees has a history of hay fever, which is exacerbated by the dust exposure, and the other employee reported sensitivity to polyester resin while at work. No other work-related symptoms were reported. Review of the OSHA logs did not reveal any injuries caused by fiberglass or chemical exposure that caused time away from work.

The bulk sample of cultured marble particulate from the grinding operation contained a trace amount of fiberglass. The fiberglass fibers in the bulk sample and tape skin samples were longer than 50 µm and had an average diameter of 10 µm. Other fibers found in the sample were cellulose, hair, and synthetic fibers.

Follow-up Site Visit

Industrial Hygiene

The mold preparation/gel coat applicator air sample pump failed during the morning of June 21, 2005, and the grinder air sample pump failed during the afternoon of June 22, 2005. This resulted in an approximate 4-hour sample for both employees. These employee's tasks did not change throughout the day. Assuming exposures remain consistent, the 4-hour samples should provide an indication of the 8-hour TWA concentration.

Total Particulate

The total particulate air sampling results are presented in Table 3. Total particulate 8-hour TWAs ranged from 0.6-43 mg/m^3. The highest total particulate concentration was found on the employee grinding cultured marble products on June 22, 2005. On both days of total particulate air sampling, this worker's 8-hour TWA concentrations exceeded ACGIH and OSHA exposure limits. All other PBZ 8-hour TWA results were below relevant exposure limits.

Respirable Particulate

The respirable particulate air sampling results are presented in Table 4. Respirable particulate 8-hour TWAs ranged from 0.09-0.40 mg/m^3. The highest respirable particulate concentration was found on the employee grinding cultured marble products on June 22, 2005. All PBZ 8-hour TWA results were below relevant exposure limits.

Styrene

The styrene air sampling results are presented in Table 5. Styrene 8-hour TWAs ranged from 0.2-31 ppm. The highest styrene concentration was found on a casting employee on June 21, 2005. Both employees in the casting area had 8-hour TWA concentrations exceeding the ACGIH exposure limit. All other PBZ 8-hour TWA results were below relevant exposure limits.

α-Methyl Styrene

The α-methyl styrene air sampling results are presented in Table 5. α-Methyl styrene 8-hour TWAs ranged from a non-detectable concentration to 0.6 ppm. The highest α-methyl styrene concentration was found on a casting employee on June 21, 2005. All PBZ 8-hour TWA results were below relevant exposure limits.

Methyl Methacrylate

The methyl methacrylate air sampling results are presented in Table 6. Methyl methacrylate 8-hour TWAs ranged from 0.1-2.8 ppm. The highest methyl methacrylate concentration was found on a worker preparing molds and spraying gel coat on June 22, 2005. All PBZ 8-hour TWA results were below relevant exposure limits.

Noise

The Quest dosimeters collect data so that one can directly compare the information with the three different noise criteria used in this survey, the OSHA PEL and AL, and the NIOSH REL. The OSHA criteria use a 90 dBA criterion and 5-dB exchange rate for the PEL and AL. The difference between the two is the threshold level employed, with a 90 dBA threshold for the PEL and an 80 dBA threshold for the AL. The threshold level is the lower limit of noise values included in the calculation of the criteria; values less than the threshold are ignored by the dosimeter. The NIOSH criterion differs from OSHA in that the criterion is 85 dBA, the threshold is 80 dBA, and it uses a 3-dB exchange rate.

DCM operations appeared to be very similar over the 2 sampling days, with the employees engaged in activities throughout the entire work shift except during scheduled break times in the morning and afternoon and during the 1-hour lunch period. The employees' noise doses calculated according to the three evaluation criteria are presented in Table 7. Two workers were found to exceed the OSHA PEL, the grinder operator and a buffer operator. Seven of the 11 surveyed employees exceeded the OSHA AL dose of 50%. All but one worker who rotated into an office environment for the afternoon portion of the shift exceeded the NIOSH REL noise dose. The use of hearing protection devices (HPDs) by many of the employees was observed during the survey.

Each of the two manufacturing sides of the DCM facility had at least two notable noise sources. The mixer and powder delivery system and the vibrating mold tables created noise on the mold set-up side of the building. On the mold removal and product finishing side, compressed air noise and the ventilation booth used by the grinder, along with the grinder itself, produced high levels of noise. These sources are identified in the real-time noise data presented in Figures 1-11. The mixer operator (Figure 2) and the casting employees (Figures 1, 6, and 11) were found to have exposures near 90 dBA while working near these sources on the mold set-up side of the facility. The grinder operator (Figure 5) had noise exposures between 90 and 100 dBA whenever he was in the work area. The noise produced by the grinder also influenced workers in close proximity to this work station. One employee buffing vanity tops for the entire work shift (Figure 10) was found to be exposed to noise greater than 90 dBA for much of the day. A second employee who also buffed large flat panels as well as removed product from molds (Figure 7) was located a little further from the grinding area but still had a portion of the work shift that exposed him to noise levels greater than 90 dBA. Employees who performed mold removal with compressed air (Figure 3, 7, and 9) had short periods of time (1-2 minutes) where the noise exceeded 103 dBA, a result of the high pitched noise produced by the compressed air interacting with the molds.

DISCUSSION

Industrial Hygiene

Air Sampling

A majority of PBZ air samples collected for total and respirable particulates indicated exposure concentrations below relevant evaluation criteria. However, the product grinder's PBZ air samples exceeded ACGIH and OSHA evaluation criteria for total particulate on both days of sampling. Grinding on long cultured marble pieces which extend outside the booth was one reason for the grinder's total particulate overexposure. Another reason was the worker's body position and rotational direction of the grinding wheel in relation to airflow into the

ventilation booth. Depending upon the cultured marble piece and the position of the worker, the rotating grinder wheel forced generated particulate against the ventilation booth airflow. The ventilation booth captured some of this particulate and transported it across the grinder's breathing zone. DCM should contact the ventilation booth manufacturer and discuss options for additional particulate control for the grinding operation. A rotating table may be an option for smaller pieces to allow the grinder to remain in a position in which the rotation of the grinding wheel moves particulate in the same direction as the airflow. Until engineering control modifications are made and subsequent air sampling confirms the reduction of total particulate exposures below the OSHA PEL, DCM should continue to require the use of N-95 filtering facepiece respirators for this operation.

Two casting employees were exposed to styrene in excess of the 8-hour ACGIH TLV. The casting area does not have local exhaust ventilation specifically engineered for this process. There is a ceiling exhaust fan above the dry material hopper (close to the casting area) although this would not be expected to significantly contribute to the removal of styrene in the area. Another contributor to the styrene exposures in the casting and surrounding areas is the lack of oven ventilation. The side of the oven in which the gel-coated molds are removed remains open during the 10-minute curing time. This allows gel coat emissions to enter the product production area even though two wall exhaust fans behind the oven assist in emission control. DCM should contact the manufacturer of the gel coat ventilation booth and oven to discuss options for controlling fugitive chemical emissions for the gel coat, oven, and marble casting operations.

One of the casting workers wore a half-face respirator with combination cartridges (organic vapor, acid gas, and P100 particulate filter [OV/AG/P100]) while another worker wore an N-95 filtering facepiece respirator. Workers casting cultured marble should continue to wear the half-face respirators and the current stock of OV/AG/P100 combination cartridges and eliminate N-95 filtering facepiece use in this area. The current protection for acid gas is not necessary in this facility. The half-face respirators DCM currently provides have an option for an organic vapor/P100 particulate filter combination cartridge or an organic vapor cartridge with an attachable N-95 particulate filter assembly. DCM should discuss respiratory protection options with the vendor. NIOSH investigators did observe respirator use by employees with facial hair. Facial hair prevents the respirator from sealing to the face and reduces the effectiveness of the respirator. DCM should ensure that employees who use respiratory protection are trained in the use, maintenance, and care of respirators, including the importance of having no facial hair when respirators are used.

The employees working with chemicals in the gel coat and casting areas should wear appropriate gloves to reduce the potential for dermal exposures. Some employees indicated that prolonged contact with chemicals resulted in a localized heat sensation. Although there are a number of chemicals that comprise the gel coat and the cultured marble material, styrene is typically the most abundant. Polyvinyl alcohol or Viton® gloves would be suitable in the gel coat and casting areas since styrene is a major component of the chemical compounds used.

Noise

The management at DCM had instituted changes in the workplace following the initial NIOSH survey based on the observations made by the NIOSH investigators about the vibrating casting tables. New mechanical vibrators were installed on all of the tables, which perceptibly reduced the noise levels produced during the casting operations. The reduction in noise was confirmed when the NIOSH investigator's sound level readings were compared to data the company provided on the casting tables prior to the change. However, the vibrator on the powder hopper at the mixer was inadvertently overlooked in the change-out process, and it still produced a noticeable noise when it cycled on and off.

Even with the noise reduction afforded by the change in mechanical vibrators, the personal noise exposures measured during the 2-day survey consistently exceeded the NIOSH REL (10 of 11 full-shift samples) and the OSHA AL (7 of 11 full-shift samples). Conversations with the workers and managers during the noise survey indicated that the activities observed over the 2 days were similar to normal operations. Thus, the workers on both sides of the building, mold preparation, casting, cast removal, and finishing, should be included in a hearing loss prevention program. The program should include additional noise testing to determine the stability of the employees' exposures and also to document any additional noise reduction as a result of new engineering controls. Controls could include new compressed air nozzles to remove the cast from the molds that have been designed to reduce the noise output without appreciably reducing the air pressure. This same nozzle technology may also apply to the spray booth operation where the coating is put on the molds to facilitate the removal process. Another engineering control that could be pursued is changes to the ventilation booth used by the grinder operator. The dosimeter data showed that this operation influenced the noise exposures of several employees working near the ventilation booth. Any changes in the workspace that removes or separates the grinding operation from the other finishing work should reduce noise exposures for these adjacent employees. Finally, it was observed that several of the rollers on the conveyor system were nylon or plastic rather than metal, particularly on the vibrating tables' conveyors. These non-metal rollers are usually quieter than the metal ones.

While the company investigates possible engineering and administrative controls, such as employee rotation through different jobs on a daily basis, the use of HPDs by employees in all areas of the facility needs to be enforced. Nearly all of the surveyed operations exceed the NIOSH REL, which puts these employees at an increased risk for occupational noise-induced hearing loss. The types of HPDs observed during the evaluation were generally made of formable materials, i.e., foam earplugs. The devices, when worn properly, can more than adequately attenuate noise to a safer level. However, they may give too much attenuation to the workers, reducing their ability to communicate with other employees or hear warning signals. Other products are available that attenuate noise in a more uniform manner, acting more like a volume control on a radio or TV. These HPDs are referred to as musician earplugs or moderate, flat-attenuation plugs. Because the TWA noise levels measured during the survey were generally less than 93 dBA, except for the employees at or near the grinding operation, the moderate amount of labeled attenuation afforded by these HPDs is sufficient to protect from the occupational noise exposures while allowing for better communication between employees.

Medical

Exposure to fiberglass, a known skin irritant, greater than 3.5 µm in diameter has been associated with severe itching, burning of the eyes, sore throat, and cough. However, not all workers with similar exposures experience symptoms.[13] One study found that skin disorders in a group of workers similar to those at DCM were common but the symptoms were mild and did not cause many lost work days.[14] The findings of this HHE are consistent with this observation. The fiberglass found on the skin of workers in this study was 10 µm in diameter. Some workers with no detectable fiberglass on their skin reported itching of the skin, while some of those who had detectable fibers did not experience any irritation. Another study of occupational dermatoses among fiberglass-reinforced plastics factory workers asserted that these workers are at high risk of developing occupational dermatoses because of their exposure to many chemicals used in the manufacture of plastics as well as to fiberglass or dust.[15] Some of these chemicals are UP base resin, cobalt chloride, benzoyl peroxide, methyl ethyl ketone peroxide, *para-tertiary* butyl catechol, styrene, and formaldehyde. Of the 29 workers in the study who underwent patch testing for the chemicals listed above, 62.1% were sensitized to at least one chemical.[15] Based

on the results of the survey at DCM, skin irritation experienced by workers is likely caused by chemical exposure as well as fiberglass or dust. In any case, direct exposure to fiberglass and chemicals should be avoided. Workers should wear proper protective clothing and equipment to minimize their exposure to fiberglass and chemicals used at DCM.

CONCLUSIONS

Based on personal air sampling, noise monitoring, and employee interviews conducted at DCM, NIOSH investigators conclude that a health hazard exists from employee exposure to total particulate, styrene, and noise. The air sample concentrations indicate that employees may not be adequately protected by the existing engineering controls. However, appropriate respiratory protection for particulates and styrene is available from DCM and worn by some employees. The personal, full-shift noise levels measured in this evaluation are consistently high enough to increase the employees' risk of occupational hearing loss if they work in this environment with unprotected ears.

With modifications to the existing engineering controls and following the recommendations provided in this report, it may be possible to decrease the current particulate, chemical, and noise exposures in this facility. When PPE is needed, the correct choice, use, and maintenance of respirators, gloves, and HPDs will be beneficial to control potential occupational exposures below the relevant evaluation criteria.

RECOMMENDATIONS

The following recommendations are based on findings during this investigation and are offered to improve the safety and health of employees working with materials used in the operations discussed in this report.

1. Establish a written respiratory protection policy according to the requirements listed in the OSHA Respiratory Protection Standard (29 CFR 1910.134). This program should include the following components: selection of respirators, medical evaluation, fit testing, use of respirators, maintenance and care of respirators, identification of filters, training and information, program evaluation, and recordkeeping. Refer to the NIOSH Respirator Decision Logic to assist in developing an effective respiratory protection program.[16]

2. Marble casting employees should wear the half-face respirator with the organic vapor/P100 particulate filter combination cartridge DCM currently provides or an organic vapor cartridge with an attachable N-95 particulate filter assembly. The grinder operator should continue to use the N-95 filtering facepiece respirator.

3. Polyvinyl alcohol or Viton® gloves should be worn in the gel coat and casting areas to protect employees from chemicals used in these areas. DCM should clearly define areas of the facility that require the use of PPE and ensure employees are aware of what types of PPE are appropriate for these areas and their limitations.

4. DCM should contact the manufacturer of the gel coat ventilation booth and oven to discuss options for control of fugitive chemical emissions, specifically styrene, for the gel coat, oven, and marble casting operations.

5. The company should institute a complete hearing loss prevention program for all production employees. The OSHA noise regulation and hearing conservation amendment can be used as a minimum guideline for such a program.[11] Additional information on hearing loss prevention programs that goes beyond the requirements of OSHA has been published.[17,18,19]

6. In the short term, DCM should investigate potential changes to the grinding ventilation booth and the process itself to reduce the grinding operator's exposures. For the long

term, isolating or removing the ventilation booth used by the grinder operator from the main workspace should be investigated. This operation produces a great deal of dust and noise that affects other employees in adjacent work areas. Putting the grinding operation in a location away from the rest of the operations will reduce the noise and dust levels on this side of the facility.

7. Employees not affected by the grinding operation should be offered different HPDs that can improve communication between employees while properly wearing the devices throughout the entire work shift. These moderate, flat-attenuating devices can be found on the Internet at www.etymotic.com or www.aearo.com under musician earplugs, high fidelity earplugs or E-A-R® Hi-Fi earplugs. Employees who are affected by the grinding operation should continue to properly wear the greater attenuating devices that were dispensed to employees prior to this evaluation.

8. New compressed air nozzles used in the coating spray operation and in mold removal should be explored to see if similar performance can be achieved with less noise during these operations. Several brands of air nozzles are advertised that have a quiet design. A search on the Internet using the term "quiet compressed air nozzle" may identify different distributors of these nozzles. The company can find nozzles that continue to do the tasks for which they were originally purchased with less noise emission.

9. The vibrator on the powder hopper at the mixer should be replaced with one of the newer types of vibrators such as those that were recently put on the vibrating mold tables.

10. A preventive maintenance program for the vibrating tables should be instituted to ensure that the new vibrators are continuing to perform as they were designed. Noise level measurements of the tables without molds and while the tables are loaded with product should be made and recorded to make sure that the levels do not change over time. These measurements can be done periodically (quarterly or semi-annually) or when employees report perceptible changes in the noise levels in their work space. If noise levels begin to increase, then the vibrators should be given appropriate maintenance or be replaced.

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TABLES

Table 1. Results of Volatile Organic Compound Air Samples Collected on December 10, 2004
Dixie Cultured Marble, Birmingham, Alabama
HETA 2001-0326-2999

Job/Location	Sample #	Sample Time (military)	Volume (liters)	Volatile Organic Compounds Major Peaks
PBZ – marble casting	A28384	1040 – 1140	3.0	Methyl acrylate Methyl methacrylate Styrene
	AO4958	1305 – 1415	3.5	Methyl methacrylate α-Methyl styrene
GA – middle of area where molds are prepared	AO5534	1046 – 1306	7.1	Styrene
PBZ – applying gel coat to molds	AO4359	1053 – 1146	2.7	Methyl methacrylate Styrene
GA – at entrance to office area	AO3393	1136 – 1343	6.5	C_8 Aliphatic hydrocarbons C_9-C_{12} Aliphatic hydrocarbons Dimethyl adipate

PBZ = personal breathing zone
GA = general area

Table 2. Results of Fiberglass Tape and Bulk Samples Collected on December 10, 2004
Dixie Cultured Marble, Birmingham, Alabama
HETA 2001-0326-2999

Job/Location	Sample #	Fibers	Average Length	Average Diameter
Tape Samples				
Clean-up	1	Glass	> 50 micrometers	10 micrometers
Product Grinding	2	Glass	> 50 micrometers	10 micrometers
Clean-up	3	Glass	> 50 micrometers	10 micrometers
Clean-up	4	ND		
Matting	5	Glass	> 50 micrometers	10 micrometers
Whirlpooling	6	Glass	> 50 micrometers	10 micrometers
Clean-up	7	ND		
**	8	Glass	> 50 micrometers	10 micrometers
Mold Preparation/Marble Casting	9	Glass	> 50 micrometers	10 micrometers
Mold Preparation	10	Glass	> 50 micrometers	10 micrometers
**	11	Glass	> 50 micrometers	10 micrometers
Marble Casting	12	Glass	> 50 micrometers	10 micrometers
**	13	ND		
Mixing	14	Glass	> 50 micrometers	10 micrometers
Spraying Gel Coat	15	Glass	> 50 micrometers	10 micrometers
Bulk Sample				
Material on floor from grinding operation		Glass Cellulose Hair Synthetic	> 50 micrometers	10 micrometers

> = greater than
ND = no fiberglass detected
** = department unknown

Table 3. Results of Total Particulate Air Samples Collected on June 21 and 22, 2005
Dixie Cultured Marble, Birmingham, Alabama
HETA 2001-0326-2999

Job/Location	Sample #	Sample Time (military)*	Volume (liters)	8-hr TWA Concentration (mg/m^3)
June 21, 2005				
PBZ – Product Grinder	B05 – 319	0721 – 1602	445	38
PBZ – Sanding and buffing product and placing fiberglass sheets on whirlpool tubs	B05 – 311	0723 – 1556	451	0.6
PBZ – Product sanding and buffing	B05 – 308	0725 – 1604	449	2.0
PBZ – Product sanding and buffing	B05 – 313	0727 – 1604	444	3.2
PBZ – Installing components in whirlpool tubs	B05 – 302	0728 – 1559	449	2.2
June 22, 2005				
PBZ – Product Grinder	B05 – 309	0715 – 1133	259	43‡
PBZ – Installing components in whirlpool tubs	B05 – 304	0720 – 1608	457	1.0
PBZ – Product sanding and buffing	B05 – 320	0730 – 1603	450	3.6
Minimum Detectable Concentration				0.04
Evaluation Criteria			OSHA Permissible Exposure Limit	15
			NIOSH Recommended Exposure Limit	NA
			ACGIH Threshold Limit Value	10

* = sample not collected during employee 1-hour lunch break
PBZ = personal breathing zone
‡ = sample was restarted after lunch, but pump was not on at the end of the shift. This sample is based on an approximate 4-hour sampling time. See Discussion section for more details.
NA = not applicable. See Evaluation Criteria section.

Table 4. Results of Respirable Particulate Air Samples Collected on June 21 and 22, 2005
Dixie Cultured Marble, Birmingham, Alabama
HETA 2001-0326-2999

Job/Location	Sample #	Sample Time (military)*	Volume (liters)	8-hr TWA Concentration (mg/m^3)
June 21, 2005				
PBZ – Product sanding and buffing	B05 – 307	0725 – 1604	767	0.09
PBZ – Product sanding and buffing	B05 – 312	0727 – 1604	771	0.17
PBZ – Installing components in whirlpool tubs	B05 – 317	0728 – 1559	763	0.13
PBZ – Miscellaneous tasks in product finishing area	B05 – 316	0729 – 1556	744	0.10
June 22, 2005				
PBZ – Product Grinder	B05 – 314	0715 – 1601	781	0.40
PBZ – Product sanding and buffing	B05 – 306	0723 – 1603	772	0.17
PBZ – Product sanding and buffing	B05 – 305	0730 – 1603	772	0.21
Minimum Detectable Concentration				0.03
Evaluation Criteria			OSHA Permissible Exposure Limit	5
			NIOSH Recommended Exposure Limit	NA
			ACGIH Threshold Limit Value	3

* = sample not collected during employee 1-hour lunch break
PBZ = personal breathing zone
NA = not applicable. See Evaluation Criteria section.

Table 5. Results of Styrene and α-Methyl Styrene Air Samples Collected on June 21, 2005
Dixie Cultured Marble, Birmingham, Alabama
HETA 2001-0326-2999

Job/Location	Sample #	Sample Time (military)	Volume (liters)	8-hr TWA Concentration (ppm)	
				Styrene	MSty
PBZ – Marble Casting	CT – 5	0709 – 1132*	13	22	0.4
	CT – 12	1235 – 1535	9.0		
PBZ – Mold Preparation and Gel coat Sprayer	CT – 3			6.2‡	0.1‡
	CT – 14	1230 – 1540	9.5		
PBZ – Mold Preparation and Marble Casting	CT – 7	0713 – 1143	14	7.2	0.1
	CT – 11	1143 – 1534	12		
PBZ – Marble Casting	CT – 4	0715 – 1135*	13	31	0.6
	CT – 10	1236 – 1532	8.8		
PBZ – Mold Preparation and Office Work	CT – 6	0716 – 1132*	13	0.2	ND
	CT – 13	1238 – 1537	9		
Minimum Detectable Concentration				0.017	0.009
Minimum Quantifiable Concentration				0.067	0.030
Evaluation Criteria	OSHA Permissible Exposure Limit			100, C 200, 600+	100
	NIOSH Recommended Exposure Limit			50, ST 100	50, ST 100
	ACGIH Threshold Limit Value			20, ST 40, A4	50, ST 100

PBZ = personal breathing zone
ND = the substance was not detected in the air at a concentration at or above the minimum detectable concentration.
* = sample not collected during employee 1-hour lunch break
‡ = sample was restarted after lunch, but pump was not on at the end of the shift. This sample is based on an approximate 4-hour sampling time. See Discussion section for more details.
+ = 5-minute ceiling concentration that cannot be exceed in any 3-hour period
ST = short-term exposure limit - a 15-minute exposure limit that should not be exceeded at any time during the day.
A4 = not classifiable as a human carcinogen

Table 6. Results of Methyl Methacrylate Air Samples Collected on June 22, 2005
Dixie Cultured Marble, Birmingham, Alabama
HETA 2001-0326-2999

Job/Location	Sample #	Sample Time (military)	Volume (liters)	8-hr TWA Concentration (ppm)
PBZ – Mold Preparation and Gel coat Sprayer	MM – 8	0710 – 1133*	13	2.8
	MM – 11	1238 – 1530	8.6	
PBZ – Mold Preparation and Marble Casting	MM – 5	0711 – 1139*	14	0.3
	MM – 14	1232 – 1603	10	
PBZ – Marble Casting	MM – 6	0712 – 1134*	13	0.5
	MM – 12	1233 – 1530	8.8	
PBZ – Mold Preparation and Office Work	MM – 4	0713 – 1133*	9.3	0.1
	MM – 13	1234 – 1555	10	
PBZ – Marble Casting	MM – 9	0714 – 1133*	14	0.6
	MM – 10	1233 – 1530	9.0	
PBZ – Mold Clean-up and Whirlpool Tub Finisher	MM – 7	0735 – 1134*	12	0.1
	MM – 15	1239 – 1603	10	
Minimum Detectable Concentration				0.01
Minimum Quantifiable Concentration				0.05
Evaluation Criteria		OSHA Permissible Exposure Limit		100
		NIOSH Recommended Exposure Limit		100
		ACGIH Threshold Limit Value		50, ST 100, SEN, A4

PBZ = personal breathing zone
* = sample not collected during employee 1-hour lunch break
SEN = potential to produce sensitization
A4 = not classifiable as a human carcinogen

Table 7. Personal Noise Exposure Doses Measured on June 21 and 22, 2005
Dixie Cultured Marble, Birmingham, Alabama
HETA 2001-0326-2999

Employee	Total Sample Time (hh:mm)	OSHA PEL (Dose %)	OSHA AL (Dose %)	NIOSH REL (Dose %)
June 21, 2005				
Mold Preparation and Marble Casting	08:18	12.3	33.4	100.5
Gel Coat Sprayer	08:25	19.1	45.6	261.0
Mold Mixing	08:23	61.7	88.7	505.5
Marble Casting	08:14	47.7	69.8	299.8
Product Removal and Buffing	08:32	23.9	37.4	327.6
Product Grinding	08:40	245.8	259.5	2338.8
June 22, 2005				
Mold Preparation and Office Work	08:43	10.2	26.9	91.7
Gel Coat Sprayer	08:10	48.1	66.1	269.3
Product Buffing	08:42	140.3	157.2	1377.5
Product Removal and Buffing	08:45	87.7	107.8	614.5
Whirlpool Tub Finisher	09:03	65.7	79.3	727.0

FIGURES

Figure 1
Form Set-up (a.m.) And Pour Table (p.m.) Worker
Dixie Cultured Marble
Birmingham, AL
HETA 2001-0326
June 21, 2005

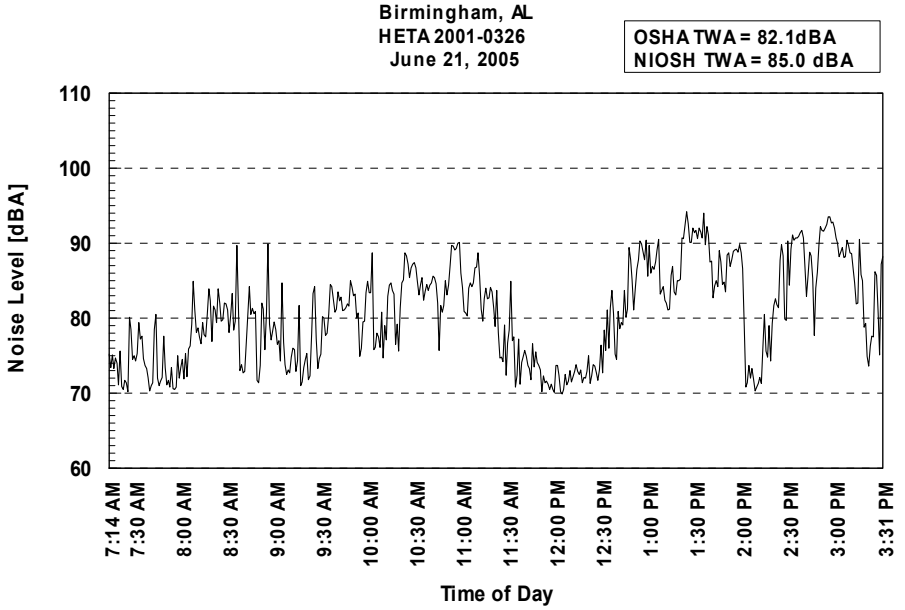

Figure 2
Mixer Operator
Dixie Cultured Marble
Birmingham, AL
HETA 2001-0326
June 21, 2005

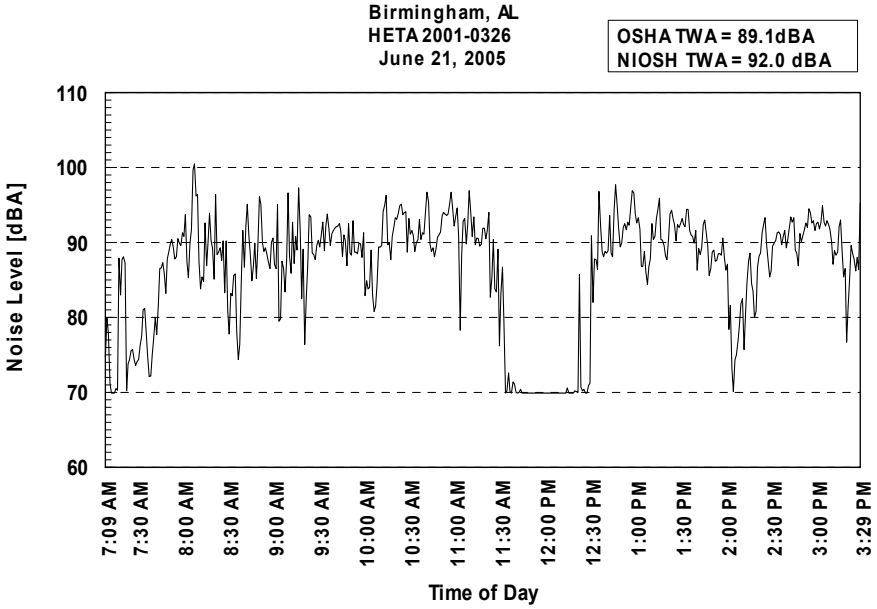

Figure 3
Mold Removal, Buffing, and Tub Finisher
Dixie Cultured Marble
Birmingham, AL
HETA 2001-0326
June 21, 2005

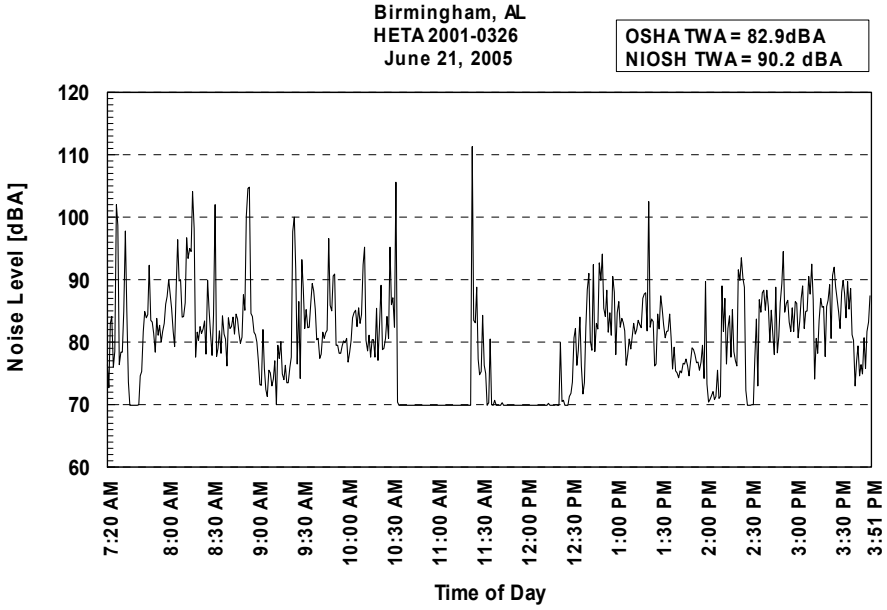

Figure 4
Mold Coating Spray Booth Worker
Dixie Cultured Marble
Birmingham, AL
HETA 2001-0326
June 21, 2005

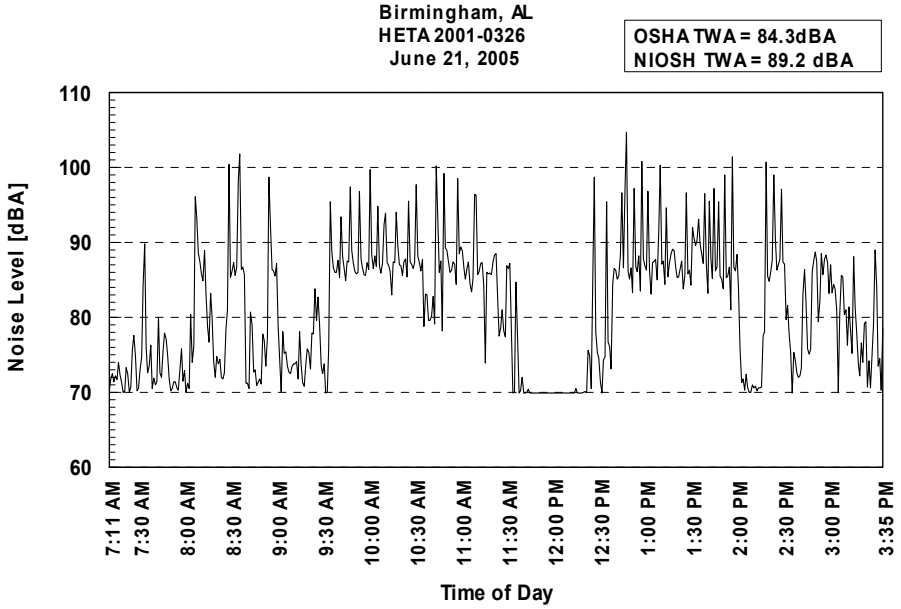

Figure 5
Grinder Operator
Dixie Cultured Marble
Birmingham, AL
HETA 2001-0326
June 21, 2005

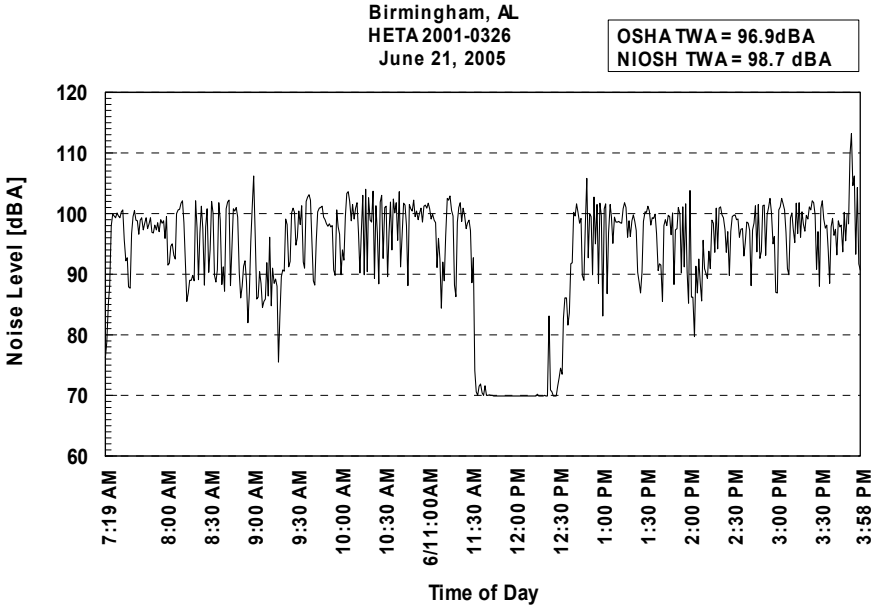

Figure 6
Pour Table Worker
Dixie Cultured Marble
Birmingham, AL
HETA 2001-0326
June 21, 2005

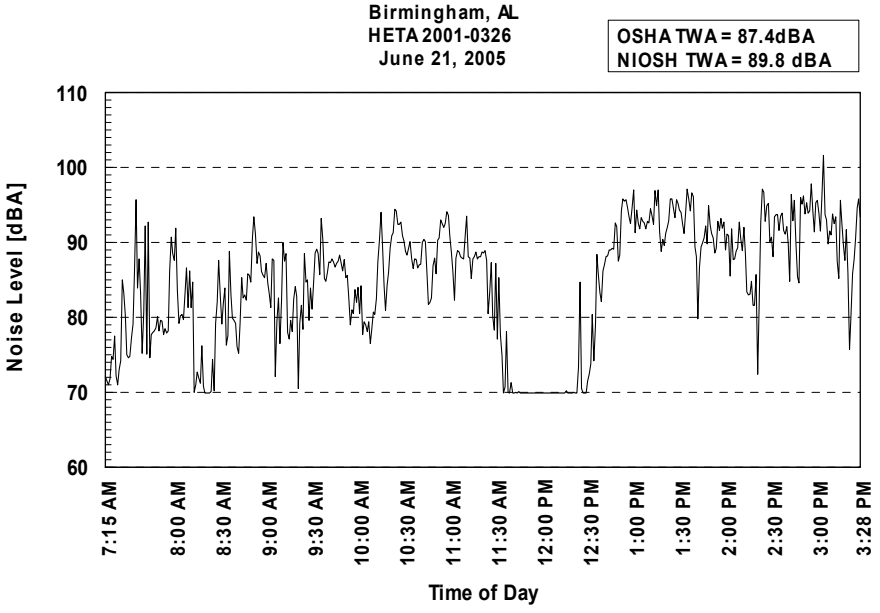

Figure 7
Mold Removal (before a.m. break) And Buffer (p.m.) Operator
Dixie Cultured Marble
Birmingham, AL
HETA 2001-0326
June 22, 2005

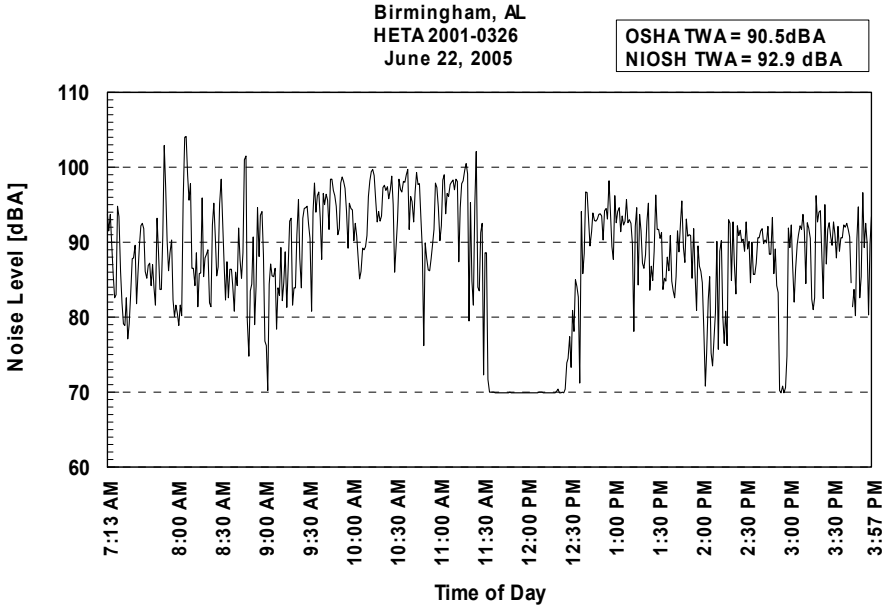

Figure 8
Form Set-up (until 1:00 p.m.) And Office Worker
Dixie Cultured Marble
Birmingham, AL
HETA 2001-0326
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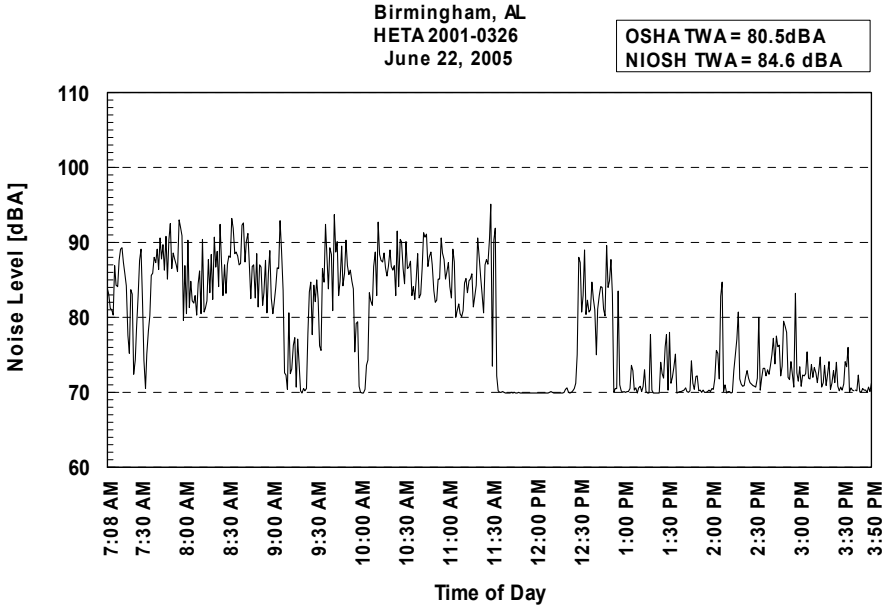

Figure 9
Whirlpool Tub Finisher
Dixie Cultured Marble
Birmingham, AL
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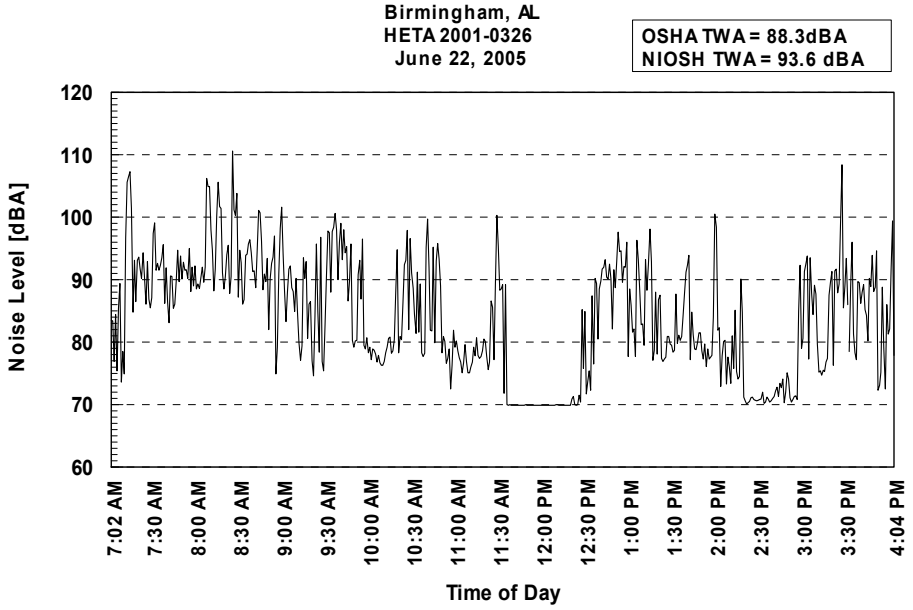

Figure 10
Buffer
Dixie Cultured Marble
Birmingham, AL
HETA 2001-0326
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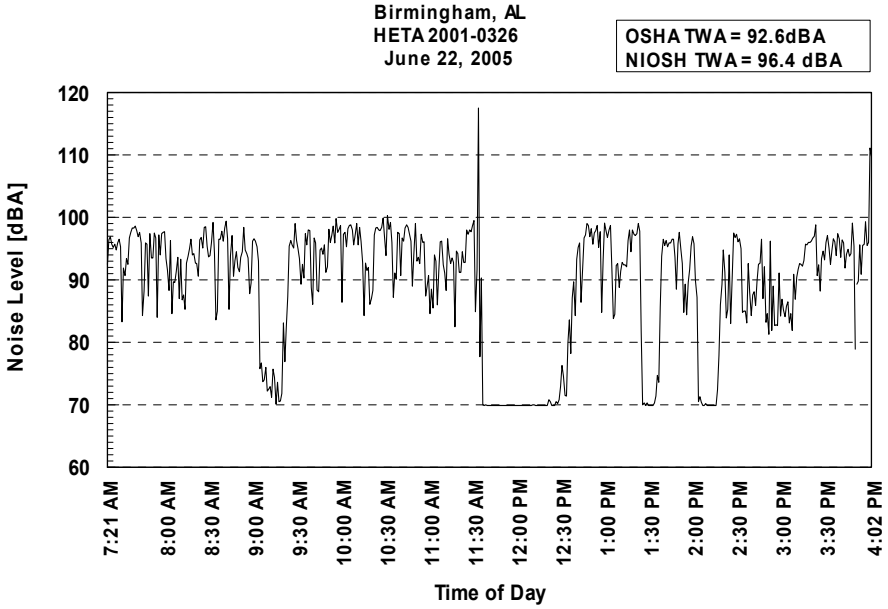
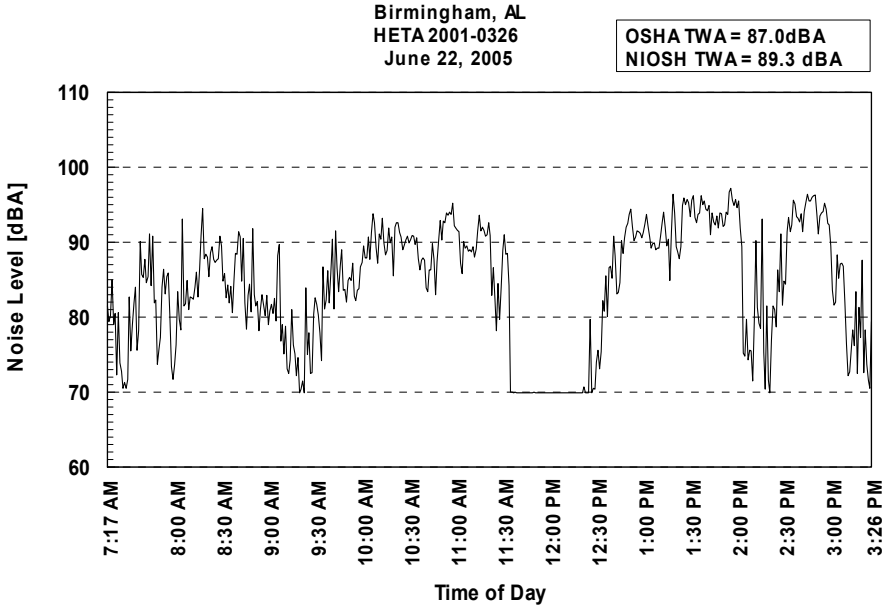


Figure 11
Mold Set-up (before a.m. break) and Pour Table Worker
Dixie Cultured Marble
Birmingham, AL
HETA 2001-0326
June 22, 2005



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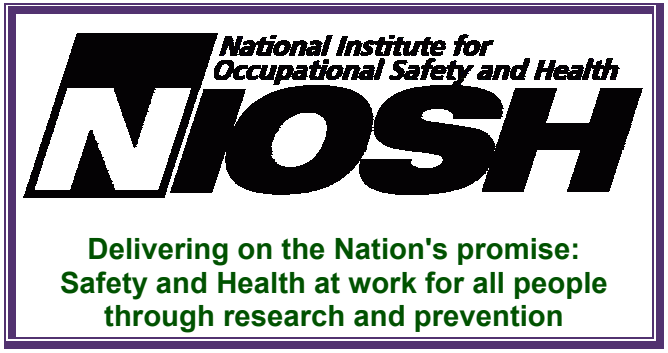

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