CDC Workplace Safety and Health

NIOSH HEALTH HAZARD EVALUATION REPORT:

HETA #2001-0461-2889
The Concrete Revolution
Denver, Colorado

January 2003

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

NIOSH

PREFACE

The Hazard Evaluations 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 employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

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 Eric J. Esswein, MSPH, CIH, of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS), Denver Field Office. Analytical support was provided by Data Chem Laboratories, Salt Lake City, UT. Desktop publishing was performed by Suzanne Eugster. Review and preparation for printing were performed by Penny Arthur.

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Highlights of the NIOSH Health Hazard Evaluation at The Concrete Revolution

NIOSH received a management request from The Concrete Revolution in Denver, Colorado, to evaluate potential occupational exposure hazards in the manufacture of custom concrete counter tops.

What NIOSH Did

- We took air samples for fine airborne dusts, silica, and asbestos.
- We measured exposures to noise.
- We took samples of settled dust and analyzed them for silica and metals.
- We evaluated the dust control ventilation systems.
- We observed work practices and equipment to make recommendations to reduce dusts in the workplace.

What NIOSH Found

- One air sample exceed the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) for exposure to respirable dust, and two samples exceeded the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) for respirable dust. The rest of the air samples were below these criteria for exposures to fine dusts.
- Dust can be better controlled with improved work practices and ventilation changes.
- Exposures to noise were below the OSHA PEL of 85 decibels as a daily average.
- Settled dust in the drying rooms contains 2-3% of crystalline silica and some metals.

What Management at the Concrete Revolution Can Do

- Make changes to the exhaust ventilation systems to improve dust extraction in the dry rooms.
- Dedicate the portable dust control system to the panel saw and consider installing a separate system for the planer.
- Periodically remove settled dust from the heaters and conduit in the dry rooms.

What Concrete Revolution Employees Can Do

- Protect your skin by using the blue nitrile gloves when working with the epoxy resins.
- Use the rubber trowel to apply patching material and only use the minimum amount necessary to patch the counter tops this can limit the amount of dusts that are created when patching is done.
- Try not to have two people sanding patch at the same time in the same dry room.
- Don't use compressed air to blow off your work clothes, use a high efficiency vacuum cleaner and wash your face and hands with soap and water at the end of the work day.
- Check the dust bag and the barrel on the dust extractor regularly and empty them when they are half full.

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Health Hazard Evaluation Report 2001-0461-2889
The Concrete Revolution
Denver, Colorado

January 2003

Eric J. Esswein, MSPH, CIH

SUMMARY

The National Institute for Occupational Safety and Health (NIOSH) received a management request from The Concrete Revolution in Denver, Colorado, to evaluate potential occupational exposure hazards in the manufacture of custom concrete counter tops. Five site visits were made to the plant between April and October 2002. Exposure assessments were conducted for noise, respirable crystalline silica, respirable dust (or particulates not otherwise regulated, respirable fraction), and asbestos fibers. Full-shift exposures to noise were less than the NIOSH recommended exposure level of 85 decibels on the A-weighted scale. Personal breathing zone (PBZ) exposures to respirable crystalline silica (as quartz and cristobalite) were below the limit of detection (LOD) for quartz in one sample, and at trace concentrations [between the LOD and the limit of quantitation (LOQ)] for five other samples. Cristobalite was never detected above the LOD nor were airborne asbestos fibers. Certain elements (metals) were detected in samples of settled dusts from drying rooms 1 and 2 but were in very low concentrations. Quartz was also detected in settled dust samples in concentrations of 2.0 to 3.3%. Three area and six PBZ air samples collected for respirable dust ranged in concentration from 1.8 to 10 milligrams per cubic meter of air (mg/m^3). One of these samples exceeded the OSHA Permissible Exposure Limit for respirable dust of 5 mg/m^3. At the time of the NIOSH survey, management and employees at the Concrete revolution were refining work practices and considering modifications to exhaust ventilation in the drying rooms to reduce particulate exposures. Work practice, housekeeping, and ventilation recommendations are provided on pages 6-7 of this report.

Occupational exposures to noise, respirable crystalline silica, asbestos and metals were all below established occupational health criteria at the time of this survey. One of nine samples for respirable dust, exceeded the Occupational Safety and Health Administration (OSHA) criterion of 5 milligrams per cubic meter of air as an 8-hour time-weighted average. Recommendations are provided to modify work practices and consider ventilation changes to better control dusts while patching and finishing custom concrete counter tops.

Keywords: concrete, counter tops, silica, respirable dust, Denver, SIC code 3272 (Concrete products)

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INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) received a management request for a health hazard evaluation from The Concrete Revolution, a small business specializing in the design, fabrication and installation of custom concrete counter tops for residential and commercial applications. Work at the Concrete Revolution involves potential exposure to fine particulates (from dusts generated when mixing concrete, and sanding grout compound), silica, noise, concrete acid stain, wood dusts, and skin sensitizing agents that are contained in epoxy-based sealants. At the time of the request employees were not reporting any occupational health symptoms believed to be related to working at this business but since manufacture of custom concrete counter tops is a relatively new niche industry, NIOSH was requested to evaluate this shop for possible occupational health hazards.

BACKGROUND

The Concrete Revolution is a small business located in a light manufacturing district west of downtown Denver, Colorado. The Concrete Revolution employs five to six full-time employees who are involved in layout, fabrication, finishing, and installation of custom concrete counter tops. Many of the manufacturing techniques and processes at The Concrete Revolution are proprietary and trade secret, therefore only a general description of the work at this facility is described in this report.

The layout and design work for a new counter top begins in the location where the counter top will be installed. A true-to-size template which defines the shape and size of the finished counter top is first sketched on cardboard. In the wood shop, a mold is built using melamine coated particle board. In the wet room, the concrete mix is prepared in a standard electric rotary mixer. Aggregate, sand and cement, strengthening fibers, colorants, and various proprietary concrete additives are combined into the mix along with water. The concrete is poured into the molds, then vibrated to insure that the wet concrete completely fills the form. The counter top is then allowed to cure for several days. After curing, the counter top is removed from the mold and flushed with water. Then the bottom of the counter top is ground smooth with a rotary grinder. The top surface is later ground smooth to the desired degree of aggregate exposure using water and a rotary grinder. The counter tops are allowed to dry in one of two drying rooms and a primer is applied to seal the counter tops. For certain finishes, water-based concrete acid stains are applied using a hand sprayer. To insure a smooth counter top surface, small surface voids are filled or "patched." A small amount of dry grout compound is mixed with a small amount of grout colorant and water is added to produce a thick paste. The paste is applied to the surfaces of the counter tops with a gloved hand and a soft rubber trowel. When the "patch" has dried, the employee uses a hand-held orbital sander and an abrasive pad to smooth the surface of the counter top. Patching is done twice to fill all visible voids in the counter top. Depending on the number of counter tops, patching may take almost a full shift to complete. When patching is completed, a final resin coating is then applied to the counter top and the piece is left to dry. The finished counter tops are transported to the customer location for final installation. Several good descriptions of building concrete counter tops have been published in speciality building magazines and instructional texts. [1,2]

An initial walkthrough survey and site visit was conducted on September 17, 2001. Follow-up visits to conduct exposure assessments could not begin until April 2002 due to NIOSH/HETAB Denver Field Office response relating to on-scene assistance at the New York City World Trade Center disaster, and immediately following that assignment, responding to the Capitol Hill anthrax bioterrorism incident.

Based on the results of the walkthrough survey, and a review of material safety data sheets and a chemical inventory report, the most likely occupational exposures were determined to be noise generated from hand-held grinders and airborne particulates (dusts), including respirable crystalline silica, while mixing concrete and while sanding counter tops after patch is applied. Inhalation exposure to acid gases from the water-based acid stains was determined to be a low risk since these stains have a low volatility, and only small amounts are used. Risks for inhalation exposures to wood dust was considered to be low when the local exhaust ventilation was used properly. Dermal (skin) exposures to sensitizing agents (epoxy resins used in various sealants) was initially identified as a possible dermal exposure hazard because latex gloves were used when working with these materials. NIOSH recommends that a more appropriate type of skin protection (disposable nitrile gloves) be used.

Employees at The Concrete Revolution are provided with appropriate personal protective equipment. Protective eye wear, hearing protection, filtering facepiece respirators (NIOSH approved N-95 rated for particulates, organic vapors, and acid gas), rubber boots and protective rubber aprons are all available for use by employees. The wet area of the workplace is protected from electrical hazards with ground fault circuit interrupters (GFCI's.) General extraction and dilution ventilation is installed in both drying rooms to reduce airborne dusts. In the wood shop, a ceiling-mounted high efficiency filter system is in place over the main work table and dedicated local exhaust ventilation (a portable dust collector) is used to collect wood dusts generated by a panel saw and a planer.

METHODS

Five site visits were made to the plant between April and October 2002. On April 2nd and 5th full-shift personal noise dosimetry was conducted on two laborers and the shop foreman. The laborers were working in the wet room (where concrete is mixed and poured into the molds) and occasionally other parts of the shop. The foreman was working in the wet room as well as the carpentry shop, the drying rooms, and the front office. Work practices included mixing and pouring concrete and using hand-held rotary grinders to smooth the tops and bottoms of recently cured counter tops. Quest™ Technologies M-27 noise logging dosimeters were used to measure exposures to noise. The dosimeters were attached to the employees' belts and the remote microphone was attached to their shirt (facing forward) at the mid-point between the ear and the outside of the employee's shoulder. The dosimeters were calibrated before and after the shift according to the manufacturer's instructions.

On April 5th, September 11th, and October 16th 2002, full-shift personal breathing zone (PBZ) air sampling was conducted on three employees to characterize exposure to respirable dusts and respirable crystalline silica (as quartz and cristobalite.) Two area samples were collected to assess for the presence of asbestos fibers. Asbestos containing materials were not known to be used in the production process but a "popped" or thermally expanded aggregate material (resembling vermiculite) is used as part of the concrete mix. Because certain types of expanded vermiculite have recently been identified to contain asbestiform (or asbestos-like minerals) two area air samples were collected near the cement mixer to screen for the presence of airborne asbestos fibers.

Sampling for respirable dusts and silica was performed using pre-weighed 37 millimeter (mm) polyvinyl chloride filters (5 micrometer pore size) installed in Dorr-Oliver cyclones. The sampling pumps were calibrated to a flow rate of 1.7 liters per minute (LPM). Samples were analyzed gravimetrically using NIOSH Manual of Analytical Methods (NMAM) Method 0600 (Particulates, not otherwise regulated).[3] Respirable crystalline silica was analyzed using NMAM Method 7500 using X-ray diffraction.[4] Sampling for airborne asbestos fibers was conducted using 25 mm mixed cellulose ester filters (1.2 micrometer pore size) in conductive filter cassettes. Sampling pumps were calibrated to a flow rate of 1 LPM. The filter samples were analyzed for total fibers by phase contrast microscopy according to NMAM 7400 and the bulk samples according to NMAM 9002 using polarized light microscopy.[5] Elements (or metals) were analyzed using inductively coupled plasma spectroscopy using NMAM 7300.[6] All sampling trains were calibrated on-site and in-line to the appropriate flow rates using a Gilabrator™ air flow calibrator. Calibrations were conducted before the sampling trains were placed on the workers and immediately after the work shift had ended and the sampling trains had been removed from the workers.

Nine bulk samples of settled dust were collected to evaluate for the presence of silica (as quartz and cristobalite) and metals (elements). Bulk samples were collected from a heater and from electrical conduit attached to the walls in drying rooms #'s 1 and 2. Several grams of settled dust were collected with a stainless steel knife and the dust was then transferred to a clean glass scintillation vial. These samples were collected as a screening tool to see if there were qualitative differences between quartz and cristobalite found in air samples and that in settled dust, and also to determine if metals might be present in these dust, either of which might suggest the need for better housekeeping to remove settled dusts. For metals (or element analyses) the samples were digested in concentrated nitric acid and analyzed by inductively coupled plasma spectroscopy for 27 discrete elements. The samples for silica were analyzed using X-ray diffraction.

To characterize extraction velocity in the drying room, velocity measurements were made on the ceiling mounted fans in dry rooms #1 and #2. A hand-held Kurz Series 490 mini-anemometer was used for these measurements. Pressurization in these rooms was also evaluated using chemical smoke.

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),[7] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[8] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[9] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criterion.

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.

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.[10] 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 Hz (the hearing range is 20 Hz to 20,000 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.[11]

The A-weighted decibel [dB(A)] is the preferred unit for measuring sound levels to assess worker noise exposures. The dB(A) 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 which are audible to the human ear. Because the dB(A) scale is logarithmic, increases of 3 dB(A), 10 dB(A), and 20 dB(A) represent a doubling, tenfold increase, and 100-fold 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)[12] specifies a maximum PEL of 90 dB(A) 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 dB(A) for no more than 4 hours, to 100 dB(A) for 2 hours, etc. Conversely, up to 16 hours exposure to 85 dB(A) 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:

$$\text{Dose} = 100 \times (C1/T1 + C2/T2 + ... + Cn/Tn),$$

where Cn indicates the total time of exposure at a specific noise level and Tn 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% are in excess of the OSHA PEL.

The OSHA regulation has an additional action level (AL) of 85 dB(A); an employer shall administer a continuing, effective hearing conservation program when the 8-hour time-weighted average (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 in excess of the OSHA PEL of 90 dB(A), feasible engineering or administrative controls shall be implemented to reduce the workers' exposure levels.

NIOSH, in its Criteria for a Recommended Standard,[13] and the ACGIH,[8] propose exposure criteria of 85 dB(A) 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 dB(A) for 8 hours, but to no more than 88 dB(A) for 4 hours or 91 dB(A) for 2 hours.

Silica

Crystalline silica (SiO_2 or quartz) and cristobalite have been associated with silicosis, a fibrotic disease of the lung caused by the deposition of fine particles of crystalline silica in the lungs. Symptoms usually develop insidiously, with cough, shortness of breath, chest pain, weakness, wheezing, and non-specific chest illnesses. Silicosis usually occurs after years of exposure, but may appear in a shorter period of time if exposure concentrations are very high.[14] The NIOSH RELs for respirable quartz and cristobalite are 50 $\mu g/m^3$, as TWAs, for up to 10 hours per day during a 40-hour work week.[7] These RELs are intended to prevent silicosis. However, evidence indicates that crystalline silica is a potential occupational carcinogen and NIOSH is currently reviewing the data on carcinogenicity.[15,16] The OSHA PEL is dependant on the percent silica in the sample; the respirable dust exposure for an 8-hour TWA must not exceed the value obtained from the formula:

$$\frac{10\ mg/m^3}{\%\ SiO_2 + 2}$$

The ACGIH TLV®s for respirable quartz and cristobalite are 100 and 50 $\mu g/m^3$, as 8-hour TWAs, respectively.[8]

Particulates not otherwise regulated (respirable fraction)

Often the chemical composition of the airborne particulate does not have an established occupational health exposure criterion. It has been the convention to apply a generic exposure criterion in such cases. Formerly referred to as nuisance dust, the preferred terminology for the non-specific particulate ACGIH TLV criterion is now *"particulates, not otherwise classified (n.o.c.),"* [or *"not otherwise regulated"* (n.o.r.) for the OSHA PEL].

The OSHA PEL for total particulate, n.o.r., is 15.0 mg/m^3 for total dust and 5.0 mg/m^3 for the respirable fraction, determined as 8-hour averages. The ACGIH recommended TLV for exposure to a particulate, n.o.c., is 10.0 mg/m^3 as total dust, for an 8-hour TWA and 3 mg/m^3 for the respirable fraction.[8] These are generic criteria for airborne dusts which do not produce significant organic disease or toxic effect when exposures are kept under reasonable control.

RESULTS

Noise

Occupational exposures to noise ranged from 74.6 to 84.2 decibels on the A-weighted scale [dB(A)]. No samples exceeded the NIOSH REL or the OHSA action level of 85 dB(A). Noise dose ranged from 11.8% to 44.9%. The daily workplace exposures were well below 100%. Table 1 summarizes these data.

Respirable dust (particulates not otherwise regulated, respirable fraction) and respirable crystalline silica (as quartz and cristobalite)

Results of air sampling to evaluate exposures to respirable dust (or particulates not otherwise regulated, respirable fraction) and respirable crystalline silica are summarized in Table 2. Six personal breathing zone (PBZ) and three area samples were collected in drying rooms 1 and 2 while employees mixed and poured concrete in the wet room and mixed, applied, and sanded the patching material on various sizes and shapes of counter tops, sinks, and other concrete products in the dry rooms.

Employee exposures to respirable crystalline silica (as quartz) were very low, of the six samples one sample was not detected to a limit of detection (LOD) of 0.01 milligrams per sample, and the rest were at trace concentrations (below the LOD and the LOQ.) Cristobalite was not detected in any of the samples to a LOD of 0.02 milligrams per sample.

Employee exposures to respirable dust ranged from 0.8 mg/m^3 while mixing and pouring concrete, to the highest exposure of 10 mg/m^3 while sanding in dry room #2. One PBZ sample exceeded the OSHA TWA criterion of 5 mg/m^3 and two PBZ samples exceeded the ACGIH TWA criterion of 3 mg/m^3. The three PBZ exposures which exceeded either criteria occurred while patching and sanding in the dry rooms. One area air sample also exceeded the ACGIH TLV of mg/m^3.

General extraction ventilation and dilution ventilation is used as an engineering control in both drying rooms. In dry room #1 a ceiling mounted vane axial fan exhausts air to the roof of the shop, and in dry room #2, a ceiling-mounted centrifugal fan exhausts air to the roof.

Bulk Dust Samples (Quartz and Cristobalite)

Analytical results of four samples of settled dust collected from the conduit and the heaters in the drying rooms indicate that quartz ranged from 2.0 to 3.3%. Cristobalite was not detected in any of the bulk samples of settled dusts from either of the drying rooms. Table 3 describes these results.

Total Fibers

Two area air samples were collected on either side of the cement mixer as concrete was prepared, blended and mixed. These samples were determined to be below the limit of detection of 0.01 fibers per cubic centimeter of air samples or <3000 fibers/filter for the 25 mm diameter filters that were used according to NIOSH sampling method 7400. Table 4 summarizes the data.

Metals (Elements)

Table 5 summarizes the results of four samples of settled dusts collected from the metal conduit in drying rooms #1 and #2. A variety of metals were present in very low concentrations in settled dusts. These elements are likely coming from metals and minerals used to make the abrasives on the sanding disks. Metals of occupational health concern were not found in significant quantities to present a health risk, although lead (Pb) was detected above the limit of detection [at approximately twice the limit of quantitation in a range of 6-11 ppm in three of the four samples. Cadmium (Cd) was detected in one sample at 1.1 ppm but was not detected in four other samples. Table 5 summarizes the sampling results.

Ventilation

The average of 12 face velocity measurements made at the pre filter (which was quite dirty) in dry room #2 showed the centrifugal fan was moving air at approximately 370 feet per minute. Twelve face velocity measurements made at the opening to the fan box in dry room #1 indicate that the vane axial fan for that system moved air at an average of about 400 feet per minute. Chemical smoke traces confirmed that both of the dry rooms were maintained under a slight negative pressure when the make up air and exhaust fans operated in these areas.

DISCUSSION AND CONCLUSIONS

Occupational exposures to noise, respirable crystalline silica, asbestos and skin sensitizers are well controlled at The Concrete Revolution. Certain work activities (i.e., sanding patched counter tops in the drying rooms) resulted in three PBZ concentrations of respirable dusts that exceeded either the OSHA PEL for respirable dusts (one instance) and the ACGIH criterion (two instances.) It is important to note that at the time the three PBZ samples that exceeded either the OSHA or the ACGIH criteria were collected, the employees wore filtering face piece respirators to reduce their dust exposures. Provided the employees had an optimal respirator fit, their actual exposures would have been reduced by at least a five-fold factor (as 5 is the minimum actual protection factor afforded by a well-fitted disposable filtering face piece respirator.)

Time-weighted average exposures to respirable dusts ranged from 1.7 mg/m^3 in the wet room to one sample of 10 mg/m^3 in dry room #2. The single highest exposure was more than twice the concentration of the next lowest exposure (10 mg/m^3 vs. 4.2 mg/m^3). A number of factors and workplace observations may explain why the highest dust concentration was notably higher than all the other dust samples collected during this investigation. One observation is that on 9/11/02, at certain times of the day another employee sanded counter tops in dry room #2. It was apparent that when the two employees worked together, the degree of dustiness in the dry rooms was noticeably greater than when the employees worked alone in either of the dry rooms. The type of exhaust fan in dry room #2 may also be influencing dust concentrations. Face velocity measurements indicate that the centrifugal exhaust fan in dry room #2 moves slightly less air than the vane axial fan in dry room #1. The intake of the fan in dry room #2 is fitted with a low efficiency filter to help prevent dust loading on the fan blades. The combination of a dirty prefilter, and a possibly partially blocked intake (due to the fact that the fan cage is located sideways in the duct opening) may be limiting the overall effectiveness of this exhaust system. When two employees sand together and in close proximity to each other, apparently sufficient concentrations of dusts maybe generated in dry room #2 to exceed the capacity of the extraction and dilution ventilation needed to keep dust concentrations below 5 mg/m^3 or lower. Finally, it is also possible that work practices influence the degree of dustiness in the dry rooms. If excessive amounts of grout are applied to the counter tops (enough so that dry grout clumps are present along the border of the counter top) these accumulations will become small airborne dust clouds when the rapidly spinning sanding disk hits them. This was observed on 09/11/02. Enhancements to the exhaust ventilation that is currently installed in the drying rooms (especially drying room #2) along with modifications to work practices is needed to reduce airborne dusts that are generated when patching counter tops. The use of directly ventilated sanders may also be quite useful in reducing dust concentrations while patching. A recent experimental study reported that the use of directly ventilated handheld sanders reduced inhalable dust concentrations by 93 to 98 percent [17]

Workplace observations and the results of air sampling suggest that the degree of dustiness in either of the dry rooms varies in relation to the length of time patching occurs as well as the number, the size, and the shape of the counter tops that are being patched. The most significant factors appear to be whether one or two employees work in a dry room at the same time, and how much excess grout is applied to the counter top before the counter top is sanded.

RECOMMENDATIONS

The following recommendations are offered by NIOSH in the interests of health and safety for employees of The Concrete Revolution.

1. To minimize dust generation in the drying rooms, employees should continue to apply the minimum amount of grout compound necessary when wet patching and sanding counter tops. Using rubber trowels and carefully applying the patching material is recommended to minimize accumulations of grout along the tops and edges of counter top.

2. When extensive patching is anticipated, plan the work so that it is distributed in both dry rooms and

try not to have two workers sanding at the same time in the same room.

3. To enhance general exhaust ventilation in dry rooms #1 and #2 retrofit the outside exhaust stacks by removing the existing conical caps and replacing with no loss caps. A vane axial fan should be located in dry room #2 rather than the centrifugal fan that is currently installed. Vane axial fans are recommended over centrifugal fans for dusty requirements because axial fan blades do not accumulate as much dust as centrifugal fan blades and are more efficient at moving dusty air. Another option is to consider the use of directly ventilated handheld sanders to reduce dust generation into the workplace environment.

4. Consider adding a dedicated dust collection device for the planer and dedicating the existing vacuum collection system to the panel saw. As currently configured, the static pressure requirements from two hoods (the planer and the panel saw) are excessive for a single capture system. All connections should be made as short as possible to maintain static pressure in the dust collection system, and take offs from hoses should be at 45 degree angles. Insuring that the edges of the sheet metal plenum on the back of the panel saw are sealed will also help to increase static pressure and improve the efficiency of the dust collection system.

5. To insure that the portable dust collection system operates at optimum efficiency, empty the cloth bag and the barrel when they become half full. Occasionally check to make sure that the exhaust plenum is not blocked or plugged on the front of the panel saw. Also insure that all small openings along the sheet metal plenum are screwed down or sealed with duct tape to maintain maximum negative pressure.

6. Employees should not use compressed air to blow dust from their clothing, faces, and hair. Using compressed air to clean clothes simply resuspends dust back into workplace air, creating an inhalation hazard. High pressure air can also cause dust and other material to be blown into the employee's eyes. A better way to remove dusts from clothing is for employees to vacuum their clothing using a high-efficiency particulate aerosol (HEPA) vacuum to remove dust from work clothes during or after the workday. Employees should also wash their hands and face with soap and water after the work shift.

7. Continue to use nitrile rather than natural rubber latex gloves when working with sensitizing resins and sealers (i.e., Allen's resin, Ancamine, and other chemicals noted on the product label or the material safety data sheet as a skin sensitizer). Natural rubber latex gloves are designed to protect skin against exposure to bloodborne pathogens, they are not intended or designed for skin protection against the sensitizing agents in resins and sealants.

8. Periodically use a HEPA vacuum cleaner to remove accumulations of settled dusts from the metal conduit and the wall-mounted heaters in the dry rooms.

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Table 1 The Concrete Revolution, Denver, CO. Noise Dosimetry April 2nd and 5th, 2002				
Job Title	**Location**	**Work Activity/ Tool**	**TWA dB(A)**	**Dose (%)**
Laborer	forms tables	using orbital grinder	84.2	44.9
Foreman	all over shop	circular saw, other tools	74.6	11.8
Laborer	forms tables	using orbital grinder	78.7	20.9
Laborer	raw materials area (cement)	cement mixer	79.3	22.8
OSHA 8 hr. time-weighted average Permissible Exposure Limit (PEL) = 90 dB(A) NIOSH 8 hr. time-weighted average, Recommended Exposure Limit (REL) = 85 dB(A) The daily workplace exposure dose should not exceed 100%				

Table 2 The Concrete Revolution, Denver, CO. Sampling for Respirable Crystalline silica and Respirable Dusts April 5th, September 11, and October 16, 2002					
Job Title / Sample # /Location	**Date**	**Quartz (mg/sample)**	**Cristobalite (mg/sample)**	**Respirable Dust (mg/m^3)**	**Comments**
Laborer BO2-273 Wet Room	04/05	Trace	ND	1.6	
Laborer BO2-276 Wet Room	04/05	Trace	ND	0.8	
Laborer BO2-282 Wet Room	04/05	Trace	ND	1.6	
Laborer BO2-277 Dry room 2	09/11	Trace	ND	10	At times two employees sanded counter tops in the same room at the same time
Laborer BO2-288 Dry rooms 1 and 2	09/11	ND	ND	4.2	Worked in both dry room at various times during the shift
Area Sample BO2-287 Dry Room 1	09/11	Trace	ND	3.1	Sample located at on the metal pole in middle of room
Laborer BO2-280 Dry Room 2	10/16	Not analyzed due to previous results showing low amounts of quartz	Not analyzed due to previous results showing cristobalite ND	3.5	Shop Foreman also working in this room sanding counter tops
Area Sample BO2-284 Dry Room 2	10/16	Not analyzed (for reason above)	Not analyzed (for reason above)	3.0	Located above area where shop Foreman was working
Area Sample BO2-285 Dry Room 2	10/16	Not analyzed (for reason above)	Not analyzed (for reason above)	1.8	Located on far wall in dry room 2

OSHA 8 hr. time-weighted average Permissible Exposure Limit (PEL) for respirable particulates not otherwise regulated = 5 milligrams per cubic meter of air (mg/m^3)
Trace = quantity determined to be between limit of detection (LOD) and limit of quantitation (LOQ)
ND= not detected

Table 3 The Concrete Revolution, Denver, CO. Settled Dust Collected from Dry Rooms #1 and #2 April 5th, 2002			
Sample #	**Analyte**	**Results (%)**	**Comment**
CRB1	Quartz and Cristobalite	2.5 /ND	Cristobalite not detected
CRB2	Quartz and Cristobalite	2.4 /ND	Cristobalite not detected
CRB3	Quartz and Cristobalite	2.0 /ND	Cristobalite not detected
CRB 6	Quartz and Cristobalite	3.3/ ND	Cristobalite not detected
ND = Not detected			

Table 4 The Concrete Revolution, Denver, CO Total Fibers (Asbestos) April 5th, 2002				
Sample #	**Sample Date**	**Sample Type**	**Total Fibers**	**Comments**
CRASB1 and CRASB1a	04/05	PVC Filter	< 3000	ND
CRASB2 and CRASBa	04/05	PVC Filter	< 3000	ND
CRASB3	04/05	PVC Filter	< 3000	Field Blank
The limit of detection (LOD) was reported as 3000 fibers per filter ND = Not detected or less than 0.01 fibers/cc				

Table 5 The Concrete Revolution, Denver, CO Elements (metals) in Settled Dust (Bulk) Samples April 5th, 2002		
Sample	**Results**	**Comments**
CRB1	Presence of: Al, Cr, Ca, Cu, Fe, Mg, Mn, Ni and Pb (Trace) Ti, and Zn	present in low microgram per gram amounts, or ppm concentrations
CRB2	Presence of: Al, Ca, Cr, Cu, Fe, Mg, Mn, Na, Ni and Ti, and Zn	
CRB3	Presence of: Al, Ca, Cr, Cu, Fe, Mg, Mn, Na, Ni, Pb Ti, and Zn	
CRB6	Presence of: Al, Ca, Cd Cr, Cu, Fe, Mg, Mn, Na, Ni, Pb Ti, and Zn	

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