# IN-DEPTH SURVEY REPORT OF FOUR SITES: EXPOSURE TO SILICA FROM HAND TOOLS IN CONSTRUCTION CHIPPING, GRINDING, AND HAND DEMOLITION

at

Frank Messer and Sons Construction Company
Lexington and Newport, KY
Columbus and Springfield, OH

REPORT WRITTEN BY.
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REPORT DATE·
April, 2001

REPORT NO.
EPHB 247 - 15a

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| SITES SURVEYED | New Construction, Newport, KY<br>New Construction, Lexington, KY<br>Building Renovation, Columbus, OH<br>Building Renovation, Springfield, OH |
| SIC CODE | 1771 |
| SURVEY DATES | May 26, 30, and 31, July 6, September 11 and 26, 2000 |
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# ABSTRACT

This report describes the exposures and controls that were evaluated at four sites where tasks such as concrete grinding with hand-held grinders (sites 1 and 2), removing brick with pneumatic hammers (site 3), and demolition of tile and plaster walls with hand tools (site 4) were performed The results at site 1 indicate that the use of local exhaust ventilation with a concrete grinder can reduce exposures to the point where a half-mask respirator provides adequate protection for the worker However, the vacuum source must be carefully selected to include features such as adequate capacity to contain the dust collected during the task, the ability to clean the filter without opening the vacuum cleaner, the ability to remove full bags without exposing the operator to the dust, flow sufficient to capture the dust at the source and transport it to the vacuum source, ease of use, and filtration efficiency adequate to prevent the vacuum source from acting as an aerosol generator for respirable dust The results at site 2 indicate that a laborer grinding concrete without local exhaust ventilation was exposed to respirable dust containing quartz between 20 and 32 times the OSHA PEL and to respirable quartz between 35 and 55 times the NIOSH REL. These results indicate that a half-mask air purifying respirator is not sufficiently protective for an employee grinding concrete with no local exhaust ventilation controls, even in a relatively open area Samples collected on one of two workers removing brick facing from a building at site 3 indicate that his exposures exceeded the NIOSH REL for quartz and the OSHA PEL for respirable dust containing 16% quartz The other worker was exposed to a slightly higher level of respirable dust, but his silica exposure could not be quantified Results from site 4 indicate that a hand-demolition task, such as pulling down a ceiling and demolishing one wall of a bathroom resulted in exposures requiring the use of respiratory protection

## INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) is located in the Centers for Disease Control and Prevention (CDC), under the Department of Health and Human Services (DHHS) NIOSH was established in 1970 by the Occupational Safety and Health Act, at the same time that the Occupational Safety and Health Administration (OSHA) was established in the Department of Labor (DOL) The OSHAct legislation mandated NIOSH to conduct research and education programs separate from the standard-setting and enforcement functions conducted by OSHA An important area of NIOSH research deals with methods for controlling occupational exposure to potential chemical and physical hazards

The Engineering and Physical Hazards Branch (EPHB) of the Division of Applied Research and Technology (DART) has been given the lead within NIOSH to study and develop engineering controls and assess their impact on reducing occupational illness. Since 1976, EPHB (and its forerunner, the Engineering Control Technology Branch) has conducted a large number of studies to evaluate engineering control technology based upon industry, process, or control technique The objective of each of these studies has been to evaluate and document control techniques and to determine the effectiveness of the control techniques in reducing potential health hazards in an industry or for a specific process

This is the preliminary report of a project to investigate exposures to construction workers that result from chipping and grinding concrete and other construction materials that contain crystalline silica, and engineering controls to reduce those exposures This report describes the exposures and controls that were evaluated at four sites where tasks such as concrete grinding with hand-held grinders (sites 1 and 2), removing brick with pneumatic hammers (site 3), and demolition of tile and plaster walls with hand tools (site 4) were performed Exposures and controls associated with tuck-pointing, which typically involves removing mortar from brick and block walls with grinders, are described in other EPHB reports from this project

## OCCUPATIONAL EXPOSURE TO CRYSTALLINE SILICA

Silicosis is an occupational respiratory disease caused by inhaling respirable crystalline silica dust Silicosis is irreversible, often progressive (even after exposure has ceased), and potentially fatal Exposure to silica dust occurs in many occupations, including construction Because no effective treatment exists for silicosis, prevention through exposure control is essential When proper practices are not followed or controls are not maintained, silica exposures can exceed the OSHA Permissible Exposure Limit (PEL) or the NIOSH Recommended Exposure Limit (REL) [1,2]

The OSHA PEL for respirable dust containing crystalline silica is expressed as an equation

$$\text{Respirable PEL} = \frac{10}{(\%\ \text{Silica}) + 2}$$

Thus, if the dust contains no crystalline silica, the PEL is 5 mg/cubic meter ($m^3$), and if the dust is 100% crystalline silica, the PEL is 0 1 mg/$m^3$ The NIOSH REL for respirable crystalline silica is a 10-hour, time-weighted average level of 0 05 mg/$m^3$. NIOSH has classified crystalline silica as a potential occupational carcinogen Therefore, NIOSH recommends that employers make efforts to reduce silica exposures below the REL

## METHODS

At each site, personal breathing zone samples were collected at a flow rate of 1.7 liters/minute using a battery operated sampling pump connected via Tygon tubing to a 10-millimeter (mm) nylon cyclone (a Dorr-Oliver cyclone) and a pre-weighed, 37-mm diameter, 5-micron (µm) pore-size polyvinyl chloride filter supported by a backup pad in a two-piece filter cassette sealed with a cellulose shrink band, in accordance with NIOSH Methods 0600 and 7500 [3] In addition to the personal samples, a bulk sample of settled dust was collected in accordance with NIOSH Method 7500

Samples were analyzed in accordance with NIOSH Methods 0600 and 7500 with modifications Gravimetric analysis for respirable particulate was carried out with the following modifications to NIOSH Method 0600 1) The filters and backup pads are stored in an environmentally controlled room (21±3 °C and 50±5% relative humidity) and are subjected to the room conditions for at least two hours for stabilization prior to tare and gross weighing; and, 2) Two weighings of the tare weight and gross weight are performed The difference between the average gross weight and the average tare weight is the result of the analysis The limit of detection for this method is 0.02 milligrams (mg)

Crystalline silica analysis was done using X-ray diffraction. NIOSH Method 7500 was used with the following modifications 1) Filters were dissolved in tetrahydrofuran rather than being ashed in a furnace, and, 2) Standards and samples were run concurrently and an external calibration curve was prepared from the integrated intensities rather than using the suggested normalization procedure These samples were analyzed for two forms of crystalline silica, quartz, and cristobalite. The limits of detection for quartz and cristobalite on filters are 0 01 and 0 02 mg, respectively The limit of quantitation is 0 03 mg for both quartz and cristobalite on filters The limits of detection in bulk samples are 0.8% for quartz and 1% for cristobalite. The limit of quantitation is 2% for both forms of crystalline silica in bulk samples.

At site 1, the specific sources of respirable particulate and respirable crystalline silica exposures associated with concrete grinding were determined by conducting video exposure monitoring for part of the morning on May 26 The worker being sampled wore a HazDust II real-time personal dust monitor equipped with a respirable particulate pre-separator, while his actions were recorded using a Canon XL1 digital video camcorder mounted on a tripod The HazDust II was equipped with a pre-weighed, 37-mm diameter, 5-µm pore-size polyvinyl chloride filter supported by a backup pad in a two-piece filter cassette sealed with a cellulose shrink band in-line after the sensor This filter was analyzed as noted above in order to determine the percentage of crystalline silica in the sample In the laboratory, the data collected with the personal dust monitor were overlaid onto the video recording

In order to assess the capacity of the vacuum cleaner used at site 1 on May 31, 2000, the vacuum cleaner bags were weighed before and after use, using a portable scale The time was also noted each time the vacuum cleaner bag was changed to determine how long it took the vacuum cleaner to reach its capacity

Also at site 1, air flow into the vacuum cleaners was calculated from static pressure measurements obtained using a Neotronics MP20SR micromanometer and a pitot tube at the end of the tool end of vacuum cleaner hose with the shroud removed

## RESULTS

### Site 1: Grinding Concrete

At site 1, sampling was conducted to assess the effectiveness of local exhaust ventilation in use with hand-held grinders used to finish concrete surfaces A total of seven personal breathing zone air samples for respirable particulate were collected Three samples were collected on May 26, and two samples were collected each day on both May 30 and 31, 2000 Air sampling results are presented in Tables 1-6

The concrete finisher sampled had about three months experience grinding concrete, beginning in March, 2000 While grinding, he wore a 3M model 6200 half-mask air-purifying respirator with dual 3M model 2096, P100 particulate filters The concrete finisher also wore a hard hat, safety glasses, ear plugs, and work gloves

On May 26, 2000, the concrete finisher was working on the ramp between levels P1 and P2 of a parking structure During the first and second sampling periods, from 7.16 am to 11 54 am, and from 12 41 pm to 1 42 pm, he ground both sides of a partial wall that formed one side of the ramp structure During the third sampling period, from 1 43 pm to 2 54 pm, the concrete finisher worked chipping concrete from the base of columns until 2 15 pm, and spent the remainder of the period grinding columns. The first sample was allowed to run during the employee's break from 8 50 am to 9.20 am, since he remained on site The sample was changed at lunch and again when the worker stopped grinding and started chipping He began the day using a Bosch 1347A model 0601347266, 4½ -inch (in) 11,000 revolutions per minute (rpm) grinder, equipped with a Pearl Abrasive Co medium PW cup wheel The grinder was fitted with a Pearl Abrasive Co Vacu-Guard shroud. The exhaust shroud is metal with an elastomeric insert to allow it to flex and maintain contact with the concrete surface A white rigid plastic insert around the bottom edge of the shroud seals the shroud to the surface. A portion of the shroud is cut out to allow the grinder to be used on inside corners The shroud was connected via a 1½-in inside diameter (i.d ) flexible hose to a WAP model SQ 10 gallon RDF 60113 vacuum cleaner with a SQ 4000 No. 29739 filter bag and a pleated paper filter around the motor All of the available vacuum cleaner bags on site were used up, and the vacuum cleaner was used without a bag until around 9 50 am This necessitated finding a second vacuum cleaner At 10 45 am, the concrete finisher switched to a Pullman Holt model 102 drum-top vacuum cleaner He used this vacuum cleaner for the remainder of the day After lunch, he used a Metabo model W7-115 Quick, 4½ -in 10,000 rpm grinder This grinder was fitted with the same Vacu-Guard shroud.

Repositioning the portable generator, extension cords, work lights, and vacuum cleaner as the work progressed slowed the pace of the work, as did the need to change the bags in the WAP vacuum cleaner and clean filters in both the WAP and Pullman Holt vacuum cleaners Cleaning the filter in the WAP vacuum cleaner involved striking the filter on a wall or on the floor The filter for the Pullman Holt vacuum cleaner was cleaned by shaking the filter The results of personal breathing zone sampling for respirable dust and crystalline silica for May 26 are presented in Table 1 and Table 2. These results indicate that although the concrete finisher was potentially exposed to respirable dust and respirable quartz concentrations (no cristobalite was found in any of the samples) in excess of the OSHA PEL and NIOSH REL, these concentrations were below the maximum use concentration (10 times the occupational exposure limit) of the respirator used by the worker

Two bulk samples collected on May 26, 2000 were found to contain 19 and 24% quartz, respectively

On the second day of sampling, May 30, 2000, the concrete finisher was working on the P2 level of the parking structure He spent the entire shift grinding concrete. The first sample was collected from 7.39 am to 11 54 am The pump was turned off and the sampler was removed from 8 57 am to 9 24 am, during the morning break The second sampling period began when the worker returned from lunch at 12 31 pm and ended when he stopped grinding for the day at 3 08 pm During the shift, the worker ground the surface of approximately 1,170 square feet (ft$^2$) of concrete walls He used the Metabo model W7-115 Quick, 4½ -in 10,000 rpm grinder, Vacu-Guard shroud, and the Pullman Holt model 102 drum-top vacuum cleaner. The concrete finisher's work was interrupted by the need to reposition the vacuum cleaner, extension cords, work lights, and portable generator as the work progressed, and by the need to clean the vacuum cleaner filter This type of vacuum cleaner posed an additional problem because by design, it relies on the suction it produces to form a seal between its drum and the drum-top. Any misalignment of these components, which rely upon an elastomeric gasket to complete the seal, resulted in diminished capture at the shroud The results of personal breathing zone sampling for respirable dust and crystalline silica for May 30 are presented in Tables 3 and 4 Once again, the results indicate that although the concrete finisher was potentially exposed to concentrations of respirable dust and respirable quartz in excess of the OSHA PEL and NIOSH REL, these concentrations were below the maximum use concentration of the respirator used by the worker.

On the third day of sampling, May 31, 2000, the concrete finisher worked on the P2 level again He spent the entire shift grinding concrete The first sample ran from 7:25 am to 11.33 am The sample was allowed to run through the morning break, from 8.53 am to 9.25 am. The second sample was started at 11 33 am, the pump was turned off and the sampler was removed during the lunch break, from 11 53 am to 12 41 pm, and the sampling period ended at 2·43 pm, when stored material blocking walls and columns precluded any more grinding that day

Approximately 1,100 $ft^2$ of concrete were ground by the concrete finisher during this shift He used the Metabo model W7-115 Quick, 4½ -in 10,000 rpm grinder, Vacu-Guard shroud, and the WAP vacuum cleaner Because of its tendency to clog frequently, the pleated paper filter was not used in the vacuum cleaner Changing vacuum cleaner bags and moving the vacuum cleaner, generator, work lights, and extension cords interrupted the finisher's work His work was also interrupted by the need to move stored material in order to gain access to the walls Bags needed to be changed about every 35 minutes The 11 bags used during the shift weighed an average of about 5 pounds when full The results of personal breathing zone sampling for respirable dust and crystalline silica for May 31 are presented in Tables 5 and 6 Like the previous two sampling days, these results indicate that although the concrete finisher was potentially exposed to concentrations of respirable dust and respirable quartz greater than the OSHA PEL and NIOSH REL, these concentrations were below the maximum use concentration of the respirator used by the worker.

Figures 1 and 2 present the real-time data obtained during grinding on May 26, while the concrete finisher used the WAP vacuum cleaner and Bosch grinder with the Pearl Vacu-Guard shroud Silica concentrations ranged from 0 017 to 1 8 mg/$m^3$, with an average concentration of 0 14 mg/$m^3$ The respirable dust concentration ranged from 0 12 to 12 mg/$m^3$. The average respirable dust concentration was 0 99 mg/$m^3$. Analysis of the filter sample from the HazDust II monitor indicated that the dust collected on that filter was 14 5% silica, which results in an OSHA PEL of 0.61 mg/$m^3$ of respirable dust These results indicate that, based on the average respirable dust concentration, a half-mask respirator provides adequate protection for this task with these controls In Figures 1 and 2, the peak at 8 12 am represents the worker changing the bag, while the peak at 8 14 am corresponds to grinding a bulge in a wall The peak at 8.24 am was the result of grinding near a floor-wall joint The large peak around 8.28 am corresponded to grinding a very uneven surface, probably the result of concrete leaking at the joint between two forms Some work with a mason's hammer was necessary to remove chunks of concrete The series of peaks between 8 36 am and 8.39 am show the performance of the system degrade as the filter loads and end with the worker cleaning the filter The peaks around 8 42 am represent removing the last vacuum cleaner bag The peak at 8:46 am was the result of grinding the complex angle formed by the intersection of the top edge of a low wall and a column The elevated levels that follow seemed to result from work on a low wall where the time between grinding on the top edge and the floor-wall joint was short. Review of the videotape and observations on the other sampling days occasionally showed dust falling out of the shroud This was probably the result of dust settling out in the corrugations of the hose due to inadequate transport velocity Flow into the WAP vacuum cleaner was approximately 87 cubic feet per minute (cfm) with a new bag, and about 31 cfm with a bag full to the point that dust was falling out of the shroud Flow into the Pullman Holt vacuum cleaner was about 30 cfm at the point the shroud was no longer working

## Site 2: Grinding Concrete

At site 2, sampling was conducted in order to determine whether a worker with respiratory protection could grind concrete off-shift without the use of local exhaust ventilation. The worker would be protected, and other workers would not be present On July 6, 2000, two personal breathing zone air samples and two general area air samples for respirable particulate were collected Air sampling results are presented in Tables 7 and 8.

The laborer grinding concrete stated that this was a typical day At the time sampling was done, he had two to three months experience as a grinder. Grinding was done using a Metabo model 7015 grinder, with a 3 ⅝ inch wheel. The grinder is rated at 10,000 rpm. A Pearl Abrasive Co Vacu-Guard ventilated shroud was mounted on the grinder; however, the shroud served only as a guard, as it was not connected to the available vacuum cleaner for the purpose of this evaluation The laborer wore a 3M 6300 series half-mask air purifying respirator equipped with model 2077 P95 filters The employer based this selection on anticipated exposures from this task. Grinding took place on the third floor of the building under construction, which was open on all sides No other employees were present on the floor most of the day The grinder spent the day grinding walls, columns, floor and wall or column junctions, and some floor areas. He ground almost continuously in the morning, and more intermittently in the afternoon, as more time was required to move to different areas to be ground The first sample was collected for 156 minutes, beginning when the employee began grinding after the NIOSH personnel arrived on the site. The employee took two 15 minute breaks, at 9:00 am and 2:00 pm, and broke for lunch from 12 00 to 12 30 pm The pump was removed during lunch, and the second sample was started after the employee returned This sample ran for 145 minutes The area samples were placed at approximately breathing zone height near an elevator shaft (about 6 feet and 15 feet away) where the employee started work in the morning, and left there for the remainder of the day

The personal breathing zone samples for respirable dust exceeded the method-recommended maximum sample loading of 2 mg and had loose particulate on the filters The personal breathing zone sample collected in the morning was treated as a bulk sample for silica analysis due to its large dust loading As such, a 2 mg portion of the sample was prepared for analysis. The personal breathing zone sample collected in the afternoon was split into three portions by volume for quantitative silica analysis due to its large dust loading The results for that sample were reported as the sum total of the three portions. Since the samples were overloaded, the results reported in the Tables 7 and 8 may be low estimates of the employee's actual exposure.

The results of the personal breathing zone samples are reported in Tables 7 and 8 . Analysis of these samples indicated that the morning sample contained 10% quartz and the afternoon sample contained 14 2% quartz The two area samples contained only trace amounts of quartz No cristobalite was detected in any of the samples. The area sample closest to the elevator shaft resulted in a respirable dust concentration of 0 15 mg/m$^3$. The more distant area sample measured a respirable dust concentration of 0 14 mg/m$^3$. Both samples were collected for 332 minutes. The 8 hour time weighted averages in Tables 7and 8 were calculated assuming no exposure occurred during the unsampled portion of the work day

## Site 3: Using Chipping Hammers to Remove Brick

At site 3, sampling was conducted to measure potential employee exposures associated with using chipping hammers to remove a portion of the brick facing from the building Four personal breathing zone air samples and one general area air sample were collected on September 11, 2000, and analyzed for respirable particulate and crystalline silica Air sampling results are presented in Tables 9 and 10.

Two laborers worked on the chipping task on the day of the survey While chipping, they wore 3M model 6800 full facepiece air-purifying respirators with dual filters One worker used 3M model 2096, P100 particulate filters, while the other used 3M model 2071 P95 particulate filters (NIOSH recommends N, P, or R 100 filters for protection against crystalline silica) The laborers also wore hard hats, ear plugs, work gloves, and safety harnesses The harnesses were secured to the basket of the Genie Boom high reach. They worked approximately 20 feet off the ground

Sampling began at approximately 9:40 am, shortly after the morning break ended The workers began chipping brick from an area above a window opening on the north side of the building with a 15 pound pneumatic chipping hammer They took turns chipping and cleaning debris Chipping stopped after 15 minutes due to problems with the hammer, and resumed 40 minutes later Chipping stopped again after 30 minutes due to the hammer, resumed 8 minutes later, and stopped after 7 minutes due to a leak in the hose supplying air to the hammer Chipping resumed after 13 minutes This time, a 40 pound chipping hammer was used Work continued for 19 minutes, when the workers had completed removing the brick from the area above the window In all, they removed 21 courses of brick from an area 10 feet wide Samplers were removed during the employees' lunch break The exposed filter samples were removed and replaced with fresh filters for the next sampling period

After lunch, sampling resumed at about 1.20 pm after the workers positioned their equipment under the next window opening, one opening east of the previous area (the area sample was moved to maintain a constant distance from the workers) The workers used a Hilti TE75 electric chipping hammer for approximately 20 minutes to open up areas for the 40 lb pneumatic hammer They then switched to the pneumatic hammer and, working west to east, removed 3-4 courses of bricks to about the midpoint of the area they were removing They worked together briefly using both hammers, and then used the 40 lb pneumatic hammer together, with one worker holding the handles while the other held the barrel of the hammer with both hands, or placed one hand on the barrel and one between the other worker's hands on the center of the handle. The workers took a break between 2 05 and 2 20 pm, and then resumed work together with the pneumatic hammer One worker briefly used the electric hammer to open up the second half of the area Working together, they completed the removal using the pneumatic hammer One worker used the electric hammer to trim the edges of the opening Work stopped for cleanup and sampling was halted at about 2:45 pm

The bulk sample of settled dust, collected from the top of the air compressor trailer, was found to contain 8 9% quartz The air samples for worker 1 contained a total of 16% quartz The air samples for worker 2 were estimated to contain a total of 3 8% quartz. Neither the bulk sample nor any of the air samples was found to contain cristobalite Tables 9 and 10 present the air sampling results Two workers working side by side were sampled for quartz Why quartz was found in quantifiable levels in the breathing zone of only one of the workers is not certain The results of the analyses of the samples for Worker 2 found quartz in an amount between the limit of detection and the limit of quantitation for the morning sample, and below the limit of detection for the afternoon sample. His exposure was estimated from these values For the result below the limit of detection (LOD), a value of the $LOD/\sqrt{2}$ was used to estimate his exposure Worker 1 was exposed to quartz above the NIOSH REL, and in excess of the calculated OSHA PEL for respirable dust containing 16% quartz Worker 2 was estimated to be exposed to quartz in excess of the NIOSH REL and calculated OSHA PEL for the length of the task, but not for an 8-hr day with no further exposure. Both workers were adequately protected by the full-facepiece respirators they wore The area sample contained respirable dust below the limit of detection for the method Based on this result, it was not analyzed for silica According to weather station data from Ohio State University (OSU), the mean temperature on September 11 was 73 °F, with a maximum temperature of 79 °F Wind was observed at the site to be blowing from the south OSU reported a mean wind speed of 7 mph, with a max of 14 mph

## <u>Site 4: Demolition with Hand Tools</u>

At site 4, sampling was conducted to measure potential employee exposures to respirable particulate and crystalline silica associated with using hammers, scrapers, spud bars, shovels, brooms, and other hand tools to pull down the ceiling and one wall of the bathroom in patient rooms and cleanup the debris The site was a nursing home undergoing renovation. Three personal breathing zone air samples were collected on September 26, 2000 and analyzed for respirable particulate and crystalline silica Air sampling results are presented in Tables 11 and 12

Three carpenters worked on the demolition task on the day of the survey While working, the carpenters wore hard hats, safety glasses, work gloves, and N95 filtering face piece respirators Two of the carpenters wore face shields One of those carpenters and the other carpenter wore Tyvek-like suits over their work clothes at their discretion

Sampling began between 9 37 and 9 50 am, the samplers were turned off during a 10 minute break from 11.18 to 11.28, and sampling continued until the lunch break at 12·02 This sampling period covered the time it took for each worker to pull down one wall and the ceiling of one bathroom, and remove the debris from the bathroom The sequence of events was typically to break up the plaster ceiling and the wall (the upper portion of the wall was plaster, the lower portion was covered with ceramic tile), cleanup the debris with a shovel, and use snips and a hammer to pull down the wire lath. One of the carpenters (carpenter 1 in Tables 11 and 12) used a Hilti TE75 electric hammer with a spade-shaped bit to break the tile, plaster, and lath at the floor-wall joint The same worker had to stop work in that room and move to another room when suspected asbestos-containing material was found behind the wall. Another carpenter (carpenter 3 in Tables 11 and 12) worked in a patient room with the window open and the unit heater and fan running

The bulk sample, collected from material that had settled on a ledge in one of the bathrooms, contained 17% quartz. Tables 11 and 12 present the air sampling results. The results of the analyses of the samples for carpenters 2 and 3 found quartz in an amount between the limit of detection and the limit of quantitation. The 8-hour time weighted averages were calculated assuming that no additional exposures occurred on the sampling day. If the carpenters continued to demolish ceilings and walls as they did during the sampling period, their 8-hour time weighted average exposure would more closely resemble the data in the columns labeled Time Weighted Average. The filtering face piece respirators used at this site were the level of respiratory protection appropriate to the task. However, NIOSH recommends N, P, or R100 respirators for tasks requiring air purifying respirators for exposure to crystalline silica rather than the N95 respirators used at this site

## DISCUSSION AND CONCLUSIONS

The results at site 1 indicate that the use of local exhaust ventilation with a concrete grinder can reduce exposures to the point where a half-mask respirator provides adequate protection for the worker. In addition to the problems with the use of the vacuum cleaner noted above, the employee reported that he needed to be more careful in order not to stumble over the vacuum cleaner hose, that the hose made the use of the grinder more awkward, that the shroud hung up on projections from the wall surface, and that the hose added to the weight he had to hold while using the grinder. This site visit also pointed out that desirable features in a vacuum cleaner used for concrete dust collection would include adequate capacity to contain the dust collected during the task, the ability to clean the filter without opening the vacuum cleaner, the ability to remove full bags without exposing the operator to the dust, flow sufficient to capture the dust at the source and transport it to the vacuum cleaner, ease of use, and filtration efficiency adequate to prevent the vacuum cleaner from acting as an aerosol generator for respirable dust.

The results at site 2 indicate the laborer grinding concrete was exposed to respirable dust containing quartz between 20 and 32 times the OSHA PEL and to respirable quartz between 35 and 55 times the NIOSH REL. These results indicate that a half-mask air purifying respirator is not sufficiently protective for an employee grinding concrete with no local exhaust ventilation controls, even in a relatively open area

For crystalline silica exposures less than or equal to 50 times the NIOSH REL of 0.05 mg/m$^3$, NIOSH recommends at a minimum, the use of an approved full-facepiece air-purifying respirator with high efficiency (N100, R100, or P100) filters, or a powered, air-purifying respirator with a tight fitting facepiece with a high efficiency (N100, R100, or P100) filter. The issue of filter efficiency is being reviewed, and may be revised by NIOSH at a later date.

During future evaluations, moving the area samples with the worker and maintaining a set distance from the work would help to define the level of respiratory protection required by other workers in the area

Samples collected on one of two workers removing brick facing from a building at site 3 indicate that his exposures exceeded the NIOSH REL for quartz and the OSHA PEL for respirable dust containing 16% quartz The worker was adequately protected by the respiratory protection he wore. The other worker was exposed to a slightly higher level of respirable dust, but his silica exposure could not be quantified. The area sample indicated that bystander exposure was minimized, probably because of the elevated work and windy day More area samples could be collected on other sites to better estimate bystander exposures Engineering controls that could be used to reduce the amount of dust generated by this task include the use of water (where feasible) and local exhaust ventilation The effectiveness of these methods could be explored at future chipping job sites

Results from site 4 indicate that the task of pulling down a ceiling and demolishing one wall of a bathroom resulted in exposures requiring the use of respiratory protection The use of engineering controls usually used in asbestos abatement tasks, such as misting, wetting surfaces with surfactant-amended water, and high efficiency particulate air (HEPA) filtered room air cleaners, may be effective in reducing respirable dust and crystalline silica exposures associated with the use of hand tools in interior demolition tasks such as this

## REFERENCES


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2. NIOSH [1997]. NIOSH pocket guide to chemical hazards Cincinnati, OH U S Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No 97-140

3 NIOSH [1994] NIOSH manual of analytical methods. 4th rev ed., Eller PM, ed Cincinnati, OH U S Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No 94-113

**TABLE 1**
**SITE 1 - MAY 26, 2000, AIR SAMPLING RESULTS FOR RESPIRABLE DUST IN PERSONAL SAMPLES**

| Sample | Duration (minutes) | Volume (liters) | Concentration (mg/m³) | Time Weighted Average (mg/m³) | 8-hr Time Weighted Average (mg/m³) | Calculated OSHA PEL (mg/m³) |
|---|---|---|---|---|---|---|
| Morning | 278 | 473 | 1.31 | | | |
| Afternoon 1 | 61 | 104 | 4.81 | 1.95 | 1.67 | 0.88 |
| Afternoon 2 | 71 | 121 | 1.98 | | | |

**TABLE 2**
**SITE 1 - MAY 26, 2000, AIR SAMPLING RESULTS FOR RESPIRABLE QUARTZ IN PERSONAL SAMPLES**

| Sample | Duration (minutes) | Volume (liters) | Concentration (mg/m³) | Time Weighted Average (mg/m³) | 8-hr Time Weighted Average (mg/m³) | NIOSH REL (mg/m³) |
|---|---|---|---|---|---|---|
| Morning | 278 | 473 | 0.125 | | | |
| Afternoon 1 | 61 | 104 | 0.365 | 0.182 | 0.155 | 0.05 |
| Afternoon 2 | 71 | 121 | 0.248 | | | |

**TABLE 3**
**SITE 1 - MAY 30, 2000, AIR SAMPLING RESULTS FOR RESPIRABLE DUST IN PERSONAL SAMPLES**

| Sample | Duration (minutes) | Volume (liters) | Concentration (mg/m³) | Time Weighted Average (mg/m³) | 8-hr Time Weighted Average (mg/m³) | Calculated OSHA PEL (mg/m³) |
|---|---|---|---|---|---|---|
| Morning | 228 | 388 | 3.22 | 2.96 | 2.37 | 0.929 |
| Afternoon | 157 | 267 | 2.58 | | | |

**TABLE 4**
**SITE 1 - MAY 30, 2000, AIR SAMPLING RESULTS FOR RESPIRABLE QUARTZ IN PERSONAL SAMPLES**

| Sample | Duration (minutes) | Volume (liters) | Concentration ($mg/m^3$) | Time Weighted Average ($mg/m^3$) | 8-hr Time Weighted Average ($mg/m^3$) | NIOSH REL ($mg/m^3$) |
|---|---|---|---|---|---|---|
| Morning | 228 | 388 | 0.284 | 0.259 | 0.208 | 0 05 |
| Afternoon | 157 | 267 | 0.223 | | | |

**TABLE 5**
**SITE 1 - MAY 31, 2000, AIR SAMPLING RESULTS FOR RESPIRABLE DUST IN PERSONAL SAMPLES**

| Sample | Duration (minutes) | Volume (liters) | Concentration ($mg/m^3$) | Time Weighted Average ($mg/m^3$) | 8-hr Time Weighted Average ($mg/m^3$) | Calculated OSHA PEL ($mg/m^3$) |
|---|---|---|---|---|---|---|
| Morning | 248 | 422 | 1.97 | 2.19 | 1 78 | 1 0 |
| Morning and Afternoon | 142 | 241 | 2 57 | | | |

**TABLE 6**
**SITE 1 - MAY 31, 2000, AIR SAMPLING RESULTS FOR RESPIRABLE QUARTZ IN PERSONAL SAMPLES**

| Sample | Duration (minutes) | Volume (liters) | Concentration ($mg/m^3$) | Time Weighted Average ($mg/m^3$) | 8-hr Time Weighted Average ($mg/m^3$) | NIOSH REL ($mg/m^3$) |
|---|---|---|---|---|---|---|
| Morning | 248 | 422 | 0 154 | 0.175 | 0.142 | 0 05 |
| Morning and Afternoon | 142 | 241 | 0 212 | | | |

## TABLE 7
## SITE 2 - JULY 6, 2000, AIR SAMPLING RESULTS FOR RESPIRABLE DUST IN PERSONAL SAMPLES

| Sample | Duration (minutes) | Volume (liters) | Concentration (mg/m³) | Time Weighted Average (mg/m³) | 8-hr Time Weighted Average (mg/m³) | Calculated OSHA PEL (mg/m³) |
|---|---|---|---|---|---|---|
| Morning | 156 | 265.2 | 27.5 | 23.6 | 14.8 | 0.74 |
| Afternoon | 145 | 246.5 | 19.5 | | | |

## TABLE 8
## SITE 2 - JULY 6, 2000, AIR SAMPLING RESULTS FOR RESPIRABLE QUARTZ IN PERSONAL SAMPLES

| Sample | Duration (minutes) | Volume (liters) | Concentration (mg/m³) | Time Weighted Average (mg/m³) | 8-hr Time Weighted Average (mg/m³) | NIOSH REL (mg/m³) |
|---|---|---|---|---|---|---|
| Morning | 156 | 265.2 | 2.75 | 2.75 | 1.73 | 0.05 |
| Afternoon | 145 | 246.5 | 2.76 | | | |

## TABLE 9
## SITE 3 - SEPTEMBER 11, 2000, AIR SAMPLING RESULTS FOR RESPIRABLE DUST IN PERSONAL SAMPLES

| Sample | Duration (minutes) | | Volume (liters) | | Concentration (mg/m³) | | Time Weighted Average (mg/m³) | | 8-hr Time Weighted Average (mg/m³) | | Calculated OSHA PEL (mg/m³) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Worker | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 |
| Morning | 132 | 133 | 224 | 226 | 1.9 | 1.9 | 1.6 | 1.8 | .74 | .84 | .55 | (1.7)* |
| Afternoon | 91 | 91 | 155 | 155 | 1.2 | 1.7 | | | | | | |

*The value in parentheses was calculated from a silica result between the limit of detection (LOD) and the limit of quantitation and a second silica result less than the limit of detection. For the result less than the LOD, a value of the LOD/$\sqrt{2}$ was used in the calculation

**TABLE 10**
**SITE 3 - SEPTEMBER 11, 2000 AIR SAMPLING RESULTS FOR RESPIRABLE QUARTZ IN PERSONAL SAMPLES**

| Sample | Duration (minutes) | | Volume (liters) | | Concentration (mg/m³) | | Time Weighted Average (mg/m³) | | 8-hr Time Weighted Average (mg/m³) | | NIOSH REL (mg/m³) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Worker | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | |
| Morning | 132 | 133 | 224 | 226 | 0 14 | (0 088)* | 0.26 | (0 071)* | 0.12 | (0 033)* | 0 05 |
| Afternoon | 91 | 91 | 155 | 155 | 0.43 | ND | | | | | |

*The concentration in parentheses was calculated from a silica result between the limit of detection (LOD) and the limit of quantitation. The TWAs in parentheses were calculated from that value and a second silica result less than the limit of detection For the result less than the LOD, a value of the LOD/$\sqrt{2}$ was used in the calculation. ND means a result below the LOD.

**TABLE 11**
**SITE 4 - SEPTEMBER 26, 2000, AIR SAMPLING RESULTS FOR RESPIRABLE DUST IN PERSONAL SAMPLES**

| Worker | Sample Duration (minutes) | Sample Volume (liters) | Respirable Dust Concentration (mg/m³) | Time Weighted Average (mg/m³) | 8-hr Time Weighted Average (mg/m³) | Calculated OSHA PEL (mg/m³) |
|---|---|---|---|---|---|---|
| Carpenter 1 | 135 | 230 | 7 8 | 7.8 | 2.2 | 2.3 |
| Carpenter 2 | 124 | 211 | 5.2 | 5.2 | 1.3 | (2 1)* |
| Carpenter 3 | 122 | 207 | 6 3 | 6.3 | 1.6 | (2.3)* |

*Values in parentheses were calculated from a silica result between the limit of detection and limit of quantitation.

**TABLE 12**
**SITE 4 - SEPTEMBER 26, 2000, AIR SAMPLING RESULTS FOR RESPIRABLE QUARTZ IN PERSONAL SAMPLES**

| Worker | Sample Duration (minutes) | Sample Volume (liters) | Respirable Quartz Concentration ($mg/m^3$) | Time Weighted Average ($mg/m^3$) | 8-hr Time Weighted Average ($mg/m^3$) | NIOSH REL ($mg/m^3$) |
|---|---|---|---|---|---|---|
| Carpenter 1 | 135 | 230 | 0.18 | 0 18 | 0.05 | |
| Carpenter 2 | 124 | 211 | (0 14)* | (0.14)* | (0.04)* | 0.05 |
| Carpenter 3 | 122 | 207 | (0 14)* | (0 14)* | (0 04)* | |

*Values in parentheses indicate a result between the limit of detection and the limit of quantitation