IN-DEPTH SURVEY REPORT OF EXPOSURE TO SILICA FROM DEMOLITION OF PLASTER CEILINGS

at

Frank Messer and Sons Construction Company
Columbus, OH

REPORT WRITTEN BY
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Mention of company names or products does not constitute endorsement by the Centers for Disease Control and Prevention

ABSTRACT

This report describes the exposures and controls that were evaluated during the interior demolition of a building The tasks evaluated were the use of a track hoe to pull down plaster ceilings, the use of a skid-steer loader to handle the debris, and the use of garden hoses by laborers to suppress dust during those tasks and at the bottom of a debris dump chute inside the building The control used during these tasks was the use of water to suppress dust An evaluation of exposures during these tasks found that on the day sampling was conducted, three of five employees sampled exceeded the OSHA PEL for respirable dust Two of five exceeded the NIOSH REL for respirable crystalline silica Eight hour time weighted average exposures to respirable dust ranged from 1 7 to 6 1 mg/m^3 Eight hour time weighted average exposures to respirable quartz ranged from 0 037 mg/m^3 (based on two quartz samples between the limit of detection and the limit of quantitation) to 0 087 mg/m^3 These results probably reflect a reduction in exposure due to the use of water to suppress dust

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 report of a site visit to evaluate exposures to construction workers resulting from pulling down plaster ceilings and disposing of the debris using skid steer loaders and an interior chute The use of water was the primary means of control This report describes the exposures that resulted from the work, as well as work practices and personal protective equipment used by the employees during their work

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 NIOSH Recommended Exposure Limit (REL), the OSHA Permissible Exposure Limit (PEL) or the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) [1-3]

The NIOSH REL for respirable crystalline silica is a 10-hour, time-weighted average level of 0 05 milligrams per cubic meter (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

The OSHA PEL for respirable dust containing 1% quartz or more 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/m^3, and if the dust is 100% crystalline silica, the PEL is 0 1 mg/m^3 For tridymite and cristobalite (other forms of crystalline silica), OSHA uses half the value calculated using the formula for quartz The ACGIH TLVs for cristobalite, quartz, and tridymite are all 0 05 mg/m^3

METHODS

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 [4] The filter cassettes were removed and replaced with a second set when the employees returned to work after lunch In addition to the personal samples, two bulk sample of settled dust were 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 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 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

RESULTS

Exposures to respirable dust and crystalline silica were evaluated while plaster ceilings were demolished on the ninth floor of a state government building in Columbus, Ohio The 240,000

square foot, fifteen story building was undergoing extensive renovation The building was built between 1931 and 1933 It included extensive art deco details such as carved wood, marble mosaics, decorative painting and murals, light fixtures, and signs

Although two days of sampling were conducted, the notes for the first day were inadvertently destroyed in the aggressive demolition environment Thus, the results of those samples could not be interpreted or presented in an appropriate context and are omitted from this report On the second day of sampling, the exposures of five employees were evaluated These included four employees on the ninth floor and one employee at ground level The employees evaluated on the ninth floor were a skid-steer loader operator working to move debris to the dump chute, a laborer working with him to spray debris with water, a track hoe operator pulling down the ceiling, and a laborer working with him spraying water on the ceiling as it was pulled down The employee on the ground floor was using a garden hose to wet construction debris at the bottom of the dump chute Construction debris included ceiling tiles, the ceiling suspension grid, insulation batts, conduit, piping, insulated PVC piping, electrical and light fixtures, and the metal laths and plaster from the ceiling Sampling pumps were turned off during the morning break, at lunch, and for the two employees who left the work area, during the afternoon break

All of the employees wore hard hats and work gloves The skid-steer loader operator and the laborer working with the track hoe operator had safety glasses The laborer working with the skid-steer loader operator wore an Allsafe 2001 N95 filtering facepiece respirator

Bulk samples were collected from settled dust on the ground floor (on top of an electrical outlet box under a bulletin board) and the ninth floor (two window sills on the west side of the building) The sample from the first floor was found to contain 2% quartz The sample from the ninth floor was found to contain 1% quartz, an amount between the limit of detection and limit of quantitation, thus with limited confidence in its accuracy In addition, the volume of material submitted in the bulk sample from the ninth floor was not enough to fill the qualitative sample holder in the laboratory, which may have resulted in a misleading result

Air sampling results are provided in Tables 1 and 2 These results show that the laborer spraying ceilings with water, the track hoe operator, and the laborer spraying debris with water at the bottom of the dump chute had exposures to respirable dust in excess of the OSHA PEL based on their 8-hour time weighted average exposures In addition, the track hoe operator and the laborer spraying debris with water at the bottom of the dump chute exceeded the NIOSH REL for crystalline silica, based on their 8-hour time weighted average exposures

Sources of dust noted during the demolition tasks included dust generated when the ceiling was disrupted by the track hoe bucket, when the material hit the floor, and when debris were moved, dropped down the dump chute, and driven through with the skid steer loader and the track hoe

DISCUSSION AND CONCLUSIONS

On the day sampling was conducted, three of five employees sampled exceeded the OSHA PEL for respirable dust Two of five exceeded the NIOSH REL for respirable crystalline silica None of these employees wore respiratory protection The use of water to suppress the dust generated during this demolition task appeared to reduce exposures to the point where the highest exposed employee (the track hoe operator) was exposed at a level about twice the exposure limits The workers exposures were within the assigned protection factor of a half-mask air-purifying respirator (10 times the exposure limit) NIOSH recommends any half-mask air-purifying respirator equipped with a high efficiency particulate filter (N100, R100, or P100) as the minimum respiratory protection required to meet the NIOSH REL (0 05 mg/m3) for workers exposed to respirable crystalline silica [5] The issue of filter efficiency is being reviewed, and may be revised by NIOSH at a later date When respirators are used, the employer must establish a comprehensive respiratory protection program, as outlined in the NIOSH Guide to Industrial Respiratory Protection and as required in the OSHA respiratory protection standard (29 CFR 1910 134 and 1926 103) Important elements of this standard are
--periodic environmental monitoring,
--regular training of personnel,
--selection of proper NIOSH-approved respirators,
--an evaluation of the worker's ability to perform the work while wearing a respirator,
--respirator fit testing, and
--maintenance, inspection, cleaning, and storage of respiratory protection equipment
The respiratory protection program should be evaluated regularly by the employer [5]

Respirators should not be used as the primary means of preventing or minimizing exposures to airborne contaminants Instead, use effective source controls such as substitution, automation, enclosed systems, local exhaust ventilation, wet methods, and good work practices Such measures should be the primary means of protecting workers However, when source controls cannot keep exposures below the NIOSH REL, controls should be supplemented with the use of respirators [5]

Controls which might be considered for additional exposure reduction in demolition tasks are worker isolation and dust suppression Worker isolation would include the use of enclosed, air conditioned cabs on demolition vehicles According to the manufacturer of the track hoe used here (a Takeuchi TB015), Takeuchi does offer enclosed cabs for many of their excavators, several of which do have optional air conditioning An extensive NIOSH research effort is ongoing to lower equipment operators' dust exposure by improving filtration efficiency and pressurization in enclosed cabs in all types of mining equipment, much of which is similar or identical to construction equipment This research is a multifaceted effort being performed in cooperative agreement with the Mine Safety and Health Administration (MSHA), several mining companies, and a number of dust filtration and pressurization manufacturers [6] The results of this research will aid in selecting appropriate equipment for demolition tasks

The employer reported that after the sampling results were received, the track hoe operator wore a half-mask respirator with P100 filters during demolition activities for the remainder of the job The employer also noted that the contractor brought box fans onto the job site to disperse the dust that was being generated and that employees in the areas discussed earlier donned filtering facepiece respirators with an assigned protection factor of five times the exposure limit

In addition to the use of water, which might damage historic building fixtures and finishes or provide moisture to foster mold growth if it escapes the demolition area, other options for dust suppression could be explored, such as the use of water with a surfactant to reduce its surface tension, thus allowing it to better wet the material while requiring the use of less water The use of a dust suppressant foam could also be investigated According to the manufacturer of one such foam, these are able to suppress dust while adding little additional moisture to the substrate being treated [7]

REFERENCES

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Table 1
April 26, 2001 Air Sampling Results for Respirable Dust in Personal Samples

Worker	Task	Sample Duration (minutes)		Sample Volume (liters)		Respirable Dust Concentration (mg/m^3)		Time Weighted Average (mg/m^3)	8-hr Time Weighted Average (mg/m^3)	Calculated OSHA PEL (mg/m^3)
		am	pm	am	pm	am	pm			
Skid-Steer Loader Operator	Move and dump debris	188	176	320	299	3 8	2 6	3 2	2 4	(2 5)
Laborer	Spray debris with water	186	137	316	233	2 4	2 7	2 5	1 7	(2 4)
Laborer	Spray ceiling with water	149	173	253	294	5 1	5 4	5 3	**3.6**	(3 0)
Track Hoe Operator	Pull down ceiling	179	177	304	301	7 9	8 6	8 3	**6.1**	2 9
Laborer	Spray debris with water at bottom of dump chute	213	129	362	219	3 0	5 5	4 0	**2.8**	(2 4)*

Values in parentheses were calculated from a quartz result between the limit of detection and limit of quantitation
Bold indicates an amount in excess of the OSHA PEL
*The morning result exceeded the limit of quantitation, while the afternoon result was between the limit of detection and limit of quantitation

Table 2
April 26, 2001, Air Sampling Results for Respirable Quartz in Personal Samples

Worker	Task	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)
		am	pm	am	pm	am	pm			
Skid-Steer Loader Operator	Move and dump debris	188	176	320	299	(0 063)	(0 067)	(0 065)	(0 049)	0 050
Laborer	Spray debris with water	186	137	316	233	(0 063)	(0 043)	(0 055)	(0 037)	0 050
Laborer	Spray ceiling with water	149	173	253	294	(0 079)	(0 068)	(0 073)	(0 049)	0 050
Track Hoe Operator	Pull down ceiling	179	177	304	301	0 12	0 12	0 12	**0.087**	0 050
Laborer	Spray debris with water at bottom of dump chute	213	129	362	219	0 083	(0 091)	(0 086)*	**(0.061)***	0 050

Values in parentheses were calculated from a quartz result between the limit of detection and limit of quantitation
Bold indicates an amount in excess of the NIOSH REL
*The morning result exceeded the limit of quantitation, while the afternoon result was between the limit of detection and limit of quantitation