HETA 2000-0309-2857
Lehigh Portland Cement Company
Union Bridge, Maryland

Ronald M. Hall, M.S.
Kristin K. Gwin, M.S.

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.

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ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Ronald Hall and Kristin Gwin of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Analytical support was provided by Data Chem Laboratories, Salt Lake City, Utah. Desktop publishing was performed by Robin Smith. Review and preparation for printing were performed by Penny Arthur.

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Highlights of the NIOSH Health Hazard Evaluation

Evaluation of Dust Exposures at Lehigh Portland Cement Company

On May 30, 2000, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Paper, Allied Industrial, Chemical, and Energy Workers Union Local 2-0031 regarding possible exposures to crystalline silica as a constituent of the fly ash (approximately 1-6%).

What NIOSH Did

- We collected area and personal breathing zone air samples in the process areas of the plant to measure silica, dust, and metals.
- We collected bulk samples of the fly ash and cement dust to measure metal content

What NIOSH Found

- Personal air sampling results for respirable dust, quartz (crystalline silica), and various metals (found in bulk samples) did not exceed exposure limits.
- Three workers (two in the mill room and one in the fringe bin dust collector area) had high total dust exposures.

What Lehigh Portland Cement Company Managers Can Do

- Shut down process equipment when repairing leaks in the equipment.
- Repair leaks in process equipment throughout the plant.
- Use engineering and administrative controls in process areas when ever feasible to reduce worker exposures to total dust.
- Use respirators to reduce workers' dust exposures when other controls are not feasible in the process areas. When respirators are used an appropriate respiratory protection program must be in place.
- Use vacuums (with P95 filters) instead of pressurized air to clean off work clothing.
- Re-sample after any process changes to evaluate worker exposures.

What the Lehigh Portland Cement Company Employees Can Do

- Follow safety policy procedures.
- Wear proper personal protective equipment as instructed by company officials (i.e., respirators) in process areas where dust concentrations are high (i.e., Raw Mill Building).

CDC Workplace Safety and Health

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National Institute for Occupational Safety and Health NIOSH

Health Hazard Evaluation Report 2000-0309-2857
Lehigh Portland Cement Company
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Ronald M. Hall, M.S.
Kristin K. Gwin, M.S.

SUMMARY

On May 30, 2000, the National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation (HHE) request from the Paper, Allied Industrial, Chemical, and Energy Workers Union Local 2-0031 regarding fly ash exposures during the cement manufacturing process at the Lehigh Portland Cement Company in Union Bridge, Maryland. The union was concerned about possible exposures to crystalline silica as a constituent of the fly ash (approximately 1-6%) used in the cement manufacturing process.

On July 24-25, 2000, NIOSH investigators conducted a site visit at the Lehigh Portland Cement Company. Area and personal breathing zone (PBZ) air samples were collected for total dust, respirable dust, and crystalline silica. Bulk samples of the fly ash and raw feed were also collected and analyzed for crystalline silica content and elements (e.g., chromium, copper, nickel, lead, magnesium, manganese, titanium, zinc, etc.). A return site visit was conducted on December 13, 2000, to collect PBZ air samples for elements.

PBZ air samples collected for respirable dust, quartz (crystalline silica), cristobalite, and elements did not indicate any exposures exceeding applicable exposure criteria. Three area samples collected at different times in the raw mill separator area indicated total dust concentrations of 149 milligrams of dust per cubic meter of air (mg/m^3), 14 mg/m^3, and 20 mg/m^3. (The settled dust [on equipment, stairs, floors, etc.] in the raw mill area, and leaks in the process equipment may affect dust sample concentrations collected at different times during the day). Three out of seven workers sampled during the initial site visit had total dust time- weighted average (TWA) exposures above the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Value (TLV®) and Mine Safety and Health Administration (MSHA) permissible exposure limit (PEL) of 10 mg/m^3. Two of these workers were performing work tasks in the mill room and had TWA exposures that also exceeded the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) for total dust (15 mg/m^3). PBZ air samples collected on a worker repairing a leak in the process equipment (located within the raw mill building) indicated an extremely high total dust TWA concentration (3800 mg/m^3). This sample was not representative of the worker's breathing zone exposure (dust was blowing directly on the sampling cassette at a high velocity while he was repairing the leak). However, because of the high concentration in this sample, it is possible that the worker's true exposure to total dust concentrations was well over applicable exposure criteria.

All area and PBZ air samples for quartz (crystalline silica) were below applicable exposure criteria. However, PBZ air samples indicated that total dust TWA exposures were in excess of applicable exposure criteria. Recommendations to control total dust exposures include shutting off process equipment when performing maintenance activities to repair leaks; fixing leaks in process equipment to reduce dust generating sources; using engineering and administrative controls when feasible; using respirators when other controls are not feasible; using vacuums (with P95 filters) instead of pressurized air to clean off work clothing; and re-sampling after any process changes to evaluate worker exposures under new conditions.

Keywords: 3241 (Cement, Hydraulic). Portland cement, cement, total dust, and fly ash

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INTRODUCTION

On May 30, 2000, the National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation (HHE) request from the Paper, Allied Industrial, Chemical, and Energy Workers Union Local 2-0031 regarding fly ash exposures during the cement manufacturing process at the Lehigh Portland Cement Company in Union Bridge, Maryland. The union was concerned about possible exposures to crystalline silica (quartz) as a constituent of the fly ash (approximately 1-6%) used in the cement manufacturing process.

On July 24-25, 2000, NIOSH investigators conducted a site visit at the Lehigh Portland Cement Company. An opening conference was held with management and union representatives, and information was obtained relating to the fly ash and the process at the facility. After the opening conference, a walk-through inspection of the facility was conducted to familiarize NIOSH personnel with the use of fly ash and the manufacturing process. Area and personal breathing zone (PBZ) air samples were collected for total dust, respirable dust, and crystalline silica. A closing conference was held on July 25, 2000, during which preliminary findings were discussed. Bulk samples of the fly ash and raw feed collected during the initial visit indicated the presence of metals. Therefore, a return visit was conducted on December 13, 2000, to collect personal breathing zone (PBZ) samples in an effort to evaluate worker exposures to metals.

BACKGROUND

Fly ash is obtained from the Baltimore Gas and Electric company and delivered to the plant during the afternoon and evening hours by semi-tractor trailers. A hose is hooked to the truck trailers, and the fly ash is pumped from the trailers to silos for storage. The fly ash is added to the process at the discharge end of the raw mill where it is mixed with other cement manufacturing constituents to create raw meal. The raw meal is pumped to one of 26 blending bins where it is eventually fed into the rotary kilns to produce calcium silicate clinkers. The clinkers are mixed with varying amounts of gypsum (hydrated calcium sulfate) to control the hardening rate, and ground into a fine powder to produce the finished product.

METHODS

A walk-through survey was conducted on July 24, 2000, to familiarize NIOSH personnel with the process and the use of fly ash. On July 25, 2000, area and personal breathing zone (PBZ) air samples were collected for total dust, respirable dust, and crystalline silica. Bulk samples of the fly ash and raw feed were also collected and analyzed for crystalline silica content and elements. A return site visit was conducted on December 13, 2000, to collect personal air samples for elements.

Total Dust and Respirable Dust

Air samples for total dust were collected on a tared 37–mm diameter, (5–µm pore–size) polyvinyl chloride (PVC) filter at a calibrated flow rate of 2 liters per minute (Lpm). The filter was gravimetrically analyzed (filter weight) according to NIOSH Method 0500.[1] Air samples for respirable dust were collected with a tared 37–mm diameter 5–µm PVC filter in conjunction with a 10–mm cyclone at a calibrated flow rate of 1.7 Lpm. The filter was gravimetrically analyzed according to NIOSH Method 0600.[1]

Bulk Samples

Bulk samples of dust material were collected from the blending bins, kiln feed, and fly ash. The bulk samples were analyzed for elements using a Perkin Elmer Optima 3000 DV inductively coupled plasma spectrometer and analyzed according to NIOSH Method 7300.[1] These bulk samples were also analyzed for quartz and cristobalite using

X–ray diffraction in accordance with NIOSH Method 7500[1] with the following modifications: (1) the 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 normalized procedure suggested in the method.

Elements

Element air samples were collected on 37–mm diameter (0.8–μm pore–size) MCE filters, using sampling pumps calibrated at 2 Lpm. Air samples for elements were quantitatively analyzed for silver, aluminum, arsenic, beryllium, calcium, cadmium, cobalt, chromium, copper, iron, lithium, magnesium, manganese, molybdenum, sodium, nickel, phosphorus, lead, platinum, selenium, tellurium, thallium, titanium, vanadium, yttrium, zinc, and zirconium using a Perkin Elmer Optima 3000 DV inductively coupled plasma spectrometer and analyzed according to NIOSH Method 7300.[1]

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 increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

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

The Lehigh Portland Cement Company is located at a quarry and therefore falls under the jurisdiction of the U.S. Department of Labor, Mine Safety and Health Administration (MSHA). MSHA regulations (30 CFR §§ 56.5001) specify that the exposure to airborne contaminants shall not exceed, on the basis of a time-weighted average, the TLVs adopted by the ACGIH in "Threshold Limit Values of Airborne Contaminants" (1973).[5]

A 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.

Total Dust and Respirable Dust

Health problems associated with various particulate exposures are influenced by four critical factors:[6]

- The type of particulate involved
- The length of exposure time
- The concentration of airborne particulates in the breathing zone of the workers
- The size of the particulates present in the breathing zone

Particulate size is the main factor that influences deposition in the respiratory system. Large particulates (> 5 µm in diameter) are likely to impact on the walls of the nasal cavity or pharynx during inspiration; medium particles (1 to 5 µm in diameter) are likely to settle out in the trachea, bronchi, or bronchioles as the air velocity decreases in the smaller passage ways; and small particles (< 1 µm in diameter) typically move by diffusion into the alveoli.[7]

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 (PNOC)," [or "particulates not otherwise regulated" (PNOR) for the OSHA PEL].[3,4]

The OSHA PEL is 15.0 mg/m^3 for total PNOR and 5.0 mg/m^3 for the respirable fraction, determined as 8-hour time-weighted averages.[4] The ACGIH recommended TLV for exposure to PNOC is 10.0 mg/m^3 for total dust (8-hour TWA) and 3 mg/m^3 for respirable particulate (8-hour TWA).[3] The MSHA (1973 ACGIH TLV) PEL for total nuisance particulates is 10 mg/m^3. These are generic criteria for airborne dusts which do not produce significant organic disease or toxic effect when exposures are kept under reasonable control.[8] Excessive concentrations of PNOCs in the work-room air may seriously reduce visibility; may cause unpleasant deposits in the eyes, ears, and nasal passages; or can contribute to injury to the skin or mucus membranes by chemical or mechanical action per se or by the rigorous skin cleansing procedures necessary for their removal.[6] NIOSH has not assigned a REL for PNOR. However, NIOSH concluded that adverse health effects could occur at the proposed OSHA PEL for PNOR.[2]

RESULTS

Total and Respirable Dust

Area Air Samples

The three area air samples collected in the raw mill separator area indicated total dust concentrations of 149 milligrams of dust per cubic meter of air (mg/m^3), 14 mg/m^3, and 20 mg/m^3 indicating that workers in this area may be exposed to total dust concentrations above occupational criteria. An area air sample collected in the blending bins area near the distribution screw indicated a total dust concentration of 0.5 mg/m^3.

Area air samples collected in the raw mill indicated concentrations of 2.6 mg/m^3 and 0.4 mg/m^3 respirable dust. The area air sample collected in the blending bin area near the distribution screw indicated a concentration of 0.06 mg/m^3 respirable dust.

Personal Air Samples

Three out of seven workers sampled during the initial site visit had total dust TWA exposures above the ACGIH TLV and MSHA PEL (10 mg/m^3). Two of these workers were performing work tasks in the mill room and had TWA exposures that also exceeded the OSHA PEL for total dust (15 mg/m^3). One of the individuals sampled indicated an extremely high total dust TWA concentration of 3800 mg/m^3. However, the circumstances involved with the collection of this sample indicate that it is probably not representative of the worker's breathing zone concentration. The worker reported repairing a leak in the process machinery while dust was blowing out a hole (at a high velocity) directly on the sampling cassette. Samples collected on a different worker in the mill room indicated a TWA exposure of 57 mg/m^3. The third worker sampled was performing maintenance activities on the fringe bin dust collector. The total dust samples collected on this worker indicated a TWA of 12.7 mg/m^3, which exceed the ACGIH TLV and MSHA PEL. A yard department worker was also sampled during clean-up activities. The samples collected on this worker indicated a total dust TWA exposure of 9.4 mg/m^3.

All respirable dust samples collected on workers during the site visit indicated respirable dust concentrations below all applicable exposure criteria. In addition, all area and PBZ air samples for quartz were below or at the limit of detection for the analytical method (0.01 mg). A limit of detection of 0.01 mg equates to a minimum detectable quartz concentration of 0.014 mg/m^3, assuming a sample volume of 740 liters. All area and PBZ air samples for cristobalite were below the limit of detection for the analytical method (0.02 mg). A limit of detection of 0.02 mg equates to a minimum detectable cristobalite concentration of 0.027 mg/m^3, assuming a sample volume of 740 liters. These minimum detectable concentrations were below the most protective occupational exposure criteria.

Elements

Personal Air Samples

PBZ samples were collected for elements during the return visit on the blending bin operator, shift repair man, miller, and vacuum truck operator. The samples were analyzed for silver, aluminum, arsenic, beryllium, calcium, cadmium, cobalt, chromium, copper, iron, lithium, magnesium, manganese, molybdenum, sodium, nickel, phosphorus, lead, platinum, selenium, tellurium, thallium, titanium, vanadium, yttrium, zinc, and zirconium. None of the PBZ samples indicated concentrations above applicable exposure criteria.

Area Air Samples

Area air samples for elements were collected north of the raw mill outlet, in the raw mill building, near the finish mill dust collector (#4), near the top of the blending bins, and near the #2 kiln. These samples also indicated element concentrations below applicable exposure criteria. However, the area samples indicated calcium concentrations between 1.8 and 4.4 mg/m^3. The analytic method measured total concentrations of calcium compounds and was not able to differentiate which calcium compounds were present. The cement manufacturing process involves the use of limestone which has a high content of calcium carbonate. Therefore, one could assume that the majority of the calcium detected on the air samples consisted of calcium carbonate. The current occupational criteria for calcium carbonate is the NIOSH REL, ACGIH TLV, and MSHA PEL of 10 mg/m^3. The current OSHA PEL for calcium carbonate is 15 mg/m^3.

Bulk Samples

Bulk samples of the fly ash and raw feed were collected and analyzed for elements during the initial survey. The results of the bulk samples indicate that the fly ash contained approximately 2 - 3 % quartz and no cristobalite. Bulk samples of the raw feed obtained from the blending bin distribution screw conveyor and kiln feed contained approximately 3 - 5% quartz and no cristobalite. These bulk samples were also analyzed for elements. The bulk samples indicated that small amounts of elements (i.e., chromium, copper, nickel, lead, magnesium, manganese, titanium, zinc, etc.) were found in the fly ash and raw feed materials. Therefore, a return visit on December 13, 2000, was conducted to collect personal samples for elements.

DISCUSSION AND CONCLUSIONS

PBZ air samples collected for respirable dust, quartz (crystalline silica), cristobalite, and elements did not indicate any exposures exceeding applicable exposure criteria. However, total dust PBZ air samples did indicate exposures exceeding applicable exposure criteria (ACGIH TLV, MSHA PEL and OSHA PEL).

MSHA Standard 56/57.5001(a) requires that a miner's exposure shall not exceed the permissible limit of any substance on the TLV list. When the TLV is exceeded, standard 56/57.5005 mandates that operators install all feasible engineering controls to reduce a miner's exposure to the TLV. Respiratory protection is required when other controls are not feasible, when establishing controls, and during occasional entry into hazardous atmospheres to perform short-term maintenance or investigations.[9] Whenever respirators are required, operators must establish a respirator program containing all elements of the standard, which incorporates ANSI Z88.2-1969.[9] The inspector must evaluate the effectiveness of the respiratory protection in order to determine whether miners are protected from overexposure.[9]

Engineering controls should be used to reduce worker exposures wherever feasible. Administrative controls and personal protective equipment (PPE) (i.e., respirators) are designed to protect workers from airborne exposures when engineering controls are not feasible or not effective in reducing air contaminates to acceptable levels. For respirators to be effective and protect workers from harmful exposures they must be selected, inspected, and maintained properly. Respirators should be inspected by the worker prior to and after each use for any defects. Respiratory protective equipment should also be cleaned and disinfected after each use. Respiratory protective devices should never be worn when a satisfactory face seal can not be obtained. There are many conditions that may prevent a good seal between the worker’s face and the respirator. Some of these conditions include facial hair, glasses, or an unusually structured face. All workers required to wear a respirator must be properly trained on the selection, use, limitations, and maintenance of the respirator and also be fit–tested to assure a proper seal between the worker’s face and the respirator prior to performing work tasks in a contaminated area. All workers should receive annual fit–testing with a quantitative testing device. When not in use, respirators must be stored in a clean environment located away from any source of contamination.

RECOMMENDATIONS

The following recommendations are provided to help reduce worker exposures to total dust in the cement manufacturing process areas.

1. Maintenance operations should not be performed on process equipment to repair leaks while the equipment is in operation. Efforts should be made to prevent and repair leaks in the process machinery throughout the plant to help reduce dust generating sources.

2. Respirators should be utilized in the cement process areas (i.e., raw mill area, fringe bin dust collector, and yard department during clean-up activities) to reduce worker exposures to total dust.

3. Water is not a viable option to help reduce dust exposures at a cement plant. Vacuum trucks should continue to be used to clean-up areas and help keep dust levels down. Other dry clean-up methods (i.e., brooms, shovels, etc.) should not be used.

4. The plant had cleaning stations which used pressurized air to blow dust off work clothing. This can be another source of dust exposure. A vacuum system should be used to remove dust from contaminated work clothing. Vacuums with good filtering mechanisms (equipped with at least N95 filters) are recommended for this cleaning task.

5. The raw mill will be replaced by a new plant within the next 6 months. Whenever a process change occurs, worker exposures should be re-evaluated to assess the worker exposures under the new conditions. Worker exposures in the cement processing areas should be re-evaluated after the

new plant is operational and the process changes are complete.

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