WORKPLACE SOLUTIONS

From the National Institute for Occupational Safety and Health

Reducing Hazardous Dust Exposure When Dowel Drilling in Concrete

Summary

Construction workers may be exposed to hazardous dust containing respirable crystalline silica when using dowel drilling machines to drill horizontal holes in concrete pavement. The National Institute for Occupational Safety and Health (NIOSH) found that exposures were reduced using tool-mounted local exhaust ventilation (LEV) and good work practices.

Description of Exposure

Breathing dust that contains respirable crystalline silica can lead to silicosis, a deadly lung disease. No effective treatment exists for silicosis, but it can be prevented by controlling workers' exposures to dust containing crystalline silica. Exposure to respirable crystalline silica has been linked to lung cancer, kidney disease, reduced lung function, and other disorders [NIOSH 2002]. Crystalline silica is found in several construction materials, such as brick, block, mortar and concrete. The NIOSH recommended exposure limit (REL) for respirable crystalline silica is 50 micrograms per cubic meter (µg/m^3) as a time weighted average for up to a 10 hour workday during a 40 hour work week. Respirable dust is the fraction of the aerosol that is small enough to reach the deeper, gas-exchange region of the lung.

Many highway construction tasks produce dusts that can contain respirable crystalline silica. These tasks include breaking pavement with jackhammers, concrete sawing, milling pavement, clean-up using compressed air, and dowel drilling [Valiante et al. 2004]. Dowel drilling machines (also known as gang drills or dowel-pin drills) are used to drill horizontal holes in concrete pavement. Dowel drilling is a task performed during new concrete airport runway and highway construction (e.g., when a lane is added) or during full-depth repair of concrete runways and highways to provide load transfer across transverse pavement joints. Steel dowels are partially inserted into the holes and fixed into place. Once the adjacent new slab is poured and cured, the dowels distribute loads between adjacent concrete pavement slabs [Park et al. 2008].

Typical dowel drilling machines have one or more drills held parallel in a frame that aligns the drills and holds them steadily during drilling. The dowel drilling machine may be self-propelled or boom mounted, and may ride on the slab or on the subbase. After drilling to a typical depth of 23 cm (9 inches), the anchoring material is placed, and the dowel is partially inserted into the hole. The diameter of the hole is determined by the dowel diameter and whether cement-based grout or an epoxy compound is used to anchor the dowels [FHWA 2006].

Dust is generated during the use of dowel drilling machines and this dust typically contains crystalline silica (Figure 1). NIOSH researchers documented respirable crystalline silica exposures for workers operating dowel drilling machines of up to 26 times the NIOSH REL during full-depth pavement repair and up to eight times the NIOSH REL during new runway construction [Linch 2002, NIOSH 2011c].

NIOSH Project

NIOSH initiated a research project to evaluate the effectiveness of dust controls for dowel drilling machines, to work with manufacturers to improve dust controls if necessary, and to promote the use of tools with dust controls [NIOSH 2012]. The results of this

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Figure 1. Laborer operating a slab-riding, four-drill dowel drilling machine without dust controls.

project demonstrate that LEV dust control systems on dowel drilling machines can be very effective. The efficacy of water sprays alone or in combination with LEV controls was not assessed in the NIOSH study.

In the first phase of the project, a pilot study was conducted that measured respirable dust emissions from a five-drill dowel drilling machine that was operated in a tent, isolated from the effects of wind, weather, and other particulates. The machine was started remotely and stopped drilling automatically at a preset depth. The pilot study showed that the LEV dust control system reduced dust concentrations by 89% [NIOSH 2008]. Two subsequent studies [NIOSH 2011a, b] were conducted under similar conditions, one with a four-drill machine and one with a five-drill machine. When the results of those two studies were combined and analyzed, they showed that emissions without the dust control were 14 times greater than when the control was in use. In other words, the dust control reduced respirable dust emissions by 93%.

In the next phase of the project, NIOSH researchers performed field studies to evaluate dowel drills used in airport runway construction [NIOSH 2011c, 2011d, 2012].Three sites were visited, including two sites where dust controls were used (two five-drill machines at the first site and two four-drill machines at the second) and one with no dust control in use (two four-drill machines). On average, the respirable dust concentration at airport runway sites where dust controls were used was one-fifth the level measured at airport runway and highway construction sites where no dust controls were used. In other words, the dust control reduced respirable dust emissions by 80%. However, even with the LEV system in use, TWA respirable crystalline silica exposures exceeded the NIOSH REL by an average of 3 times and up to 8 times [NIOSH 2012].

NIOSH researchers [NIOSH 2013] also investigated whether the greater reductions of dust seen in the first phase of the project compared with those in the second phase were due to the design of the control, its use and maintenance, or operator training. A study was conducted at a training center using a new one-drill machine transported from the factory (Figure 2). A representative of a drill manufacturer instructed apprentice trainers in the use and maintenance of the drill prior to air sampling. The drill-mounted dust control performed well under the conditions of the test, controlling silica exposures to levels below the NIOSH REL when the drill was properly used and maintained by trained operators.

Figure 2. Trainer operating a slab-riding, single-drill dowel drilling machine with LEV system at training center.

Controls

NIOSH identified two manufacturers of dowel drills in the United States. Both manufacturers offer optional dust control systems on their new equipment. Dust controls can also be retrofitted to older model drills. Those dust control systems, like most LEV systems, consist of hoods, ducts, air cleaners, and air movers. The hoods surround the steel and bit at the work surface (Figure 3). They collect the concrete dust produced in an air stream directed toward the hood. Flexible ducts convey the dust and air to the air cleaner. The air cleaner contains a cartridge filter to remove the contaminant from the airstream. The air mover must produce the desired air flow despite losses due to friction, fittings, and hood entry [ACGIH 2010]. Both manufacturers also sell water spray systems to suppress drilling dust. Water spray systems were not evaluated during the NIOSH project.

Recommendations

NIOSH has evaluated LEV dust control measures to reduce worker exposure to hazardous dust during dowel drilling operations and recommends their use [NIOSH 2008, NIOSH

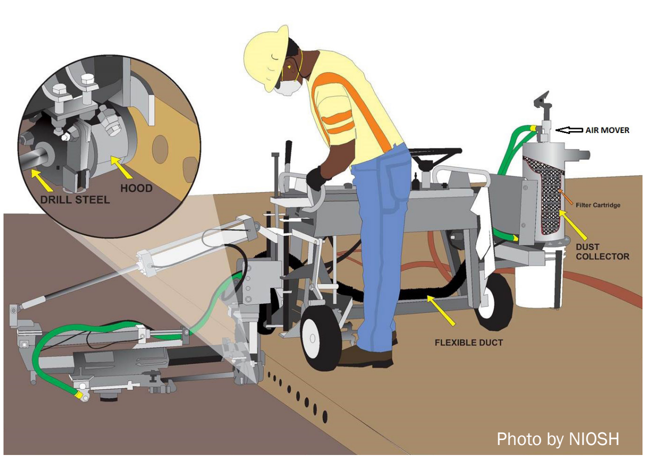

Figure 3. Diagram of slab-riding, single-drill dowel drilling machine showing the major components of the LEV system.

2011a, 2011b, 2011c, NIOSH 2012, NIOSH 2013]. The recommendations below should reduce exposures associated with dowel drilling.

LEV System

These recommendations are based on good industrial ventilation engineering design practices. NIOSH researchers did not encounter any dowel drill dust controls that incorporated all of these features.

- Use smooth ducts and maintain duct transport velocity at 3,500 to 4,000 feet per minute [ACGIH 2010].
- Provide duct clean-out points.
- Install pressure gauges across dust collection filters so the drill operator knows when to clean or change the filter.

Work Practices

- Train workers to use and maintain the dust collector in accordance with manufacturer specifications.
- Avoid work practices that place the worker in a dust cloud, such as marking pavement while the drill is running. Ensure that workers nearby are also protected from dust exposures.
- Provide a covered receptacle near the drill to discourage drill operators from dumping the collected concrete dust on the ground, where it can become airborne.
- Do not clean the cartridge filter manually with compressed air. In addition to creating a hazardous dust cloud, compressed air can damage the filter.
- Review the trouble-shooting guide provided by the manufacturer to recognize signs that the dust collector is not working properly.
- Dust that collects in the exhaust hoses should be removed manually, for example, by raising and lowering the drill array. Compressed air should not be used to clean the hoses.

Site Set-Up

- Develop a site-specific safety and health plan. The plan should include guidance for recognizing when silica dust may be generated and describe strategies to control or eliminate dust. Include engineering controls, personal protective equipment, and work practices.
- During dowel drilling operations, use LEV or wet control systems to control dust. When purchasing dowel drilling equipment, opt for dust controls. Always use the dust control system and keep it well maintained. Do not use equipment if the dust control system is not working properly.
- Establish a documented maintenance program for the dust control systems.
- Provide training to drillers in the use of controls and work procedures.
- During dowel drilling, perform air monitoring of respirable crystalline silica exposures to make sure engineering controls are working and to determine whether workers need respiratory protection.

Respirators

- The dust controls identified in this report should greatly reduce worker exposure to hazardous dust; however, NIOSH-certified respirators may still be necessary to reduce exposure to crystalline silica below the NIOSH REL of 50 $\mu g/m^3$.
- With properly functioning dust controls in place, it may be possible to use less restrictive respirators, such as those with an assigned protection factor of 10, since the amount of hazardous dust has been decreased.
- Exposure monitoring is necessary to determine what type of respirator is needed.
- Employers should follow the Occupational Safety and Health Administration (OSHA) Respiratory Protection Standard (29 CFR 1910.134) (www.osha.gov/SLTC/etools/respiratory/index.html).

Personal Hygiene, Protective Clothing, and Work Practices

- Wash hands and face before eating, drinking, or smoking.
- Do not eat, drink, or use tobacco products in the work area where construction activities are being performed.
- Change into disposable or washable work clothes at the worksite. If possible, shower and change into clean clothes before leaving the worksite to avoid contaminating cars,

homes, and other work areas. If it is not possible to shower or change into clean clothes, use a vacuum with a high-efficiency filter to remove dust from clothes. An effective method to remove dust from clothing involves a booth under negative pressure that uses an air spray manifold to blow dust from clothing [Pollock et al. 2006].

- Do not use a compressed air hose to remove dust from clothing.
- Park cars where they will not be contaminated with silica dust.
- Remove dust from equipment using a water hose rather than compressed air.

This document was prepared by Alan Echt, NIOSH Division of Applied Research and Technology, and John J. Whalen, formerly with NIOSH. Kimberly Clough-Thomas (NIOSH Health Effects Laboratory Division) prepared the illustration.

References

ACGIH® [2010]. Industrial ventilation—a manual of recommended practice. 27th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

FHWA [2006]. Full-depth repairs. Washington, DC: U.S. Department of Transportation, Federal Highway Administration, Office of Pavement Technology. Available on-line at http://www.fhwa.dot.gov/PAVEMENT/concrete/full5.cfm. Accessed February 24, 2015.

Linch KD [2002]. Respirable concrete dust-silicosis hazard in the construction industry. Appl Occup Environ Hyg *17*:209–221.

NIOSH [2002]. NIOSH Hazard Review: Health effects of occupational exposure to respirable crystalline silica. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2002-129.

NIOSH [2008]. In–depth survey report: Preliminary evaluation of dust emissions–control technology for dowel-pin drilling at Minnich Manufacturing, Mansfield, OH. By Echt A, Mead KR, Farwick DR, Feng HA. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Report No. EPHB 334-11a.

NIOSH [2011a]. In-depth survey report: control technology for dowel-pin drilling in concrete pavement at Minnich Manufacturing, Mansfield, OH. By Echt A, Mead K, Feng HA, Farwick D. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, EPHB 347–12a.

NIOSH [2011b]. In-depth survey report: control technology for dowel-pin drilling in concrete pavement at EZ Drill, Perry, OK. By Echt A, Mead K, Feng HA, Farwick D. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, EPHB 347-13a.

NIOSH [2011c]. In-depth survey report: control technology for dowel-pin drilling in concrete at the Columbus Municipal Airport, Columbus, IN. By Echt A, Mead K, Kovein R. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, EPHB 347-14a.

NIOSH [2011d]. In-depth survey report: control technology for dowel drilling in concrete at the Springfield-Branson National Airport, Springfield, MO. By Echt A, Hirst DVL, Kovein R. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, EPHB 347-15a.

NIOSH [2012]. In-depth survey report: control technology for dowel drilling in concrete at the Hartsfield-Jackson Atlanta International Airport, Atlanta, GA. By Echt A, Kovein R, Lambright J. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, EPHB 347-16a.

NIOSH [2013]. In-depth survey report: control technology for dowel drilling in concrete at Laborers International Union of North America Local 172, Folsom, NJ. By Echt A, Mead K, Kovein R. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, EPHB 347-17a.

Park C-G, Jang C-I, Lee S-W, Won J-P [2008]. Microstructural investigation of long-term degradation mechanisms in GFRP dowel bars for jointed concrete pavement. J Appl Polym Sci *108*:3128–3137.

Pollock DE, Cecala AB, Zimmer JA, O'Brien AD, Howell JL [2006]. A new method to clean dust from soiled work clothes. In: Mutmansky JM, Ramani RV eds. Proceedings of the 11th U.S./North American Mine Ventilation Symposium (University Park, PA, June 5–7, 2006). London: Taylor & Francis Group, pp. 197–201.

Valiante DJ, Schill DP, Rosenman KD, Socie E [2004]. Highway repair: a new silicosis threat. Am J Public Health *94*:876–880.

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As part of the Centers for Disease Control and Prevention, NIOSH is the Federal agency responsible for conducting research and making recommendations to prevent work-related illnesses and injuries. All *Workplace Solutions* are based on research studies that show how worker exposures to hazardous agents or activities can be significantly reduced.

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