In-Depth Survey Report

A Laboratory Evaluation of Capture Efficiencies of the Vacuum Cutting System on a Wirtgen W 250 Cold Milling Machine at Payne & Dolan Inc., Racine, Wisconsin

Conducted with assistance from the Silica/Milling-Machines Partnership, affiliated with and coordinated through The National Asphalt Pavement Association (NAPA)

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Site Surveyed: Payne & Dolan Inc., Racine, Wisconsin

NAICS Code: 237310 (Highway, Street, and Bridge Construction)

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Abstract

In August 2011, NIOSH researchers and the Silica/Milling-Machines Partnership coordinated by the National Asphalt Pavement Association (NAPA) conducted laboratory testing of the Vacuum Cutting System (VCS) on a Wirtgen W 250 cold milling machine. The testing was conducted indoors at a Payne & Dolan, Inc., repair facility in Racine, Wisconsin.

All tests were conducted on a stationary machine with the drum spinning and the belts moving but without any reclaimed asphalt pavement moving through the system. The machine was set up to simulate the amount of open area around the drum that would be present during a typical milling job. Smoke and tracer gas were used as surrogates for silica dust to evaluate capture efficiencies of the dust emission-control system in the drum housing of the machine. Smoke was used as an initial qualitative test to visually check for leaks from the drum housing of the machine. Sulfur Hexafluoride (SF_6) was used to quantitatively evaluate capture efficiency of tracer gas released in the drum housing of the machine.

Five capture efficiency tests were conducted at a single flow rate on the Wirtgen W 250 cold milling machine. The overall mean capture efficiency as measured by the Brüel & Kjær monitor was 92.7% with a lower 95% confidence limit of 92.0%. The overall mean capture efficiency as measured by the Miran SapphIRe monitor was 93.5% with a lower 95% confidence limit of 92.7%. Additional field testing is recommended to verify the laboratory results. The testing reported here only evaluated capture efficiency in the drum housing. Other potential dust release locations on the machine such as the transition between the primary and secondary conveyor and the top of the secondary conveyor were not evaluated during this testing but would be evaluated during field testing.

Introduction

Background for Control Technology Studies

The National Institute for Occupational Safety and Health (NIOSH), Centers for Disease Control and Prevention (CDC) is the primary Federal agency engaged in occupational safety and health research. Located in the Department of Health and Human Services, it was established by the Occupational Safety and Health Act of 1970. This legislation mandated NIOSH to conduct a number of research and education programs separate from the standard setting and enforcement functions carried out by the Occupational Safety and Health Administration (OSHA) in the Department of Labor. 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 has been given the lead within NIOSH to study the engineering aspects of health hazard prevention and control.

Since 1976, EPHB has conducted a number of assessments of health hazard control technology on the basis of industry, common industrial process, or specific control techniques. Examples of these completed studies include the foundry industry; various chemical manufacturing or processing operations; spray painting; and the recirculation of exhaust air. The objective of each of these studies has been to document and evaluate effective control techniques for potential health hazards in the industry or process of interest, and to create a more general awareness of the need for or availability of an effective system of hazard control measures.

These studies involve a number of steps or phases. Initially, a series of walk-through surveys is conducted to select plants or processes with effective and potentially transferable control concept techniques. Next, in-depth surveys are conducted to determine both the control parameters and the effectiveness of these controls. The reports from these in-depth surveys are then used as a basis for preparing technical reports and journal articles on effective hazard control measures. Ultimately, the information from these research activities builds the data base of publicly available information on hazard control techniques for use by health professionals who are responsible for preventing occupational illness and injury.

Background for this Study

NIOSH is studying the effectiveness of dust-emission control measures during asphalt pavement-milling operations. The initial aim of this project is to determine if the dust emission-control systems installed on new pavement-milling machines and operated according to the manufacturers' recommendations are adequate to control worker exposures to respirable dust, especially that containing crystalline silica, a long-recognized occupational respiratory hazard. Chronic over-exposures to such dust may result in silicosis, a chronic progressive lung disease that eventually may be disabling or even fatal, and an increased risk of lung cancer

[NIOSH 2002]. The long term goal of this project is to adequately control worker exposures to respirable dust and crystalline silica by providing data to support the development of a set of best practice guidelines for the equipment if the engineering controls are adequate, or to develop a set of recommendations to improve the performance of controls if they are not adequate.

Many construction tasks have been associated with overexposure to crystalline silica [Rappaport et al. 2003]. Among these tasks are tuck pointing, concrete sawing, concrete grinding, and abrasive blasting [NIOSH 2000; Thorpe et al. 1999; Akbar-Kanzadeh and Brillhart 2002; Glindmeyer and Hammad 1988]. Road milling has also been shown to result in overexposures to respirable crystalline silica [Linch 2002; Rappaport et al. 2003; Valiante et al. 2004]. However, all three of those road-milling studies are limited because they do not provide enough information about the operating parameters and engineering controls present on the milling machines to determine if the overexposures were due to a lack of effective controls or poor work practices. This study is helping to fill that knowledge gap.

A variety of machinery are employed in asphalt pavement recycling, including cold-planers, heater-planers, cold-millers, and heater-scarifiers [Public Works 1995]. Cold-milling, which uses a toothed, rotating drum to grind and remove the pavement to be recycled, is primarily used to remove surface deterioration on both petroleum-asphalt aggregate and Portland-cement concrete road surfaces [Public Works 1995]. The milling machines used in cold-milling are the focus of this investigation.

The large cold-milling machine evaluated during this study was a Wirtgen W 250 with a 980 horsepower (HP) dual diesel engine and a 2.2 meter (7.2 ft) wide drum capable of milling 1,200 tons of asphalt per hour. Most half-lane cold-milling machines have a spinning drum with teeth to remove pavement onto a primary conveyor then to a secondary conveyor and into a dump truck. All production milling machines are also equipped with water-spray systems to cool the cutting teeth and suppress dust. The evaluated Wirtgen W 250 cold-milling machine also had a local exhaust ventilation system referred to as a Vacuum Cutting System (VCS) to capture dust generated in the drum housing and along the primary conveyor.

This laboratory research evaluated the performance of the VCS using smoke and tracer gas testing to simulate the emissions of respirable dust. Five tracer gas tests were conducted on a stationary machine with the drum spinning and the belts moving but without any reclaimed asphalt pavement moving through the system. The machine was set up to simulate the amount of open area around the drum that would be present during a typical milling job.

This study is facilitated by the Silica/Milling-Machines Partnership, which is affiliated with and coordinated through the National Asphalt Pavement Association (NAPA). The partnership includes NAPA itself, the Association of Equipment Manufacturers (AEM), the manufacturers of almost all pavement-milling machines sold in the U.S., numerous construction contractors, the International Union of Operating Engineers (IOUE), NIOSH, and other interested parties.

Previous Silica/Milling Machines Studies

NIOSH researchers collaborated with the Silica/Milling-Machines Partnership to conduct field research on respirable-dust and crystalline-silica exposures and exposure controls from 2003 through 2010. The studies were performed with five of the largest domestically-marketed manufacturers of cold-milling machines. With the assistance of the Partnership in identifying pavement-milling job sites appropriate for study and in arranging for the field work, NIOSH researchers completed a pilot field survey [Echt et al. 2004], four in-depth field surveys with different manufacturers from 2004 to 2006 [Echt et al. 2007; Blade et al. 2009a; Blade et al. 2009b; Blade et al. 2009c], a large study of milling machines from four different manufacturers in 2008 [Blade et al. 2011], and a second large study of milling machines from five different manufacturers in 2010 [Hammond et al. 2011].

The following conclusions are based on the research conducted on controls from five different manufacturers from 2003 to 2010:

(1) During the first four studies, NIOSH researchers collected personal breathing zone samples by hanging personal sampling pumps and sampling media on operators and ground crew from multiple manufacturers of cold-milling machines with water-flow dust suppression controls operated at normal and maximum water flow rates. When using water-flow dust suppression, personal breathing zone sampling results from the studies conducted between 2004 and 2006 for respirable crystalline silica varied dramatically by manufacturer, by study site, and within study site. Between 2004 and 2006, 56 personal breathing zone samples of respirable crystalline silica exposures were collected at four different highway sites from four different cold-milling machine manufacturers. Three of the 12 personal breathing zone samples from the 2004 study in Wisconsin were below the limit of detection and the remaining nine ranged from 0.04 to 0.17 milligrams (mg) of respirable crystalline silica per cubic meter (m^3) of air [Echt et al. 2007]. Five of the 12 personal breathing zone samples from the 2006 study in Minnesota were below the limit of detection while the remaining 7 samples ranged from 0.02 to 0.06 mg/m^3 [Blade et al. 2006a]. All 22 personal breathing zone samples from the 2006 testing in South Dakota were below the limit of detection [Blade et al. 2009b]. The 10 personal breathing zone samples from the 2006 study in New York ranged from 0.016 to 0.36 mg/m^3 [Blade et al. 2009c].

(2) In addition to evaluating worker exposures using personal breathing zone sampling, controls were evaluated by measuring the reduction in respirable dust concentrations from area samples mounted to the cold-milling machines of five manufacturers. Between 2003 and 2010, testing of water-spray dust suppression controls indicated that raising the water flow rate of the milling-machine water-spray systems from the “normal” rate to the maximum rate did not consistently

reduce respirable dust concentrations by an appreciable and statistically significant amount. The data revealed appreciable reductions in some cases but not in others.

(3) The local exhaust ventilation control tested in 2008 resulted in reduction in respirable dust concentrations of approximately 60% when compared to the baseline respirable dust concentration on the same machine [Blade et al. 2011]. The local exhaust ventilation control tested in 2010 resulted in reduction in respirable dust concentrations of 80% at the medium air flow rate and 69% at the low air flow rate when compared to the baseline respirable dust concentration on the same machine [Hammond et al. 2011].

After the 2010 testing in Wisconsin, the Silica/Milling-Machines Partnership members decided to further develop and test LEV controls to achieve more consistent and statistically significant reductions in emissions of respirable dust and crystalline silica. The 2011 testing phase began with initial laboratory testing of the ventilation controls from different manufacturers of cold milling machines with future plans to conduct field testing to verify the laboratory results.

Methodology

Tracer Gas

Tracer gas is commonly used to evaluate capture efficiencies of local exhaust ventilation systems even when those systems are designed to control a hazard in particulate form. Tracer gas has been used to evaluate local exhaust on asphalt paving machines [Mickelson et. al. 1999], and to evaluate hoods designed to capture particles generated from grinding wheels [Fletcher, 1995]. Probably the most common application of tracer gas occurs in fume hood testing for local exhaust ventilation hoods [ANSI/ASHRAE 1985] that are designed to capture both gases and particles.

Past NIOSH testing has resulted in the development of a model that uses tracer gas to evaluate local exhaust ventilation of mail-processing equipment [Beamer B, 2004]. The model for using tracer gas followed a thorough literature review which found multiple sources that indicated tracer gas is an appropriate evaluation method to test the capture efficiency of a hazard in particulate form. In ANSI/ASHRAE Standard 110-1985 the point is made that "fine dust, small enough to be of health significance will be carried along with the hood air currents in a fashion similar to the transport of a gas." Hemeon, in "Plant and Process Ventilation," states that "to control small particle motion, one must control the motion of the air in which the small particles are suspended [Hemeon, 1999]." In "Risk Assessment of Chemicals," Leeuwen describes how "small particles tend to behave like gases [Leeuwen et al. 2007]." The most compelling study compared capture efficiencies measured by tracer gas and aerosol tracer techniques and concluded that the transfer of aerosol to a local exhaust system was "nearly identical to that of a gas" for particles with diameters less than 30 µm [Beamer D, 1998]. This indicates that tracer gas is a reasonable substitute for respirable crystalline silica particles that are capable of being inhaled deep into the lungs.

Materials Equipment and Facilities

The following list describes the materials, equipment, and facilities used to conduct a laboratory tracer gas test of the Wirtgen W 250 cold-milling machine:

- Wirtgen W 250 asphalt milling machine fitted with a VCS system
- Building with large opening (overhead door) to the outdoors and house local exhaust ventilation system
- Smoke generator
  - Category 2 Hurricane Fog Machine, Chauvet USA, Hollywood, FL
- PVC pipe: 5.08 cm (2-inch), schedule 40, 2.4 meter (m) (8 feet) long, capped on one end, 6.35 millimeter (mm) (1/4-inch) diameter holes drilled in a line every 15.24 centimeters (cm) (6 inches) on center (smoke distribution pipe)
- Tracer gas cylinder: Sulfur Hexaflouride (SF_6) CP-grade, 99.8% pure, with pressure regulator
- An SF_6 detector with detection limit as low as 0.01 ppm and calibration curve as high as 15 ppm SF_6 with an accuracy of at least ± 0.01 ppm
  - Brüel & Kjær (B&K) multigas monitor type 1302
    - Sampling
      - S/N: 1804892
    - Background
      - S/N: 171524
  - Miran SapphIRe
    - Model:205B-XL2A3S
    - S/N: 205B80183-453
- Teflon tubing: 3.175 mm (1/8-inch) outside diameter, 6 m (20 feet) long
- Copper pipe: 12.7 mm (1/2-inch) inside diameter, the same length as the drum width, 0.8 mm (1/32-inch) diameter holes drilled in a line every 30.5 cm (12 inches) on center (tracer gas distribution pipe)
- Polyethylene (PE) tubing: 6.35 mm (1/4-inch) outside diameter, 30.5 m (100 feet) long
- A mass flow controller with shut-off valves and a range from 50 to 1,000 cc/minute of SF_6
  - Aalborg mass flow controller
    - Model: GFC17
    - S/N: 232901-1
    - SF_6 0-100 ml/min

- Copper tubing: 6.35 mm (1/4-inch) outside diameter, 30.5 cm (12 inches) long (sampling probe), sealed at one end, 1.6 mm (1/16-inch) diameter holes drilled in a line every 2.54 cm (1 inch) on center starting 2.54 cm (1 inch) in from the sealed end (the number of holes depends on the diameter of the ventilation exhaust duct: a 20.32 cm (8-inch) exhaust duct would require the use of a sampling probe with seven 1.6 mm (1/16-inch) holes)
- Hot wire anemometer (Velocicalc Plus Anemometer, Model 8388, TSI Incorporated, P.O. Box 64394, St. Paul, Minnesota, 55164)
- Oil boom

Process

The tracer gas evaluation of the VCS on the Wirtgen W 250 asphalt milling machine was conducted on August 2-3, 2011 at the Payne & Dolan repair facility in Racine, Wisconsin. The test was designed as a first step in determining the capture efficiency of the system. The test consisted of three main parts. First, preparation of the machine to approximate as close to actual milling conditions as can be achieved in a lab, and positioning the exhaust of the VCS in an area that will prevent the buildup of tracer gas in the room. Second, conduct a smoke test and visual inspection of the machine to ensure there are no obvious leaks in the system. Finally, conduct the tracer gas test and record and analyze data.

Environment Preparation

The milling machine was equipped with a front gradation control beam, rear scraper blade, and edge protection plates that are flush with the ground during normal milling operations. During this testing the rear scraper blade was lowered to the ground in the same position as normal milling operations. However, the front gradation control beam and the edge protection plates were several inches above the ground to allow for the smoke and tracer gas test equipment to be positioned inside the drum housing. An oil boom was placed in between the front gradation control beam and the ground to simulate the amount of open area that would be present during normal milling operations. Wood blocks and cardboard were used to fill in gaps under the edge protection plates, as shown in Figure 1.

Figure 1: View of side skirt placement

The VCS exhaust is channeled into the secondary conveyer area of the machine as part of the original machine design. The house exhaust system at the Payne & Dolan facility was used to place the conveyer area under negative pressure as shown in Figure 2, thereby exhausting the tracer gas outside the building. This prevented the background levels of SF_6 from building up and affecting the test results. Tracer gas was used to measure the airflow of the VCS with the house system turned on and off to verify that the house exhaust system did not alter the airflow of the VCS.

Figure 2: House exhaust system

Smoke Test

A smoke test was performed prior to the tracer gas test to visually check the system for leaks. Smoke was released from a Category 2 Hurricane fog machine under the cutting drum. The smoke was released through an 2.4 m (8 foot) long, 5.08 cm (2 inch) diameter PVC pipe system with 16, 6.35 mm (¼ inch) holes drilled along the length to achieve even distribution under the drum. The pipe system was positioned just in front of the cutting drum with all of the holes inside the dust housing as shown in Figure 3.

Figure 3: Smoke test pipe placement

Smoke was released into the drum housing with the cutting drum, primary conveyor, and VCS system active. The system was visually inspected to determine if there were any obvious leaks.

The sequence of the smoke test is outlined below:

- Verify that the smoke test will not set off a fire alarm or fire-suppression system.
- Position the house local exhaust ventilation system near the outlet to the VCS to route the smoke to the outdoors.
- Place the 5.08 cm (2-inch) diameter smoke distribution pipe directly beneath the cutter drum and secure in a horizontal position.
- Connect the smoke generator to the distribution pipe.
- Clear the cutter drum area of any extraneous materials.
- Activate the VCS silica dust exhaust ventilation system, house local exhaust ventilation system, and the smoke generator.
- Inspect the separating barrier for integrity failures and correct them as required.
- Inspect the VCS for unintended leaks at all fittings.
- Deactivate the VCS for a short time to simulate a no-control condition for comparison purposes.
- Deactivate the smoke generator and wait for smoke levels to subside. If desired, turn on additional exhaust ventilation to clear the room more quickly.
- Disassemble the test equipment (the smoke generator may be HOT).

Tracer Gas Test

Dosing

For the VCS efficiency test, sulfur hexaflouride tracer gas (minimum purity 99.8%) was released in the drum housing of the milling machine through an 2.4 m (8 foot) long 12.7 mm (½-inch) diameter copper pipe with eight 0.8 mm ($^1/_{32}$-inch) diameter holes drilled every 30.5 cm (12-inches) on center. One end of the pipe was capped and the other end had a quick connect fitting. To represent 100% capture of the released tracer gas, a section of Teflon tubing with a quick connect fitting on one end was placed in the duct system, as shown in Figure 4. The flow of tracer gas was controlled using an Aalborg mass flow controller calibrated for SF_6 and connected to a CGA-590 regulator and tracer gas cylinder using 6.35 mm (¼-inch) Teflon tubing and Swagelok connections as shown in Figure 5. A section of 6.35 mm (¼-inch) Teflon tube with Swagelok fittings and a quick connect fitting joined the outlet of the mass flow controller and the tracer gas release location in the duct representing 100% capture or release location in the drum housing. A B&K multigas monitor was set up as an area monitor to check for any rise in background levels of SF_6 near the dosing area just outside of the drum housing.

The mass flow controller was set so the concentration was below the Miran SapphIRe maximum recommended instrument range of 4 ppm. The mass flow controller was set to 150 ml/min, which at the VCS's flow rate gave a concentration of about 3.7 ppm during the 100% capture test.

Figure 4: Tracer gas 100% capture

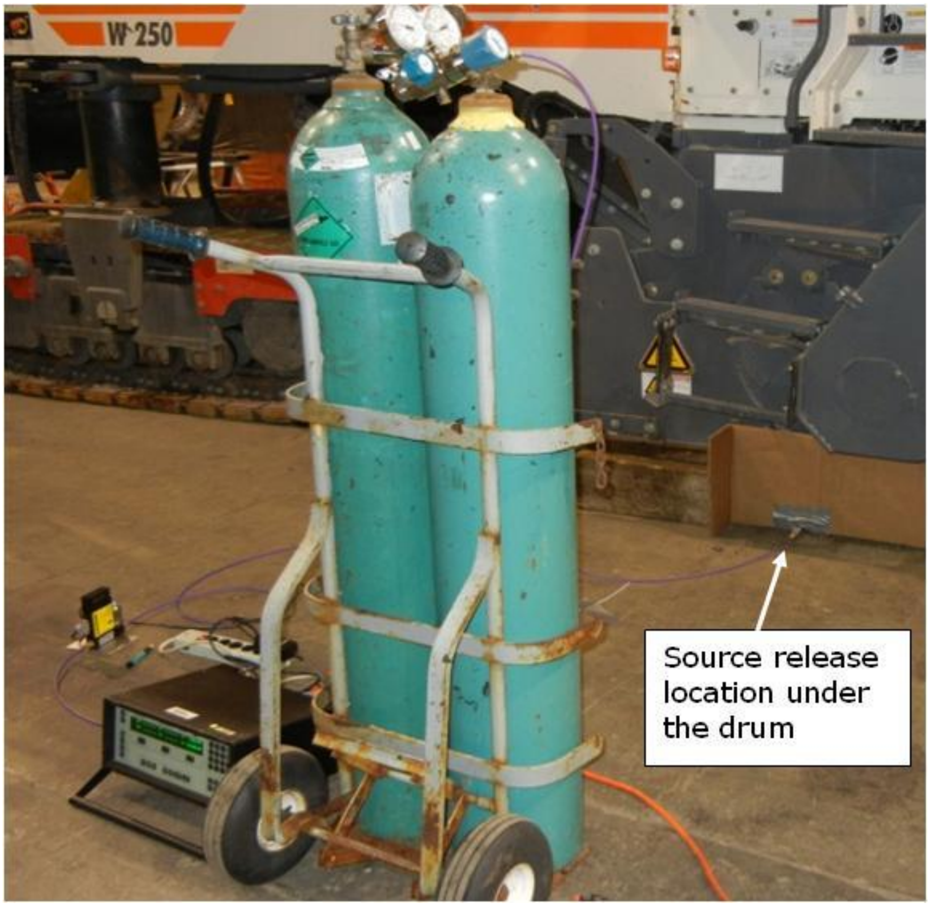

Figure 5: Tracer gas source

Sampling

Air sampling was performed by inserting a probe directly into the duct and perpendicular to the airflow downstream of the fan as shown in Figure 6. The air was drawn through a 6.35 mm (¼-inch) diameter copper probe with 1.6 mm ($^{1}/_{16}$-inch) holes drilled on center every 2.54 cm (1-inch). Air was drawn through the probe to a tee-fitting where the air was delivered through separate Teflon tubes to a Miran SapphIRe, and a B&K multigas monitor. The exhaust ports on each instrument were routed back into the exhaust of the VCS system downstream of the sampling location.

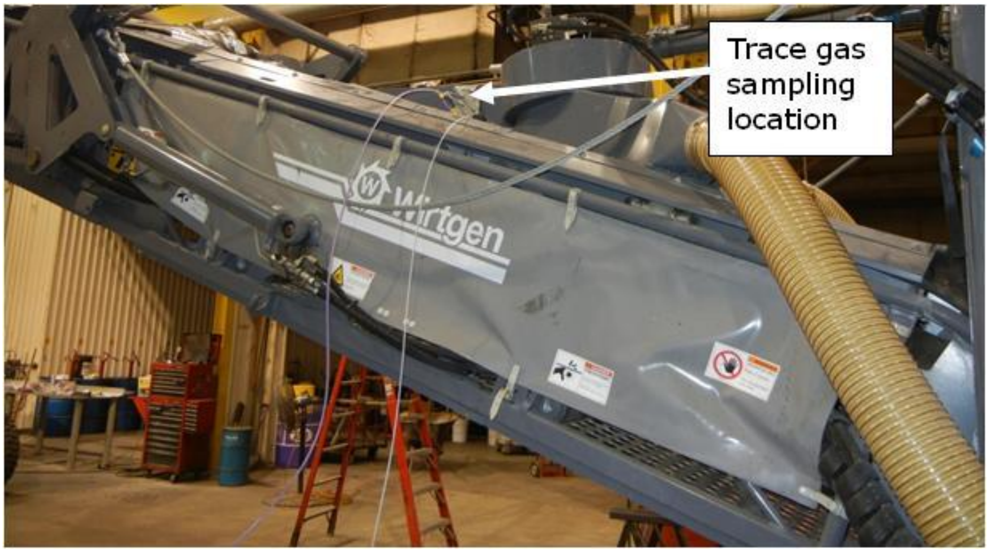

Figure 6: Sampling probe placement

Test Procedure

To determine the capture efficiency of the system, sulfur hexafluoride was released into the ventilation system at two points, directly into the exhaust duct system to ensure 100% capture of the gas, and in the cutter drum housing area to simulate small dust particles generated during milling. The tracer gas concentration during each condition was measured downstream of the fan and a capture efficiency ratio was calculated by dividing the drum housing release SF_6 concentration by the 100% capture SF_6 concentration. Gas was released until five-minutes of steady state values were recorded on both the B&K and Miran SapphIRe. The gas was shut off to allow the SF_6 concentration in the system to decay between each release condition. The capture efficiency was then determined from the average of the five-minute samples for each test using Equation 1. The 100% capture and drum housing release measurements were adjusted for any change in average background SF_6 concentration by drawing an interpolation line from the before and after background SF_6 measurements and subtracting the corresponding background concentration from the measured value.

$$\eta = \frac{C_{SF_6}}{C^*_{SF_6}} \times 100\% \qquad (1)$$

Where

η = the capture efficiency,
C_{SF_6} = the average concentration of SF_6 (parts per million) detected in the duct, and
$C^*_{SF_6}$ = the average concentration of SF_6 from the 100% capture test.

Control Technology

Description of tested dust-emission control configuration

The equipment evaluated during this laboratory study was a 980 hp Wirtgen W 250 cold milling machine with a local exhaust ventilation system referred to as a VCS. The VCS was designed to create a negative pressure in the milling drum housing using a fan and flexible hose system and to exhaust the air away from any workers. The current focus of this study is to determine if additional LEV based dust controls provide for more consistent more consistent and statistically significant reductions in emissions of respirable dust and crystalline silica. Individual system details may be released after initial testing with all participating manufacturers.

Results

Smoke Evaluations

The smoke test evaluation provided qualitative information for verifying the integrity of the house exhaust ventilation system connection at the outlet of the VCS and for checking for any obvious leaks in the drum housing before conducting tracer gas capture tests. No smoke was observed around the machine when smoke was released in the drum housing area with the VCS operating. Smoke was observed leaking out of the drum housing when the VCS system was turned off. Smoke testing results also indicated good air capture of the house exhaust system at the outlet to the VCS.

Tracer Gas Results

Tracer gas capture efficiency results were calculated for both the B&K and the Miran SapphIRe data. The two tracer gas analyzers were both calibrated to SF_6. Results from the five individual capture efficiency trials along with the average and lower 95% confidence limit are provided in Table 1. Every effort was made to hold all conditions constant from trial to trial. Results using the two instruments were very similar and differences were 1.2% or less for all trials. The mean capture efficiency from the B&K and Miran SapphIRe data were 92.7% and 93.5% respectively. The lower 95% confidence limits were 92% and 92.7% for the B&K and Miran SapphIRe results respectively.

Table 1: Tracer gas capture efficiency of the drum housing of the Wirtgen W 250.

Trial	Capture Efficiency (B&K)	Capture Efficiency (Miran SapphIRe)
1	91.6%	92.3%
2	93.2%	94.0%
3	93.4%	93.6%
4	93.0%	94.2%
5	92.4%	93.3%
Average	92.7%	93.5%
Lower 95% confidence limit	92.0%	92.7%

Relative humidity measurements were recorded throughout the testing and ranged from 41% to 63%. However, the capture efficiency calculation is a ratio of two consecutive tests with little humidity fluctuation over the short time period used for any individual capture efficiency ratio.

Conclusions and Recommendations

Based on the laboratory test results of this report, the Wirtgen W 250 VCS design has potential to significantly reduce worker exposure to respirable crystalline silica during asphalt pavement milling operations. The wind speed, silica dust emission rate, work practices of individuals, dust emissions from sources other than the evaluated drum housing, and other factors may affect actual reductions in occupational exposures outside of the laboratory setting.

The following general recommendations are provided for consideration of improvements to future VCS designs:

- This testing only evaluated VCS capture efficiency from the cutter drum housing area of the cold milling machine. The VCS system was not designed to control dust generated from other areas such as the transition between the primary and secondary conveyor. It is recommended that future designs should consider adding local exhaust ventilation controls to the transition between the primary and secondary conveyor since this transition area is near the operator and may present a secondary source of dust generation. Transition area covering and sealing varies between manufacturers. Field testing should help determine if ventilation is required in this area for various milling machine manufacturers.
- Dust will also be released at the outlet of the VCS system. Although the location of the VCS outlet is far away from operators, certain wind conditions may cause the operator breathing zone to pass through airborne dust released at the VCS outlet. Future VCS designs should also consider the feasibility of adding cyclonic or other filtration provisions to remove dust from the VCS airstream.
- The testing described in this report was performed indoors under ideal laboratory/factory conditions. Additional NIOSH field testing is recommended to verify the laboratory results.

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The authors would like to thank management and staff at Payne & Dolan and Wirtgen America for their gracious hospitality and assistance during this testing at the Payne & Dolan repair facility in Racine, Wisconsin. Their commitment to the testing of engineering controls to reduce occupational exposures to respirable crystalline silica is an admirable pledge.

References

American Society of Heating, Refrigeration and Air-Conditioning Engineers "ANSI/ASHRAE Standard 110-1985, Method of Testing Performance of Laboratory Fume Hoods" ASHRAE 1985.

Beamer B [2004]. Development of a Model for Evaluation of Local Exhaust Ventilation for Mail-Processing Equipment. A Dissertation submitted to the Division of Research and Advanced Studies in the Department of Mechanical, Industrial, and Nuclear Engineering. University of Cincinnati, Cincinnati, OH.

Beamer D, Muller JP, Dessagne M [1998]. Comparison of Capture Efficiencies Measured by Tracer Gas and Aerosol Tracer Techniques. International Journal of Indoor Environment and Health. Volume 8 Issue 1, Pages 47 – 60, 1998.

Blade LM, Shulman SA, Colinet J, Chekan G, Garcia A [2009a]. In depth field evaluation: dust-control technology for asphalt pavement milling, at U.S Highway 2 resurfacing project, Wilton, Minnesota, June 20 through 22, 2006. 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. Report No. EPHB 282-15a.

Blade LM, Garcia A, Shulman SA, Colinet J, Chekan G [2009b]. In depth field evaluation: dust-control technology for asphalt pavement milling, at South Dakota Highway 79 resurfacing project, Buffalo Gap, South Dakota, August 15 through 17, 2006. 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. Report No. EPHB 282-14a.

Blade LM, Shulman SA, Garcia A, Marlow DA [2009c]. In depth field evaluation: dust-control technology for asphalt pavement milling, at New York State Thruway (Interstate Highway 90) resurfacing project, Hamburg, New York, September 25 and 26, 2006. 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. Report No. EPHB 282-16a.

Blade LM, Shulman SA, Cecala A, Chekan G, Zimmer J, Garcia A, Lo LM, Calahan J [2011]. Field Research Study: Dust Control Technology for Asphalt Pavement Milling Controlled-site testing at the site of the former Marquette County Airport, Marquette, Michigan June and September 2008. 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. Report No. EPHB 282-17a.

Echt A, Shulman S, Colinet J, Goodman G [2004]. Results of a pilot study of dust control technology for asphalt milling, at Payne & Dolan, Inc., U.S. route 12 project, Wisconsin, October 7 through 9, 2003. 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. Report No. EPHB 282-11b.

Echt A, Garcia A, Shulman S, Colinet J, Cecala A, Carlo RV, Zimmer J [2007]. In depth survey of dust control technology for asphalt milling, at Northeast Asphalt, Inc., state routes 22 and 64 projects, Wisconsin, July 13 through 15, 2004. 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. Report No. EPHB 282-12a.

Fletcher B. The Design of Local Exhaust Ventilation Hoods for Grinding Wheels. Ann. occup. Hyg., Vol. 39, No. 5, pp. 535-543, 1995.

Glindmeyer HW, Hammad YY [1988]. Contributing factors to sandblasters' silicosis: inadequate respiratory protection equipment and standards. J Occup Med 30(12):917–921.

Hammond DR, Blade LM, Shulman SA, Zimmer J, Cecala A, Joy G, Lo LM, Chekan G [2011]. Field Research Study: Dust Control Technology for Asphalt Pavement Milling Controlled-site testing at State Highway 47, Bonduel, Wisconsin August 9-18, 2010. 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. Report No. EPHB 282-18a.

Hemeon, Wesley. Hemeon's Plant and Process Ventilation, 3rd ed. Boca Raton: Lewis Publishers, 1999.

Leeuwen CJ van, Vermeire T [2007]. Risk Assessment of Chemicals: An Introduction 2nd edition. Published by Springer, New York, NY, pp 84.

Linch KD [2002]. Respirable concrete dust – silicosis hazard in the construction industry. Appl Occup Environ Hyg 17(3):209–221.

Mickelsen LR, Mead KR, Shulman SA, Brumagin TE [1999]. Evaluating engineering controls during asphalt paving using a portable tracer gas method. American Journal of Industrial Medicine. Volume 36 Issue S1, Pages 77 – 79.

NIOSH [2000]. Respirable crystalline silica exposures during tuck pointing. 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. 2000-113.

Public Works [1995]. Pavement recycling. Public Works 126: April 15, 1995.

Rappaport SM, Goldberg M, Susi P, Herrick RF [2003]. Excessive exposure to silica in the U.S. construction industry. Ann Occup Hyg 47(2):111–122.

Thorpe A, Ritchie AS, Gibson MJ, Brown RC [1999]. Measurements of the effectiveness of dust control on cut-off saws used in the construction industry. Ann Occup Hyg 43(7):443–456.

Valiante DJ, Schill DP, Rosenman KD, Socie E [2004]. Highway repair: a new silicosis threat. Am J Public Health 94(5):876–880.

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