An Evaluation of the Pullman-Ermator S26 and S13 Vacuums with a Newly Patented Dust Hood

I. Introduction

CPWR - the Center for Construction Research and Training, is a non-profit research and training organization affiliated with North America's Building Trades Unions. CPWR also serves as the National Institute for Occupational Safety and Health's (NIOSH) Construction Center. Between 2012 and 2014, CPWR conducted evaluations of dust capture, or local exhaust ventilation (LEV), systems for tuckpoint grinders. Tuckpointing is known to generate very high respirable silica dust levels, often exceeding occupational exposure limits by ten to well over one hundred fold. Silica is associated with silicosis, a sometimes fatal, but totally preventable disease, and has also been associated with other illnesses including lung cancer and autoimmune disorders.

In 2013 CPWR evaluated the performance of the Ermator S26 HEPA Dust Extractor (Pullman-Ermator, Tampa, FL) used in combination with two Bosch grinders (Robert Bosch Tool Corporation, Prospect, IL) and two ICS Dust Director shrouds (Industrial Contractors' Supplies, Inc., Huntingdon, PA)**.** The two Bosch grinders - models 1775E and AG40-85, were fitted with 1/4-inch wide, 4½-inch diameter segmented diamond abrasive blades made by DeWalt (model #DW4740).

Figure 1: Pullman-Ermator Dust Hood

The tested system was among the three most highly rated systems by the CPWR Silica PACT (Partnership for Advancing Control Technologies). One of the more attractive features of the S26 Ermator vacuum is that it is designed to provide suction to two grinders. Following that evaluation, Pullman-Ermator developed and patented a new dust shroud which fits on the tuckpoint grinder and directs dust into the hose leading to the vacuum.

In 2014, Frederik Akermark, Vice President of Sales for Pullman- Ermator, asked CPWR to repeat the trials conducted in 2013 utilizing their newly patented dust hood as part of the LEV system **(see Figure 1).** In response, we were able to conduct a limited scheduled for another tuckpoint grinder LEV system. A small number of samples were also collected using the S13 vacuum, which only provides dust capture for one grinder.

II. Methods

All sampling was conducted at Bricklayers Local 1 Training Center at 2702 Black Lake Place, Philadelphia, PA. Pam Susi, CPWR; Mike Cooper, a consultant to CPWR; and Tanushree Chakvarty, Colden Corp. made up the industrial hygiene research team. Journeymen tuckpointers operated the equipment being evaluated. GK 2.69 cyclonic sampling devices (BGI Inc., Waltham, MA) with pre-weighed, 37 mm diameter, 5-micron pore size polyvinyl chloride (PVC) filters were placed in the breathing zone of sampled workers and connected with tubing to GilAir-5 personal sampling pumps (Sensidyne, Inc., Clearwater, FL) calibrated at 4.2 liters per minute.

Task time-weighted average (TWA) exposures were collected during three[1] paired randomized trials using the grinder *with* and *without* the S26 Pullman-Ermator vacuum and shroud **(see Figures 2 & 3)**. Because two workers wore sampling devices for each trial when using the S26, this resulted in a total of six samples collected with the vacuum in place and an additional six samples collected without the vacuum. Four trials with the S13 vacuum and three without the vacuum were also conducted.

Sample time duration for "no-control" trials was about 10 minutes and about 24 minutes for "control" trials with LEV. The longer sampling time for "control" trials was necessary to collect the minimum amount of silica necessary to measure exposures down to the NIOSH Recommended Exposure Limit (REL) of 0.05 mg/m^3 using NIOSH Method 7500. However, we paused grinding at 10 minute intervals and had the tuckpointers take brief rest breaks during "control" runs to minimize the possibility that fatigue from longer sampling durations would impact dust generation rates.

Figure 2. Using the Bosch grinder without LEV

We also measured static pressure to determine air flow through the tested LEV systems. Static pressure, with the vacuum on and the grinder off, was measured before and after each trial with the vacuum to monitor changes in air flow over time. The static pressure was measured at a port attached to a 2-inch diameter steel pipe positioned more than 3 duct diameters downstream from the shroud's air intake using a UEi EM200 Electronic Manometer (Universal Enterprises, Inc., Beaverton, OR).

[1] In previous evaluations, we used five paired trials with and without the tested LEV system to be able to measure exposure difference with and without the treatment with some statistical confidence. Since this evaluation was not part of the research project as planned and budgeted for, limited time only allowed for 3 paired trials.

III. Results

Respirable silica dust levels were reduced by 98% using the S26 vacuum and by 96% using the S13 vacuum. Time-weighted average respirable silica dust levels without use of the S26 LEV system were approximately forty-five times greater than those measured with use of the system. Respirable silica dusts levels without use of the S13 LEV system were twenty-five times higher than those measured with use of the S13 system. Sampling results for the S26 and S13 vacuum evaluations appear in **Tables 1 and 2,** respectively.

Figure 3: Grinding with the Ermator S26 vacuum, Bosch grinder and Ermator Dust Hood

Table I: Respirable Silica Exposures with and without LEV Using the S26 Vacuum and Newly Patented Dust Hood– Both Workers

	Average (mg/m^3)	Standard Deviation	Range (mg/m^3)	Sample Size	Hazard Ratio (Average/ NIOSH REL)
with LEV	0.181	0.070	0.079 – 0.285	6	3.62
without LEV	8.12	2.93	4.04-13.2	6	162

Table 2: Respirable Silica Exposures with and without LEV Using the S13 Vacuum and Newly Patented Dust Hood

	Average (mg/m^3)	Standard Deviation	Range (mg/m^3)	Sample Size	Hazard Ratio (Average/ NIOSH REL)
with LEV	0.231	0.062	0.161-0.311	4	4.62
without LEV	5.85	0.465	5.56-6.38	3	117

With regard to LEV air flow measurements, the flow of air in ventilation systems is governed by fundamental principles that describe the behavior of gases. Pressure measurements taken within a ventilation system along with knowledge of hood (or shroud) entry losses can be used to calculate air flow. Hood entry losses are dependent on the shape and configuration of a particular hood or shroud and described by the term "coefficient of entry (C_e)". The C_e is the ratio of *actual* air flow through a hood and *theoretical air flow* absent hood entry losses. Given hood C_e, static pressure (SP) measurements, and the area of the duct where SP measurements were taken, air flow can be calculated. Working with Dr. John Meeker, Univ. of Michigan, CPWR determined the C_e for the Ermator Dust Hood to be 0.65.

Air flow measured downstream from a single grinder and shroud averaged 79.5 cubic feet per minute (cfm), indicating an average flow rate of 159 cfm was being supplied at the main duct supplying suction for two grinders. Collingwood and Heitbrink[2] found that the minimum exhaust flow for capturing silica and other particulate under ideal conditions is 21.25 cfm per inch of grinder blade diameter (96 cfm for a 4.5-inch diameter grinding blade).

IV. Discussion/Conclusion

Although use of the S26 and S13 vacuums with the newly patented shroud resulted in substantial respirable silica exposure reductions, task TWA exposures were on average still higher than the NIOSH REL and the proposed OSHA Permissible Exposure Limit (PEL) of 0.05 mg/m^3. However, it should be noted that these exposure limits are based on a ten hour and eight hour time-weighted averaging time, respectively. For our evaluations grinding was continuous. On an actual job other tasks such as scaffold erection, repointing, tool set up and pick up and breaks would likely result in a much lower TWA exposure. Based on the mean exposure level measured with the S26 vacuum of 0.181 mg/m^3, the NIOSH REL would be exceeded after 133 minutes or a little over two hours of continuous grinding. Still, tuckpointing without any LEV commonly results in exposures hundreds of times the NIOSH REL; so reductions to less than 10 times the REL is a vast improvement and, if used with a negative

[2] Collingwood S. & Heitbrink W.A. [2007] 'Field Evaluation of an Engineering Control for Respirable Crystalline Silica Exposures During Mortar Removal'. Journal of Occupational and Environmental Hygiene, 4:11, 875 – 887.

pressure air-purifying respirator as part of a comprehensive respiratory protection program, should result in exposures less than the NIOSH REL.

We compared the results of our evaluation conducted in 2013 (which involved use of the exact same vacuum and grinder models but with a different dust shroud) with results from 2014. In 2014, the ICS Dust Director shroud was replaced with the newly patented Pullman-Ermator dust hood. Mean respirable silica exposure levels were much lower in 2014, going from 0.823 mg/m^3 in 2013 to 0.181 mg/m^3 in 2014. However, this 78% reduction can't be solely attributed to use of the new dust hood since baseline exposures without use of a LEV system were also much higher in 2013 – 690 times the NIOSH REL in 2013 and 162 times the NIOSH REL in 2014. Although the equipment used and wall where grinding occurred were the same for both years, we had to use different tuckpointers in 2014 as were used in 2013. This introduces inter-worker variability which can be a substantial source of variance in personal exposure measurements along with environmental factors we couldn't control that might impact exposure (e.g. wind and heat which may impact productivity). However, trials were conducted in roughly the same time of year in 2013 (June) as 2014 (May) and windy conditions were not observed in either year. In addition, our sample size was smaller in 2014. We may have seen a wider range of exposures in 2014 had we been able to conduct two additional paired trials in 2014 (a total of five paired trials) as done in 2013.

While the percent respirable silica exposure reduction was 98% in both years, exposures without use of LEV in 2013 were 41.9 times those measured with LEV. In 2014, exposures measured without LEV were 44.9 times those measured with LEV. Comparison of exposure ratios with and without LEV adjusts for differences in baseline exposures between years. While it's hard to say conclusively that the newly patented Pullman-Ermator shroud reduced exposures from those measured in 2013, since worker technique, among other variables, may also contribute to LEV performance, there does appear to be a small measurable improvement in respirable silica reduction using this measure of performance.

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