Applied Occupational and Environmental Hygiene
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/uaoh20

Control of Wood Dust from Rotational Hand-Held Sanders

Vladimir Hampl [a], Jennifer L. Topmiller [a], Daniel S. Watkins [a] & Donald J. Murdock [a]
[a] National Institute for Occupational Safety and Health, Division of Physical Sciences and Engineering, 4676 Columbia Parkway, Cincinnati, Ohio, 45226, USA
Published online: 24 Feb 2011.

Control of Wood Dust from Rotational Hand-Held Sanders

Vladimir Hampl, Jennifer L. Topmiller, Daniel S. Watkins, and Donald J. Murdock
National Institute for Occupational Safety and Health, Division of Physical Sciences and Engineering, 4676 Columbia Parkway, Cincinnati, Ohio 45226

An association between nasal cancer and other health effects and occupations involving exposure to wood dust has been clearly established in the literature. Therefore, it was deemed necessary to conduct research to develop new improved methods to control this dust. This article reports on the research that has been conducted by investigations at the National Institute for Occupational Safety and Health (NIOSH) on rotational hand-held sanders. A new control system was developed to be used in conjunction with existing controls that are used on these sanders, which consist of an aspirator and a perforated sanding disc pad. The new control system includes additional suction applied to the sander body and a specially designed, slotted sanding disc pad to relieve the increased pressing of the sander to the sanded surface imposed by the increased vacuum. The newly designed sanding disc pad also captures wood dust from the sanded surface directly at the pad periphery. In the laboratory, the new control system reduced the wood dust emissions by over 90 percent compared with emissions from the aspirator-controlled sanders that are currently in use. An average reduction in wood dust emissions of 80 percent was achieved during the field tests which is in very good agreement with the laboratory results. The newly designed system does not interfere with the worker's activity, does not require special maintenance, and would be inexpensive to commercialize and operate. **Hampl, V.; Topmiller, J.L.; Watkins, D.S.; Murdock, D.J.: Control of Wood Dust from Rotational Hand-Held Sanders. Appl. Occup. Environ. Hyg. 7(4):263–270; 1992.**

Introduction

According to a 1987 report by the National Institute for Occupational Safety and Health (NIOSH),[1] the association between nasal cancer and occupations involving exposure to wood dust has been clearly established in the literature. More recently, other authors have documented the risk of nasal cancer resulting from prolonged periods of exposure to wood dust.[2,3] Therefore, NIOSH researchers have been conducting studies to develop new and improved methods to control wood dust from woodworking operations. Research on reduction of wood dust emissions from horizontal belt sanders, shapers, routers, and large diameter disc sanders has been completed and reported previously.[4–7]

The research presented here deals with control techniques for air-powered, rotational, hand-held sanders. One of the most common problems within the woodworking industry is the control of wood dust emissions from hand tool operations, namely hand sanding. For rotational hand sanders, the wood dust emissions are mainly attributed to the rotation of the sanding pad. The rotating pad acts as a blower which generates a stream of flowing air that is thrown outward from the pad periphery. Wood dust entrained in the air flow pattern is thrown into the work area. Local exhaust ventilation is the primary method of controlling wood dust emissions at most woodworking machines. However, such systems, in general, cannot be successfully applied at hand-sanding operations because of the wide variation of hand sander applications.

There are a number of patents describing control devices for these sanders, such as application of shrouds or brushes covering the entire sanding disc pad[8–10] or the combination of an aspirator and a perforated sanding disc pad.[11,12] The latter system is commercially available and in use. Application of an external exhaust system in combination with a perforated sanding pad also has been noted.[13] However, very often, the wood dust emissions from hand sanders are not controlled at all.

Even with the use of these controls, significant amounts of wood dust are still emitted into the work area. The aspirator–perforated disc pad system was found ineffective because of the insufficient vacuum capacity of the aspirator. It also does not capture the dust left on the sanded surface. Application of an external vacuum and perforated pad may be beneficial for increasing the capture capacity. However, the increased suction draws the sander toward the sanded surface making the sanding operation more difficult, especially when a large flat surface is sanded. The shroud or brush application is not practical because these devices usually cover the sanded surface and obstruct the vision of the operator during sanding.

Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health (NIOSH).

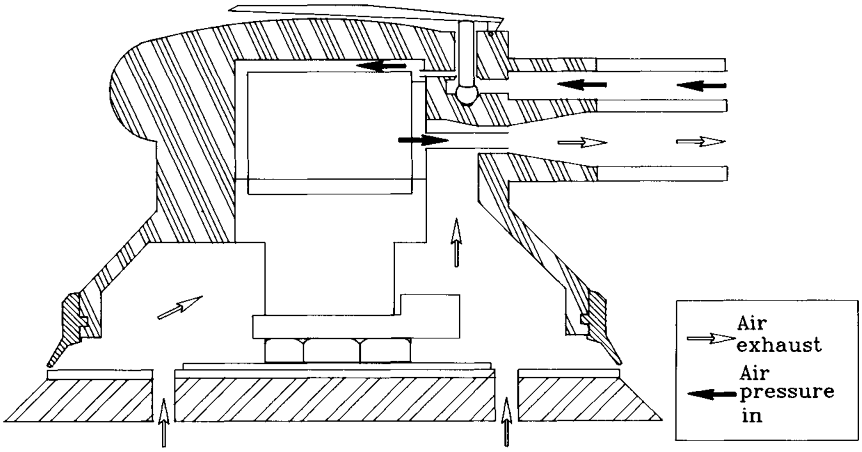

FIGURE 1. Diagram of aspirator-controlled disc sander.

The purpose of this research was to develop a system to solve these problems and to improve dust collection capacity.

Laboratory Experiments

Laboratory Sander

Preliminary measurements conducted with uncontrolled and aspirator-controlled sanders showed that the aspirator control reduced, to some extent, the amount of the wood dust emitted. A typical number of 180,000 particles per 2.5 L (approximately 0.1 ft^3) were found during a 20-second sampling interval compared to a number of 521,000 particles obtained under the same conditions at the uncontrolled sander. Therefore, the subsequent laboratory experiments were mainly conducted on an air-powered, random, orbital disc sander (Figure 1) provided with the aspirator and the perforated sanding disc pad (Dynabrade, Inc., Model 56008). The sander was operated at a compressed air pressure of 6.1 atm (90 psi) resulting in 9800 revolutions per minute. During sanding, the revolutions were significantly decreased and fluctuated due to variation of sander pressure to the sanded surface. Therefore, it was impossible to measure the disc revolutions accurately because of the constantly changing rotational speed of the disc.

Air Flow Investigation

As stated previously, the air flow may affect wood dust emissions. Therefore, the air flow pattern was investigated qualitatively by using a smoke test and quantitatively by measurement of the air velocity. Air velocity was measured using an anemometer (TSI, Inc., Model 1050, or Kurz Instruments, Inc.). The anemometer signal was recorded on a multichannel analyzer (Tracor Northern Co., Model TN 1710). An automatically driven device moved the velocity sensor in the direction perpendicular to the sanding disc pad periphery so that the air velocity profile was obtained as a function of distance from the pad periphery.

For the noncontrolled sander, smoke tests showed that the rotating sanding pad acted as a blower. The smoke was pushed from the pad periphery into the laboratory whether the sander was in the sanding or nonsanding position. At the aspirator-controlled sander, a lesser amount of smoke was emitted into the laboratory. The smoke was partially pulled into the sander through the perforated pad and between the sanding disc pad and the shroud. This also was confirmed by measurements of air velocity at the disc pad periphery. When the noncontrolled sander was in the sanding position, the air velocity was significantly reduced to 1.0 m/s (200 ft/min) compared with the velocity of over 11.1 m/s (2200 ft/min) obtained when the sander was in the nonsanding position. For the aspirator-controlled sander, the air velocity of approximately 1.0 m/s (200 ft/min) was generally found at both nonsanding and sanding positions. This indicates that:

- The air blowing intensity due to the rotating disc pad is significantly reduced while sanding.
- The suction power of the aspirator does not change appreciably during sanding but may not be sufficient to control the emitted particles effectively.

It was, therefore, anticipated that increasing the suction would increase the capture capacity of the sander. An additional exhaust system described below was designed and installed on the aspirator-controlled sander. It was found that more particles were collected because of the increased suction; however, substantial amounts of particles were still emitted because the air was drawn in mostly between the shroud and the disc pad, rather than at the pad periphery where most of the particles were originated. Also, the increased vacuum created by this exhaust system tended to pull the sander toward the wood piece being sanded. This made operation difficult particularly when a flat surface was being sanded. Therefore, a new sanding disc pad was designed to alleviate these problems.

Description of Designed Control

The new control system consisted of two parts: 1) an additional exhaust ventilation system and 2) a sander pad provided with curved slots.

Additional Exhaust Ventilation System

A general view of the additional exhaust ventilation system is shown in Figure 2a. The exhaust was a simple 1.3-cm × 1.9-cm (0.50-inch × 0.75-inch), horseshoe-shaped tube provided with three, 0.95-cm (3/8-inch) o.d., inlet tubes. It was found that the size of the exhaust tube may vary; however, it should not interfere with the operator's activity, i.e., it should not affect the operator's grip on the sander. Referring to Figure 2b, the exhaust tube was located above an existing shroud and fitted tightly around the sander body. The inlet tubes were affixed to connect the exhaust tube tightly to the sander body. One of the inlet tubes (2a) was located at the center of the exhaust tube arc, 180 degrees from the compressed air inlet. The other two inlet tubes (2b and 2c) were symmetrically located on both sides of the central inlet tube (2a) at an angle of approximately 60 degrees with the central inlet tube. Both exhaust tube ends were combined into one round outlet tube. The outlet tube was connected via a flexible hose to a standard industrial vacuum cleaner. Before connecting the outlet tube to the flexible hose, this tube was combined with the compressed air exit to simplify the design.

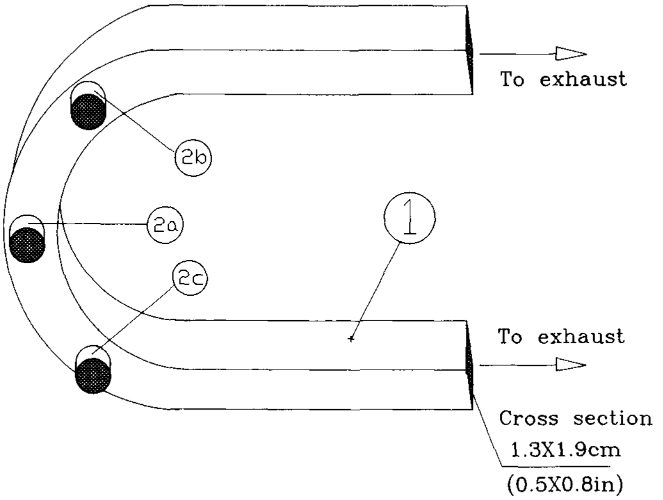

FIGURE 2a. Diagram of additional exhaust system. Legend: exhaust tube, 1; inlet tubes, 2a, 2b, and 2c.

Sander Pad with Curved Slots

The new design of the sander pad is shown in Figure 3. The pad was provided with curved slots, corresponding in number to the standard pad holes. By radiating out to the edge of the pad, the slots connected the holes inside the pad area with the pad periphery. The slots have a semicircular cross section with a diameter equal to the diameter of the holes. The angle between the longitudinal slot axis at the slot opening and the pad periphery tangent (in the direction of the pad rotation) was derived from the ratio of dust particle and air suction velocities and the angle of trajectories of the emitted particles. This angle was determined by measurements of the radial and tangential velocities of the emitted particles using a Laser Doppler Velocimeter (Dantec Company, Model 5490A-00). The average resultant trajectory angle was found to be 30 ± 9 degrees.

Measurement of Control Performance

The evaluation of the newly designed control system was based on the reduction of the number of wood dust particles emitted into the work area. The measurement of the concentration of emitted particles was taken with only the aspirator control operating and then with the designed control and the aspirator operating. The relative reduction ratio (RD) was defined as follows:

$$\text{RD}\ (\%) = 1 - \left(\frac{\text{particle number concentration with designed control operating}}{\text{particle number concentration with only aspirator control operating}} \right) \times 100 \quad \textbf{(1)}$$

The wood dust particle concentration was measured by

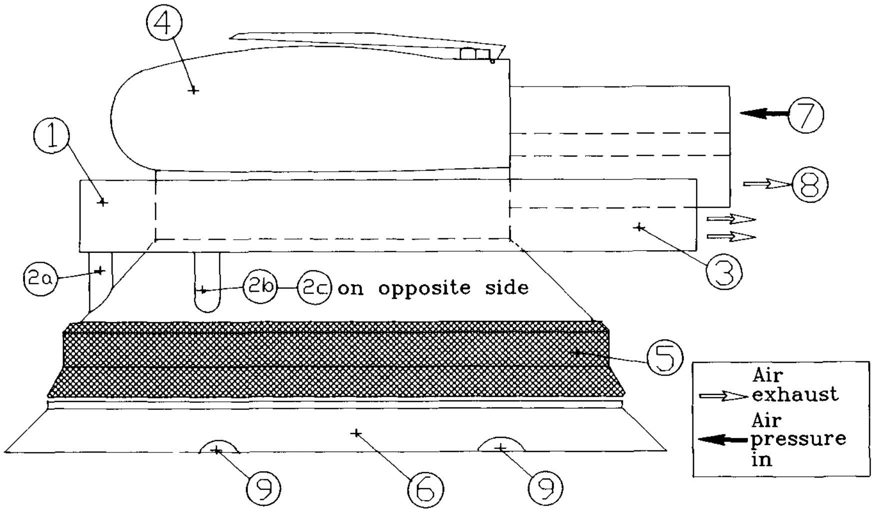

FIGURE 2b. Location of new control system. Legend: exhaust tube, 1; inlet tubes, 2a, 2b, and 2c; outlet tube, 3; sander body, 4; shroud, 5; sanding pad, 6; compressed air inlet, 7; compressed air exit, 8; curved slots, 9.

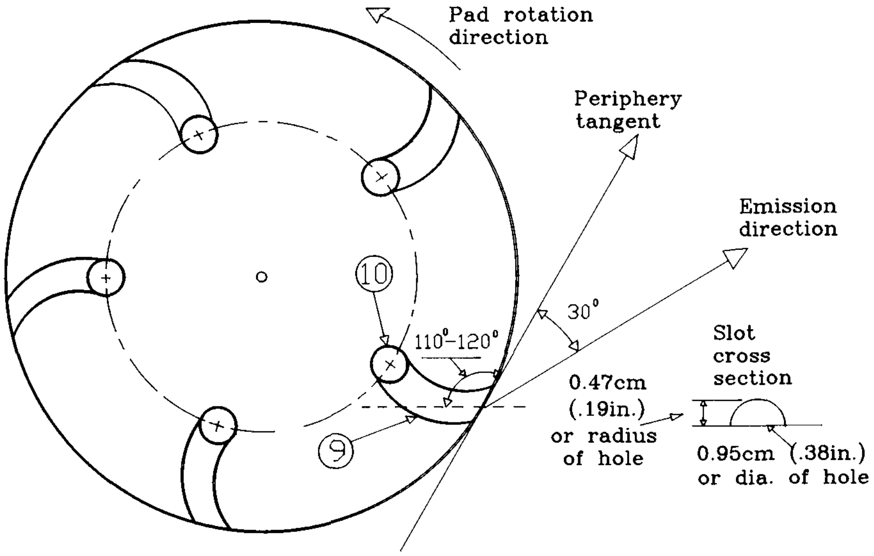

FIGURE 3. Diagram of slotted pad. Legend: curved slots, 9; standard pad holes, 10.

a light-scattering analyzer (Climet Instrument Co., Model CL-208A). The output signal from the particle analyzer was measured by a multichannel analyzer (Tracor Northern Co., Model TN 1710). Since the particle concentrations were collected under the same sampling conditions, error caused by anisokinetic sampling was minimized.

To simulate the operator's activity during measurements, the sander was firmly held in a stationary position while the sanded wood was moving. This motion was initiated by a specially designed device enabling simultaneous movement of the wood in the x and y directions at different speeds (Figure 4). This arrangement allowed:

- Simulation of the operator's sanding motion.
- Sanding at a constant pressure.
- Sampling the emissions at fixed positions.

For the laboratory experiments, the following sampling method was used. First, the background particle concentration was measured without sanding. Then, the sander was started. Since the particle cloud was unstable at the beginning of the sanding, sampling was initiated 60 seconds after the sanding was started. The wood dust was sampled 12 times in sequence for each sampling set at 20-second intervals at each sampling position. Generally, two to three sampling sets were measured. All data were corrected for background. Due to the variability of the dust emissions during sanding, the samples were collected in two directions at a distance of 2.5, 15.2, and 30.5 cm (1, 6, and 12 in.) from the disc pad periphery and 2.5 and 7.6 cm (1 and 3 in.) above the sanded surface. Location of sampling positions is shown in Figure 5.

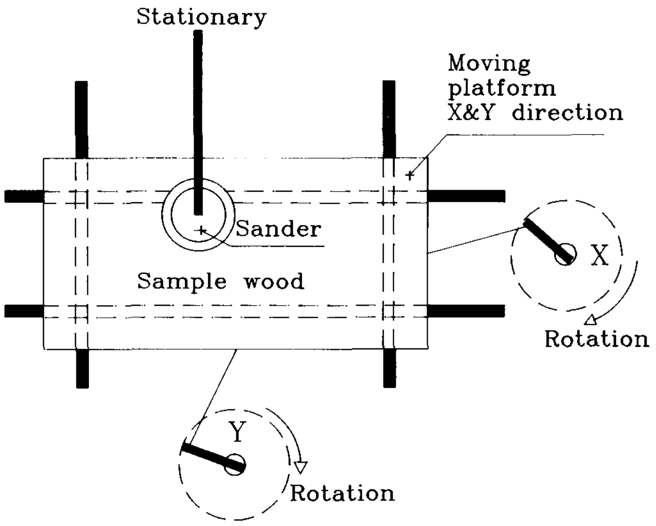

FIGURE 4. Diagram of sanding equipment.

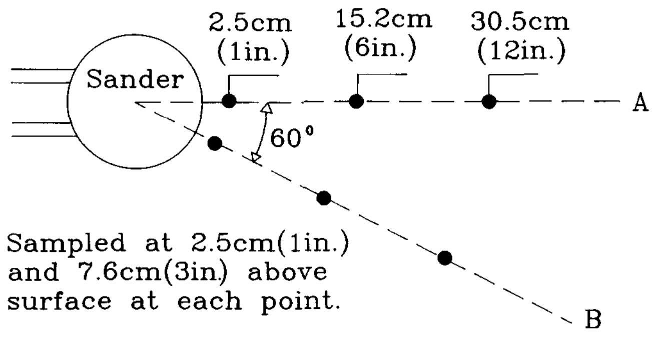

FIGURE 5. Laboratory sampling location.

The effect of the additional vacuum on the concentration of the dust particles emitted from the sander equipped with the designed control is shown in Table I.

The performance of the newly designed control compared with the aspirator control is indicated in Table II, where the average relative reduction (RD) of over 90 percent obtained at different sampling locations is shown.

Field Experiments

Field tests were conducted at an operation where wooden

TABLE I. Average Particle Number Concentration Emitted Per Time Unit at Different Suction Parameters (Standard Deviation in Parentheses)

Vacuum in cm Water Gauge (in. w.g.)			
2.5 (1 in.)*	12.7 (5 in.)	25.4 (10 in.)	38.1 (15 in.)
250,360 (166,170)	156,520 (29,439)	5580 (2140)	3480 (2360)

Average laboratory data collected at all sampling locations.
*No additional exhaust; vacuum originated by aspirator.

TABLE II. Average Relative Reduction (RD) in Wood Dust Particles at Various Distances from Sander (Standard Deviation in Parentheses)

Reduction (%)			
2.5 cm (1 in.)	15.2 cm (6 in.)	30.5 cm (12 in.)	Sampling Direction
99.1 (0.6)	99.0 (0.7)	98.7 (0.7)	A*
97.4 (2.5)	97.9 (1.5)	97.2 (2.2)	B*

Newly designed control operated at 25.4 cm H_2O (10 in. H_2O) of vacuum.
*See Figure 5.

chests of different sizes and wood types were sanded. During sanding, the chests moved on a conveyor belt passing around the operator. During the field test, the following measurements were conducted:

- Particle concentration measurements using a light-scattering photometer (Climet, Model 208A).
- Particle mass measurements using a near-infrared-scattering photometer (Hand-Held Aerosol Monitor [HAM], Model 1055, ppm, Inc., Knoxville, Tennessee).
- Area and personal particle mass measurements using membrane filters.

Location of the samplers is schematically shown in Figure 6. During sampling, the sanding operation under investigation was separated from nearby sanding operations by two plastic partitions. The purpose of these partitions was twofold:

- To minimize the effect of incident wood dust originated by nearby sanding operations on the measurements.
- To allow the operator to sand only within the confines of the partitions where the samplers were located.

The partitions contained special openings to allow movement of the chests. For the tests, all necessary equipment was affixed to the sander so that it could be used either with the standard perforated sanding pad and the aspirator or with the newly designed control consisting of the additional vacuum system and the slotted sanding disc pad.

Results on average RD of 80 percent in wood dust emissions, calculated from Equation 1, are shown in Table III. The wood dust concentration data from area and personal membrane filter sampling, expressed in mg/m^3, are shown in Tables IV and V, respectively.

Discussion of Results

As shown previously and demonstrated in Figure 7, the system consisting of the aspirator and the perforated pad did reduce the wood dust emissions compared to the emissions from the uncontrolled sander. However, a substantial amount of particles was still emitted into the work area. This is due to the insufficient suction power of this control technique. During the laboratory experiments, it was found that the aspirator system only created a vacuum of approximately 5 cm water gauge (w.g.) (approximately 2 in. w.g.). Increasing the vacuum power with an additional suction source caused difficulties in the sanding operation.

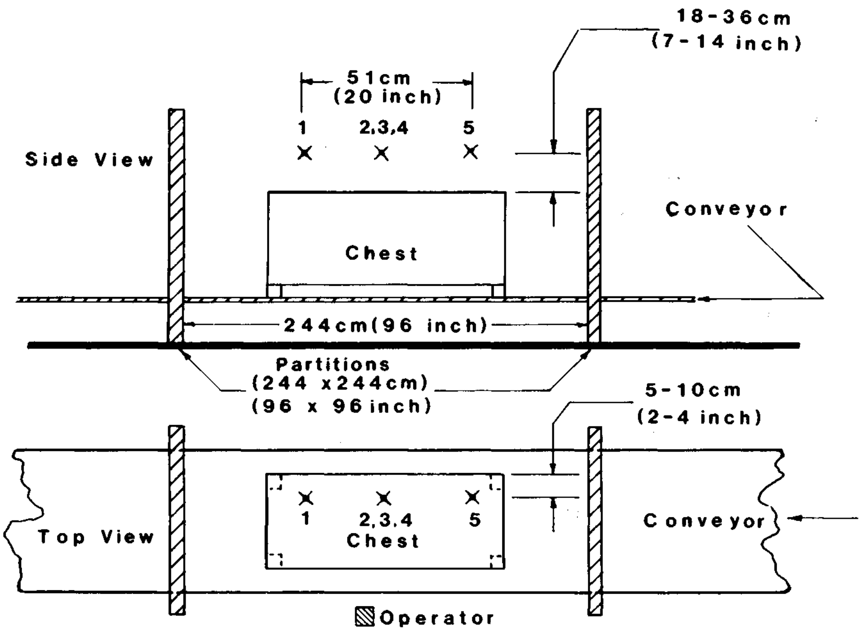

FIGURE 6. Sampling location diagram. Legend: Membrane filter, 1 and 5; Climet, 2; and Hand-Held Aerosol Monitor (HAM), 3 and 4.

TABLE III. Relative Reduction in Wood Dust Emission (%) (Average Field Test Data–Standard Deviation in Parentheses)

	Sampling Position						
	1	2	3	4	5	Personal	Remarks
Day 1	84.7 (8.3)	83.1 (3.7)	91.1 (3.2)	90.1 (8.7)	85.5 (12.4)	79.8 (15.4)	
Day 2	72.7 (1.7)	69.1 (5.6)	73.6 (6.0)	81.7 (9.4)	67.0 (21.0)	65.8 (10.6)	Loose particles on filters collected at standard control. Sampling may be affected by nearby sanding operation.
Day 3	76.9*	78.9 (5.7)	89.2 (3.3)	89.9*	79.6*	82.6*	Sanding interrupted or stopped very often during sampling.

*Standard deviation not calculated due to insufficient number of data.

TABLE IV. Particle Mass Concentration in mg/m³ Area Sampling: Membrane Filter Field Test Data

	Position						
	1 Control		4 Control		5 Control		
	Aspirator	Combined	Aspirator	Combined	Aspirator	Combined	Remarks
Day 1	11.81	1.14	8.68	0.09	15.45	1.00	
	8.91	2.50	7.60	0.97	7.53	1.77	
	7.30	0.65	1.66*	0.57	2.30*	0.90	
Day 2	5.19	1.27	5.57	0.74	2.37	1.05	Loose particles on filters collected at standard control. Sampling may be affected by nearby sanding operation.
	4.66	1.28	2.36	1.09	2.49	1.50	
	4.23		7.30		6.79		
Day 3	6.51	1.27	7.02	0.59	9.06	1.54	Sanding interrupted or stopped very often during sampling.
	4.50		4.61		6.01		

*Data related to oak dust.

The sander was pressed to the sanded surface, and it was difficult to use, particularly when a flat surface was sanded.

TABLE V. Particle Mass Concentration in mg/m³ Personal Sampling: Membrane Filter Field Test Data

	Aspirator Control	Combined Control	Remarks
Day 1	8.07	1.52	
	8.56	1.33	
	0.91*	0.68	
Day 2	4.25	1.08	Loose particles on filters collected at standard control. Sampling may be affected by nearby sanding operation.
	3.43	1.71	
	4.59		
Day 3	2.70	0.36	Sanding interrupted or stopped very often during sampling.
	2.06		

*Data related to oak dust.

The newly designed slotted sanding pad relieved this pressure. In addition, this sanding pad also captured the wood dust remaining on the sanded surface at its periphery which was not observed when only the perforated pad was used. This dust was not collected by the perforated pad but was re-aerosolized by the operator's repetitious movements and emitted into the work area. An angle of 110–120 degrees between the longitudinal slot axis at the slot opening and the pad periphery tangent was found to be most efficient regarding dust capture (Figure 3).

The increased vacuum power, in combination with the described sanding pad, significantly reduced the amounts of particles emitted into the laboratory (Table I and Figure 8). The straight line in Figure 8 was calculated using the least squares method. As evident from this table and figure, a typical average particle concentration of 250,000 was reduced down to an average concentration of 5000 particles emitted when a higher suction was applied. There was no statistical difference calculated from 95% confidence intervals between the results obtained at the vacuum of

25.4 and 38.1 cm w.g. (10–15 in. w.g.). This may indicate that the new control may be used at the vacuum of 25.4 cm w.g. (10 in. w.g.) to achieve adequate control performance. This vacuum was easily achieved by a standard industrial vacuum cleaner used for both the laboratory and field tests.

As evident from Table II, a significant reduction (over 90%) in wood dust emissions compared to the emissions from the aspirator-controlled sander was achieved in the laboratory at all sampling points and both sampling directions A and B (Figure 5).

The field test confirmed the laboratory results (Table III). An average relative reduction in wood dust emissions of 70–90 percent was achieved for all area and personal sampling during the field tests. The vacuum applied during the field tests was approximately 20 cm w.g. (8 in. w.g.) resulting in a concentration range of 18,000–45,000 particles emitted. As is evident from Figure 8, this range is in very good agreement with the laboratory data for a given suction. This was the highest achievable vacuum which could have contributed to somewhat lower reduction in dust emission compared with the performance achieved in the laboratory of the designed control.

During the field tests, normal plant working activity continued; therefore, the sanding operation could not be isolated. This made the field tests very difficult. During sampling, the chests were located on a moving conveyor belt. Consequently, the operator could not remain stationary and very often changed his position. Because it was impossible to move the samplers along with the chests, the samplers were located in a fixed position within the confines of the plastic partitions. This arrangement limited, to some extent, the operator's movement. In spite of these partitions, the operator very often started sanding too far from the samplers. The sampling was also affected by emissions from nearby sanding operations. The adjacent operator often sanded very close to the outside partition wall allowing dust to pass through the opening in the partition. Since the relative reduction, as defined, is a ratio of wood dust amount with the designed control operating to the amount with the aspirator control operating, these activities also may contribute to lowering the reduction of the wood dust emissions.

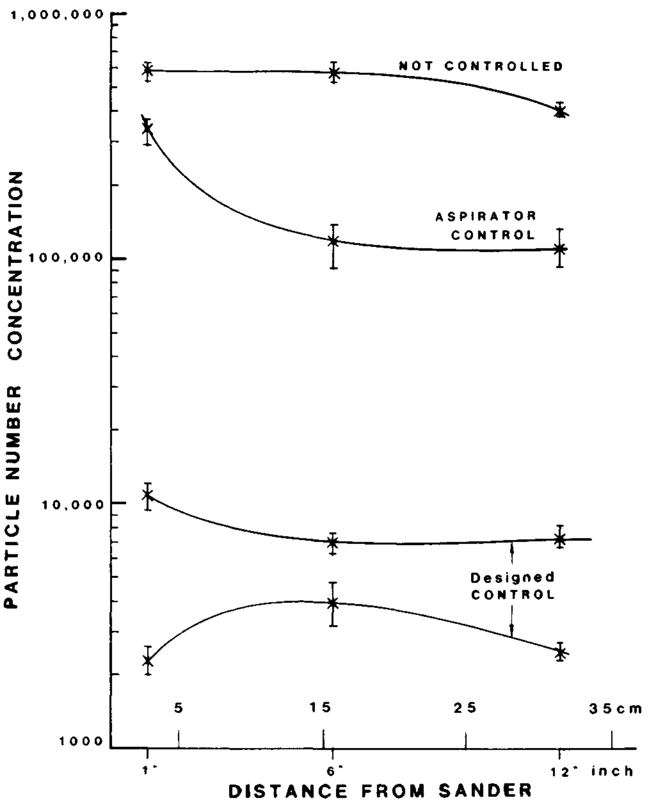

FIGURE 7. Typical particle number concentration versus distance from sander (laboratory experiments).

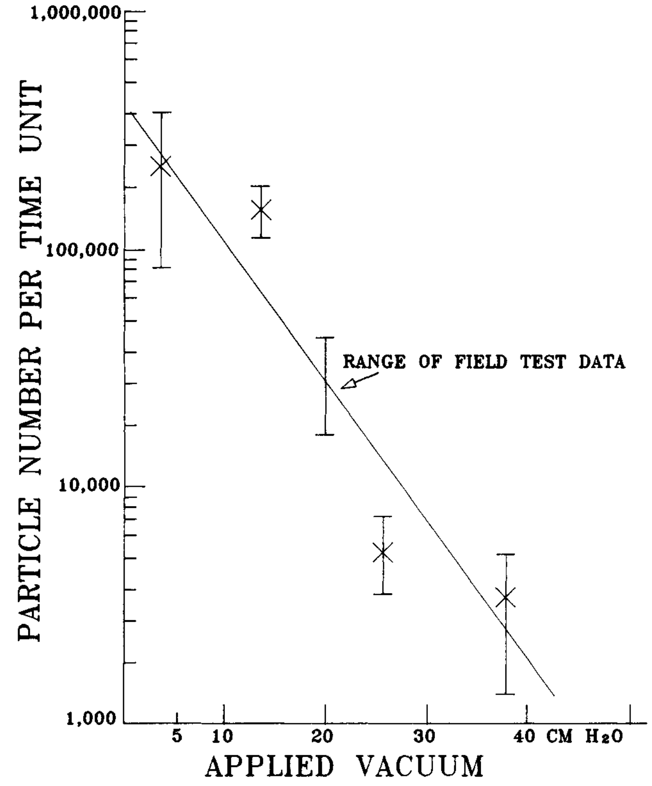

FIGURE 8. Average particle number at different vacuum parameters (laboratory experiments).

It also should be noted that the membrane filter sampling was conducted over a variable time period according to our research needs and may differ from the time used for the sampling method recommended by NIOSH.[14] Nevertheless, the test results show that the new control is very efficient and could be a very useful tool for reduction of wood dust emissions from hand-held sanders.

With the described control operating, the wood dust concentration at the sampling locations and in the breathing zone of the operator was reduced well below the Occupational Safety and Health Administration permissible exposure limit of 5 mg/m^3[15] down to 1 to 2 mg/m^3 as demonstrated in Tables IV and V. It should be noted that these data were obtained during sanding of a mixture of various wood types, such as pine, poplar, maple, and cherry. The oak emission data are labeled by an asterisk to emphasize a very low emission rate of the oak dust.

Since the emphasis of this research was oriented toward collection efficiency, a detailed cost analysis of that ventilation system was not generated. However, cost data on the development of the prototype system is available: cost of material was $60; cost of labor was $360 (30 hours at $12 per hour). The industrial production of these devices would be more economical. The cost for an industrial vacuum cleaner would also be part of the instrument costs. However, experience from visits to woodworking facilities indicates that these vacuum cleaners are generally available and used in most of these facilities.

Conclusions

A control system was developed and evaluated for the control of wood dust emissions from rotational, hand-held sanders. This system included an exhaust system installed on an aspirator-controlled sander and a specially designed slotted sanding disc pad. This sanding pad not only relieves the pressing of the sander to the sanded surface caused by the increased vacuum but also captures wood dust from the sanded surface directly at the pad periphery. This system can also be used for electrically powered, rotational, hand-held sanders not controlled by an air aspirator. In the laboratory, the described control reduced total wood dust emissions by over 90 percent, compared with emissions from the aspirator-controlled sanders. The laboratory data were verified by field tests conducted at a hand-sanding operation. The field tests data were in excellent agreement with the laboratory results and confirmed that this system is very effective. The control system could be a useful tool for reducing wood dust emissions from hand-held sanders. The control system has the following advantages:

- It significantly reduces wood dust emissions into the work area.
- It does not interfere with the operator's activity.
- It can be used for both air-powered and electrically powered sanders.
- It is inexpensive to commercialize and operate.

Acknowledgment

The authors wish to acknowledge the management of The Lane Company, Altavista, Virginia, for their cooperation during the field demonstration portion of this research.

References

1. Tatken, R.: Health Effects of Exposure to Wood Dust: A Summary of the Literature. National Institute for Occupational Safety and Health. Cincinnati, OH (June 1987).
2. Scheidt, R.; Bartsch, R.: Risk of Nasal Cancer Following Occupational Exposure to Wood Dust: A Review. Zbl. Arbeitsmed. 39:315–320 (1989).
3. Bolm-Audorf, U.; Vogel, C.H.; Horowitz, H.J.: Berufliche und ausserberufliche Risikofaktoren von Nasen—Rachentumoren. Staub–Reinhaltung der Luft 49:389–393 (1989).
4. Hampl, V.; Johnston, O.E.: Control of Wood Dust from Horizontal Belt Sanding. Am. Ind. Hyg. Assoc. J. 46(10):567–577 (1985).
5. Huebener, D.J.: Dust Controls for a Wood Shaper. Appl. Ind. Hyg. 2(4):164–169 (1987).
6. Hampl, V.; Johnston, O.E.; Topmiller, J.L.; Murdock, Jr., D.J.: Control of Wood Dust from Automated Routers. Appl. Ind. Hyg. 5(7):419–427 (1990).
7. Hampl, V.; Johnston, O.E.: Control of Wood Dust from Disc Sanders. Appl. Occup. Environ. Hyg. 6(11):938–944 (1991).
8. Quintana, P.: U.S. Patent No. 3,646,712 (March 7, 1972).
9. Rúdiger, G.: U.S. Patent No. 4,135,334 (January 23, 1979).
10. Tanner, J.G.: U.S. Patent No. 4,765,099 (August 23, 1988).
11. Hutchins, A.A.: U.S. Patent No. 3,785,097 (January 15, 1974).
12. Huber, P.W.: U.S. Patent No. 4,531,329 (July 30, 1985).
13. Sioux Tools, Inc.: Catalogue No. 901 (1990).
14. National Institute for Occupational Safety and Health: NIOSH Manual of Analytical Methods, 3rd ed. P.M. Eller, Ed. DHHS (NIOSH) Pub. No. 84-100; NTIS Pub. No. PB-85-179-018. National Technical Information Service, Springfield, VA (1984).
15. U.S. Department of Labor, Occupational Safety and Health Administration: Title 29, Code of Federal Regulations, Part 1910, Air Contaminants; Final Rule. Fed. Reg. 54(12):2957 (January 19, 1989).

Received 5/21/91; review decision 7/15/91; accepted 9/17/91