SURVEY REPORT: AN ENGINEERING CONTROL EVALUATION FOR REDUCING EXPOSURE TO REFRACTORY CERAMIC FIBERS DURING SANDING

**Conducted at Fireline, Inc.
Youngstown, Ohio**

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REPORT DATE
April 2003

FILE NO
EPHB 246-11a

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Centers for Disease Control and Prevention
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STUDY SITE.	FIRELINE, Inc Youngstown, Ohio
SIC CODE	3299
STUDY DATES	November 5, 2002
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DISCLAIMER

Mention of company names and/or products does not constitute endorsement by the Centers for Disease Control and Prevention (CDC)

INTRODUCTION

On November 5, 2002, the National Institute for Occupational Safety and Health (NIOSH) conducted an engineering control evaluation at Fireline, Inc in Youngstown, Ohio Fireline developed a local exhaust ventilation system to capture and collect airborne refractory ceramic fibers (RCF) during the sanding of vacuum-formed parts This system was installed on a disc sander and was evaluated by NIOSH along with representatives from the RCF manufacturer, Unifrax Corporation The primary objective of the study was to determine the operating conditions and effectiveness of the engineering control which was designed and incorporated into the sanding process

BACKGROUND

Fireline Inc , is a small company that manufactures vacuum formed ceramic fiber parts At the time of the survey, 67 workers were employed, 50 of these employees work in the plant while 17 work in the office Fireline operates on a 3 shift basis with most workers (34) on the first shift The sanding area is staffed 24 hours a day by one worker with an additional worker packing the material for shipment

The manufacturing of various RCF products is composed of a number of tasks including, forming the part, drying, and finishing the part through sanding, sawing or other processes to meet the customer specifications Fireline purchases refractory ceramic fiber in bulk and vacuum forms the materials into various shapes as specified by the customer Brass screened dies with perforated screen re-enforcements are made for the various shapes that are ordered The die is mounted on the appropriate dip machine The operator uses a foot pedal activated control switch to lower the die into the ceramic fiber slurry tank A limit switch is triggered when the die reaches the bottom of the tank to activate the vaccum A timer activates a switch to remove the die from the slurry tank after the part has been formed around the die The operator sets the timer for the appropriate amount of time needed to form the part When formed, the operator removes the ceramic fiber part by hand from the die and places them into trays The tray of parts is then placed onto a conveyor belt and is dried in a radio wave oven After drying, the parts are transferred to the sanding station Once sanded, the part is removed from the station, inspected and packed into a cardboard tray for shipping All RCF parts are finished on the disc sander

PROCESS/ENGINEERING CONTROL DESCRIPTION

Disc Sander/Engineering Control Description

A floor-standing disc sander made by Fireline was used for evaluation The sanding wheel was 20 inches in diameter and operated at a speed of 1150 revolutions per minute (rpm) The zirconium 50 grit paper was manufactured by Arc Abrasive (Troy, Ohio) The pedestal disc sander was outfitted with a local exhaust ventilation (LEV) system (see Figures 1 and 2) An aluminum shroud was constructed which enclosed the entire disc with only a small cutout opening to allow for the part to be sanded The opening in the shroud is adjustable to allow for the sanding of parts of various dimensions The part used for evaluation was a ceramic fiber sleeve which houses and protects an instrumentation probe used to test process parameters, such as temperature of molten metals, in foundry operations The RCF sleeve was approximately 2 inches diameter and 4 inches in length

A ventilation duct take-off is located on the lower rear of the sander and uses a 6-inch flexible duct and connects into an aluminum rigid main exhaust duct which provides exhaust outlets for other workstations within the plant A pitot tube traverse was performed in the 6 inch rigid duct to determine the exhaust air flow rate for the shroud system The velocity in the duct was measured to be 5,400 feet per minute yielding an overall exhaust flow rate of 1,060 cubic feet per minute

Process Description

The sanding process is partially automated and is performed according to the following steps

1) The operator pulls the unfinished part from a box and places the part on a spindle by hand
2) The operator uses a foot pedal to activate a pneumatic air cylinder that causes the spindle to rotate driving the part into the sanding wheel
3) The part is sanded to the desired dimensions and the spindle returns to the initial position
4) The part is removed from the spindle and packed by hand in a box for inspection and shipping

The cycle time controls the amount of time that the part is in contact with the sanding wheel and is adjustable by the operator This adjustment allows the operator to work at a pace that is comfortable and efficient The cycle time used during the trial runs was 1 7 seconds while the typical cycle time used by an experienced operator is 0 75 seconds

METHODS

Evaluation of the Effectiveness of the Control

Three trials were conducted both with the exhaust ventilation system on (a k a control-on) and with the system off (control-off) The same operator was used in each trial to minimize variability between trials Each control-on trial lasted for approximately 10 minutes allowing the operator to sand between 88 and 92 parts When the control was turned off, the trial duration was shortened to 5 minutes and 46 pieces due to concern for overloading the sample filters The control-off runs were conducted after first shift when the work area was vacated Following the completion of each run, the ventilation system was turned on and the area was cleaned using a HEPA vacuum to minimize contamination between runs The ambient air dust concentration was monitored using a Met One, model 227B, hand-held particle counting instrument manufactured by Pacific Scientific Instruments (Grants Pass, OR)

The Met One was used to determine when ambient dust concentrations had reached background levels prior to initiating a new trial

Personal and Area Sampling

Personal samples were collected using SKC Inc Airchek 2000 model 210-2002 sampling pumps (Eighty Four, PA) Since concentrations were not known a priori, 2 personal samples were collected on the operator at flow rates of 2 and 3 liters per minute (lpm) This was done to collect a quantifiable amount of fibers while attempting to minimize the possibility that the filters would be overloaded An area sample located close to the process was collected at a flow rate of 15 lpm using a Gilian (West Caldwell, NJ) Aircon 2 high-volume air pump (see Figures 3 and 4) Personal and area samples for fibers were collected on 25 millimeter (mm) diameter, mixed cellulose ester, 0 8 μm pore size filters The samplers were 3-piece cassettes with a 50 mm electrically conductive extension cowl Samples were analyzed for fibers by phase contrast microscopy according to NIOSH Method 7400, "B" counting rules[1]

RESULTS

The results for the individual samples are shown in Table I The differences between the personal samples collected at each of the given sample flow rates (2 or 3 lpm) were minor and did not affect the estimates of reduction The personal breathing zone average concentration decreased from 44 fibers/cubic centimeter (f/cc) with the control-off to 0 35 f/cc with the control-on Figure 5 shows the average fiber concentrations measured on the lapel and the associated standard deviation for the control-on and control-off trials

DISCUSSION

The pedestal disc sander operation is used frequently in RCF processing to obtain a desired product dimension In disc sanding, the surface of the RCF workpiece is abraded to yield the proper profile The friction between the wheel/belt and the workpiece results in the release of particles and fibers from the workpiece These particles are ejected at high speeds along a path tangential to the rotation of the wheel The respirable particles, if not captured, could be carried into the breathing zone of the worker resulting in exposure to the RCF fibers and dust particles

The use of a nearly completely enclosing shroud along with an exhaust flow rate of approximately 1000 cfm reduced the operator exposure by 99% (lower 95% Confidence Interval = 99%) Following the completion of the control-on runs, a worker was sampled for a period of 47 minutes (see Table I) The personal breathing zone concentration for the worker measured during this period was 0 25 f/cc The results of this sample showed that the control was very effective at reducing the fiber concentration in the personal breathing zone even at the much higher production rate of part processing (30 parts per minute for the worker versus 9 parts per minute for the experimental runs)

The exhaust flow rate of 1,000 cfm used is higher than that specified by the Industrial Ventilation Manual which recommends an exhaust flow rate of 550 cfm for an 18-26 inch diameter sanding disc (design plate VS-95-12)[2] However, this system was evaluated while other LEV systems which are also served by the same exhaust fan were not in operation It is important to consider the impact of the reduced flow rates that will be encountered when more than one LEV system are operating simultaneously Reportedly, only one operation uses the ventilation system during a typical day However, if more than one workstation requiring the use of the ventilation system is operated at the same time as the disc sanding operation, a further evaluation should be conducted The use of more than one workstation at one time will reduce the airflow rate to each individual workstation and may result in reduced collection efficiency or inadequate duct transport velocity

CONCLUSIONS AND RECOMMENDATIONS

Engineering controls can be manufactured and installed on standard disc sanders and can significantly reduce operator exposure However, a key to their effectiveness is that the system must be designed and maintained properly Thorough system checks should be performed periodically to verify that the system is operating as designed These checks should include visual inspection of the work area and the ducting to check for any damage to the shroud or ducting The work area should be kept clean and the ducting should be checked for settled fibers and dust Fibers and dust build-up in the ducts are signs of inadequate transport velocity Also, checks of static pressure and duct flow rates should be performed and compared to the values specified in the ACGIH Ventilation Manual The most pertinent evaluation of system performance is the measurement of worker exposure Worker exposure to RCF materials should continue to be monitored on at least an annual basis to verify that the system is continuing to provide good control of airborne fibers

Engineering controls provide an effective method for reducing worker exposure to RCF fibers The implementation of engineering controls can have a beneficial impact on worker exposure The implementation of a LEV system as described in this paper reduced the operator exposure by two orders of magnitude The development and test of well-designed LEV control systems can provide valuable information to the large number of customers/end users of RCF materials

ACKNOWLEDGMENTS

The authors gratefully acknowledge Ms Barbara Burley of Fireline, Inc for her cooperation and support during this evaluation We would also like to acknowledge Mr Robert Vitucci of Fireline for his work in developing the engineering control utilized in this evaluation In addition, we would like to thank Mr Dean Venturin of Unifrax Corporation for his help in conducting this evaluation and his continued efforts in working with NIOSH to highlight the importance of using engineering controls to minimize exposures in the RCF industry

REFERENCES

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[2]**ACGIH (2001).** Industrial Ventilation A Manual of Recommended Practice 24th Ed Cincinnati American Conference of Governmental Industrial Hygienists (ACGIH), 2001

Table I Airborne RCF Sample Results

Run no.	Control Status	Sample Location	Flow Rate (lpm)	Elapsed Time (min)	No of Pieces Processed	Concentration (f/cc)
1	On	Lapel	2	10	88	0 65
1	On	Lapel	3	10	88	0 59
1	On	Area	15	10	88	0 36
2	On	Lapel	2	10 68	92	0 22
2	On	Lapel	3	10 68	92	0 28
2	On	Area	15	10 68	92	0 11
3	On	Lapel	2	9 5	92	0 22
3	On	Lapel	3	9 5	92	0 16
3	On	Area	15	9 5	92	0 12
Worker	On	Lapel	3	47	1440	0 25
4	Off	Lapel	2	4 3	46	37 92
4	Off	Lapel	3	4 3	46	35 28
4	Off	Area	15	4 3	46	
5	Off	Lapel	2	4 41	46	50 20
5	Off	Lapel	3	4 41	46	36 99
5	Off	Area	15	4 41	46	
6	Off	Lapel	2	4 333	46	53 05
6	Off	Lapel	3	4 333	46	Overloaded
6	Off	Area	15	4 333	46	Overloaded

Figure 1 Disc Sander with Shroud and Un-Sanded Ceramic Sleeve Part

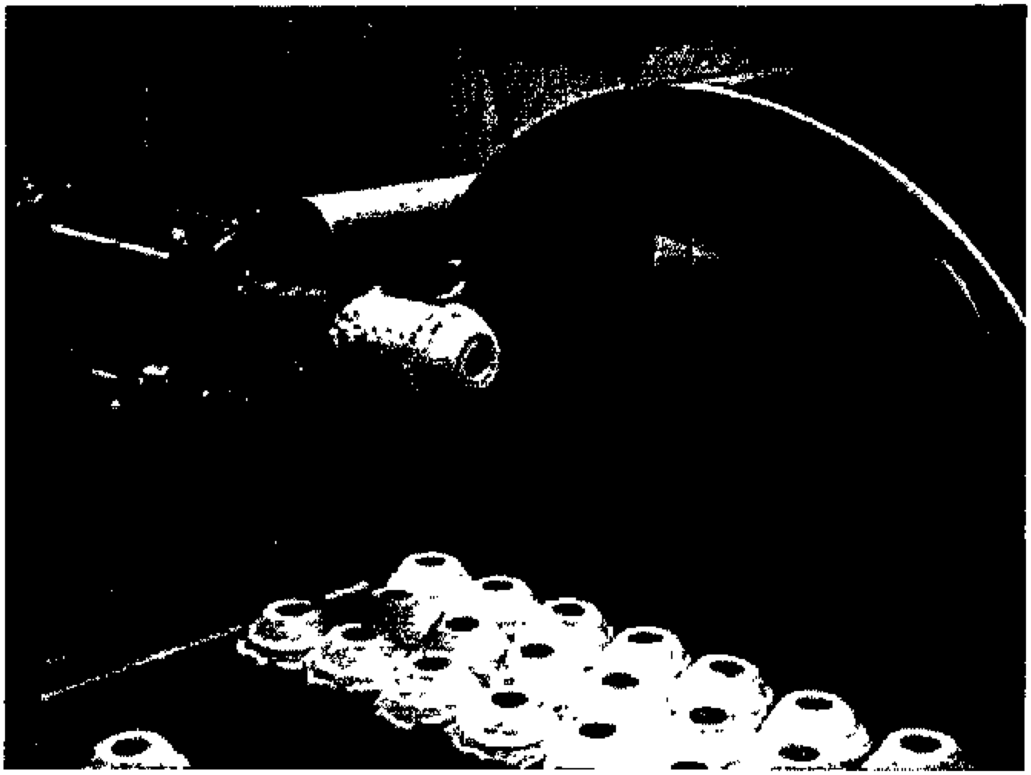

Figure 2. Sketch of Disc Sander with Ventilation System Details

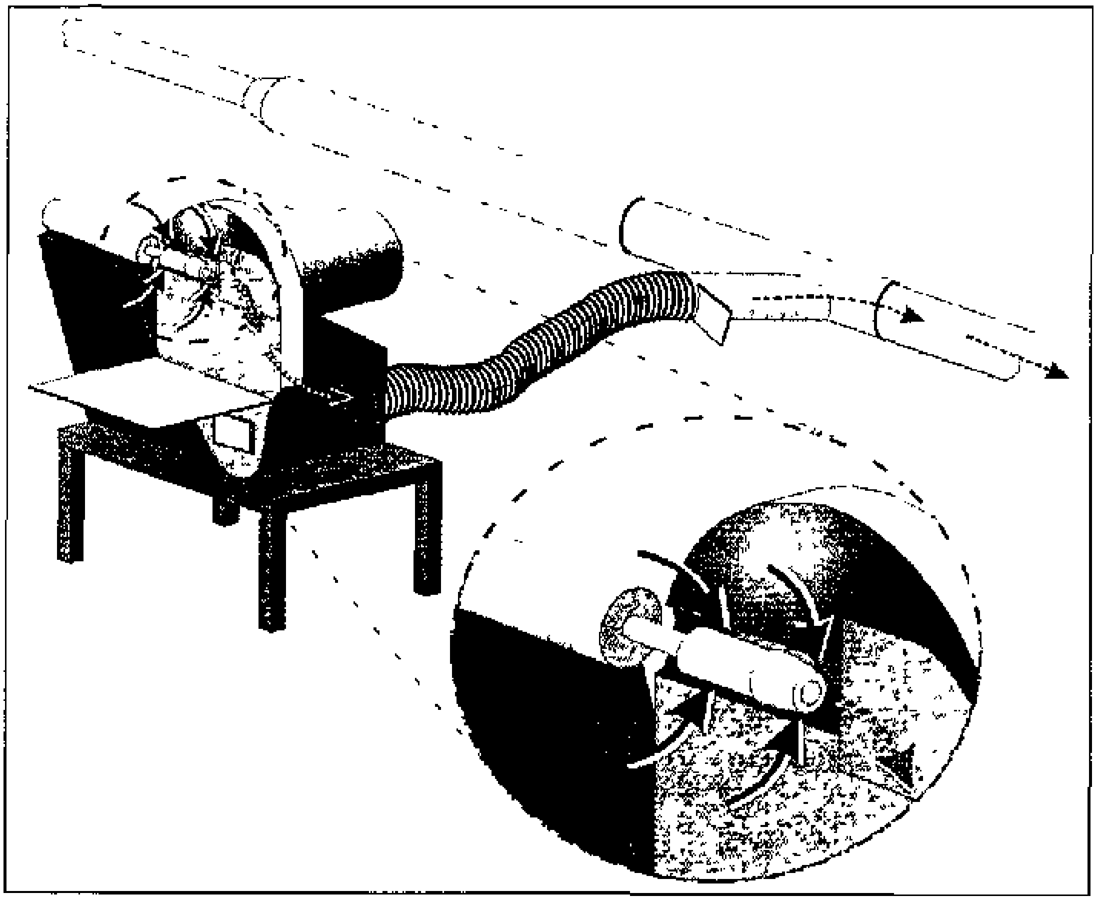

Figure 3 Sketch of Worker and Air Sampler Orientation During Trial Runs

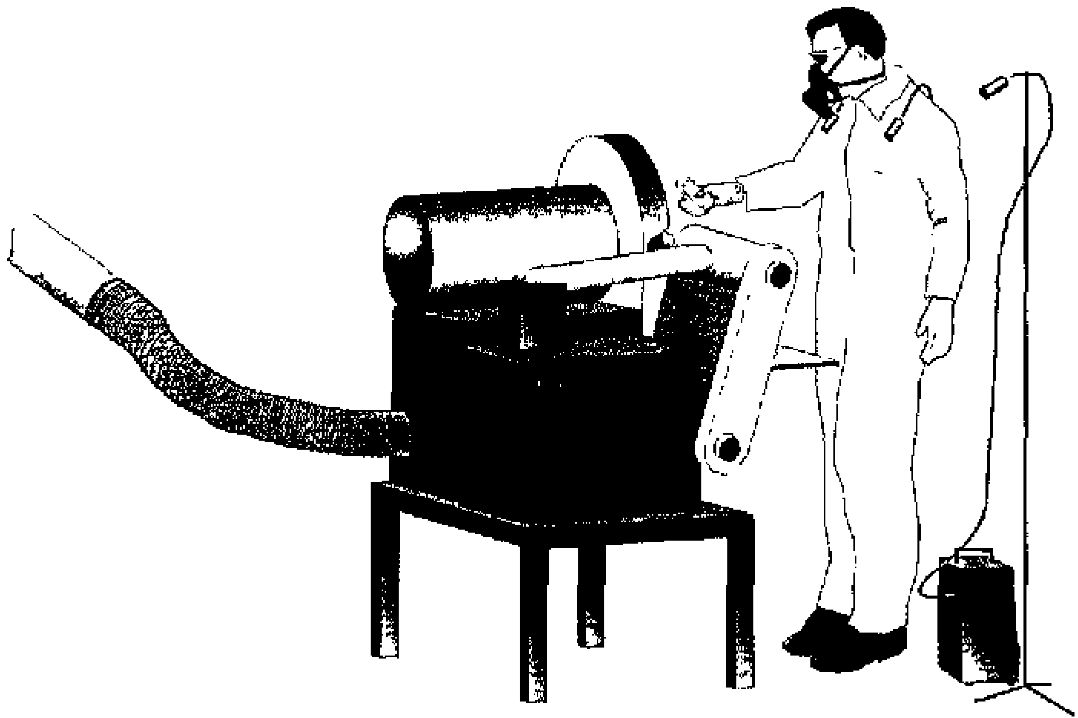

Figure 4 Photo of Trial Runs with Area and Personal Samplers during a Control-Off Run

Figure 5. Comparison of average personal RCF concentrations for control-on and control-off runs