International Union of Operating Engineers
National Hazmat Program

Human Factors Assessment Report

Porter-Cable Circular Saw
OENHP #: 2001-04, Version A

Report Issued: January 2002

International Union of Operating Engineers National Hazmat Program
International Environmental Technology and Training Center

Human Factors Assessment Report

Frank Hanley, General President

The OENHP would like to thank the following team members for their participation in this assessment and for the professional expertise they provided:
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Porter-Cable Circular Saw
(OENHP #: 2001-04, Version A)

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1.0 EXECUTIVE SUMMARY

Florida International University's (FIU) Hemispheric Center for Environmental Technology (HCET) evaluated five saws for their effectiveness in cutting specially prepared fiberglass-reinforced plywood crates. These crates were built as surrogates for crates that presently hold radioactively contaminated glove boxes at the Department of Energy's (DOE) Los Alamos facility. The Porter-Cable circular saw was assessed on August 15 - 16, 2001 (Porter-Cable #1 and Porter-Cable #2, respectively). During the FIU test of efficacy, a team from the Operating Engineers National Hazmat Program (OENHP) evaluated the occupational safety and health issues associated with this technology.

The Porter-Cable saw is a straightforward machine for cutting wood of varying thickness. The blade is fully guarded with a fixed upper and a lower retractable guard. The lower guard retracts as the blade engages the work piece. The unit is operated with an on/off guarded trigger switch and is supported with a handgrip mounted near the front of the saw. The saw is equipped with a directional nozzle, which aims sawdust away from the operator and the line of cut. An optional vacuum system, attached to the directional nozzle, is used to remove and collect dust.

During the demonstration of Porter-Cable #1, personal noise sampling indicated that one worker was under and one was at the Occupational Safety and Health Administration's (OSHA) Action Level of 85 decibels (dBA) with time-weighted averages (TWA's) of 82.7 and 84.6 dBA, respectively. During the demonstration of Porter-Cable #2, however, both workers did exceed the Action Level with TWA's of 89.7 and 90.0 dBA. These data are not entirely representative as they were gathered during a simulation and not at the actual worksite. Additional sampling should be conducted on-site, but the workers should wear hearing protection until it is determined that it is no longer necessary.

The total nuisance dust sample for Porter-Cable #1 was 3.53 milligrams per cubic meter (mg/m^3, which is lower than the OSHA Permissible Exposure Limit (PEL) of 15 mg/m^3 and the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Value (TLV) of 10 mg/m^3. Porter-Cable #2's nuisance dust results yielded a value of 22.05 mg/m^3, which is over the PEL and TLV. The fiber analysis for the first demonstration yielded 12.9 fibers per cubic centimeter (f/cc), which is much higher than the PEL of 1 f/cc. Galson Laboratories considered the fiber analysis for the second demonstration void due to the overloading of dust on the filter.

Kickback, the sudden reaction to a pinched blade, is possible with this saw and could cause the saw to lift up and out of the work piece and toward the operator. Proper work position and firm control of the saw minimizes the potential for a sprain or strain. Care needs to be exercised to support the work piece properly and to not force the tool.

2.0 INTRODUCTION

2.1 OENHP Safety and Health Assessment

On August 15 and 16, 2001, three safety professionals from OENHP performed the human factors assessment in a containment called a PermaCon facility located in the high bay building at FIU located at 10555 West Flagler Street, Miami, Florida, 33174. Team members included John Kovach, Jeana Harrison, and Aaron Ondo.

The PermaCon is equipped with dual-hinged panels for access, two standard doors with stainless steel covering on the inside face, two type A transfer panels, two make-up air inlets, five windows on the side panels, and ten portals on the roof to allow for external lighting. The PermaCon dimensions are 20 x 16 x 12 feet. A portable High Efficiency Particulate Air (HEPA) filtration unit is connected to rear air outlets to generate negative pressure in the PermaCon during evaluations. The HEPA filtration unit draws 1,720 cubic feet of air each minute (cfm) at 1-inch static pressure (sp) water gauge (wg) and 1,060 cfm at 9 inches sp wg. HEPA unit efficiency is 99.97 percent for 0.3-micrometer particles.

2.2 Technology Description and Operation

The Porter-Cable circular saw (model number 743) was tested on a specially prepared, 4 x 4 x 8 foot fiberglass-reinforced plywood crate at FIU in August 2001. In conjunction with FIU's evaluation of efficiency and cost, this report covers the hazard analysis and safety evaluation that the OENHP conducted during the test. The Porter-Cable saw was tested on two separate days due to the overheating of the saw used on August 15th (Porter-Cable #1). A second saw of the same model was purchased and used on August 16th (Porter-Cable #2).

The Porter-Cable circular saw is a hand-held tool with a 7¼inch diameter blade. The saw contains a fixed upper and a retractable lower blade guard to prevent access to the blade during operation. The maximum cutting depth is approximately 2¼inches. The unit is operated with an on/off guarded trigger switch and is supported with a handgrip mounted near the front of the saw. The saw is equipped with a directional nozzle, which aims sawdust away from the operator and the line of cut. An optional vacuum system, attached to the directional nozzle, was used to remove and collect dust. An adjustable lever sets the depth of cut. The retractable blade guard permits blind or plunge cuts and protects from blade access during shutdown and blade coast. Blade changes are accomplished using a blade lock button to hold the blade firm while removing the retaining bolt.

3.0 METHODOLOGY

3.1 Methodology for Assessment of Safety Issues

The team completed a Job Hazard Analysis (JHA) after the evaluation. This is a well-established tool. The JHA systematically identifies all of the steps required to operate a piece of equipment or complete a task. The potential hazards of each step are listed

and the methods to control these hazards are identified. The information from the JHA was then used to create a Technology Safety Data Sheet (TSDS). This innovative tool is required by the Department of Energy for all of the technologies funded by the Office of Science and Technology. See Section 6.0 for completed safety analyses.

3.2 Methodology for Assessment of Health Issues

Noise levels, total nuisance dust, and fiberglass dust were evaluated during the dismantling of the 4 x 4 x 8 foot fiberglass-reinforced plywood crate each day. All samples were measured during the approximate 27- and 110-minute operations of the Porter-Cable circular saw.

3.2.1 Noise Sampling

Personal noise levels were evaluated using Quest Q-300 data-logging noise dosimeters. These instruments were pre- and post-calibrated at 114.0 dBA with a Quest Q-10 acoustical calibration unit.

3.2.2 Nuisance Dust

Dust monitoring was conducted by drawing air with a MSA Escort Elf air-sampling pump through a pre-weighed PVC 37-millimeter (mm) filter in a closed-face cassette. Sampling and analysis followed the National Institute for Occupational Safety and Health (NIOSH) Manual of Analytical Methods (NMAM) 0500 gravimetric method for total dust. The cassettes were pre-weighed by Galson Laboratories, an American Industrial Hygiene Association Accredited lab. Pre- and post-sampling calibration was accomplished with a BIOS International DryCal DC1 primary calibration system. The level of quantification reported by the lab was 0.05 mg.

3.2.3 Fiberglass

Fiberglass monitoring was conducted by drawing air with a MSA Escort Elf air-sampling pump through a MCE 25-mm filter in an open-faced cowl. Analysis was conducted with phase contrast microscopy using NMAM 7400, Revision #3, which is a fiber-counting method. The cowls were prepared and analyzed by Galson Laboratories. Pre- and post-sampling calibration was performed in the same manner as the nuisance dust samples.

4.0 RESULTS AND DISCUSSION

4.1 Safety Issues

The Porter-Cable saw is a straightforward machine used to cut wood of varying thickness. The blade is fully guarded. The lower blade guard retracts as the blade engages the work piece. Kickback, the sudden reaction to a pinched blade, is possible with this saw and could cause the saw to lift up, out, and toward the operator. Proper work position and firm control of the saw minimizes the potential for a sprain or strain. Care needs to be exercised to support the work piece properly and to not force the tool.

Table 6.3.1 contains a summary of safety and health features for the five saws used in the demonstration.

4.2 Health Issues

4.2.1 Noise

The OSHA Action Level for noise exposure under 29 CFR 1910.95 is 85 dBA, averaged over an 8-hour time period. From OSHA's Hearing Conservation Amendment of 1983, exceeding this level means the employer must administer a continuing, effective hearing conservation program. OSHA also requires that workers exposed above 90 dBA as an 8-hour TWA must be protected – preferably through engineering or administrative controls. If neither is feasible, the employer must provide PPE, such as earmuffs or earplugs.

During the first demonstration, personal noise sampling indicated that one worker was under and one was at the Action Level with TWA's of 82.7 and 84.6 dBA, respectively. During the second demonstration, however, both workers did exceed the Action Level with TWA's of 89.7 and 90.0 dBA. These data are not entirely representative as they were gathered during a simulation and not at the actual worksite. Additional sampling should be conducted on-site, but the workers should wear hearing protection until it is determined that it is no longer necessary. Noise data for all of the saws used in the demonstration are listed in Table 6.3.2.

4.2.2 Nuisance Dust and Fiberglass

Air sampling was performed while the workers dismantled the fiberglass-reinforced crates. Results from the total nuisance dust (i.e., particulate not otherwise regulated) and fiberglass samples for all saws in the demonstration are listed in Table 6.3.2. The total nuisance dust sample for Porter-Cable #1 was 3.53 mg/m^3, which is lower than the OSHA PEL of 15 mg/m^3 and the ACGIH TLV of 10 mg/m^3. Porter-Cable #'s nuisance dust results yielded a value of 22.05 mg/m^3, which is over the PEL and the TLV. The fiber analysis for the first demonstration yielded 12.9 f/cc, which is much higher than the PEL of 1 f/cc. Galson Laboratories considered the fiber analysis for the second demonstration void due to the overloading of dust on the filter.

5.0 RECOMMENDATIONS

The nuisance dust sample for the second demonstration was higher than the regulatory standard and it is possible that the corresponding fiberglass sample will also be above the PEL. The fiber analysis for Porter-Cable #1 did yield a fiber count that was more than 12 times the PEL. Engineering controls should be used to eliminate these problems whenever possible. Where this is not possible, administrative controls, training, and proper PPE should be used. A specific example of an engineering control for this saw is the use of a higher flow vacuum attached to the directional nozzle. Other examples of engineering controls include two specialized ventilation systems: a downdraft hood and a capturing hood with a flexible duct (see Section 6.4 for figures). With a downdraft hood, a crate would sit on the top of the hood so the dust would be

pulled down into the hood. A ventilation system such as this requires specialized knowledge and should be designed by a ventilation engineer.

Fiberglass is known to be a strong irritant and is a possible human carcinogen. Therefore, the workers should continue to wear appropriate suits and gloves, as well as a full-face air-purifying respirator. The respirator should be equipped with a combination organic vapor and acid gas cartridge with a particulate filter, since during the demonstration, the workers complained of an odd smell, which may have been from the breakdown of the fiberglass.

Kickback is possible with this saw and can be reduced through the use of simple engineering controls and training. Use of wedges to eliminate blade pinch will reduce the amount of kickback experienced by the worker. Training on use of wedges and how to use the saw (i.e., don't force the tool) will also help to reduce the occurrences of this problem.

6.0 APPENDIX

6.1 Job Hazard Analysis

Job Hazard Analysis
Porter-Cable Circular Saw (OENHP #: 2001-04, Version A)

Sequence of Job Steps	Potential Accident or Hazard	New Procedure or Protection
Phase 1: Construction/Start-up		
Pre-operation inspection	• Saw or cord damage may cause shock	• Inspect saw for obvious damage and frayed/cut cord. • Check for misalignment of blade. • Check that blade is installed properly (not backward). • Check for binding of moving parts. • Use qualified personnel and manufacturer-authorized parts.
	• Failure of on/off switch and/or retractable blade guard may cause kickback or cuts/abrasions	• Inspect blade guards. • Inspect on/off switch. • Use qualified personnel and manufacturer-authorized parts.
Powering saw	• Wrong amperage extension cord causing an electrical hazard	• Inspect extension cord to verify adequacy to handle saw amperage.
	• Failure of on/off switch; failure on may cause cuts or abrasions	• Remove power from the saw by using proper method to unplug tool i.e. grip plug and remove from outlet (socket).

Job Hazard Analysis Porter-Cable Circular Saw (OENHP #: 2001-04, Version A)		
Sequence of Job Steps	**Potential Accident or Hazard**	**New Procedure or Protection**
	• Ungrounded outlet causing an electrical hazard	• Inspect outlet to verify proper grounding and polarity by checking the outlet with a receptacle circuit tester. • Use an outlet with a ground fault circuit interrupter (GFCI).
	• Abnormal noise or vibration due to improper mounting of blade may cause kickback, cuts, and/or abrasions.	• Turn off the saw. • Remove power to the saw. • Check proper mounting of blade. • Use qualified personnel and manufacturer-authorized parts.
Phase 2: Operation		
Operation of saw in horizontal and vertical motions	• Blade exposed when guard is retracted, may lead to cuts or abrasions	• Train users on proper positioning of saw. • Check guard for sticking. • Use leather-work gloves. • Pick up and store saw properly.
	• Vibration to hands during use may lead to vibration-induced nerve damage known as Raynaud's Syndrome.	• Secure working piece. • Ensure that adjustable shoe is in firm contact with the cutting surface – helps to reduce vibration. • Wear gloves with vibration-dampening material. • Control personnel duty time.
	• Excessive heat at blade cutting edge leading to exposure to a hot surface	• Do not force tool. • Inspect condition of blades and replace worn blades.
	• Kickback of saw may cause sprain or strain	• Avoid pinching blade. • Secure working surface using supports such as wedges. • Do not force tool. • Utilize proper ergonomic position. • Wear hand and eye protection.
	• Excessive exposure to noise could lead to temporary or permanent hearing loss	• Wear ear protection (ear plugs or muffs) properly while saw is in use.
	• Excessive sparking may lead to equipment damage and electrical hazard	• Remove power to the saw. • Inspect saw periodically. • Use qualified personnel and manufacturer-authorized parts.

Job Hazard Analysis
Porter-Cable Circular Saw (OENHP #: 2001-04, Version A)

Sequence of Job Steps	Potential Accident or Hazard	New Procedure or Protection
Phase 3: Maintenance (Emergency and Routine)		
Cleaning	• Exposure to energized parts	• Remove power source before beginning maintenance (use proper lockout/tagout procedures). • Use qualified personnel and manufacturer-authorized parts.
	• Exposure to contamination	• Use safety and health information such as Material Safety Data Sheets (MSDS's) for proper procedures and necessary personal protective equipment.
Blade replacement	• May lead to cuts and abrasions	• Follow manufacturer's procedures. • Use eye and hand protection.
Phase 4: Shutdown (Emergency and Routine)		
Remove power	• Shock	• Use proper method to unplug tool i.e. grip plug and remove from socket (outlet).
Phase 5: Decontamination/Decommissioning		
Wipe the saw to remove contamination	• Exposure of operator or maintenance personnel to site-specific contaminants	• Use safety and health guidance such as Material Safety Data Sheets (MSDS's) to determine proper procedures and necessary personal protective equipment. • Dispose of waste using approved procedures.

6.2 Technology Safety Data Sheet

Technology Safety Data Sheet
Porter-Cable Circular Saw (OENHP #: 2001-04, Version A)

Section 1: Technology Identity		
Technology Name(s):		Emergency Contact:
Porter-Cable Circular Saw		1-800-4US-TOOL
Manufacturer's Name and Address:		Information Contact:
Porter-Cable Corporation 4825 Highway 45 North Jackson, TN 38305		1-800-4US-TOOL
Date Prepared:	TSDS Version Number:	Prepared By:
8/23/01	2001-04, Version A	John Kovach, MS; Jeana Harrison; Aaron Ondo, MS; Bruce Lippy, CIH, CSP

Section 2: Technology Description

The Porter-Cable circular saw is a handheld tool with a 7¼inch diameter blade. The saw contains a fixed upper and a retractable lower blade guard to prevent access to the blade during operation. The maximum cutting depth is approximately 2¼inches. The unit is operated with an on/off guarded trigger switch and is supported with a handgrip mounted near the front of the saw. The saw is equipped with a directional nozzle, which aims sawdust away from the operator and the line of cut. An optional vacuum system, attached to the directional nozzle, was used to remove and collect dust. An adjustable lever sets the depth of cut. The retractable blade guard permits blind or plunge cuts and protects from blade access during shutdown and blade coast. Blade changes are accomplished using a blade lock button to hold the blade firm while removing the retaining bolt.

Section 3: Technology Pictures

Figure 1. An operator making a vertical cut with the Porter-Cable Circular Saw. For this demonstration, the optional vacuum was attached to the directional nozzle.

Technology Safety Data Sheet
Porter-Cable Circular Saw (OENHP #: 2001-04, Version A)

Section 4: Safety Hazards	
Hazard Category: 4 – Could result in death or permanent total disability 3 – Could result in permanent partial disability or injuries or occupational illness that may result in hospitalization of at least three persons 2 – Could result in injury or occupational illness resulting in one or more lost work days 1 – Could result in injury or illness not resulting in a lost work day	
A. Buried Utilities, Drums, and Tanks	Hazard Rating: N/A
• Buried utilities, drums, and tanks are not associated with this technology.	
B. Chemical (Reactive, Corrosive, Pyrophoric, etc)	Hazard Rating: N/A
• Chemical use is not associated with this technology.	
C. Confined Space	Hazard Rating: N/A
• Confined space is not a hazard associated with this technology.	
D. Electrical	Hazard Rating: 1
• Shock due to insufficient amperage in cord and/or ungrounded outlets may occur. • Performing maintenance or blade changes while machinery is energized may lead to shock. Following lockout/tagout procedures will reduce this risk. • Exposure to a damaged extension cord may lead to shock.	
E. Explosives	Hazard Rating: N/A
• Explosives are not associated with this technology.	
F. Fire Protection	Hazard Rating: N/A
• The facility fire protection plan should cover this tool, as it does not present an additional fire hazard.	
G. Gas Cylinders	Hazard Rating: N/A
• Gas cylinders are not used with this technology.	
H. Ladders/Platforms	Hazard Rating: N/A
• Electrical shock is possible when used with metal ladders or platforms.	
I. Lockout/Tagout	Hazard Rating: 1
• The facility's lockout/tagout procedures and manufacturer's recommended procedures should cover this tool.	
J. Mechanical Hazards	Hazard Rating: 2
• Cuts or abrasions may occur from contact with saw blade during use and blade changes.	
K. Moving Vehicles	Hazard Rating: 1
• This saw does not utilize any moving vehicles, although one will be used to move the fiberglass-reinforced crates to the decommissioning area. The workers should be aware of the normal hazards associated with moving vehicles.	
L. Overhead Hazards	Hazard Rating: 1
• During dismantlement of the fiberglass-reinforced crates, pieces of crate could fall upon completion of a cut or when the top of the crate is removed. Workers should wear hard hats when working on crates.	
M. Pressure Hazards	Hazard Rating: N/A
• There are no pressure hazards associated with this technology.	

N. Slips/Trips/Falls	Hazard Rating: 1
• Electrical cords should be properly managed during cutting operations. • Work area should be kept clean and organized to eliminate possible tripping hazards.	
O. Suspended Loads	Hazard Rating: N/A
• Suspended loads are a site-specific hazard and are not part of this technology.	
P. Trenching/Excavation	Hazard Rating: N/A
• Trenching and excavation are not used for this technology.	
Section 5: Health Hazards	
A. Inhalation	Hazard Rating: 2
Inhalation hazards are highly dependent upon the type of material being cut. • General inhalation hazards associated with woodworking: o Wood dust o Plywood resins • Inhalation hazards associated with the disassembly of fiberglass-reinforced plywood crates: o Fiberglass dust (possible human carcinogen) o Fiberglass resins o Vapors and formaldehyde	
B. Skin Absorption	Hazard Rating: 2
Skin absorption is largely based upon the material being cut. • Fiberglass dust causes skin irritation (associated with the disassembly of fiberglass-reinforced plywood crates).	
C. Noise	Hazard Rating: 2
A noise assessment should be conducted on-site during actual use of the technology to determine type of hearing protection required. • Excessive noise from tool and cutting operations may cause hearing damage. • Excessive noise from ventilation and filtration system, as well as any noise from nearby operations, may cause hearing damage.	
D. Heat Stress/Cold Stress	Hazard Rating: 2
Heat stress is generally site-specific, although there are heat stress issues associated with this tool. • Heat stress can be generated by personal protective equipment such as: Tyvek suits, full face respirators, and gloves. • Heat from hand tool during extended tool duty time may cause heat stress. • Extended worker duty time could cause heat stress, especially if the worker is working in hot conditions or wearing personal protective equipment.	
E. Ergonomics	Hazard Rating: 2
• Hand/arm vibration from the tool may cause nerve damage known as Raynaud's Syndrome. • Static and awkward operating postures may cause pain in the hands and/or arms. • Awkward lifting of tool may cause pain in the hands and/or arms.	
F. Ionizing Radiation	Hazard Rating: N/A
• Ionizing radiation is site-specific.	
G. Non-ionizing Radiation	Hazard Rating: N/A
• Non-ionizing radiation is site-specific.	
H. Biological Hazards	Hazard Rating: N/A
• There are no biological hazards associated with this technology.	

I. Other	Hazard Rating: N/A

- None

Section 6: Phase Analysis

A. Construction/Start-up

- Identify hazards through a pre-job analysis to determine personal protective equipment required.
- Inspect saw for obvious damage that may cause excessive vibration and potential for electrical shock.
- Select proper blade for each job so that worker fatigue and kickback is minimized and to reduce potential for sprains.
- Check power cords for proper amperage, frays, and cuts to protect against electrical shock.
- Ensure blades are straight and the teeth are sharp to reduce amount of force needed and to minimize vibration.
- Ensure blades are properly mounted to start work to avoid kickback or sprain.

B. Operation

- Maintain proper work position, don't overextend arms.
- Wear proper safety protection for hands (leather work gloves with rubber grips), eyes (safety glasses or goggles), and ears (ear plugs or ear muffs), and respiratory protection (depends upon the operation).
- Do not bind the blade between work pieces; do not force tool.
- Change blade only while the tool is not energized and use approved lockout/tagout procedures.
- Use proper amperage power cord and a grounded outlet.

C. Maintenance (Emergency and Routine)

- Check for damage to the saw and frayed cord.
- Perform all maintenance with the power off (unplug saw) and use approved lockout/tagout procedures.
- Conduct maintenance with qualified personnel and use manufacturer's authorized parts.

D. Shutdown (Emergency and Routine)

- Keep blade away from body while shutting down the tool.
- Grip plug and remove from socket (outlet).
- Maintain proper ergonomic position to avoid cuts and abrasions by the blade.

E. Decontamination/Decommissioning

- Use approved decontamination procedures.
- Discard unit using approved procedures.

Section 7: Worker Protection Measures

A. Exposure Monitoring

- Noise sampling should be conducted during the actual use of the tool to determine the actual noise levels and the proper personal protective equipment necessary.
- Air sampling should be conducted during the actual use of the tool to determine levels of site-specific contaminants in the air. Nuisance dust is associated with woodcutting and fibers are associated with the cutting of fiberglass-reinforced crates.

B. Worker Training

Worker training should include the following elements:

- Pre-job walk through
- Manufacturer's operating procedures
- Respirator training
- Personal protective equipment to be used
- Hearing conservation program, including the proper use of ear plugs
- Lockout/tagout procedures
- Electrical training
- Recognition of heat stress symptoms
- Recognition of ergonomic issues and symptoms

C. Medical Surveillance

- Audiograms must be administered if the noise levels are above 85 decibels. Workers whose personal noise sample yields results greater than 85 decibels must be placed in a hearing conservation program, which includes audiograms.

D. Engineering Controls

- No additional engineering controls are recommended.

E. Administrative Controls

- Worker training
- Controlled duty time of personnel and the equipment

F. Personal Protective Equipment

- Gloves
- Safety glasses or goggles
- Hearing protection
- Any other site-specific equipment

Section 8: Emergency Preparedness

- Emergency response procedure should identify how the hazards identified in this TSDS are being addressed. Each worker should be trained and understand how to respond.

Section 9: Comments, Lessons Learned, and Special Considerations

- No additional comments, lessons, or special considerations.

6.3 Summary of All Saws

During the week of August 13-16, 2001, five saws were tested on specially prepared 4 x 4 x 8 foot plywood and fiberglass reinforced plywood crates at FIU. The following tables summarize the results of the OENHP evaluation. Table 6.3.1 summarizes the safety features for the saws tested, and table 6.3.2 summarizes the results of noise and dust measurements obtained during these operations.

Table 6.3.1. Comparison of Safety and Health Features for Saws During the Simulation.

Saw (OENHP#)	Blade Guarding	Power Switch	Thermal Overload	Electrical Cord/Plug	Dust Control
DeWalt Reciprocating (2001-01-A)	Blade partially exposed at all times	On/off switch	No overload or thermal shutoff	Double insulated cord	No control of dust at point of cut
Milwaukee Worm Drive Circular (2001-02-A)	Upper and retractable lower guard	On/off switch	No overload or thermal shutoff	Grounded plug	No control of dust at point of cut
Porter-Cable Circular (2001-04-A)	Upper and retractable lower guard	On/off switch	No overload or thermal shutoff	Double insulated cord	Directional discharge away from worker; vacuum attachment for dust collection
Evolution 180 Circular (2001-03-A)	Upper guard, chip collector, retractable lower guard	On/off switch	Overload shutoff	Double insulated cord	Metal chip collector
Adamant Circular (2001-05-A)	Blade partially exposed at all times	Interlocking on/off switch	Stall overload, and shutoff	Grounded plug	No control of dust at point of cut

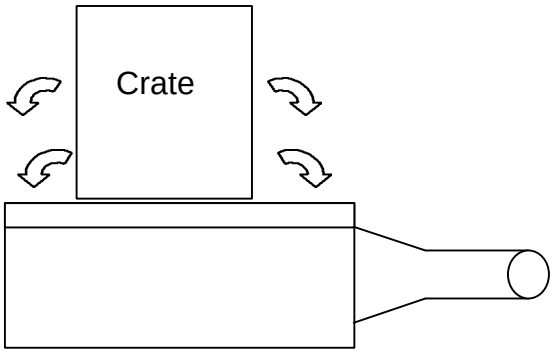
Table 6.3.2. Comparison of Industrial Hygiene Sampling Data from the Simulation.

Saw	Nuisance Dust (mg/m^3)	Fiberglass Dust (f/cc)	Noise TWA - Dosimeter 1 (dBA)	Noise TWA - Dosimeter 2 (dBA)
DeWalt Reciprocating	10.69	1.70	88.3	90.6
Milwaukee Worm Drive Circular	36.07	Void[1]	82.7	84.6
Porter-Cable Circular #1	3.53	12.9	77.1	78.3
Porter-Cable Circular #2	22.05	Void[1]	89.7	90.0
Evolution 180 Circular	3.5[2]	1.74[2]	69.1	68.8[2] / 69.8[3]
Average ± Standard Deviation	15.2 ± 13.9	5.5 ± 6.5	81.4 ± 8.5	80.4 ± 9.7
Coefficient of variation	91.8	118.5	10.4	12.0

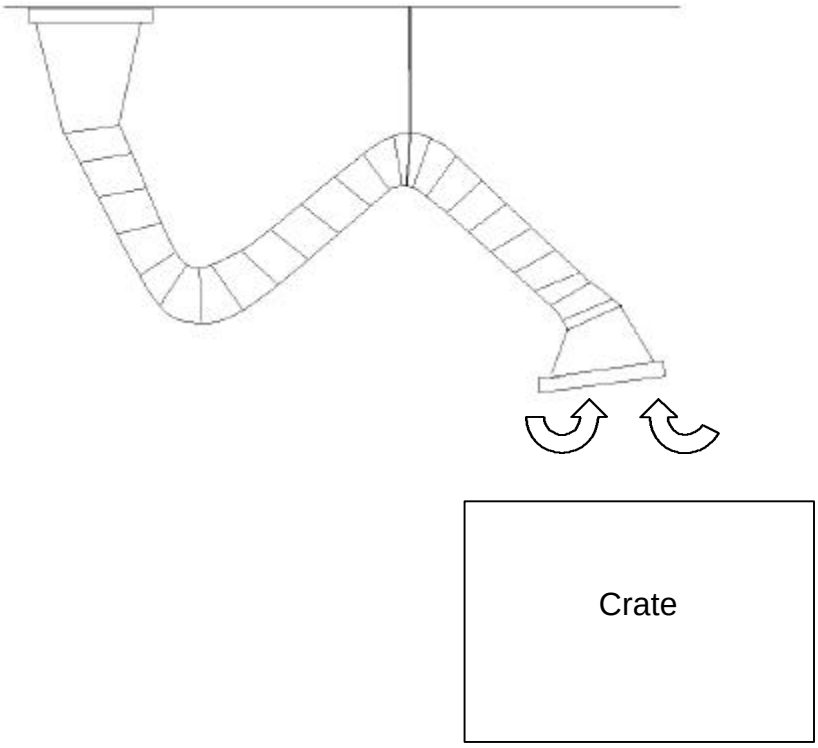
[1] Void: Filter was overloaded – sample could not be analyzed.
[2] Evolution 180 with fiberglass-reinforced plywood crate
[3] Evolution with ¼inch stainless steel only

6.4 Figures and Drawings

6.4.1 Drawing of a Downdraft Hood



6.4.2 Drawing of a Capture Hood



6.5 Industrial Hygiene Data

Certificates of Analysis for laboratory data are available upon request via the contact information in the front of this document.

6.5.1 Noise Sampling Data

INTERNATIONAL UNION OF OPERATING ENGINEERS
INTERNATIONAL ENVIRONMENTAL TECHNOLOGY AND TRAINING CENTER
1293 Airport Road Beaver, WV 25813
(304) 253-8674 Fax: (304) 253-1384

Industrial Hygiene Noise Sampling Data: Noise

Project: FIU - Saws	**Calibrator**
Address: Hemispheric Center for Environmental Technology	Mfr.: Quest Technologies
Florida International University	Model: QC-10
10555 West Flagler St, CEAS 2100	Serial No.: QE7030012
C/S/Z: Miami, FL 33174	Cal. Date: 6/6/2001
Phone: 305-348-2590 Fax: 305-348-6308	**Instrument**
Sampling Data	No. 1
Name:	Mfr.: Quest Technologies
Job title/description:	Model: 300
	Serial No.: QC 7010089
	Cal. Date: 6/6/2001
	Exchange Rate (3 to 6 dB):
	Dose Criterion (80 to 90 dB):
PPE Used: full face-piece respirator with G/V cartridges, Tyvek suits, ear plugs, Tyvek suits, gloves	Filter Weighting (A, B, or C):
	Response (Slow or Fast):

Calibration

Pre					Post					
Date (M/D/Y)	Time (24H:M)	Target (dB)	Actual (dB)	Diff. (%)	Date (M/D/Y)	Time (24H:M)	Target (dB)	Actual (dB)	Diff. (%)	1
8/13/01	11:35	114.0	113.1	0.79	8/13/01	16:00	114.0	113.1	0.79	
8/14/01	8:10	114.0	113.1	0.79	8/15/01	8:10	114.0	113.5	0.44	
8/15/01	8:10	114.0	113.5	0.44	8/16/01	8:05	114.0	113.1	0.79	
8/16/01	8:05	114.0	113.1	0.79	8/16/01	10:45	114.0	113.1	0.79	

Noise Data and Information

Location	Type (P or A)	Date (M/D/Y)	Start (24H:M)	Stop (24H:M)	Time (min)	Lav (dB)	TWA (dB)	Lmax (dB)	Lpk (dB)	8hr % Dose	8 hr Proj. % Dose
A	P	8/13/01	13:40	15:33	113	98.0	88.3	112.1	118.6	78.83	302.20
B	P	8/14/01	9:20	9:45	25	89.4	69.1	110.9	118.4	5.55	92.60
C	P	8/14/01	10:50	11:42	52	97.9	82.7	113.7	118.5	36.66	299.20
D	P	8/15/01	13:30	13:57	27	97.7	77.1	111.0	118.4	16.73	290.00
E	P	8/16/01	8:25	9:30	65	100.3	89.7	114.7	118.6	96.02	417.00

Location	Description
A	DeWalt Reciprocating Saw
B	Evolution 180 Saw - used with pump #2
C	Milwakee Saw - used with pump #2
D	Porter Cable Saw #1 - Used with pump #3
E	Porter Cable Saw #2 - Used with pump #3

Calibration by: Jeana M. Harrison Signature: Date:
Sampling by: Jeana M. Harrison Signature: Date:

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INTERNATIONAL ENVIRONMENTAL TECHNOLOGY AND TRAINING CENTER
1293 Airport Road Beaver, WV 25813
(304) 253-8674 Fax: (304) 253-1384

Industrial Hygiene Noise Sampling Data: Noise

Project: FIU - Saws

Address: Hemispheric Center for Environmental Technology
Florida International University
10555 West Flagler St, CEAS 2100
C/S/Z: Miami, FL 33174
Phone: 305-348-2590 Fax: 305-348-6308

Sampling Data

Name:
Job title/description:

PPE Used: full face-piece respirator with G/V cartridges, Tyvek suits, ear plugs, Tyvek suits, gloves

Calibrator

Mfr.: Quest Technologies
Model: QC-10
Serial No.: QE7030012
Cal. Date: 37048

Instrument

No. 2
Mfr.: Quest
Model: 300
Serial No.: QC 7010093
Cal. Date: 6/6/2001
Exchange Rate (3 to 6 dB):
Dose Criterion (80 to 90 dB):
Filter Weighting (A, B, or C):
Response (Slow or Fast):

Calibration

Pre					Post				
Date (M/D/Y)	Time (24H:M)	Target (dB)	Actual (dB)	Diff. (%)	Date (M/D/Y)	Time (24H:M)	Target (dB)	Actual (dB)	Diff. (%)
8/13/01	11:40	114.0	114.1	0.09	8/13/01	16:00	114.0	113.4	0.53
8/14/01	8:10	114.0	113.9	0.09	8/15/01	8:10	114.0	113.4	0.53
8/15/01	8:10	114.0	113.4	0.53	8/16/01	8:10	114.0	113.9	0.09
8/16/01	8:10	114.0	113.9	0.09	8/16/01	10:55	114.0	113.9	0.09

2

Noise Data and Information

Location	Type (P or A)	Date (M/D/Y)	Start (24H:M)	Stop (24H:M)	Time (min)	Lav (dB)	TWA (dB)	Lmax (dB)	Lpk (dB)	8hr % Dose	8 hr Proj. % Dose
F	P	8/13/01	13:40	15:33	113	100.3	90.6	113.4	119.4	109.50	420.50
G	P	8/14/01	9:20	9:45	25	89.1	68.8	110.9	119.2	53.00	88.74
H	P	8/14/01	10:50	11:42	52	100.1	84.6	115.3	119.3	47.48	403.60
I	P	8/15/01	13:30	13:57	27	99.0	78.3	111.6	119.2	19.81	350.80
J	P	8/16/01	8:25	10:15	110	100.7	90.0	115.1	119.3	100.40	442.80
K	P	8/16/01			15	94.8	69.8	112.5	118.9	6.12	196.70

Location	Description
F	Dewalt Reciprocating Saw
G	Evolution 180 with crates - used with pump #3
H	Milwakee - used with pump #3
I	Porter Cable #1 - used with pump #2
J	Porter Cable #2 - used with pump #4
K	Evolution 180 with 1/4" stainless steel

Calibration by: Jeana M. Harrison Signature: Date:
Sampling by: Jeana M. Harrison Signature: Date:

6.5.2 Air Sampling Data

INTERNATIONAL UNION OF OPERATING ENGINEERS
INTERNATIONAL ENVIRONMENTAL TECHNOLOGY AND TRAINING CENTER
1293 Airport Road Beaver, WV 25813
(304) 253-8674 Fax: (304) 253-1384

Industrial Hygiene Air Sampling Data: Information

Project: FIU - Saws
Address: Hemispheric Center for Environmental Technology
Florida International University
10555 West Flagler St, CEAS 2100
C/S/Z: Miami, FL 33174
Phone: 305-348-2590 Fax: 305-348-6308

Personal Sampling Data

Name:
Job title/description:
PPE used: full-facepiece respirator with G/V cartridges, ear plugs, Tyveck suits, gloves
Ventilation: HEPA vacuum for containment

Contaminant(s) Sampled

Dust: Total Dust (nuisance)
Fume:
Gas:
Mist:
Vapor:
Other:
Analytical Method: 500
Min: Max: (L/Min)

Media

Mfr.: SKC
Lot No.: 762
Cassette: 37 mm
Filter: PVC
Pore size: 5.0 µm
Face: (O/C) Closed
Tube: NA
Treat.: NA

Date (m/d/y)	Time (H:M)	Temp (°F)	Pres. ("Hg)	RH (%)

Sample No.	Type P,A,B	Date (M/D/Y)	Instrument Serial No.	Pump No.	Use 24 hour Military Time (24HH:MM) Start	Stop	Start	Stop	Start	Stop	Start	Stop	Total (min)
111	P	8/13/01	8575	3	13:41	15:35							114
112	B	8/13/01			14:40	15:51							71
113	P	8/14/01	8575	3	9:20	9:50							30
114	A	8/13/01	8682	2	14:40	15:51							71

Sample No. 111 — Location: Inside Permacon with DeWalt
Blank No. 112 — Task: Cutting fiberglass reinforced plywood boxes
Comments:

Sample No. 112 — Location: BLANK
Blank No. — Task:
Comments:

Sample No. 113 — Location: Inside Permacon with Evolution 180
Blank No. — Task: Cutting fiberglass reinforced plywood boxes
Comments:

Sample No. 114 — Location: Area outside Permacon; near inlet
Blank No. — Task: Cutting fiberglass reinforced plywood boxes
Comments:

Sampling by: Jeana M. Harrison Signature: Date:
Sampling by: Jeana M. Harrison Signature: Date:

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Industrial Hygiene Air Sampling Data: Information

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Address: Hemispheric Center for Environmental Technology
Florida International University
10555 West Flagler St, CEAS 2100
C/S/Z: Miami, FL 33174
Phone: 305-348-2590 Fax: 305-348-6308

Personal Sampling Data

Name:
Job title/description:

PPE used: full-facepiece respirator with G/V cartridges, ear plugs, Tyveck suits, gloves
Ventilation: HEPA vacuum for containment

Contaminant(s) Sampled

Dust: Total Dust (nuisance)
Fume: 0
Gas: 0
Mist: 0
Vapor: 0
Other: 0
Analytical Method: 500
Min: 0 Max: 0 (L/Min)

Media

Mfr.: SKC
Lot No.: 762
Cassette: 37 mm
Filter: PVC
Pore size: 5.0 µm
Face: (O/C) Closed
Tube: NA
Treat.: NA

Date (m/d/y)	Time (H:M)	Temp (°F)	Pres. (“Hg)	RH (%)

Sample No.	Type P,A,B	Date (M/D/Y)	Instrument Serial No.	Pump No.	Use 24 hour Military Time (24HH:MM) Start	Stop	Start	Stop	Start	Stop	Start	Stop	Total (min)
115	A	8/14/01	8572	4	9:20	11:47							147
116	B	8/14/01			9:25	11:47							142
117	P	8/14/01	8575	3	10:50	11:48							58
118	P	8/15/01	8682	2	13:30	13:57							27

Sample No. 115 — Location: Outside Permacon; near inlet
Blank No. — Task: Cutting fiberglass reinforced plywood boxes
Comments:

Sample No. 116 — Location: BLANK
Blank No. — Task:
Comments:

Sample No. 117 — Location: Inside Permacon with Milwakee
Blank No. 116 — Task: Cutting fiberglass reinforced plywood boxes
Comments: Lost filtration in Permacon for 5 minutes

Sample No. 118 — Location: Inside Permacon with Porter Cable #1
Blank No. 119 — Task: Cutting fiberglass reinforced plywood boxes
Comments:

Sampling by: Jeana M. Harrison Signature: Date:
Sampling by: Jeana M. Harrison Signature: Date:

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Industrial Hygiene Air Sampling Data: Information

Project: FIU - Saws

Address: Hemispheric Center for Environmental Technology
Florida International University
10555 West Flagler St, CEAS 2100
C/S/Z: Miami, FL 33174
Phone: 305-348-2590 Fax: 305-348-6308

Personal Sampling Data

Name:
Job title/description:

PPE used: full-facepiece respirator with G/V cartridges, ear plugs, Tyveck suits, gloves
Ventilation: HEPA vacuum for containment

Contaminant(s) Sampled

Dust: Total Dust (nuisance)
Fume: 0
Gas: 0
Mist: 0
Vapor: 0
Other: 0
Analytical Method: 500
Min: 0 Max: 0 (L/Min)

Media

Mfr.: SKC
Lot No.: 762
Cassette: 37 mm
Filter: PVC
Pore size: 5.0 µm
Face: (O/C) Closed
Tube: NA
Treat.: NA

Date (m/d/y)	Time (H:M)	Temp (°F)	Pres. ("Hg)	RH (%)

Sample No.	Type P,A,B	Date (M/D/Y)	Instrument Serial No.	Pump No.	Use 24 hour Military Time (24HH:MM)								Total (min)
					Start	Stop	Start	Stop	Start	Stop	Start	Stop	
119	B	8/15/01			13:30	14:00							30
120	A	8/15/01	8572	4	13:35	14:00							25
121	P	8/16/01	8572	4	8:25	9:30	9:50	10:15					90
122	A	8/16/01	8682	2	8:30	10:25							115

Sample No. 119 — Location: BLANK
Blank No. — Task:
Comments:

Sample No. 120 — Location: Outside Permacon; near inlet
Blank No. 119 — Task: Cutting fiberglass reinforced plywood boxes
Comments:

Sample No. 121 — Location: Inside Permacon with Porter Cable #2
Blank No. 123 — Task: Cutting fiberglass reinforced plywood boxes
Comments:

Sample No. 122 — Location: Outside Permacon; near inlet
Blank No. 123 — Task: Cutting fiberglass reinforced plywood boxes
Comments:

Sampling by: Jeana M. Harrison Signature: Date:
Sampling by: Jeana M. Harrison Signature: Date:

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Industrial Hygiene Air Sampling Data: Information

Project: FIU - Saws
Address: Hemispheric Center for Environmental Technology
Florida International University
10555 West Flagler St, CEAS 2100
C/S/Z: Miami, FL 33174
Phone: 305-348-2590 Fax: 305-348-6308

Personal Sampling Data

Name:
Job title/description:

PPE used: full-facepiece respirator with G/V cartridges, ear plugs, Tyveck suits, gloves
Ventilation: HEPA vacuum for containment

Contaminant(s) Sampled

Dust: Total Dust (nuisance)
Fume: 0
Gas: 0
Mist: 0
Vapor: 0
Other: 0
Analytical Method: 500
Min: 0 Max: 0 (L/Min)

Media

Mfr.: SKC
Lot No.: 762
Cassette: 37 mm
Filter: PVC
Pore size: 5.0 µm
Face: (O/C) Closed
Tube: NA
Treat.: NA

Date (m/d/y)	Time (H:M)	Temp (°F)	Pres. ("Hg)	RH (%)

Sample No.	Type P,A,B	Date (M/D/Y)	Instrument Serial No.	Pump No.	Use 24 hour Military Time (24HH:MM) Start	Stop	Start	Stop	Start	Stop	Start	Stop	Total (min)
123	B	8/16/01			8:30	10:25							115
													0
													0
													0

Sample No. 123 — Location: BLANK
Blank No. — Task:
Comments:

Sample No. 0 — Location:
Blank No. — Task:
Comments:

Sample No. 0 — Location:
Blank No. — Task:
Comments:

Sample No. 0 — Location:
Blank No. — Task:
Comments:

Sampling by: Jeana M. Harrison Signature: Date:
Sampling by: Jeana M. Harrison Signature: Date:

INTERNATIONAL UNION OF OPERATING ENGINEERS
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3775 Morgantown Industrial Park Bldg 400, Morgantown, WV 26501
(304) 284-9129 Fax: (304) 284-9130

Industrial Hygiene Air Sampling Data: Information

Project: FIU - Saws
Address: Hemispheric Center for Environmental Technology
Florida International University
10555 West Flagler St, CEAS 2100
C/S/Z: Miami, FL 33174
Phone: 305-348-2590 Fax: 305-348-6308

Personal Sampling Data

Name:
Job title/description:
PPE used: full face-piece respirator with G/V cartridges, ear plugs, Tyvek suits, gloves
Ventilation: HEPA vacuum for containment

Contaminant(s) Sampled

Dust:
Fume:
Gas:
Mist:
Vapor:
Other: Fiberglass (fiber count)
Analytical Method: 7400
Min: 0.5 Max: 16 (L/Min)

Media

Mfr.: Zefon
Lot No.: 2522
Cassette: 25 mm
Filter: MCE
Pore size: 0.8 µm
Face: (O/C) open
Tube: na
Treat.: na

Date (m/d/y)	Time (H:M)	Temp (°F)	Pres. ("Hg)	RH (%)

Sample No.	Type P,A,B	Date (M/D/Y)	Instrument Serial No.	Pump No.	Use 24 hour Military Time (24HH:MM) Start	Stop	Start	Stop	Start	Stop	Start	Stop	Total (min)
B176962	P	8/13/01	8572	4	13:40	15:33							113
B176969	B	8/13/01			14:40	15:50							70
B177013	P	8/14/01	8682	2	9:20	9:47							27
B176956	P	8/14/01	8682	2	10:50	11:47							57

Sample No. B176962 — Location: Inside Permacon with DeWalt Reciprocating Saw
Blank No. B176969 — Task:
Comments:

Sample No. B176969 — Location: BLANK
Blank No. — Task:
Comments:

Sample No. B177013 — Location: Inside Permacon with Evolution 180
Blank No. 177106 — Task:
Comments: Evolution saw began to smoke, therefore use was discontinued

Sample No. B176956 — Location: Inside Permacon with Milwakee
Blank No. 177106 — Task:
Comments:

Sampling by: Jeana M. Harrison Signature: Date:
Sampling by: Jeana M. Harrison Signature: Date:

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Industrial Hygiene Air Sampling Data: Information

Project: FIU - Saws
Address: Hemispheric Center for Environmental Technology
Florida International University
10555 West Flagler St, CEAS 2100
C/S/Z: Miami, FL 33174
Phone: 305-348-2590 Fax: 305-348-6308

Personal Sampling Data
Name:
Job title/description:

PPE used: full face-piece respirator with G/V cartridges, ear plugs, Tyvek suits, gloves
Ventilation: HEPA vacuum for containment

Contaminant(s) Sampled
Dust: 0
Fume: 0
Gas: 0
Mist: 0
Vapor: 0
Other: Fiberglass (fiber count)
Analytical Method: 7400
Min: 0.5 Max: 16 (L/Min)

Media
Mfr.: Zefon
Lot No.: 2522
Cassette: 25 mm
Filter: MCE
Pore size: 0.8 µm
Face: (O/C) open
Tube: na
Treat.: na

Date (m/d/y)	Time (H:M)	Temp (°F)	Pres. ("Hg)	RH (%)

Sample No.	Type P,A,B	Date (M/D/Y)	Instrument Serial No.	Pump No.	Use 24 hour Military Time (24HH:MM) Start	Stop	Start	Stop	Start	Stop	Start	Stop	Total (min)
B177106	B	8/14/01			9:25	11:47							142
B176951	P	8/15/01	8575	3	13:30	13:57							27
B177168	B	8/15/01			13:30	14:00							30
B176997	P	8/16/01	8575	3	8:25	9:30	9:50	10:15					90

Sample No. B177106 — Location: BLANK
Blank No. — Task:
Comments:

Sample No. B176951 — Location: Inside Permacon with Porter Cable #1
Blank No. B177168 — Task:
Comments:

Sample No. B177168 — Location: BLANK
Blank No. — Task:
Comments:

Sample No. B176997 — Location: Inside Permacon with Porter Cable #2
Blank No. B176957 — Task:
Comments:

Sampling by: Jeana M. Harrison Signature: Date:
Sampling by: Jeana M. Harrison Signature: Date:

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INTERNATIONAL ENVIRONMENTAL TECHNOLOGY AND TRAINING CENTER
1293 Airport Road Beaver, WV 25813
(304) 253-8674 Fax: (304) 253-1384

Industrial Hygiene Air Sampling Data: Information

Project: FIU - Saws
Address: Hemispheric Center for Environmental Technology
Florida International University
10555 West Flagler St, CEAS 2100
C/S/Z: Miami, FL 33174
Phone: 305-348-2590 Fax: 305-348-6308

Personal Sampling Data
Name:
Job title/description:
PPE used:
Ventilation:

Contaminant(s) Sampled
Dust: 0
Fume: 0
Gas: 0
Mist: 0
Vapor: 0
Other: Fiberglass (fiber count)
Analytical Method: 7400
Min: 0.5 Max: 16 (L/Min)

Media
Mfr.: Zefon
Lot No.: 2522
Cassette: 25 mm
Filter: MCE
Pore size: 0.8 µm
Face: (O/C) open
Tube: na
Treat.: na

Date (m/d/y)	Time (H:M)	Temp (°F)	Pres. ("Hg)	RH (%)

Sample No.	Type P,A,B	Date (M/D/Y)	Instrument Serial No.	Pump No.	Use 24 hour Military Time (24HH:MM) Start	Stop	Start	Stop	Start	Stop	Start	Stop	Total (min)
B176957	B	8/16/01			8:30	10:25							115
													0
													0
													0

Sample No. B176957 — Location: BLANK
Blank No. — Task:
Comments:

Sample No. 0 — Location:
Blank No. — Task:
Comments:

Sample No. 0 — Location:
Blank No. — Task:
Comments:

Sample No. 0 — Location:
Blank No. — Task:
Comments:

Sampling by: Jeana M. Harrison Signature: Date:
Sampling by: Jeana M. Harrison Signature: Date:

6.6 Acronym List

ACGIH	American Conference of Governmental Industrial Hygienists
AIHA	American Industrial Hygiene Association
cfm	Cubic feet per minute
dBA	Decibels in A-weighted scale
DOE	Department of Energy
f/cc	Fibers per cubic centimeter
FIU	Florida International University
HCET	Hemispheric Center for Environmental Technology
HEPA	High Efficiency Particulate Air
IUOE	International Union of Operating Engineers
JHA	Job Hazard Analysis
mg/m^3	Milligrams per cubic meter
MSDS	Material Safety Data Sheet
NETL	National Energy Technology Laboratory
NIOSH	National Institute for Occupational Safety and Health
NMAM	NIOSH Manual of Analytical Methods
OENHP	Operating Engineers National Hazmat Program
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit
PPE	Personal protective equipment
REL	Recommended Exposure Limit
sp. wg.	Static pressure water gauge
TLV	Threshold Limit Value
TSDS	Technology Safety Data Sheet
TWA	Time-weighted average