Automated Abrasive Blasting Equipment for Use on Steel Structures

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Case Studies

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PART I: CURRENT STATUS OF TECHNOLOGY

This is the report of a project performed to determine the feasibility of using automated paint-removal technology on steel structures (ships, bridges, storage tanks, etc.). The major goal of the project was to determine the current status of the technology. This involved determining the number of prototypes currently available, the development stage of each prototype, and on which steel structures each prototype can be used. Observation of prototype systems in operation was a critical component of this project.

Methods

Prototype automated abrasive blasting systems were identified through a literature review and a review of trade magazines and buyers' guides, through attendance at trade shows or conferences, by Internet search, and through contacts in the abrasive blasting industry. Once a prototype was identified, arrangements were made to attend projects where the product was in use, or to attend product demonstrations. At a minimum, the manufacturer's product literature or published peer-reviewed literature was obtained for each prototype.

Results

Descriptions of Automated Abrasive Blasting Devices

Coke Steel Erection/The Auto Blaster. The Auto Blaster (Figure 1) was designed for removing paint from flanged-beam structures such as bridges and highway overpasses. This automated blasting system consists of a 40-ft by 2-ft working platform suspended from either end by drive wheel assemblies which propel the Auto Blaster as it travels the length of the bridge. Three-inch drive and guide wheels allow the system to pass under diaphragm stiffeners welded to the web of the beam. One of the drive assemblies floats, to allow the device to be adjusted to accommodate different structural widths, and the drive assemblies adjust to allow its use on beams of various flange widths. Eight articulating arms, each bearing a blasting nozzle, move vertically and horizontally to allow for simultaneous abrasive blasting of both sides of four I-beams.

The machine can be operated in an automatic or manual mode, using a wireless hand-held controller. The blasting speed of the machine is adjustable from 2 to 75 feet per minute. Micro switches with small extension rods are positioned to stop the platform when it encounters an obstruction, such as a bridge pier or diaphragm. The motors and electronics are totally enclosed to prevent contamination with abrasive or debris. The platform can be used for manual touch-up blasting (the nozzles can be quickly disconnected from the articulation mechanisms) and painting.

The advantage of the Auto Blaster over conventional abrasive blasting is its ability to operate automatically or via remote control from outside the
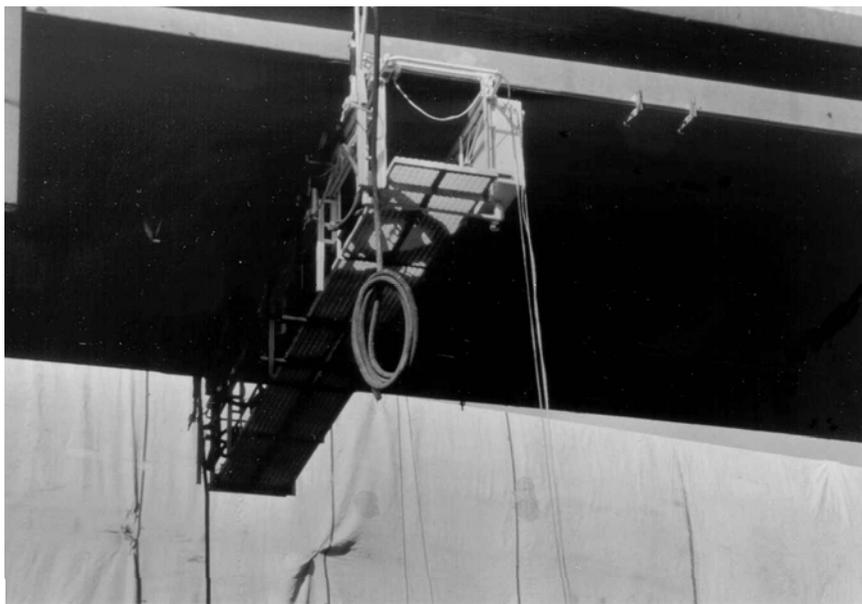

FIGURE 1
Auto Blaster.

containment, allowing the operator to work outside of the containment. Air sampling was conducted by a National Institute for Occupational Safety and Health (NIOSH) investigator during a demonstration on a bridge mock-up inside a 50-ft by 50-ft by 15-ft high containment with 10,000 cfm nominal exhaust. The sampling revealed that lead concentrations inside the containment, where no personnel are required to work, ranged from 2800 to 10,300 μg/m^3 during two seven-minute tests. Samples collected outside the entrance to the containment and at the blast equipment (locations that are as close to the contamination source as personnel will get) contained 2 μg/m^3 and 5 μg/m^3, respectively. According to the manufacturer, the equipment is capable of blasting up to 4000 ft^2 of beam in about 50 minutes.

Flow International Corporation/ HydroCat. A waterjet system developed by Flow International Corporation (Kent, WA) (Figure 2) is designed to remove coatings from structures with possible applications to marine and non-marine industries. The HydroCat can be used to strip the coatings from overhead surfaces (such as the bottom of ship hulls), vertical surfaces (tanks, ship hulls), as well as flat decks (non-skid decking, etc.). The unit uses a rotating head assembly with eight Hornet nozzles, which deliver water at a nominal pressure of 40,000 psi and a flowrate of 6.5 gallons per minute (gpm). The HydroCat unit measures 27 inches by 30 inches overall with a 12 inch rotating waterjet, and weighs approximately 160 pounds. The rotating waterjet head assembly is contained in a vacuum shroud which seals against the surface being cleaned and contains the effluent water and debris removed from the ship surface. The high level of vacuum also is used to attach the unit to the ship when operations require a vertical or overhead traverse path along a ship hull. Two motors mounted on the HydroCat chassis drive the four wheels and provide the motive force to move the unit along the surface. The speed of the unit can be adjusted to provide cleaning rates ranging from 100–1000 ft^2/hr, based on the coating type, thickness, and surface finish requirements. The operation of the unit is supported by two 10 ft skids, one containing the Husky water pump assembly and the second containing the FlowVac vacuum system. A water filtration unit with a one cubic yard filter bag is also provided to remove solids from the effluent water.

A small control unit (15 × 8 inches) is used to start and shut down the water pump and vacuum system, control the direction and speed of the unit, and control the winches, which are used during vertical surface cleaning operations. A joystick is used to allow the operator to manually steer the unit, and an autosteer switch allows the semiautonomous operation of the unit after it has been properly aligned. Two winches are used during vertical operations to prevent the unit from swinging away from the ship surface in the event of loss of power or the loss of vacuum. This feature is strictly incorporated for safety reasons to prevent injury to personnel or damage to the ship. The controller can be placed on a table or can be worn over the shoulder for convenient operation.

A NIOSH researcher observed the HydroCat while it cleaned an inside deck of a cargo ship stationed at a pier. The unit removed an estimated 30 mil paint coating at a rate of 480–500 ft^2/hr during the demonstration. The surface was stripped down to bare metal and the area directly behind the unit was completely dry to the touch. There were no visible emissions and no water mist was observed in the immediate vicinity of the unit. The operation required the use of one person to control the unit, with an additional person to provide occasional visual alignment and to move cables and hoses. The unit previously has been used to clean a vertical surface (underwater hull) with minimal interferences from vacuum hoses and electrical cables. The unit cleaned the surface within four to six inches of obstructions. The A-3000 handheld pneumatic waterjet can be used to remove coatings from areas inaccessible to the HydroCat.

U.S. Navy/High Pressure Water Jet Paint Removal and Recovery System. This system is a spin-off of a National Aeronautics and Space Administration/United Technologies project to develop an advanced stripping system
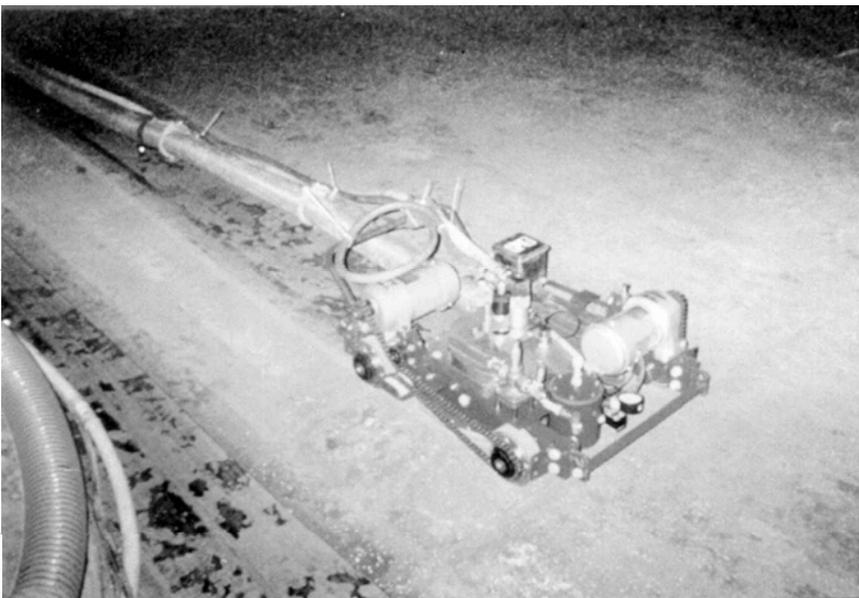

FIGURE 2
HydroCat.

based on high-pressure waterjet cleaning. The Navy's system, the Hull Jet 60 (Naval Surface Warfare Center, West Bethesda, MD and Pratt and Whitney, Huntsville, AL) (Figure 3), was developed by the Naval Surface Warfare Center (Carderock Division) and United Technologies Pratt and Whitney Waterjet Systems (the Air Force developed the Large Aircraft Robotic Paint Stripping system). The system is designed for use on large ships, barges, floating drydocks, and other vessels. The system consists of a modified high-reach with the manipulator frame mounted in place of the bucket, a 20-foot CONEX box housing a diesel-powered high pressure pump, a 40-foot CONEX box housing water purification equipment, a generator, an air compressor, and a remote operator's console. The system is controlled from the remote console. The tool consists of a 6-inch long belt-driven rotating bar (the high-pressure water-blast nozzle) with 22 orifices which discharge 40,000 psi water at 10 gpm. The blast nozzle is housed in a shroud equipped with two vacuum hoses. Two concentric rings of nylon bristles form the seal between the shroud and the surface. This assembly is mounted on a frame approximately eight feet by eight feet, which it traverses. The system is capable of fully automatic or manual operation.

NIOSH investigators observed the system removing the freeboard paint from the hull of an aircraft carrier. The coating was removed to bare metal in the 30 ft^2 operating window in approximately five minutes with no visible emissions. Use of the system eliminates the need for expensive containments and allows other trades to work adjacent to the paint-removal operation. It is capable of removing one layer of coating at a time, or complete removal. It is suited to large, flat areas, such as ships' hulls and flight decks. A 17-h pound hand-held version of the tool is being developed, as is a version capable of traveling beneath the vessel's hull in drydock.

The Navy claims that the system can reduce the waste generated from the hull of one aircraft carrier from 6,000,000 pounds generated by dry abrasive blasting to 100,000 pounds. The system also reduces cost by eliminating the need for containment construction and cleanup ($1.4 million for a recent amphibious assault ship [LHA]). The Navy points to other savings as well, through eliminating the need for personal protective equipment (PPE), reduced waste disposal costs, producing a cleaner surface, allowing other maintenance activities to take place near the operation, reducing time in drydock, and reducing man-hour requirements. In four demonstration projects, the average removal rate for coating ranging from flight-deck non-skid to removing a five-coat system from the underwater hull of an aircraft carrier in drydock was 178 ft^2/hour.

North Carolina State University (NCSU) Construction Automation & Robotics Laboratory/Robotic Bridge Maintenance System. This prototype (Figure 4) was developed by North Carolina State University's Construction Automation & Robotics Laboratory with help from the Federal Highway Administration and the North Carolina Department of Transportation. NIOSH researchers observed its operation at a bridge test facility. The system consists of a four degree-of-freedom robotic arm and containment system mounted on a gantry table attached to the end of a modified truck-mounted peeper crane. A gripper mounted on the robot's wrist grips a universal attachment, which allows it to hold a selection of tools. The system is capable of remote inspection, spray washing, depainting, and painting of bridge I-beams and bridge bearings. The system can be deployed autonomously using a CAD drawing of the bridge, an overlay algorithm, and information from encoders mounted on the crane's joints.

Alternatively, the system can be teleoperated using two cameras which are part of the system, one mounted on the arm of the robot (this camera is also used for inspection tasks) and the other placed on the bridge. Sonars mounted on the boom, robot, and containment system are used to position the robot once deployed under the bridge.

The system has gone through several test and demonstration phases on an experimental bridge structure. Several of the components, such as the robot manipulator, the vision system, and the modified crane boom, have performed very well. Other elements, such as the
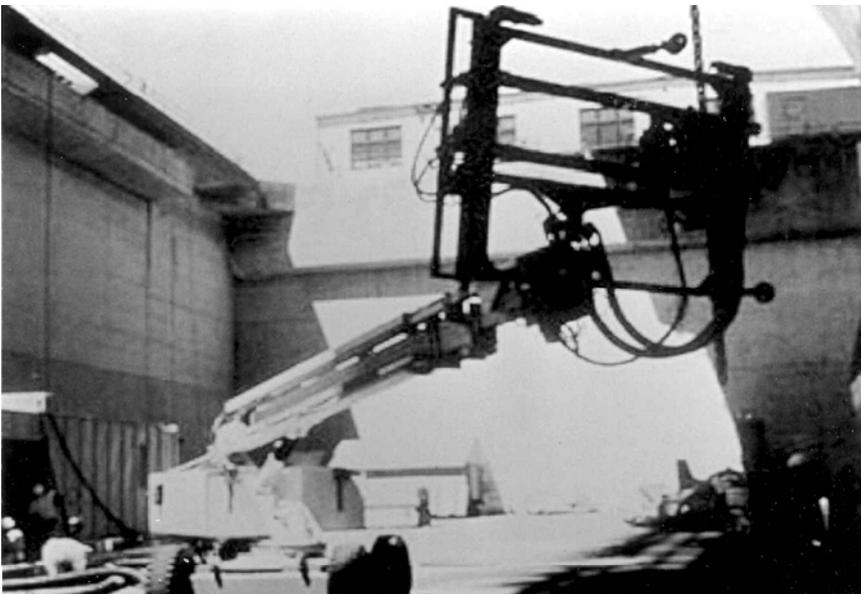

FIGURE 3
Hull Jet 60.

containment system for the sand blasting operation, still need further improvements. One test performed prior to the NIOSH site visit included the use of a frozen CO_2 (dry ice) system, called Cryoblaster, developed by Oak Ridge National Laboratory (Oak Ridge, TN). In that experiment the Cryoblaster was operated by the robot manipulator and removed the paint from the steel surface, reportedly without creating the large amount of contaminated debris created by sandblasting.

Pittman Vacuum Blasting System Inc./Vacuum Abrasive Steel Cleaning and Reclamation System. NIOSH researchers observed the operation of this system, which incorporates the Pittman Vacuum Blasting System (PVBS) (Burlington, Ontario, Canada) Vacuum Abrasive Steel Cleaning and Reclamation System (Figure 5), during the overhaul of a research vessel. Observations indicate that the PVBS automated blasting tool effectively removed and contained lead-based paint during the

demonstration. Details of the measurements in the reduction of occupational exposures to lead are summarized in Part II of this study. The system observed included the blast head, a trailer housing the cleaning and reclamation system, an electric winch, and a hand-held controller. The PVBS marine vacuum blast head, demonstrated on a ship's superstructure during a NIOSH site visit, consisted of two conventional abrasive blasting nozzles connected via blast hoses to the blast pot. The nozzles, located 18 inches apart, traveled inside the blast head on a slide mechanism which moved back and forth driven by an air cylinder. Reed switches, which sensed the magnetic piston inside the air cylinder, controlled the stroke of the nozzles. The blast head rode over the surface of the hull on rubber skirts. The head was held in intimate contact with the hull surface by the force of the vacuum, however, some leakage of abrasive and debris was noted during the demonstration. A newer model, which incorporated three blast

nozzles and an improved seal was scheduled to be delivered after the demonstration. The top and bottom skirts rode on skis to allow them to travel over obstructions. Blast media, rust, and paint were contained within the tool and immediately vacuumed to the cleaning and reclamation system. A variable speed electric winch allowed the blast head to travel up and down the hull at the rate required to achieve the desired finish. A single pass cleaned the tested portions of the superstructure to a white metal finish.

The cleaning and recycling system includes a 7-ft diameter displacement chamber which allows heavy particles to leave the airstream for separation and recycling. Smaller particles move with the airstream to the filtration system. The filtration system is an on/off line independent system housed in two tanks, each of which holds five cartridge filters. The cartridge filters have a computer-controlled pulse jet reverse air wash cleaning system. When one filter loads, it goes off-line and enters the cleaning cycle, while the other unit comes on-line. As each cartridge is cleaned, a group of valves connecting the filter unit to the main vacuum in the displacement chamber, via the paint dust filter, open simultaneously. The self-cleaning paint dust filter deposits the fine dusts into a drum for disposal.

Abrasive is recycled from within the main vacuum unit by transporting spent abrasive from the displacement chamber via a vibratory conveyor. A two-tier separation process takes place during transport. One screen allows all of the fine material, such as spent abrasive, to be separated. A second screen separates larger waste products, such as rust. The material remaining in the vibratory conveyor is recyclable abrasive, which is fed to the blast pot via a vacuum line. Patented compensation valve technology allows the use of one vacuum system to perform several tasks. All equipment in the PVBS unit is computer-controlled with operator input via a touch screen display.

The manufacturer's literature claims a production rate of 600 ft^2/h per tool to a white metal finish. Savings in operating costs are realized by the ability for other
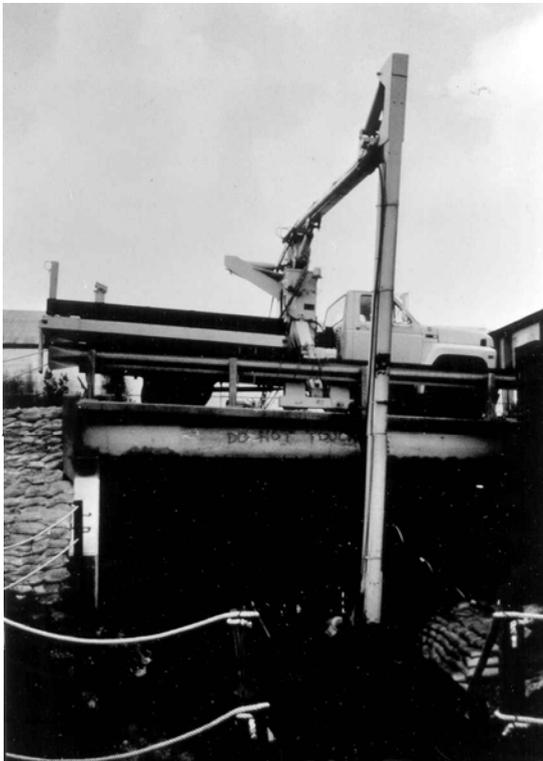

FIGURE 4
Robotic Bridge Maintenance System.

trades to work alongside the unit, no need for containment or PPE, the ability of the equipment to run continuously, and conservation of abrasive through separation and reuse. In addition to the automated unit described, hand-held tools are available for use with the PVBS unit.

Prototypes where no site visit was made. Four additional devices were identified, but site visits were not performed. The En-vac is a joystick-steered, rate controlled abrasive-blasting robot manufactured by MHI Marine Engineering, Ltd. (a subsidiary of Mitsubishi Heavy Industries, Ltd. Portland, OR). The system consists of the robot, recycling unit, filter unit, and vacuum unit. The robot head is held to the work surface by a vacuum that also serves to contain emissions. The En-vac can accommodate a range of abrasives, but the manufacturer claims that the best results are achieved with the Society of Automotive Engineers (SAE) G50 steel grit. The unit is suitable for steel and concrete structures, including storage tanks and spheres, ships, tank interiors, and process equipment.

The University of Texas, Automated Surface Finishing System for Large Diameter Storage Tanks consists of a motion module which rolls along the tank's surface. The motion module is attached to the tank's wind girt using two steel cables. The system can be configured for either blasting or painting by changing the process module attached to the motion module. An over spray unit mounts to the back of the system for use in painting operations. A closed loop system, using a PC-based control program, operates the system via an axis controller using feedback from a motor-mounted encoder.[1]

There are eleven models of U.S. Filter/European Blast Cleaning Equipment (EBE) machines ranging from hand-held vacuum blasters and small spot blasting machines to large vertical machines for steel and concrete, as well as a machine for the underside of ships. All EBE machines are electrically driven, some have their own integral hydraulic drive system which allows the machine to traverse the surface being cleaned at a continuous, controlled speed. Abrasive is thrown at the surface to be cleaned by centrifugal force imparted by feeding the abrasive radially onto paddle-like blades attached to high-speed rotating wheel.

Abrasive rebounding from the cleaned surface is recovered for reuse. This process is assisted by airflow created by two exhaust fans (one on the dust collector, one on the machine). Air enters the machine through a brush screen at the rear, travels across the work surface, up the reclaim duct, through the separator, dust collector, and fan to atmospheric discharge. Containment is achieved by resilient urethane seals at the front, a brush screen across the air intake at the rear, and spring-loaded manganese seals at each side.

The Pentek, Inc. WallWalker (Coraopolis, PA) is an automated blasting and painting system designed for use on tanks, ships, stacks, and buildings. Up to three standard blast nozzles can be mounted on a four-wheel shrouded work head providing production comparable to three experienced blasting operators. The WallWalker work head is vacuum sealed to the surface and attached by a once-fed-through cable system to two pivoting automated cable feed motors mounted in the upper left and right parameters of the work area. A VAC-PAC vacuum system provides two-stage HEPA filtration for hazardous materials with continuous reverse flow pulse jet cleaning to maximize filter life. It reportedly captures 99.5 percent of abrasives, paint, dust, and debris without the use of external containment structures. Optional work heads include ultra high pressure water jetting, scabbling, CO_2 blast, and inspection systems.

Discussion

Nine prototype automated abrasive blasting devices were identified. Five site visits were conducted where observational data were collected. Devices were boom-mounted, suspended by cables, or self-propelled while held against the surface with a vacuum. Abrasive media varied from high-pressure water to silica sand. Availability ranged from developmental designs in university laboratories to marketed systems. Many of these prototypes will reduce employee exposures to lead (and silica), although determining the extent of the exposure reduction requires more in-depth study. Abrasive blasting, construction,
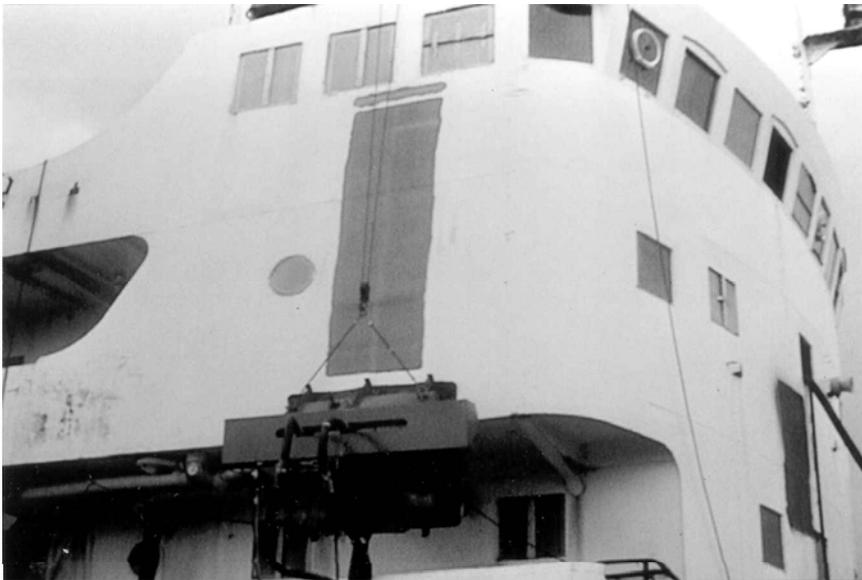

FIGURE 5
Pittman Vacuum Blasting System.

demolition, and painting contractors should explore the economic trade-offs involved in acquiring and using this technology. For most prototypes, advantages include eliminating the need to construct large ventilated containment structures, the ability to perform other tasks, such as repainting alongside the prototype, and reduced compliance costs. However, the original equipment costs may, in some cases, exceed the costs of traditional abrasive blasting devices. In addition, many of the prototypes described in this report are best suited for depainting large, flat, surfaces, such as storage tanks and ship hulls. Additional research is required to determine the potential for employee exposures from equipment maintenance, discharge from abrasive recycling systems and improper use of the technology.

Conclusion

Increased capital investment must be made into these emerging technologies to bring them into full scale production and use, so that their potential for reducing employee exposures can be realized.

PART II: REDUCTION OF OCCUPATIONAL EXPOSURES TO LEAD

In addition to determining the feasibility of using automated paint-removal technology on steel structures, a second goal was to document the degree to which the automated technology reduced occupational exposures to lead. This involved air sampling to determine employee exposures to lead while operating or observing the operations of automated equipment.

The system that was evaluated was the Pittman Vacuum Blasting System (PVBS) Vacuum Abrasive Steel Cleaning and Reclamation System. (A detailed description of this system is presented in Part I of this article.)

Measuring Procedures

Measurements were conducted to determine the ability of the PVBS system to reduce exposures associated with the

removal of lead paint from steel structures by controlling emissions at their source, reducing or eliminating the need to construct and maintain ventilated enclosures, and eliminating or reducing the need for respiratory protection. Thus, exposure monitoring was conducted to determine the airborne concentrations of metals and total particulate during operation of the PVBS system. In addition, bulk samples of paint chips and spent abrasive blasting media were collected at various points on the process to provide information about the ability of the PVBS system to clean the media prior to reuse.

Two personal breathing zone (PBZ) samples and one general area (GA) sample for metals and total particulate were collected for approximately one hour while two laborers used a PVBS handheld tool to clean the deck of a research vessel.

These samples were collected at a flow rate of 2 L/min. The laborers traded duties during the job, each taking a turn holding the hose or operating the tool.

Two PBZ samples and one GA sample were also collected during a brief demonstration of the PVBS automated blasting tool removing paint from the superstructure of the vessel. PBZ samples were collected for 15 minutes on the top man and the operator. The area sample was collected at the operator's position. These samples were collected at a flow rate of 4 L/min.

Two PBZ samples and one GA sample were collected during another brief demonstration of the PVBS automated blasting tool removing paint from another portion of the vessel's superstructure. PBZ samples were collected for 21 and 22 minutes from the controller and the top man, respectively. The area sample was collected on top of a welding box on the pier beneath the portion of the ship being depainted. These samples were also collected at a flow rate of 4 L/min.

Air samples for metal and total particulates collected on 37-millimeter diameter, 5-micron pore-size polyvinyl chloride (PVC) filters in two piece cassettes connected via Tygon tubing to

battery-powered air sampling pumps. For PBZ samples, the filter cassette was clipped to the employee's lapel, while the sampling pump was worn on a belt around the employee's waist. The air samples were analyzed for metals by inductively coupled argon plasma–atomic emission spectroscopy (ICAP-AES), and gravimetrically for total particulate using NIOSH Methods 7300 and 0500 (both with modifications), respectively.[2] The air samples collected during the use of the hand-held tools were analyzed for elements by NIOSH Method 7300 (the list of elements and their analytical limits are provided in Table I), modified for PVC filter

TABLE I
Analytical limits for metal samples collected during use of PVBS hand-held tools μg/filter

	LOD[A]	LOQ[B]
Al	0.4	1
As	0.9	3
Ba	0.02	0.07
Be	0.004	0.01
Ca	0.9	3
Cd	0.03	0.1
Co	0.05	0.2
Cr	0.2	0.7
Cu	0.03	0.1
Li	0.009	0.03
Fe	0.3	1
Mg	0.2	0.7
Mn	0.004	0.01
Mo	0.1	0.3
Na	0.8	3
Ni	0.2	0.4
Pb	0.2	0.7
P	0.5	2
Pt	0.9	3
Se	0.5	2
Ag	0.03	0.1
Te	0.3	1
Tl	0.9	3
Ti	0.05	0.2
V	0.03	0.1
Y	0.005	0.02
Zn	0.2	0.7
Zr	0.03	0.1

[A]LOD = limit of detection.
[B]LOQ = limit of quantitation.

digestion.[2] The air samples collected during the use of the automated blasting head were analyzed for trace metals (arsenic, cadmium, lead, selenium, and thallium) by NIOSH Method 7300.[2] These samples were digested and analyzed according to the method. However, each sample was diluted to a final volume of 25 mL because of the probability that there would not be enough sample to perform the trace analysis.

Four bulk samples were collected during this site visit:

from the deck of the cabin after cleaning using a PVBS hand-held tool (blasting grit and paint particles),

from the waste hopper of the PVBS trailer, a sample of settled dust (mostly paint chips),

from the top of the welding box on the pier beneath the area of the ship that was depainted,

and (paint chips and blasting grit) from inside the lip of the automated blasting tool.

The bulk sample of paint chips collected from the top of the welding box was analyzed for lead using flame atomic absorption spectrophotometry. The limit of detection of this method was 0.004 percent by weight. The limit of quantitation was 0.01 percent by weight. The remaining bulk samples were analyzed for metals according to NIOSH Method 7300.[2]

Results
Air Samples

No arsenic, cadmium, lead, selenium or thallium were detected on any of the air samples collected during the operation of the automated blasting tool. The limits of detection for these samples ranged from 0.01 μg/filter for cadmium to 0.08 μg/filter for lead. For a maximum sample volume of 88 L for this set of samples, the minimum detectable concentrations ranged from 0.11 μg/m^3 for cadmium to 0.91 μg/m^3 for lead. The minimum quantifiable concentrations ranged from 0.23 μg/m^3 to 3.4 μg/m^3, based upon a maxi-

mum sample volume of 88 L, and limits of quantitation which ranged from 0.02 μg/filter for cadmium to 0.3 μg/filter for lead. Total particulate analyses of these samples also produced results less than the limit of detection (0.02 mg).

The results from the elemental analyses of air samples collected during the use of the hand-held tool are provided in Table II. Analyses of these samples for total particulate were less than the 0.02 mg limit of detection for this method. The results in Table II were calculated based upon the actual time the workers used the PVBS hand-held tool. These

TABLE II
Metal exposures during use of PVBS hand-held tools inside cabin μg/m^3

	Laborer sample	Area sample	Laborer
Volume (liters)	132	130	136
Al	ND[A]	ND	ND
As	ND	ND	ND
Ba	0.55	ND	trace[B]
Be	0.60	trace	ND
Cd	trace	ND	ND
Co	1.8	ND	ND
Cr	ND	ND	ND
Cu	trace	ND	trace
Fe2O3 (as Fe)	15	ND	25
MgO	trace	trace	ND
Mn	0.21	ND	0.26
Mo	ND	ND	ND
Ni	ND	ND	ND
Pb	ND	ND	ND
Pt	ND	ND	trace
Se	ND	ND	ND
Ag	trace	ND	ND
Te	ND	ND	ND
Tl	ND	ND	ND
TiO2	trace	ND	trace
V2O5	ND	trace	ND
Y	ND	ND	ND
ZnO	53	8.6	55
Zr	ND	ND	ND

[A]ND = a value below the limit of detection.
[B]trace means a value between the limit of detection and the limit of quantitation.

TABLE III
Results of bulk sample analyses

Analyte	Bulk sample results (microgram/gram)		
	NLO cabin	Blasting tool	Waste hopper
Aluminum	380	350	4700
Arsenic	54	68	50
Barium	13	51	7400
Beryllium	3.0	3.9	2.1
Calcium	180	trace[A]	6400
Cadmium	30	32	24
Chromium	1500	1700	800
Cobalt	48	51	70
Copper	1200	1300	940
Iron	850000	860000	390000
Lithium	ND[B]	ND	6.6
Magnesium	110	94	10000
Manganese	8000	8700	4200
Molybdenum	330	340	120
Nickel	740	770	350
Lead	49	48	2000
Phosphorus	370	390	420
Platinum	2800	3100	1200
Selenium	ND	ND	ND
Silver	ND	ND	ND
Sodium	330	ND	2200
Tellurium	80	73	34
Thallium	ND	ND	ND
Titanium	34	16	240
Vanadium	98	95	44
Yttrium	trace	ND	1.5
Zinc	1900	820	38000
Zirconium	ND	ND	5.9

[A]trace means a result between the limit of detection and the limit of quantitation.
[B]ND means a result less than the limit of detection.

results can be compared against the relevant occupational exposure criteria if one assumes that exposures would have remained constant during the remaining seven hours of the work day. This may have some predictive value for similar operations during future projects. None of the exposures exceeded their applicable occupational exposure criteria.

Bulk Samples

Analysis of the bulk sample of paint chips revealed that the paint

removed from the superstructure during the demonstration contained 0.03 percent lead by weight. Results of the analyses of the remaining bulk samples are provided in Table III. These results indicate that the separation process effectively concentrated the lead waste in the waste hopper. However, without samples of both unused and recycled shot, the remaining results are difficult to interpret.

Discussion and Conclusion

Observations and air sampling data indicate that the PVBS automated blasting tool effectively removed and contained lead-based paint during the demonstration. While the NIOSH researchers observed some paint chips escaping from the ship-to-tool seal, either their particle size, prevailing winds, or other conditions prevented them from reaching the breathing zones of the tool's operators. Following this demonstration, both the tool and the seal were modified, so that this leakage may no longer be a concern. It would be interesting and worthwhile to repeat this evaluation during the operation of the PVBS automated blasting tool in its current configuration over several complete work shifts during a lead-based paint removal project.

It would also be worthwhile to confirm the effectiveness of the waste separation and concentration process during shot recycling. Multiple homogeneous samples of fresh shot, recycled shot, waste material, and the coating/substrate matrix would have to be obtained and analyzed in order to have confidence in the results of that analysis. Preliminary data collected during this brief study indicated that the system removes and concentrates lead from the spent shot during the recycling process and deposits the lead in the waste hopper.

Acknowledgment

Field assistance provided by James D. McGlothlin, Ph.D.

Mention of company names or products does not constitute endorsement by the Centers for Disease Control and Prevention.

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