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BOA: Pipe Asbestos Insulation Removal Robot System

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3.10 BOA: Pipe-Asbestos Insulation Removal Robot System

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Abstract

The *BOA* system is a mobile pipe-external robotic crawler used to remotely strip and bag asbestos-containing lagging and insulation materials (ACLIM) from various diameter pipes in (primarily) industrial installations. Steam and process lines within the DOE weapons complex warrant the use of a remote device due to the high labor costs and high level of radioactive contamination, making manual removal extremely costly and highly inefficient. Currently targeted facilities for demonstration and remediation are Fernald in Ohio and Oak Ridge in Tennessee.

Overview

The two-phase program has progressed past Phase I with a proof-of-concept prototype development and testing scope, and is currently in Phase II. As part of the current scope, a complete regulatory, market and cost/benefit study has been completed. Current efforts are targeted towards the design of a prototype system to abate steam and process lines in the 4 to 8-inch diameter range at a DoE facility by October 1996. In the first-phase effort completed in December 1994, we developed and tested a proof-of-concept prototype system using preliminary locomotion and removal systems, with fiberglass insulation as a surrogate material (see Figure 1) [4].

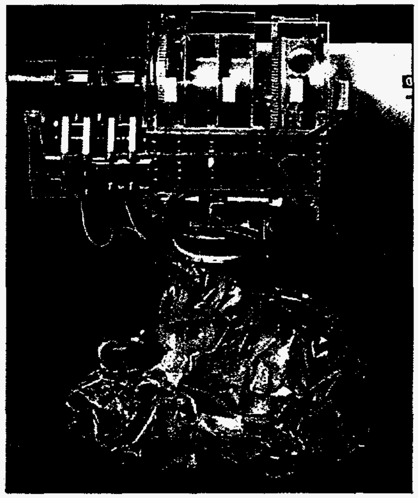

Figure 1 : BOA Phase I Prototype Robot

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Preliminary Experimental Results

It was determined that such a self-propelled, negative-pressure mini-containment system could meet EPA and OSHA mandated fiber-count levels during abatement operations, and that automated removal operations on piping could achieve a high removal rate. Using a mechanical cutting method (circular diamond-grit coated blade), we were able to achieve a net abatement rate of 4 ft./hr., which we knew we had to improve on to make the system more cost-effective. Compressing the material off the pipe once cut, was not sufficient to guarantee removal 100% of the time without some form of human assistance. This result lead us to the realization that a truly reliable and omni-directional cutting system was needed. The use of fiberglass as a surrogate was changed to Calcium Silicate (Calsil), since it was termed more akin to asbestos-containing material (ACM) in the field. This change made in-situ compression of the ACLIM unrealistic and the need for water-assisted/misted cutting and size reduction necessary, further aiding to reduce loose fiber emanation.

Based on these main and other secondary results, the DoE review panel decided to continue the project into Phase II. A revised statement of work for Phase II called for improvements and refinement to the design of the robotic removal head and locomotor system, further guided by a regulatory analysis and a market study and cost/benefit analysis to determine regulatory and performance requirements, market size and commercial potential of such systems for the DoE and within the abatement contractor industry.

Current Efforts & Results

The overall study clearly highlighted guidelines in the areas of regulatory compliance and certification, potential market sizes in the DoE and industry, as well as overall performance requirements and system-cost boundaries in order to be competitive and achieve substantial savings in the thermal insulation abatement market segment.

Regulatory Analysis

As part of the regulatory analysis, we charted a 'certification' path for any alternative abatement method proposed to EPA and OSHA. Even though OSHA/EPA do not certify equipment for use in abatement jobs, they do specify system performance in terms of allowable exposure limits (which aids somewhat in system design), work practices (process of using abatement techniques and equipment) and approval processes (permitting, notification, etc.). From a design stand-point, we will have to ensure we meet the fiber-emissions level regulations, which currently lie at 0.1 fibers/cc - as spelled out in 40 CFR Part 61 [3]. These restrictions imply the use of static and dynamic seals, positive airflow at all times, proper wetting and fiber-sealing and a proper deployment procedure to avoid any fiber release. The 'certification' process that BOA will have to go through, involves the drafting of a technical performance report by an on-site industrial hygienist or project designer with P.E. license which is then submitted to the DC-office of OSHA for review and acceptance - a process spelled out in 29 CFR 1926.1101 (g) (6) [2]. Local, state and regional EPA and OSHA officials are kept abreast of the development and are invited to view the deployment and check for compliance on top of the required independent air monitoring. A full timeline and a list of deliverables and names within EPA and OSHA have been drafted for implementation during Phase II.

Market Study

A thorough review of thermal insulation systems and the asbestos abatement industry within the DoE and industry was conducted [1]. It was determined that the DoE has about 2 million linear feet of total piping (1.5M indoors, 0.5M outdoors) of medium bore-size (4 to 8 in. DIA.) in need of abatement, collected in the six major sites (Savannah River, Hanford, INEL, Oak Ridge, Rocky Flats, Fernald). A breakdown by site and indoors/outdoors is given in Table 1 below.

Table 1 :DoE pipe footage breakdown

DoE SITE	Outdoor	Indoor	TOTAL
Savannah River	110,000	562,000	672,000
Hanford	100,000	300,000	400,000
INEL	60,000	189,000	249,000
Oak Ridge	30,000	184,600	214,600
Rocky Flats	60,000	186,000	246,000
Fernald	70,000	48,700	118,700
TOTAL	430,000	1,460,300	1,890,300

The industrial market size was determined to be about 33.5 million linear feet each year over the next 10 years [1]. We believe that a BOA-like system, attacking only a portion of that market (4 to 8 inch diameter piping) currently abated with glovebags (22%) and then only in more sizeable installations where clearances are available for the robot to work on pipes, would be applicable to up to 0.5 million linear feet total within the DoE and about 1.5 million linear feet a year within the industrial market segment.

Cost/Benefit Analysis

Based on the potential performance of a robot abating at a rate of 40 linear feet per hour, compared with about 3 to 6 feet in DoE/Industry, with associated per-foot abatement costs ranging between $25 and $150 for Industry/DoE, it was determined that substantial savings could be realized with the use of such a robot system [5]. Overall abatement costs could decrease between 25% and 50%, depending on whether the system replaces a current glovebag or full-containment method. Overall savings were thus computed to lie between $10 million and $15 million for DoE, which does not even count savings due to reduced radiation exposure, work-crew reduction and insurance savings, overall worker safety and potential litigation cost savings. Potential unit sales to DoE (and/or its M&Os and subcontractors) and commercial asbestos abatement contractors were estimated to be between 150 and 300 units over the next 7 years, depending on the size of the contractor and job, as well as the final production cost of the system.

Based on the study period at the beginning of Phase II, we also developed a new cutting method to allow more reliable rapid cutting and ease the waste transport. A new operational scenario reflecting the guidelines and lessons learned from the study itself is detailed below:

Operational Scenario

The BOA system consists of a robotic on-pipe locomotion and removal head sized for different pipe diameters, remotely controlled by a single operator from a button-box and inter-connected to off-board logistics support systems (see Figure 2). These off-board systems consist of the positioner that allows the system to be positioned on and off the pipe and around obstacles, the control and computer box to monitor and control all systems, the remote HEPA vacuum and bagging station and the water-based pressure-washer system.

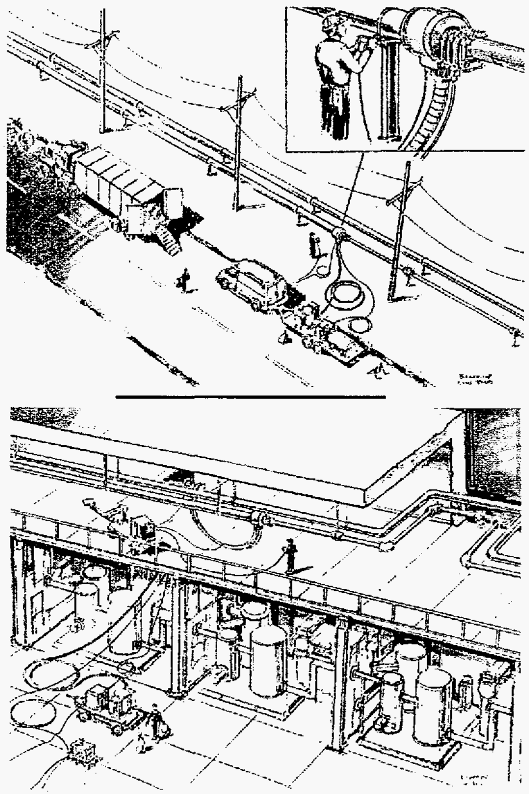

Figure 2 : BOA Deployment Concepts

BOA is projected to be able to abate straight sections of pipe at a rate of 40 ft./hr. using a hybrid endmill/water-jet cutting system which can handle all forms of ACLIM, including aluminum lagging, steel bands and wires, wire-mesh and screws (cut by the endmill), and any form of insulation material such as the simulant CalSil (cut by the water-jet). A picture of lagging and insulation samples we will need to deal with is shown in Figure 3.

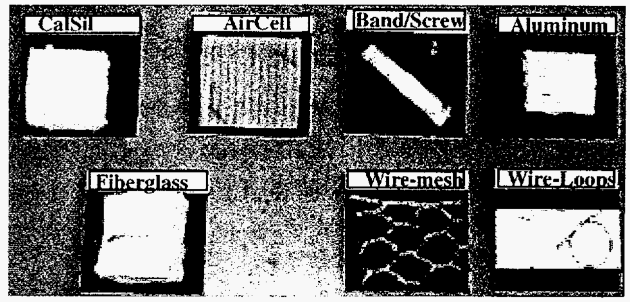

Figure 3 : Lagging & insulation material

The robot can get past hangers unassisted, sealing the insulation left around the hanger (=/- 6in.) for manual post-removal. In the case of obstacles such as valves, junctions, bends, tees, etc., the robot is emplaced around the obstacle using the work positioner and letting the robot self-start behind the obstacle. Once a section of pipe has been cleared, the locomotor clamps onto the pipe and inches along the pipe using a triple tripod clamping mechanism connected by guide-rails and linear electric actuators. The diced-up insulation blocks are roughly 2 inches on edge, and are water-blasted into the waste-chute which leads into the vacuum hose connected to the HEPA vacuum via a water-separation and waste-bagging unit. The water is separated and re-used, while the waste material is bagged into standard 6-mil poly bags by the second operator. Bagging operations can occur as far away as 500 feet from the actual pipe abatement location.

Competing Technologies

The BOA system is unique in that it represents a new class of abatement technology that is currently not available, namely a self-locomoting negative pressure mini-enclosure for automated pipe-insulation abatement. The only 'mechanized' solutions for pipe insulation abatement contractors consist of a re-usable glovebag and a remoted vacuum filtering and bagging system as shown in Figure 4.

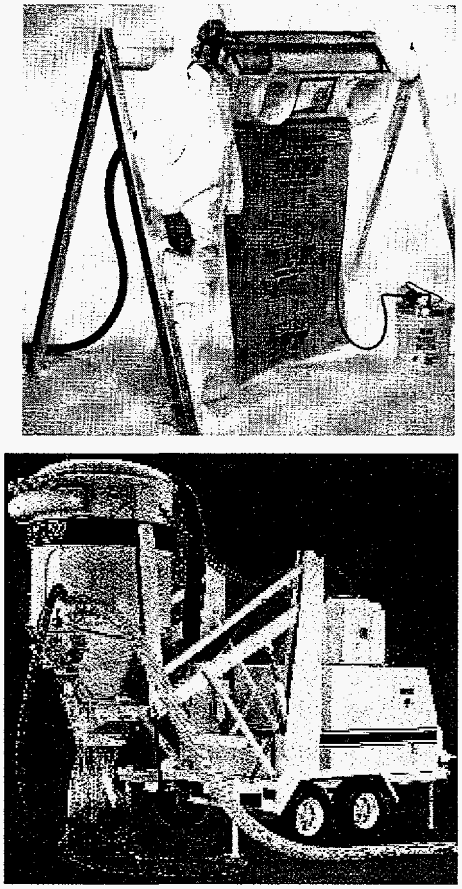

Figure 4 : 'Competing' Technologies

Ongoing Work

We are currently in the design phase of the prototype system, which we intend to present to a DoE review panel in November 1995. Current plans are to build and test the robot system and carry out an acceptance test at CMU at the end of July 1996. Upon successful completion, DoE will build a full-scale partial cold-test replica of the designated final test site, where we intend to perform a full-scale cold-demo by October 1996, and thereafter a full-scale asbestos abatement field trial at the chosen DoE site location.

Acknowledgments

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References

[1] The Jennings Group, Inc., Asbestos Abatement Contracting Industry 1993, May 1993. (Copyrighted)

[2] OSHA - 29 CFR 1926.1101, 29 CFR 1910, et al., "*Occupational Exposure to Asbestos; Final Rule*', August 10, 1994

[3] EPA - 40 CFR Part 61, "*National Emissions Standards for Hazardous Air Pollutants*", November 20, 1990

[4] H. Schempf, J. Bares, "*BOA: Asbestos Pipe Insulation Removal Robot System - Phase I*", DOE/MC/30362 -- 4049, DE95000095), National Technical Information Service, Springfield, VA, February 1995

[5] Schempf et al., "*BOA: Market Study, Cost Benefit Analysis & Regulatory Review - Topical Report*", Draft Version, METC/CMU, Pittsburgh/Morgantown, PA/WV, July 1995

[6] Site Survey Reports from several sites: Oak Ridge, Fernald, INEL, Savannah River, Rocky Flats & Hanford