INNOVATIVE TECHNOLOGY

Summary Report

Advanced Recyclable Media System®

OST Reference #1971

Deactivation and Decommissioning
Focus Area

Demonstrated at
Argonne National Laboratory-East
Argonne, Illinois

MASTER

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Innovative Technology

Summary Report

Purpose of this document

Innovative Technology Summary Reports are designed to provide potential users with the information they need to quickly determine if a technology would apply to a particular environmental management problem. They are also designed for readers who may recommend that a technology be considered by prospective users.

Each report describes a technology, system, or process that has been developed and tested with funding from DOE's Office of Science and Technology (OST). A report presents the full range of problems that a technology, system, or process will address and its advantages to the DOE cleanup in terms of system performance, cost, and cleanup effectiveness. Most reports include comparisons to baseline technologies as well as other competing technologies. Information about commercial availability and technology readiness for implementation is also included. Innovative Technology Summary Reports are intended to provide summary information. References for more detailed information are provided in an appendix.

Efforts have been made to provide key data describing the performance, cost, and regulatory acceptance of the technology. If this information was not available at the time of publication, the omission is noted.

All published Innovative Technology Summary Reports are available on the OST Web site at http://OST.em.doe.gov under "Publications."

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SECTION 1

SUMMARY

Technology Description

The objective of the Large-Scale Demonstration Project (LSDP) is to select and demonstrate potentially beneficial technologies at the Argonne National Laboratory East's (ANL) Chicago Pile-5 (CP-5) Research Reactor. The purpose of the LSDP is to demonstrate that using innovative and improved deactivation and decommissioning (D&D) technologies from various sources can result in significant benefits, such as decreased cost and increased health and safety, as compared with baseline D&D technologies. This report describes a demonstration of the Advanced Recyclable Media System® technology which was employed by Surface Technology Systems, Inc. to remove coatings from a concrete floor. This demonstration is part of the CP-5 LSDP sponsored by the U.S. Department of Energy (DOE) Office of Science and Technology Deactivation and Decommissioning Focus Area (DDFA).

The Advanced Recyclable Media System® (ARMS) technology is an open blast technology which uses a soft recyclable media. The patented ARMS Engineered Blast Media, Figure 1, consists of a fiber-reinforced polymer matrix which can be manufactured in various grades of abrasiveness. The fiber media can be remade and/or reused up to 20 times and can clean almost any surface (e.g., metal, wood, concrete, lead) and geometry including corners and the inside of air ducts.

Figure 1. ARMS Engineered Blast Media.

The ARMS equipment is divided into three units: the feed unit, the sifter/classifier unit, and the media remake unit. Two of these units are pictured in Figure 2. The media is propelled from the feed unit toward the surface to be cleaned by a portable blast nozzle. The used media is then manually collected and placed into the sifter/classifier unit. Large debris (>1/4-in) and small fines (<1/16-in) are discarded as waste and the remaining media can either be sent for media remake or can be recycled back into the feed unit for reuse. The media remake unit combines media, that has been reused from 10-12 times (cycles) and which has lost most of its abrasive qualities, with new abrasive, polymer, and steam to produce new media. A vapor injection system (not demonstrated) can also be connected to the blast unit to introduce pressurized vapor into the blast air system. This system can be used to lower dust generation or to introduce chemical agents (e.g., flash rusting inhibitors, pre-treatments, or innovative surface treatment chemicals) into the blast stream.

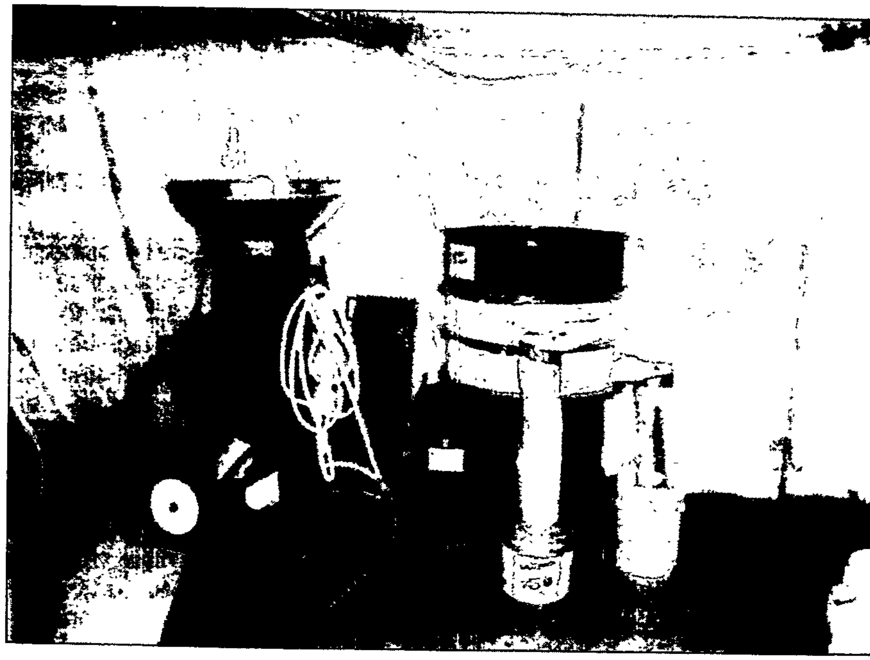

Figure 2. ARMS feed unit and sifter/classifier.

The ANL baseline technology, mechanical scabbling, uses a manually driven floor/deck scaler suitable for thick coating removal and the surface preparation of large areas of concrete floors. This unit is equipped with eleven 1-in-diameter pistons that impact the floor at a rate of 2,300 blows/min/piston. An aluminum shroud surrounds the pistons capturing large pieces of debris; however, an attached dust collection/vacuum system is not being used. Instead, a containment system (i.e., a plastic tent) is erected over the area to be decontaminated to minimize the potential release of airborne dust and contamination.

The advantage of the ARMS technology over the baseline mechanical scabbling technology is that since ARMS is an open blast technology, the media can reach the floor area in corners, against walls, and around obstacles for decontaminating.

Technology Status

CP-5 is a heavy-water moderated and cooled, highly enriched, uranium-fueled thermal reactor designed to supply neutrons for research. The reactor, which had a thermal-power rating of 5 megawatts, was operated continuously for 25 years until its final shutdown in 1979. These 25 years of operation produced activation and contamination characteristics representative of other nuclear facilities within the DOE Complex and private sector nuclear facilities. CP-5 possesses many of the essential features of other DOE and commercial nuclear facilities and can be used safely as a demonstration facility for the evaluation of innovative technologies for the future D&D of much larger, more highly contaminated facilities.

The ARMS technology was evaluated as part of the LSDP for concrete removal of 262 square feet (ft^2) of flooring on the service floor of the CP-5 Research Reactor. The evaluation period (September 22 to 26, 1997) included the mobilization, demonstration, and demobilization of this technology. Radiological surveys were performed both before and immediately after the demonstration. The purpose of these surveys was to determine the level of decontamination achieved through the removal of the floor coatings by the soft media blasting system.

Surface Technology Systems, Inc. personnel operated the ARMS equipment for the demonstration. ANL personnel from the CP-5 Project and the Environment, Safety, and Health (ESH) Division provided support in the areas of health physics (HP), industrial hygiene (IH), waste management (WM), and safety engineering. Florida International University - Hemispheric Center for Environmental Technology (FIU-HCET) performed the data collection, including benchmarking and cost information. The U.S. Army

Corps of Engineers (USACE) performed the analysis of the cost data, and ICF Kaiser, International performed the analysis of the benchmarking information.

Key Results

The key results of the demonstration are as follow.

- The ARMS technology operated by Surface Technology Systems, Inc. successfully blasted the 262 ft^2 of flooring in the demonstration area at a rate of 41.9 ft^2/h. This rate includes a crew of three persons performing the following tasks:
  - blasting the floor
  - collecting the discharged media
  - sifting the media
  - recycling the media back into the media feed unit.
- A temporary containment tent was erected around the demonstration area using PVC piping and flame retardant reinforced poly. At the end of the demonstration, an administrative decision was made to discard the poly without performing a radiological survey to determine if it could be released. The PVC piping was surveyed and released to the vendor.
- The demonstration began with 200 lb (7.52 ft^3) of new media. This media was recycled approximately 16 times during the blasting. At the end of the demonstration, a total of 0.8 ft^3 of spent fines (<1/16-in) and large (>1/4-in) pieces of concrete were collected and discarded as waste. The amount of media considered to be reusable was measured to be 4 ft^3.
- After the demonstration, the radiological level of the spent fines (<1/16-in) was 3,000 dpm, and the remaining reusable media (>1/16-in) levels were measured to be 300-500 dpm.
- Blasting of the floor reduced the contamination levels in the demonstration from an area of total beta/gamma fixed contamination ranging from 3,200 to 263,200 dpm/100 cm^2 to four localized hotspots ranging from 4,000 to 19,000 dpm/100 cm^2.

Contacts

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Web Site

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SECTION 2

TECHNOLOGY DESCRIPTION

Technology Schematic

The ARMS soft recyclable media system removes and absorbs low-level radioactive surface contaminants, oil, scales, greases, PCBs, paint, soot, lead, graphite, rust, and asbestos from metals, concrete, wood, and graphite. The blast media consists of a urethane foam-based matrix which is manufactured in various grades of abrasiveness. The most aggressive media would be made of fiber and steel grit or aluminum oxide. These can remove up to 2-3 mils of paint, rust, or scale. The fiber media can be remade and reused 20 times and typical decontamination factors are in the range of 300 for a single pass. The ARMS is an open blast system, which is routinely used in a glovebox or contained area, and can clean almost any surface geometry including corners and the inside of air ducts.

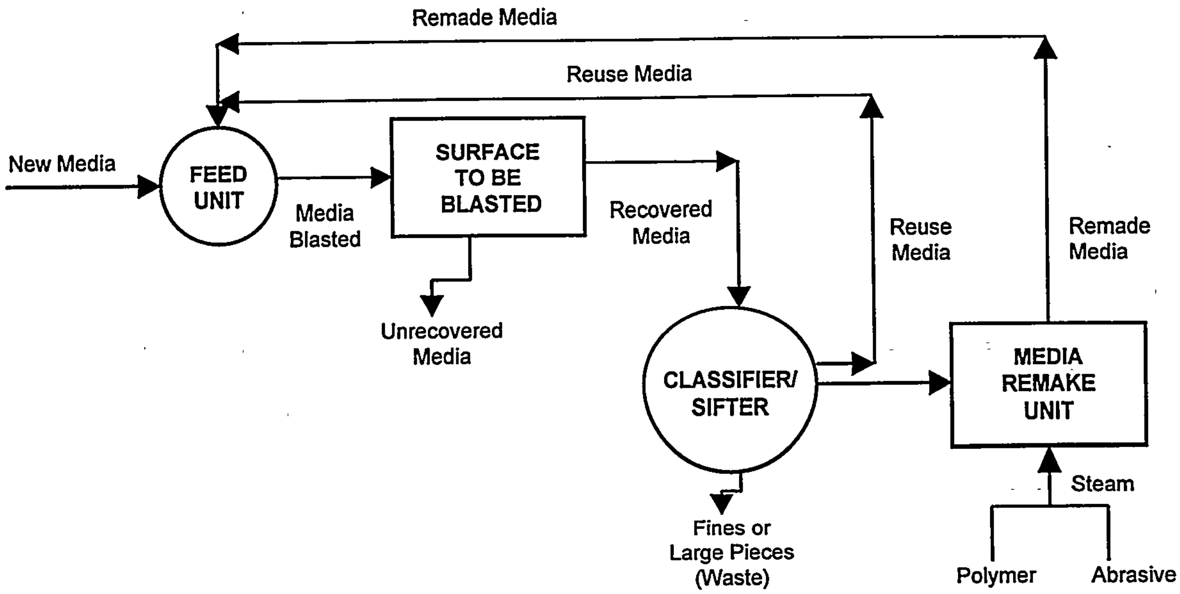

Figure 3. Process flow chart for ARMS.

The ARMS technology is divided into the following four units (including the media):

ARMS Engineered Blast Media

This media utilizes a fiber reinforced polymer matrix as its foundation. Five types of media can be produced depending on the fiber medium and abrasive additives used. These include the following:

- ARMS Cleaning Fiber Media - No abrasive content, used for soft substrate cleaning, grease and oil removal. Safe for rubber and plastic surfaces.
- ARMS Plastic Fiber Media - Non-aggressive cleaning media. Used for coating removal on sensitive substrates.
- ARMS Walnut Fiber Media - Low abrasive cleaning media. Used for coating removal on sensitive substrates and equipment. Effective in cleaning harder surface contaminants.

- ARMS Aluminum Oxide Fiber Media (B)- Up to 3 mil Profile. Used for industrial coating removal and decontamination.

- ARMS Aluminum Oxide Fiber Media (C) - Over 3 mil Profile. Most aggressive media available. Faster cutting than Type B Aluminum Oxide Fiber Media.

When the media is blasted at the surface of a substrate, it compresses entrapping contaminants from the surface in its matrix. The fiber matrix transfers energy efficiently to the surface, minimizing rebound of the media from the surface into the air. This matrix can also absorb heated vapor, injected into the blast unit from a vapor injection system, and transfer it to a surface for accelerated treatment or to maximize dust suppression.

The media can be recycled (or reused) up to 20 times and can be remade by mixing spent media, new polymer, abrasive, and steam in the ARMS Remake Unit.

ARMS Feed Unit

This unit is a pneumatically powered device for propelling a media against surfaces to be cleaned or otherwise prepared. A hopper stores the media, which is then fed by a variable-speed auger device into the metering chamber, which mixes the cleaning media with compressed air. The mixture of the media and compressed air is then propelled toward the surface using standard blasting hoses and nozzles. This unit is on wheels and is portable.

- Dimensions (L x W x H) — 32 in x 32 in x 60 in
- Weight — 450 lb
- Vendor advertised production rate — 50 - 150 ft^2/h (depending on the paint)
- Air compressor required — 250 cfm of 90 psi air

ARMS Sifter Units

The media that has been expelled from the Feed Unit was then collected manually using plastic shovels and placed into an electrically powered sifter unit. The ARMS sifter unit typically used by Surface Technology Systems, Inc. augers the media, causing it to pass through a series of four progressively finer screens. Large debris (>1/4-in such as paint chips, wood, rust particles, etc) and the powdery residue and debris (<1/16-in) are separated for disposal as waste. Media sized from 1/8 to 1/4-in is fed back into the hopper of the Feed Unit for immediate reuse and the 1/16 to 1/8-in sized media is then available to send to the Media Remake Unit.

- Dimensions (L x W x H) — 72 in x 34 in x 72 in
- Weight — 400 lb

This unit was not able to be demonstrated at CP-5 because it was too tall to fit into the elevator to be lowered into the demonstration area. Instead, the vendor brought an engineered media classifier manufactured by Midwester Industries, Inc. but sold by ARMS. This sifter operates by electrically vibrating the media in a rotational pattern through a series of three progressively finer screens. At each level of screening, the proper sized pieces of media or debris are expelled out side exits into 5-gal drums. The media to be reused is then manually loaded back into the Feed Unit, the fines and large debris are placed in a 55-gal drum for disposal.

- Dimensions (L x W x H) — 33 in x 41 in x 51 in
- Weight — 650 lb

ARMS Media Remake Unit

This unit combines used media, polymer, an abrasive, and steam to produce new media. An auger churns the used media while premixed bags of polymer are added. Steam is injected into the chamber and reacts with the polymer to form new media. Abrasive material can be added also depending on the aggressiveness required for the media. This unit is typically used for large projects involving the blasting of over 10,000 ft^2 of surface. *The media remake unit was not demonstrated at CP-5 but at the Surface Technology Systems, Inc. location in Akron, Ohio on October 21, 1997.*

- Dimensions (L x W x H) 52 in x 24 in x 60 in
- Weight 400 lb

The following was also required for the operation of the ARMS system at the CP-5 LSDP:

- 250 cfm air compressor
- 115 V AC, 20 A, single phase power source,
- 1,000 - 2,000 cfm HEPA ventilation system, and
- Two containment tents made of PVC piping and flame retardant poly. One encompassed the entire demonstration area and the second smaller mobile tent was placed over the local blasting area.

System Operation

- The ARMS blast unit was manually operated by pulling a squeeze trigger on the nozzle. If this trigger was not engaged, the blast unit would not operate.

- The blasting operator sat on a small wheeled garden chair while blasting the floor. This allowed him/her from having to bend or stoop over while blasting the floor.

- After blasting a small area of floor, the blasting operator would move the small containment tent and the other technicians would manually scoop the media from the floor with a plastic shovel. This media was then placed into the sifter and the reusable media was then loaded back into the Feed Unit.

- Decontamination of the ARMS technology included removing the filters from the ventilation system, and wiping the equipment, hoses, and PVC piping from the containment tent using damp rags. At the end of the demonstration, the entire floor was vacuumed with a small HEPA vacuum, especially around the edges of the tenting.

- The main waste stream from this operation is a powdery mixture of media and paint chips. A few large pieces (>1/4-in) of concrete were also removed from soft-concrete areas of the floor during blasting. Secondary waste included the remaining reusable media, the pre-filter and HEPA filter from the ventilation system, 600 ft^2 of tenting material, PPE, and damp rags used during equipment decontamination.

SECTION 3

PERFORMANCE

Demonstration Plan

The demonstration of the ARMS technology from Surface Technology Systems, Inc., was conducted according to the approved test plan, *CP-5 Large-Scale Demonstration Project: Test Plan for the Demonstration of the Advanced Recyclable Media System Technology at CP-5* (Strategic Alliance for Environmental Restoration, 1997). The objective of the demonstration was to remove the contaminated paint coating from 600 ft^2 of concrete flooring on the service floor of the ANL CP-5 Research Reactor facility. The concrete is approximately 40 years old and is covered with multiple layers of paint. The decision to perform coating removal for these demonstrations was based on the potential future need to reuse the floor space where demonstrations were held. Coating-removal technologies tend to yield a smooth surface that can be easily repainted or covered, whereas concrete-removal technologies can leave an uneven, rough surface that could be difficult to reuse.

Radiological surveys for both fixed and removable radioactivity were conducted both before and immediately after the demonstration. The purpose of these surveys was to determine the level of decontamination achieved by the concrete removal.

During the demonstration, evaluators from FIU-HCET collected data in the form of visual and physical measurements. Time studies were performed to determine the production rate of the technology and implementation costs. The end-point condition left by the demonstration was compared with the requirement of removing the coating and any subcoating to produce a bare concrete floor. Additional field measurements collected included secondary waste generation, potential personnel exposure, and ease of equipment operation. The performance of the ARMS technology was evaluated against that of the baseline technology, which is manual mechanical scabbling.

Treatment Performance

Table 1 presents both the results of the demonstration of the Surface Technology System, Inc. ARMS technology and a comparison with the baseline technology.

Deviations from the test plan include the following:

- The size of the demonstration area was reduced from 600 ft^2 to 262 ft^2 because of a need for CP-5 personnel to be able to reach vital equipment in the area during the demonstration.

- The paint on the main part of the floor of the demonstration area appeared to be a stain and sealer instead of a paint and primer. The stain was found to have penetrated the top 1/16-1/8 in layer of the concrete. Also, three locations (37-in by 62-in areas) in the demonstration area, where pump equipment had previously been bolted to the floor, had been patched with a cement filler and then painted over. The concrete in these locations were "softer" and pieces of the cement patch came up when blasted.

- The equipment operators were required by ANL to wear supply air respirators during the demonstration. This requirement is outside of normal operations for Surface Technology Systems, Inc. and the Material Safety Data Sheet for the ARMS media recommends the use of a dust/mist respirator.

Table 1. Performance data

Criteria	ARMS	Baseline manual mechanical scabbling
Applicable surface	Paint coating removal from floor	1/4-in concrete removal from floor
Production rate (removal rate only) (1)	41.9 ft^2/h for a crew of three	200 ft^2/h for a crew of three
Amount and type of primary waste generated	0.8 cubic feet (ft^3) of both a powdery paint and media mixture (<1/16-in) or large concrete pieces (>1/4-in).	An estimated 24 ft^3 of a mixture of powdery and large pieces of paint chips and concrete (as this requires manual cleanup, no vacuum system is attached)
Type of secondary waste generated	Reusable media left after the demonstration - 4.0 ft^3 Pre-filters - two units HEPA filter - one units Tent enclosure material - 600 ft^2 (2)	Tent-enclosure materials and worn pistons/scabbling bits
Airborne radioactivity generated by equipment	All airborne radiological measurements measured outside the enclosure tent were at or below background levels.	As the baseline technology is not connected to a vacuum system, up to 10 percent of debris generated can become airborne.
Noise level	100 dBA at the blasting nozzle (per vendor, not measured), hearing protection is required.	84 dBA (per vendor, not measured).
Capability to access floor-wall unions	Able to reach against edges of walls and into corners.	No closer than 1 in
Development status	Commercially available.	Commercially available. Compatible vacuum systems are also available.
Ease of use	Training = 2 h/person Blasting operator sat on wheeled garden stool while blasting.	Training required = 2 h/person. Walk behind, push-floor model. Moderate-to-heavy vibrations can cause operator fatigue.
End-point condition	Upper layer(s) of paint was removed down to stained concrete layer. In locations where there was cement patches, all paint was removed as well as a few large chunks of cement leaving a rough surface.	Paint coating is removed, leaving a rough, bare concrete surface.
Worker safety	Tripping hazard caused by multiple hoses.	Flying concrete poses a potential eye hazard.

(1) Includes blasting time and manual collection (i.e., shoveling) of media from previously blasted floor areas. Many times these tasks were performed simultaneously by separate operators, however, sometimes the blasting operator would stop and collect the media before continuing with the blasting.

(2) An administrative decision was made at CP-5 not to survey the tent for possible release but instead to dispose of the tent material. The PVC piping was surveyed and released to the vendor at the end of the demonstration.

Radiological surveys of the demonstration area were performed before and after the demonstration. Radiological contamination prior to the demonstration included an area of fixed beta/gamma contamination ranging from 3,200 to 263,200 dpm/100cm^2. After the demonstration, the contamination was localized to four hotspots which ranged from 4,000 to 19,000 dpm/100 cm^2. After the demonstration, the radiological level of the spent fines was 3,000 dpm and the remaining reusable media levels were measured to be 300-500 dpm.

SECTION 4

TECHNOLOGY APPLICABILITY

Competing Technologies

In addition to the ARMS technology, a number of other technologies are available to D&D professionals for removing coatings from concrete floor surfaces.

Examples of competing technologies include:

- manual mechanical scabbling (ANL baseline technology),
- remotely operated mechanical scabbling,
- centrifugal shot blast,
- milling,
- flashlamp,
- carbon dioxide blasting,
- grit blasting,
- high pressure and ultra-high pressure water blasting,
- sponge blasting,
- laser ablation,
- wet ice blasting, and
- various chemical-based coating removal technologies.

Technology Applicability

The ARMS technology, employed by Surface Technology Systems, Inc. is a commercially available technology the primary application of which is removal and absorption of low-level radioactive surface contaminants, oil, scales, greases, PCBs, paint, soot, lead, graphite, rust, and asbestos from metals, concrete, wood, and graphite.

The advantages the ARMS offers include:

- The ability of the ARMS technology to reach into corners and against edges of walls and obstructions.

- The fact that the ARMS media is capable of being recycled up to 20 times during a blasting operation. Also, for large projects (over 10,000 ft^2) the media can be remade thus reducing the need to purchase new media to replace the spent media that is too small to recycle.

The shortcoming of the ARMS technology is that because it is an open blast technology, a vacuum system cannot be incorporated to minimize airborne dust thereby eliminating the need for a containment tent.

Patents/Commercialization/Sponsor

This demonstration used an existing commercial technology. The ARMS equipment and the Engineered Blast Media is made and patented by Advanced Recyclable Media Systems, Inc.. Surface Technology Systems, Inc. sells the ARMS system as a service providing either (1) the equipment with a supervisor, equipment operator technicians, and a health physics technician or (2) the equipment with a supervisor allowing the site personnel to operate the equipment.

SECTION 5

COST

Introduction

This cost analysis summarizes and evaluates the innovative technology (ARMS) and estimates the potential for savings relative to the baseline technology (manual mechanical scabbling). The objective is to assist the decision-maker that is debating whether further investigation of the innovative technology is warranted. This analysis strives to develop realistic estimates that represent actual D&D work within the DOE Complex. However, this is a limited representation of actual cost, because the analysis uses only data observed during the demonstration. Some of the observed costs are eliminated or adjusted to make the estimates more realistic. These adjustments are allowed only when they do not distort the fundamental elements of the observed data of production rate, quantities, or work elements. They eliminate only those activities that are atypical of normal D&D work. Descriptions contained in later portions of this analysis detail the changes to the observed data.

Methodology

This cost analysis compares two decontamination technologies, an innovative media recycling technology and a conventional manual mechanical scabbling technology, the baseline. The media recycling technology was demonstrated at the CP-5 under controlled conditions with vendor personnel and equipment. Work process activities were timed and quantities were measured so that production rates could be determined.

Data collected during the demonstration includes the following:

- activity duration,
- work crew composition, and
- equipment and supplies used to perform the work steps.

A demonstration of the baseline manual mechanical scabbling technology was not performed. Baseline information is developed from the following sources:

- existing CP-5 budget or planning documentation
- historical experience at ANL, and
- experience-based judgment of D&D personnel at ANL.

Since the baseline costs are not based on presently observed data, additional effort is applied in setting up the baseline cost analysis to ensure unbiased and appropriate production rates and crew costs. Specifically, a team consisting of members from the Strategic Alliance (ICF Kaiser, ANL D&D technical specialist, and test engineer for the demonstration) and the USACE reviewed the estimate assumptions to ensure a fair comparison.

The cost analysis data is displayed in a predetermined activity structure. The activities are extracts from the *Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary* (HTRW RA WBS), (USACE, 1996.) An interagency group developed the HTRW RA WBS, and its use in this analysis provides consistency to established national standards.

Some costs are omitted from this analysis so that it is easier to understand and to facilitate comparison with costs for the individual site. The ANL indirect expense rates for common support and materials are omitted from this analysis. Overhead rates for each DOE site vary in magnitude and in the way they are applied. Decision-makers seeking site-specific costs can apply their site's rates to this analysis without having to first retract the rates used by ANL. Engineering, quality assurance, administrative costs and taxes on services and materials also are omitted from this analysis for the same reasons indicated for the overhead rates.

The standard labor rates established by ANL for estimating D&D work, are used in this analysis for the portions of the work performed by local crafts. Additionally, the analysis uses an 8-h workday with a 5-day week.

The equipment hourly rates, representing the Government's ownership, are based on general guidance contained in Office of Management and Budget (OMB) circular No. A-94 *Cost Effectiveness Analysis*. The rate consists of ownership and operating costs. Operating costs consist of fuel, filters, oil, grease and other consumable items plus repairs, maintenance, overhauls and calibrations.

Cost Data

Table 2. Innovative technology acquisition costs

Acquisition option	Item	Cost
Equipment purchase	**Main unit**	
	Feed Unit	$12,000
	Media Classifier	$10,000
	Remake Unit	
	Blender	$ 8,000
	Vapor Generator	$ 5,000
Vendor provided service	Crew and equipment (not including remake unit, compressor, or ventilation equipment)	$ 1,500/day
Equipment lease	Not available	

The cost of operation of the equipment will include an air compressor, HEPA system, containment tent, and fiber media (aluminum oxide 50 lb. bag costs approximately $100 per bag). If the equipment is purchased, the vendor will require that the Site sign a licensing agreement (agrees not to compete with the vendor). Costs for media will be in proportion to the size of the job (200 lb. used in this demonstration for 262 ft^2) except for situations where the remake unit is used.

Table 3. Summary of unit costs & production rates observed during the demonstration

Innovative technology			Baseline technology		
Cost element	**Unit cost**	**Production rate**	**Cost element**	**Unit cost**	**Production rate**
ARMS	$1.52/ft^2	41 ft^2/h	Mechanical Scabbling	$ 1.98/ft^2	200 ft^2/h

The unit costs and production rates shown do not include mobilization, set up, maintenance/repair, or other costs associated with non-productive portions of work. The intention of this table is to show unit costs at their elemental level, which are free of site-specific factors such as work culture or work environment influences on productivity loss factors or costs which can vary from one situation to the next (for example disposal of leftover media may not be required in cases where it can be recycled). Consequently, the unit cost for ARMS is the unit cost shown for the "Blast Floor" line item of Table C-2 of Appendix C. The Scabbling unit cost is the addition of the"Removal of Concrete Floor Costings" plus the "Equipment Operating Costs" plus "Load Rubble in Containers" line items of Table C-3 of Appendix C. Tables C-2 and C-3 can be used to compute site-specific costs by inserting quantities and adjusting the units for conditions of an individual job.

Summary of Cost Variable Conditions

The DOE complex presents a wide range of D&D work conditions because of the variety of functions and facilities. The working conditions for an individual job directly affect the manner in which D&D work is performed and, as a result, the costs for an individual job are unique. The innovative and baseline technology estimates presented in this analysis are based upon a specific set of conditions or work practices found at CP-5, and are presented in Table 4. This table is intended to help the technology user identify work differences that can result in cost differences.

Table 4. Summary of cost variable conditions

Cost variable	ARMS	Manual mechanical scabbling
	Scope of Work	
Quantity and type	262 ft^2; Coated concrete floor.	262 ft^2 not demonstrated but was computed to be comparable to ARMS quantity.
Location	Service floor of CP-5 Test Reactor including open areas, edges, foundation vertical edges, and under cramped stairway.	Assumed to be similar.
Nature of work	Reduce radiological levels. Blast concrete to remove coating and recycle media. Work area is 25 ft in length, 4 ft at one end and 17 ft at the opposite end.	Reduce radiological levels. Remove ¼ in of concrete (inherent in equip) along with coating.
	Work Environment	
Worker protection	Anti-contamination coveralls with hood, and respirator.	Anti-contamination coveralls with hood, and respirator.
Level of contamination	The demonstration area is not a radiation area. Concrete chips and dust (airborne) created by blasting equipment. Tenting is required.	Assumed baseline would be same as demonstration area, which is not a radiation area. Concrete chips and dust (airborne) created by equipment. Temporary tent required.
	Work Performance	
Acquisition means	Vendor personnel and equipment used in demonstration, but this analysis is based on using site craft and site ownership.	Local craft workers with site owned equipment.
Production rates	Net effective productivity with three person crew is 41 ft^2/crew-h (production rate for 25 ft by 11 ft (at the mid point) room)	Assumed constant rate for three person crew is 200 ft^2/crew-h.
Equipment & crew	One HPT and three D&D workers for setup and operation (an additional worker required if remake unit used)	One HPT and three D&D workers for operation
Work process steps	1. Floor is blasted; 2. The media from the floor is then scooped up using a plastic shovel and squeegee; 3. The media is placed in the sifter and the large/fine pieces are removed as waste. The remaining pieces are placed back into the media unit for recycling or remade.	1. Scabble the surface area to ~1/4 in depth with 1 machine leaving debris and airborne contaminants. 2. Sample rubble (HPT) 3. Manually clean up and load into containers by other worker.
End product	Removed stained surface of concrete (approximately 1/16 in).	Coating and ¼ in concrete removed.

Potential Savings and Cost Conclusions

For the conditions and assumptions stated in Table 4, the innovative ARMS technology saves approximately 8 percent over the baseline manual mechanical scabbling. Figure 4 is a summary and comparison of the two technologies for the 262 ft^2 of decontamination performed for the demonstration.

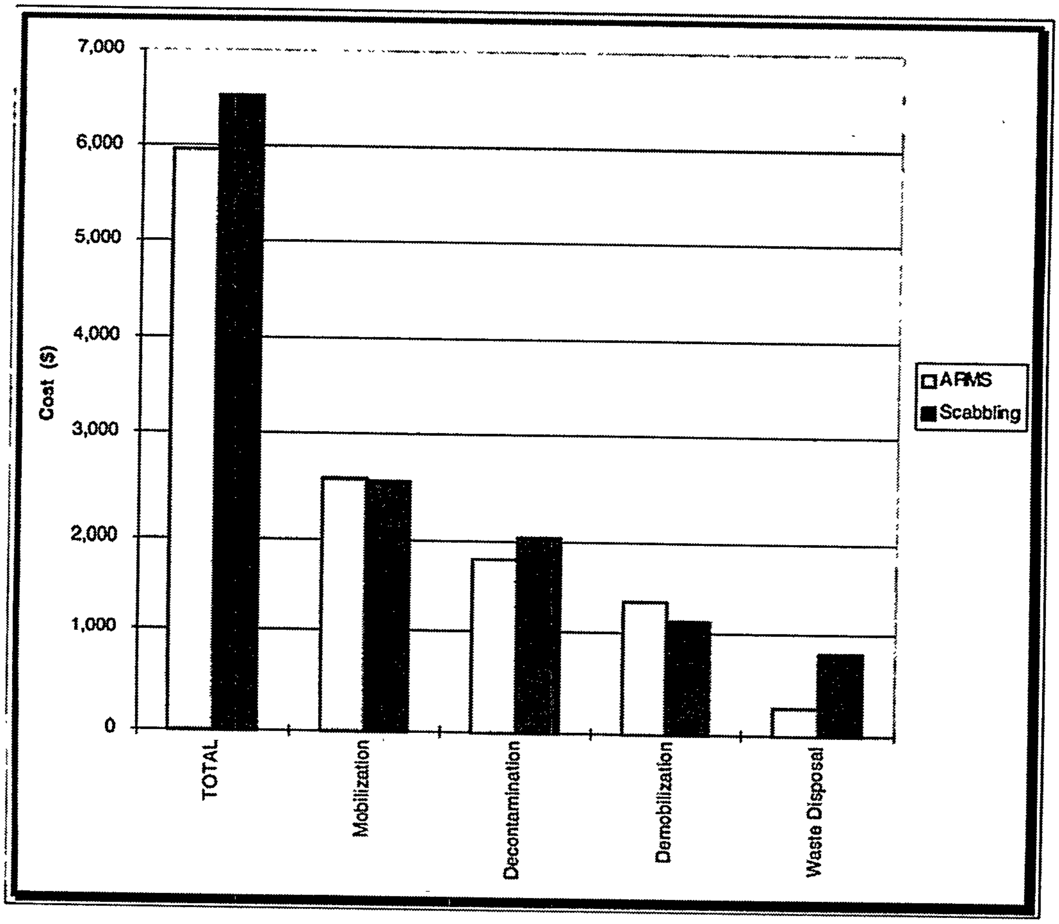

Figure 4. Cost comparison.

The costs for the ARMS and the manual mechanical scabbling technologies are similar for the 262 ft^2 size of job, despite the scabbling's assumed production rate of 200 ft^2/h relative to the 41 ft^2/h for the ARMS. This difference in production rates results in more of a cost difference with the larger sized jobs as shown in Figure 5. It is important to recognize that the production rates for both technologies can vary over a wider range (manual mechanical scabbling varies from 30 ft^2/h to over 490 ft^2/h with cutting widths varying from 2 in to 18 in and the ARMS reportedly varies from 40 to 200 ft^2/h). The production rate for ARMS was affected by the size of the demonstration area and other sites could have significantly higher production rates where the cost for ARMS may be less than computed by this cost analysis. Other factors affecting ARMS production rates are the type of surface being decontaminated, type of contamination, and level of contamination.

To optimize ARMS to make it more cost effective, it is necessary to improve the production rate of the technology. As discussed in Section 7, one suggestion is to add a vacuum system to the blast head unit to collect the used media after blasting, place it directly into the sifter unit, and then automatically move the sifted media into the feed hopper for recycling. Automating this process would reduce the amount of time spent manually shoveling the media into buckets and handling it between units. Thus increasing the production rate as measured in this demonstration. Also, for large-size jobs (greater than 10,000 ft^2) the use of the remake unit reduces the quantity of media used for blasting/ft^2 blasted as well as the amount of waste generated/ft^2 blasted.

Job Size Comparison

This cost analysis includes an extrapolation of costs for work that is larger than the demonstration. The extrapolation is not a precise estimate of that size of job, but is intended to present the fixed costs of mobilization and demobilization costs in a reasonable proportion to the decontamination costs which vary with the size of the job. Also, this analysis can provide some estimate of the cross-over point (if there is one) in preference of one alternative over another. In the case of the ARMS technology, the use of media remake equipment in addition to the equipment demonstrated becomes more desirable with larger-sized jobs. The remake equipment will minimize the quantity of waste generated and, for large jobs, provides substantial savings over the ARMS alone. Figure 5 provides an estimate of total cost as a function of job size for ARMS, ARMS plus the remake unit, and manual mechanical scabbling.

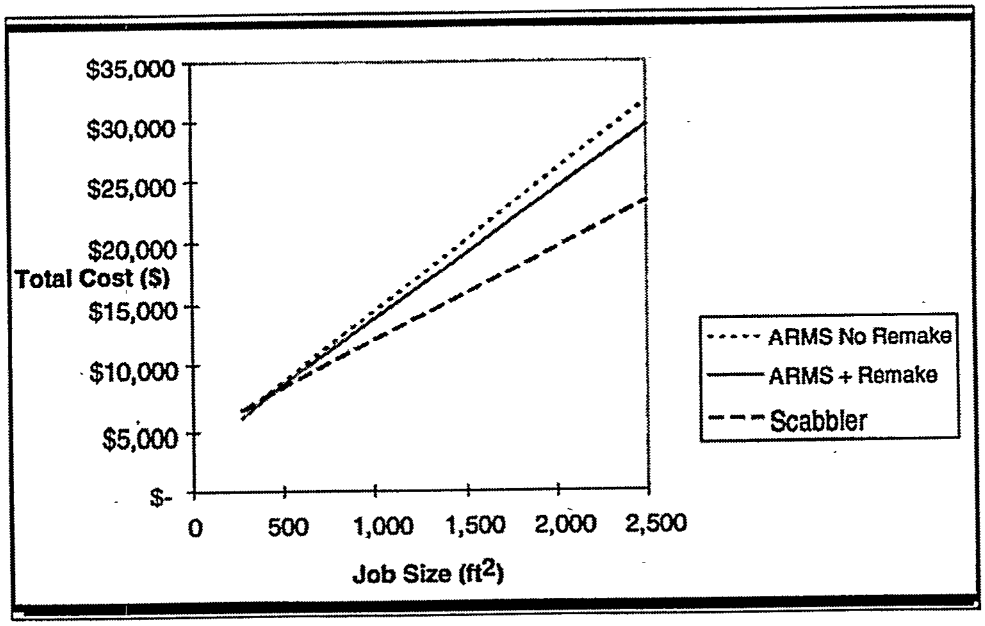

Figure 5. Job size comparison.

This extrapolation of costs is based on a production rate of 41 ft^2/h for ARMS and 200 ft^2/h for manual mechanical scabbling. For situations where ARMS achieves a production rate that is similar to the one assumed for scabbling (i.e., 200 ft^2/h), then the ARMS would be less expansive than scabbling.

For the conditions of the demonstration, ARMS has similar costs as the baseline, but under conditions where the maximum production rate for ARMS is achieved, then ARMS can save on costs for disposal (by using the remake unit).

SECTION 6

REGULATORY/POLICY ISSUES

Regulatory Considerations

The regulatory/permitting regulations related to use of the ARMS technology at the ANL CP-5 Research Reactor consist of the following:

- Occupational Safety and Health Administration (OSHA) 29 CFR 1926

—1926.300 to 1926.307	Tools - Hand and Power
—1926.400 to 1926.449	Electrical - Definitions
—1926.28	Personal Protective Equipment
—1926.52	Occupational Noise Exposure
—1926.102	Eye and Face Protection
—1926.103	Respiratory Protection

- OSHA 29 CFR 1910

—1910.101 to 1910.120 (App E)	Hazardous Materials
—1910.211 to 1910.219	Machinery and Machine Guarding
—1910.241 to 1910.244	Hand and Portable Powered Tools and Other Hand-Held Equipment
—1910.301 to 1910.399	Electrical - Definitions
—1910.95	Occupational Noise Exposure
—1910.132	General Requirements (Personal Protective Equipment)
—1910.133	Eye and Face Protection
—1910.134	Respiratory Protection
—1910.147	The Control of Hazardous Energy (Lockout/Tagout)

- 10 CFR 835 — Occupational Radiation Protection
- Building Officials and Code Administrators (BOCA) International, Inc. -National Building Code

Disposal requirements/criteria include the following issued by the U.S. Department of Transportation (DOT) and DOE:

- 49 CFR Subchapter C — Hazardous Materials Regulations

—171	General Information, Regulations, and Definitions
—172	Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements
—173	Shippers - General Requirements for Shipments and Packagings
—174	Carriage by Rail
—177	Carriage by Public Highway
—178	Specifications for Packagings

- 10 CFR 71 — Packaging and Transportation of Radioactive Material

If the waste is determined to be hazardous solid waste, the following Environmental Protection Agency (EPA) requirements should be considered:

- 40 CFR Subchapter I — Solid Waste

Waste acceptance criteria (WAC) from the following disposal facilities used by ANL include:

- *Hanford Site Solid Waste Acceptance Criteria*: WHC-EP-0063-4,
- *Barnwell Waste Management Facility Site Disposal Criteria:* S20-AD-010, and
- *Waste Acceptance Criteria for the Waste Isolation Pilot Plant:* DOE/WIPP-069.

Waste form requirements/criteria specified in these WACs may require the stabilization or immobilization of final waste streams because of their powdery consistency. This requirement would be valid for any aggressive coating/concrete removal technology. These are the same regulations that govern the baseline technology, manual mechanical scabbling.

Safety, Risks, Benefits, and Community Reaction

With respect to safety issues, ARMS is a relatively safe technology. Being an open blast technology there are safety issues relating to the high pressure propulsion of media through a hand-held nozzle. Examples of these issues include potential injury to extremities from placing a finger or foot in front of a nozzle in operation and penetrating PPE and/or the containment tent by striking the material with the media. The safety requirements, however, are not as stringent as those needed for sand blasting because the media being used is a soft urethane foam-based matrix.

The use of the ARMS technology rather than manual mechanical scabbling would have no measurable impact on community safety or socioeconomic issues.

SECTION 7

LESSONS LEARNED

Implementation Considerations

The ARMS system demonstrated at CP-5 by Surface Technology Systems, Inc. is commercially available and has been used at various commercial and nuclear facilities. There are no implementation considerations for use of the ARMS technology in the decontamination of concrete floors.

Technology Limitations and Needs for Future Development

ARMS would benefit from the following design improvements.

- It is recommended that a suction/vacuum hose be added that can be used to suction the used media from the area that was just blasted and carry the media directly to the ARMS sifter unit. The sifter unit would then deposit the sifted media directly into either 55-gal drums for disposal or the Feed Unit for recycling. This improvement would eliminate the need for handling the used media, reduce the risk of personnel slipping and falling on media not collected using the manual method, and will lower the amount of small fines that may become airborne during handling.

Technology Selection Considerations

ARMS is an effective technology for the removal of paints and coatings from large floor, wall, or ceiling areas. This technology is also applicable for the removal and absorption of low-level radioactive surface contaminants, oil, scales, greases, PCBs, paint, soot, lead, graphite, rust, and asbestos from metals, concrete, wood, and graphite. The media can be made to varying degrees of aggressiveness and is capable of being reused and remade, thereby reducing both costs for new media and secondary waste costs. Being an open blast technology, however, some type of ventilated containment system is needed during equipment operation.

APPENDIX A

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APPENDIX B

ACRONYMS AND ABBREVIATIONS

Acronyms/Abbreviations	Description
A	amperes
ACE	activity cost estimate
ALARA	as low as reasonably achievable
ANL	Argonne National Laboratory
ARMS	Advanced Recyclable Media System®
BOCA	Building Officials and Code Administrators
cfm	cubic feet per minute
CFR	Code of Federal Regulations
cm^2	centimeters squared
CP-5	Chicago Pile-5
D&D	deactivation and decommissioning
dBA	decibels
DDFA	Deactivation and Decommissioning Focus Area
Decon	decontamination
DOE	Department of Energy
DOT	Department of Transportation
dpm	disintegration per minute
Equip	equipment
EPA	Environmental Protection Agency
ESH	Environment, Safety and Health
FETC	Federal Energy Technology Center
FIU-HCET	Florida International University - Hemispheric Center for Environmental Technology
ft	foot or feet
ft^2	square feet (foot)
ft^3	cubic feet (foot)
gal	gallon
HEPA	high efficiency particulate air
HP(T)	Health Physics (technician)
h	hour
HTRW	hazardous, toxic, radioactive waste
IH	Industrial hygiene
in	inches
lb	pounds
IUOE	International Union of Operating Engineers
LF	linear feet (foot)
LS	lump sum
LSDP	large scale demonstration project
min	minute
OMB	Office of Management and Budget

Acronyms/Abbreviations	Description
OSHA	Occupational Safety and Health Administration
PLF	productivity loss factor
PPE	personnel protective equipment
psi	pounds per square inch
RA	remedial action
Resp	respirator
TC	total cost
Tech(s)	technician(s)
TQ	total quantity
TWA	time weighted average
UC	unit cost
USACE	United States Army Corps of Engineers
WAC	waste acceptance criteria
WBS	work breakdown structure
WM	waste management
V	volts

APPENDIX C

TECHNOLOGY COST COMPARISON

This appendix contains definitions of cost elements, descriptions of assumptions, and computations of unit costs that are used in the cost analysis.

Innovative Technology - ARMS

Mobilization (WBS 331.01)

Construct Temporary Facilities (airborne contaminant enclosure)

Definition: This cost element provides for the supply and erection of a temporary structure to contain airborne contaminants in the area being decontaminated. It includes decon workers and HPT coverage. It includes the building materials. Dismantling of the "tent" is in the demobilization account.

Assumptions: Conceptual scope definition is from ANL D&D personnel. A temporary enclosure for airborne contaminant containment is erected using unistrut material ($2.00/linear foot (LF) plus $1.00/LF for fittings and connections) as studs, beams, and bracing for walls and ceiling and visqueen ($.01/$ft^2$) as the enclosing membrane.

Transport Equipment and Drive to Site

Definition: This two cost elements provides for transportation of the site-owned decontamination equipment from its storage area to a staging area near the facility being decontaminated. Therefore, this cost includes a truck and forklift and the operators, the decon workers loading and hauling the subject construction equipment, and the hourly charges for the equipment transporting and transported.

Assumption: Distance to a site warehouse varies, but is less than 2 miles. The flatbed truck and pneumatic forklift are rentals using rates from the Dataquest construction equipment rental rate book. Loading takes 2 h.; driving, 0.5 h; and returning to the equipment pool, 0.25 h.

Unload Equipment at Site and Survey

Definition: Unloading delivered equipment includes time required for the decon crew to off load equipment from the truck using a forklift, move the equipment to a staging area, and unpack for radiological survey by the HPT.

Assumptions: A 2-h period to unload/unpack and survey the equipment is assumed. Procurement's effort to receive purchased equipment and complete paperwork is excluded. Forklift plus operation costs is included in the crew rate, taken from Dataquest construction equipment pricing book.

Return Truck/Forklift

Definition: The truck and driver return from the drop off point. Drive time of 15 min is assumed.

Decontamination (WBS 331.17)

Blast Floor/Recycle Media

Definition: This activity includes the labor and equipment costs for the feed unit and the media classifier.

Assumptions: The observed production rate of 41 ft^2/h for a crew of two (D&D workers assumed) is used for computing costs for the 262 ft^2 size of job analysis. For the extrapolated cases the remake unit is considered by adding an additional D&D worker and increasing the production rate by 10 percent (45 ft^2/h) because of the additional labor and because of the improved quality of the media (harder and more effective at removal). Those estimates assuming use of the remake unit are based on use of the feed unit, media classifier, blender, and vapor generator. All equipment costs are based on the purchase prices quoted by the vendor with 9.3 percent added for the purchase administration and computation of an hourly rate for that equipment based on assumptions of Government ownership. The observed cost for media was used for computing the cost of decontaminating the 262 ft^2 area (for the extrapolated case, this cost for media is included in the Consumables cost item since for this case where the remake unit is used, the media use is not in proportion to the area decontaminated).

Consumables

Definition: This cost element includes materials consumed in the course of performing the decontamination work.

Assumptions: The HEPA filter is assumed to be disposed of at the end of the job. For the extrapolated case using the remake unit, the fines are assumed to be remade into new media. Some new media will need to be added but at a lower rate than if there were on remake unit. This analysis assumes that the media required for the job is 1/4 of the amount required for situations where the remake unit is not used.

Remake Media

Definition: This cost analysis provides for the labor and equipment costs for the remake unit.

Assumptions: For the 262 ft^2 case, there are no costs for the remake unit included in the estimate, but the extrapolation based on the remake unit, these costs are included.

Daily Safety Meeting

Definition: Provides for time taken away from work day for safety meetings.

Assumptions: Assumes 25 min/day, based on normal practice at ANL.

Health Physics Support

Definition: Provides for escort and monitoring by HPT.

Assumptions: Full time HPT for the duration of the decontamination work is assumed.

Productivity Loss Factor

Definition: Losses from productive work occurring during the course of the work due to PPE changes, ALARA, height of reach inefficiencies, etc.

Assumption: A PLF is a factor which multiplies the work time to account for the necessary activities which do not directly accomplish the work (i.e. work breaks) or to account for conditions which result in decreases in production rates (i.e. heat stress, etc.). Since the non-productive activities in the demonstration are atypical of normal D&D work, most of these activities have been screened out of this analysis. In an effort to restore the costs to a more realistic estimate of typical D&D work, a PLF from the baseline is used to make the innovative analysis comparable with the baseline estimate (from ANL documentation, which is based upon AIF, 1986) and is 1.15 based on the following factors.

Base	1.00	
+ Height factor	0.00	
+ Radiation/ALARA	0.00	(included in observed production rate)
+ Protective Clothing	0.15	
= Subtotal	1.15	
x Respiratory Protection	1.00	(no factor required, covered in the observed times)
= Subtotal	1.15	
x Breaks	1.20	
= Total	1.35	

Personal Protective Equipment (PPE)

Definition: Equipment worn by workers for health and safety purposes.

Assumptions: The following table indicates the typical PPE worn for normal D&D work at ANL:

Table C-1. Personal protective equipment

Equipment	Quantity in Box	Cost Per Box	Cost Each	No. of Reuses	Cost Each Time Used	No. Used Per Day	Cost Per Day Per Person
Respirator			1,933	200	10	1	10.00
Resp Cartridges			9.25	1	9.25	2	18.50
Booties	200	50.00	0.25	1	0.25	4	1.00
Tyvek	25	85.00	3.4	1	3.4	4	13.60
Gloves (inner)	12	2.00	0.17	1	0.17	8	1.36
Gloves (outer pair)			7.45	10	0.75	1	0.75
Glove (cotton Liner)	100	14.15	0.14	1	0.14	8	1.12
Total							$46.33

The PPE costs are predominantly from the ANL activity cost estimate (ACE) sheets (costs for outer gloves, glove liners, and respirator cartridges are from commercial catalogs).

Waste Disposal (WBS 331.18)

Waste Disposal

Definition: This cost element accounts for the time and equipment required to pick up containers and assemble them in a designated area awaiting transportation.

Assumptions: During the demonstration of this technology, only 1 ft^3 of primary waste (paint chips, blaster media, and concrete pieces) was generated and directly placed into a barrel or container.

The secondary waste consists of 4 ft^3 of reusable media which would not be disposed of is some situations (the extrapolated case was estimated assuming the reuasable material was not disposed). An All-in-one Disposal Fees rate/ft^3 covers any and all activity associated with waste disposal. Fees are those in the 1996 ACE sheets from ANL.

Demobilization (WBS 331.21)

Electrical Disconnection

Definition: This cost element covers the disconnection of the 200 LF of air compressor hoses and the roll-up activity for travel.

Survey & Decontaminate Equipment

Definition: This cost element provides for radiological survey of equipment by a site HPT to ensure that contaminated equipment does not leave the site or work area and includes costs for decontaminating it. Costs include HPT labor plus decon crew stand-by or assistance time. The decontamination of equipment involves wiping equipment with damp rags.

Assumptions: Two (2) h of the total observed 2.2 h (2 h and 12 min) are for survey.

Pack up and load out Equipment

Definition: This cost element covers time and equipment required for crew to pack up and load rental and owned equipment in a truck for return.

Assumptions: Time required is 2 h to pack and load up using a forklift for 2 h of the total duration.

Equipment Transport

Definition: The account covers the cost to transport the equipment back to the origin.

Assumption: The estimate assumes local crew members cause no personnel transportation costs to the project. The transport of the equipment is the same as in the mobilization account, except in reverse.

The activities, quantities, production rates and costs observed during the demonstration are shown in Table C-2.

Table C-2. Summary costs for innovative technology

Work Breakdown Structure (WBS)	Unit Cost (UC) Labor Hour (h)	Labor Rate	Equipment Hour	Equipment Rate	Other Rate	Total UC	Total Quantity (TQ)	Unit of Meas.	Total Cost (TC) note	Note: TC=UC x TQ Comments
MOBILIZATION WBS 331.01								Subtotal	2,542	
Build Containment Tent	0.003	$ 101		$ -	$ 4	$ 4	349	ft²	1472	Three D&D workers @ $33.60/h plus material.
Health Physics Tech (HPT) for Tent	1.21	$ 56		$ -	$ 13	$ 68	1	Lump Sum (LS)	$ 68	Covers building tent only. Other includes waste disposal at 0.25 ft³ at $52.78/ft³.
Transport Equipment Load at Warehouse	2.00	$ 147	2	$ 32.51		$359	1	Trip	$ 359	Truck @ $19.78/h, forklift @ $12.73/h, teamster $39.85/h, operator $39.85/h, and two D&D workers for 2 h @ 33.60/h.
Drive to Site	0.5	$ 147	0.5	$ 54.23		$ 101	1	Trip	$ 101	Same as above plus ARMS standby @ $8.60/h and compressor standby @ 13.12/h.
Unload Equipment at Site and Survey	2	$ 203	2	$ 54.23		$ 514	1	Trip	$ 514	Same as above plus HPT for survey.
Return Truck/Forklift	0.25	$ 80	0.25	$ 32.51		$ 28	1	Trip	$ 28	
DECONTAMINATION - WBS 331.17								Subtotal	$1,806	SCOPE: 262 square feet (ft2)
Blast Floor	0.02	$ 67.20	0.02	$ 21.72	$ 1.52	$ 4	262	ft²	$ 957	Two D&D workers @ $33.60/h, blaster and sifter @ $8.60/h, air compressor @ $13.12/h, media @ $100/50 lb bag ($1.52/ft²).
Remake Media	0.02	$ 33.60	0.02	$ 5.34		$ 1		ft²	$ -	Remake spent media (used only for larger jobs) requires one D&D worker and equipment costs of $5.34/h.
Daily Safety Meeting	0.25	$ 123.20	0.25	$ 21.72		$ 36	1	Days	$ 29	For two D&D workers and one HPT.
Health Physics Support	6.27	$ 56				$ 351	1	LS	$ 351	HPT monitoring.
Productivity Loss Factor (PLF)	2.19	$ 123.20	2.19	$ 21.72		$ 275	1	LS	$ 318	Accounts for unproductive time (e.g., donning and doffing PPE). A factor of 1.35 was used.
Personnel Protective Equipment (PPE)					$46.33	$ 46	3	Person Day	$ 151	Two D&D plus one HPT (three persons total) @ $46.33/day each for PPE.
DEMOBILIZATION - WBS 331.21								Subtotal	$11,351	
Disconnect Hoses	0.5	$ 33.60	0.5	$ 21.72		$ 28	1	LS	$ 28	Disconnect air compressor hoses (200 ft) and roll up for travel.
Survey/Decon Equipment	2.2	$ 235	2.2	$ 21.72		$ 565	1	LS	$ 565	One HPT and one D&D worker plus equipment standby.
Move Equipment and Load Out	2.0	$ 147	2.0	$ 54.23		$ 402	1	LS	$ 402	See Mobilization.
Return to Warehouse	0.5	$ 147	0.50	$ 32.51		$ 90	1	LS	$ 90	Return equipment to warehouse. Hours were taken from baseline technology.
Dismantle Tent	0.003	$ 101	0			$ 0.762	349	ft²	$ 266	Three D&D workers.
WASTE DISPOSAL - 331.18								Subtotal	$ 264	
Disposal Fees (Primary/Secondary)					$ 52.78	$ 52.78	5	ft³	$ 264	Primary waste includes paint chips, fines, and 4 ft³ of media (potentially recyclable).
								Total	$ 5,962	

Mobilization (WBS 331.01)

Construct Temporary Facilities (airborne contaminant enclosure

Definition: This cost element provides for the supply and erection of a temporary structure to contain airborne contaminants in the area being decontaminated. It includes decon workers and HPT coverage. It includes the building materials. Dismantling of the "tent" is in the demobilization account.

Assumptions: Conceptual scope definition is from ANL D&D personnel. A temporary enclosure for airborne contaminant containment is erected using unistrut material ($2.00/LF plus $1.00/LF for fittings and connections) as studs, beams, and bracing for walls and ceiling and visqueen ($.01/ft^2) as the enclosing membrane.

Transport Equipment and Drive to Site

Definition: This two cost elements provides for transportation of the site-owned decontamination equipment from its storage area to a staging area near the facility being decontaminated. Therefore, this cost includes a truck and forklift and the operators, the decon workers loading and hauling the subject construction equipment, and the hourly charges for the equipment transporting and transported.

Assumption: Distance to a site warehouse varies, but is less than 2 miles. The flatbed truck and pneumatic forklift are rentals using rates from the Dataquest construction equipment rental rate book. Loading takes 2 h.; driving, 0.5 h; and returning to the equipment pool, 0.25 h.

Unload Equipment at Site and Survey

Definition: Unloading delivered equipment includes time required for the decon crew to off load equipment from the truck using a forklift, move the equipment to a staging area, and unpack for radiological survey by the HPT.

Assumptions: A 2-h period to unload/unpack and survey the equipment is assumed. Procurement's effort to receive purchased equipment and complete paperwork is excluded. Forklift and operation cost is included in the crew rate, taken from Dataquest construction equipment pricing book.

Return Truck/Forklift

Definition: The truck and driver return from the drop off point. Drive time of 15 min is assumed.

Decontamination (WBS 331.17)

Radiological Survey

Note: This cost element is for radiological surveying to characterize the work place to facilitate making a work plan well before starting the decontamination effort.

Assumption: Not applicable. There is no cost effect for this analysis. This activity is assumed completed prior to decontaminating the area.

Set-Up or Move Equipment and check it out

Definition: This cost element includes time to lay out the equipment and hoses in preparation for the day's work. With the air supply compressor outside the facility, air hoses are strung through doors, penetrations, and cable hangers to the work area. The scabblers, hand tools, air manifolds, waste containers, and other incidental consumables are taken to the work area from the staging area. Set up excludes the erection costs of a temporary containment tent. It is covered in the mobilization activity.

Assumptions: The May 1996 ACE sheets included scaffolding because the scope also involved walls. The analysis scope is for the floor only. Therefore, the baseline 4 h were reduced to 2 h, eliminating 50 percent of the time assumed to be for scaffolding.

Remove Floor Surface Concrete

Definition: This cost element consists of:

- Scabble the floor concrete making one pass of 1/4-in removed including replacing consumable scabbler bits that wear with use.
- The activity consists of one decon worker scabbling with a machine, one decon worker as support or tender and one HPT as the rad monitor and/or escort.
- HPT activity is taking readings of the area and/or the rubble during removal at full time participation along with the decon personnel.
- The manual function to clean up and package the concrete rubble into containers is required. Transporting it to disposal collection area is excluded.
- The production rate will vary depending upon the thickness of the concrete to remove to obtain acceptable radiation readings.
- Cost of manual mechanical scabbling equipment and consumable bits is in this cost element.
- Cost of PPEs is included. See Table C-1.
- Any lost time from production is included. This involves daily safety meetings, daily work planning reviews, dressing out with PPEs, heat or temperature stress, work breaks, etc., which is accounted for through a factor.

Assumptions:

- The quantity scope for the baseline is the same as the demonstration, 262 ft^2 for comparison equality.
- One crew of two decon workers and one HPT are required. Those three people handle the scabbling, sampling, clean up, and containerizing as a team for which the estimate is separated into two sub-elements of cost by craft.
- One manual mechanical scabbling machine is used.
- Base line technology produces primary waste that is manually vacuumed up, radiological monitored, and packaged. It amounts to 19.5 ft^3.
- The decon crew workers are qualified to change out the worn bits. Standby time is necessitated by this activity.
- Production rate in this analysis is 200 ft^2/h for the one machine, a Model SF-11, Trelawny, one person scabbling (67 ft^2/person-h as a net effective rate for a three person crew). The scabbler is priced using the $9.95/h from the 1996 ACE sheets including all assumptions made at that time.
- A safety meeting occurs and is in the baseline factor for loss of productivity.

Productivity Loss Factor

Definition: A factor applied to productive hours (the PLF) to compensate for breaks, dressing and undressing in PPE, etc.

Assumption: The PLF used, 2.05, and the PPE costs are predominantly from the ANL baseline 1996 ACE sheets. (costs for outer gloves, glove liners, and respirator cartridges are priced from commercial catalogs).

Waste Disposal (WBS 331.18)

Waste Disposal

Definition: This cost element accounts for the time and equipment required to pick up containers and assemble them in a designated area awaiting transportation.

Assumptions: Baseline waste generated is calculated at 0.03 ft^3/ft^2 as taken from the May 1996 ACE sheets that amounts to 19.5 ft^3 including a 70 percent efficiency factor. The secondary waste consists of a couple of bags of expended scabbling bits, used PPEs, and swipes. The cost is represented as an All-in-one disposal fee rate/ft^3 from the same 1996 estimate and covers all waste disposal related activities.

Demobilization (WBS 331.21)

Remove Temporary Facilities (airborne contaminant enclosure)

Definition: This cost element provides for the dismantling of a temporary structure used to contain airborne radioactivity during decontamination activities. It includes decon workers and HPT coverage. It includes gathering up and containerizing the waste building materials. PPE and a PLF are included.

Assumptions: Labor required is three persons for 3-h to dismantle and load up waste.

Survey and Decontaminate Equipment

Definition: This cost element provides for radiological survey of the equipment by a site HPT to ensure that contaminated equipment does not leave the site or work area or to ready it for the next use. It covers costs to decontaminate it. Costs include HPT labor plus decon crew stand-by or assistance time, including the use of PPE and experiencing a PLF.

Assumptions: Survey and decontamination requires 2-h based on an allocation from the 4-h in the original baseline.

Pack up and Move Equipment

Definition: This cost element covers time and equipment required for crew to pack up and load rental and owned equipment in a truck for return.

Assumptions: Time required is 2-h to pack and load up using a forklift for 2-h of the total duration.

Equipment Transport back to Warehouse

Definition: The account covers the cost to transport the equipment back to the origin.

Assumption: The estimate assumes local crew members cause no personnel transportation costs to the project. The transport of the equipment is the same as in the mobilization account, except in reverse.

Table C-3. Cost summary for baseline technology

Work Breakdown Structure (WBS)	Unit Cost (UC) Labor Hour(H)	Labor Rate	Equipment H	Equipment Rate	Other Rate	Total UC	TQ Qnty	Unit of Measure	Total Cost (TC) note	Note: TC=UC x TQ Note: Qnty = Quantity; TQ=total quantity Comments
MOBILIZATION WBS331.01								Subtotal:	$ 2,525	
Build containment tent	0.0035	$ 101			$ 3.86	$ .21	349	ft²	$ 1,471	Three decon for 3-h @ $33.60/h plus materials.
Health Physics Tech (HPT) for Tent	1.2	$ 56			$ 13.20	$ 81	1	Lump Sum (LS)	$ 81	Covers building tent only. Other decon waste at .25 ft³ at $52.78/ ft³.
Transport Equipment (Equip.) - load at warehouse	2	$ 147	2	$ 32.51		$ 359	1	Trip	$ 359	Truck, forklift, teamster, operator, and two decon workers for 2 h.
Drive to site	0.5	$ 147	0.5	$ 42.46		$ 95	1	Trip	$ 95	Same as above, ½-h, add scabbler.
Unload Equip at site and survey	2	$ 203	2	$ 42.46		$ 491	1	Trip	$ 491	Same as above, 2-h, add HPT for survey.
Return truck/forklift	0.25	$ 80	0.25	$ 32.51		$ 28	1	Trip	$ 28	
DECONTAMINATION- WBS 331.17								Subtotal:	$ 2,033	**SCOPE: 262 square feet (ft²)**
Move Equip to Work Area	2	$ 67.2	2	$ 38.47		$ 211	1	LS	$ 211	On-site labor two decon technicians (techs) @ $33.60/h for 2 h plus equip standby.
Decontaminate Concrete	0.005	$ 67.2	0.005	$ 38.47	$ -	$ 0.53	262	ft²	$ 139	Two decon workers; one machine at 200 ft²/h including replacements, total 3.25 h.
Equip Operating costs										Varies with life of bits and replacement frequency.
Consumable Bit wear					$ 0.22	$ 0.22	262	ft²	$ 57	Per operating cost calculation.
Air Compressor costs			1.31	$ 7.00		$ 9.18	1	LS	$ 9	Air compressor, 250 ft³/min.
Air tools consumables.			1.31	$ 0.27		$ 0.36	1	LS	$ 0	
HPT Sample rubble and surface radioactivity	4.31	$ 56.0				$ 242	1	LS	$ 242	One HPT at $56/h, same h as decon plus manual loading.
Load Rubble in containers	0.38	$ 67.2	0.38	$ 38.47		$ 40.26	7.9	ft³	317	
Daily Safety Meeting	0.25	$ 123.20	0.25	$ 38.47	$ -	$ 40.42	1	Day	$ 48	Waste at .021 ft³/ft² with 70percent eff. = .03.
Personnel Protective Equip (PPE)					$ 46.33	$ 46.33	6	Man Days	$ 278	Three workers @ $46.33/day.
Productivity Loss	4.53	$ 123.2	4.53	$ 38.47		$ 732	1	LS	$ 732	Factor: 2.05 per '96 Activity Cost Estimate (ACE) sheets.
								Subtotal:	$ 1,139	
DEMOBILIZATION - WBS 331.21										
Decon and Survey Equip	2	$ 67	2	$ 38.47		$ 211	1	LS	$ 211	
HPT work effort	3.2	$ 56			$ 13.20	$ 193	1	LS	$ 193	Other decon waste @ .25 ft³ at $52.78/ ft³.
Move Equip and Load out	2	$ 147	2	$ 42.46		$ 379	1	LS	$ 379	Assumed reverse of the mobilization.
Return to warehouse	0.5	$ 147	0.5	$ 32.51	$ -	$ 90	1.0	trip	$ 90	Assumed reverse of the mobilization.
Dismantle temporary tent	0.0035	$ 101			$ 0.41	$ 0.76	349	ft²	$ 266	Three decon, 3 h @ $33.60 plus materials.
WASTE DISPOSAL - WBS 331.18								Subtotal:	$ 804	
Disposal Fees-Primary and secondary					$ 52.78	$ 52.78	15.2	ft³	$ 804	From '96 ACE,Table 2.0,p. 1.11 of 1.33
								Total	$ 6,500	

APPENDIX D

FLORIDA INTERNATIONAL UNIVERSITY DEMONSTRATION

Technology Description

A technology assessment of the Advanced Recyclable Media System (ARMS) technology was performed at the FIU-HCET from July 21-28, 1997. The ARMS equipment was comprised of a feed unit and a sifter unit (see Figure D-1). The feed unit is a portable pneumatically powered device that propels the sponge media against the contaminated surface. Sponge media is manually loaded into a hopper mounted on top of the feed unit, and is fed to an auger device that mixes the cleaning media with compressed air. The sifter unit is used to mechanically remove large debris and powdery residues from the sponge media after use. The sifter vibrates causing the media to fall downward through a series of separation screens to remove the debris from the recyclable media. The difference between the equipment used for the CP-5 demonstration and the equipment used at HCET was the sifter unit. Detailed descriptions for each of the ARMS equipment can be found in Section 2 of this document.

Figure D-1. ARMS equipment used at HCET.

System Operation

- The ARMS blast unit was manually operated by pulling a squeeze trigger on the nozzle. If this trigger was not engaged, the blast unit would not operate.

- The demonstration was performed inside of a plastic containment tent which was installed by Surface Technology Systems, Inc. A two tent system (side by side) was erected, one tent against the area to be blasted held the blasting operator and nozzle while the second tent contained the feed unit and sifter unit.

Demonstration Plan

In a project for the Fernald Environmental Management Project and the Mound Environmental Management Project, Fluor Daniel Fernald contracted FIU-HCET to evaluate and test commercially available technologies for their ability to decontaminate radiologically contaminated walls and ceilings. The results of this project are presented in the final report, *Evaluation of Coating Removal and Aggressive Surface Technologies Applied to Concrete Walls, Brick Walls, and Concrete Ceilings,* (HCET, 1997*)*. The metal decontamination demonstrations were funded by FETC, D&D Focus Area.

The demonstrations were held at the FIU campus on the following substrates:

- 10 ft x 20 ft poured concrete wall, coated with an epoxy polyamine coating,
- 10 ft x 20 ft poured concrete ceiling, coated with an epoxy polyamine coating,
- 4 ft x 4 ft x 1/2 in carbon steel plates, coated with an epoxy polyamine coating,
- 4 ft x 4 ft x 1/2 in rusted carbon steel plates,
- 10 ft rusted I-beam made from carbon steel, and
- 10 ft I-beam coated with Rust-O-Lastic coating.

During the demonstration, FIU-HCET evaluators collected data in the form of visual and physical measurements. Time studies were performed to determine the production rate of the technology and implementation costs. Additional field measurements collected include secondary waste generation, operation/maintenance requirements, and benefits and limitations of the technology. In addition, to enhance the technology assessment process, the International Union of Operating Engineers (IUOE) provided a review of the health and safety factors pertinent to the test.

Treatment Performance

Table D-2 presents the results of the FIU-HCET demonstration of the ARMS technology as demonstrated by Surface Technology Systems, Inc.

Table D-2. Performance data

Criteria	Walls	Ceiling
Applicable surface	Coated poured concrete wall	Coated poured concrete ceiling
Depth achieved	Coating removal	Coating removal
Total surface area	192.5 ft^2	181.66 ft^2
Production rate (blasting time only)	43.9 ft^2/h	127.03 ft^2/h
Noise level	8-h time weighted average (TWA) doses ranging from 103.5 dBA and 116.4 dBA. (1)	
Health and safety issues	High level of dust inside containment tent during blasting (2). Potential for sprain/stain/fatigue to arms, shoulders, upper back, and lower back (3) Communication problems due to noise levels.	
Waste volume generated (paint and spent media)	3.85 ft^3	1.82 ft^3
End point achieved	Bare concrete	Concrete with patches of primer still attached.

Criteria	Coated Plate	Rusted Plate	Coated I-beam	Rusted I-beam
Applicable surface	Coated carbon steel plate	Rusted carbon steel plate	Coated I-beam	Rusted I-beam
Depth achieved	Coating removal	Rust removal	Coating removal	Rust removal
Total surface area	76 ft^2	128 ft^2	194.72 ft^2	167.98 ft^2
Production rate (removal rate only)	30.4 ft^2/h	75.29 ft^2/h	75.47 ft^2/h	81.94 ft^2/h
Noise levels	8-h TWA doses ranging from 92.3 dBA to 114.7 dBA (4) .			
Health and safety issues	Same as concrete walls and ceilings.			
Waste volume generated (paint and spent media)	1.60 ft^3	0.64 ft^3	0.97 ft^3	0.84 ft^3
End point achieved	White metal finish			

(1) Operators routinely wear both internal ear plugs and ear muffs during blasting.
(2) The vendor states that the concrete used for the FIU demonstration was extremely soft generating an excessive amount of dust.
(3) Per the vendor, the blast nozzle and associated hoses weigh approximately 8 lb.
(4) Operators routinely wear both internal ear plugs and ear muffs during blasting.

Implementation Considerations

The ARMS technology has been used successfully in commercial facilities for the removal of hazardous material. There are no implementation considerations for use of this equipment.