Rotary Peening With Captive Shot

Deactivation and
Decommissioning Focus Area

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INNOVATIVE TECHNOLOGY
Summary Report

Rotary Peening With Captive Shot

OST Reference # 1812

Deactivation and
Decommissioning Focus Area

Demonstrated at
Chicago Pile 5 (CP-5) Research Reactor
Large-Scale Demonstration Project
Argonne National Laboratory - East
Argonne, Illinois

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 online at http://em-50.em.doe.gov.

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Technology Description

Roto Peen with captive shot removes coatings and surface contamination from concrete floors. The objective of treating radioactively contaminated concrete floors during the Deactivation and Decommissioning (D&D) process is to reduce the surface contamination levels to meet regulatory criteria for unrestricted use.

How it Works

Roto Peen uses centrifugal force to remove coatings and surface contamination from concrete floors. A series of 3M™ Heavy Duty Roto Peen flaps supporting tungsten carbide shot are mounted on a CPM-4 Concrete Planer provided by EDCO. The planer provides the correct rotational speed for the Roto Peen. A vacuum system, the VAC-PAC® Model 24 provided by Pentek, is then attached to the concrete planer. It is a pneumatically driven vacuum system with isolated filters that permit the waste generated to be collected directly into a drum. The system is also outfitted with a Pb Sentry from West Environmental to monitor vacuum pressure at the planer. This proprietary system will shut off electrical power to the concrete planer should the detected vacuum drop below a safe threshold. The EDCO Concrete Planer is designed to remove paints and other surface contaminants from flat, horizontal areas. It has a cutting width of 5.5 in and the depth of removal is determined by the rate of speed with which the unit is driven.

Demonstration Summary

The U.S. Department of Energy (DOE) Chicago Operations Office and DOE's Federal Energy Technology Center (FETC) jointly sponsored a Large-Scale Demonstration Project (LSDP) at the Chicago Pile-5 Research Reactor (CP-5) at Argonne National Laboratory-East (ANL). The objective of the LSDP is to demonstrate potentially beneficial D&D technologies in comparison with current baseline technologies. As part of the LSDP, Roto Peen with captive shot was demonstrated March 17-20, 1997, to treat a 20 x 25 ft area of radioactively contaminated concrete floor on the service level of the CP-5 building.

Handled by two CP-5 ANL operators, the 3M™ Roto Peen technology removed the coatings from a 425 ft^2 area at a rate of 71 ft^2/h. The coating removal left a uniform appearance on the Roto Peen finished surface. The radiological levels of the original floor were thus reduced from 70,000 to 16,000 dpm/100cm^2 on one hot spot and below or at background levels on the other parts of the area. There was no airborne generation detected.

Figure 1. 3M™ Roto Peen demonstration.

Figure 2. Heavy duty Roto Peen flaps.

Benefits

In comparison with the baseline technology, which is mechanical scabbling, the main advantage of the Roto Peen technology is that the dust and debris are collected simultaneously during the coating removal. Thus the amount of airborne and loose contamination generated is considerably reduced.

The 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., plastic tent) is erected over the area to be decontaminated to minimize the potential release of airborne dust and contamination.

Key Results

- The Roto Peen with captive shot technology was able to remove paint coatings at a rate of 71 ft^2/h with a two-person crew and a 5.5-in cutting width machine and reduce contamination levels on the floor to background levels.

- The vacuum system component of the Roto Peen technology performed sufficiently to maintain airborne radioactivity levels in the area of the demonstration at background levels. In contrast, the baseline technology of scabbling has the potential for high levels of airborne contamination.

- The Roto Peen technology was able to remove the floor's paint coatings with very little concomitant concrete removal. This resulted in minimal waste generation of 2.1 ft^3 of powder. The baseline technology of scabbling would result in higher waste generation because a measurable depth (¼ in to ½ in) of concrete is removed along with the floor coatings.

Technology Contacts

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Web Site

The CP-5 LSDP Internet address is http://www.strategic-alliance.org.

Other

All published Innovative Technology Summary Reports are available online at http://em-50.em.doe.gov. The Technology Management System, also available through the EM50 Web site, provides information about OST programs, technologies, and problems. The OST Reference # for Roto Peen with captive shot is 1812.

SECTION 2

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The technology uses 3M™ Heavy Duty Roto Peen (HDRP) flaps supporting tungsten carbide shot mounted on a rotating hub. The particular unit demonstrated is supported by an EDCO CPM-4 concrete planer that maintains the correct rotational speed for the Roto Peen. This concrete planer is connected to a vacuum system, the VAC-PAC® model 24 provided by Pentek, and driven by an air compressor that remained outside the CP-5 facility during the demonstration. A Pb Sentry, from West Environmental, is mounted to the concrete planer and is used to monitor adequate vacuum pressure at the planer.

3M™ Heavy Duty Roto Peen

The 3M™ Heavy Duty Roto Peen flap consists of tungsten carbide shot attached to a flexible, heavy duty material and mounted on an aluminum hub. As the hub rotates, the shot particles on each flap impact against the surface, mechanically fracturing and removing coatings. The shot remains captive to the tool and under complete control by the operator.

Several different types of flaps are available for removing coatings from steel or concrete surfaces. Type A, for hard concrete, was demonstrated at CP-5. Using different units, the 3M™ system is also capable of removing coatings from walls and pipes.

Concrete Planer

The concrete planer used to drive the 3M™ Heavy Duty Roto Peen is provided by EDCO. Specifically, the EDCO model CPM-4 floor unit, which requires 208 VAC at 30 amp single phase to rotate the Roto Peen at 1,800 rpm and has the following specifications:

- Weight: 180 lb
- Height: 38 in
- Width: 18 in
- Length: 38 in
- Cutting width: 5.5 in

The cutting width of the concrete planer used in this demonstration was 5.5 in but larger units with cutting widths up to 12 in are available from EDCO.

Pb Sentry Vacuum Monitor

The Pb Sentry is West Environmental proprietary technology designed for this application. The electrical source to the planer is passed through the Pb Sentry, which interrupts the electrical supply to the concrete planer when a variation in vacuum pressure at the CPM-4 shroud is detected. The level of vacuum pressure is monitored via a tube connected at the vacuum port on the shroud that runs back to the Pb Sentry. The settings on the monitor are adjustable for both upper and lower vacuum pressure readings.

Vacuum System

Pentek's VAC-PAC® used in conjunction with the Roto Peen offers two-stage positive filtration of particulate. The debris removed by the Roto Peen flaps are collected in this vacuum system that also features Pentek's patented controlled seal drum system that allows the operator to fill, seal, remove, and replace the waste drum under controlled vacuum conditions. This minimizes the operator's exposure to the waste and the possibility of releasing airborne contamination during drum change.

Several standard VAC-PAC® models are available from Pentek, with various specifications and performance capabilities. The model 24 used at CP-5 is air-powered by an air compressor that remains outside the facility. The air compressor is a Leroy 750, diesel fueled with 300 ft^3/min at 100 psig because of the 300 ft of air line hose from the air compressor to the vacuum system.

The VAC-PAC® model 24 has the following parameters:

- Rated vacuum flow: 600 ft^3/min
- Rated static lift: 100 in Water Gauge
- Weight: 750 lb
- Height: 72 in
- Width: 28 in
- Length: 48 in

- Primary roughing filter cartridges: Three at 8 in diameter
  Efficiency: 95 percent at 1 micron

- Secondary HEPA filter: One at 12 in $\times$ 24 in
  Efficiency: 99.97 percent at 0.3 micron

For the operation of the vacuum system, the utilities require a 110 VAC at 15 amp electrical current source and 75 ft of 3-in diameter reinforced vacuum hose connecting the CPM-4 unit to the VAC-PAC®.

SECTION 3

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Coating Removal

The demonstration was conducted according to the approved test plan, *CP-5 Large-Scale Demonstration Project: Test Plan for the Demonstration of 3MÔ Heavy-Duty Roto Peen and VAC-PAC® System*.

The demonstration area was located on the service level of the CP-5 building in an area approximately 20 x 25 ft. The concrete floor had multiple layers of contaminated paint on the surface. The area is enclosed to the west by 8 linear feet (lin ft) of cabinets and 12 lin ft of hoses running along the wall and to the east by 5 lf of concrete wall and 15 lf of steel floor plate. The north and south ends are open areas. The Roto Peen machine was able to maneuver within 1 in of the floor plate and within 12 in of the cabinets and hoses.

The CP-5 operators were required to wear one layer of Tyvek, a full-faced air purifying respirator, work boots, and gloves. Due to the temperature in the room being very hot, the two operators were replacing each other approximately every 30 min during the demonstration. After the low vacuum setting was adjusted, the concrete planer would automatically shut off as soon as the operators lifted it up to move it. Using the 3M™ Roto Peen technology, the operators removed the surface paint coating from approximately 425 ft^2 of concrete floor in the demonstration area at a rate of approximately 71 ft^2/h. The depth of removal, determined by the rate of speed with which the concrete planer is driven, was about 1/16 in. This removed all the coatings from the concrete surface and achieved a uniform appearance on the finished surface. The finished surface has slight groove lines in it but is otherwise smooth.

Cabinets that were in the demonstration area for another operation at CP-5 were covered with plastic as a precautionary measure. The hoses connected to those cabinets were left on the floor adjacent to the wall. As a precaution to prevent damage to the hoses, the unit was not operated within 1 ft of the hoses. However, the unit was able to remove concrete floor coatings about 1-2 in from other obstacles.

Radiological Results

The first survey, prior to the demonstration, showed that six portions of the 425 ft^2 area contained elevated fixed total beta/gamma contamination. The radiological levels for these six locations ranged from approximately 6,000 to 70,000 dpm/100 cm^2 and were at or below background levels for the remaining parts of the floor.

After the coating removal, results of the second survey of the area indicate that five of the six contaminated locations were at or below background levels. The contamination of the sixth location was reduced from 70,000 to 16,000 dpm/100 cm^2. Pre- and post- demonstration results are listed in Table 1. The elevated readings in the sixth location could possibly be the result of a crack in the area that has trapped the contamination and cannot be removed by superficial decontamination methods.

Table 1. Radiological results

Location	Total Area (cm^2)	Pre-demonstration Total β/γ (dpm/100cm^2)	Post-demonstration Total β/γ (dpm/100cm^2)
1	300	6,300	< 500
2	100	12,200	< 500
3	100	10,500	< 500
4	100	6,300	< 500
5	100	7,300	< 500
6	400	70,700	16,000

Following the coating removal demonstration, it took three people approximately 80 min to clean the concrete planer (without the Roto Peen flaps) and the vacuum system, using wet rags. A final survey of the equipment did not show any contamination, and it was released to the vendors.

Waste Generation

Because the shot remains captive to the tool, the primary waste generated by the Roto Peen was the actual concrete and paint debris removed from the floor. Via the vacuum system, the waste was collected into a standard 55 gal drum. After the demonstration, the investigation of the drum showed that approximately 2.1 ft^3 (120 lb) of primary waste, in the form of powdery concrete and paint chips, was generated. All airborne radiological measurements were found to be at or below background levels. The vacuum system was sufficient to contain the dust generated during decontamination.

Survey smears taken from the outside of the secondary waste bags, containing Tyveks, high-efficiency particulate air (HEPA) cartridges, gloves, shoe covers, Roto Peen flaps, roughing filters, HEPA filter, the vacuum hose, rags and smear papers, did not show any removable contamination (see Appendix B). However they were handled as contaminated trash for disposal.

Summary of Demonstration Results

The results of the demonstration of the 3M™ Roto Peen technology are listed in Table 2 below:

Table 2. Performance data

Criteria	Innovative technology: Roto Peen with captive shot	Baseline technology: mechanical scabbling
Applicable surface	Coating removal from painted concrete floor (horizontal unit demonstrated: other units capable of decontaminating walls and pipes)	¼ in concrete removal from floor
Production rate (coating removal rate only)	71 ft^2 /h	200 ft^2/h
Depth of removal	1/16 in	¼ to ½ in
Cutting width	5.5 in	Variable
Minimum crew size	Two people	Three people
Amount and type of primary waste generated	2.1 ft^3 of powdery mixture of paint and concrete (contained by vacuum system)	Amount estimated to be 24 ft^3 of a mixture of powdery and large pieces of paint chips and concrete (requires manual cleanup: no vacuum system is attached)
Type of secondary waste generated	Used personnel protective equipment (PPE), filters, flaps, hoses, rags, smear papers	Used PPE, tent enclosure, worn pistons
Airborne radioactivity generated by equipment	No visible dust during the demonstration; airborne activity levels were at or below background at all times	Not connected to vacuum system; up to 10% of debris generated can become airborne
Noise level	100 dBA @ 5 ft	84 dBA (per vendor)
Capability to access floor-wall unions	1-2 in is required	1 in
Developmental status	Commercially available components	Commercially available; compatible vacuum systems are also available
Safety concerns	Main hazards are heavy equipment operation and noise	Flying concrete pieces pose eye hazard: airborne activity; heavy equipment operation hazards; noise
Set-up time	Minimal	Prerequisite erection of temporary airborne enclosure

SECTION 4

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Technology Applicability

In order to meet regulatory criteria for unrestricted use, any site that has a need for coating removal from concrete floors would benefit from the use of the 3M™ Roto Peen technology. Demonstrated from March 17-20, 1997, as an alternative to the scabbling technology for removing coating layers from a large area of concrete floor, this technology showed several advantages:

- The shot remained captive to the 3M™ Heavy Duty Roto Peen flaps considerably reducing the amount of waste, which was mainly paint chips with a powdery consistency. Therefore, the secondary waste consisted only of protective clothing, Roto Peen flaps, filters, the vacuum hose, some tape, smear papers, and rags.

- The CPM-4 concrete planer provided by EDCO is well designed. It is very easy to operate and replacement of the flaps can be done in a minimal amount of time. There was no need to vacuum the floor after the coating removal was done, because no dust was left on the floor after the pass of the concrete planer.

- The VAC-PAC® is efficient and well designed. The controlled-seal drum fill system allows waste drums to be filled, sealed, removed, and replaced while minimizing the possibility of operator exposure or the release of airborne contamination. The HEPA filter and roughing filters are also easily accessible.

- The Pb Sentry was designed to function transparently. It adds an important worker safety feature to the overall system by cutting off power to the planer should the detected vacuum drop below a safe threshold, and it automatically shuts off the machine when it is lifted from the floor.

The ease of operating the equipment, no generation of airborne dust, and less secondary waste make the 3M™ Roto Peen technology a useful tool in reducing project costs. The only disadvantage was the slow rate of the coating removal. However larger units are available from EDCO, which may greatly increase the rate of removal.

There are a number of technologies currently available to D&D professionals for the purpose of removing coatings from concrete floor surfaces.

Other technologies available are:

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

Data comparing the performance of Roto Peen with captive shot to all the competing technologies listed above is not available.

SECTION 5

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Introduction

This cost analysis compares the relative costs of the innovative and baseline technologies and presents information that will assist D&D planners in decisions about use of the innovative technology in future D&D work. This analysis strives to develop realistic estimates that represent actual D&D work within the U.S. 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 will include refinements to make the estimates more realistic. These are allowed only when they do not distort the fundamental elements of the observed data of productivity rate, quantities, or work elements. They eliminate only those activities that are atypical of normal D&D work. Descriptions contained in Appendix B of this analysis detail the changes to the observed data. The *CP-5 Large-Scale Demonstration Project, Data Report for the Demonstration of the 3M™ Heavy-Duty Roto Peen and VAC-PAC®* (ANL, 1997) provides additional cost information.

Methodology

This cost analysis compares two decontamination technologies, an innovative Roto Peen with captive shot technology and the baseline, a conventional mechanical scabbling technology. The Roto Peen with captive shot technology was demonstrated at CP-5 under controlled conditions with facility personnel operating vendor-provided equipment. Work process activities were timed and quantities were measured to determine production rates.

Data collected during the demonstration included the following:

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

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

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

Because the baseline costs are not based on currently 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, an ANL D&D technical specialist, and a test engineer for the demonstration) and the U.S. Army Corps of Engineers (USACE) reviewed the assumptions to ensure a fair comparison.

The cost analysis data are displayed in a predetermined activity structure. The activities are extracts from the *Hazardous, Toxic, and Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary* (HTRW RA WBS), (USACE, 1996.) The HTRW RA WBS was developed by an interagency group, 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 rate for materials and subcontracts is included in this analysis at 9.3 percent but will vary at other sites. Overhead rates for each DOE site vary in magnitude and in the way they are applied and are excluded in this cost analysis. Decision makers

seeking site specific costs can apply their site's rates to this analysis without having to first retract ANL's rates except the 9.3 percent for materials and subcontracts. This omission does not sacrifice the cost saving accuracy, because overhead is applied to both the innovative and baseline technology costs. Engineering, quality assurance, administrative costs, and taxes on services and materials also are omitted from this analysis for the same reason indicated for the overhead rates.

The standard labor rates, established by ANL for estimating D&D work, are used in this analysis because all the work was performed by local crafts. Additionally, the analysis uses an eight hour work day with a five 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 for 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.

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 influence the manner in which D&D work is performed. 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 3. This table is intended to help the technology user identify work differences that can cause cost impacts.

Table 3. Summary of cost variable conditions

Cost Variable	Innovative technology: Roto Peen with captive shot	Baseline technology: mechanical scabbling
Scope of Work		
Quantity & Type of Material	425 ft^2; coated concrete floor	425 ft^2, comparable to demo area, but approx. 1/6 of original baseline scope of 2,542 ft^2, concrete floor
Location	Service floor of CP-5 including open areas, and edges	CP-5; same service floor area, open areas only
Nature of work	Reduce radiological levels. Remove coating (and 1/16 in of concrete)	Reduce radiological levels. Remove ¼ in of concrete (inherent in equipment) along with coating
Work Environment		
Level of contamination	Six portions on the floor have elevated fixed total beta/gamma contamination	Assumed baseline would be same as demonstration area
Level of airborne contamination during D&D activity	No airborne exposure, therefore no tent required. Vacuum system integral with equipment. Debris continuously contained in drums	Concrete chips and dust (airborne) created by equipment. Temporary tent required; estimated to cover 133% of area being worked
Personnel protection eq. (PPE) requirements	PPE worn: clothes, gloves, respirators as a requirement, despite no airborne contaminants	Temporary tent required; 565 ft^2 used. Requires PPE and respirator, same as demonstration

Table 3. Summary of cost variable conditions (cont.)

Cost Variable	Innovative technology: Roto Peen with captive shot	Baseline technology: mechanical scabbling
Work Performance		
Acquisition means	Subcontracted vendor provided equipment and consumable captive shot flaps. This analysis is based on site craft using that equipment, but as government owned and some equipment as rental	Site craft workers with site owned and some rental equipment
Scale of production	1. Demonstrated in large unconfined areas 2. Crew size: 2; 1 with machine, 1 supporting person 3. Equipment: floor, walk behind model, 5.5" cut width	1. Based on large open area and some tight areas inaccessible for the size of machine 2. Crew size: 3; 1 with scabbling machine and 2 supporting people 3. Equipment: Large, floor walk behind model, 11" cut width
Production rates (crew size)	Experienced a rate of **71 ft^2/h** for the person running the EDCO CPM-4 concrete planer - net effective production with two persons on crew is **35.5 ft^2 per person-hour**	Assumed constant rate: **200 ft^2/h** for the person running the pneumatic machine - net effective production with three persons on crew is **67 ft^2/person-hour**
Primary waste	2.84 ft^3	12.8 ft^3
Secondary waste	Vacuum hoses, worn flaps, PPE and swipes, filters: estimated 16 ft^3	Worn scabbling bits, swipes, PPE: estimated 14.7 ft^3 (2 drums)
Work process steps	1. Remove the surface coating and concrete, using one electric driven machine with continuous vacuum collection into closed drum container	1. Scabble the surface area to ~ ¼ in depth with one pneumatic machine leaving debris and airborne contaminants 2. Sample rubble health physics technician (HPT) 3. Manually clean up and load into containers by other worker
End condition	Coating and 1/16 in concrete removed; radiation reduced to at or below background level	Coating and ¼ in concrete removed; Assumed radiation would be reduced as well or better due to depth of cut (not demonstrated)

Potential Savings and Cost Conclusions

For the conditions and assumptions stated, the innovative technology Roto Peen with captive shot saves approximately 50 percent over the baseline scabbling alternate for this demonstration scope of 425 ft^2. Figure 3 is a summary and comparison of the potential savings between the two technologies.

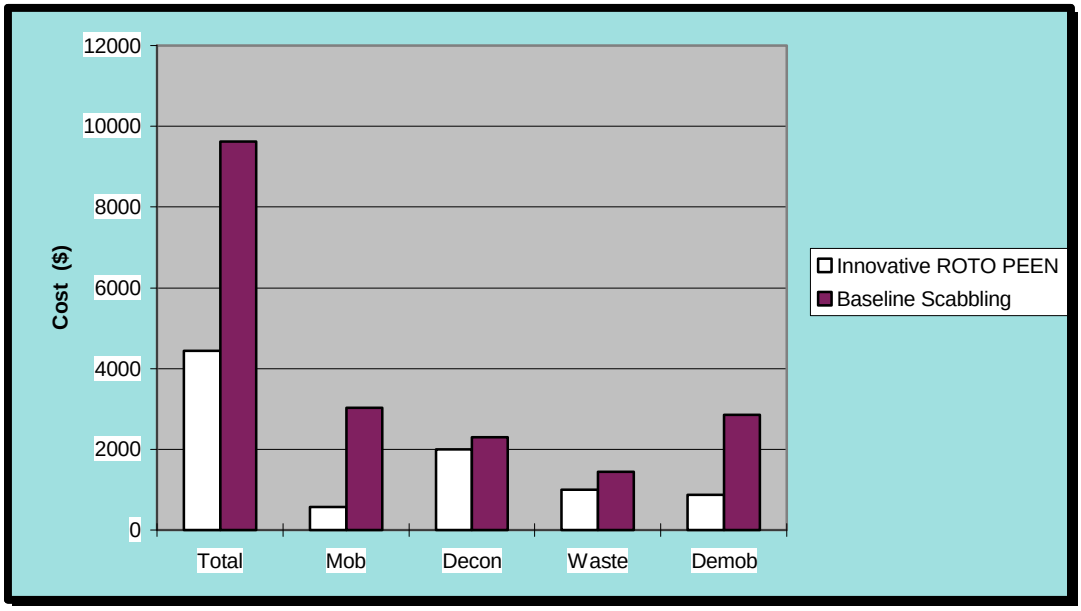

Figure 3. Total and major work breakdown.

The major contributor to the savings is the elimination, in the baseline mobilization and demobilization phases, of a temporary structure to contain the airborne contaminants. That amounts to $2,405. The innovative technology does not require a temporary enclosure because all debris is continuously vacuumed as it is generated. Minor savings include rubble loading, which is eliminated because the vacuum dumps directly into a closed drum container. Waste disposal is the next largest savings. Removal of 1/16 in of concrete generates a smaller quantity of waste than does a ¼-in depth of concrete. The savings from all these activities will vary with the size of the area to be decontaminated.

Other potential cost differences at various sites can include:

- production rates of the machine model and its cut width and depth capabilities,
- mobilization (mob) and demobilization (demob) of equipment and personnel,
- training of new or vendor personnel,
- health and safety and site requirements, and
- size of the area undertaken as a single continuous project effort.

The production rates and operating costs for scabbling and Roto Peen with captive shot will vary depending upon site specific conditions and the model of the machine selected. The available production rates range from 30 ft^2/h to over 450 ft^2/h.The width of cut affects the production rate and ranges from 2 in to 18 in. Some wide cut, large floor models are easy to use but hard to maneuver in tight spots, whereas the small hand-held units work well in confined spaces such as underneath stairways, but cause worker fatigue. Scabbling, with its superior production rate, actually costs less than Roto Peen with captive shot technology for the coating removal activity. However, the extra handling and cleanup of the debris from the scabbler and the resultant productivity loss results in higher costs for the total decontamination activity.

This analysis assumes government ownership of equipment. If vendor services are utilized at other sites, there will be additional costs for mobilizing and training vendor personnel.

Depending on the situation at any given site, a health and safety requirement beyond regulatory minimums could be imposed that would still require a tent-like structure be erected even though the innovative technology eliminates airborne contamination.

Some sites will choose to discard the scabbling or concrete planer at the end of a small project or keep it for extended and future projects. That depends on the investment made and decontamination possible for continued use. Amortizing equipment ownership over greater scope will result in lower unit rates. The primary roughing filters and the secondary HEPA filters, used for only 425 ft^2, were discarded following the demonstration. The $989 cost of filters resulted in a unit cost of $2.33/ ft^2 or $164.83/h for the 6 productive hours in use, a relatively high cost element. However, the design of the filter system provides for automatic blow-back filter cleaning about every 30 seconds. This increases the life of the roughing filters to about 9 months or 1 yr of continuous, normal use and the HEPA filter to about 1 yr. For the cost analysis, a life of 1 yr and 500 h of use for both filters is utilized, which equates to cleaning 35,420 ft^2/yr. Assuming that volume of use reduces the two unit costs to $0.0279/$ft^2$ and $1.98/h, respectively. This is a dramatic reduction in unit cost that depends on the planned use of the technology at each site.

All factors discussed above affect costs for both technologies. A user should compute the estimated potential savings for D&D work by substituting the expected quantities, mobilization details, equipment investment, and production rates into Table B-1 to calculate a site-specific cost for their situation.

SECTION 6

[redacted]

Regulatory Considerations

The regulatory/permitting issues related to the use of the 3M™ Roto Peen technology at the ANL CP-5 Research Reactor consisted of the following safety and health regulations:

- Occupational Safety and Health Administration (OSHA) 29 *Code of Federal Regulations* (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

—1910.211 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

Disposal requirements/criteria include the following Department of Transportation (DOT) and DOE requirements:

- 49 CFR Subchapter C Hazardous Materials Regulation

—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 Packaging

- 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) requirement should be considered:

- 40 CFR Subchapter 1 Solid Waste

These are the same regulations that govern the baseline technology of mechanical scabbling.

The waste form requirements/criteria specified by disposal facilities are used by ANL:

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

These waste form requirements/criteria may require the stabilization or immobilization of final waste streams because of their powdery consistency. This requirement would be valid for the Roto Peen, scabbling, or any other aggressive coating/concrete-removal technology.

Since Roto Peen with captive shot is designed for the decontamination of structures, there is no regulatory requirement to apply CERCLA's nine evaluation criteria. However, some evaluation criteria required by CERCLA, such as protection of human health and community acceptance, are briefly discussed below. Other criteria, such as cost and effectiveness, were discussed earlier in this document.

Safety, Risks, Benefits, and Community Reaction

The Roto Peen technology incorporates a vacuum system to collect the dust of the removed coating. During the demonstration, no increase in airborne activity levels above background was detected. It is possible that the requirement for operators to have respiratory protection may be eased, allowing for greater worker efficiency and time savings.

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

SECTION 7

[redacted]

The 3M™ Heavy Duty Roto Peen technology demonstrated on the service floor of the CP-5 Research Reactor is a commercially available product that does not have any implementation issues. The setup time is very short and the equipment is easy to operate. It is very clean and does not generate airborne dust.

The setup of the low vacuum point on the Pb Sentry, which automatically shuts off the machine when it is lifted from the floor, should be done before starting the work. It needs to be calibrated to the vacuum system being used.

The demonstrated unit has a slow rate of coating removal but larger units are available and would allow the operators to increase the rate of removal.

The 3M™ Roto Peen technology is a superficial decontamination method and cracks or joints in the area which have trapped contamination cannot be effectively decontaminated.

To meet regulatory criteria for unrestricted use, any site that has a need for contaminated coating removal from concrete floors without any contaminated cracks would benefit from the use of the 3M™ Roto Peen technology.

APPENDIX A

[redacted]

Strategic Alliance for Environmental Restoration, CP-5 Large-Scale Demonstration Project, *Test Plan for the Demonstration of 3M™ Heavy-Duty Roto Peen and VAC-PAC® System*, Argonne National Laboratory, March 1997.

Strategic Alliance for Environmental Restoration, CP-5 Large-Scale Demonstration Project, *Data Report for the Demonstration of 3M™ Heavy Duty Roto Peen and VAC-PAC® System*, Argonne National Laboratory, June 1997.

APPENDIX B

TECHNOLOGY COST COMPARISON

This appendix contains the activity dictionaries with definitions of cost elements, descriptions of assumptions and some computations of unit costs. It also contains the cost analyses.

Activity Dictionary

Innovative Technology -- 3M™ Heavy Duty Roto Peen with captive shot
(with a VAC-PAC® and Pb Sentry)

Mobilization (mob) (WBS 331.01)

Equipment Transport

Definition: This cost element provides for transportation of the site-owned decontamination (decon) equipment from its storage area to a staging area near the facility being decontaminated. Therefore, this cost includes a truck and forklift, the teamster and operator, and the riggers loading and hauling the subject construction equipment and the hourly charges for the transporting equipment and that being transported.

Assumption: Distance to a site warehouse varies, but less than 2 mi is assumed. The pickup truck and pneumatic forklift are rented using rates from the Dataquest construction equipment rental rate book. Loading takes 0.5 h and driving takes 0.25 h for a duration of 0.75 h. Returning the transportation equipment to the equipment pool takes 0.25 h and is a concurrent activity. Therefore, 1 h is priced. See note under off-load activity.

Note: This scenario diverges from the actual demonstration conditions wherein the vendor mobilized their representatives and equipment from both Minneapolis, MN, and Pittsburgh, PA.

Off-load and Unpack Equipment and Pre-survey Equipment

Definition: This cost element provides for three activities with different crews. It includes 1) the riggers time to off-load equipment from the truck using a forklift, 2) the decon workers to move the equipment to a staging area and unpack it for survey, and 3) a radiological survey of the equipment by an HPT to ensure that contaminated equipment is not brought on site. Duration includes decon crew standby during HPT pre-survey.

Assumptions: 3.5 h are assumed for off-loading, unpacking, and surveying the equipment.

Note: The first day (8 h) consisted of four activities observed, but not timed. The duration has been allocated as follows: Equipment transport (previous activity), 0.75 h; this activity of three sub-activities, 3.5 h; set up and move in (a following activity), 2.25 h; and lost time not attributable to D&D activities but to facilitate the demonstration, 1.5 h. However, this distribution was further based on similar activities observed and timed during the demobilization phase. The crews involved varied in composition.

Training

Definition: This cost element captures the cost of site and health and safety related training required for subcontractor personnel or other unqualified personnel.

Assumptions: There is no cost applicable due to the assumption that local site personnel are trained already. However, the vendor personnel were trained in order to carry out the demonstration.

Radioactivity Surveys of the Area

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

Assumption: Not applicable and no cost effect for this analysis. This activity is assumed completed prior to decontamination activities.

Set Up, Move and/or Check Out Equipment

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 floor planer, any hand tools, and other incidental consumables are taken to the work area from the staging area.

Assumptions: The duration for moving equipment and set up is assumed to be 2.25 h based upon observed demonstration time during the demobilization phase. See note above under off-load.

Remove Floor Surface Coatings

Definition: This cost element consists of:

- Removing the coatings off the concrete floor and operational maintenance of replacing the roughing and HEPA filters with clean ones and consumable parts that wear.
- The activity labor consists of two decon workers.
- Cost of equipment is included in the activity, and consumable equipment and supplies are listed as a sub-breakout of this cost element because it is so variable.
- Packaging of primary waste is automatic into the VAC-PAC® and its container.
- Transporting to disposal collection area is excluded.
- Cost of PPE is included. See unit cost derivation in the next table.
- Any lost time from production is included as a factor. This involves safety meetings, daily work planning reviews, dress-out with PPE, heat or temperature stress, and work breaks.

Assumptions:

- The quantity scope for the demonstration is 425 ft^2.
- Two decon workers are used. One actively operating the EDCO CPM-4 floor model concrete planer which utilizes the Roto Peen with captive shot to remove the coatings. The other assists with hoses and electric power cords.
- An HPT is not necessary to accomplish the main task (and not priced).
- Production rates used are 71 ft^2/h per two person crew (or 35.5 ft^2 h per person) for the demonstration based on observed, timed activities. The crew composition is shown in Table B-1. The time observed was 6 h.
- One decon crew worker is qualified to change out the worn Roto Peen with captive shot flap parts. The other decon worker is on standby while changing flaps.
- The equipment configuration eliminates the vacuuming step because the VAC-PAC® is connected to and continuously vacuums debris from the EDCO CPM-4.

- A 20 min safety meeting was held on two mornings (not counted in the 6 h).
- PPE changes and other related productivity losses were not measured in the demonstration but experienced. A productivity loss factor (PLF) of 1.49 is applied.

Productivity Loss Factor

Definition: A factor applied to productive hours to compensate for loss of production while attending safety meetings, dressing and undressing in PPE, work breaks, heat and cold work stress, etc.

Assumption: A PLF from the baseline 1996 activity cost estimate (ACE) sheets of 1.49 is used to make the innovative case comparable to the baseline.

PPE Cost Per Day Calculation

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 (Resp)			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 Collection

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

Transport to the Disposal Site

Definition: This cost element is for the charges for the volume of waste being shipped to a commercial off-site facility.

Disposal Fees

Definition: This cost element accounts for the fees charged by the commercial facility for dumping the waste at their site.

Assumptions: (for all three of the accounts above combined as one price)

- During the demonstration of this technology, only 2.84 ft^3 of primary waste (paint and some concrete chips) was generated and directly vacuumed into a barrel or container.

- The secondary waste consists of a bag of the expendable vacuum hose, used PPE, and swipes handled after the work is completed. (Estimated at 16 ft^3, not supported by demo data.)

- Cost is represented as an All-in Disposal fee rate per ft^3 for contact-handled (<200 mrem/h) low level radioactive waste (LLW) and covers a base rate, transportation costs, container cost and/or cask rental, and ANL indirect costs.

Demobilization (WBS 331.21)

Survey and 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 assistance and or stand-by time.

Assumptions: Demonstration times observed are 80 min for decontamination of equipment by two decon workers and an HPT and 1 h for survey by HPT only.

Pack Up and Load Equipment

Definition: This cost element covers the labor and equipment time to pack up and load out the equipment onto a truck for returning to a point of origin.

Assumptions: Demonstration times observed are 2 h for boxing up using two decon workers and 30 min for loading the equipment using three riggers and a teamster.

Personnel and Equipment Transport

Definition: Transport of equipment back to the warehouse involves obtaining transport equipment from the equipment pool, driving loaded truck to the warehouse, and off-loading at the warehouse.

Assumption: Return trip mileage to a warehouse is less than 2 mi and is basically the reverse of mobilization. Crafts involved are thee riggers and a teamster. Equipment included is a pickup truck, forklift, and the decon equipment. The estimate assumes a duration of 45 min plus 15 min for a concurrent activity.

Note: This scenario diverges from the actual demonstration conditions wherein the vendor demobilized their representatives and equipment back to both Minneapolis, MN, and Pittsburgh, PA.

Cost Analysis

Innovative Technology -- Roto Peen with captive shot (and a VAC-PAC® and a Pb Sentry)

The cost for performing work using the Roto Peen with captive shot technology consists of the following activities:

1) mobilization of equipment;
2) unloading to a staging area;
3) set-up of equipment and hoses;
4) removal of the floor coating (about 1/16 in of concrete*)* using an EDCO CPM-4 floor model concrete planer using a Roto Peen with captive shot, a Pb Sentry, and a VAC-PAC®;
5) replacement of consumable flaps when necessary;
6) use of PPE;
7) decontamination of the reusable equipment;
8) collection of all waste;
9) handling the drums containing the waste;
10) demobilization back to point of origin; and
11) disposal fees.

The projection of demonstration costs to reflect a commercial cost for the scope of work includes adjustments as a result of the assumptions shown below:

- An EDCO CPM-4 concrete planer with a Pb Sentry and a VAC-PAC® (assuming long-term need) are purchased by a site and delivered to and received by the warehouse. The procurement indirect expense (PIE) rate for ANL of 9.3 percent has been applied to equipment and services purchased in determining the hourly rate.
- Mobilization consists of loading with a forklift large and small tools at the warehouse tool room, hauling them with a site truck (at rental rates) to the facility, unloading them at a staging area using site personnel, and returning the transporting equipment to the equipment pool. The reverse holds for demobilization. Three riggers and a teamster are involved.

- A decontamination labor crew of two ANL facility workers, hired locally, require no mobilization or training because of previous qualifications.

- The technology demonstrated is coating removal, but additionally about 1/16 in of concrete is removed from a test area of 425 ft^2.

- Hourly rates for Government owned equipment are based on amortizing the initial purchase price, including its shipping costs, over the service life of the equipment using a discount rate prescribed in the OMB circular No. A-94 of 5.8 percent. Service life of 5 to 15 yr (depending on the individual piece of equipment) is used with an assumed use of 500 h/yr.

- There is no difference in the PPE requirements between this technology and the baseline, and in fact, PPE were worn.

- The observed time of 6 h removing coatings from 425 ft^2 results in a production rate of 71 ft^2/h. The definition also encompasses assistance in handling air and electrical cords and a prorated allowance for captive shot flap replacement. Because of the two-person crew, the effective production rate becomes 35.5 ft^2/person-hour.

- The captive shot flaps were not changed in the course of the demo. The flaps had 10 h of previous wear when the demonstration started and added 6 h more during it. This analysis assumes one change is necessary every 30 h, or 2,100 ft^2, of use, a portion of which has been considered in the analysis. The lifetime of the flaps will depend on the type of surface being cleaned.

- The primary waste generation volume factor is 0.0067 ft^3/ft^2 including a 78 percent bulking factor.

- The VAC-PAC® roughing filters, designed with a continuous cleaning feature, and the HEPA filters are reusable over several jobs or larger scope quantities. Filters are expected to last 9-12 mo (assumed 1 yr at 500 h of use) based on conservative extrapolation of information provided during a phone conversation with a Pentek representative.

- Radiological survey of the floor before and after the task is excluded because it is a characterization function.

- Mark-up of labor and equipment costs for the ANL overhead rate is excluded.

- A PLF of 1.49 is applied to the Roto Peen with captive shot demonstration activities. The data is adjusted from the ACE sheets, CP-5 Cost Estimate qualifications, page 1.12 through 1.14 of 1.33 issued by ANL Technology Development Division of the D&D Project. While the demonstration was timed and conducted wearing PPE, the time was not recorded separately for safety meetings and suiting up and suiting off. The details are:

Base	1.00	
+ Height factor	0.00	(not applicable, since work is on the floor)
+ Radiation/ALARA	0.20	
+ Protective Clothing	0.15	(to account for dress-out)
= Subtotal	1.35	
x Respiratory Protection	1.00	(no factor required, covered in the observed times)
= Subtotal	1.35	
x Breaks	1.10	
= Total	1.49	

The activities, quantities, production rates and costs observed during the demonstration form the basis of the values shown in Table B-1, Innovative Technology Cost Summary.

TABLE B-1 INNOVATIVE TECHNOLOGY COST SUMMARY

Work Breakdown Structure (WBS)	Unit Cost (UC) Labor Hour (hr) Rate	Equipment Hour 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 (mob)- WBS 331.01						**Subtotal:**	**$ 567**	
Transport Equipment (Eq.) - Load at warehouse	0.5 $ 161	0.5 $ 25.41		$ 93	1	Lump Sum (LS)	$ 93	Truck, forklift, teamster, & 3 riggers for 4.5 h total to mobilize
Drive to staging & Unload Eq.	0.75 $ 161	0.75 $ 39.39		$ 150	1	Trip	$ 150	
Return Transport Eq. to pool	0.25 $ 80	0.25 $ 25.41		$26	1	Trip	$ 26	
Unpack equipment	2 $ 67	2 $ 13.01		$160	1	LS	$ 160	
Pre-survey equipment	1 $ 123	1 $ 13.01		$136	1	LS	$ 136	
DECONTAMINATION (decon) - WBS 331.17						**Subtotal:**	**$ 2,000**	**SCOPE: 425 square feet (ft^2)**
Move eq. to work area & set up task equipment	2.25 $ 67	2.25 $ 37.78		$ 236	1	LS	$ 236	On-site labor 2 decon technicians (techs) @ $67.20/crew for 2.25 h plus Eq. standby
Scarify concrete floor	0.01408 $ 67	0.014 $ 37.78	$ -	$ 1.48	**425**	ft^2	$ 628	Production rate: 71 ft^2/h by 1 person while another assists. No flap replacement. Operating costs are below. Duration is 6 h.
HPT escort/ as needed	0 $ 56			$ -	**6**	h	$ -	Not required
Eq. Operating costs								
Replacement Flaps		1 $ 60.27		$ 60.27	6	h	$ 361	1 drum x 50 Roto Peen flaps per drum x 1 changes x $30.14/flap for 1,750 ft^2=~$60.27/hr
Air Compressor costs		1.000 $ 17.32		$ 17.32	6	h	$ 104	Air Compr. 750 cubic feet per minute (ft^3/min)
Air tools/filters consumables		1.000 $ 3.55		$ 3.55	6.0	h	$ 21	Assumed filter life = 500 h
Sample rubble & surface						ft^2	$ -	**No sampling required with technology**
Load Rubble in containers			$ -	$ -	2.84	ft^3	$ -	**Auto-vacuumed**. Waste generated=2.84 CF
Personnel Protective Eq. (PPE)			$ 93	$ 93	1.1	day	$ 103	2 decon techs @$46.33/day
PRODUCTIVITY LOSS	1.00 $ 67	1.00 $ 118.92		$ 186	2.9	h	$ 546	Factor: 1.49 per ACE sheets from ANL
DEMOBILZATION (demob) - WBS 331.21						**Subtotal:**	**$ 873**	
Demob Equipment								
Decon Equipment including HPT	1.33 $ 123	1.33 $ 13.01	$ 13.20	$ 194	1	LS	$ 194	"Other" is for waste generated by eq. decon at .25 ft^3 @ $52.78/ft3. Time per demo.
Survey Eq. for free release	1 $ 56	1 $ 13.01		$ 69	1	LS	$ 69	1 HPT, 1 h per demo time
PPE during decon		1.98	$ 139	$ 139	0.25	day	$ 34	2 decon techs, 1 HPT @$46.33/day
PPE during survey		1.49	$ 46	$ 46	0.19	day	$ 9	1 HPT at $46.33/day
PRODUCTIVITY LOSS	1.00 $ 123	1.00 $ 13.01		$ 119	1.1	h	$ 136	Figured at 1.49 per 1996 ACE sheets
Pack up equipment	2 $ 67	2 $ 13.01		$ 160	1	LS	$ 160	Reverse of mobilization. Time per demo.
Pool eq. to staging area	0.25 $ 80	0.25 $ 25.41		$ 26	1	trip	$ 26	Reverse of mobilization. Time per demo.
Load truck and return to whse	0.75 $ 161	0.75 $ 39.39		$ 150	1	LS	$ 150	Reverse of mobilization. Time per demo.
Unload at warehouse	0.5 $ 161	0.5 $ 25.41	$ -	$ 93	1.0	LS	$ 93	Reverse of mobilization. Time per demo.
WASTE DISPOSAL - WBS 331.18						**Subtotal:**	**$ 994**	
Disposal Fees-Prime & 2nd			$ 52.78	$ 52.78	18.8	ft3	$ 994	From 1996 ACE, Table 2.0, pg. 1.11 of 1.33
						Total	**$ 4,433**	

Baseline Technology - Scabbling

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 included in the demobilization account.

Assumptions: Conceptual scope definition is from ANL D&D personnel. A temporary enclosure for airborne contaminants is erected using unistrut material ($2.00 per lin ft plus $1.00/ lin ft for fittings and connections) as studs, beams, and bracing for walls and ceiling and visqueen ($.01/$ft^2$) as the enclosing cover. Labor consists of three decon workers ($33.60/h) for 2 h to erect a size of 565 ft^2.

NOTE: Since this decontamination test area (425 ft^2) is smaller than the area basis (650 ft^2) used in development for another demonstration, the area for this tent is reduced to 565 ft^2. The time to erect has been reduced to 2 h from 3 h in a direct proportion to the area reduction ratio (565 ft^2/865 ft^2). No PLF or PPE are used during erection but are during dismantling. This activity is completed prior to mobilizing for the decon activities. The unit rate is 2 h/565 ft^2 or 0.0035 h/ft^2.

Equipment Transport

Definition: This cost element 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 transporting equipment and that being transported.

Assumption: Distance to a site warehouse varies, but is less than 2 mi. 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

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. This activity is combined with the survey activity below.

Assumptions: A 2 h period to unload/unpack the equipment is assumed. Procurement's effort to receive purchased equipment and complete paperwork is excluded. Forklift operator is included in the crew rate, and forklift rental rate (base) is $11.65/h, taken from Dataquest construction equipment pricing book.

Survey Equipment

Definition: This cost element provides for radiological survey of the equipment by a site HPT to ensure that contaminated equipment is not brought on-site. Costs include crew stand-by time plus HPT labor. This activity is combined and concurrent with the unloading activity above.

Assumptions: Equipment survey is required.

Training

Definition: This cost element captures the cost of Site and Health and Safety related training required for subcontractor personnel or other unqualified personnel.

Assumptions: No cost to this element. Personnel on site already are trained.

Radiological Survey

Note: This cost element is for radiological surveying to characterize the workplace 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 consumable supplies are taken to the work area from the staging area. Set-up excludes the erection costs of a temporary containment tent, 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 original baseline 4 h were reduced to 2 h, eliminating 50 percent of the time assumed to be required for scaffolding.

Remove Floor Surface Concrete

Definition: This cost element consists of:

- Remove the floor concrete making one pass of ¼ in removed including replacing consumable tool bits that wear with use.
- The activity consists of one decon worker operating the 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 scabbling equipment and consumable bits is in this cost element.
- Cost of PPE is included. See table in Innovative Technology section, this appendix.
- Any lost time from production is included. This involves daily safety meetings, daily work planning reviews, dressing out with PPE, heat or temperature stress, work breaks, etc., which is accounted for through the PLF.

Assumptions:

- The quantity scope for the baseline is the same as the demonstration, 425 ft^2 for comparison equality.
- One crew of two decon workers and one HPT are required. Those three people handle the scabbling, sampling, cleaning up, and containerizing as a team for which the estimate is separated into two sub-elements of cost by craft.
- One scabbling machine is used.

- Baseline 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. Stand-by time is necessitated by this activity.

- Production rate in this analysis is 200 ft^2/h for the one machine, a Model -11, Trelawny. The net effective production rate is 67 ft^2/person-hour due to the three-person crew. The scabbler is priced at an ownership hourly rate of $9.95/h based on pricing information from ANL D&D personnel.

- A safety meeting occurs and is in this analysis through use of the 2.05 PLF.

Productivity Loss Factor

Definition: A factor which is applied to productive hours (the PLF) to compensate for safety meetings, 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.)

Note: The cost per day calculation for PPE is the same as in the Innovative Technology section in this appendix.

Waste Disposal (WBS 331.18)

Waste Collection

Definition: This cost element accounts for the time and equipment required to pick up containers and assemble them in a designated area. It does not cover the time and equipment to package into containers the primary waste generated by the decon activity.

Transport to Disposal Site

Definition: This cost element is for the charges for the volume of waste being shipped to a commercial off-site facility.

Disposal Fees

Definition: This cost element accounts for the fee charged by the commercial facility factor for dumping the waste at their site.

Assumptions (for all three of the accounts above combined as one price):

- Primary waste generated of 19.5 ft^3 is calculated at 0.03 ft^3/ft^2 including a 70 percent efficiency bulking as taken from the May 1996 Activity Cost Estimate sheets.

- The secondary waste consists of a couple of bags of expended scabbling bits, used PPE and swipes, and no vacuum hoses. Assumed 14.7 ft^3.

- Not applicable, as such, to each of the detailed accounts, but all three accounts are covered with a single rate per ft^3.

- Cost is represented as an All-in Disposal fee rate per ft^3 for contact handled (<200 mrem/h) LLW and covers a base rate, transportation costs, container cost and/or cask rental, and ANL indirect costs.

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. It includes decon workers and HPT labor. It includes gathering up and containerizing the waste building materials. PPE and a PLF are included due to the airborne contamination.

Assumptions: As originally defined by ANL personnel for another demonstration, labor required is three persons for 3 h to dismantle and load up waste. However, the time has been reduced to 2 h due to the size reduction for a smaller tent than the other demonstration basis.

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 Load Equipment

Definition: This cost element covers the time and equipment required for the crew to pack up and load the 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.

Personnel and Equipment Transport

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

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

Cost Analysis

The cost of performing the work consists of the following activities:

- mobilizing the site-owned equipment from a warehouse,
- unloading the equipment at the staging area,
- moving it into the work area,
- scarifying the concrete with the mechanical scabbling tool,
- sampling the rubble and floor surface for radioactivity,
- loading the rubble into transfer containers and transferring the waste,
- demobilizing the equipment,
- charges for waste disposal, and
- returning the equipment to the warehouse.

The baseline includes the following assumptions:

- Mobilization consists of a forklift loading tools at the warehouse tool room, a rented truck hauling them to the facility and unloading them near the work area using site personnel, and returning the transport equipment to the equipment pool.

- The construction of a temporary enclosure is necessary to contain airborne contaminants during the work operation. The conceptual scope, provided by ANL D&D personnel, involves unistruts as studs, beams, and braces and visqueen as walls and ceiling. Erection requires three persons for 3 h, as does the dismantling activity following decontamination.

- Setup involves moving equipment into the work area, stringing the air hoses from the compressor outside, dressing up, and other preparatory activities.

- Work is performed by local site craft using a site-owned mechanical scabbling tool and other owned and rented equipment. The crew consists of two decon workers and one HPT (acts as the escort). Additional administrative, engineering, and supervisory personnel are excluded from the analysis, assuming their costs are accounted for in distributed costs and are equal in both cases.

- Concrete removal is to a depth of one-quarter inch. Waste is vacuumed manually and placed in containers. The ¼-in depth makes the baseline comparable to the innovative technology.

- Production rate is 200 ft^2/h/one decon tech scabbling (200 ft^2/h/person) and one decon tech performing all other supplemental removal activities. The HPT assists full-time by checking the radioactivity level of the rubble.

- The scabbling activity includes the time for replacement of worn bits by the qualified decon tech.

- The factor for waste volume generation is 0.03 ft^3/ft^2, including a 70 percent efficiency bulking factor.

- Equipment operating costs are listed separately from hourly ownership rates because the consumable usage may vary by site.

- Pricing for the scabbler is taken from the 1996 ACE sheets with all applicable assumptions used in that document. ANL personnel indicated the scabbler would be discarded at the end of the CP-5 project.

- The decontamination area is modified to 650 ft^2 to match the demonstration area.

- The PLF, applied to the productive work hours, accounts for health and safety (H&S) considerations that typically occur. The calculation is as follows. (Markup of labor and equipment costs for the ANL overhead rate is not included.)

Base	1.00
+ Height factor	0.00 (not applicable; work is on the floor)
+ Radiation/ALARA	0.20
+ Protective clothing	0.15
= Subtotal	1.35
x Respiratory protection	1.38
= Subtotal	1.86
x Breaks	1.10
= Total	2.05

The activities, quantities, production rates, and costs used in the baseline calculations are shown in Table B-2.

TABLE B-2 BASELINE COST SUMMARY (SCABBLING TECHNOLOGY)

Work Breakdown Structure (WBS)	Unit Cost (UC) Labor Hour(h)	Labor Rate	Equipment Hr	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 (mob)- WBS 331.01								**Subtotal:**	**$ 3,025**	
Build containment tent	0.0035	$ 101			$ 3.07	$3.41	565	ft^2	$ 1,930	3 decon wrkr, 2 h @ $33.60 plus materials
Health Physics Tech (HPT) for Tent	2.0	$ 56			$ 13.20	$123	1	LS	$ 123	Covers building tent only. Other: decon waste at .25 ft^3 at $52.78/$ft^3$
Transport Equipment (Eq.) - load at warehouse	2	$ 147	2	$ 32.51		$ 359	1	Trip	$ 359	Truck, forklift, teamster, operator, & two decon workers for 2 h
Drive to site	0.5	$ 147	0.5	$ 42.46		$ 95	1	Trip	$ 95	Same as above, 0.5 h, add scabbler
Unload Equipment at site & survey	2	$ 203	2	$ 42.46		$491	1	Trip	$ 491	Same as above, 2 h, add health physics tech (HPT) for survey
Return truck/forklift	0.25	$ 80	0.25	$ 32.51		$28	1	Trip	$ 28	
DECONTAMINATION (decon) - WBS 331.17								**Subtotal:**	**$ 2,296**	**SCOPE: 425 Square Feet (SF) (Sq Ft)**
Move Eq. to Work Area	2	$ 67.2	2	$ 38.47		$ 211	1	LS	$ 211	On-site labor 2 decon technicians(techs) @ $33.60/h for 2 h plus Eq. Standby
Removal of concrete floor coatings	0.005	$ 67.2	0.005	$ 38.47	$ -	$ 0.53	**425**	ft^2	$ 225	Two Decon workers; one machine at 200 ft^2/h including replacements, total 3.25 h.
Eq. Operating costs										Varies with life of bits, replacement frequency
Consumable (consum) Bit wear					$ 0.22	$ 0.22	425	ft^2	$ 93	Per operating cost calculation which is similar to PENTEK consumable rates/ft^2
Air Compressor costs			2.125	$ 7.00		$ 14.86	1	LS	$ 15	Air Compressor,250 ft^3/min
Air tools consum.			2.125	$ 0.27		$ 0.58	1	LS	$ 1	
HPT Sample rubble & surface radioactivity	0.012	$ 56.0				$ 0.68	425	ft^2	$ 287	One HPT at $56/h, same hrs as decon.plus manual loading.
Load Rubble in containers	0.235	$ 67.2	0.235	$ 38.47	$ -	$24.86	12.8	ft^3	$ 317	Waste at .021 ft^3/ft^2 w/ 70% efficiency= .03.
Personnel Protective Eq. (PPE)					$ 139	$ 139	2.0	day	$ 278	3 men x $46.33/day
PRODUCTIVITY LOSS	1.000	$123.2	1.000	$ 38.47		$ 162	5.38	Hr	$ 870	Factor: 2.05 per '96 ACE sheets
DEMOBILZATION (demob) - WBS 331.21								**Subtotal:**	**$ 2,850**	
Decon & Survey Equipment	2	$ 67	2	$ 38.47		$ 211	1	LS	$ 211	
HPT work effort	8.1	$ 56			$ 13.20	$ 468	1	LS	$ 468	Other: decon waste at .25 ft^3 at $52.78/$ft^3$
PPE during decon			6.16		$ 278	$ 278	2.00	day	$ 556	Crew of 3 plus 3 for tent dismantle
PRODUCTIVITY LOSS	1.0	$ 123	1.00	$ 38.47		$ 162	4.16	Hr	$ 672	Figured at 2.05 per 1996 ACE sheets.
Move Equipment & 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	0.0035	$ 38.47	$ 0.36	$ 0.84	565	ft^2	$ 474	3 decon wrkr, 2 h @ $33.60 plus materials
WASTE DISPOSAL - WBS 331.18								**Subtotal:**	**$ 1,449**	
Disposal Fees-Prime & 2nd					$ 52.78	$ 52.78	27.5	ft^3	$ 1,449	From '96 ACE, Table 2.0, pg. 1.11 of 1.33
								Total	**$ 9,621**	

APPENDIX C

Technology Description

The 3M™ Heavy Duty Roto Peen Flap technology was demonstrated at the Hemispheric Center for Environmental Technology at Florida International University from April 30 to May 2, 1996. The 3M™ Heavy Duty Roto Peen Flap is tungsten carbide shot brazed to a hardened steel rivet that is supported by a flexible flap. The shot rivet is kept captive to the equipment by mounting the flaps in a slotted hub. Three different size planers were demonstrated, Figure C-1; each has different cutting widths for use on different areas of the floor space (e.g., main open area of floor, near edges, and around obstructions). Table C-1 includes the specifications for each of these pieces of equipment.

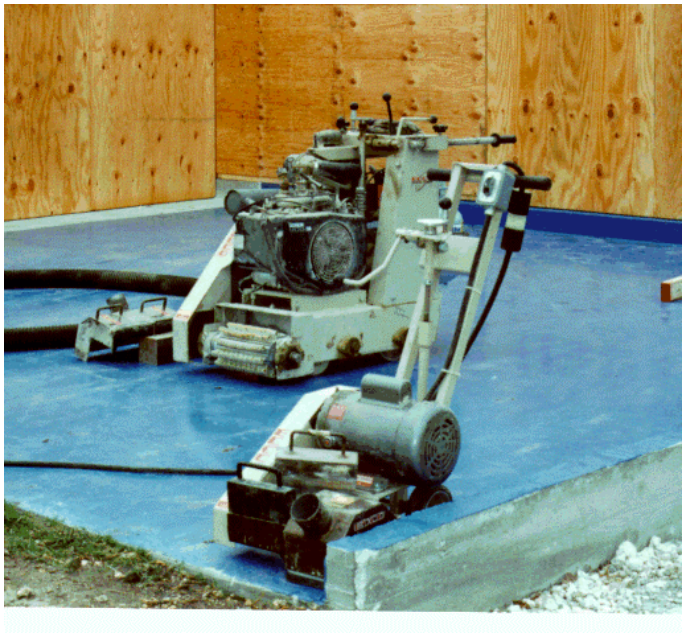

Figure C-1. CPU-10 and CPM-4E equipment.

Table C-1. Equipment specifications

Criteria	CPU-10-18KE	CPM-4E	PEENA CLEANER
Manufacturer	EDCO	EDCO	Unique Systems
Floor unit or hand-held	Floor unit	Floor unit	Hand-held
Weight	575 lb	180 lb	9 lb
Dimensions (WxLxD)	24 in x 45 in x 38 in	18 in x 38 in x 38 in	14.5 in x 9 in x 9 in
Speed	1,700-1,800 rpm	1,800 rpm	1,200-3,700 rpm adjustable
Cutting width	10 in	5.5 in	2 in
Media used	3M™ Heavy Duty Roto Peen flaps - Type A	3M™ Heavy Duty Roto Peen flaps - Type A	3M™ Heavy Duty Roto Peen flaps - Type A
Amount of media required (no. of flaps)	200 flaps	50 flaps	10 flaps

Criteria	CPU-10-18KE	CPM-4E	PEENA CLEANER
Vendor advertised life of flaps	30 h	30 h	30 h
Utilities required	Propane	220 volt 1 phase	110 volt 15 amp
Able to attach a vacuum source	Yes	Yes	Yes

A non-nuclear vacuum system, manufactured by Tornado, was demonstrated with the equipment described above. The Tornado vacuum directed the dust and debris generated from the coating removal into a 55-gal drum collection system. However, the system did not have HEPA filters.

System Operation

- The CPU-10 was self-propelled and required one hand placed on the rail at all times to steer the equipment with the other hand operating the speed control. The unit has hydrostatic forward and reverse drive, a depth control, an engage/disengage lever for the scaling head, an oil alert, a meter for monitoring the number of hours the head has been operating, and a lifting bail.
- The CPM-4 was a stand-behind push unit with variable depth control. This unit also has an engage/disengage lever to raise and lower the scaling head.
- The PEENA Cleaner is hand-held and requires one hand on the trigger at all times to operate with the other hand on the handle located at the top of the unit to push the equipment across the floor.
- The floor to be decontaminated must be dry to ensure that the substrate removed does not clog the hoses.
- Simultaneous to the decontamination of the floor, the dust and debris are vacuumed by the equipment and the debris collected in a 55 gal drum.

Demonstration Plan

In a project for the Fernald Environmental Management Project, Fluor Daniel Fernald contracted the Hemispheric Center for Environmental Technologies at Florida International University (FIU-HCET) to evaluate and test commercially available technologies for their ability to decontaminate radiologically contaminated concrete flooring. The results of this project are presented in the final report, *Analysis of Potential Concrete Floor Decontamination Technologies.*

The demonstrations were held at the Florida International University campus on 20 ft x 40 ft concrete slabs prepared specifically for these demonstrations. The concrete slabs were 6 in thick and had a final compressive strength of 5,700 psi. One-half of the slab (20 ft x 20 ft) was coated with an epoxy urethane coating. A 6-in dike surrounded each test section to aid in the evaluation of the technology's capability to remove concrete at the interface of a floor and a wall. These demonstrations were not conducted in a radiological environment.

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 C-2 presents the results of the FIU-HCET demonstration of 3M™'s Heavy Duty Roto Peen flaps using various types/sizes of floor equipment.

Table C-2. Performance data

Criteria	EDCO CPU-10-18KE	EDCO CPM-4E	PEENA CLEANER
Applicable surface	Coating removal, main floor area	Coating removal, edges of floors	Coating removal, edges of floors
Production rate for a one-person crew	298 ft^2/h	95 ft^2/h	107 ft^2/h
Floor space worked	740 ft^2	50 ft^2	10 ft^2
Type of primary waste generated	A fine powder	A fine powder	A fine powder
Type of secondary waste generated	Roto Peen flaps	Roto Peen flaps	Roto Peen flaps
Media used	3M™ Roto Peen flaps, Type A	3M™ Roto Peen flaps, Type A	3M™ Roto Peen flaps, Type A
Noise level	91.9 dBA (1)	(1)	(1)
Capability to access floor-wall unions	No closer than 5 in	No closer than ¾ in	No closer than ¾ in
Section of floor space worked	Open area, no obstructions	Edge of floor next to walls	Edge of floor next to walls and around obstructions
Development status	Commercially available	Commercially available	Commercially available
Ease of use	Self-propelled floor unit`	Stand-behind push model	Hand-held unit requires operators to be on hands and knees
End-point condition	Smooth, flat surface	Smooth, flat surface	Smooth, flat surface
Worker safety	Tripping hazard from hoses and cords. Exposed rotating machinery. Burn hazard from muffler.	Tripping hazard from hoses and cords.	Arm-hand vibration.

[1] Individual measurements for noise control were not performed. This number represents an average across the entire demonstration.

Implementation Considerations

- Technology requires an integral HEPA vacuum system to meet the U.S. DOE's radiological control requirements.
- The vacuum shroud on the EDCO equipment could not be adjusted to ensure a good seal of the interface with the concrete. This resulted in small pieces of debris being expelled from the vacuum shroud.
- The vacuuming of debris from the EDCO equipment was more efficient when the equipment was used in the direction which allowed the material to move toward the vacuum connection. When the equipment was operated in the opposite direction, minimal debris was vacuumed from the floor.

APPENDIX D

[redacted]

ACE	activity cost estimate (sheets)
ALARA	as low as reasonably achievable
amp	amplifier
ANL	Argonne National Laboratory
β/γ	beta/gamma
cm^2	square centimeters
CFR	*Code of Federal Regulations*
CP-5	Chicago Pile-5
D&D	decontamination and decommissioning
dBA	decibels
DDFA	Deactivation and Decommissioning Focus Area
Decon	Decontamination
Demo	Demonstration
Demob	Demobilization
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
dpm	disintegrations per minute
EPA	U.S. Environmental Protection Agency
Eq.	equipment
ESH	Environment, Safety, and Health
FCCM	facilities capital cost of money
FETC	Federal Energy Technology Center
FIU-HCET	Florida International University - Hemispheric Center for Environmental Technology
ft^2	square feet
ft^3	cubic feet
h	hour(s)
H&S	health and safety
HDRP	Heavy Duty Roto Peen
HEPA	high efficiency particulate air
HPT	health physics technician
HTRW	hazardous, toxic, radioactive waste
IUOE	International Union of Operating Engineers
in	inch (es)
lb	pound (s)
lin ft	linear foot (feet)
LLW	low-level waste
LS	lump sum
LSDP	Large-Scale Demonstration Project
mi	mile (s)
min	minute (s)
Mob	mobilization
mrem	millirem
OMB	Office of Management and Budget
OSHA	Occupational Safety and Health Administration
PIE	procurement indirect expense
PLF	productivity loss factor
PPE	personnel protective equipment

psi	pounds per square inch
psig	pounds per square inch gallons
Qnty	quantify
RA	remedial action
Resp.	respirator
rpm	revolutions per minute
TC	total cost
TQ	total quantity
UC	unit cost
USACE	U.S. Army Corps of Engineers
VAC	volts alternating current
WAC	waste acceptance criteria
WBS	work breakdown structure
WM	waste management
WMO	waste management operations