WSRC-TR-99-00458

# ALARA(TM) 1146 Strippable Coating

by

V. Fricke

Westinghouse Savannah River Company
Savannah River Site
Aiken, South Carolina 29808

S. Madaris

FIU-HCET

C. May

SRTC

DOE Contract No. **DE-AC09-96SR18500**

This paper was prepared in connection with work done under the above contract number with the U. S. Department of Energy. By acceptance of this paper, the publisher and/or recipient acknowledges the U. S. Government's right to retain a nonexclusive, royalty-free license in and to any copyright covering this paper, along with the right to reproduce and to authorize others to reproduce all or part of the copyrighted paper.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

This report has been reproduced directly from the best available copy.

Available for sale to the public, in paper, from: U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161
phone: (800) 553-6847
fax: (703) 605-6900
email: orders@ntis.fedworld.gov
online ordering: http://www.ntis.gov/ordering.htm

Available electronically at http://www.doe.gov/bridge
Available for a processing fee to U.S. Department of Energy and its contractors, in paper, from: U.S. Department of Energy, Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831-0062
phone: (865)576-8401
fax: (865)576-5728
email: reports@adonis.osti.gov

## DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

# ALARA™ 1146 Strippable Coating

Deactivation and Decommissioning Focus Area

*Prepared for*
U.S. Department of Energy
Office of Environmental Management
Office of Science and Technology

October 1999

WSRC-TR-99-00458

INNOVATIVE TECHNOLOGY
Summary Report

# ALARA™ 1146 Strippable Coating

OST Reference #2314

Deactivation and Decommissioning Focus Area

*Demonstrated at*
321-M Fuel Fabrication Facility
Large-Scale Demonstration and Deployment Project
Savannah River Site
Aiken, South Carolina

WSRC-TR-99-00458

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."

# TABLE OF CONTENTS


1. SUMMARY page 1
2. TECHNOLOGY DESCRIPTION page 5
3. PERFORMANCE page 8
4. TECHNOLOGY APPLICABILITY AND ALTERNATIVES page 11
5. COST page 12
6. REGULATORY AND POLICY ISSUES page 13
7. LESSONS LEARNED page 14

**APPENDICES**

A. REFERENCES page 15
B. RADIOLOGICAL DATA page 17
C. TECHNOLOGY COST COMPARISON page 21
D. ACRONYMS AND ABBREVIATIONS page 23

# SECTION 1
# SUMMARY

Strippable or temporary coatings are innovative technologies for decontamination that effectively reduce loose contamination at low cost. These coatings have become a viable option during the deactivation and decommissioning (D&D) of both U.S. Department of Energy (DOE) and commercial nuclear facilities to remove or fix loose contamination on both vertical and horizontal surfaces. The ALARA™ 1146 strippable coating was demonstrated as part of the Savannah River Site LSDDP and successfully removed transferable (surface) contamination from multiple surfaces (metal and concrete) with an average decontamination factor for alpha contamination of 6.68 and an average percentage of alpha contamination removed of 85.0%. Beta contamination removed was an average DF of 5.55 and an average percentage removed of 82.0%. The Innovative Technology offers a 35% cost savings over the Baseline Technology.

## Technology Summary

ALARA™ 1146 is a water-borne vinyl strippable coating that is free of solvents and toxic materials. It is used to mechanically lock radionuclides and remove them from substrates. The main characteristics of this coating include rapid application and removal, reduced waste volumes, immobilization of surface contaminants, and reduction of surface contamination. ALARA™ 1146 has been used to decontaminate reactor cavities during outages at commercial nuclear facilities. This strippable coating has a low odor, does not contain chlorides, and comes in two colors, yellow and blue. The blue is for routine use, while the yellow has been certified for use in reactor outages.

**Figure 1. ALARA™ 1146 being removed from wall.**

### *Problem Addressed*

Residual contamination is often non-adherent and can lead to an airborne activity problem. In addition, for D&D projects there is no guaranteed ability to process liquid waste such as in the Savannah River Site (SRS) 321-M facility. Any liquid wastes would have to be collected and transported to another location for processing. Consequently, it is important to eliminate such wastes or keep them to a minimum. Therefore, there is a consequent need for a technology to remove surface contamination without producing liquid secondary waste.

### *How It Works*

Applied over a contaminated surface, ALARA™ 1146 attracts and binds surface contaminants. The coating migrates into the micro-voids of the surface to contact contaminants. Upon cure, the product mechanically locks the contaminants into a polymer matrix. Removal of the film decontaminates the

substrate and produces a solid waste.

### *Potential Markets*

ALARA™ 1146 is well-suited to any decontamination project where the objective is to remove surface contamination including radionuclides, dirt, PCBs, asbestos particles, and loose paint. Typical applications are for bare and painted concrete, wood, carbon steel, stainless steel, plastic, and insulation. It is best for projects where the generation of liquid wastes is not desirable.

### *Advantages Over the Baseline*

The baseline technology for the 321-M Deactivation Project is the Kelly Decontamination System. This system uses superheated pressurized water to remove contaminants from floors and walls. The spray head incorporates a shrouded vacuum pickup to remove water and contaminants from the surface being cleaned. The ALARA™ 1146 strippable coating reduces or eliminates the quantity of liquid waste as compared to the baseline technology.

## Demonstration Summary

This report covers the period of May 11 – May 18, 1999, when the ALARA™ 1146 strippable coating was demonstrated as part of the Savannah River Site Large-Scale Demonstration and Deployment Project (LSDDP).

The purpose of the demonstration was to evaluate the effectiveness, efficiency, and cost of the ALARA™ 1146 strippable coating as an alternative to the baseline Kelly Decontamination System for the removal of surface contamination from metal and concrete facilities. Radiological surveys, for transferable contamination, were performed both before the strippable coating was applied and after the coating was removed. The purpose of these surveys was to determine the level of decontamination achieved by the ALARA™ 1146.

The primary participants in the conduct of the demonstration were Westinghouse Savannah River Company (WSRC) personnel. The vendor, Williams Power Corporation, provided the spray application equipment and operational direction. The United States Army Corps of Engineers (USACE) performed a cost analysis.

### *Demonstration Site Description*

The 321-M Fuel Fabrication Facility at SRS was built in the 1950s to manufacture fuel tubes for the SRS production reactors. The manufacturing involved precise weigh-out of aluminum and enriched uranium, melting them together into alloy, extruding the alloy into tubes, and various steps involving machining, welding, and chemical cleaning. As a consequence, about 9,000 square feet inside the facility have been contaminated with Highly Enriched Uranium (HEU). Contamination is present on floors and walls, on dust in the overheads, and on the surfaces of storage racks and carts used to move components around. It is also present on the outside surfaces of equipment enclosures and both inside and outside hoods and gloveboxes. The facility has no liquid waste processing system in service requiring all liquid waste to be collected and transported to a second facility for processing.

The demonstration of the ALARA™ 1146 strippable coating was performed in the following locations within the 321-M contaminated area:

- Machining Room – approximately 1100 square feet ($ft^2$) of wall space and 500 $ft^2$ of floor area.
- Log Storage Room – approximately 200 $ft^2$ of wall area.
- Casting Room Cooling Hut – approximately 500 $ft^2$ of wall, floor, and ceiling area.

The Machining Room and Log Storage Room walls are painted carbon steel, and the floors are concrete with an epoxy coating. The Casting Room Cooling Hut walls and ceiling are unpainted carbon steel, while the floor is concrete with an epoxy coating.

*Key Results*

The ALARA™ 1146 strippable coating was successfully demonstrated at the SRS 321-M facility with the following key results:

- The ALARA™ 1146 strippable coating successfully removed transferable (surface) contamination from multiple surfaces (metal and concrete) with an average decontamination factor for alpha contamination of 6.68 and an average percentage of alpha contamination removed of 85.0%. Beta contamination removed was an average DF of 5.55 and an average percentage removed of 82.0%.

- Although use of the ALARA™ 1146 resulted in significant reduction in overall contamination in the demonstration areas, transferable contamination levels in several localized spots remained above the criteria for unrestricted release. To release these areas, either additional applications of the ALARA™ 1146 strippable coating or use of another decontamination technology would be required.

- No observable increase in airborne contamination was noted during the ALARA™ 1146 demonstration.

- ALARA™ 1146 strippable coating was easily applied using spray paint equipment. The cured coating was also easy to remove, coming off in large pieces.

- A minimum of liquid waste was generated (approximately six gallons of water) during the demonstration, which was used to clean the spray equipment after use.

- The total costs of the comparative demonstrations are $7,539 (Innovative) and $11,582(baseline). The unit cost per SF including mobilization and demobilization is $4.85 versus $7.45. The Innovative Technology offers a 35% cost savings over the Baseline Technology.

*Regulatory Considerations*

There are no regulatory permits required to use the ALARA™ 1146 strippable coating.

*Commercial Availability*

ALARA™ 1146 is fully developed and commercially available from Williams Power Corporation. It has been used for over 15 years in the decontamination of reactor cavities worldwide.

*Future Plans*

The ALARA™ 1146 strippable coating will be used on future D&D projects at SRS both as a fixative and decontamination technology.

## Contacts

### Technical

Jeffrey Lee, Westinghouse Savannah River Company, (803) 725-0652; jeffreyw.lee@srs.gov
Cecil May, Savannah River Technology Center, (803) 725-5813; cecil.may@srs.gov
T. J. McNamara, Williams Power Company, (410) 620-3373; mcnamara@wmsgrpintl.com

### Management

Cecil May, Test Engineer, Savannah River Technology Center, (803) 725-5813; cecil.may@srs.gov
John Pierpoint, Project Manager, Westinghouse Savannah River Company, (803) 725-0649, john.pierpoint@srs.gov

Martin Salazar, U.S. Department of Energy, Savannah River Operations Office; (803) 557-3617; martin.salazar@srs.gov
George Mishra, U.S. Department of Energy, Savannah River Operations Office; (803)725-7239; george.mishra@srs.gov
John Duda, Federal Energy Technology Center, (304) 285-4217, jduda@fetc.doe.gov
The 321-M LSDDP Internet address is **http://www.srs.gov/general/srtech/lstd/index.htm**

**Licensing**

[No licensing or permitting activities were required to support this demonstration.]

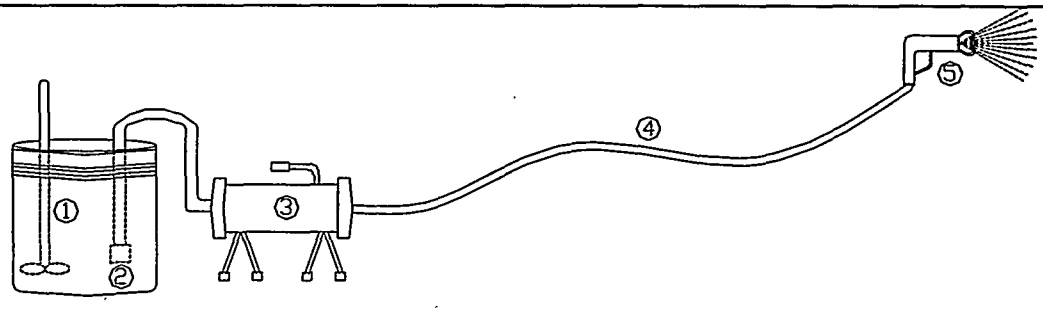
**Other**

All published Innovative Technology Summary Reports are available on the OST Web site at http://ost.em.doe.gov under "Publications." The Technology Management System, also available through the OST Web site, provides information about OST programs, technologies, and problems. The OST reference number for **ALARA™ 1146 Strippable Coating ® is 2314.**

# SECTION 2
# TECHNOLOGY DESCRIPTION

## Overall Process Definition

The ALARA™ 1146 strippable coating is a water-borne vinyl butyl, which can be sprayed, rolled, brushed, or pour squeegeed onto the surface to be decontaminated in the same manner as paint (see Figures 2 and 3). The vendor, however, recommends spray application for decontamination purposes. The coating is free of solvents and toxic materials. Applied over a contaminated surface, ALARA™ 1146 strippable coating migrates into micro-voids of the surface to contact and bind surface contaminants. Upon curing, the product mechanically locks the contaminants into a polymer matrix. Removal of the film decontaminates the surface and produces a solid waste. The ALARA™ 1146 can be applied to bare and painted concrete, wood, carbon and stainless steel, plastic, and insulation.




1. Mixer: Electric drill and stirrer used to mix the ALARA™ 1146 prior to and during application.
2. ALARA™ 1146: Container (1 or 5 gal) of liquid strippable coating.
3. Spray Equipment: Graco Ultra Plus 1500 Electric Airless Spray Applicator. Both the strippable coating and the spray applicator remained in an uncontaminated area during the demonstration.
4. Hose: 100 ft of ¼-in. diameter sleeved in plastic to prevent contamination. Spray Gun: Graco Silver Plus Airless
5. Spray Gun, 0.517 in. reversible tip. Held 10 – 12 inches (in.) from surface.

**Figure 2. Process diagram of ALARA™ 1146 application.**

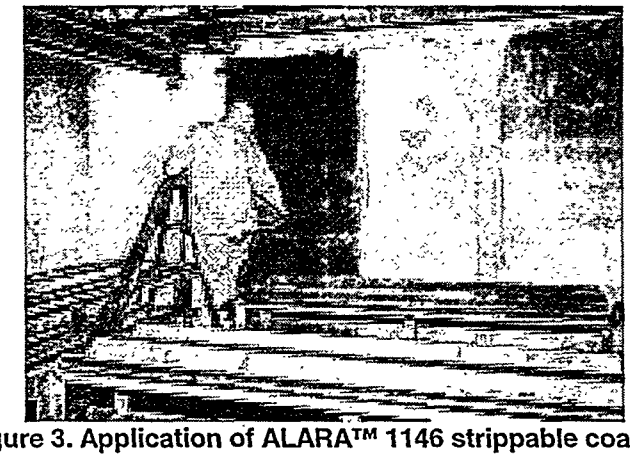


**Figure 3. Application of ALARA™ 1146 strippable coating.**

The baseline approach to removing surface contamination from the 321-M Deactivation Project at SRS is the use of the Kelly Decontamination System (Figure 4). This technology uses superheated pressurized water to remove contaminants from floors and walls. The superheated water flashes to steam when it impacts the surface of the debris. The hood of the steam/vacuum cleaning head traps and collects dislodged contaminants, steam, and water droplets. The waste stream passes through a liquid separator, a demister, and a high efficiency particulate air (HEPA) filter that removes contaminants and discharges clean air to the atmosphere.

**Figure 4. Photos of the Kelly Decontamination SVC System.**
(photographs copied from the *Steam Cleaning Technology* ITSR [redacted])

For D&D projects, there is no guaranteed ability to process liquid waste, as in the 321-M facility at SRS. Therefore, the contaminated liquid waste generated by the Kelly Decontamination System must then be collected and transported to a second SRS facility for processing. The ALARA™ 1146 strippable coating was selected for demonstration at SRS because the coating constitutes a solid waste, making disposal easier.

## System Operation

An airless spray system with the following specifications is recommended for applying the ALARA™ 1146 strippable coating:

| | |
|---|---|
| Pump Ratio: | 30:1 (minimum) |
| GPM Output: | 3.0 (minimum) |
| Hose: | 3/8 – 1/5 in. ID |
| Tip Size: | 0.021 – 0.025 in. |
| Output psi: | 1800 – 2300 |
| Electrical: | 110 volts |

Table 1 summarizes the operational parameters and conditions of the ALARA™ 1146 strippable coating during the SRS demonstration.

**Table 1. Operational parameters for ALARA™ 1146**

| Equipment Specifications and Operational Parameters | |
|---|---|
| Surface preparation | None required |
| Application conditions<br>Normal<br>Minimum<br>Maximum | <br>70°F (21°C) at 50% RH<br>40°F (4°C) at 10% RH<br>90°F (32°C) at 85% RH |
| Recommended thickness<br>Wet film<br>Dry film | <br>45 – 50 mils (1125 – 1250 microns)<br>20 – 30 mils (500 – 750 microns) |
| Application equipment used for the demonstration | Graco Ultra Plus 1500 Electric Airless Sprayer<br>Graco Silver Plus Airless Spray Gun, 0.517 Reversible Tip<br>Two 50-ft, ¼-in. diameter hoses<br>Electrix mixer |
| Application instructions | Hold spray gun perpendicular to surface and approximately 10 – 12 in. from surface. Move spray gun slowly (10 – 15 in./sec) across area. |
| Percentage overlap each pass | 50% |
| Theoretical coverage<br>(25 mils (625 microns) thickness) | 26 $ft^2$/gal<br>(0.6 $m^2$/l) |
| Number of gallons of ALARA™ 1146 used for the demonstration | 70 |
| Drying times [a]<br>Set to touch<br>Foot traffic<br>Removal | <br>9 h<br>18 h<br>24 h |
| **Manpower Skills and Training Requirements** | |
| Work crew | Two to three full-time mechanics |
| Specialized skills | None required |
| Training | The vendor supplied training to the mechanics on the operation of the Graco airless spray applicator. |
| **Potential Operational Concerns** | |
| Operating | During spraying, the spray gun tip can get clogged and would have to be taken apart and cleaned. The use of a reversible tip minimizes this concern. |
| Safety/health | Airline respirators are recommended by the vendor to prevent inhalation of over-spray.<br>Full-face respirators were required by SRS due to possible airborne contamination while spraying. |
| Environmental | Potential release of airborne radionuclides during strippable coating application |

[a] Based on 25 mils (625 microns) at 75°F (25°C) and 75% relative humidity (RH).

# SECTION 3
# PERFORMANCE

## Demonstration Plan

### Demonstration Site Description

The demonstration of the ALARA™ 1146 was conducted according to the approved Westinghouse Savannah River Company, 321-M Large-Scale Demonstration and Deployment Project Demonstration Test Plan, *ALARA™ 1146 Cavity Decon Strippable Coating*. The demonstration of the innovative technology was performed at the 321-M Fuel Fabrication Facility at SRS. This facility was built in the 1950s to manufacture fuel tubes for the SRS production reactors. The facility covers approximately 62,000 $ft^2$ and contains casting, forging, extruding, and machining equipment that were used to produce uranium-aluminum fuel tubes. Approximately 9,000 $ft^2$ inside the facility have been contaminated with HEU.

### Demonstration Objectives

The principal goal of the demonstration was to establish whether the ALARA™ 1146 strippable coating could safely and effectively remove loose contamination from various materials and surfaces, and to compare the performance and cost to the baseline technology. This determination would be based on the strippable coating's ability to achieve the following objectives:

- Reduced generation of liquid waste relative to the baseline technology
- Ability to remove surface contamination from multiple surfaces and materials
- Ease of application and removal.

### Demonstration Boundaries

The ALARA™ 1146 strippable coating was demonstrated on painted and unpainted carbon steel and epoxy coated concrete. The coating is also capable of decontaminating other materials such as wood, plastic, and insulation; however, these other materials were not demonstrated. The ALARA™ 1146 can also be used to protect clean surfaces from becoming contaminated and can be left in place over long periods of time. These capabilities were also not demonstrated during this demonstration.

## Results

The following table describes the areas in the 321-M facility that were included in the ALARA™ 1146 demonstration:

**Table 2. Demonstration areas and materials**

| Area | Painted Carbon Steel Walls | Epoxy Coated Concrete Floors | Unpainted Carbon Steel Walls and Ceiling |
|---|---|---|---|
| Machining Room | 878 $ft^2$ | 330 $ft^2$ | --- |
| Log Storage Room (south and west walls) | 132 $ft^2$ | -- | --- |
| Casting Room Cooling Hut (inside hut – includes racks and/or shelves) | 250 $ft^2$ | 525 $ft^2$ | 730 $ft^2$ |

The ALARA™ 1146 successfully demonstrated its ability to safely and effectively remove surface contamination from metal and concrete surfaces. Table 3 summarizes the decontamination results from the demonstration. Individual decontamination results can be found in Appendix B.

**Table 3. Decontamination summary for ALARA™ 1146 by material**

| Material | Transferable alpha (•) contamination | | Transferable beta/gamma (•/•) contamination | |
|---|---|---|---|---|
| | Avg. DF [a] | Percent Removed [b] | Avg. DF | Percent Removed |
| Painted carbon steel | 5.06 | 80.2 | 9.00 | 88.9 |
| Unpainted carbon steel | 8.32 | 88.0 | 4.75 | 78.9 |
| Painted Equipment | 20.36 | 95.1 | 6.90 | 85.5 |
| Epoxy coated concrete | 6.25 | 84.0 | 3.00 | 66.7 |
| **Total for all surfaces [c]** | **6.68** | **85.0** | **5.55** | **82.0** |

[a] Decontamination factors (DF) = initial contamination/final contamination. Contamination results were reported in dpm/100 $cm^2$.
[b] Percent contamination removed = 100 * (1-1/DF)
[c] DFs were not measured for the baseline (Kelly Decontamination System). However, discussions with field personnel experienced with the Kelly indicate comparable DFs can be expected.

Contamination decreased from an average transferable alpha contamination level of 2,044 dpm/100 $cm^2$ with a maximum level of 60,000 dpm/100 $cm^2$ to an average of 417 dpm/100 $cm^2$ with a maximum contamination level of 10,000 dpm/100 $cm^2$. In over one-third of all survey locations, the alpha transferable contamination levels were reduced to less than the survey instrument's Minimum Detectable Activity (MDA). Beta transferable contamination was decreased from an average level of 5,162 dpm/100 $cm^2$ with a maximum level of 40,000 dpm/100 $cm^2$ to an average of 1,384 dpm/100 $cm^2$ with a maximum contamination level of 12,000 dpm/100 $cm^2$ beta. In over two-thirds of all survey locations, the beta transferable contamination levels were reduced to less than the survey instrument's MDA. This decrease in contamination levels, however, did not result in a change in radiological postings in the demonstration area. Additional applications of the ALARA™ 1146 strippable coating or the use of a different decontamination technology would be required to achieve unrestricted release in these areas.

Table 4 compares the key performance indicators of the baseline and innovative technologies that were assessed during the demonstration.

**Table 4. Comparison of key performance indicators of cleaning technologies**

| | Kelly Decontamination System (baseline)[a] | ALARA™ 1146 Strippable Coating (innovative) |
|---|---|---|
| Total area included in demonstration | 264.51 $ft^2$ | 2845 $ft^2$<br>1550 $ft^2$ removed, remaining left in place as a fixative |
| Work surfaces | Segmented tank flats. | Epoxy coated concrete floor, painted and unpainted metal wall and ceiling. Also some metal equipment. |
| Required personnel | Three person crew<br>Single full-time HP | Three person crew<br>Single ¼-time HP |
| Set-up time (man hrs) | 20 (equipment prep only)[b]<br>41 (includes training and mobilization) | 2 |

[a] Data taken from ITSR, *Steam Vacuum Cleaning Technology* for the short wall cleaning tool only.
[b] Data collected from use at SRS.

| | Kelly Decontamination System (baseline)[a] | ALARA™ 1146 Strippable Coating (innovative) |
|---|---|---|
| Productivity ($ft^2$/man-h[c]) | 135.6 | 186.6 (application)<br>465.0 (removal)<br>133.1 (overall productivity) |
| Total volume cleaning media used during demonstration | 91.18 gal water | 70 gal strippable coating<br>(14 five-gallon buckets) |
| Water usage (gal/$ft^2$) | 0.34 | 0.003 |
| Utilities | Vacuum pump: 480V, 15A, 3 phase<br>Control Unit: 480V, 60A, 3 phase<br>Separator: 110V, 6A, single phase<br>Water: 30-40 psig at 3 gal/min | Spray applicator: 110V |
| Primary waste generated | Contaminated liquid waste | Contaminated solid waste |
| Secondary waste generated | Vacuum hoses<br>HEPA filter<br>Disposable PPE | Plastic sleeving for hose<br>Empty ALARA™ 1146 buckets<br>Rags (for cleanup of equipment)<br>Spray gun (contaminated)<br>Disposable PPE |
| Radiological survey of primary waste stream | Not measured | Highest survey reading of cured coating as removed from surfaces (as gross contamination)<br>20,000 • dpm/100 $cm^2$<br>30,000 • /• dpm/100 $cm^2$ |
| Airborne contamination | Virtually eliminated when the system is used with the steam/vacuum cleaning heads. | Job specific air samples were collected every 15 min. during coating removal. No observable increase in airborne contamination was noted. |

[c] Includes only actual time in cleaning debris (Kelly) or applying and removing coating (ALARA™). Does not include preparing for or decontaminating equipment or demonstrated surfaces.

# SECTION 4
# TECHNOLOGY APPLICABILITY AND ALTERNATIVES

## Competing Technologies

The baseline technology that competes with the ALARA™ 1146 strippable coating is the Kelly Decontamination System. The baseline technology produces a large amount of liquid waste that must be contained and transported to a second facility at SRS for processing. The strippable coating produces a minimal amount of liquid waste, and the solid waste generated is easier for disposal.

The other competing approach is manual wiping and cleaning. The advantage of this approach is the lower cost than other competing technologies. However, the disadvantages to manual wipe and clean are the increased exposure of personnel to contamination and the potential of re-contaminating or smearing the contamination along the surface due to improper technique. The use of the ALARA™ 1146 strippable coating allows D&D personnel to minimize exposure by fast application and the fact that the transferable contamination is locked within the coating during removal of the strippable coating. In addition, fewer personnel would need to be involved to decontaminate a large area using the strippable coating versus manual cleaning.

## Technology Applicability

The ALARA™ 1146 strippable coating is a fully mature and commercially available technology designed for the decontamination of surfaces, which have transferable (non-fixed) contamination. Although the ALARA™ 1146 was demonstrated at SRS mostly on large flat surfaces (walls, floors, etc.), the coating has also been proved effective in decontaminating components such as glove boxes, hand tools, casks, reactor headstands, reactor coolant pumps, reactor vessel studs, and underwater lights.

There are two versions of the ALARA™ 1146 strippable coating product.

**Cavity Decon Yellow.** Manufactured in compliance with ANSI N101.4 and ASTM D3843, this coating is typically used in reactor cavity decontamination during outages.

**Strippable Blue.** This coating is manufactured for non-reactor cavity decontamination activities where product certification is not required. *The formulations are the same, however, this product was not certified for compliance with ANSI and ASTM.*

Other potential DOE or commercial nuclear applications include the use of the ALARA™ 1146 strippable coating to protect clean surfaces so that they will not become contaminated. It can be used to cover clean equipment and scaffolding prior to use in a contaminated area. This coating can also be used to lock down or fix contamination on surfaces for long periods of time. Previous assessments performed at both SRS and Florida International University has shown the ALARA™ 1146 strippable coating to be both durable and easy to remove after long periods (i.e., 180 days).

## Patents/Commercialization/Sponsor

ALARA™ 1146 strippable coatings are manufactured by Carboline® of St. Louis, Missouri. Williams Power Corporation is the exclusive vendor of the ALARA™ 1146 product, from which it can be purchased. The product is protected in the United States under patents and trademarks. No permits were required to demonstrate the ALARA™ 1146 strippable coating at SRS.

# SECTION 5
# COST

## Methodology

This cost analysis compares the innovative ALARA 1146 Strippable Coating Technology with the baseline Kelly Steam Vacuum Technology. These two comparable technologies remove surface contamination. The Strippable Coating technology was demonstrated at the DOE-Savannah River Site (SRS) and the Kelly technology was evaluated using recorded data in the Innovative Technology Summary Report, Steam Vacuum Cleaning Technology, OST Reference #1780. Only applicable portions of the report were used. Specifically, those identifying capital equipment cost, performance data for the short wall cleaning tool, and equipment cleanup.

The Kelly Steam Vacuum Technology demonstration was done at Fernald Environmental Management Project-Building 1A, Fernald Ohio. This innovative technology uses a coating material that is sprayed onto a surface, allowed to dry for 24 hours and then manually peeled off. The sprayed material encapsulates the surface debris and pulls up the surface contamination when peeled off. The film layer is then treated as contaminated waste. The baseline technology uses the kinetic energy of pressurized superheated water to remove contamination from surface debris. The superheated water flashes to steam when it contacts the surface. This process takes place under a vacuum hood. The recovered steam and water are processed through a HEPA filter and only clean air is discharged into the atmosphere.

The cost analysis was based on recorded data performance of both innovative and baseline technologies. This analysis strives to develop realistic estimates that represent actual inactivation work within the SRS. The site demonstration of the innovative technology was based on the strippable coating material being applied to and removed from 1,555 SF of surface. The data was collected on site during the Large Scale Demonstration Project (LSDP) at building 321-M. Descriptions contained in later portions of this analysis detail changes to the observed data.

The cost analysis compares the two decontamination technologies: ALARA 1146 Strippable Coating Technology and a conventional decontamination method using the Kelly Steam Vacuum system. Cost and performance data were collected for each technology during their respective demonstrations. The following cost elements were identified from the Hazardous, Toxic and Radioactive Waste Remedial Action Work Breakdown Structure (WBS) and Data Dictionary (HTRW RA WBS), US Army Corps of Engineers. Data was collected to support a cost analysis based on those elements:

- mobilization
- decontamination
- waste disposal
- demobilization
- personal protective equipment

Mobilization costs include transporting the technology equipment to the demonstration site, installation of temporary work areas, and installation of temporary utilities.

Decontamination includes all direct and indirect activities associated with performing decontamination/cleaning work, equipment repositioning, and troubleshooting.

Waste disposal includes both solid and liquid waste. The baseline generates contaminated liquid waste and the innovative technology generates a solid waste. Cost for disposal of the two waste types is based on current cost at SRS. Solid waste is disposed at $106 per cubic foot. Liquid waste is disposed at an average cost of $1.83 per gallon with an additional $1,000 sampling/testing fee.

Demobilization includes removal of temporary work areas and utilities equipment decontamination and removal of the technology equipment from the site.

Personal Protective Equipment (PPE) costs are included in this demonstration. A total of eight sets of PPE's were used for the demonstration. After application, the material is applied one day and allowed to

dry 24 hours before removal. One set of PPE's per person is required per day for the two-day process. PPE's requirements for the two technologies are the same.

## Cost Analysis

Data were collected during the demonstrations for the cost elements. Work was measured and unit costs determined on the basis of square feet of surface cleaned per hour. For each element, detailed costs were determined from the data collected. For labor-intensive activities, a production rate was calculated from the performance data. Both of the technologies are similar in labor effort. Both use handheld equipment with three-man labor crews.

Labor rates used in the Innovative Technology analysis were those in effect for the SRS site labor agreement. The analysis for the Baseline Technology (Kelly Steam Cleaner) uses the unit cost information extracted from the provided report (OST Ref.# 1780). Cost for mobilization, demobilization, and waste disposal was provided by SRS. Crews for the various activities were based on the recorded data in the Kelly Steam Report and labor rates were adjusted to SRS site labor rates, to give an accurate cost comparison. Indirect costs were omitted from the analysis, since overhead rates can vary greatly between contractors. Engineering, quality assurance, administrative costs, and taxes were also omitted from the analysis. Adding site-specific indirect costs to produce a site-specific unit cost that includes indirect costs can modify the bare unit costs determined by the analysis.

Capital equipment costs for the Innovative and Baseline technologies are based on the cost of ownership. The cost of the spray applicator for the Strippable Coating is $4,950.00 with a useful life of five to 10 years. This report will assume a five-year useful life since maintenance cost is not considered. No information was collected to determine the projected time of use per year. The following assumptions are made to assign equipment cost dollar figures to the project: 1) expected useful life of the new technology equipment is five-years; 2) equipment is operated eight hours per day, five days a week for 26 weeks a year. The material cost for the strippable coating is $96.00 per gallon. The recorded application data is .025 gallons per SF. Based on these assumptions, the extended equipment cost per hour of operation would be approximately $ 0.95. The Baseline technology equipment has a capital cost of $194,000.00 and an estimated useful life of 15 years. The baseline equipment is estimated to be shared with numerous projects and used 50 weeks per year. The average hourly equipment cost is estimated to be $6.46.

The unit production rate for application of the strippable coating is averaged for the demonstration area applied. Approximately 2,845 SF of ALARA 1146 strippable coating were applied during the demonstration, however, not all of this was removed but was left on as a fixative. Since only 1,555 SF were stripped during the demonstration, the unit production rate was used to create the cost summary data sheet, which is based on a job size of 1,555 SF. The Baseline Technology was also based on unit production rates. The baseline is based on 264 SF of similar work recorded in the Kelly Report. The unit rate is used to create the Baseline Cost Summary spread sheet, which is projected on 1,555 SF. For fixed cost elements (independent of the quantity of decontamination work), costs were calculated as lump sum costs instead of unit costs. Unit cost elements (dependent on the quantity of decontamination work) were based on the quantity of decontamination performed.

A comparison of the major cost elements is shown in Table 4. The mobilization and demobilization cost are not included in the summary unit costs and the units are expressed in SF/Hr.

**Table 4 Summary Unit Cost Comparison**

| Strippable Coating (Innovative) | | | Kelly Steam Vacuum System (Baseline) | | |
|---|---|---|---|---|---|
| Cost Element | Unit Cost | Production Rate | Cost Element | Unit Cost | Production Rate |
| Decontamination and Waste Disposal | $4.75/SF | 133.1 SF/Hr | Decontamination and Waste Disposal | $7.07/SF | 135.6 SF/Hr |

## Cost Comparison

Figure 1 is a cost comparison for the Innovative and Baseline Technologies. Both technologies are based on the purchase of the equipment. The cost of the capital investment will differ somewhat in each of the two technologies. The Innovative technology is specialized and its use is estimated to be lower than the baseline technology. The estimated cost for both technologies are spread over their useful life.

The cost of performing the decontamination work was found to be lower, on average, in the Innovative Technology, independent of mobilization and demobilization cost. The equipment cost varies greatly between the two technologies with an approximate cost difference of $189,000.00. The life spans are comparable, five to 10 years for the innovative equipment and 15 years for the baseline equipment. There is no break-even point for this comparison. The innovative technology is less expensive, independent of the quantity/job size. The innovative equipment is easier to mobilize. It does not require a water source to operate and it is not internally contaminated as it is operated. The baseline steam cleaning/vacuum equipment recycles the cleaning liquid and is labor intensive to decontaminate/clear from the controlled area. On the other hand, the innovative equipment required only flushing with clean water and is easily cleared from the controlled area.

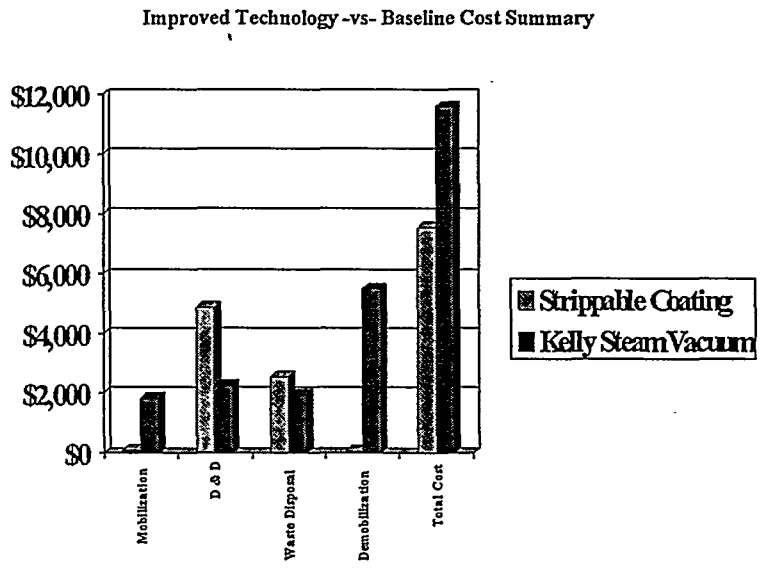



**Figure 1. Estimated Cost Summary**

## Cost Conclusions

The Strippable Coating Technology offers cost savings over the Baseline Technology. The total costs of the comparative demonstrations are $7,539 (Innovative) and $11,582(baseline). The unit cost per SF including mobilization and demobilization is $4.85 versus $7.45. The Innovative Technology offers a 35% cost savings over the Baseline Technology.

# SECTION 6
# REGULATORY AND POLICY ISSUES

## Regulatory Considerations

Although there were no site–specific regulatory or permitting issues concerning the ALARA™ 1146 demonstration at SRS, the following general safety and health regulations should be considered in applying the ALARA™ 1146 strippable coating by spray applicator:

Occupational Safety and Health Administration (OSHA) 29 Code of Federal Regulations (CFR) 1910

| | |
|---|---|
| 1910.94 | Ventilation |
| 1910.134 | Respiratory protection |
| 1910.269 | Electric power generation, transmission, and distribution |

**OSHA 29 CFR 1926**

| | |
|---|---|
| 1926.57 | Ventilation |
| 1926.103 | Respiratory protection |
| 1926.302 | Power-operated hand tools |

There are no Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or other regulatory considerations related to this technology.

## Safety, Risks, Benefits, and Community Reaction

The application of the ALARA™ 1146 strippable coating can pose a health hazard to workers by the inhalation of overspray. Therefore, the vendor recommends the use of fresh airline respirators during spray application of their product. On the positive side, the use of the ALARA™ 1146 substantially reduces levels of surface contamination and reduces the worker exposure to these health hazards.

The main benefit of the ALARA™ 1146 strippable coating is that the waste product is disposed of as a solid waste, thus minimizing liquid waste that cannot be processed at the facility being deactivated. A further benefit is that the ALARA™ 1146 entraps contaminants in the matrix of the solid waste, eliminating the chance that the contaminants could become airborne during the handling and packaging of the waste material.

The use of the ALARA™ 1146 strippable coating instead of the Kelly Decontamination System should have no potential socioeconomic impacts. The community perspective would likely be positive since it eliminates the chance for spills due to transporting contaminated liquid waste from the facility being deactivated to a second facility for processing.

# SECTION 7
# LESSONS LEARNED

## Implementation Considerations

The ALARA™ 1146 strippable coating is a fully developed and commercially available technology. The product can be purchased in one-gallon and five-gallon containers and can be stored for up to one year.

The following items should be considered when selecting the ALARA™ 1146 as a decontamination or fixative technology:

- While the product is easily applied by standard spray paint equipment, it tends to run down vertical surfaces if applied too thick. Several thinner coats are recommended.
- Manufacturer recommends the spray method of application for best performance. The force of the spray assists the coating in migrating into the surface micro-voids.
- Use an airless spray pump that meets the minimum requirements listed in Section 3. A pump capable of operating without undue stress during a work shift will assure maximum efficiency.
- Thoroughly mix the strippable coating product with an electric mixer prior to spray application. Strain the coating using a fine wire screen or paint strainer to remove partially dried particles and lumps.
- Routinely clean the pump filter during the work shift to remove any collection of partially dried particles.

## Technology Limitations and Needs for Future Development

The ALARA™ 1146 strippable coating would benefit from the following design improvements:

- A faster drying time than 24 hours would significantly improve worker productivity.

## Technology Selection Considerations

The ALARA™ 1146 strippable coating is an effective product for the removal of surface contamination. The use of strippable coatings is especially applicable for facilities with a need to minimize the amount of liquid waste generated during decontamination activities.

# APPENDIX A
# REFERENCES


Hemispheric Center for Environmental Technology. 1999. *Assessment of Strippable Coatings for Decontamination and Decommissioning, Final Report.* Prepared for the U.S. Department of Energy, January.

U.S. Army Corps of Engineers (USACE). 1996. *Hazardous, Toxic, and Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary.* Washington, D.C.: USACE.

U.S. Army Corps of Engineers (USACE). 1995. *Construction Equipment ownership and Operating Expense Schedule, Region II.*Washington, D.C.: USACE, August.

Fernald Large-Scale Demonstration Project. 1999. *Steam Vacuum Cleaning Technology.* DOE/EM-0416, Prepared for the Department of Energy, May.

Westinghouse Savannah River Company. 1999. *321-M Large Scale Demonstration and Deployment Project, Demonstration Test Plan, ALARA™ 1146 Cavity Decon Strippable Coating,* May.

# APPENDIX B
# RADIOLOGICAL DATA

This Appendix provides additional details concerning the radiological surveys performed both prior to and after the demonstration of the ALARA™ 1146 strippable coating.

| | | Transferable • Contamination dpm/100 cm² | | | | Transferable • /• Contamination dpm/100 cm² | | | |
|---|---|---|---|---|---|---|---|---|---|
| Surface | Survey Point | Before | After | DF[a] | Percent Removed[b] | Before | After | DF | Percent Removed |
| Log Storage Room | | | | | | | | | |
| Wall | 120 | 36 | <20[c] | 1.80 | | <200 | <200 | - | |
| Wall | 121 | 47 | 25 | 1.88 | | <200 | <200 | - | |
| Wall | 122 | 20 | <20 | - | | <1,000 | <200 | - | |
| Wall | 123 | 400 | 37 | 10.81 | | <200 | <200 | - | |
| Wall | 124 | <20 | <20 | - | | <200 | <200 | - | |
| Wall | 125 | <20 | <20 | - | | <200 | <200 | - | |
| **Avg. for painted carbon steel** | | | | **3.87** | **74.2** | | | **NA** | **NA** |
| Machining Room | | | | | | | | | |
| Wall | 1 | 24 | <20 | 1.20 | | <200 | <200 | - | |
| Wall | 2 | 82 | 63 | 1.30 | | <200 | <200 | - | |
| Wall | 3 | 156 | 69 | 2.26 | | <200 | <200 | - | |
| Wall | 4 | 82 | 87 | - | | <200 | <200 | - | |
| Wall | 5 | 55 | <20 | 2.75 | | <200 | <200 | - | |
| Wall | 6 | 165 | 41 | 4.02 | | <200 | <200 | - | |
| Wall | 7 | 48 | 28 | 1.71 | | <200 | <200 | - | |
| Wall | 8 | 98 | 20 | 4.90 | | <200 | <200 | - | |
| Wall | 9 | 31 | 41 | - | | <200 | <200 | - | |
| Wall | 10 | 70 | <20 | 3.50 | | <200 | <200 | - | |
| Wall | 11 | 40 | <20 | 2.00 | | <200 | <200 | - | |
| Wall | 12 | 42 | <20 | 2.10 | | <200 | <200 | - | |
| Wall | 13 | 39 | <20 | 1.95 | | <200 | <200 | - | |
| Wall | 14 | 26 | <20 | 1.30 | | <200 | <200 | - | |
| Wall | 15 | 20 | <20 | - | | <200 | <200 | - | |
| Wall | 16 | 31 | <20 | 1.55 | | <200 | <200 | - | |
| Wall | 17 | 107 | <20 | 5.35 | | <200 | <200 | - | |
| Wall | 18 | 300 | 36 | 8.33 | | <1,000 | <200 | - | |
| Wall | 19 | 38 | <20 | 1.90 | | <200 | <200 | - | |
| Wall | 20 | 139 | 32 | 4.34 | | <200 | <200 | - | |
| Wall | 21 | 68 | <20 | 3.40 | | <200 | <200 | - | |
| Wall | 22 | 50 | <20 | 2.50 | | <200 | <200 | - | |
| Wall | 23 | 52 | 37 | 1.41 | | <200 | <200 | - | |
| Wall | 24 | <20 | <20 | - | | <200 | <200 | - | |
| Wall | 25 | 20 | 21 | - | | <200 | <200 | - | |
| Wall | 26 | 20 | <20 | - | | <200 | <200 | - | |
| Wall | 27 | <20 | 23 | - | | <200 | <200 | - | |
| Wall | 28 | <20 | 35 | - | | <200 | <200 | - | |

[a] Decontamination Factor (DF) = initial contamination/final contamination
[b] Percent (%) contamination recovered = (initial – final)/initial * 100
[c] Less than values were treated as absolute value of number in calculations.

| | | Transferable Contamination dpm/100 cm$^2$ | | | | Transferable Contamination dpm/100 cm$^2$ | | | |
|---|---|---|---|---|---|---|---|---|---|
| Surface | Survey Point | Before | After | DF[a] | Percent Removed[b] | Before | After | DF | Percent Removed |
| Wall | 29 | <20 | <20 | - | | <200 | <200 | - | |
| Wall | 30 | 132 | <20 | 6.60 | | <200 | <200 | - | |
| Wall | 31 | 77 | <20 | 3.85 | | <200 | <200 | - | |
| Wall | 32 | 70 | 30 | 2.33 | | <200 | <200 | - | |
| Wall | 33 | <20 | <20 | - | | <200 | <200 | - | |
| Wall | 34 | <20 | 25 | - | | <200 | <200 | - | |
| Wall | 35 | 26 | 400 | - | | <200 | 1,000 | - | |
| Wall | 36 | 400 | 32 | 12.50 | | 1,000 | <200 | 5.00 | |
| Wall | 37 | 98 | 35 | 2.80 | | <200 | 1,000 | - | |
| Wall | 38 | 1,400 | 800 | 1.75 | | 2,000 | <200 | 10.00 | |
| Wall | 39 | 123 | <20 | 6.15 | | <200 | <200 | - | |
| Wall | 40 | 61 | 30 | 2.03 | | <200 | <200 | - | |
| Wall | 41 | 52 | 43 | 1.21 | | <200 | <200 | - | |
| Wall | 42 | 38 | <20 | 1.90 | | <200 | <200 | - | |
| Wall | 43 | 54 | 30 | 1.80 | | <200 | <200 | - | |
| Wall | 44 | 93 | 28 | 3.32 | | <200 | <200 | - | |
| Wall | 45 | 227 | 62 | 3.66 | | <200 | <200 | - | |
| Wall | 46 | 107 | 64 | 1.67 | | <200 | <200 | - | |
| Wall | 47 | 800 | 172 | 4.65 | | <1,000 | <200 | - | |
| Wall | 48 | 208 | <20 | 10.40 | | <200 | <200 | - | |
| Wall | 49 | 64 | 103 | - | | <200 | <200 | - | |
| Wall | 50 | 77 | 41 | 1.88 | | <200 | <200 | - | |
| Wall | 51 | 75 | 32 | 2.34 | | <200 | <200 | - | |
| Wall | 52 | 139 | 202 | - | | <200 | <200 | - | |
| Wall | 53 | 22 | <20 | 1.10 | | <200 | <200 | - | |
| Wall | 54 | <20 | <20 | - | | <200 | <200 | - | |
| Wall | 55 | 23 | 138 | - | | <200 | <200 | - | |
| Wall | 56 | 68 | 2,000 | - | | <200 | 3,000 | - | |
| Wall | 58 | 296 | 25 | 11.84 | | <200 | <200 | - | |
| Wall | 59 | 200 | 39 | 5.13 | | 1,000 | <200 | 5.00 | |
| Wall | 60 | 151 | <20 | 7.55 | | <200 | <200 | - | |
| Wall | 63 | 400 | <20 | 20.00 | | <1,000 | <200 | - | |
| Wall | 64 | 123 | <20 | 6.15 | | <200 | <200 | - | |
| Wall | 65 | 20 | <20 | - | | <200 | <200 | - | |
| Wall | 66 | 178 | <20 | 8.90 | | <200 | <200 | - | |
| Wall | 67 | 339 | <20 | 16.95 | | <200 | <200 | - | |
| Wall | 68 | 41 | 55 | - | | <200 | <200 | - | |
| Wall | 69 | 1,200 | 20 | 60.00 | | 1,000 | <200 | 5.00 | |
| Wall | 70 | 236 | 28 | 8.43 | | <200 | <200 | - | |
| Wall | 71 | 72 | 36 | 2.00 | | <200 | <200 | - | |
| Wall | 72 | 118 | 36 | 3.28 | | <200 | <200 | - | |
| Wall | 73 | 600 | 25 | 24.00 | | <1,000 | <200 | - | |
| Wall | 74 | 45 | 27 | 1.67 | | <200 | <200 | - | |
| Wall | 75 | 45 | 21 | 2.14 | | <200 | <200 | - | |
| Wall | 76 | <20 | 30 | - | | <200 | <200 | - | |
| Wall | 77 | 70 | 25 | 2.80 | | <200 | <200 | - | |
| Wall | 78 | <20 | 30 | - | | <200 | <200 | - | |

| | | Transferable • Contamination dpm/100 cm$^2$ | | | | Transferable • /• Contamination dpm/100 cm$^2$ | | | |
|---|---|---|---|---|---|---|---|---|---|
| Surface | Survey Point | Before | After | DF[a] | Percent Removed[b] | Before | After | DF | Percent Removed |
| Wall | 79 | <20 | <20 | - | | <200 | <200 | - | |
| Wall | 80 | 52 | <20 | 2.60 | | <200 | <200 | - | |
| Wall | 81 | 22 | <20 | 1.10 | | <200 | <200 | - | |
| Wall | 82 | 58 | <20 | 2.90 | | <200 | <200 | - | |
| Wall | 83 | <20 | <20 | - | | <200 | <200 | - | |
| Wall | 84 | 59 | 25 | 2.36 | | <200 | <200 | - | |
| Wall | 85 | <20 | 25 | - | | <200 | <200 | - | |
| Wall | 86 | 20 | 32 | - | | <200 | <200 | - | |
| Wall | 87 | 49 | <20 | 2.45 | | <200 | <200 | - | |
| Wall | 88 | <20 | <20 | - | | <200 | <200 | - | |
| Wall | 89 | 43 | 23 | 1.87 | | <200 | <200 | - | |
| Wall | 90 | <20 | 28 | - | | <200 | <200 | - | |
| Wall | 91 | <20 | 21 | - | | <200 | <200 | - | |
| Wall | 92 | <20 | 32 | - | | <200 | <200 | - | |
| Wall | 93 | 50 | <20 | 2.50 | | <200 | <200 | - | |
| Wall | 94 | 50 | <20 | 2.50 | | <200 | <200 | - | |
| Wall | 95 | <20 | <20 | - | | <200 | <200 | - | |
| Wall | 96 | 43 | <20 | 2.15 | | <200 | <200 | - | |
| Wall | 97 | <20 | <20 | - | | <200 | <200 | - | |
| Wall | 98 | <20 | <20 | - | | <200 | <200 | - | |
| Wall | 99 | <20 | <20 | - | | <200 | <200 | - | |
| Wall | 100 | <20 | <20 | - | | <200 | <200 | - | |
| Wall | 101 | <20 | 35 | - | | <200 | <200 | - | |
| Wall | 102 | 31 | 21 | 1.48 | | <200 | <200 | - | |
| Wall | 103 | <20 | <20 | - | | <200 | <200 | - | |
| Wall | 104 | 151 | 30 | 5.03 | | <200 | <200 | - | |
| Wall | 105 | 68 | <20 | 3.40 | | <200 | <200 | - | |
| Wall | 106 | <20 | <20 | - | | <200 | <200 | - | |
| Wall | 107 | 20 | <20 | - | | <200 | <200 | - | |
| Wall | 108 | 144 | 21 | 6.86 | | 4,000 | <200 | 20.00 | |
| **Avg. for painted carbon steel wall** | | | | **5.13** | **80.5** | | | **9.00** | **88.9** |
| Lathe-Bottom | 56A | 6,000 | 1,000 | 6.00 | | 5,000 | 2,000 | 2.50 | |
| Lathe-Top | 57 | 2,400 | 23 | 104.35 | | 3,000 | <200 | 15.00 | |
| Equipment | 61 | 98 | 181 | - | | <200 | <200 | - | |
| Equipment | 62 | 45 | 48 | - | | <200 | <200 | - | |
| Equipment | 116 | 1,400 | 1,000 | 1.40 | | 4,000 | 1,000 | 4.00 | |
| Equipment | 117 | 3,200 | 600 | 5.33 | | 5,000 | <1,000 | 5.00 | |
| Equipment | 118 | 6,600 | 2,000 | 3.30 | | 8,000 | 1,000 | 8.00 | |
| Equipment | 119 | 1,400 | 800 | 1.75 | | <200 | 1,000 | - | |
| **Avg. for painted carbon steel equipment** | | | | **20.36** | **95.1** | | | **6.90** | **85.5** |
| Floor | 109 | 4,800 | 600 | 8.00 | | 1,000 | <1,000 | - | |
| Floor | 110 | 3,000 | 400 | 7.50 | | <1,000 | <1,000 | - | |
| Floor | 111 | 3,000 | <200 | 15.00 | | 3,000 | <1,000 | 3.00 | |
| Floor | 112 | 2,800 | 400 | 7.00 | | 1,000 | <1,000 | - | |
| Floor | 113 | 1,800 | 400 | 4.50 | | 1,000 | <1,000 | - | |
| Floor | 114 | 1,400 | 400 | 3.50 | | 1,000 | <1,000 | - | |

| | | Transferable Contamination dpm/100 cm² | | | | Transferable Contamination dpm/100 cm² | | | |
|---|---|---|---|---|---|---|---|---|---|
| Surface | Survey Point | Before | After | DF[a] | Percent Removed[b] | Before | After | DF | Percent Removed |
| Floor | 115 | 1,800 | 200 | 9.00 | | 1,000 | <1,000 | - | |
| **Avg. for painted concrete floor** | | | | **7.79** | **87.2** | | | **3.00** | **66.7** |
| Casting Room Cooling Hut | | | | | | | | | |
| Wall | 1 | 4,000 | 2,000 | 2.00 | | 4,000 | 2,000 | 2.00 | |
| Wall | 2 | 4,000 | 600 | 6.67 | | 4,000 | <1,000 | 4.00 | |
| Wall | 3 | 4,000 | 500 | 8.00 | | 4,000 | <1,000 | 4.00 | |
| Wall | 4 | 4,000 | 600 | 6.67 | | 6,000 | <1,000 | 6.00 | |
| Wall | 5 | 6,000 | 800 | 7.50 | | 6,000 | <1,000 | 6.00 | |
| Ceiling | 6 | 6,000 | 200 | 30.00 | | 6,000 | <1,000 | 6.00 | |
| Wall | 7 | 6,000 | 400 | 15.00 | | 6,000 | <1,000 | 6.00 | |
| Wall | 8 | 2,000 | 1,000 | 2.00 | | 4,000 | 1,000 | 4.00 | |
| Wall | 9 | 4,000 | 2,000 | 2.00 | | 2,000 | 3,000 | - | |
| Ceiling | 10 | 12,000 | 1,000 | 12.00 | | 20,000 | 2,000 | 10.00 | |
| Wall | 11 | 4,000 | 1,000 | 4.00 | | 4,000 | <1,000 | 4.00 | |
| Ceiling | 12 | 2,000 | 2,000 | - | | 4,000 | 2,000 | 2.00 | |
| Wall | 13 | 2,000 | 600 | 3.33 | | 2,000 | <1,000 | 2.00 | |
| Wall | 14 | 8,000 | 1,000 | 8.00 | | 4,000 | <1,000 | 4.00 | |
| Wall | 15 | 8,000 | 400 | 20.00 | | 6,000 | <1,000 | 6.00 | |
| Wall | 16 | 10,000 | 3,000 | 3.33 | | 10,000 | 3,000 | 3.33 | |
| Wall | 17 | 10,000 | 2,000 | 5.00 | | 8,000 | <1,000 | 8.00 | |
| Wall | 22 | 60,000 | 10,000 | 6.00 | | 40,000 | 12,000 | 3.33 | |
| **Avg. for unpainted carbon steel** | | | | **8.32** | **88.0** | | | **4.75** | **78.9** |
| Floor | 18 | 5,000 | 800 | 6.25 | | 4,000 | <1,000 | 4.00 | |
| Floor | 19 | 3,000 | 1,000 | 3.00 | | 2,000 | <1,000 | 2.00 | |
| Floor | 20 | 4,000 | 2,000 | 2.00 | | <1,000 | 2,000 | - | |
| Floor | 21 | 6,000 | 2,000 | 3.00 | | 3,000 | 1,000 | 3.00 | |
| **Avg. for painted concrete floor** | | | | **3.56** | **71.9** | | | **3.00** | **66.7** |

[a] Decontamination Factor (DF) = initial contamination/final contamination
[b] Percent (%) contamination recovered = (initial – final)/initial * 100
[c] Less than values were treated as absolute value of number in calculations.

# APPENDIX C
# TECHNOLOGY COST COMPARISON

## Introduction

The analysis in this appendix strives to develop realistic estimates to compare costs between an innovative technology (Strippable Coating) and a baseline technology (Kelly Steam Vacuum Cleaner). The baseline utilizes super heated steam and vacuum combination equipment currently used for surface radiological decontamination at SRS. The innovative technology uses a sprayed on coating to encapsulate the surface contamination and removes the contamination when stripped.

The selected activities being analyzed comes from Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary (HTRW RA WBS), USACE, 1996. The HTRW RA WBS, developed by an interagency group, was used in this analysis to provide consistency with the established national standards.

Some costs are omitted from this analysis so that it is more realistically reflects a typical commercial application. The general and administrative (G&A) markup costs for the site contractor managing the demonstration 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 G&A rate to this analysis without having to first back out the rates used at SRS.

The following assumptions were used as the basis for the innovative technology cost analysis:

- Oversite, engineering, quality assurance, and some administrative cost for the demonstration were not included.
- As applicable, equipment hourly rates for innovative and baseline pieces of equipment reflect government ownership, and are based on general guidance contained in the Office of Management and Budget's (OMB) Circular No. A-94 for Cost Effectiveness Analysis.
- Equipment unit rates are determined based on information recorded in the ACOE data collection forms.
- Standard labor rates established by the Savannah River Site for estimating D&D work were used for the work performed by local crafts.
- The analysis expresses all work on an hourly basis.

## Mobilization (WBS 331.01)

Move Equipment into CA, Setup, Check and Test Equipment: SRS labor to move equipment into the CA, setup CA, and test equipment.

D&D Activity – Decontamination and Dismantling Activity (WBS 331.17)

Apply Coating: This activity includes mixing coating, operating sprayer, and spraying the strippable coating onto the contaminated areas.

Remove Coating: Labor to manually strip/peel off the applied coating and pack as contaminated waste.

Equipment Cleanup: Labor cost to clean filters, flush equipment with clean water, and general cleanup of equipment. Remove any disposable protective material from equipment.

Don/Removal of Personnel Protective Equipment, (PPE): Don and remove PPE's as required to perform work in a CA.

WASTE Disposal (WBS 331.18): Disposal of contaminated waste generated by the strippable coating.

Demobilization (WBS 331.21)

Remove Equipment from Radiological Areas: Labor to decontaminate, clear and remove equipment from CA.

The details of the cost analysis for the Innovative and baseline technologies are summarized in Table C-1 and C-2.

## Table C-1. Strippable Coating Cost Data

| Work Breakdown Structure (WBS) | Unit Cost (UC) | | | | | | Total Quanity (TQ) | Unit of Measure | Total Cost (TC) | Crew | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Labor | | Equipment | | Other | Total Unit Cost | | | | | |
| | Hrs | Rate | Hrs | Rate | | | | | | | |
| Moblization (WBS 33.01) | | | Subtotal | | | | | | $ 92.16 | | |
| Move Equip. into CA, Setup, Check and Test Equipment | 1 | $ 92.16 | | | | | 1 | Each | $ 92.16 | 2 Mechanics, 1 HP Tech.(1/4 time) | |
| Decontamination & Dismantling Activity (WBS 331.17 | | | Subtotal | | | | | | $ 4,848.58 | | |
| Apply Coating | 0.002 | $134.49 | 0.002 | $ 2.50 | $3,672.00 | $ 2.61 | 1555 | SF | $ 4,051.17 | 3 Mechanic , HP Tech.(1/4 time) | "Other" is Material Cost |
| Remove Coating | 0.0011 | $ 92.16 | | | | $ 0.10 | 1555 | SF | $ 153.34 | 2 Mechanic , HP Tech.(1/4 time) | |
| Equipment Cleanup | 1 | $ 84.66 | | | | | 1 | Each | $ 84.66 | 2 Mechanics | |
| Don/Removal of Personeal Protective Equipment, (PPE) | 1.6 | $134.49 | | | $ 129.04 | $ 279.70 | 2 | Day | $ 559.41 | 3 Mechanics & 1 HP Tech. | "Other" cost is PPE, $16.13/set. |
| Waste Disposal (WBS 331.18) | | | Subtotal | | | | | | $ 2,543.98 | | |
| Waste Disposal | | | | | | $ 1.64 | 1555 | SF | $ 2,543.98 | | |
| Demobliziation WBS 33.21 | | | Subtotal | | | | | | $ 54.25 | | |
| Remove Equipment from Radiological Areas | 0.75 | $ 72.33 | | | | | 1 | LS | $ 54.25 | 1 Mechanic &1 HP Tech. | |
| | | | | | | | | | | | |
| **Total Cost For The Demonstration** | | | | | | | | | $ 7,538.97 | | |

NOTES
1. TC = UC X TQ (where TC = total cost, UC = unit cost, and TQ = total quanity), LS = Lump Sum
2. Labor Rates are $42.33/hr for Mechanic, $30.00/hr for Health Protection (HP) Technician, Spray Equipment cost are $2.50/Hr.
3. Cost of shipping equipment is included in the Equipment Capital Cost.

## Table C-2. Kelly Steam/Vacuum Cleaner Data Obtained from Report #1780

| Work Breakdown Structure (WBS) | Unit Cost (UC) | | | | | | Total Quantity (TQ) | Unit of Measure | Total Cost (TC) | Crew | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Labor | | Equipment | | Other | Total Unit Cost | | | | | |
| | Hrs | Rate | Hrs | Rate | | | | | | | |
| Mobilization (WBS 33.01) | | | | | | Subtotal | | | $ 1,849.75 | | |
| Unload, Move Equip. into CA, Setup, Check and Test Equipment | 20 | $ 92.16 | 1 | $ 6.55 | | $ 1,849.75 | 1 | Each | $ 1,849.75 | 2 Mechanics, 1 Forklift, 1 HP Tech. (1/4 time) | |
| Decontamination & Dismantling Activity (WBS 331.17 | | | | | | Subtotal | | | $ 2,245.84 | | |
| Steam/Vacuum Cleaning | 0.0074 | $134.49 | 0.0074 | $ 6.46 | | $ 1.04 | 1555 | SF | $ 1,621.91 | 3 Mechanic , 1 HP Tech (1/4 time) | |
| Don/Removal of Personnel Protective Equipment, (PPE) | 1.6 | $134.49 | | | $ 193.56 | | 2 | Day | $ 623.93 | 3 Mechanic , 1 HP Tech | "Other Cost" are PPE's, 3 sets per worker and 4 workers required |
| Waste Disposal (WBS 331.18) | | | | | | Subtotal | | | $ 1,982.76 | | |
| Waste Disposal | | | | | $ 0.63 | $ 0.63 | 1555 | SF | $ 982.76 | | |
| Waste Sample Analysis (WBS 331.18.1) | | | | | | Subtotal | | | | | |
| Waste Sample Analysis | | | | | $1,000.00 | $ 1,000.00 | 1 | Each | $ 1,000.00 | | |
| Demobilization (WBS 331.21) | | | | | | Subtotal | | | $ 5,503.68 | | |
| Remove Equipement from Radiological Area | 48 | $114.66 | | | | | 1 | Each | $ 5,503.68 | 2 Mechanics, 1 HP Tech. | The Kelly Report states that 96 work hours are required, It is assumed that this is 96 Manhours of work plus HP Tech. |
| **Total Cost For The Demonstration** | | | | | | | | | $ 11,582.03 | | |

NOTES
1. TC = UC X TQ (where TC = total cost, UC = unit cost, and TQ = total quantity), LS = Lump Sum , Labor rates are weighted average rate of the crew composition.
2. Labor Rates are $42.33/hr for Mechanic, $30.00/hr for Health Protection (HP) Technician
3. Equipment is site owned and located. No mobilization/demobilization shipping cost incurred.
4. Unit Cost for "Steam/Vacuum Cleaning" and "Equipment Cleanup" items are taken from the Steam Vacuum Cleaning Report, OST Ref. # 1780.

# APPENDIX D
# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| $\alpha$ | Alpha |
| $\beta$ | Beta |
| $\gamma$ | Gamma |
| CFR | Code of Federal Regulations |
| $cm^2$ | Square centimeters |
| D&D | Deactivation and Decommissioning |
| DF | Decontamination factor |
| DOE | Department of Energy |
| dpm | Disintegrations per minute |
| $ft/ft^2$ | Feet/Square feet |
| gal | Gallon |
| h | Hour |
| HEPA | High efficiency particulate air |
| HEU | Highly enriched uranium |
| ID | Internal diameter |
| in. | Inch |
| LSDDP | Large Scale Demonstration and Deployment Project |
| MDA | Minimum detectable activity |
| OSHA | Occupational Safety and Health Administration |
| OST | Office of Science and Technology |
| PPE | Personal protective equipment |
| RH | Relative humidity |
| SRS | Savannah River Site |
| USACE | United States Army Corps of Engineers |
| WSRC | Westinghouse Savannah River Company |