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Technology Evaluation Report

Bartlett Services, Inc. Stripcoat TLC Free™ Radiological Decontamination of Americium

Office of Research and Development
National Homeland Security Research Center

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National Homeland Security Research Center
Office of Research and Development
U.S. Environmental Protection Agency
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DISCLAIMER

The U.S. Environmental Protection Agency (EPA), through its Office of Research and Development's National Homeland Security Research Center (NHSRC), funded and managed this technology evaluation partially through Chemical, Biological, Radiological Nuclear Defense Information analysis Center (CBRNIAC) Technical Area Task #794 (contract number SP0700-00-D-3180) and partially through contract No. EP-C-10-001 with Battelle. This report has been peer and administratively reviewed and has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use of a specific product.

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Foreward

The U.S. Environmental Protection Agency (EPA) holds responsibilities associated with homeland security events: EPA is the primary federal agency responsible for decontamination following a chemical, biological, and/or radiological (CBR) attack. The EPA's Homeland Security Research Program (HSRP) was established to conduct research and deliver scientific products that improve the capability of the Agency to carry out these responsibilities.

An important goal of the HSRP's research is to develop and deliver information on decontamination methods and technologies to clean up CBR contamination. When supporting or directing such a recovery operation, EPA and other stakeholders must identify and implement decontamination technologies that are appropriate for the given situation. The EPA's National Homeland Security Research Center (NHSRC) has created the Technology Testing and Evaluation Program (TTEP) in an effort to provide reliable information regarding the performance of homeland security-related technologies. Through TTEP, the HSRP provides independent quality assured performance information that is useful to decision makers in purchasing or applying the tested technologies. Potential users are provided with unbiased, third-party information that can supplement vendor-provided information. Stakeholder involvement ensures that user needs and perspectives are incorporated into the test design so that useful performance information is produced for each of the tested technologies. The technology categories of interest include detection and monitoring, water treatment, air purification, decontamination, and computer modeling tools for use by those responsible for protecting buildings, drinking water supplies and infrastructure, and for decontaminating structures and the outdoor environment.

The HSRP is pleased to make this publication available to assist the response community to prepare for and recover from disasters involving CBR contamination. This research is intended to move EPA one step closer to achieving its homeland security goals and its overall mission of protecting human health and the environment while providing sustainable solutions to our environmental problems.

Jonathan G. Herrmann
National Program Director
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Abbreviations/Acronyms

Am	americium
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
Bq	Becquerel(s)
CBR	chemical, biological, and/or radiological
cm	centimeter(s)
DARPA	Defense Advanced Research Projects Agency
DF	decontamination factor
DHS	U.S. Department of Homeland Security
DoD	U.S. Department of Defense
EPA	U.S. Environmental Protection Agency
Eu	europium
g	gram(s)
IEEE	Institute of Electrical and Electronics Engineers
INL	Idaho National Laboratory
keV	kilo electron volt(s)
L	liter(s)
m	meter(s)
mL	milliliter(s)
Mm	millimeter(s)
µCi	microCurie(s)
nCi	nanoCurie(s)
NHSRC	National Homeland Security Research Center
NIST	National Institute of Standards and Technology
NA	not applicable
%R	percent removal
PE	performance evaluation
PPE	personal protective equipment
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
QMP	quality management plan
RDD	radiological dispersal device
RH	relative humidity
RML	Radiological Measurement Laboratory
RSD	relative standard deviation
Stripcoat	Bartlett Services, Inc. Stripcoat TLC Free™
TSA	technical systems audit
TTEP	Technology Testing and Evaluation Program
Th	thorium

Executive Summary

The U.S. Environmental Protection Agency's (EPA's) Homeland Security Research Program (HSRP) is helping to protect human health and the environment from adverse impacts resulting from acts of terror by carrying out performance tests on homeland security technologies. Through its Technology Testing and Evaluation Program (TTEP), the National Homeland Security Research Center (NHSRC) evaluated the performance of the Bartlett Services, Inc. Stripcoat TLC™ Free strippable coating (Stripcoat). The objective of evaluating Stripcoat was to test its ability to remove radioactive americium (Am)-243 from the surface of unpainted concrete.

Stripcoat is designed to be applied as a "paint-like" coating which is intended to bind the Am-243 physically so that the Am-243 along with the cured coating can be removed from the surface causing little or no surface damage. Prior to the evaluation of Stripcoat, 15 centimeter (cm) × 15 cm unpainted concrete coupons were contaminated with Am-243 at an activity level of approximately 50 nanoCuries (nCi), measured by gamma spectroscopy. The contaminated coupons were then placed in a coupon test stand, and, following manufacturer's recommendations, two coats of Stripcoat were applied to all the coupons in the test stand, which were then allowed to dry overnight. The coating was then peeled from the coupons and collected for disposal. This procedure was performed twice, and then the residual activity on the contaminated coupons was measured to determine the decontamination efficacy achieved. This report documents the decontamination efficacy achieved along with important deployment and operational factors determined based on the laboratory experience and material properties. A summary of the evaluation results for Stripcoat is presented below. Discussion of the observed performance can be found in Section 5 of this report.

Decontamination Efficacy: The decontamination efficacy (in terms of percent removal, %R) attained by Stripcoat was evaluated following contamination of the coupons with approximately 50 nCi Am-243. These coupons were placed on a test stand to create a vertical concrete surface to which Stripcoat was applied, then removed. Overall, Stripcoat decontaminated the concrete coupons with an average %R of 46 ± 4.6%. A limited evaluation of cross contamination was performed, and the results confirmed that slight cross contamination did occur.

Deployment and Operational Factors: Stripcoat is supplied "ready for use" as a coating with a consistency similar to wall paint. Stripcoat was applied following manufacturer's recommendation to the surfaces with a standard paint brush (10 cm wide). The concrete coupons used during this evaluation totaled 0.16 square meters (m^2) and application (two coats) required three minutes for each coat separated by a two hour drying time between coats. The objective of application was to attain a layer of "paint-like" coating approximately one millimeter (mm) thick. However, because a measurement of coating thickness could not readily be performed, a qualitative guideline was followed. The

coating was applied to a thickness sufficient to cover the surface by visual inspection but not so thick that the coating ran down the wall. Following the two-coat application, the Stripcoat was allowed to dry overnight and was then removed by pulling the coating from the surface by hand (technician was in anti-contamination personal protective equipment). This two-coat application followed by removal was performed twice. The combined time required to remove both applications of the coating was five minutes for all seven coupons, which translates to approximately 1.9 m^2 per hour. The amount of waste generated (removed coating) was 32 grams (g), or approximately 198 grams/m^2 for each two coat application. In addition, Stripcoat was well suited for rough or jagged surfaces as the cured coating was easily removed across the gaps between coupons (a distance of approximately 0.3-0.7 cm) that created an irregular surface. The surface finish of the concrete was affected very little by the application and removal of the Stripcoat, as only very small pieces (~1 mm in length) of surface concrete residue were visibly removed.

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1.0 Introduction

The U.S. Environmental Protection Agency's (EPA's) Homeland Security Research Program (HSRP) is helping to protect human health and the environment from adverse effects resulting from intentional acts of terror. With an emphasis on decontamination and consequence management, water infrastructure protection, and threat and consequence assessment, HSRP is working to develop tools and information that will help detect the intentional introduction of chemical, biological, or radiological contaminants into buildings or water systems, the containment of these contaminants, the decontamination of buildings and/or water systems, and the disposal of material resulting from cleanups.

The National Homeland Security Research Center (NHSRC), through its Technology Testing and Evaluation Program (TTEP), works in partnership with recognized testing organizations; with stakeholder groups consisting of buyers, vendor organizations, and permitters; and with the participation of individual technology developers in carrying out performance tests on homeland security technologies. The program evaluates the performance of innovative homeland security technologies by developing evaluation plans that are responsive to the needs of stakeholders, conducting tests, collecting and analyzing data, and preparing peer-reviewed reports. All evaluations are conducted in accordance with rigorous quality assurance (QA) protocols to ensure that data of known and high quality are generated and that results are defensible. High-quality information is provided that is useful to decision makers in purchasing or applying the evaluated technologies. Potential users are provided with unbiased third-party information that can supplement vendor-provided information. Stakeholder involvement ensures that user needs and perspectives are incorporated into the evaluation design so that useful performance information is produced for each of the evaluated technologies.

The performance of the Bartlett Services, Inc., Stripcoat TLC-Free™ strippable coating (Stripcoat) for decontamination of radioactive americium from unpainted concrete was recently evaluated. Americium was selected as the radiological contaminant because of its availability for possible use in a radiological dispersion device (RDD) as the result of its common application in smoke detectors in the form of americium-241 (Am-241). Am-243 was chosen for this study as a surrogate for Am-241. Am-241 is primarily an alpha emitter and cannot be easily quantified in the laboratory with gamma counting. Am-243, an alpha emitter like Am-241, is also a gamma emitter allowing measurement by gamma counting. Because of the nature of the chemical isotopes the Am-243 was judged to behave the same as Am-241 for this experiment, and therefore the efficacy of decontamination would be comparable.

A contamination level of 50 nCi/coupon was chosen based on (1) the detectability capabilities of available laboratory instrumentation and (2) on laboratory health- and safety-based use limits. Actual contamination levels expected outside of the blast zone resulting from an americium-based RDD would likely be significantly lower than detection limits of the instrumentation available for performing radiological decontamination research.

Concrete was selected as a surface because of its prevalence as a building material. This evaluation was conducted according to a peer-reviewed Quality Assurance Project Plan (QAPP) entitled, "The Performance of Strippable Coatings for Decontamination of Americium from Urban Substrates", Version 1.0, dated November 21, 2011, that was developed according to the requirements of the TTEP Quality Management Plan (QMP) Version 3, January 2008 (both are available upon request).

The following performance characteristics of Stripcoat were evaluated:

- Decontamination efficacy defined as the extent of radionuclide removal following application and removal of Stripcoat. Another quantitative parameter evaluated was the potential for cross contamination onto adjacent uncontaminated surfaces due to the decontamination procedure.
- Deployment and operational characteristics including rate of surface area decontamination, applicability to irregular surfaces, skilled labor requirement, utilities requirements, extent of portability, shelf life of media, secondary waste management including the estimated amount and characteristics of the spent media, and cost.

This evaluation took place in December 2011 at the U.S. Department of Energy's Idaho National Laboratory (INL). This report describes the quantitative results and qualitative observations gathered during this evaluation of Stripcoat.

2.0 Technology Description

This report provides results for the evaluation of Stripcoat. The following is a description of Stripcoat, based on information provided by the vendor. The information provided below was not verified during this evaluation.

Stripcoat is a non-hazardous nontoxic strippable coating designed for safely removing and preventing the spread of radioactive contamination. As shown in Figure 2-1, Stripcoat is sold as a "paint-like" formulation and application options include use of a brush, roller, or sprayer. The target thickness during application is 1 mm. While curing, Stripcoat mechanically entraps contamination. Following application, the coating requires 4-10 hours to cure prior to removal (overnight was used during this evaluation). The dried coating containing the encapsulated contamination can then be peeled off the surface and disposed. Stripcoat can also serve as a barrier to prevent contamination from attaching to a surface or as a covering to contain contamination.

Figure 2-1. Stripcoat TLC-Free™.

3.0 Experimental Details

3.1 Experimental Preparation

3.1.1 Concrete Coupons

Concrete coupons were prepared in a single batch of concrete made from Type II Portland cement. The ready-mix company that supplied the concrete for this evaluation provided the data shown in Table 3-1 about the cement clinker used in the concrete mix. The American Society for Testing and Materials (ASTM) C150[1] requirement for Type II Portland cement is that the tricalcium aluminate be less than 8% of the overall cement clinker. As shown in Table 3-1 the cement clinker used for the concrete coupons was 4.5% tricalcium aluminate. Because the only difference between Type I and II Portland cements is the maximum allowable tricalcium aluminate content and the maximum for Type I is 15%, the cement used during this evaluation meets the specifications for both Type I and II Portland cements.

Table 3-1. Concrete Characterization

Cement Constituent	Percent of Mixture
Tricalcium Silicate	57.6
Dicalcium Silicate	21.1
Tricalcium Aluminate	4.5
Tetracalcium Aluminoferrite	8.7
Minor constituents	8.1

The wet concrete was poured into 0.9 m square plywood forms (approximately 4 cm deep) with the surface exposed, and the surface "floated" to allow the smaller aggregate and cement paste to float to the top (the surface used for this evaluation), and then cured for 21 days. Following curing, the 4 cm thick squares were cut with a laser-guided rock saw to the desired concrete coupon size of approximately 15 cm ×15 cm. The coupons had a surface finish that was consistent across all the coupons. This concrete was judged to be representative of exterior concrete commonly found in urban environments in the United States as shown by INL under a U.S. Department of Defense, Defense Advanced Research Projects Agency (DARPA) and U.S. Department of Homeland Security (DHS) project[2].

3.1.2 Coupon Contamination

Six contaminated coupons were spiked with 2.5 milliliters (mL) of unbuffered, slightly acidic aqueous solution containing 20 nanoCuries (nCi)/mL Am-243 which corresponds to an activity level of approximately 50 ± 5 nCi per coupon. Application of the Am-243 in an aqueous solution was justified because even if Am-243 were dispersed in a dry particle form following an RDD event, morning dew or rainfall would likely occur before the surfaces could be decontaminated. Such an event would increase the likelihood that the Am-243 would no longer be bound to the particles and that a chemical decontamination technology for decontaminating the concrete surface would be preferable. In addition, from an experimental standpoint, the ability to apply liquids homogeneously across the surface of the concrete coupons greatly exceeds that capability for dry particles. The liquid spike was delivered to each coupon using an aerosolization technique developed by INL under the DARPA/DHS project[2]. Coupons were contaminated approximately two weeks before use and were stored in a steel drum used for transport to the INL Radiological Measurement Laboratory (RML). Storage conditions were not monitored during this time period, but, aside from the vehicle transport (a few hours), the drum was unopened and located in working laboratories.

The aerosol delivery device was constructed of two syringes. The plunger and needle were removed from the first syringe and discarded. A compressed air line was then attached to the rear of the syringe. The second syringe contained the contaminant solution and was equipped with a 27 gauge needle, which penetrated through the plastic housing near the tip of the first syringe. Compressed air flowing at a rate of approximately 1 - 2 liters (L) per minute created a turbulent flow through the first syringe. When the contaminant solution in the second syringe was introduced, the contaminant solution became nebulized by the turbulent air flow. A fine aerosol was ejected from the tip of the first syringe, creating a controlled and uniform spray of fine liquid droplets onto the coupon surface. The contaminant spray was applied all the way to the edges of the coupon, which were taped (after having previously been sealed with polyester resin) to ensure that the contaminant was applied only to the working surfaces of the coupons. The photographs in Figure 3-1 show this procedure being performed using a nonradioactive nonhazardous aqueous dye to demonstrate that 2.5 mL of contaminant solution is effectively distributed across the surface of the coupon.

Figure 3-1. Demonstration of contaminant application technique.

3.1.3 Measurement of Activity on Coupon Surface

Gamma radiation from the surface of each contaminated concrete coupon was measured to quantify contamination levels both before and after use of Stripcoat on the coupons. These measurements were made using an intrinsic high purity germanium detector (Canberra LEGe Model GL 2825R/S, Meriden, CT). After being placed in the detector, each coupon was measured until the average activity level of Am-243 from the surface stabilized to a relative standard deviation (RSD) of less than 2%. Gamma-ray spectra acquired from Am-243 contaminated coupons were analyzed using INL RML data acquisition and spectral analysis programs. Radionuclide activities on coupons were calculated based on efficiency, emission probability, and half-life values. Decay corrections were made based on the date and the duration of the counting period. Full RML gamma counting QA/quality control (QC), as described in the QAPP, was employed and certified results were provided.

3.1.4 Surface Construction Using Test Stand

To evaluate Stripcoat on vertical surfaces only (simulating walls), a stainless steel test stand that held three rows of concrete coupons was used. The test stand was erected within a radiological hood. As shown in Figure 3-2, three rows of two contaminated concrete coupons were placed on the right side of the test stand and the single uncontaminated coupon was placed on the left side of the bottom row and treated with Stripcoat in the same way as the other coupons. This coupon, referred to as the cross contamination blank, was used to observe possible cross contamination caused by use of Stripcoat on contaminated surfaces adjacent to uncontaminated surfaces. The Stripcoat was applied to all coupons in a single, continuous operation, including the blank, using the same paintbrush as was used for the other coupons.

Figure 3-2. Test stand with concrete coupons.

3.2 Evaluation of Stripcoat

The seven concrete coupons in the test stand (six contaminated and one cross contamination blank) were treated with Stripcoat. The application of Stripcoat was performed using a standard 10 cm paint brush. The specifications of the paint brush were not critical as a perfectly smooth application was not required. The paint brush was loaded with wet Stripcoat by dipping the brush into a plastic bag containing the wet Stripcoat and then the wet Stripcoat was applied generously until the entire surface of the coupon was covered. The wet coating was then worked into the coupon surfaces by brushing in a circular motion across the coupons. The brush was used to smooth the applied Stripcoat on each concrete coupon. If there were areas of the coupons that were observed to not be covered completely, additional wet Stripcoat was added. The first coat of Stripcoat was allowed to dry for two hours and a second coat was added on top of the initial coat following the same procedure. The coupons were then allowed to dry overnight. Removal of the dried Stripcoat was accomplished by manually peeling away the coating beginning at the corners of the coupons. The application time included only the time for painting the coating onto the coupon surface and then working the coating into the surface. The dry, removed coating from one of the Stripcoat applications was weighed to determine the amount of waste generation per unit area. The overall decontamination method (two applications) for Stripcoat included:

1. Apply coating followed by two-hour drying time and apply a second coat;
2. Dry overnight;
3. Remove dried coatings;
4. Apply wet coating followed by two-hour drying time and apply a second coat;
5. Dry overnight; and
6. Remove final dried coatings.

The experimental timeline can be summarized as follows. The six coupons were contaminated on November 30. The first application (two coats) of Stripcoat was completed on December 12 and allowed to dry overnight. Removal of the dried coating was performed on December 13. The second and final application/removal cycle was performed in an identical way on December 13 and 14. Therefore, the final removal of Stripcoat was performed 15 days following application of the Am-243 to the coupons. The temperature and relative humidity (RH) were recorded during the application and removal of the Stripcoat. Over the duration of testing, the temperature and RH in the laboratory where the coupons were stored and the evaluation was performed was always within the range of 22–23°C and 14-18% RH, respectively.

4.0 Quality Assurance/Quality Control

QA/QC procedures were performed in accordance with the QMP and the QAPP for this evaluation.

4.1 Intrinsic Germanium Detector

The germanium detector was calibrated weekly during the overall project. The calibration was performed in accordance with standardized procedures from the American National Standards Institute (ANSI) and the Institute of Electrical and Electronics Engineers (IEEE).[3] In brief, detector energy was calibrated using thorium (Th)-228 daughter gamma rays at 238.6, 583.2, 860.6, 1620.7, and 2614.5 kilo electron volts (keV). Table 4-1 gives the calibration results across the duration of the project. Each row gives the difference between the known energy levels and those measured following calibration (rolling average across the six most recent calibrations). Pre-contamination measurements were performed in late September and the post-contamination results were measured in late November. Each row represents a six-week rolling average of calibration results. In addition, the energies were compared to the previous 30 calibrations to confirm that the results were within three standard deviations of the previous calibration results. All the calibrations fell within this requirement.

Table 4-1. Calibration Results – Difference (keV) from Th-228 Calibration Energies

	Calibration Energy Levels in keV				
Date Range (2011)	**Energy 1 238.632**	**Energy 2 583.191**	**Energy 3 860.564**	**Energy 4 1620.735**	**Energy 5 2614.511**
10-18 to 11-22	-0.002	0.007	-0.002	-0.205	0.020
10-24 to 12-6	-0.003	0.009	-0.028	-0.160	0.019
11-1 to 12-13	-0.001	0.003	-0.010	-0.060	0.007
11-8 to 12-20	-0.004	0.014	-0.039	-0.278	0.027

As described in the QAPP, gamma ray counting was continued on each coupon until the activity level of Am-243 on the surface had a relative standard deviation (RSD) of less than 2%. This RSD was achieved during the first hour of counting for all the coupons measured during this evaluation. The final activity assigned to each coupon was a compilation of information obtained from all components of the electronic assemblage that comprises the "gamma counter," including the raw data and the spectral analysis described in Section 3.1.3. Final spectra and all data that comprise the spectra were sent to a data analyst who independently confirmed the "activity" number arrived at by the spectroscopist. When both the spectroscopist and the data analyst independently arrived at the same value, the data were considered certified. This process defines the full gamma counting QA process for certified results.

The background activity of the concrete coupons was determined by analyzing two arbitrarily selected coupons from the stock of concrete coupons used for this evaluation. The ambient activity level of these coupons was measured for one hour. No activity was detected above the minimum detectable level of 0.2 nCi on these coupons. Because the background activity was not detectable (and the detectable level was approximately 10 times lower than the post-decontamination activity levels), no background subtraction was required.

Throughout the evaluation, a second measurement was taken on two coupons in order to provide duplicate measurements to evaluate the repeatability of the instrument. One of the duplicate measurements was performed after contamination prior to application of Stripcoat and one was performed after decontamination. Both of the duplicate pairs showed a difference in activity levels of 5% or less, which was at or within the acceptable difference of 5%.

4.2 Audits

4.2.1 Performance Evaluation Audit

RML performs monthly checks of the accuracy of the Th-228 daughter calibration standards by measuring the activity of a National Institute of Standards and Technology (NIST)-traceable europium-152 (Eu-152) standard (in units of Becquerels, Bq) and comparing the results to the accepted NIST value. Results within 7% of the NIST value are considered to be within acceptable limits as per the INL RML QC requirements. The Eu-152 activity comparison is a routine QC activity performed by INL, but, for the purposes of this evaluation, serves as the performance evaluation (PE) audit, an audit that confirms the accuracy of the calibration standards used for the instrumentation critical to the results of an evaluation. Table 4-2 gives the results of each of these audits for the detector that was used during this evaluation. All results are within the acceptable difference of 7%.

Table 4-2. NIST-Traceable Eu-152 Activity Standard Check

Date	Eu-152 (keV)	NIST Activity (Bq)	INL RML Result (Bq)	Difference
12-15-2011	Average	124,600	122,600	0.5%
	122	124,600	118,900	1.6%
	779	124,600	122,200	1.3%
	1408	124,600	118,700	1.5%

4.2.2 Technical Systems Audit

A TSA was conducted during testing at INL to ensure that the evaluation was performed in accordance with the QAPP and the TTEP QMP. As part of the audit, the actual evaluation procedures were compared with those specified in the QAPP. In addition, the data acquisition and handling procedures were reviewed. No significant adverse findings were noted in this audit. The records concerning the TSA are stored indefinitely with the QA Manager.

4.2.3 Data Quality Audit

At least 10% of the data acquired during the evaluation were audited. The QA Manager traced the data from the initial acquisition, through reduction and statistical analysis, to final reporting, to ensure the integrity of the reported results. All calculations performed on the data undergoing the audit were checked. No significant findings were noted.

4.3 QA/QC Reporting

Each assessment and audit was documented in accordance with the QAPP and the QMP.

There were two deviations from the QAPP during this evaluation. First, the target coupon contamination levels were slightly outside the acceptable limits for two coupons. The upper limit of the acceptable range was 55 nCi and one coupon had activities of 58 nCi. There was no negative impact to the evaluation due to this deviation because the levels were just slightly outside the acceptable limits. Second, the QAPP stated that a single coupon test stand would be used for strippable coating application. This text was included as a typographical error as all parties involved understood that the expectation was that a multi-coupon test stand would be used.

5.0 Evaluation Results and Performance Summary

5.1 Decontamination Efficacy

The decontamination efficacy was determined for each contaminated coupon in terms of %R and decontamination factor (DF) as defined by the following equations:

$$\%R = (1 - A_f/A_o) \times 100\% \text{ and } DF = A_o/A_f$$

where A_o is the radiological activity from the surface of the coupon before application of Stripcoat and A_f is radiological activity from the surface of the coupon after removal of the strippable coating. While the DFs are reported in the following data tables, the narrative describing the results will focus on the %R.

Table 5-1 presents the %R and DF for Stripcoat. The coupon position numbers indicate the location within the surface (Positions 1-6) as defined in Figure 3-2. The activity for each of the contaminated coupons (pre-decontamination) was between 50 nCi and 58 nCi. The overall average (plus or minus one standard deviation) of the contaminated coupons was 54 ± 2.6 nCi, a variability of 6%. The post-decontamination coupon activities were significantly less than the pre-decontamination activities with an average %Rs of 46 ± 4.6%.

Table 5-1. Decontamination Efficacy Results

Coupon Position	Pre-Decontamination Activity (nCi/coupon)	Post-Decontamination Activity (nCi/coupon)	%R	DF
1	54	32	42	1.7
2	58	32	45	1.8
3	54	26	51	2.1
4	54	32	41	1.7
5	51	25	52	2.1
6	50	26	48	1.9
Avg	**54**	**29**	**46**	**1.9**
SD	**3**	**3**	**5**	**0.2**
Cross contamination blank	**<0.2**	**0.5**	**NA**	**NA**

NA-removal data not applicable to the cross contamination blank coupon

As described above in Section 3.1, the cross contamination blank was included in the test stand to evaluate the potential for cross contamination due to application and removal of the Stripcoat. This coupon had not been contaminated and the pre-decontamination activity measurements indicated extremely low background levels of activity (0.2 nCi). This coupon was decontaminated using Stripcoat along with the other contaminated coupons in a single continuous operation using one brush. When all of the coupons were removed from the test stand following the two application and removal cycles of Stripcoat, the cross contamination blank coupon indicated an activity level that was 0.5 nCi, an activity 0.3 nCi higher than the detection limit of the gamma counter (i.e., above background). This increased level of activity was less than 1% of the activity added to each of the contaminated coupons (~50 nCi); not a large amount, but enough to note that the possibility exists that cross contamination to locations previously not contaminated is a possibility when using Stripcoat in a wide area application. The most likely routes for cross contamination would be transfer of contamination from one coupon to another during application of the Stripcoat, and contamination of the bulk Stripcoat during application with a paint brush. However, another possible scenario would include accidentally touching the cross contamination blank with a gloved hand that had just been used to apply or remove Stripcoat from the contaminated coupons.

5.2 Deployment and Operational Factors

Table 5-4 summarizes practical information (both qualitative and quantitative) gained during the evaluation of Stripcoat. A number of operational factors were documented by the technician who performed the testing. The application process as described in Section 3.2 included application with a 10 cm wide paint brush. Three minutes was required to apply each coat of Stripcoat to all seven coupons. The overall time required to remove the dried coating from all seven coupons was five minutes. These application and removal times are applicable only to the experimental scenario using small concrete coupons. If Stripcoat were to be applied to larger surfaces, larger paint application tools such as rollers or sprayers would likely be used which would impact the application rate. In addition, larger sections of dry coating could likely be removed in a similar amount of time as was required for the small coupons.

Figure 5-1 shows the application and removal of Stripcoat. Stripcoat appears to be well suited for rough or jagged surfaces, as the cured coating was easily removed across the gaps between coupons (a distance of approximately 0.3-0.7 cm) that created an irregular surface. Figure 5-2 shows that the coupon surfaces were left largely unchanged by the Stripcoat as only very small amounts (~1 mm in length) of surface concrete residue were removed.

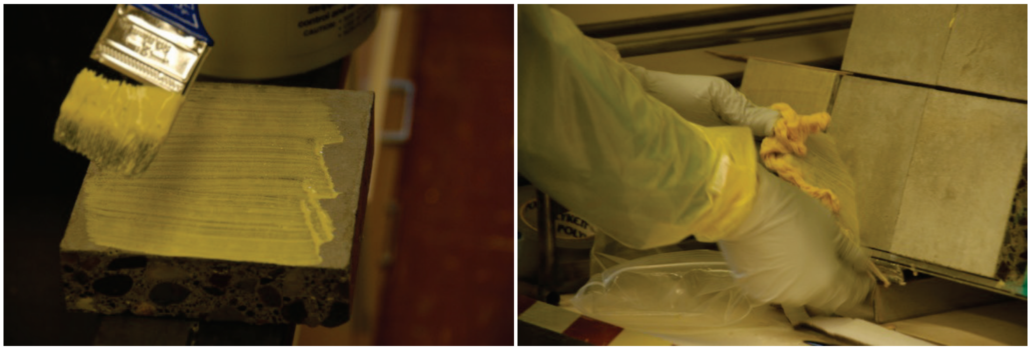

Figure 5-1. Application and removal of Stripcoat.

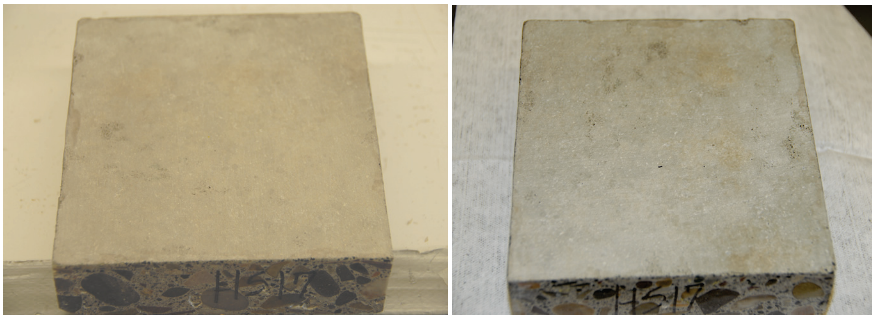

Figure 5-2. Coupons before (left) and after (right) decontamination with Stripcoat.

Throughout the evaluation, technicians were required to use full anti-contamination personal protective equipment (PPE) because the work was performed in a radiological hood using Am-243. Whenever radioactively contaminated material is handled, anti-contamination PPE is required and any waste (e.g., peeled coating) will be considered low level radioactive waste and must be deposed of accordingly. The level of PPE required was not driven by the use of Stripcoat, which is not hazardous, but by the interaction with surfaces contaminated with Am-243.

All of the operational information gathered during this evaluation was gathered during use of Stripcoat on relatively small surfaces (0.16 m^2) that were built with concrete coupons. Some of the information given in Table 5-2 could, therefore, differ if Stripcoat were to be applied to a larger surface or to a surface with a significantly different surface texture or porosity.

Table 5-2. Operational Factors for Stripcoat

Parameter	Description/Information
Decontamination rate	Coating preparation: Provided ready for use. Application: Application by brush required approximately 3 minutes at 100 mL per coat onto 0.16 m^2 for an application rate of 3.2 m^2/hour and a Stripcoat volumetric use rate of 625 mL/m^2 for each coat. Two application/removal cycles were used in this evaluation. Larger scale application (e.g. by sprayer) would likely improve the application rate. Drying time: overnight Removal time: Five minutes for all seven coupons for a rate of 1.9 m^2/hour
Applicability to irregular surfaces	Application to more irregular surfaces than that encountered during this evaluation would not seem to be much of a problem as a paint brush can coat most types of surfaces accessible to an operator. Stripcoat cures to a very elastic film that is conducive for use on the surfaces made from concrete. In most cases, Stripcoat could be removed across the borders of coupons even when separated by several mm.
Skilled labor requirement	After a brief training session to explain the procedures, no special skills would be required to perform both the application and removal procedures successfully.
Utilities requirement	No utilities were required in this case because paint brush application was used. Stripcoat can be applied using a paint sprayer which would require at minimum 120 volts alternating current power.
Extent of portability	With the exception of extreme cold, which would prevent the application of the water-based Stripcoat, the technology is not limited due to portability.
Shelf life of media	Shelf life is advertised as one year.
Secondary waste management	Solid waste production: approximately 396 g/m^2 for two applications of two coats.
Surface damage	No visible surface damage; removed only loose particles that were consequently stuck to the removed coating.
Cost	The material cost is approximately \$23.50/L corresponding to \$16.66/m^2 per application; Bartlett suggests two applications which would correspond to approximately \$33.00/m^2. Labor costs were not calculated.

6.0 References

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3. Calibration and Use of Germanium Spectrometers for the Measurement of Gamma Emission Rates of Radionuclides, American National Standards Institute. ANSI N42.14-1999. IEEE New York, NY (Rev. 2004).

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