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DECONTAMINATION OF SAVANNAH RIVER PLANT H-AREA HOT-CANYON CRANE

by

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ABSTRACT

Decontamination techniques applicable to the remotely operated bridge cranes in canyon buildings at the Savannah River Plant (SRP) were identified and were evaluated in laboratory-scale tests. High pressure Freon® blasting was found to be the most attractive process available for this application. Strippable coatings were selected as an alternative technique in selected applications. The ability of high pressure Freon blasting plus two strippable coatings (Quadcoat® 100 and Alara 1146) to remove the type of contamination expected on SRP cranes was demonstrated in laboratory-scale tests.

Quadrex HPS was given a contract to decontaminate the H-Area hot canyon crane. Decontamination operations were successfully carried out within the specified time-frame window. The radiation level goals specified by SRP were met and decontamination was accomplished with 85% less personnel exposure than estimated by SRP before the job started. This reduction is attributed to the increased efficiency of the new decontamination techniques used.

INTRODUCTION

The Savannah River Plant (SRP), operated for the U.S. Government by the Du Pont Company, has safely produced special nuclear materials for both defense and peaceful applications since 1953. Fuel irradiated in SRP nuclear reactors is processed in canyon facilities to recover products. Because of the high radiation fields, all manipulations inside the canyons are performed using a remotely operated 45,000-kg (50-ton) bridge crane equipped with trolley mounted 45,000- and 9,000-kg (50- and 10-ton) lifting hooks, two monorail assemblies, and a cantilevered, shielded operations cab.[1]

Maintenance operations on the bridge crane are done in a room approximately 15 x 15 x 9 meters (50 x 50 x 30 ft). The front side of the room is a sliding shield door that separates the maintenance area from the hot canyon. In this area, components such as crane hooks and attached impact wrenches are routinely decontaminated using steam, manual cleaning, and low-pressure Freon blasting techniques to allow hands-on maintenance. Over approximately 30 years of operation, however, accumulated contamination resulted in increased radiation levels which made it necessary to decontaminate the entire crane. The gamma contamination was as high as 1000 mR/hr.

This paper describes the identification, testing, and implementation of decontamination techniques to reduce these radiation levels. The health physics aspects of this work were reported elsewhere.[2]

DECONTAMINATION TECHNIQUES CONSIDERED

Water Based

Decontamination techniques applicable to the entire crane were surveyed. These processes include water blasting, steam blasting, chemical, and electrochemical techniques. In all these processes, the equipment being decontaminated becomes wet. This is a major disadvantage because several days may be required to dry electrical equipment on the crane before it could be returned to service.

Mechanical Techniques

In these techniques, such as abrasive blasting, the contamination is removed from the surface by abrasion. In the case of canyon cranes these techniques could not be used.

Strippable Coatings

In these techniques, a material is applied to the surface being decontaminated. As the film dries, it incorporates the radioactive material. When completely dry, the film is stripped from the surface for disposal. A major disadvantage of these techniques is that only accessible surfaces of the crane could be decontaminated.

Freon® Blasting

High pressure Freon blasting is the most attractive process available for this application. In this technique, a high pressure stream of Freon is directed toward the surface being decontaminated. This stream dislodged particles of radioactive contamination that are not bonded to the surface. High pressure Freon blasting is a more effective decontamination technique than high pressure water blasting because Freon is denser than water (1.565 gm/cm^3 vs 1 gm/cm^3), and its viscosity (0.694 centipoise) and its surface tension (17.3 dynes/cm) are respectively, 69 percent and 23 percent that of water. A more dense cleaning stream will expend more energy on a surface than a stream of less dense material. More "scrubbing" will be produced by a more viscous stream than by a less viscous stream. A cleaning fluid with a lower surface tension will be more likely to penetrate small crevices than a fluid with higher surface tension. Its dielectric properties, high resistance to the flow of electric current and compatibility with electrical materials allow electronic and electrical equipment to be rapidly cleaned. Freon's low latent heat of vaporization (35.07 cal/gm) and low boiling point (47.6 °C) allow it to rapidly separate from higher boiling contaminants via distillation, with filtration to remove particulate material. With subsequent distillation and condensation, the solvent may be recovered for indefinite reuse while reducing radioactive waste to a minimum.[3,4]

High pressure Freon blasting was selected as the most attractive process for application to the entire crane. Strippable coatings were selected as an alternative technique in selected applications.

DEMONSTRATION OF SELECTED TECHNIQUES IN LABORATORY-SCALE TESTS

Freon Blasting

Laboratory-scale tests were carried out to demonstrate applicable decontamination techniques. The ability of high pressure Freon blasting to remove non-adherent radioactive contamination from a variety of surfaces was evaluated. Test specimens were coupons of Type 304L SS, low carbon steel, and carbon steel painted with a Du Pont Colar® epoxy top coat. A 0.05 mL drop of contaminant was applied to one face of a 2.5 x 7.6 cm (1 x 3 in.) specimen. On some specimens the contamination was coated with a layer of Mystic JT-6* which is typical of the type of grease used in SRP Separation Areas, on canyon cranes.

® Freon is a registered trademark of Du Pont.

Decontamination by blasting with Type TF Freon at a 45° angle for 1 min. at 17 L/min (4 1/2 gal/min) flow was evaluated. Blasting pressures of 34, 103, 172, and 262 bar (500, 1500, 2500, and 3800 psi) were used. In most tests the distance between the nozzle and the specimen was 15.2 cm (6 in.) In tests at 262 bar (3800 psi) this distance was decreased to 5 cm (2 inches) and 1.3 cm (1/2 inch).

Results indicate that the high pressure Freon blasting technique is very effective for crane decontamination. Up to 99.9% of the smearable radioactive contamination was removed from the samples. The effectiveness of the technique increases as the blasting pressure increases, and as the blasting distance decreases.

Quadcote® 100

Quadcote 100 is a strippable decontamination coating marketed by Quadrex HPS Inc, Gainesville, FL. Quadcote 100 is applied to the surface being decontaminated. When completely dry, the film cracks and spalls off the surface. Decontamination is completed by collection and disposal of the spalled material.

Coupon Tests

The ability of Quadcote 100 to remove radioactive material from horizontally oriented metal surfaces was evaluated. In these tests, contamination was baked-on the surface of the specimens by heating contaminated specimens 1 hour at 600°C. Quadcote 100 was painted on the contaminated and heated specimens with a paint brush after the specimens had cooled to room temperature.

Overnight all films had dried, and were easily removed. Almost all the oxide film was removed from the stainless steel by the Quadcote 100 plus 33 vol% 6M HNO_3 solution. Less stainless steel oxide was removed by Quadcote 100 alone. Previous tests have shown that heating contaminated specimens causes contamination to be incorporated in the stainless steel oxide film which forms. Decontamination is achieved only by removal of the tightly adherent oxide film from the stainless steel.[5,6]

Glove Box Test

The ability of Quadcote 100 to remove radioactive contamination was evaluated in a contaminated Type 304L stainless steel glove box. Smearable contamination in the box, initially

* Cato Oil and Grease Co., Oklahoma City, OK.

® Quadcote is a registered trademark of Quadrex HPS, Inc.

greater than the detection limit of 10^5 d/m alpha, was reduced to about 8 x 10^4 d/m after two applications of Quadcote. It was not reduced further during four subsequent applications even when 33 volume percent nitric acid was added to the Quadcote.

The Quadcote spalled free when applied to the horizontal bottom of the box. When painted on vertical surfaces, the film thinned during drying leaving a layer which did not spall, and could only be removed by scraping, with considerable effort.

Alara 1146

Alara 1146 is a strippable coating produced by Imperial Coatings. Alara does not spontaneously spall but can be easily removed by hand. It is applied as a liquid and can be disposed of as a solid.

Coupon Tests

Results of tests with contaminated Type 304L stainless steel coupons were encouraging. A 0.0008 to 0.0013 mm (3 to 5 mil) thick coating was applied, allowed to dry, and removed by hand. Smearable contamination was reduced from 250,000 d/m alpha to 2000 d/m alpha (DF 125). The film was easy to remove in one piece.

Glove Box Test

Alara 1146 was applied to the interior surfaces of the contaminated Type 304L stainless steel glove box used in previous tests with Quadcote 100. This strippable coating is effective on both horizontal and vertical surfaces. It was easily removed by hand in large sheets. Smearable contamination was further reduced.

APPLICATION OF DECONTAMINATION TECHNIQUES

Quadrex HPS Inc. was contracted to decontaminate the hot canyon crane and the crane maintenance area.

Preparation

In preparation for the project, Quadrex HPS Inc. developed and implemented several modifications to the standard design high-pressure Freon equipment. These modifications were necessitated by the perceived potential for waste generation with high radiation levels and included:

- Replacing the standard Tool Decontamination Unit (TDU) filter with a remotely located filter.
- Designing the remote filter and piping system to accommodate rapid handling for further reduced radiation exposure to personnel.
- Designing a shielded container for the disposal of remote filters.
- Designing enclosures to collect Freon after component spraying.
- Designing an auxiliary Freon feed to the TDU to increase Freon capacity within the unit.

Additionally, a project plan was developed for the decontamination work. The project plan specified the work to be done, the sequence of the work, the decontamination techniques to be used, and the administrative framework in which the project would be accomplished.

Project Administration

A decontamination team, consisting of a Project Manager, three project foremen, and twelve decontamination technicians was provided by Quadrex HPS Inc. The project schedule was established at fourteen work days.

A primary concern during the decontamination project was minimizing personnel exposure. A maximum total project radiation exposure limit of 17 REM whole body was established for the project.

A SRP Subcontractor Liaison Team was established to provide overall direction and administration of the project. The Liaison Team met daily to review and evaluate project performance in order to determine appropriate resolutions to problems, direct future work activities, and review current and projected radiation exposures.

Specific decontamination goals (radiation levels) were established prior to starting the decontamination effort. Table I presents a listing of the starting radiation levels, the specified goals, and the radiation level achieved after decontamination.

TABLE 1. Decontamination Results

Crane Part	Radiation Level (mR/hr at 45.7 cm) Start	Goal	Finish
Impact Wrenches	1000	25	20
Monorails	600	25	20
Bridge	400	25	25
Crain Maintenance Area (Walls and Floor)	100	10	5

Initial Cleaning

As a first step in the decontamination process, an initial clean-up of the crane was undertaken. All loose items (i.e.: tools, shielding, waste, etc.) were removed from the top of the crane. Utilizing vacuum cleaners and scrapers, loose dust and dirt were removed. The vacuum cleaners were of minimal benefit due to heavy accumulations of oil and grease which combined with the dust and dirt, necessitating the manual scraping and pickup.

When the crane had been cleaned, it was moved into the canyon area and the shielded door to the crane maintenance area was closed. Since the crane was the major contributor to radiation exposure, removal of the crane at this point allowed personnel to continue the initial cleanup of the crane maintenance area in a reduced radiation field.

After a general cleanup of the walls, rails and floor area, the crane maintenance area walls were coated with Alara 1146 strippable coating. Prior to coating the walls, two test areas were selected and coated with Quadcote-100 and Alara 1146 respectively. Once the coatings dried, removal was attempted to determine which coating would be used. The Alara 1146 coating was easily removed, while the Quadcote-100 coating adhered to the surface, therefore, Alara 1146 was used to coat the remainder of the walls.

Crane Decontamination

The crane was returned to the crane maintenance area for decontamination. The 45,000 kg lifting hook was positioned in the Remote Decon Chamber (RDU) for decontamination. After two hours of decontamination it was removed and wrapped in plastic to prevent recontamination. Radiation levels were reduced from 50 to 17 mR/hr gamma at 45.7 cm (18 in.).*

The impact wrenches were removed from the crane for decontamination in the RDU. Initial surveys of the wrenches indicated 1000 mR/hr. Most areas on the impact wrenches were readily decontaminated; however, in the area of the socket and the kickbar, decontamination with Freon proved ineffective due to imbedded contamination. The sockets and kickbars were replaced. Both impact wrenches were decontaminated to 20 mR/hr.

A Visqueen™ enclosure was constructed around one end of the crane bridge in preparation for spraying with high-pressure Freon. The enclosure drained to a collection container where the Freon could be pumped through the remote filters to the Tool Decontamination Unit sump for reuse. Utilizing the remote spray nozzle from the TDU, the end of the crane bridge was sprayed with high-pressure Freon. Fifty-five gallons of Freon was sprayed and approximately one pint drained to the collection barrel. The sprayed Freon vaporized rapidly after hitting the crane surface due to high temperatures (approximately 68°C) and high air flow through the area. Based on the rapid vaporization of the Freon, it was decided not to build containments around the remainder of the crane since collection of the Freon had been ineffective in this application.

Visqueen was placed on the floor area under the crane bridge to collect falling contamination while spraying with Freon. The Visqueen was periodically replaced during subsequent decontamination. High-pressure Freon spraying of the crane bridge proved effective in reducing levels from 400 to 25 mR/hr.

The two monorails on the crane were decontaminated with high- pressure Freon spray. Both monorails were enclosed in Visqueen which drained to the collection drum. This resulted in the recovery of approximately 40 to 50% of the sprayed Freon. In accordance with the project plan, the steel and electrical cables were removed from the takeup reels and discarded as waste. The monorails were decontaminated from levels of 600 to 20 mR/hr.

Crane Maintenance Area

The stainless steel walls of the crane maintenance area were initially coated with Alara 1146 coating. This coating was left in place to protect the walls during the crane decontamination. After the crane decontamination was completed, the walls were stripped by peeling the coating from the surface. A second coat of the Alara 1146 coating was applied to the crane maintenance area walls, allowed to dry, and removed. Radiation surveys after removal of the second coat of the Alara 1146 coating indicated that most of the contamination had been removed. Radiation levels were reduced from 100 mR/hr to 5 mR/hr. Cleaning the stainless steel floor of the crane maintenance area with Freon reduced levels from 100 mR/hr to 5 mR/hr.

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* All subsequent radiation measurements were made at 45.7 cm (18 in.).

™ Visqueen is a Trademark of Ethyl Corp.

Performance of Decontamination Techniques

Most decontamination techniques utilized in the decontamination project proved to be successful.

- High-pressure Freon spray readily removed contamination from complex surfaces and, in most cases, no further decontamination was necessary. The Freon spray was particularly useful in removing grease and oil deposits which is difficult by any other means.
- The Alara 1146 strippable coating was useful in decontaminating large surface areas such as walls. The coating can be easily applied and when dry, is removed with minimal effort. Generally, it required two coatings to achieve the desired thickness and, in some areas, up to four coatings were necessary.
- Quadcote-100 proved difficult to use. In several areas it seemed to work well; however, these areas were relatively flat, metallic surfaces. On complex surfaces, concrete walls, or painted surfaces, the Quadcote-100 did not flake and was difficult to remove.

Personnel Exposure

Considerable effort was expended to reduce radiation exposure to a minimum. After reviewing the initial surveys of the areas, an exposure forecast was developed to act as a benchmark in controlling exposures. Actual experiences were significantly less than projected. Total radiation exposure for Quadrex HPS personnel was 2.5 REM versus a goal of 17 REM set by SRP. This reduction is attributed to the increased efficiency of the new decontamination techniques used.

ACKNOWLEDGMENT

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