DEMONSTRATION OF CRYSTALLINE ICE BLAST DECONTAMINATION TECHNOLOGY

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ABSTRACT

The Oak Ridge National Laboratory (ORNL) is a multi-purpose research and development facility operated by Martin Marietta Energy Systems, Inc., for the U. S. Department of Energy (DOE). ORNL coordinated a series of demonstrations with Applied Radiological Control, Inc. of Kennesaw, Georgia, to assess the capabilities of the crystalline ice blast (CIB) system for decontamination technology. This report discusses the CIB system and presents a summary of radiological and environmental data compiled during the demonstrations. Phase 1 was centered around the removal of permanent coatings from different materials, utilizing the impaction and fracture process provided by the ice blast. Phase 2 was performed in a ventilated glove box within the Manipulator Rebuild Shop to obtain data to evaluate this technology as a decontamination tool and to support development proposals. This effort was followed in Phase 3 by the successful application of the technology to the decontamination of lead brick. The test objectives were (1) to demonstrate the ability of the ice blast system to successfully decontaminate fixed contamination from lead, and (2) to accomplish the decontamination while not creating a mixed hazardous secondary waste.

PHASE 1

Phase 1 of the decontamination demonstration was conducted in the shop area at the Radiochemical Development Facility (RDF) - Building 3019 Complex at ORNL. A clear Plexiglas enclosure was constructed to provide a sealed containment area and to permit the ice blast operation to be observed. A ventilation system with a capacity of 1000 scfm and high efficiency particulate absolute (HEPA) filters was installed to maintain a regulated negative pressure of 1.5 to 2.0 in. water gauge in the enclosure. The demonstration was centered around the removal of permanent coatings from different materials, utilizing the impaction and fracture process provided by the ice blast. Permanent coatings were successfully removed from cinder block, concrete, fiberglass, and metals with no visual damage imparted to the substrate. Tests were performed to determine the correct positioning of the blast nozzle (angle, distance from surface, traverse speed) for optimum removal rate for fixed contamination. The byproducts of this demonstration were collected using a HEPA-filtered vacuum and were stored for future recycle system experimentation and analysis for waste acceptance. The run time during this evolution was 2h, with 11 gal of wastewater being produced and collected.

PHASE 2

Phase 2 of the demonstration, which was conducted in the Manipulator Rebuild Shop, the ice blast nozzle was installed in a facility glove box and used to clean discarded hand tools and manipulator parts. This demonstration was performed to obtain data that would allow the technology to be evaluated as a decontamination tool and to support development proposals. The radiological conditions during the CIB decontamination test performed in a ventilated glove box within the Manipulator Rebuild Shop are summarized in the paragraphs that follow. All materials used in the test, except for items 1 and 2, had been previously decontaminated via hand wipe or 1000-psig hot-water jetting.

It is significant to note that the decontamination was accomplished without damage to the material substrate and did not produce a liquid mixed waste. A summary of the conditions and results is presented in Table 1. The tests completed to date have produced a minimal amount of waste with no indication of airborne contamination.

- The technical parameters for the CIB system during the tests were as follows:

  Air - 80 to 200 psig
  Volume - 130 to 205 scfm
  Velocity - 1600 to 1814 ft/s
  Liquid Low-Level Waste - approximately 11 gal/h

- The ORNL radiological release limits are as follows:

  <1000 dpm $\beta\gamma$ direct (probe)

< 300 dpm α direct (probe)
< 200 dpm/100 cm^2 $\beta\gamma$ transferable (smear)
< 20 dpm/100 cm^2 α transferable (smear)

PHASE 3

In Phase 3, the CIB technology was applied to the decontamination of lead bricks. The test objectives were, first to demonstrate the ability of the ice blast system to successfully decontaminate nontransferable (fixed) contamination from lead and, second, to accomplish the decontamination while avoiding the production of a mixed hazardous secondary waste. The following is a summary of radiological and environmental conditions realized during the CIB decontamination of 66 lead bricks *approximately 1960 lb).

Radioactive lead is stored on-site at ORNL for recycle. The current methods for lead decontamination involve the use of abrasive techniques and generate a mixed hazardous secondary waste. Because a method for disposal of mixed waste has not been identified, this type of waste must be stored on-site. Thus, it is essential to find or develop a method that is highly effective for the decontamination of lead but does not produce a hazardous solid waste as defined by the Resource Conservation and Recovery Act (RCRA).

A customized ventilated glove box was designed and installed in the Plexiglas enclosure in the shop area of RDF, Building 3019, to facilitate the lead brick decontamination. The customized glove box allowed for (1) free movement of the ice blast nozzle in and out of the box, (2) a heated base to facilitate the melting of spent ice, (3) a positive collection of liquid for analysis, and (4) adequate ventilation to maintain a negative pressure (1000-ft^3/min ventilation unit with HEPA filtration). The system is illustrated in Fig. 2. Several tests were conducted to determine the correct positioning of the blast nozzle to obtain the optimum decontamination factor.

The lead bricks used in this demonstration had been previously decontaminated via surfactant and handwipes to remove loose contamination. The results for 38 lead bricks showed <200 dpm of transferable beta-alpha contamination per 100 cm^2. The average loose contamination level for the remaining 32 lead bricks was approximately 500 dpm of transferable beta-alpha per 100 cm^2. No transferable alpha contamination above background was detected. A summary of predecontamination levels of fixed alpha, beta, and gamma contamination is shown in Table 2 (see Appendix A for detailed radiological data).

Test results for 62 of the 66 lead bricks employed in testing were decontaminated to a level below ORNL's release limits. Four bricks remained contaminated upon termination of the demonstration. The decontamination factors ranged from 1 to 2750, with an average of 180 for nontransferable contamination. The liquid waste generated by the CIB technique was analyzed to determine whether it was characteristically hazardous. Under RCRA guidelines hazardous wastes are either ignitable, reactive, corrosive, or toxic according to a specified test called the Toxicity Characteristic Leaching Procedure (TCLP). The TCLP toxic waste is waste that has the potential to leach certain metals, pesticides, or organics using the extraction that is detailed in an appendix to the Environmental Protection Agency Regulations, 40 CFR part 261. Maximum levels of contaminants for the toxicity characteristic indicate that the concentration of lead must be equal to or greater than 5.0 mg/L in order to be considered hazardous. The liquid waste that was generated by the demonstration of CIB lead decontamination was analyzed under these guidelines with negative results. No hazardous waste was produced. A total of 60 gal of liquid waste was generated for this demonstration. A TCLP test was completed on five samples, of the liquid waste generated. All samples analyzed less than the 5-mg/L release limit for identifying hazardous waste. Data from both the TCLP analysis and the radionuclide analyses for ^{137}Cs and ^{90}Sr are provided in Table 3. All elements of the system were surveyed/analyzed to determine the displacement of the contamination and to evaluate for waste acceptance.