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Decontamination and Reconditioning of the Argonne National Laboratory - West Casting Laboratory Alpha Glove Box.

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Abstract

The Casting Laboratory (CL) alpha glove box was used to melt and cast metallic uranium and plutonium fuels as part of the Department of Energy's Liquid Metal Fast Breeder Reactor Program. This highly contaminated alpha glove box was decontaminated and reconditioned to allow a change in mission. The goal of reconditioning was to install experimental apparatus and to improve contamination control prior to introducing plutonium-238 into the CL glove box. Construction of a glove box containment structure and an increase in room ventilation were required. A temporary breathing air station was provided for personnel protection as well as personnel comfort. The historical contamination levels, the decontamination techniques, and the results of decontamination also are presented. The health physics aspects of the CL alpha glove box project may be applicable to other glove box refurbishment or decommissioning projects.

Introduction

Plutonium-238 (^{238}Pu) metal was introduced at the Argonne National Laboratory - West (ANL-W) site during ceramic waste form research activities which were part of the Spent Fuel Treatment Demonstration Project. Ceramic waste form research required the performance of accelerated alpha radiation damage research. Radiological damage to ceramic waste forms can be caused by three mechanisms: elastic collisions which cause atomic displacements, ionization effects, and transmutation. The ceramic waste form research focused on the atomic

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displacements caused by alpha radiation. Introduction of ^{238}Pu into the ceramic waste matrix allows one to simulate 1,000 years of storage in approximately four years. The cost and schedule for converting the ANL-W, Fuel Manufacturing Facility from a uranium facility to a plutonium facility resulted in the decision to locate the experimental apparatus in the Casting Laboratory (CL) glove box which was classified as a plutonium facility. Project needs required the installation of a small-scale molten salt furnace, a hot uniaxial press, and other equipment into the CL glove box.

The CL is located in the B-wing of the Laboratory and Office building on the ANL-W site. The CL glove box is a large two-sided, argon atmosphere glove box constructed by connecting two smaller glove boxes via a central feed through. Each side of the CL glove box has two rows of four windows. The lower windows are 3 ft. x 3 ft. and contain two sets of clamp-on type glove ports: one above the other. The upper windows are 1 ft. x 3 ft. and contain single sets of clamp-on type glove ports. The southern glove box is partitioned into a south section and a center section while the northern glove box is not partitioned. The south section of the south glove box was used for final decontamination and packaging of fuel pins prior to their removal from the glove box. This section had the lowest level of plutonium-239 (^{239}Pu) contamination. The central section of the south glove box was used to load fuel slugs into fuel pins and to weld the pins closed. As a result, this section had a higher level of ^{239}Pu contamination. The northern glove box housed the casting furnace. This section was used to load the casting crucible, to cast metallic plutonium fuels, and to shear the fuel slugs to appropriate lengths. The north section had the highest level of ^{239}Pu contamination. The air flow within the glove box was from the south section to the center section and then to north glove box.

The CL glove box was used to process 300 grams of ^{239}Pu per metallic fuel casting without significant contamination control problems. A series of experimental castings, each containing up to 5 grams of americium-241 (^{241}Am), also was performed in the CL glove box without significant contamination control problems. However, minor contamination has been associated with handling these quantities of material in the CL glove box. Plutonium-238 (^{238}Pu) has a 87.7 year half-life which is approximately 275 times shorter than ^{239}Pu (24,000 years) and approximately five times shorter than ^{241}Am (433 years) resulting in equivalent differences in specific activity. Plutonium-238 has a specific activity of $6.3 \times 10^5 \text{ MBq g}^{-1}$, ^{239}Pu has a specific activity of $2.2 \times 10^3 \text{ MBq g}^{-1}$, and ^{241}Am has a specific activity of $1.3 \times 10^5 \text{ MBq g}^{-1}$. Due to its high specific activity, ^{238}Pu has unique characteristics which present serious contamination control concerns which in turn created concern about the ability of the glove box to contain ^{238}Pu without significant contamination control problems.

Glove Box Reconditioning

Evaluation of CL reconditioning options

The primary goal of reconditioning was to install equipment for use in ceramic waste form development (installation would not require the glove box to be breached). The secondary goal was to improve the radiological conditions and the contamination control capabilities of the CL glove box. Historically, the glove box has had significant levels of alpha contamination and radiological conditions would be improved by decontaminating the glove box. The most recent glove box smears were taken in November 1994 and showed significant levels of contamination (Table 1). The glove box has been used infrequently since November 1994, so these levels were considered to be representative of the current conditions.

Contamination control could be improved by replacing the clamp-on type glove ports and/or replacing the window gaskets and windows. Providing proper containment while changing gloves on the clamp-on type glove ports is difficult and mistakes often lead to contamination of the glove port, the window, and other areas of the CL. Also, the window gaskets were more than 15 years old and their integrity could not be verified. With the introduction of ^{238}Pu , it was desirable to change the window gaskets, windows, and glove ports to eliminate any potential for external contamination of the glove box. Therefore, several decontamination and reconditioning options were developed.

Decontamination of the CL glove box prior to implementation of the new program would provide a cleaner environment during equipment installation. However, this option would not provide better contamination control once ^{238}Pu was introduced into the glove box.

Changing a few selected windows and glove ports following decontamination would provide lower contamination levels during equipment installation. This change would include the use of new gaskets which would provide better seals and contamination control. The installation of push-through glove ports would limit the potential for contamination spread during routine glove changes. The removal of windows would eliminate several complications expected during equipment installation. With this option, there was a risk of ^{239}Pu contamination spread when the glove box is breached and ^{238}Pu contamination spread during ceramic waste form research.

Changing all gaskets, windows, and glove ports following decontamination would provide lower contamination levels during equipment installation. The change of windows would include the

use of new gaskets which would provide better seals and contamination control. The installation of push-through glove ports would limit the potential for contamination spread during routine glove changes. The removal of windows would eliminate several complications expected during equipment installation. With this option, there would be a risk of ^{239}Pu contamination spread when the glove box was breached. However, the potential for ^{238}Pu contamination spread during ceramic waste form research would be significantly reduced.

After considering the operational history of the CL glove box, the characteristics of ^{238}Pu , and the reconditioning options, it was still unclear if the risk of breaching the glove box for these modifications outweighed the risk of no action. For this reason, a decision was made to decontaminate the CL glove box and a three-week long decontamination effort was begun. The first week was spent performing housekeeping activities on the glove box. Housekeeping activities identified all nonessential equipment and materials which could be removed from the glove box. Once identified, these items were sealed in plastic bags, bagged out of the glove box, and placed in 55-gallon waste drums. All essential items and items too large to bag out of the glove box were stored in either the casting furnace or the transfer port.

The initial decontamination consisted of a thorough cleaning of all surfaces with disposable paper wipes dampened with industrial glass cleaner. The north glove box and center section of the south glove box were cleaned three times using this technique while the south section of the south glove box was cleaned twice. This technique removed all visible grime from the glove box surfaces and presumably removed a significant portion of the loose contamination. Then, a commercial decontamination solution and disposable paper wipes were used to perform a final

cleaning of the glove box. During this step, all three sections of the glove box were cleaned five separate times. At the completion of decontamination, smears were taken using 1.75 in. smear discs which showed significant improvement in the contamination levels (Table 1). Due to the dramatic decrease in contamination levels, it was decided to replace all gaskets, windows, and glove ports.

Push-through glove ports were selected to replace the clamp-on type glove ports. The push-through design of the new glove ports should eliminate most contamination control concerns during glove changes. The new push-through glove ports did not fit into the existing window openings cut for the clamp-on type glove ports, so replacement of the glove ports required replacement of the window gaskets and windows. A decision was made to replace the existing plexiglass windows with stronger lexan windows.

Preparations for CL reconditioning

It is standard practice at ANL-W to design and procure secondary containment constructed of herculite for projects with significant contamination concerns. Unfortunately, the schedule for CL modifications and the room size did not allow for use of a herculite containment structure. Instead a containment structure was constructed from lumber and fire retardant plastic which is the standard practice for projects with low levels of contamination. The lumber was coated with a latex fire retardant paint prior to construction. The walls of the containment structure were constructed with 2 in. x 4 in. lumber using standard house framing construction. The south wall was framed approximately 3 ft. from the double door entry to the CL, so a step out area could be established. This wall was constructed with two doors for containment entry from and exit to the

step out area. After the frame was completed, fire retardant plastic was attached to the outside of the structure and a second layer was attached to the inside of the structure. The floor of the containment structure was covered with blotter paper for ease of decontamination during glove box modifications. All external surfaces of the glove box also were covered with plastic. Individual sections of plastic were removed when access to a specific area of the glove box was required.

Building the containment structure and covering the glove box with fire retardant plastic required both the continuous air monitor (CAM) and the fix air sampling system (FASS) be taken out of service. To compensate for the loss of air monitoring, portable air samplers were placed inside the containment structure and in the step out area. These air samplers were run during each entry and the samples were counted at the conclusion of each entry. Airborne alpha activity was not detected inside the containment structure or in the step out area at any time during glove box reconditioning.

During the design phase of this project it was determined that an increase in glove box ventilation was required. Two options were investigated: locating a temporary, higher efficiency particulate air (HEPA) filtered blower in the B-wing corridor or using the room ventilation to increase the existing glove box ventilation. The temporary, HEPA filtered blower would be placed in the B-wing corridor and connected to an existing glove port. A negative pressure would be provided to the glove box by the blower and the blower exhaust would be routed to the room exhaust. Placing the blower in the B-wing corridor would have required removal (and eventual replacement) of several cinder blocks to permit routing of the temporary ductwork

through the wall. The removal of these cinder blocks was unacceptable, so the second option was pursued.

Increasing the glove box ventilation by temporarily connecting it to the room exhaust would result in contamination of this system. The damper downstream of the room exhaust was set to provide an air flow rate of 1500 cubic feet per minute (CFM) and had the ability to provide 2400 CFM of air flow. With this option, the air flow would be from the B-wing corridor, to the CL, to the containment structure, to the glove box, and to the HEPA filtered room exhaust. The risk of contaminating the room exhaust was found to be acceptable. Thus, one end of a flexible hose was connected to an existing glove port on the north glove box and the other end was connected to the room exhaust. The down stream damper on the room exhaust was then opened to provide 2400 CFM of air flow. This provided an appropriate negative pressure for the glove box and the containment structure.

In 1995, a similar window and glove port replacement project was performed on a similar alpha glove box. This work was performed wearing full face respirators, cotton coveralls, two pair of tyvex coveralls, two pair of gloves, and two pair of shoe covers. Due to the stress of working in a respirator and this level of protective clothing, only one window could be replaced by the crew before reaching exhaustion. Therefore, a decision was made to provide breathing air to the CL specifically for the glove box reconditioning project. Plant air was plumbed into the B-wing corridor outside the CL, four breathing air hose penetrations were made through the CL's south wall, and a portable air station was procured.

The portable air station provided Grade-D air for working in hazardous environments with airline respirators. The system was designed to provide continuous positive pressure to Type-C respirators. In the event of a main air supply pressure failure, the portable air station automatically switched to reserve air cylinders. If the system switched to reserve air, an alarm would activate to warn workers. When the main air supply was restored, the system automatically would return to normal operation.

CL reconditioning

At this point, the CL was prepared and the glove box reconditioning could begin. First, the upper windows on the CL glove box were replaced. The use of breathing air allowed as many as three windows to be changed during a single entry. Once all eight upper windows were changed, three of the four windows in the north glove box were replaced. At this point, placement of equipment into the glove box could begin. The equipment to be installed into the glove box consisted of a hot uniaxial press, a small scale molten salt furnace, a large transfer port, and two small hoists. Installation of this equipment required that several cuts and welds be made on the floor and south end of the glove box. A plasma torch was used to make the required cuts and tungsten inert gas welding was used to make the required welds. During cutting and welding operations, cotton coveralls and tyvex coveralls used as protective clothing were replaced with fire resistant cotton coveralls and fire resistant tyvex coveralls. The difficulty of cutting and welding through glove ports was eliminated by coordinating all cutting and welding operations with lower window removal. Once cutting and welding was completed in a section of the glove box, a new lower window was installed. Installation of new lower windows at this time prevented them from being damaged during cutting and welding operations.

Clean-up of CL reconditioning

At the completion of the job, all nonessential items were removed from the glove box and disposed of as radioactive waste. The internal surfaces of the glove box were then cleaned with industrial glass cleaner. After several wipe downs, all construction grime was removed and the interior of the glove box was painted. Once the interior was painted, the blotter paper floor of containment was removed, disposed of as radioactive waste, and replaced with new blotter paper. The plastic sheeting covering the glove box exterior was removed and disposed of as radioactive waste. The inner layer of plastic was removed and disposed of as radioactive waste. The lumber used to frame the containment structure was surveyed with a hand-held meter for contamination and was found to be contamination free. The blotter paper floor of the containment structure was surveyed using a dust mop. The floor was found to be clean, but was disposed of as contaminated waste. A dust mop survey was then completed for the CL floor and it was found to be contamination free. The outer layer of plastic on the containment structure was removed and disposed of as radioactive waste. The frame of the containment structure was dismantled and surveyed with a hand-held meter, again, prior to disposal as clean waste. At this point, a detailed smear survey was completed on the glove box exterior. Low levels of alpha contamination were discovered on several windows and glove ports. This contamination was tracked to the glove insertion tool. All windows and glove ports, as well as the glove insertion tool, were decontaminated to background levels. Finally, the CAM and the FASS were returned to service to monitor radiological conditions during ceramic waste form research.

Conclusion

The introduction of ^{238}Pu into the CL glove box created concern about the ability of the facility to isolate this material from the work place. The goal was to recondition the glove box prior to the introduction of ^{238}Pu . However, concerns about the existing level of ^{239}Pu contamination made reconditioning of the glove box risky. For this reason, a commitment was made to decontaminate the glove box before finalizing a decision on reconditioning. The level of ^{239}Pu contamination was decreased by several orders of magnitude by committing the necessary resources to decontamination and through the use of different decontamination solutions. The low level of contamination present after decontamination reinforced a decision to recondition the glove box.

The glove box required significant preparation after decontamination and prior to reconditioning. A containment structure was built to protect against the spread of contamination. Supplemental air monitoring was established to passively monitor airborne contamination levels and the potential spread of contamination. A breathing air station was established in the CL corridor to protect workers from airborne activity and to provide comfort during glove box modifications. The ventilation system was modified to boost the negative pressure on the glove box during modifications.

These preparations resulted in the successful reconditioning of the glove box. The breathing air station provided sufficient respiratory protection for workers during the project. Also, the level of comfort provided by breathing air allowed workers to change up to three windows during a single entry. In the past, workers in respirators were able to only change one window before

reaching exhaustion. The supplemental air monitoring showed the negative pressure provided to the glove box was successful at preventing the spread of airborne contamination. The final smear survey showed the containment structure was successful at preventing the spread of contamination to the walls and floor of the CL. The reconditioning of the highly contaminated casting laboratory alpha glove box was accomplished by committing proper resources to the project, employing good health physics practices, and establishing proper contamination control measures.

Table 1. Gross alpha contamination levels (becquerels 100 cm⁻²).

Smear Location	November 1994	June 1996
North box, East window	6.7×10^4	5.2×10^0
North box, West window	5.3×10^4	3.7×10^1
North box, Floor	3.0×10^5	5.7×10^1
Center box, East Window	4.5×10^4	4.7×10^1
Center box, West Window	4.0×10^4	3.0×10^1
Center box, Floor	1.9×10^5	3.7×10^1