Plutonium Immobilization Program - Cold Pour Phase 1 Test Results

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PLUTONIUM IMMOBILIZATION PROJECT – COLD POUR PHASE 1 TEST RESULTS (U)

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ABSTRACT

The Plutonium Immobilization Project will disposition excess weapons grade plutonium. It uses the can-in-canister approach that involves placing plutonium-ceramic pucks in sealed cans that are then placed into Defense Waste Processing Facility canisters. These canisters are subsequently filled with high-level radioactive waste glass. This process puts the plutonium in a stable form and makes it unattractive for reuse. A cold (non-radioactive) glass pour program was performed to develop and verify the baseline design for the canister and internal hardware. This paper describes the Phase 1 scoping test results.

Figure 1: Typical rack

process puts the plutonium in a stable form and makes it unattractive for reuse. A cold (non-radioactive) glass pour program was performed to develop and verify the baseline design for the canister and internal hardware. This paper describes the Phase 1 scoping test results.

I. BACKGROUND

The Plutonium Immobilization Project (PIP) is a DOE-sponsored joint venture combining the talents of the Savannah River Site (SRS), Lawrence Livermore National Laboratory (LLNL), Argonne National Laboratory (ANL), and Pacific Northwest National Laboratory (PNNL) to disposition excess weapons grade plutonium. This project uses the can-in-canister (CIC) approach. CIC involves encapsulating plutonium in ceramic forms (or pucks),

placing the pucks in sealed stainless steel puck cans, placing the cans in long cylindrical magazines, latching the magazines to racks inside Defense Waste Processing Facility (DWPF) canisters, and filling the DWPF canisters with high-level waste glass. This process puts the plutonium in a stable form and makes it unattractive for reuse.

The DWPF has successfully filled hundreds of empty canisters, so glass flow behavior in empty canisters is well understood. However, the CIC hardware presents a new set of operational concerns. Among these, premature glass freezing and CIC hardware structural integrity are issues that require additional study. Both modeling and test programs are underway to address these issues. Described herein are the results of the first phase (Phase 1) of non-radioactive glass pour tests which were designed to assess hardware structural integrity and glass flow characteristics under all DWPF conditions.

II. DISCUSSION

The objective of Phase 1 testing was to observe the effects of the glass on the hardware, and vice versa. The Phase 1 cold pours tested three hardware configurations. All three configurations consisted of fully equipped DWPF canisters (i.e. internal rack and full compliment of magazines and cans). Three rack designs, eight magazine designs, and two lateral latching configurations were tested. (Typical rack and magazine designs are shown in Figures 1 and 2.) Each rack carried seven magazines, and each magazine held four cans. All internal hardware (rack, magazines, and cans) was made of 304L stainless steel. The cans were loaded with

Figure 2:
Typical
magazine

either non-radioactive titanate-based ceramic pucks (fabricated by LLNL), ceramic surrogate logs, or stainless steel bars. The ceramic pucks could not be used exclusively because not enough were available in time for the test. Therefore, ceramic logs (Harbison-Walker Aurex 90 chrome-alumina brick) were used because their thermal properties were similar to the ceramic pucks. These ceramic logs were lighter than the pucks; therefore, stainless steel bars were installed in appropriate can locations to simulate the effects of a full weight magazine. For these tests, the racks were configured with four different magazine types. Three of the magazine types were arranged in pairs (taking up six positions) and a fourth type was placed in the seventh position. Magazine pairing was done to observe glass flow between like magazine types. Finally, two canister assemblies were filled with simulated DWPF waste glass at the actual pour rate and a third was partially filled at a lower "worst case" fill rate.

III. TEST RESULTS

Phase 1 test results consist of observation of glass flow, temperature measurements and hardware deformation measurements.

A. GLASS FLOW

Digital video recorded during the pour and post-test destructive analysis were used to assess glass flow.

A video recording taken during the pour provided larger-scale visual information on glass flow phenomena. Frames from that recording are shown in Figures 3 and 4. Figure 3 shows the pour just beginning. Figure 4 was taken at a glass height of approximately 6" (150 mm), and glass can be seen flowing over the lower plate of the rack. No voiding or premature glass freezing was observed.

B. TEMPERATURE ANALYSIS

One of the three test configurations was instrumented (23 thermocouples, digital video camera, and scale). Both glass and metal temperatures were measured at various heights and radial locations. Figure 5 (next page) shows glass temperatures at various heights, measured roughly 6" (150 mm) from the center of the canister. This figure gives a good indication of maximum glass temperatures inside the canister. Can temperatures were also measured, and Figure 6 (next page) shows temperature data taken from the can OD on the inboard side. This temperature reading is an important parameter in determining can material strength and internal pressure. Preliminary modeling showed that temperatures must exceed 1100C

Figure 3: Glass pour video (beginning of pour)

Figure 4: Glass pour video (height approx. 6" (150mm))

to affect can structural integrity. As shown in Figure 6, can temperatures stayed below 900C.

C. HARDWARE DEFORMATION

Post-test destructive analysis for evidence of hardware deformation consisted of making radial cuts at different elevations through each of the test canisters. Some cuts were performed using a diamond wire saw and others were done with a large band saw. These cuts exposed glass and metal cross-sections for inspection. Figure 7 shows a typical section. Visual examinations verified that the simulated waste glass filled small crevices in the magazines and completely filled the annular spaces between the magazines and cans, indicating good glass flow. Dimensions such as magazine OD, can OD, support rod OD, and support rod spacing were also taken at each of the exposed cut faces. These measurements verified that the CIC hardware did not experience measurable plastic deformation during the pour or later as the glass cooled.

Figure 5: Glass temperatures at various heights (height measured from canister bottom).

Figure 6: Can temperatures at various heights (height measured from canister bottom).

Figure 7: Canister slice with close-up

D. CONCLUSIONS

Favorable results were achieved in the PIP Phase 1 cold pour test program. No voiding was observed, and glass appeared to have filled all spaces in the canister including small crevices between steel parts. No measurable plastic deformation was observed in any of the CIC hardware.

IV. PLANNED ACTIVITIES

The Phase 1 Test pours conducted in 1999 were scoping tests intended to verify design concepts. A second phase of cold pour testing at CETL is planned for FY 2000. These tests are intended to increase confidence in the hardware and are not expected to result in design changes. Phase 2 will also be used to demonstrate compliance with the Plutonium Immobilization Product Specification (PIPS) and therefore must be performed in accordance with the applicable repository Quality Assurance requirements, e.g., RW-0333P. The development of other PIP equipment will continue through 2001, then SRTC will prepare a series of System Design Descriptions. These documents will become the design basis for the Architectural and Engineering Firm chosen to build the PIP facility.

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Dr. Gregory L. Hovis is a Principal Engineer in the Savannah River Technology Center (SRTC) Engineered Equipment and Systems Department. [SRTC is the applied research and development laboratory at the SRS.] Lee Hamilton is a Senior Mechanical Engineer in the

Engineered Equipment and Systems Department, and Michael Smith is a Principal Engineer in the SRTC Waste Treatment Technology Department.

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