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H Canyon Safeguards Test Bed Activities

Lindsay Sexton, Kenneth S. Fuller, Jr., Michael K. Holland

Savannah River National Laboratory, Aiken, SC, USA,

Abstract

Over the past few years, the National Nuclear Security Administration Office of Nuclear Safeguards and Security has sponsored a project to establish a Safeguards Test Bed at the Savannah River Site's (SRS) H Canyon Facility to evaluate novel technologies being developed across the DOE complex. H Canyon provides an appropriate location for testing many technologies focused on monitoring the back end of the nuclear fuel cycle because it is the only nuclear chemical separations plant still in operation in the U.S. Historically, this facility recovered uranium and neptunium-237 from aluminium-clad, enriched-uranium fuel tubes from SRS nuclear reactors and other domestic and foreign research reactors. Today the facility, in conjunction with SRS HB Line nuclear facility, is working to provide the initial feed material to the Mixed Oxide Fuel Fabrication Facility. Many additional campaigns are also in the planning process, including processing of used nuclear fuels. These on-going campaigns serve as the basis for safeguards technology demonstrations. The F/H Analytical Laboratory, which supports H Canyon operations, has also been included as a part of the Safeguards Test Bed.

H Canyon, F/H Analytical Laboratory, and the Savannah River National Laboratory (SRNL), have collaborated with several groups in the DOE complex to conduct demonstrations of novel safeguards technologies at SRS facilities. The first technology to be installed and tested as part of the Safeguards Test Bed was an in-line UV-visible spectrophotometer, developed at Argonne National Laboratory (ANL), to monitor Pu in solution. Testing of this instrumentation was recently completed. This spectrophotometer was effective at monitoring the Pu valence states during H Canyon operations. There are currently three additional technologies planned for demonstration in either H Canyon or F/H Laboratory. These include an additional ANL UV-visible spectrophotometer that will be tested at another location in H Canyon; a benchtop high resolution x-ray spectrometer, being developed by Los Alamos National Laboratory (LANL) that will be tested in F/H Analytical Laboratory; and a wavelength dispersive spectrometer, also being developed at LANL, that will be tested in H Canyon. This paper will summarize current R&D testing and discuss possible future collaborations.

Introduction

The Savannah River Site's (SRS) H Canyon Facility is the only large scale, heavily shielded, nuclear chemical separations plant still in operation in the U.S. The facility's operations historically recovered uranium-235 (U-235) and neptunium-237 (Np-237) from aluminium-clad, enriched-uranium fuel tubes from Site nuclear reactors and other domestic and foreign research reactors. Today the facility, in conjunction with HB Line, is working to provide the initial feed material to the Mixed Oxide (MOX) Facility also

located on SRS. Many additional campaigns are also in the planning process. Furthermore, the facility has started to integrate collaborative research and development (R&D) projects into its schedule.

H Canyon can serve as the appropriate testing location for many technologies focused on monitoring the back end of the fuel cycle, due to the nature of the facility and continued operation. Over the past few years, the National Nuclear Security Administration Office of Nuclear Safeguards and Security has sponsored a project to establish a Safeguards Test Bed at the SRS H Canyon Facility to evaluate novel technologies being developed across the DOE complex. The F/H Analytical Laboratory, which supports H Canyon operations, has also been included as a part of the Safeguards Test Bed. The purpose of conducting these demonstrations at H Canyon will be to demonstrate the capabilities of the emerging technologies in an operational environment.

H Canyon Background

H Canyon (Figure 1) was constructed in the early 1950's and began operation in 1955. The facility's operations historically recovered U-235 and Np-237 from aluminum-clad enriched-uranium spent fuel from site nuclear reactors and other domestic and foreign research reactors using a chemical separations process.

Figure 1. H Canyon Facility at Savannah River Site

The H Canyon facility is 1025 feet long, 122 feet wide and 71 feet tall. It consists of both a warm and hot canyon divided into 18 sections/cells with several areas to accommodate the various stages of material stabilization. Between the canyon processing areas are control rooms to monitor equipment and overall operating processes, equipment and piping gallery for solution transport, and sampling aisles for process monitoring (Figure 2). So that worker exposure is minimized, work in the canyon, including maintenance, is remotely performed by unique overhead bridge cranes. Thick, dense concrete walls separate workers from the actual processing areas, providing added protection.[1,2]

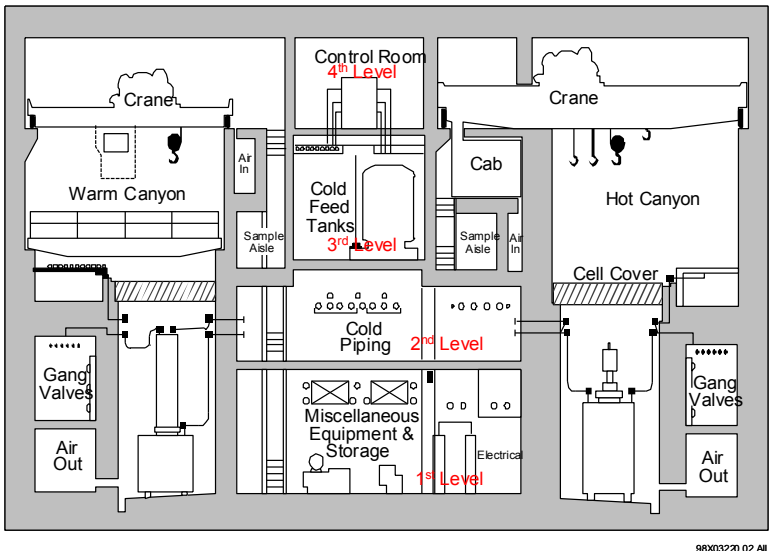


Figure 2. Cross-section of H Canyon.

The sample aisle, located on the 3rd level of both the hot and warm Canyon, is used to obtain sample solutions from Canyon vessels for process control and material accountability. Process solutions are obtained via an air-assisted vacuum lift sampler. The system draws the process liquid from the vessel through piping embedded in the thick concrete wall to a sampling station provided for each vessel, as shown in Figure 3. To ensure homogeneity, the solution in the vessel is agitated for a period of time prior to sampling. The agitated liquid is recirculated through a small vial (10 ml) for a minimum of thirty minutes to further ensure homogeneity.

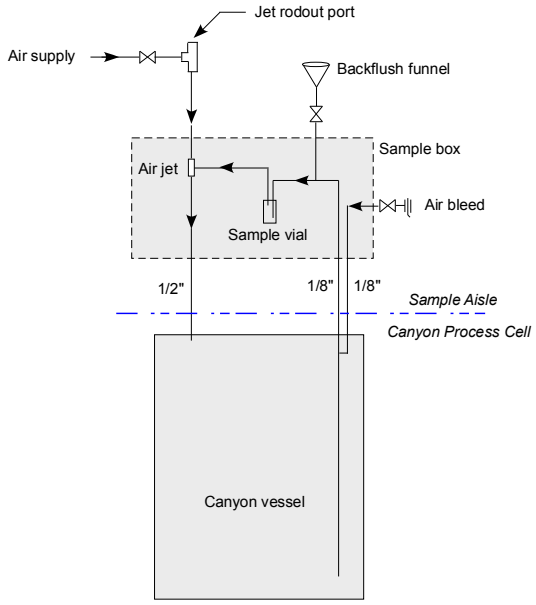


Figure 3. Schematic of H Canyon sampler.

For solutions of low radiation, the sample vials can be placed directly onto the needles to allow circulation of the liquid. For highly radioactive solutions, the sample vial is introduced into the sample box via a heavily shielded "doorstop" made of lead or depleted uranium (Figure 4). The doorstop is rolled into position under the needles, and then raised by a pneumatic cylinder to allow the needles to penetrate the rubber septum in the vial cap.

The sample aisle has proven to be a very convenient location for testing instruments in the Canyon, as it has less contamination than the processing areas, is easier to access, and is the most cost-effective testing site.

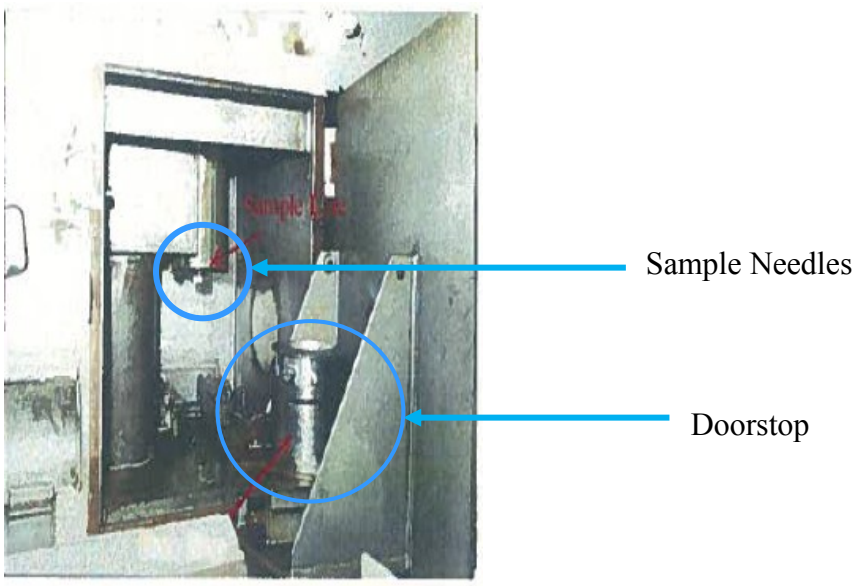


Figure 4. Shielded sampler on hot sample aisle.

Test Bed Background

The H Canyon Safeguards Test Bed project began in FY11 as a feasibility study funded by the Next Generation Safeguards Initiative (NGSI), Office of Nonproliferation and International Security (NIS), National Nuclear Security Administration (NNSA). In the feasibility study the team at SRNL outlined the logistics and requirements for setting up a test bed at H Canyon. In FY12, the NNSA sponsor identified three technologies they were interested in deploying as part of the H Canyon Safeguards Test Bed. These technologies were: 1) a UV-visible spectrometer to monitor Pu in solution (Argonne National Laboratory (ANL)), 2) a high resolution X-Ray fluorescence (hiRX) spectrometer (Los Alamos National Laboratory (LANL)), and 3) a wavelength dispersive spectrometer (WDS) (LANL). The SRNL team worked with the technology developers to investigate the options for testing in H during FY12. During this fiscal year the Test Bed team also decided to add F/H Analytical Laboratory to the test bed project, as it was well suited for deployment of the hiRX technology. In FY13, the first technology to be testing as part of the project was installed. This was the UV-visible spectrometer being

developed at ANL. In FY14, the Test Bed team has been working to install and test an additional UV-visible spectrometer in H Canyon and the hiRX instrument in F/H Laboratory. In FY15, the team will continue working to install and test the WDS equipment.

The Process

A flow chart detailing the typical process for identifying and testing new technologies in the H Canyon Safeguards Test Bed is shown in the figure below. The first step in the process is to identify a potential technology. In all previous cases, technologies have been identified through DOE sponsors. Following identification, an initial on-site meeting at the testing facility (H Canyon or F/H Laboratory) is held. At this meeting researchers and technology developers are given the opportunity to tour the facility and discuss testing feasibility with facility personnel. If the project is determined to be feasible a proposal of work is typically drafted, and at this point in the process funding should be secured before moving forward.

As soon as funding for a test bed deployment is secured, SRNL and the facility will start working closely with researchers to determine the best testing location, instrument requirements, design changes to the facility, etc. These details are typically discussed during a second on-site meeting at SRS. From this meeting, the H Canyon Test Bed program will create a scope document, schedule for performing the work, and begin working on engineering design changes. Note that requirements for scope, schedule, and engineering will vary depending on the facility, and technology. However, in general, this part of the process results in approval documentation that facility managers and design engineers must then approve. Following facility approval the fabrication, installation and testing of the instrument in the Test Bed can be performed.

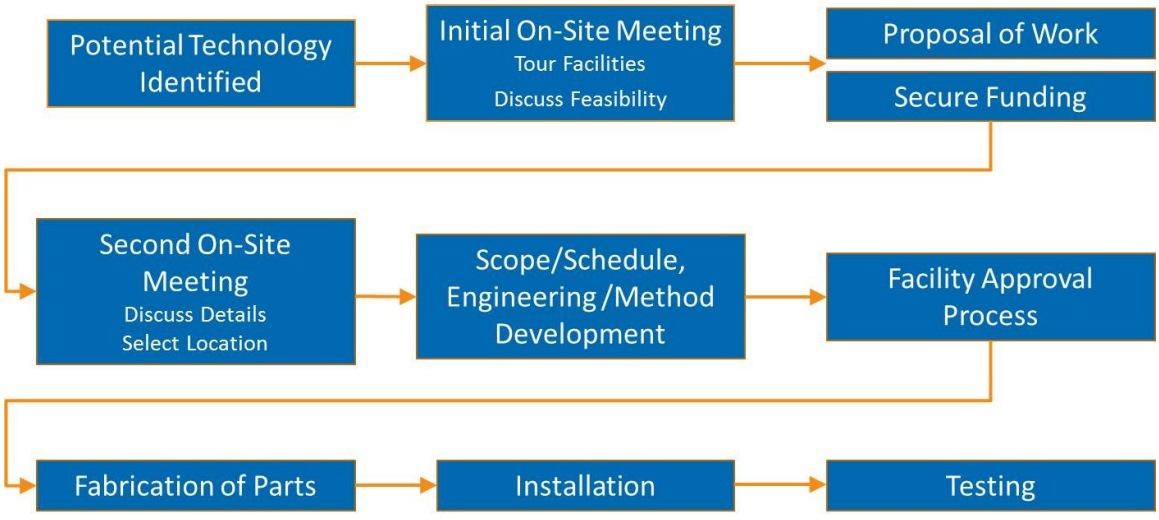


Figure 5. Typical H Canyon Test Bed Process for deploying instrumentation for testing.

Case Studies

To illustrate the typical deployment process the installation and testing of the UV-visible spectrometer, developed at ANL, and the hiRX, developed at LANL, will be presented.

UV-Visible Spectroscopy to Monitor Pu Concentration in Solution.
SRNL, SRS and ANL began working together in FY12 on the deployment of a UV-visible spectrometry system to measure Pu concentration in an H Canyon process stream. In December of 2011, ANL researchers traveled to SRS for an initial on-site meeting to discuss the feasibility of testing their equipment. At this meeting the ANL researchers were allowed to tour H Canyon, meet with Canyon personnel, and receive feedback and suggestions for how and where to deploy the equipment. Following the meeting the ANL and SRS teams worked together to come up with an initial plan for a deployment of the ANL equipment.

A second on-site meeting at SRS was held in July of 2012. At this meeting the details of the planned test bed deployment were discussed. The team decided to coincide testing with the MOX feedstock production campaign. A testing location in-line with a sampler on the hot sample aisle was selected (sampler 12.2). The processing vessel connected to the sampler contained material directly downstream from the dissolver. The testing location was chosen because previous spectroscopy testing had been completed at the site and the needed fiber optic cables for instrument communication were already in place. Design requirements for interfacing the UV-visible spectrometry cell with the sampler were also discussed.

Following this meeting the ANL and SRS teams began working together on the engineering design for a sample flow loop that would remove air from the process stream before flowing into the spectroscopy cell. This design was incorporated into a temporary modification change request to the H Canyon facility. The temporary modification and safety review were approved by H Canyon management in November of 2012. After approval paperwork was complete, the fabrication of the UV-visible sample flow loop began. The installation of the flow loop was then completed in December of 2012. In March of 2013, the spectrometer, light source and optical switches were installed in the H Canyon control room (4^{th} level). Fiber optic cables ran from the control room (4^{th} level) to the sample aisle (3^{rd} level) to connect the equipment.

Testing of the UV-visible spectrometer began the week following completion of the installation. The UV-visible process monitor development team from ANL spent three days at the H Canyon facility testing their equipment in March 2013. In cooperation with H Canyon and SRNL personnel a great deal was accomplished. The overall result was that the UV-visible process monitor was very effective at detecting the presence of Pu in the process stream. The sampling system was designed, built and installed successfully, and performed well. The overall system operated stably for up to six hours and showed that the Pu concentration did not change throughout that time. The system also detected unexpected metals and forms of Pu, showing that the system is capable of characterizing

off normal solution chemistry. The system has since been used by the Canyon to monitor Pu valence adjustments (Pu(VI) to Pu(IV)) with ferrous sulfamate (Figure 7).

Figure 6. ANL's UV-visible spectroscopy equipment installed in-line with H Canyon sampler (hot sample aisle).

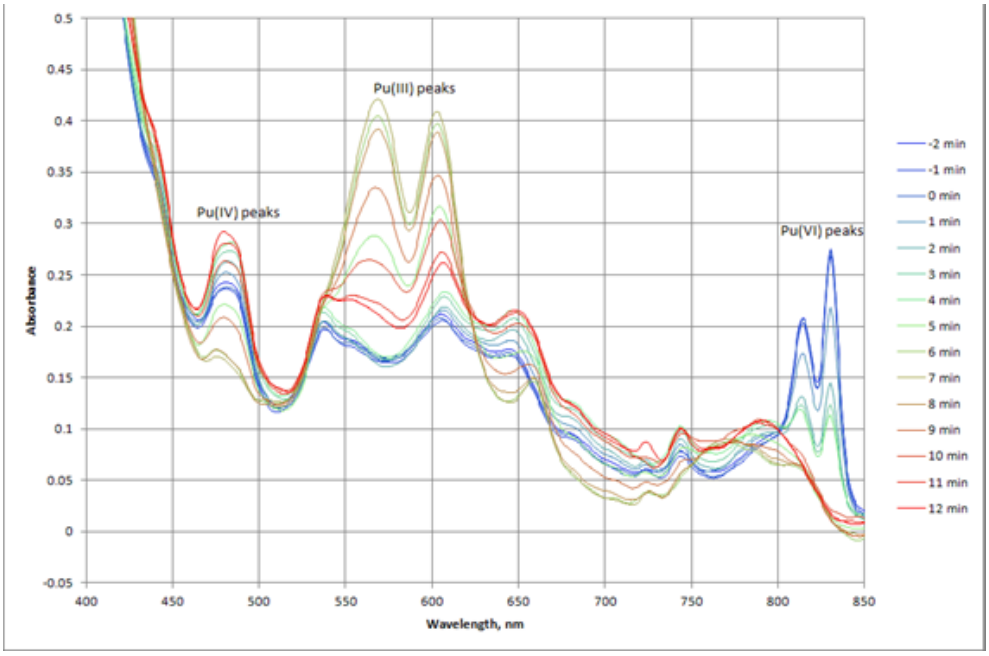


Figure 7. UV-visible spectroscopy data obtained over time during reduction of Pu(VI) to Pu(IV) solution with ferrous sulfamate.

hiRX to Determine Pu Concentration in Spent Fuel.

SRNL, SRS and LANL also began working together in FY12 on the deployment of a high resolution x-ray fluorescence instrument (hiRX) to measure Pu concentration in an H Canyon process stream. In December of 2011, LANL researchers participated in the same initial on-site meeting described above to discuss the feasibility of testing their equipment. At this meeting the LANL researchers were allowed to tour H Canyon, meet with Canyon personnel, and receive feedback and suggestions for how and where to deploy the equipment. During this meeting it was determined that F/H Analytical Laboratory, which analyzes H Canyon samples, would be a more appropriate test location for hiRX. Testing in F/H Laboratory would allow for bench top testing with Canyon solutions of dissolved fuel.

Following the meeting the LANL and SRS teams worked together to come up with an initial plan for a deployment of the LANL equipment. A second on-site meeting was then held in July 2012. During this meeting SRNL, LANL, and the prototype manufacturer, X-ray Optical Systems (XOS) discussed design parameters, user and performance specifications, sample preparation, and facility requirements. LANL and XOS then began working on the hiRX prototype, while SRNL prepared scope and schedule documents and a method development and testing plan. SRNL also consulted during the prototype design and fabrication process and provided an initial GUM (Guide to Uncertainty in Measurement) analysis.

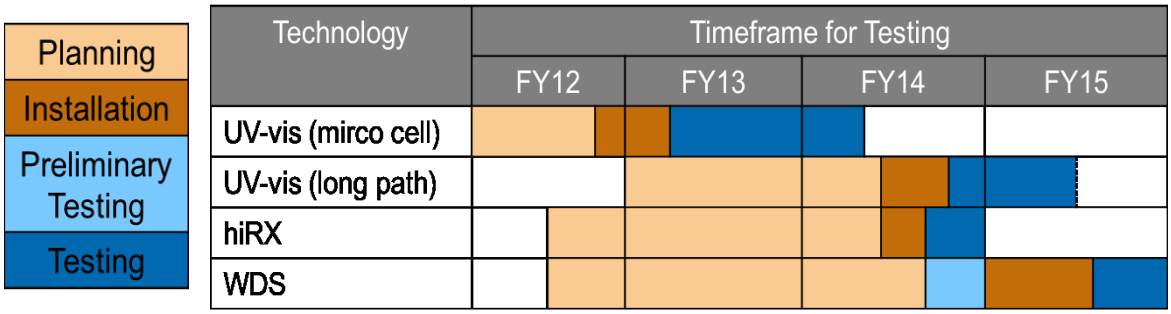
In April of 2014, facility approval for the installation and testing of the hiRX prototype in F/H Laboratory was completed. This included a review by the Laboratory's New Analytical Services Committee and a safety evaluation. XOS completed fabrication of the instrument prototype in March 2014 and SRNL received hiRX in late June. The instrument is currently undergoing testing, which is expected to be completed by the end of September 2014.

Figure 8. hiRX prototype instrument. *Photo compliments of LANL.*

Summary and Conclusions

A process for identifying and bringing in instruments for testing as part of the Safeguards Test Bed has been established. This process, however, varies depending on the particular technology and facility where testing is to occur, as illustrated in the case studies described above. The time frame for completing the process will also vary depending on technology readiness level, project complexity, available facility resources and facility priority. The table below summarizes the duration of various phases of the process for the technologies discussed above, as well as projects that are still in the planning process.

Table 1. Deployment and testing time frame for technology demonstrations.



The completed and ongoing demonstrations at H Canyon have been very successful and have proven the value of collaborative R&D efforts at the Canyon. This work has also opened the possibility for additional projects as added value is seen from both the researchers and facility operators. Over the next several years more projects will be added to the Canyon collaborative R&D portfolio.

Acknowledgements

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References

1. *H Canyon Facts Sheet*, Savannah River Nuclear Solutions, December 2010.
2. *H Canyon: A Unique National Asset*, Savannah River Nuclear Solutions, February 2011.