Fuel Identification in Reactor Fuel Storage Basin Decommissioning

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Abstract: The 105-F or F Reactor was one of the nine reactors constructed by the U.S. Government to support the plutonium production effort initiated in 1942. Deactivation of the F Reactor Fuel Storage Basin (FSB) occurred in 1970. After the FSB was partially drained and all readily identifiable high-dose items removed, fine streambed sand backfill was placed into the remaining 6.1 m (20 ft) of the basin. The FSB is now being excavated and removed as part of Interim Safe Storage of the adjacent reactor building. Removal of any remaining potential spent nuclear fuel (SNF) elements and fuel fragments will be accomplished by using a remote-controlled excavator with bucket, shear, and grapple attachments to expose and remove the fuel elements. Characterization of the final 76 cm (30 in) of sediment is being provided by a combination of several different radiological survey instruments, including an In-Situ Object Counting System (ISOCS[TM5]), GammaCam[TM6], and Laser-Assisted Ranging and Data System (LARADS[TM7]), plus other standard radiological survey tools. The system is able to distinguish fuel pieces from other activated items by the ratio of Cs-137 to Co-60 activity. Use of these various tools will greatly reduce worker exposure and overall cost during SNF removal.

The 105-F or F Reactor was one of the nine water-cooled, graphite-moderated reactors constructed by the U.S. Government to support the plutonium production effort initiated in 1942. The reactor is located along the southern bank of the Columbia River in southeastern Washington State. Construction of the 105-F Reactor began December 1943; operations began in February 1945, and the reactor was shut down in June 1965.

Deactivation of the F Reactor Fuel Storage Basin (FSB) occurred in 1970. Liquid was pumped from the basin until 0.6 m (2 ft) of water remained. Within this bottom 0.6m (2 ft) of water, sediment/sludge and miscellaneous items were left behind. Items known to have been left behind in the basin include fuel buckets, fuel spacers, process tubes, tongs, wooden floor decking, and monorail pieces. It is also suspected that there may be as many as 5 fuel pieces remaining at the bottom of the basin. After the FSB was partially drained, fine stream-bed sand backfill was placed into the remaining 6.1 m (20 ft) of the basin.

The FSB is being remediated in two stages. Stage I will address the FSB fill material from the surface to approximately 5.3 m (17.5 ft) below grade. Stage II will address the remaining 76 cm (30 in) of basin fill material and basin structure itself. The majority of the material and structure

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5 ISOCS is a trademark of Canberra Industries, 800 Research Parkway, Meriden, CT 06450

6 GammaCam is a trademark of AIL Systems, Inc., 455 Commack Road - Deer Park, NY 11729

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will be removed using heavy equipment that is typically used for D&D below-grade material removal, structure demolition, and large-scale soil remediation work.

Removal of fuel elements and hot spot materials will be accomplished during Stage II by using a remote-controlled excavator (such as a Brokk 330, see Figure 1) with bucket, shear, and grapple attachments to expose and remove the fuel elements or hot spot materials. Radiological characterization of the backfill material below 5.3 m (17.5 ft) will be provided a combination of several different radiological survey instruments, including an In-Situ Object Counting System (ISOCS), Gamma Camera (GammaCam), and Laser-Assisted Ranging and Data System (LARADS), plus other standard radiological survey tools (henceforth referred to as the Advanced Characterization System, or ACS). The ACS is able to distinguish fuel pieces from other activated items by using the ratio of Cs-137 to Co-60 activity. Use of the remote excavator and the ACS will greatly reduce worker radiological exposure during lower fill removal and fuel dispositioning, plus provide real-time radioassay for identifying potential SNF.

Figure 1 – Brokk 330N with multiple attachments

The identification and removal of small fuel pieces from beneath 76 cm (30 in) of soil has been an interesting and unique challenge. The goal of the characterization effort has been to minimize worker exposure during excavation, and limit the amount of material shipped to the fuel storage facility. In the past, the only means of identifying potential spent nuclear fuel (SNF) was by initial visual identification in the field followed by radioassay after the SNF had been sent to the storage facility. Many items that appeared to be fuel in previous basin cleanout projects at other reactors were processed, packaged, and shipped to the storage facility, only to be rejected as actual SNF after assay. This resulted in unnecessary additional packaging, transportation, and disposal costs to the project, and additional sampling costs for the storage facility. The ACS used at F reactor is the first attempt to provide real-time assay results in the field, so that only actual SNF is packaged and sent to the storage facility.

The ISOCS uses a high-purity germanium detector for isotopic identification of radionuclides that emit gamma radiation. The unit can be operated remotely by radio frequency (RF) transmitter. The GammaCam generates computer-based images of the gamma ray spectrum and combines digital photograph images with images of gamma ray emissions. The ISOCS and GammaCam are mounted together in a weatherproof mobile basket that can be lifted and positioned with a crane (Figure 2). The LARADS core modular components consist of an auto-tracking theodolite, RF data modems, a rugged field computer with customized software, and low range/high range dose rate instrumentation packaged in a weather-tight container. The theodolite (a modified civil surveying "total station") determines range, azimuth, and elevation to the target, in this case the radiation detector package.

The ACS will be used throughout the removal of the lower 76 cm (30 in) of fill material. Calculations using Microshield™[8] have determined that the ACS should be able to "see" a 2.5 cm (1 in) piece of SNF under 38 cm (15 in) or less of soil with a high degree of certainty, taking into account the radiological background interference from contaminated sediment and contamination on the FSB walls and floor. Therefore, the ACS will be used initially to look for SNF in the top 38 cm (15 in) of fill material, then this material will removed as a single lift to provide access to the last 38 cm (15 in). It is anticipated that all of the fuel buckets (which are 56 – 58 cm (22-23 in) tall) will be removed during excavation of the first lift, so that the only material remaining in the lower lift will be potential SNF and other small items such as fuel spacers, process tubes, tongs, etc. A survey with the ACS of the final 38 cm (15 in) of material will identify any "hot spots" for further removal, or verify that no potential SNF is present, which will allow unrestricted excavation and removal of the remaining material.

Figure 2 – Deployment of GammaCam at 105-F Reactor Fuel Storage Basin

8 Microshield is a trademark of Grove Engineering, 1700 Rockville Pike, Suite 525, Rockville, MD 20852