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Screening of Items for National Nuclear Material Archive

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ABSTRACT

The United States Department of Energy established a National Nuclear Materials Archive to identify, retain, characterize, and manage nuclear material items of historical or forensic interest. Savannah River National Laboratory screened nearly 20,000 items located at the Savannah River Site and identified 341 as potential "Items of Interest." From earlier evaluation and nomination, fuel slugs from the Oak Ridge X-10 Reactor were the first items from SRS to be accepted into the Archive. The X-10 Reactor was the first continuously operating manmade nuclear reactor, starting up in 1943 as part of the Manhattan Project, and served as a prototype for materials production reactors that were built at Hanford and Savannah River.

BACKGROUND

In 2006, a United States National and Homeland Security Directive established the Nuclear Materials Information Program (NMIP), assigned to the Department of Energy (DOE). The primary objective of the NMIP Materials portfolio is for robust technical nuclear forensics analysis to support the national attribution capability.[1]

Figure 1 shows the cornerstones of the NMIP Materials portfolio, including the U.S. National Nuclear Forensics Library (NNFL) (data gathered on items of forensic interest), an "Archive" of items that represent components of the nuclear fuel cycle and production programs, and sponsorship of data gathering and sample analysis. The goal of the Materials portfolio is to ensure the U.S. government could quickly identify nuclear material out of regulatory control as being of U.S. origin or not. The International Atomic Energy Agency (IAEA) is promoting the development of similar programs in all member states to support law enforcement responses to a nuclear security event.[2]

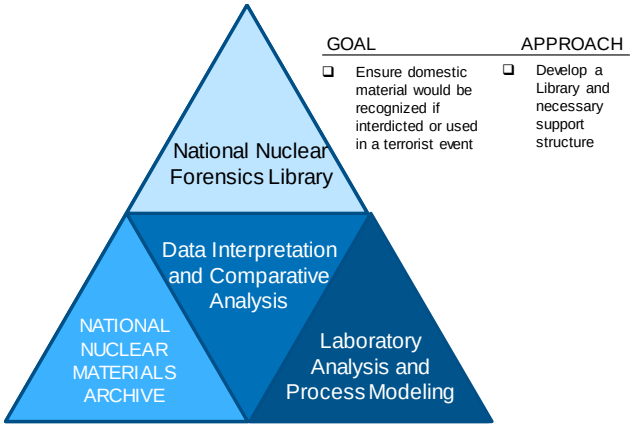

Figure 1. NMIP Materials Portfolio

Considerable information has been gathered for the NNFL, including historical records characterizing materials during the production cycles. Thousands of items from these legacy operations were identified as candidates for a materials Archive. The Archive would identify, store, and track relevant nuclear materials samples that are held anywhere in the United States. Tasks for the Archive program therefore include Sample Selection and Utilization, Sample Storage, Sample Handling and Processing, Transportation and Packaging, and control functions such as database and quality assurance management.

Around 2010, an initial list of more than 30,000 original candidate items was compiled, these items currently being stored across the DOE complex. The bulk of the 30,000 items were remnants from production operations and were stored primarily at the Savannah River Site (SRS), Los Alamos National Laboratory (LANL), and the Oak Ridge Y-12 Plant, with lesser quantities elsewhere in the complex. Many of the original items were similar to each other, and only a small fraction would be carried forward in the studies. Others were judged to be of low interest for retention, analysis, and forensics, either because they resulted from imperfect "pedigree" (tracking from their original creation), or because they were heavily blended materials from 60 years of material recycling and reuse.

After the initial screening of candidate items across the DOE complex, the development of a physical Archive proceeded slowly. In 2016, DOE established a National Nuclear Materials Archive (NNMA) Lead Material Management Organization (LMMO) as a partnership among NMIP, the Office of Nuclear Forensics (NA-83), and the Office of Nuclear Materials Integration (NA-532 or ONMI). [3] ONMI is providing integration support under the banner of DOE Order 410.2 "Nuclear Materials Management," [4] to facilitate progress in item identification and selection, tracking and prioritization, and physical activities. In 2017, the list of 30,000 candidate items was reduced to approximately 700 "Items of Interest," and several nominated items were formally accepted into the Archive, including seven X-10 graphite fuel reactor slugs.

SAVANNAH RIVER ARCHIVE PRESCREENING

Supporting the LMMO, a Prescreening Team at SRNL followed the lead of previous evaluation by the NMIP Archive Sample Selection and Utilization Committee. SRS operated nuclear materials production reactors and is where surplus plutonium from other sites has been consolidated for permanent disposition. The surplus materials resulted from a wide variety of weapons support and fuel cycle operations across the United States.

Of the original 30,000 items identified, SRS had nearly 16,000 of them. The largest single category of the 16,000 items was 6,800 drums of heavy water moderator from idled SRS production reactors; the drums were judged to be neither rare nor unique on a forensic basis. However, three drums of "Dana Water" remain in inventory, examples of heavy water made before the start of atmospheric weapons tests and thus virtually free of tritium contamination. Those drums were tagged as Items of Interest.

Other large quantities of items included legacy surplus plutonium from Rocky Flats, Hanford, LANL, Lawrence Livermore National Laboratory, and SRS. Only a handful of these items was

judged to be representative of unusual or unique origin. The final prescreening reduced the Items of Interest to a manageable handful of 341 items for further evaluation. Other inventory groups were described to allow further review of highly populated categories for examples of unusual nature or pedigree. Irradiated Mark-18A targets, previously identified as the unique source for plutonium-244, are part of a separate materials recovery program sponsored by ONMI. [5]

OAK RIDGE X-10 REACTOR SLUGS

Figure 2. Fueling the X-10 Reactor (circa 1952)

The NNMA accepted a formal nomination of the known, remaining X-10 reactor slugs. In 1943, the X-10 Graphite Reactor (Figure 2) was the first manmade reactor to achieve continuous operation. [6] The reactor was built at the Clinton Engineering Works, later known as the Oak Ridge reservation, following the success of the Manhattan Project's Chicago Pile, and was intended to produce small amounts of plutonium and to prototype fuel cycle and chemical separation support functions that would be implemented at a larger scale for the Hanford production reactors.

Eight of the fuel slugs, loaded during 1943-1945 and irradiated for five years, were transferred to Brookhaven National Laboratory (BNL) in two shipments in 1950 and 1951. One of the fuel slugs was analyzed in the early 1950s and the remaining slugs were sealed and placed in storage. In 2010, BNL sought to reduce its inventories of special nuclear material (SNM), and concluded that the seven remaining slugs were excess to their needs. SRNL recognized the unique nature of the items and agreed to accept the material from BNL for R&D support.

The primary core of the fuel elements is approximately 1 kilogram each of depleted uranium. They measure 10 cm in length by 2.5 cm in diameter (Figures 3 and 4). After irradiation, a typical slug contained 0.9 gram of plutonium with an assay >99% plutonium-239. Reactor codes also predict a unique distribution of fission products. They are currently stored at SRNL in polycarbonate containers with lead shielding in an SNM safe.

Figure 3. Fresh Fuel Slug

Figure 4. Irradiated Slug

ARCHIVE TRACKING AND COORDINATION

ONMI has implemented item-level coordination across the DOE Complex by introducing tracking of accepted Archive items and other candidate items within the Nuclear Materials Management systems. ONMI augmented the annual Nuclear Materials Inventory Assessment, prepared by each site, to include tags for items accepted or nominated for inclusion in the Archive, plus Items of Interest and items previously evaluated and rejected.

FUTURE ACTIVITIES

NNMA activities are complementary to activities of other organizations that are studying rare, unique, or representative nuclear materials, especially those of forensic interest. Archive items and candidates are typically small in SNM content, but different programs have different priorities for analysis, sampling, and storage. The nuclear materials generally are surplus to current programmatic needs and may be subject to disposition if they are not designated for long-term retention. DOE is seeking to consolidate storage capabilities that can be tailored to this mission, to include provisions for opening containers, sampling and analyzing, and repackaging for continued storage (if necessary) or disposition.

The LMMO team is refining a program plan to follow the entire life cycle of NNMA materials (Figure 5): identify data gaps on categories of nuclear materials of interest; institutionalize the identification and selection process; specify sampling and analysis priorities for each candidate item; and develop transportation, retention, and disposition plans.

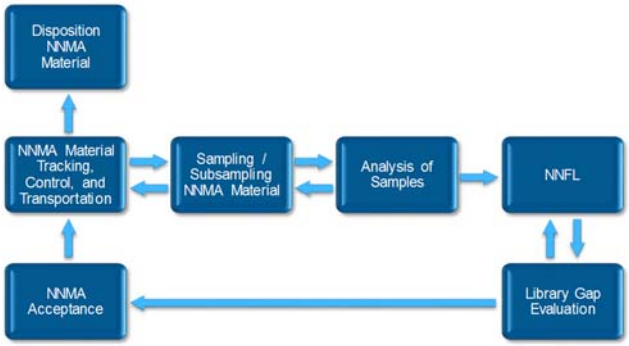

Figure 5. Functions for a Fully Operational NNMA

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