National Nuclear Materials Archive (NNNMA)- Specimen Selection and Sampling at the Y-12 National Security Complex

Jason McCall
Y-12 National Security Complex
Managed and Operated by Consolidated Nuclear Security, LLC

David Speaks
Y-12 National Security Complex
Managed and Operated by Consolidated Nuclear Security, LLC

Matt Thornbury
Y-12 National Security Complex
Managed and Operated by Consolidated Nuclear Security, LLC

ABSTRACT

The National Nuclear Security Administration's (NNSA) Y-12 National Security Complex (Y-12) is a designated National Nuclear Materials Archive (NNMA) site. In order to support the NNMA program, Y-12 is contributing to the fulfillment of specimen needs by implementing a contemplative and anticipatory specimen selection and sampling process for items of nuclear forensic interest. Y-12's historical and continued contributions to the DOE/NNSA nuclear inventory have made the site a prime candidate for finding items of interest for the NNMA program with a traceable production pedigree. The NNMA specimen selection process is guided by the designated NNMA Program Manager. NNMA specimen demand is constituted by the nuclear material items that are representative of the United States (U.S.) Department of Energy (DOE)/NNSA historical and current nuclear fuel cycle. The items of interest are selected as NNMA specimens based on the program demand guidance via NNMA Blue Books. These Blue Books provide the starting point for the subsequent specimen sampling which is an intrinsic function of the NNMA. Y-12 uses various processes for determining the specific items that meet NNMA demand needs and then schedules sampling for subsequent analytical functions. Selection and sampling these items for the NNMA program is a dedicated effort that spans thousands of items located in various buildings throughout the large Y-12 complex. Selecting and sampling these specimens support various U.S. counterterrorism and counterproliferation missions by enabling comparative analyses against interdicted or other nuclear materials located outside of administrative control. Through these activities, Y-12's expertise with U.S. nuclear production and processing operations contributes to the creation of a robust nuclear forensics capability.

EXECUTIVE SUMMARY

The Y-12 National Security Complex (Y-12), located in Oak Ridge, TN, plays an integral part in the National Nuclear Materials Archive (NNMA) program managed by the National Nuclear

Security Administration (NNSA) Office of Counterterrorism and Counterproliferation—Nuclear Forensics (NA-83). The NNMA's mission is focused on collecting, analyzing, and preserving nuclear material specimens that are representative of United States historical and current production signatures, including uranium components in the nuclear weapons program, for forensics purposes. The NNMA makes use of Y-12's wide range of uranium materials process knowledge and expertise to ensure that the identification, selection, and storage/preservation of NNMA uranium specimens are accomplished in support of overall archive objectives. This also involves ensuring that sub-samples are shipped to various labs for forensics-quality analysis.

Since 2010, Y-12 has participated in efforts to identify and preserve uranium materials onsite that meet the acceptance criteria for inclusion in the NNMA. In 2018, under renewed funding from NA-83, Y-12 re-started actively identifying Items of Interest (IOI) in inventory to nominate for analysis and inclusion in the NNMA. IOIs deemed to sufficiently warrant inclusion in the archive are nominated quarterly via the formal program process.

The decision to nominate IOIs is preceded by an investigation of the process history of the specific material. This investigation is used to determine whether the material fills a NNMA "coin slot." The coin slots are pre-determined material descriptions for which the NNMA preferentially desires to retain archive samples as part of the overall program objective. Coin slots are defined primarily by the material, production process, and timeframe in which the material was produced.

Starting in August 2020 and quarterly through May 2021, Y-12 has nominated a total of 108 items for the NNMA in approximately 40 separate nomination packages. The items nominated include materials that represent final products such as weapon system parts, fabricated fuel assemblies, and intermediate process materials.

The effort to provide samples of accepted NNMA materials for high-fidelity laboratory analysis began in 2019 when Y-12 began creating sub-samples from existing specimens in the NNMA. In March 2021, Y-12 began collecting new archive specimens and sub-samples for laboratory analysis from items that were more recently nominated and accepted into the NNMA. A total of 38 additional specimens/sub-samples will have been created by Y-12 by the end of FY 2021.

The process for determining which NNMA items are selected for sampling during a given period is dependent on ease of access/availability, similarity to other potential items, and the requirements of the analytical laboratories. Y-12 works toward batching as many items together for sampling in order to make the process as efficient as possible.

Y-12 support of the NNMA is anticipated to continue over the next several years. However, the identification of new items for nomination to the NNMA is anticipated to slow over the next year, and the focus will shift to further collecting and sampling of currently accepted specimens, shipping of sub-samples to analytical laboratories, and preservation efforts for ensuring that the forensics value of retained NNMA specimens is guaranteed.

BACKGROUND
Since 2010, the Y-12 National Security Complex has supported efforts to identify and retain Y-12 materials of potential interest to the National Nuclear Materials Archive (NNMA). Initial work completed through approximately 2012 with funding from the Department of Energy (DOE) Office of Intelligence/Counter-intelligence identified several pre-existing samples of weapon system parts and other items that were nominated and accepted into the NNMA. Following several years of transition of the NNMA from DOE to NNSA oversight, Y-12 resumed efforts to identify, evaluate, and nominate materials in FY 2018 with funding from the NNSA Office of Counterterrorism and Counterproliferation—Nuclear Forensics (NA-83). Sufficient funding required to support a full-fledged program capable of accomplishing significant scope in support of the NNMA program was received in FY 2021, and Y-12 has made steady progress towards the program's material identification, selection, nomination, and sample collection goals. Y-12 also continues to support the forensics analysis of specimens by creating sub-samples of specimens for shipment to NNMA analytical laboratories.

SPECIMEN SELECTION
The initial step in the process of a material being accepted into the NNMA is the identification of an "Item of Interest" or IOI. A list of the IOIs at Y-12 is maintained so that each of these materials can be flagged in the inventory management system to prevent them from being dispositioned while being considered for NNMA nomination.

Y-12 utilizes in-house materials tracking/inventory databases and other means, such as interfacing with long-time employees with knowledge of historical projects, to carry out the IOI identification step. To assist in these searches, the NNMA program has identified specific needs for certain materials and listed them in "Blue Books" for each major material of interest. These are high-level material demand lists for each of the materials identified for inclusion in the NNMA. Each of these Blue Books has more specific "Coin Slots" identified that describe in more detail the exact material desired for the NNMA, i.e., a production process of the material and, in many cases, a specified range of dates during which it was produced. Using the data from the appropriate Blue Book and related coin slots, it is possible to compare materials inventory databases against the NNMA requirements to complete searches for potential IOIs. Given the large number of uranium objects in storage at Y-12, the Uranium Blue Book coin slots are of most interest by Y-12 for searching and researching potential IOIs.

Separately, the NNMA Program has identified target quantities that are requested to be obtained for each coin slot. This quantity helps determine the number of individual items that may need to be considered for potential nomination in order to meet the minimum amount requested for long-term retention as part of the NNMA. In turn, the selection of specific IOIs, and in particular the number of specific items, may also be tied into this quantity requirement for some situations.

The decision to nominate an IOI for inclusion in the NNMA is preceded by an investigation of the process history of the material in question. The results of this investigation will determine if

the material fills a needed NNMA coin slot or not and ultimately whether it should be nominated for the archive. This information is relatively easy to obtain for certain materials such as weapon system components but can be challenging for other materials without the same level of quality control history. This process also becomes more difficult with older material, and conversely easier for new materials, due to the progressive evolution of electronic records keeping over time.

Without sufficient information about what the material is and when it was produced, it may not be possible to justify a NNMA nomination. In these cases, the material is classified by Y-12 as either "still under investigation" (if there is an indication that more background information can possibly be found) or as "Do Not Nominate" (if no additional information is expected). It may also be possible that the material is found to be of sufficient interest for nomination to the NNMA but it does not fit into an existing coin slot. In these cases, a new coin slot requesting the new material may be included as part of the nomination.

Starting in April 2020 and quarterly through May 2021, Y-12 has nominated 108 additional items for possible inclusion in the NNMA by way of approximately 40 separate nomination packages. To date, all but two of these nominations have been accepted with the remaining items also anticipated to be accepted following resolution of programmatic questions. The items nominated over the past two years include materials from final products such as uranium weapon system parts, fabricated fuel assemblies and intermediate process materials.

SPECIMEN SAMPLING AND SUB-SAMPLING FOR ANALYSIS
Once an item is accepted into the NNMA, Y-12 starts the planning process for obtaining the target amount of the item for long-term retention as a NNMA specimen. Y-12 refers to this process as "sampling," and the planning for carrying out this process is done using standard Y-12 process documentation procedures. In some cases, the entire item (or items) comprises less than the target amount for the specific coin slot. In this case, the whole item is typically utilized but may still require a "sampling" step in order to convert it to the NNMA storage configuration.

The process for determining which NNMA items are selected for sampling during a given period is dependent on a number of factors including ease of access/availability, co-location with other NNMA items, similarity to other available NNMA items, and the current mix of material types scheduled for shipment to the analytical laboratories. Y-12 prefers to batch as many items as possible together for sampling in order to make the process as efficient as possible. This reduces the number of internal documents that must be generated as well as the review/approval time required for each. Batching also allows for the production area being utilized for the sampling to conduct the process in a campaign-type approach in which tooling and fixtures are set up only one time for the entire set of materials being sampled.

Depending on the number of individual items that make up the target amount for each coin slot, certain samples that have been created will also be selected for collection of a smaller amount of material that will be shipped out for forensics-quality analysis by one of the NNMA analytical

laboratories. Y-12 refers to this process as "sub-sampling" and the process is typically carried out at the same time as the NNMA target amount for the sample is being obtained.

The effort to provide sub-samples of accepted NNMA specimens for laboratory analysis began in 2019 when Y-12 started creating sub-samples from existing specimens in the NNMA dating back to the 2012 time period. More than 70 of these sub-samples were sent out for analysis prior to FY 2021. In March 2021, Y-12 also began collecting new archive specimens and associated sub-samples from items that were more recently nominated and accepted into the NNMA. It is currently anticipated that a total of at least 38 new specimens/sub-samples will have been created by Y-12 by the end of FY 2021.

The process for obtaining NNMA samples and sub-samples for analysis typically involves a drilling/machining process for metal specimens. In these operations, as much care as possible is taken during each sample collection to avoid contamination from the surrounding area and from any residual materials remaining from obtaining previous samples. Machine tools and handling items are thoroughly cleaned or changed out between samples, and care is taken to keep each sample isolated until it is packed into an individual container. The exterior of each sample is also cleaned to remove any surface contaminants prior to being packed.

For various reasons, the amount of material per sub-sample requested by each of the analytical laboratories varies between less than 1 gram (g) up to 5 g each which requires these quantities to be taken into consideration when planning for the creation of each individual sub-sample. As such, a multi-year detailed schedule of anticipated shipments to each of the laboratories has been developed by the NNMA program so that these requirements can be included early in the Y-12 process planning paperwork. In order to meet the lab material quantity requirements, it is also necessary to accurately weigh each sample on precision scales prior to being packed for shipment. This information is typically required by the receiving site for obtaining internal authorizations necessary to allow shipment of the material from Y-12.

Y-12 has not yet sampled any non-metal or complex items but anticipates doing so in early FY 2022. Depending on the actual material, this process could be significantly more difficult (in the case of obtaining uranium fuel samples) or significantly easier (when obtaining samples of oxide powders). Y-12 is currently developing the appropriate process instructions for these other material types.

Photos of key steps in the process for obtaining samples and sub-samples from Y-12 metal specimens to date are shown in Figures 1–5. The sub-samples of NNMA specimens being shipped out to other sites for analysis require packing into custom foam inserts within the shipping container drum as shown in Figure 6.

YPH-19-850107.jpg

Figure 1: Uranium Metal Sample Collection

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Figure 2: Cleaning of NNMA Metal Sample

YPH-19-850116.jpg

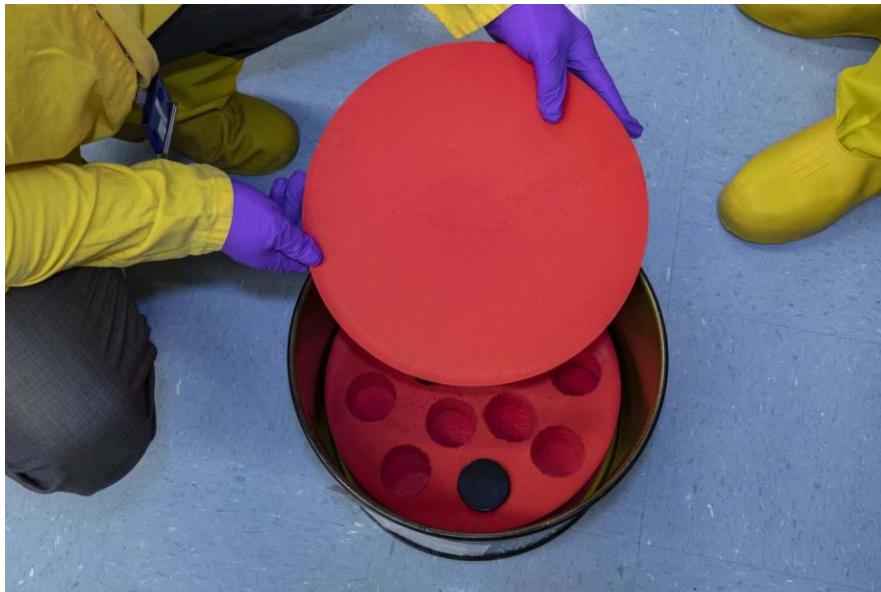**Figure 3: NNMA Metal Samples Being Placed in Glass Storage Jar**

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Figure 4: NNMA Samples Being Weighed

Figure 5: NNMA Sub-Sample on a Scale

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Figure 6: Packing of NNMA Sub-Sample Packed in Foam Insert for Shipment

SUMMARY AND CONCLUSIONS

Since 2018, Y-12 has made significant progress towards goals established by the NA-83 NNMA Program with respect to the identification, selection, nomination, and sample collection of materials for long-term storage and preservation. Y-12 has also been active in supplying sub-samples of NNMA specimens to analytical laboratories for high-fidelity nuclear forensics analysis. It is anticipated that this support for the NNMA will continue for several more years as

the focus moves from the identification and nomination phase towards a sustained effort for obtaining the target quantities of materials for NNMA storage and preservation as well as shipping out the associated sub-samples of these specimens for analyses. A key emphasis will be on ensuring that the forensics value of each NNMA sample is maintained over the anticipated life of the archive.