Contract No:

This document was prepared in conjunction with work accomplished under Contract No. 89303321CEM000080 with the U.S. Department of Energy (DOE) Office of Environmental Management (EM).

Disclaimer:

New Methodology for Peaceful Use Restriction Management at the Savannah River Site*

Catherine M. Mussi[1], Fay Armstrong[2]
1: Savannah River National Laboratory, Aiken SC, USA
2: Savannah River Site, Aiken SC, USA

Abstract:

The Savannah River Site (SRS) contains one of the most diverse collections of nuclear material in the world. These materials also have diverse histories, and many have picked up peaceful use restrictions, like foreign obligations, over time. The acceleration of disposition efforts for this material, as well as the decision to start up a pit production facility, led to an effort to create a more robust system for tracking, auditing, and managing restricted use materials at SRS.

Facility Background:

The Savannah River Site (SRS) is a 310 square-mile site originally built in the 1950s to produce nuclear weapons program material, namely plutonium (Pu) and tritium using High Enriched Uranium (HEU) fuel in heavy water moderated reactors. The site included five production reactors, two large-scale chemical separations facilities, fuel and target fabrication, heavy water purification, and various other support facilities. The site maintained a production mission until the early 1990s when the reactors were shut down as part of the end of the Cold War. As needs changed the capabilities of facilities at SRS were retasked to support processing nuclear materials for safe storage and eventual disposition to support nonproliferation objectives.

Currently there are two distinct pathways that handle peaceful use restricted material at SRS. The surplus plutonium disposition program, and the off-specification (offspec) uranium disposition program. The surplus plutonium disposition program prepares excess Pu for disposal by oxidizing any metal items and diluting the oxide with an adulterant to create a safe and stable waste form for emplacement at the Waste Isolation Pilot Plant. This is a bulk process that splits parent items into a number of smaller quantity items with a reduced attractiveness level suitable for disposal.

The offspec uranium disposition program is for Enriched Uranium (EU) materials that do not meet the purity requirements for reuse without extensive reprocessing like spent fuel from research reactors. These materials are dissolved in batches as part of a bulk process, whereafter the uranium can be run through the H-Canyon solvent extraction process for HEU recovery. Multiple types of fuel are typically dissolved together in the same batch and mixed to create a target enrichment to optimize recovery efficiency. This results in a large volume of pure HEU solution of a consistent enrichment that can be blended to provide a Low-Enriched Uranium product.

Peaceful Use Restrictions:

There are multiple types of peaceful use restrictions that can be placed on nuclear material and they typically can be separated into two groups: domestic encumbrances and foreign obligations. Domestic encumberences are restrictions resulting from an independent US declaration that the material will be under restrictions. The extent of the restriction depends on the details of the declaration and the

same material can be subject to more than one domestic encumberence if it was included in more than one declaration. As an example, much of the SRS inventory of High Enriched Uranium (HEU) and Pu were declared surplus by the Nuclear Weapons Council in 1994 restricting the material from potential use for nuclear explosive purposes. Some of this was then subsequently included in a voluntary offer agreement with the IAEA placing it under IAEA safeguards resulting in it being subject to more than one encumbrance.

There is also a large quantity of foreign obligated material at SRS. Foreign obligations are peaceful use restrictions that result from activities subject to international agreements. A common source of foreign obligated materials at SRS are US origin materials that have been repatriated after being lent to a foreign entity for use in peaceful research programs like research reactor fuel. As materials move throughout the fuel cycle the quantities are tracked and foreign obligations can be layered as the material is transported throughout the world during its lifetime making it subject to more than one agreement and complicating tracking. Table 1 shows the entities that have foreign obligations being tracked on materials at SRS:

Table 1: Foreign Obligation Partners for SRS

Australia	Canada	Euratom[1]	Japan
Switzerland	Argentina	Brazil	Chile

Peaceful use restrictions are assigned and tracked on the site level by submitting transaction and obligation information to the Nuclear Materials Management and Safeguards System (NMMSS) which is the US state system of accounting. This is done using the DOE/NRC Transaction Form 741. Item level tracking of peaceful use restrictions is not required in NMMSS as long as each facility has enough special nuclear material (SNM) inventory in peaceful uses to cover the balance. There is a mechanism using the DOE/NRC Form 741 to transfer restrictions onto substitution materials at another site without materials needing to undergo shipment. Table 2 shows a listing of restricted material types at SRS and what quantities associated with those materials are tracked.

Table 2: Peaceful Use Restriction Tracking Quantities

Material Type	Domestic Encumbrance	Foreign Obligation
Depleted Uranium	N/A	Element mass (kg)
Natural Uranium	N/A	Element mass (kg)
Enriched Uranium	Element Mass (g)	Element and Isotope Mass (g)
Plutonium	Element Mass (g)	Element mass (g)

[1] Euratom is comprised of the following 27 member states: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden. Materials transferred by the United Kingdom under a Euratom agreement have remained governed by the agreement at time of transfer and have not been retroactively converted to a United Kingdom Obligation.

SRS made the decision in 2003 to begin tracking at the item level as a best practice even though it was not required at the time. Today DOE sites are now required to perform a Nuclear Material Inventory Assessment (NMIA) for planning purposes that identifies programmatic aspects of the nuclear materials that are not tracked by MC&A including what materials are being protected as under peaceful use restrictions. This process ensures those materials are not being used for any weapons program activities at that site that are not allowable under their agreements or declarations. SRS goes to the next level and tracks exactly which agreement(s) each item is subject to as a best practice due to the large variety of restrictions present at the site.

This item level tracking can then be used by the facility to make sure they retain that required balance and that the transfer of peaceful use restrictions is documented appropriately if that material leaves the site. If foreign obligated materials are to undergo processing or disposition the site is required to notify the National Nuclear Security Administration's (NNSA) Office of Nonproliferation and Arms Control (NPAC) who will work with the US Department of State to communicate with partner countries and provide guidance to the site to ensure all activities are compliant and properly documented. To date SRS has gotten concurrence and allowance for reprocessing HEU Spent Nuclear Fuel (SNF) through H-Canyon for recovery to downblend for peaceful uses. SRS is currently undergoing this process again to receive guidance for processing foreign obligated materials through the downblend process for plutonium for disposition to include the materials currently under IAEA safeguards.

Prior Methodology:

The original methodology that SRS used was developed before the plutonium disposition program chose downblending as the preferred alternative and before the announcement of the construction of a pit facility at the site. The end result was that the only restricted use material that was moving at all, other than materials undergoing standard surveillances for storage, was the SNF being processed through H-Canyon.

Since H-Canyon is a large bulk process mixing materials of various enrichments of uranium, it was troublesome to determine how to track the partial obligations in the process. Referring back to table 2, it is easily seen how tracking partial uranium obligations becomes problematic when different enrichments are mixed since both element and isotope are tracked separately and will not match the product enrichment. That difficulty is then made worse if Natural Uranium (NU) is added for additional adjustments since they are a separate category from the product material and tracked with a different unit.

With no local defense programs using any of the material types under peaceful use restrictions and only one facility resulting in movement a simplified item-based approach was selected. This item-based approach relied on the fact that the requirement was for a total quantity to be protected instead of specific items. This meant that it was not required for the facility to apply proportionality to the contents as long as it contained material without peaceful use restrictions that was greater than process and sampling losses. So, losses in the facility could be neglected by effectively applying the total to unrestricted material, since they would never bring the total process below the required quantity. The reconciliation of peaceful use restrictions was then simplified to:

$$H - Canyon\ quantity > Total\ Restrictons - \Sigma\ Restricted\ use\ items$$

This works by adding up all items per restriction type and subtracting them from the total restrictions of that type for the site to get a total remainder for each. Add up each remainder to get the total restrictions left over and ensure it is less than the total material protected in H-Canyon. If this is true, all restrictions are covered and the site is compliant. This very simple method was considered very credible because dissolution of items was the only authorized activity that would result in an item leaving inventory and dissolution plans were made from a reduced list containing only authorized materials. The only other activity was blending NU with the HEU solution and that conversion of obligations from NU to EU was performed in batches while blending was being performed.

New Methodology:

When DOE announced that a pit production facility was planned for SRS, it led to a reevaluation of how the reconciliation was performed. SRS has always strived to implement best practices and wanted to have a mechanism to ensure that peaceful use restricted materials were properly accounted for and tracked. A new method was desired that offered a way to audit to assure that all items that should be tagged as restricted use were and that there were no systematic errors resulting in substitutions onto H-Canyon material. The only way to accomplish this though was to rebuild and reconcile H-Canyon to explicitly calculate what restrictions should be in the canyon to verify if the quantity of restrictions outside of the canyon was correct.

The first step was to produce a baseline of starting items that could be added together to recreate the total material in H-Canyon and the current inventory to combine with previous processing plans to document exactly which restrictions were introduced into the bulk process. This was done by reviewing the initial balance declaration, all relevant 741 forms, and the authorized materials listing used to create batch plans. The result was a list of all peaceful use restriction transactions, a list of all items in current inventory, and a list of items eligible to be processed since the H-Canyon restart in 2013. The 2013 cutoff was chosen because the H-Canyon tanks had undergone flushing of legacy material prior to that date and no foreign obligated materials had been dissolved. This allowed for the starting canyon inventory to act as a single item initial condition rather than a complex mixed item.

With the initial baseline set all assigned peaceful use restrictions were mapped to the item set using original documents to verify that all item tags were complete and correct. Once all item level tags were reconciled the inventory was examined for any splitting transactions due to sampling or processing to ensure that the full quantity was located and not improperly attributed to decay.

Once all the items matched the site total expected inventory, it was time to rebuild H-Canyon by referencing all the batch plans and item additions to recreate the bulk item. There had been no shipments of nuclear material out of the process since the restart so all sampling, and processing losses were still able to be attributed to unrestricted material. The resulting quantity was then compared to current inventory values to ensure no material additions were missed and that it matched within the expected margin of error.

This resulted in a listing of combinations of use restrictions that could be traced back to official records for audits and verification. The resulting partial foreign obligations for enriched uranium do not match the enrichment of the resulting item, but instead would be better considered at mapping to specific individual particles within the whole due to varying enrichments and the obligations being

explicitly added. This allows for flexibility for the enrichment to be further modified as part of the process without amplifying losses related to any attempts to convert the obligation to meet the product enrichment. An example of how this is documented is shown in Table 3.

Table 3: Foreign Obligations for a Split Item

Item	Element (g)	Isotope (g)
Obligation A (from 20% U-235 item)	100	20
Obligation B (from 50% U-235 item)	100	50
Resulting split item (35% U-235)	200	70

Conclusion:

The new methodology of reconciling and managing the peaceful use restrictions has given SRS greater confidence that we can continue to meet future reporting requirements and offer assurances that we are handling peaceful use material appropriately as we move forward with the new pit production mission. By completing a full reconciliation of H-Canyon materials, SRS can now provide DOE with the connection between the quantities being tracked in our inventory and exact program planning activities and transactions involving those items. Reports can now be produced for exact quantities in use by various programs and can be tied to the item's disposition. This shows that even difficult facilities to manage can use innovative methods to provide better information and tracking to stakeholders.

References:

Magoulas, V. E. (2013). Savannah River Site's H-Canyon Facility: Impacts of Foreign Obligations on Special Nuclear Material Disposition. *INMM 54th Annual Meeting*. Palm Desert, CA, USA.

Meehan, R., Dessaules, P., & Tabatabai, A. (2019). Management of Foreign Obligated Nuclear Material in the United States. *INMM 60th Annual Meeting.* Palm Desert, CA, USA.