Waste Determination Equivalency – 12172

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ABSTRACT

The Savannah River Site (SRS) is a Department of Energy (DOE) facility encompassing approximately 800 square kilometers near Aiken, South Carolina which began operations in the 1950s with the mission to produce nuclear materials. The SRS contains fifty-one tanks (2 stabilized, 49 yet to be closed) distributed between two liquid radioactive waste storage facilities at SRS containing carbon steel underground tanks with storage capacities ranging from 2,800,000 to 4,900,000 liters. Treatment of the liquid waste from these tanks is essential both to closing older tanks and to maintaining space needed to treat the waste that is eventually vitrified or disposed of onsite.

Section 3116 of the *Ronald W. Reagan National Defense Authorization Act of Fiscal Year 2005* (NDAA) [1] provides the Secretary of Energy, in consultation with the Nuclear Regulatory Commission (NRC), a methodology to determine that certain waste resulting from prior reprocessing of spent nuclear fuel are not high-level radioactive waste if it can be demonstrated that the waste meets the criteria set forth in Section 3116(a) of the NDAA. The Secretary of Energy, in consultation with the NRC, signed a determination in January 2006, pursuant to Section 3116(a) of the NDAA, for salt waste disposal at the SRS Saltstone Disposal Facility.

This determination is based, in part, on the *Basis for Section 3116 Determination for Salt Waste Disposal at the Savannah River Site* [2] and supporting references, a document that describes the planned methods of liquid waste treatment and the resulting waste streams. The document provides descriptions of the proposed methods for processing salt waste, dividing them into “Interim Salt Processing” and later processing through the Salt Waste Processing Facility (SWPF). Interim Salt Processing is separated into Deliquification, Dissolution, and Adjustment (DDA) and Actinide Removal Process/Caustic Side Solvent Extraction Unit (ARP/MCU).

The Waste Determination was signed by the Secretary of Energy in January of 2006 based on proposed processing techniques with the expectation that it could be revised as new processing capabilities became viable. Once signed, however, it became evident that any changes would require lengthy review and another determination signed by the Secretary of Energy.

With the maturation of additional salt removal technologies and the extension of the SWPF start-up date, it becomes necessary to define “equivalency” to the processes laid out in the original determination. For the purposes of SRS, any waste not processed through Interim Salt Processing must be processed through SWPF or an equivalent

process, and therefore a clear statement of the requirements for a process to be equivalent to SWPF becomes necessary.

INTRODUCTION

The Secretary of Energy, in consultation with the Nuclear Regulatory Commission (NRC), signed a determination in January 2006, pursuant to Section 3116(a) of the *Ronald W. Reagan National Defense Authorization Act of Fiscal Year 2005* [1], for salt waste disposal at the SRS Saltstone Disposal Facility. Section 3116 of the NDAA provides the Secretary of Energy, in consultation with the NRC, a methodology to determine that certain waste resulting from prior reprocessing of spent nuclear fuel are not high-level radioactive waste if it can be demonstrated that the waste meets the criteria set forth in Section 3116(a) of the NDAA.

This determination is based, in part, on the *Basis for Section 3116 Determination for Salt Waste Disposal at the Savannah River Site* [2] and supporting references, a document that describes the planned methods of liquid waste treatment and the resulting waste streams. The document provides descriptions of the proposed methods for processing salt waste, dividing them into “Interim Salt Processing” and later processing through the Salt Waste Processing Facility (SWPF). Interim Salt Processing is separated into Deliquification, Dissolution, and Adjustment (DDA) and Actinide Removal Process/Caustic Side Solvent Extraction Unit (ARP/MCU).

Savannah River Remediation LLC (SRR) has investigated alternate salt processing treatment options to supplement SWPF. To be consistent with the *Section 3116 Determination for Salt Waste Disposal at the Savannah River Site* [3], hereinafter referred to as: 3116 Determination, signed by the Secretary of Energy, any alternate treatment process must meet the performance described for SWPF in the 3116 Basis Document, or, equivalently, must produce a similar final Decontaminated Salt Solution (DSS) as described for SWPF in the 3116 Basis Document.

With the maturation of these additional salt removal technologies and the extension of the SWPF start-up date, it becomes necessary to define “equivalency” to the processes laid out in the original determination. For the purposes of SRS, any waste not processed through Interim Salt Processing must be processed through SWPF (or an equivalent process), and therefore a clear statement of the requirements for a process to be equivalent to SWPF was necessary.

In order for an alternate treatment process to be consistent with the 3116 Determination made by the Secretary of Energy, it must produce final waste streams with levels of targeted radionuclide removal similar to those described for SWPF in the 3116 Basis Document and associated references. This equivalency is defined in the following sections.

Salt Waste Processing Facility Treatment Process

The SWPF treatment process is designed to remove targeted radionuclides (cesium and strontium) and has the added benefit of varying degrees of actinide removal. SWPF uses MST strikes and subsequent cross-flow filtration to remove strontium and actinides, and liquid-liquid extraction to remove cesium.

The SWPF is referred to as the *"cornerstone of the salt processing strategy."* [2] It is designed to include three basic operations: the Alpha Strike Process (ASP), Caustic Side Solvent Extraction (CSSX), and the Alpha Finishing Process (AFP).

The ASP, illustrated in Fig. 1, will be the initial processing stage of SWPF, operating in batch mode to remove insoluble solids and varying quantities of soluble strontium and actinides from the waste feed by adsorption onto MST. In the ASP, MST will be added to the incoming salt waste and the resulting slurry will be filtered to concentrate the MST and insoluble solids. This filtration step accounts for the removal of the spent MST and associated adsorbed radionuclides and the insoluble solids removed by SWPF. The resulting filtrate, or Clarified Salt Solution (CSS), will be sent to CSSX and the concentrated MST/solids will be washed and sent to the Defense Waste Processing Facility (DWPF).

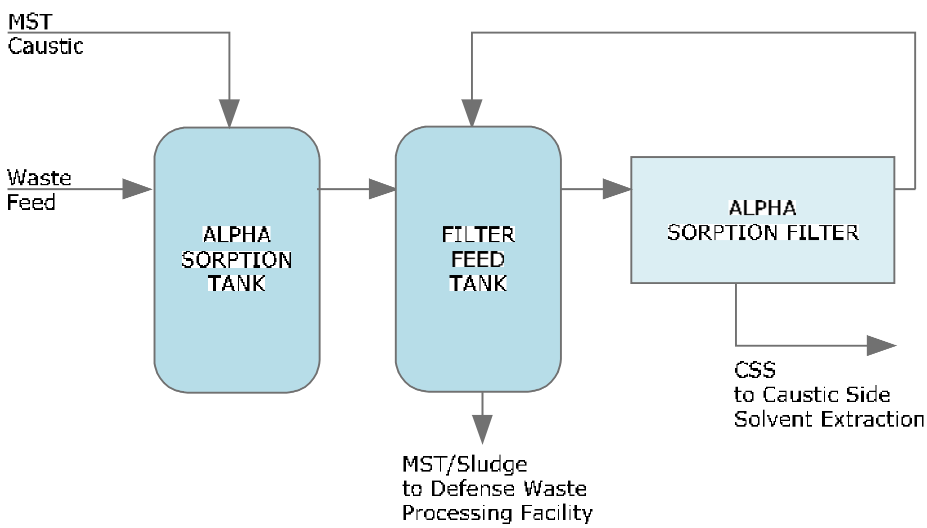

Fig. 1: The SWPF Alpha Strike Process (ASP) used for removal of strontium and actinides from salt waste. [2]

The second SWPF processing operation, presented in Fig. 2, will use the CSSX process to remove cesium from the CSS. The 3116 Basis Document describes it as:

> *"…a continuous flow process, utilizing centrifugal contactor stages for extracting (16 stages), scrubbing (2 stages), stripping (16 stages), and washing (2 stages) CSS streams."* [2]

The 3116 Basis Document describes how cesium will be captured by contacting the aqueous salt solution with a specially engineered organic extractant. The cesium will then be stripped from the organic solvent by contact with a dilute nitric acid strip solution and separation of the phases. The scrub and wash stages will be used to condition and purify the solvent for recycling. The strip effluent (high cesium concentration) also will be sent to DWPF for vitrification. After allowing for Ba-137m decay (half-life of approximately two minutes), the DSS, which will be comprised of the aqueous effluent raffinate from the extraction stages and aqueous wash effluent from the wash stages, will be monitored to confirm that process requirements have been met. The DSS then will be sent to the Saltstone Facility feed tank or to the AFP if additional strontium and actinide removal is desired.

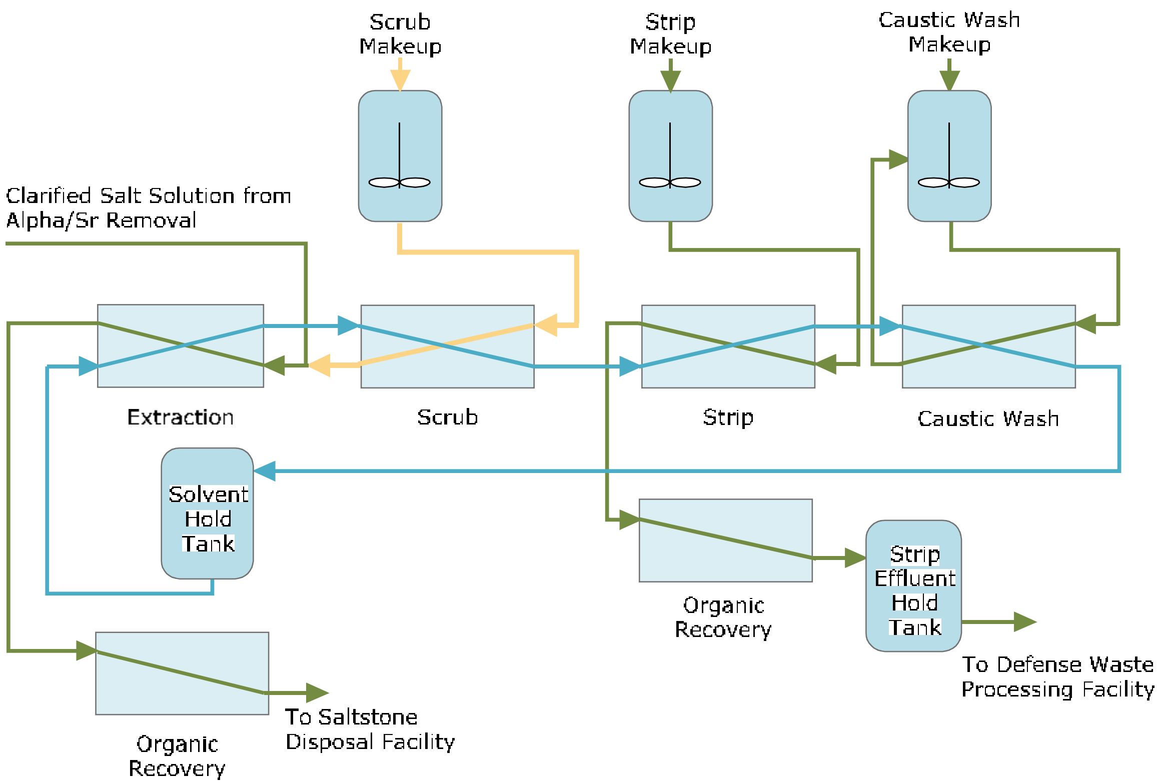

Fig. 2: Caustic Side Solvent Extraction (CSSX) process used to remove cesium from waste. [2]

The 3116 Basis Document describes the AFP as *"the final SWPF unit operation in which an additional MST strike may be performed."* It continues to explain:

> *"This unit operation will be located downstream of CSSX and will remove Sr and actinides not removed in ASP. AFP will be similar to ASP in equipment/tank sizes, configuration, and operational sequence. AFP will provide the benefit of additional MST strike capability without any reduction in SWPF throughput and allows the equipment to be located in a contact-handled area of the plant."* [2]

SWPF EQUIVALENCY

The SWPF process, as described previously, decontaminates salt solution by removing cesium via extraction, strontium and actinides via MST adsorption, and insoluble particles via filtration. In order to be considered equivalent to SWPF, a process must remove comparable amounts of cesium, strontium, actinides, and insoluble solids to that described for SWPF in the 3116 Basis Document and supporting references. The following sections outline the assertions made in the 3116 Basis Document and its references concerning this removal before describing the specific requirements concerning cesium removal, strontium and actinide removal, and filtration effectiveness necessary to demonstrate SWPF equivalency.

3116 BASIS DOCUMENT

Cesium Removal

The 3116 Basis Document contains several statements about the abilities of SWPF to remove radionuclides from salt waste. The 3116 Basis Document makes the general statement that:

> *"SWPF will provide a much higher decontamination factor (DF)[13] for Cs than the MCU, about 40,000 and 12, respectively"* [2]

Footnote 13 defines the DF as the:

> *"…quotient of the influent concentration of a given radionuclide and the effluent concentration of that same radionuclide."* [2]

Strontium and Actinide Removal

Strontium and actinide removal is described in the 3116 Basis Document in terms of strontium removal and overall alpha-emitting TRU actinide removal. The 3116 Basis Document states:

> *"SWPF is anticipated to remove 99.98% of the Sr and 96% of the alpha-emitting TRU activity."* [2]

One supporting reference document, Radionuclides in SRS Salt Waste, describes the calculation of these removal efficiencies:

> *"Removal efficiencies for alpha-emitting TRU were identified based on weighted averages of the individual removal efficiencies of Pu-238, Am-241, Cm-244, and Pu-239. These four nuclides contribute approximately 99% of the TRU alpha activity and therefore are considered the primary nuclides impacting TRU alpha removal."* [4]

As part of this analysis, the insoluble fractions of the species (comprised of the insoluble salt fraction and dry sludge) are assumed to be completely removed via filtration, while nominal DFs are applied to the soluble fractions. The resulting TRU activity is approximately 4% of the total original TRU activity (soluble and insoluble), for an overall removal percentage for alpha-emitting TRU species of 96%. The strontium removal percentage is calculated similarly, with 0.02% of the strontium remaining for a combined soluble and insoluble strontium removal percentage of 99.98%. [4]

These removal efficiencies are based on the assumption that all activity due to solids is removed during processing. If soluble strontium and actinide removal is considered separately from solids removal with the same basis of calculation, 95% of the soluble strontium and 82% of the soluble TRU activity is removed.

The soluble strontium and actinide removal percentages presented are based on lab-scale MST strike experiments with a 12-hour strike time. The 3116 Basis Document explains the significance of the MST strike time and number of strikes in footnote 24:

> *"At this time, a minimum of one strike is anticipated for all [SWPF] waste batches. Reduction of the soluble concentration of actinides and Sr is dependent on the concentration of the incoming waste stream, duration of the MST strike, and the number of strikes." [2]*

The 3116 Basis Document does not list a specific requirement for solids removal via filtration, but the assumption is stated:

> *"…the amounts of solids passing through the Alpha Strike Process in SWPF (which includes a filtration step) were negligible, so solids were not included in the calculation." [2]*

Additional reference documentation supporting the 3116 Basis Document presents the assumption that solids removal for SWPF ranges between 99.5% and 100%. [5]

CESIUM REMOVAL REQUIREMENTS

The SWPF CSSX unit is designed to remove cesium from salt solution. Estimates based on projected inventories of waste tanks, such as those in the 3116 Basis Document and associated references, estimate a 40,000 DF over the entire inventory intended for treatment by SWPF. [6] Therefore, for a process to be considered equivalent to SWPF, said process must produce a cesium DF averaged over the lifetime of the process of 40,000 or greater.

STRONTIUM AND ACTINIDE REMOVAL REQUIREMENTS

The SWPF removes strontium and actinides via adsorption onto MST and subsequent filtration. The filtration also removes insoluble solids entrained in the salt solution. The 3116 Basis Document bases its analysis of SWPF on DFs based on a specific MST strike time of 12 hours. In order to demonstrate equivalency to SWPF, a process must provide, at a minimum, soluble strontium and alpha-emitting TRU removal consistent with the laboratory test results for an SWPF MST strike time of 12 hours used to support the 3116 Basis Document, 95% and 82%, respectively.

The SWPF process is expected to utilize cross-flow filtration system similar to that currently found in the ARP/MCU interim salt treatment process, which serves as a smaller scale demonstration of the capabilities of SWPF. These filters are 0.1-micron Mott cross-flow filters, which must, as described earlier, remove at least 99.5% of solids. [5] Filtration is expected to remove solids, insoluble radionuclides and MST as part of the decontamination, and is therefore a significant element of equivalency to SWPF. In order to demonstrate equivalency with SWPF, a process must remove at least 99.5% of solids.

CONCLUSIONS

The Secretary of Energy's 3116 Determination that certain SRS waste can be treated as low-level waste was based, in part, on the 3116 Basis Document. The 3116 Basis Document describes a final waste stream that the Secretary of Energy, in consultation with the Nuclear Regulatory Commission, has determined complies with the criteria set forth in the *Ronald W. Reagan National Defense Authorization Act (NDAA) for Fiscal Year 2005*, Section 3116. [1] The 3116 Basis Document also describes the proposed method of achieving this waste stream via salt waste treatment with SWPF.

Equivalency of any alternate salt waste treatment process with the SWPF treatment process is defined by production of the final waste stream approved by the Secretary of Energy. Therefore, equivalency is also defined by similar removal of targeted radionuclides as that described in the 3116 Basis Document for SWPF. This removal effort targets cesium removal, strontium and actinide removal, and filtration, all of which must be equivalent to the parameters described in the 3116 Basis Document and supporting references.

Cesium removal requires an overall average DF of 40,000. Strontium and actinide removal includes treatment equivalent to a MST strike time of at least 12 hours or a soluble strontium removal of 95% and an overall soluble alpha-emitting TRU removal of 82%. Filtration for an equivalent process must remove 99.5% or more of the solids. Table I summarizes the requirements for demonstration of equivalency to SWPF for targeted radionuclide removal as described in the 3116 Basis Document.

Table I: Summary of SWPF Equivalency Requirements

Species	Equivalency Requirement
Cesium	40,000 DF (Average)
Soluble Strontium and Actinides	Alpha-emitting TRU removal ≥ 82% and Strontium removal ≥ 95%
Insoluble Solids	≥ 99.5% solids removed

Any process that can meet these parameters is considered an equivalent treatment process to SWPF as described in the 3116 Basis Document and supporting references. The process will produce an equivalent DSS and therefore is included in the scope of the determination made by the Secretary of Energy.

REFERENCES

[1] NDAA_3116, *Public Law 108-375, Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005, Section 3116, Defense Site Acceleration Completion*, October 28, 2004.

[2] DOE-WD-2005-001, *Basis for Section 3116 Determination for Salt Waste Disposal at the Savannah River Site*, Savannah River Site, Aiken, SC, January 2006.

[3] DOE_01-17-2006, Bodman, S. W., *Section 3116 Determination for Salt Waste Disposal at the Savannah River Site*, U.S. Department of Energy, Washington DC, January 17, 2006.

[4] CBU-PIT-2005-00195, *Radionuclides in SRS Salt Waste*, Savannah River Site, Aiken, SC, Rev. 1, September 7, 2005.

[5] CBU-PIT-2005-00215, Pike, J., *Detailed Basis for Assumptions Used to Determine Radionuclide Process Removal Efficiencies*, Aiken, SC, Rev. 0, September 6, 2005.

[6] CBU-PIT-2005-00013, d'Entremont, P. D. and Drumm, M. D., *Radionuclide Concentrations in Saltstone*, Savannah River Site, Aiken, SC, Rev. 3, June 21, 2005.