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ENGINEERING DOCUMENT CHANGE CONTROL

Change Identification

1. Category:
   - ☐ Direct Revision ☐ Supplemental Change ☐ Page Change
   - ☐ Supersedure ☐ Cancel/Void ☒ New

2. Classification of Change, or if New, CB?
   - ☐ Major ☐ Minor ☐ Conf Baseline (CB)

3. Date: 04/22/2004

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11. Plan:

Provide a description and justification for the measurement methods used to determine fissile mass for the limited control facilities that satisfy the requirements of HNF-7098.

12. Criteria:

Chapter 2, Section 3.2.5, of HNF-7098 Rev 5.

13. Change or Document Description:

WD/GRP methodology to account for (or consider) uncertainty in the fissile mass for storage of or operations involving fissionable materials.

14. Documents Issued or Changed by this EDC:

Document	Page	Revision	Document Title or Comments
HNF-20558	All	0	Initial issue of "Fissile Mass Measurement Methods for Waste Disposal/Groundwater Remediation Project Facilities"

15. Technical Justification (Need):

Requirement of HNF-7098.

Evaluation and Coordination

16. Change or Document Impact:

Implement process in project and facility procedures as needed. May impact future contracts for NDA trailers.

17. Affected Documents:

Document Number	Page	Revision	Person Notified/Comments
WMP-200 Section 4.4		2	RP Bushore

ENGINEERING DOCUMENT CHANGE CONTROL (continued)

Verification

18. Verification:

Peer review by FH Criticality Safety.

19. Approvals/Reviews:

Initials, Last Name, Date, MSIN	Initials, Last Name, Date, MSIN
Technical Authority: RP Bushore, S2-55 RPBushore 04/22/04	Technical Authority Manager: JR Weidert, S2-55 John R Weidert 5-4-04
Reviewer (Title): RP Bushore, SWOC CSR RPBushore 04/22/04	Reviewer (Title): TS Vail, 618 CSR Terry S. Vail 05/04/04
Reviewer (Title): MF Hackworth, WRAP CSR [illegible] 5/4/04	Reviewer (Title): RJ Bottenus, WD/GRP Chief Engineer [illegible] Bottenus 5/4/04
Reviewer (Title): RR Connolly, Waste Services Manager [illegible] for R.R. Connolly 5/04/04	Reviewer (Title): H Toffer, FH/FFS Criticality Safety H Toffer 05/24/04
Reviewer (Title): JE Fialkovich, FH N&CS [illegible] 5/20/04	Reviewer (Title): AL Ramble, Director FH N&CS [illegible] 5/24/04

Solution

20. Change Description (Solution) - Continuation Sheet:

DISTRIBUTION SHEET

To	From	Page 1 of 2
Distribution List	WD/GRP Nuclear & Criticality Safety	Date 05/20/2004
Project Title/Work Order HNF-20558, Rev 0, *Fissile Mass Measurement Methods for Waste Disposal/Ground Water Remediation Project Facilities*		HNF-EDC-04-20559

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
Waste Disposal/Groundwater Remediation Project					
N. M. Abdurrahman	T4-52	X			
J. D. Ahlers	T4-09	X			
R. R. Ames	S2-55	X			
R. J. Bottenus	T4-52	X			
T. A. Brown	T4-04	X			
B. V. Burrow	T4-10	X			
R. P. Bushore	S2-55	X			
M. A. Cahill	T4-04	X			
R. E. Chase	T4-51	X			
R. R. Connolly	T4-09	X			
T. M. Crane	T3-28	X			
J. E. Geary	T4-51	X			
G. A. Glover	T4-04	X			
R. D. Greenwell	T4-04	X			
M. F. Hackworth	T4-55	X			
F. K. Hamada	T4-04	X			
L. C. Hulstrom	E6-35	X			
D. Levinskas	T3-28	X			
P. J. MacBeth	S2-55	X			
S. L. Metzger	T3-28	X			
J. A. Nielsen	T4-09	X			
D. E. Nester	T4-05	X			
D. A. Pratt	T4-03	X			
D. R. Pyzel	T4-04	X			

DISTRIBUTION SHEET (continuation)

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Distribution List	WD/GRP Nuclear & Criticality Safety	Date 05/20/2004
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L. W. Roberts	S2-55	X			
J. R. Rosser	T4-03	X			
C. L. Stratman	T4-09	X			
N. J. Sullivan	T3-28	X			
G. C. Triner	A3-02	X			
T. S. Vail	S2-55	X			
M. S. Waters	T4-09	X			
J. R. Weidert	S2-55	X			
R. E. Wilkinson	T3-28	X			
Other Fluor Hanford					
J. E. Fialkovich	A0-26	X			
B. S. Mo	T5-54	X			
A. L. Ramble	A0-26	X			
G. W. Ryan	X4-07	X			
Fluor Government Group/FH Affiliates					
C. S. Eberle	A0-26	X			
D. G. Erickson	E6-17	X			
H. Toffer	A0-26	X			
DOE-RL					
L. T. Nirider (SED)	A5-18	X			

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Fissile Mass Measurement Methods for Waste Disposal/Groundwater Remediation Project Facilities

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Fluor Hanford
P.O. Box 1000
Richland, Washington

Contractor for the U.S. Department of Energy
Richland Operations Office under Contract DE-AC06-96RL13200

Fissile Mass Measurement Methods for Waste Disposal/Groundwater Remediation Project Facilities

R P Bushore, Fluor Hanford

May 2004

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Fluor Hanford
P.O. Box 1000
Richland, Washington

Contractor for the U.S. Department of Energy
Richland Operations Office under Contract DE-AC06-96RL13200

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Executive Summary

This document provides a description and justification for the measurement methods used to determine fissile mass for Waste Disposal/Groundwater Remediation Project (WD/GRP) limited control facility operations that will satisfy the requirements of the Fluor Hanford Criticality Safety Program. For many facilities and fissile containers, the uncertainty cannot be quantified, and the fissile mass is not known with precision. There is reasonable confidence that conservatism was applied in the past to assure that the fissile mass limits were met.

To validate this, comparisons will be made at least annually to see how well the new NDA values compare with the old. Fissile mass uncertainty will continue to be considered in the waste acceptance process and during facility operations. Significant anomalies with fissile mass identified through NDA will be investigated to evaluate whether other actions are needed. These commitments and the specific processes that accomplish them will be implemented in facility and project administrative procedures. This methodology will be reviewed at least every two years and updated as needed.

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1.0 INTRODUCTION

This document has been prepared to meet the requirements of HNF-7098, *Criticality Safety Program*, that "...the facility/project shall document a description and justification for the measurement method(s) being used to determine the fissile material mass and associated uncertainty." It also is a corrective action response for a Fiscal Year 2003 Criticality Safety Self Assessment finding and a June 2003 Central Waste Complex (CWC) occurrence. It impacts the 618-10 and 618-11 Burial Grounds, all Solid Waste Operation Complex (SWOC) facilities, and Waste Services.

The description and justification for the measurement methods used to determine fissile mass for the limited control facilities within the Waste Disposal/Groundwater Remediation Project (WD/GRP) to satisfy the requirements of the Fluor Hanford Criticality Safety Program is provided in this document. The acceptability of the measurement methods is denoted by the approval of this document by the Director of Fluor Hanford Nuclear and Criticality Safety.

2.0 SCOPE

The Scope of this document includes all aspects of the receipt, packaging, handling, storage, and inventory of fissile material bearing containers, sumps, tanks, processes, and systems in all WD/GRP facilities. The parameters, criteria, and conclusions presented in this document are specific to the accuracy of fissile material mass measurements regardless of the location or facility. The facilities affected by this document are the 618-10 and 618-11 Burial Grounds and the SWOC facilities (CWC, Low Level Burial Grounds [LLBG], T Plant, and the Waste Receiving and Processing Facility [WRAP]). WD/GRP Facilities that are classified as exempt according to HNF-7098 are excluded from consideration in this document, except for the applicability of inventory controls that are in place to protect the facility classification.

Generally, containers with transuranic (TRU) and suspect TRU that may be reclassified as low level waste (LLW) are stored in the LLBG. The TRU will be retrieved from storage and will be moved to the CWC for staging or temporary storage before being processed in WRAP, which certifies the TRU waste for shipment to the Waste Isolation Pilot Plant (WIPP) in New Mexico, its permanent disposal site. LLW will remain in or return to the LLBG for its permanent disposal. T Plant supports these activities and additionally provides limited treatment and decontamination. It also provides storage for remote handled waste, such as Shippingport blanket fuel assemblies (BFAs) and K Basins sludge. The 618-10 and 618-11 Burial Grounds are inactive, covered with several feet of soil, and waste sampling activities will not begin until a sampling and analysis plan has been approved by the DOE.

3.0 BACKGROUND

Measurement accuracy requirements associated with control of fissionable material are addressed in Section 3.2.5 of HNF-7098, *Criticality Safety Program*, Chapter 2, "Control of Fissionable Material," as follows:

> If mass limits are applied, it is important that the measured mass values conservatively account for uncertainties in the measurement methods. Mass values are determined either by direct measurement (weighing), NDA or sampling methods, use of historical records, or some combination thereof. In all cases, uncertainties must be conservatively accounted for. Uncertainties with weighing are not usually difficult to estimate. Extra care must be taken in the estimation of mass uncertainties based on NDA or sampling methods, or when mass values are derived only from historical records.
>
> Where the accuracy of the measurement method is well known (within $\pm$5% at the 95% confidence limit), as is usually the case for most weighing methods, the reported mass may be used to confirm compliance with the CPS mass limit. If the measurement method accuracy is not well known, i.e., when only historical records are relied on, then allowance for potentially higher mass values due to the inaccuracy are required. In that case, the facility/project shall document a description and justification for the measurement method(s) being used to determine the mass and associated uncertainty.

The basis for fissile mass limits is provided in various Criticality Safety Evaluation Reports (CSERs) or Criticality Safety Analysis Reports (CSARs) and addenda. Most do not provide a detailed discussion of how uncertainty of the fissile mass is to be considered in meeting those limits. This document provides the description and justification for consideration of fissile mass uncertainty at WD/GRP facilities. The precision, accuracy, and representativeness (of samples) for the measurement have direct impacts on data quality. In the discussion the following definitions will be used:

Accuracy - The degree of agreement between a measured value and an accepted reference of the true value as determined by the percent recovery (%R).

Bias – The systematic error component of the measurement uncertainty; that is, a constant positive or negative deviation of the method average from the correct value or an accepted reference value under specific measurement conditions.

Fissile – Nuclide will sustain a chain reaction by thermal (slow) neutron-induced fission.

Fissile Gram Equivalent (FGE) – Amount of ^{239}Pu (in grams) which will produce the equivalent reactivity as another nuclide at optimal shape, moderation, and reflection. Usually calculated by multiplying the FGE conversion factors from HNF-5134 by the mass of fissionable isotope in grams.

Fissionable – Nuclide is capable of sustaining a nuclear chain reaction at some neutron energy. Includes all fissile nuclides.

Nondestructive Assay (NDA) – Assay methods for waste items that do not affect the physical or chemical form of the material.

Precision - A measure of the mutual agreement among individual measurements of the same property made under prescribed similar conditions; expressed as a standard deviation or percent relative standard deviation (%RSD).

Representativeness - A measure of the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition.

Total Measurement Uncertainty (TMU) – The total measurement error from all sources of variance, including counting statistics, precision, instrument bias, and interference effects such as variable matrices, isotopic compositions, spatial distributions, self shielding, contaminating radionuclides, and others.

Unit Cell – A fissionable material control zone with a defined boundary with restrictions on total fissile mass.

[Primary sources for definitions: DOE/CBFO-01-1005, DOE/RL-96-68, CSER 00-005 (HNF-5134), and CSER 00-020 (HNF-6747).]

NDA processes provide for calibration using known standards and quality assurance verification of results to assure the validity of the measurements, the processes, and the programs. NDA includes fixed and portable systems and may include passive/active neutron measurement in addition to gamma energy analysis.

Nondestructive Evaluation (NDE) methods are used to examine the physical nature of the package contents or packaging. X-ray radiography is used to generate a visual perspective of the contents of containers. Visual Examination (VE) techniques are used for a fraction of the containers. This includes opening and at least visually inspecting the contents. The contents of inner packages may be exposed for repackaging. The NDE is used to confirm information provided about the package from the generator of the waste. These methods provide additional assurance that the accepted data are representative of the actual contents. Similar activities may be performed at the generating site. NDE is conducted for all TRU containers. Any containers which have not been through VE will go through radiography.

Conservatively accounting for uncertainty for every container could significantly overestimate the overall inventory, unless the facility has data for each container that will allow calculating overall measurement uncertainty with due consideration for dependencies between the individual variances (e.g., applying the root-mean-square function). Overestimating the container inventory results in applying more conservative controls, including additional spacing, stacking limitations, or placement in single container arrays. This uses more of the limited storage space and requires additional management attention. WRAP usually has this data readily available in its Data Management System (DMS) when packaging drums for a WIPP shipment or repacking drums in a glovebox because each drum has new NDA data. For a standard distribution, there should be about as many containers with actual fissile mass values less than the measured value as those with actual values greater than the measured values. It is not credible that all containers have greater fissile mass than is indicated by a measurement method. In addition, measurement uncertainty from a criticality safety perspective is less of a concern for containers with low mass than for containers with a large mass, i.e., accuracy is more important when hundreds of grams are involved. Only about 5 percent of SWOC waste drums have nominal values over 75 FGE, excluding the more recent receipts of the Pipe Overpack Containers (POCs) where the mass inventory and distribution are well known.

4.0 DESCRIPTION OF PROGRAM FOR WD/GRP

All containers and applicable facilities with non-exempt quantities of fissionable material that are the custodial responsibility of WD/GRP have a fissile mass assigned. Waste generators have always provided container fissile mass inventory estimates that were based on a variety of information. The assignment of either total fissile mass or fissile material concentration was accomplished in one or more of the following methods:

1. Direct sampling of a material through destructive analysis. Examples include isotopic determinations by chemical analysis, mass spectroscopy, etc.

2. Indirect methods such as NDA. Examples include passive and active neutron interrogations, gamma spectroscopy, fluorescence techniques, etc.

3. Calculating inventories based on some physical understanding of materials of a system such as a tank, process line or container. Examples include irradiated and depleted fuel calculations.

4. Assigning a fissile mass value to a system or container based on indirect quantitative data. Examples include hand held alpha and/or beta/gamma monitors.

5. Assigning a fissile mass value to a system or container based on historical data or anecdotal information.

A hardcopy of shipping papers for fissile material bearing containers received and stored in WD/GRP facilities was retained and the information input to electronic databases. Since the early 1980s several versions of the electronic databases have been utilized to store container information. The current database is titled the Solid Waste Information Tracking System (SWITS).

The historical databases as well as SWITS generally have the flexibility to accept isotope quantities as mass or curies; however, some early container data were recorded only as total plutonium and either natural, depleted, or enriched uranium (without enrichment or isotopic information). Presently, the fissionable material mass of containers in SWITS is converted to FGE per HNF-5134, *CSER 00-005: Determination of Fissile Gram Equivalence for Hanford Solid Waste Operations*; however, only the fissile isotopes have any measurable impact. The

FGE concept compares the quantity of individual isotopes with the reactivity of ^{239}Pu by a ratio of the minimum critical masses. Previous practices included summing the fissile mass from ^{239}Pu, ^{233}U, as well as the ^{235}U in uranium when greater than 0.72 percent enriched. This was more conservative than the present FGE conversion method. Frequently only ^{239}Pu and ^{240}Pu were recorded and ^{241}Pu and fissile isotopes that are only present in low concentrations were not reported. A significant fraction of the ^{241}Pu in most containers has decayed to ^{241}Am. At other times the total Pu grams were used for acceptance rather than ^{239}Pu grams.

All containers, packages, and established facility inventories are managed as though the assigned fissile mass represents the actual mass without any consideration of accuracy. This is mainly because TMU has not historically been a priority for WD/GRP facilities so the waste generators and facility engineering/operations have not been compelled to generate and provide that information. Currently, much of the fissile mass managed by WD/GRP that is without accuracy determinations is isolated from hands on or remote accuracy measurements (buried, canyon tanks, sumps, piping systems, shielded, etc.) and considered unavailable, given the current configuration. However, confidence is high in the supposition that assigned fissile mass values used for acceptance of waste containers based on historical, anecdotal, or process information were generally conservative based on the established acceptance requirements. Even though fissile mass has been discovered to exceed assigned values these instances are the exception and it may in part reflect more conservative measurement techniques in use today.

Stringent uncertainty requirements for shipments of TRU waste containers to WIPP have led to the generation and documentation of TMU information for those containers. Uncertainty data collected to certify these waste packages for shipment will be used for all aspects of handling, storage, and shipment when and where available. Old and new waste packages that contain fissionable materials but do not have measurement uncertainty information may be accepted, handled, stored, and transported. Assigned fissile mass quantities can be generated using the direct, indirect, anecdotal, or process knowledge methodologies based on a graded approach similar to the general waste acceptance criteria in Appendix A. On a case by case basis operations may require quantified confidence determinations where potential fissile mass may approach or exceed a criticality limit.

The bases for fissile mass and/or concentration that are compared to criticality safety mass limits and controls for compliance shall be documented. WD/GRP Waste Services, the facility Criticality Safety Representative (CSR), or inventory custodian will document the basis or method used for fissile mass determinations that is sufficient to demonstrate the facility is operating in compliance with criticality safety mass limits. This requirement applies to new waste acceptance, although for existing containers it frequently is documented in hardcopy records or by SWITS showing incorporation of NDA results after transfer to WRAP. Given that critical parameters must achieve optimal (worst case) conditions for safety to be compromised, measurement accuracy considerations become important only when actual values exceed the assigned mass values and also exceed the evaluated conditions or limits. Therefore, compliance with fissile mass limits may be accomplished by measurements that demonstrate that the container, package, facility or portion of a facility is below a specified mass value rather than quantifying the exact inventory within $\pm$5% at the 95% confidence level.

4.1 Fissile Mass Assignment Methodologies

The previous section listed 5 methodologies used to assign a fissile mass to containers, processes or systems. As the actual fissile mass increases, the uncertainty of the assigned value is more important. In all cases, containers, process, and systems will be managed according to the assigned fissile mass.

4.1.1 Assigned Mass Values Without Uncertainty

Containers, processes, and systems with an assigned fissile mass that exceeds 200 FGE, but no quantified uncertainty information, will be received, handled, stored, transported, and managed after a review of the mass by the CSR. The CSR will utilize one or any combination of the 5 methodologies discussed above to establish the likelihood that the actual fissile mass is greater or less than the assigned value or quantify the measurement accuracy. An adjustment of the fissile mass according to the recommendation of the CSR will be completed if needed. Quantified uncertainty values for buried waste packages will not (and cannot) be determined. Also, uncertainty will not be tracked for the LLBG mixed waste trenches.

Waste or process tanks, sumps, piping systems, filters, ducts, and equipment containing liquids and/or solids (or sludge) can be managed as individual pieces or Unit Cells of 200 FGE or less without consideration for the measurement accuracy or confidence. No credit is taken for absorbers (other than the ^{238}U in uranium) so the actual critical mass is estimated to be several times to orders of magnitude higher than the minimum critical mass of 530 g for ^{239}Pu. Before conducting operations in a Unit Cell with a fissile mass in excess of 200 FGE, the inventory will be reviewed by the facility CSR.

A Unit Cell is an area with a defined boundary in which independent activities involving active, intrusive work are carried out. It may also be a process system such as the decontamination liquid tanks in 221-T, which have fissile mass estimated using a combination of methods 1 and 3. A Unit Cell currently is limited to a maximum fissile inventory of 200 FGE. The number of containers is not limited as long as the total remains under that value. Containers may be stacked or opened and the contents treated (e.g., examined, sampled, combined, separated, or repackaged). Once a container has been opened or fissile-contaminated material exposed (e.g., the plastic covering has been removed from equipment) in a Unit Cell, the area must receive a re-baseline NDA or be shown to be fissile free (e.g., no alpha or other fissile contamination, or no inner packages were opened in the process) in order to zero the fissile holdup, even if all containers or material have been removed. Unit Cells with liquid waste inventories shall demonstrate that conservative fissile mass estimating techniques are followed.

Most Unit Cell operations involve low fissile mass and strict radiological control practices are in place to minimize potential for spread of alpha contamination. For decontamination activities, indirect readings (method 4) should not be used for estimates above 100 FGE. For waste repackaging operations, historical data (method 5) may be used as long as it is based on NDA data up to 200 FGE, although the uncertainty or NDA method may not be known. Containers or equipment totaling over 100 FGE require confirmation by records review that NDA (method 2) was previously performed before being opened in a Unit Cell. For Unit Cell operations above 200 FGE, use of NDA (method 2) and accounting for measurement uncertainty will be required.

4.1.2 SWOC waste packages with uncertainty data

If uncertainty data are available and it is well known ($\pm$ 5% at the 95% confidence level), the reported mass will be used by the CSR to confirm compliance with the CPS mass limits and when assigning CPS container types. If outside this range, 1 TMU will be used as the uncertainty in assigning container types if it is available rather than just the 2σ method uncertainty. This provides additional conservatism.

WRAP glovebox operations will consider measurement uncertainty in meeting the total mass limit and also in tracking holdup, as described later in Section 5.0 under "Intrusive Operations". T Plant will also consider measurement uncertainty for the container and in determining holdup (if any) for any Unit Cell operation that exceeds 200 FGE and whenever Unit Cell inventory is not zeroed at the end of an activity.

5.0 DISCUSSION AND JUSTIFICATION

Appendix A summarizes waste acceptance requirements that generators must follow prior to sending waste packages to the WD/GRP facilities.

A summary of historical requirements for fissile mass measurements associated with waste containers is provided in Appendix B. There is no indication that fissile material mass uncertainty data was generated or considered when fissile materials were packaged, processed or received, although the NDA method frequently is cited. Only in isolated cases is uncertainty data available today. The documents cited in Appendix B provide some level of assurance (confidence) that generators had safeguards in place to limit the potential for over batching and measurement uncertainty was a consideration, but the quantification of that uncertainty was never realized.

The containers with the most accurately measured fissile mass currently being received at WD/GRP facilities currently are the POCs from the Plutonium Finishing Plant (PFP). The special nuclear material being packaged in PFP is transferred from material balance areas (MBAs) whose inventory is closely tracked. The individual cans are assayed before placement in the container, which provides for greater accuracy and precision. This measurement accuracy and uncertainty is intended to satisfy the stringent requirements for receipt at WIPP. In any case, the final assay is usually not the only basis for assurance that the container meets criticality limits. This was generally true in the past as well.

Data for older containers were transcribed into the SWITS predecessor RSWIMS database in the early 1980s based on the hard copy records. These were later converted to the SWITS database. Isotopic data may have been available on the record, but normally only total plutonium (usually the record provided the ^{240}Pu content), depleted uranium, natural uranium, or enriched uranium masses were entered in the database, as well as other waste package information. The SWITS value is used to manage the fissile material. For older records there is generally less detail, and values entered were frequently round numbers (grams and nominal ^{240}Pu content). There are strikeouts, writeovers, and illegible copies in many cases. Frequently a single record was provided for a single shipment, which could be twenty or more drums or boxes. Although any attached MBA records usually would provide an isotopic distribution, there frequently was no tie showing how the fissionable material was distributed in individual containers of the shipment. There may have been additional records or correspondence, including generator records that would have provided additional information at the time, but these generally are not available today.

There is high confidence that containers met the fissile mass limits at the time of receipt, but there is low confidence in what the assigned value should be for any single container. There is high confidence in the fissile mass marked on the side of the older containers, when available, although different methods were used to determine that value. Most containers have the total Pu or fissile mass marked on the side. After extended storage in buried retrievable storage, or after exposure to sun and other environmental elements, these labels may no longer be legible when retrieved, and are not used for management of the containers.

Uncertainty data are not components of the SWITS database. Appendix A summarizes data quality requirements in place to assure that waste packages meet facility limits. Isotopic uncertainty data are also required in order to meet the acceptance requirements for shipping TRU waste containers to WIPP for disposal, but their requirements are generally even more conservative.

Uncertainty data are available in DMS for waste containers that have been assayed at WRAP, and are provided in hardcopy records for TRU waste going to WIPP, including those packages that are directly certified by the PFP, currently limited to POCs. WRAP determines TMU as specified in HNF-4050, *Total Measurement Uncertainty (TMU) for NDA of TRU Waste at the WRAP Facility*, in order to meet the requirements for shipping waste containers to WIPP. In addition to routine calibrations, WIPP certification requires periodic testing with blind standards following DOE/CBFO-01-1005, *Performance Demonstration Program Plan for Nondestructive Assay of Drummed Wastes for the TRU Waste Characterization Program.*

New NDA data are evaluated by a team of experts and blended with acceptable knowledge (AK) or best available data about the waste package (e.g., hard copy records and waste stream data) and are verified before being uploaded to SWITS. In many cases a known isotopic distribution (process knowledge) is applied to measurements of only a single or limited number of isotopes to generate values for isotopes that are not directly measured. HNF-18009, *Comparison of WRAP NDA Fissile Grams Equivalent Data to Acceptable Knowledge*, shows a positive bias for NDA compared to reported values. The fissile mass data assigned by WRAP tend to be more conservative compared to the original data. This results in more conservative handling of containers that have been newly assayed. The data have not been normalized for different generators or waste streams.

WD/GRP NDA programs provide for calibration of equipment using known standards and quality assurance verification of results to assure the validity of the measurements, the processes, and the program. NDA includes fixed and portable systems and may include passive/active neutron measurement in addition to gamma energy analysis. NDE using x-ray radiography is conducted for all TRU containers that do not receive VE. A quality control program is in place requiring VE of a fraction of the containers to confirm information provided about the package from the generator of the waste. VE percentages are increased if problems are identified with particular generators or waste streams. These provide additional assurance that the accepted data are representative of the actual contents. Similar activities may be performed at the generating site.

HNF-EP-0063, *Hanford Site Solid Waste Acceptance Criteria*, has specified since 2000 that the uncertainty be added to the measured value (if not within 5% at 95 percent confidence) for SWOC acceptance of newly generated waste. A summary of other waste acceptance criteria currently in use is provided in Appendix A. In the past waste containers and equipment for decontamination have been accepted from generators based on AK for mass, which may or may not include NDA or sampling data, thus this information in most cases is not available. The majority of waste containers do not have verifiable accuracy for the isotope masses. The older the waste package, the less detailed the information that is available. Even less is known about the contents of individual shipments or waste packages at the 618-10 or 618-11 Burial Grounds.

NDA processes typically provide a measured value and the standard deviation (1σ) for the method being used. Statistically the method provides 95% confidence that the actual value is less than the mean plus 1.96σ (usually rounded to 2σ) under specified conditions. 1σ for drums is typically below 5 percent at WRAP and under 1 percent (for ^{239}Pu) using calorimetry as NDA at PFP. TMU takes into account other effects or conditions that could occur such as matrix differences, geometry, end effects, or shielding, but is not necessarily representative of any particular waste package. TMU generally exceeds 2σ for the NDA method, with a factor of two not being unusual. WRAP tends to be qualitatively conservative and thus ends up with a higher mass value for waste packages compared to the original generator data.

Radionuclide inventories for newly generated waste should generally be determined following the practices described in Appendix A. It is expected that there is sufficient conservatism in the criticality safety evaluations to account for some measurement uncertainty. For containers that are reasonably expected to have a low fissile mass (e.g., < 15 FGE) in comparison to limits (200 FGE for most drums), process knowledge is considered to be acceptable, following a graded approach, without having quantifiable precision for the measured value. The accuracy of the measured value may be accepted for control of the container or system, rather than adding the uncertainty. Because the precision is not known, neither is the confidence level. Higher confidence (on a percent basis) would be expected for containers or systems with fissile material masses that are close to the mass limit because facility personnel are more careful when operating near limits to minimize having to repackage containers. This is supported by container records documenting use of NDA methods that progress from the less precise methods (NaI) for low FGE containers to the more precise methods (segmented gamma scan and calorimetry) as mass values approach 200 FGE.

As new validated isotopic data become available, SWITS is updated and the container is managed according to the new data. Once available these data will also be considered by the CSR for assignment or update of the SWOC CPS Container Types that are used to designate the required criticality controls, whether using TMU, method uncertainty (2σ), or typical TMU values (e.g., 10 to 20 percent) where no specific values are available. Once uncertainty has been considered in assigning container types, the measured value plus uncertainty is not a factor for handling and storage of SWOC waste containers except for CPS Container Types 5 and 6, which are discussed in more detail below.

CPS Container Type 6 provides conservative container and array limits of 119 FGE (22.5 % of the minimum critical mass for ^{239}Pu) in conjunction with spacing to assure low reactivity for both storage and disposal, with no credit taken for packaging or form and distribution of the material. The basis for this limit in CSAR 82-003 (as modified by CSER 95-007) is that even if an array is double batched and placed with another double batched array or two single batched arrays with no separation (3 or more errors), there would still be at most 90% of the minimum critical mass and criticality is incredible.

There are currently only a few of these Type 6 containers that have not already been disposed in trenches. Three LLW containers are currently stored in 2403-WD, consisting of uranium-contaminated silt and rust in large (3-m^3) concrete boxes. The highest assigned ^{235}U mass is 192 grams, but this is only 11.6 FGE because of the low enrichment. There are two TRU K Basins ion exchange modules (IXMs) stored at Burial Ground 218W4C Trench 20 assigned about 30 FGE each, with two other TRU IXMs still at K Basins. LLW IXMs typically have about 15 FGE and go directly to disposal. IXM buildup is monitored to keep from reaching higher values that would result in designation as TRU, with no path forward currently available for disposal of the TRU IXMs. The IXM is large enough to internally provide sufficient separation from the fissile material, but additional spacing is provided from the edges.

Bulk waste or "supersack" waste shipments have typically consisted of dump truck size loads with 10-15 FGE dispersed in the waste, followed by backfill of at least 3 feet of clean soil. The form and distribution alone are sufficient to provide for criticality prevention. This type of waste is difficult to characterize and provide meaningful accuracy, thus criticality reviews primarily confirm that conservative estimating techniques are demonstrated to have been followed.

Uncertainty will be considered in the acceptance of new waste containers with high fissile mass (over 100 FGE). Waste containers should be exempted from use of uncertainty to compare with CPS Container Type 6 array total limits. The low fissile limits provided by the CSER already provide sufficient margin.

Small CPS Container Type 5 waste boxes generally have fissile mass well below the 250 FGE limit for placement in a multi-container array. With a 500 FGE total array limit and no single box over 250 FGE, the reactivity for metal boxes is much lower than a drum array (which has no total fissile mass limit), as discussed in CSER 03-026, even with double batching. CSAR 79-038 uses areal density comparisons to demonstrate incredibility and allows non-metal containers. For a stacked 500 FGE array with the minimum size box (2.5 ft x 2.5 ft x 2.5 ft), areal density would be at most one-third of the 240 FGE per square foot required for criticality in a fully reflected infinite slab. As stated in CSAR 79-038 Addendum 6, "In the case of double batching, the average surface density of fissile material and the total fissile material are still below the critical areal density by a large margin." Fissile boxes are not stacked in underground storage arrays, where full reflection is possible, thus the maximum areal density is at most one-third of the minimum required for criticality even with double batching. At other SWOC locations, there is no reflection from above, and side reflection is limited to non-fissile containers that may be used for spacing. This provides additional criticality margin.

Most metal boxes that may have been originally treated as CPS Container Type 5 are less than 200 FGE and are being relabeled and arrayed the same as drums and are identified as CPS Container Type 2; thus, there are no array limitations other than stacking. Because of their larger size, these stacked boxes have lower reactivity than stacks of drums. Few CPS Container Type 5 box arrays are expected (primarily those metal boxes with between 200 and 250 FGE and fiberglass reinforced plywood (FRP) boxes up to 250 FGE). All boxes with over 250 FGE reported mass will be handled the same as CPS Container Type 4, which requires a single container array with spacing. Even without the spacing, the reactivity is lower than for stacks of drums. Boxes over 250 FGE have a minimum size of 5 ft x 4 ft x 3 ft. Boxes over 350 FGE up to 1000 FGE have a minimum size of 7 ft x 4 ft x 4 ft. Areal density is lower than for the stacked 500 FGE array. In addition no boxes have been accepted with assigned values over 500 FGE. There also were restrictions on what (form or distribution) was placed in these burial boxes, although it is usually not possible to determine the actual distribution from the record.

Required spacing distance between arrays is typically a defense-in-depth control which is not calculation based (e.g., CSAR 79-038). The box CSERs have already adequately considered uncertainty. Waste containers should be exempted from use of uncertainty to compare with CPS Container Type 5 array total limits. Uncertainty will be considered in the acceptance of new boxes with high fissile mass (over 100 FGE).

The total fissile mass in the LLBG mixed waste trenches (CSER 03-014) will be the sum of a number of well-dispersed waste packages with relatively small fissile mass. The uncertainty of the total will be a relatively low percentage and it is nearly incredible that the fissile material can have any significant transport before the trench is capped, after which it will be near zero. The average fissile density values will also be a fraction of the maximum values, because only a fraction of containers will approach the maximum, most waste will be non-fissile, and dirt fill and stabilizing materials (e.g., grout) are also interspersed. Conservatism already applied in the criticality analysis is sufficient in meeting trench limits. Application of uncertainty in meeting overall trench limits is not needed as long as individual containers meet the waste acceptance criteria.

The actual distribution of fissile material is dispersed and non-credited absorbers are present for the typical waste. CSERs usually assume optimal conditions. It approaches incredible that all worst case conditions occur simultaneously for the type of material handled at WD/GRP facilities: e.g., compact (or spherical) geometry, full reflection, and optimal water moderation, then assuming all containers are at the measured value + 2σ before consideration of the credited contingencies. Therefore, it is reasonable to use the measured fissile mass as the controlling value without considering uncertainty.

SWOC and 618-10/11 Waste:

For existing SWOC waste, unless data have been provided by the waste generator, quantified uncertainty of fissile mass can be obtained only for packages that have been through NDA at WRAP, Accelerated Process Line (APL) trailers, or some portable NDA method. Radioassay data for newly generated waste is prepared following HNF-EP-0063, Section 2.4 (as shown in Appendix A). For the typical contamination-level waste generated by WD/GRP facilities, process knowledge and scaling factors may be used to establish radionuclide content following a graded approach.

Scaling factors are also used for the uranium content of waste containers being generated at PFP. Total uranium is usually calculated by applying a U:Pu ratio and the known ^{235}U enrichment. Although plutonium isotopes may be known with a high confidence, uncertainty associated with uranium isotopes or enrichment is not readily available even today. More restrictive WIPP uncertainty requirements results in reduced loading of these containers. In addition, ^{235}U is accounted by WIPP on a 1 g = 1 FGE basis that neglects the reduction due to ^{238}U poisoning that is normally credited at the SWOC by CSER 00-005. WRAP measures ^{235}U and ^{238}U directly and uses an appropriate uranium isotopic profile to calculate the remaining uranium isotopes of interest.

618-10/11 waste was disposed between 1953 and 1967 and was not planned for retrieval. Limited records are available for what was disposed. This waste is buried underground (shielded facility) and will have to be characterized as it is retrieved since it is unlikely that retrieved waste, whether in intact containers or otherwise, can be traced back to the original data. 618-10/11 are currently not managed by mass controls, and thus are considered outside the scope of the requirement. Since it is not possible to quantify either precision or accuracy, the available data must be accepted. It is expected that these factors will be taken into account as part of characterization following a sampling plan prior to retrieval of the waste.

Mixed Fission Product Caisson storage began in 1968 as a replacement for the 618-11 Caissons and retrieval is not currently planned; however, some TRU waste was inadvertently placed after the April 1970 cutoff and some retrieval is likely. Alpha Caisson storage began in May 1970 for storage of remote handled, TRU waste. No new caisson waste has been added since 1989. This waste is buried underground (shielded facility) and will have to be characterized as it is retrieved as it is unlikely that retrieved waste, whether in intact containers or otherwise, can be traced back to the original data.

New CSER 01-006 (HNF-8319) included requirements for three independent measurements of mass to assure drum mass is less than 200 FGE. Actual values are under 100 FGE. There is no need to apply uncertainty for these drums. Where concentrations of fissile material may exist, CSER 01-010 (HNF-8854) places additional control requirements that further reduce reactivity. This CSER assumes moderators better than water (i.e., carbon) may be present in unusual amounts while assuming all drum fissile masses are 22 percent above the mass limit. While occasional overbatches are possible, underbatches also occur, and this level of anticipated bias should provide sufficient conservativism.

Although there are known cases where high mass drums from a similar waste stream are stored together, the average drum mass at the SWOC is only about 15 FGE. In practice, except for the retrieval trenches, arrays do not have top reflection and array sizes are more limited than those analyzed in the original CSERs because of operational and regulatory requirements, providing reduced reactivity and increased margin.

LLBG TRU Retrieval Trenches:

From April 1970 until early 1989, most TRU waste was placed in buried retrievable storage in various configurations. Appendix B provides a discussion of uncertainty extracted from some of the early criticality documents. In most cases uncertainty has not been directly addressed. Criticality safety engineers preparing CSARs and CSERs involving special waste packages usually had detailed knowledge of the waste containers and the assay methods that were in use at the time they were packaged when establishing the applicable limits and controls. PNNL-10910, *EBRII Cask Characterization Measurements*, provides additional information on those containers.

Statistical sampling methods have been used for some fissile-contaminated bulk waste received for disposal at the LLBG trenches. The CSER for this waste ignores the presence of the contaminated, bulk material and the total FGE involved typically has been a small fraction of the mass limit. This limit is also used for small numbers of packaged uranium bearing waste that typically is mixed with non-fissile containers and frequently is stabilized by grouting, which precludes some contingencies.

CSER 03-026 evaluates continued storage of waste containers in LLBG retrievable storage based on the as found condition; however, generally the most limiting containers are evaluated as being together and also assuming all containers have been overbatched. The burial ground conditions – up to five high, 12 x 12 arrays with top, bottom, and side reflection generally provide for a much more reactive arrangement than in other SWOC storage locations.

Storage of Waste Containers Awaiting NDA:

Although allowed by CSERs and safety basis to be stacked up to three high, arrays are only two containers wide, and aisle spacing is provided. Reflection is reduced and potential for increasing moderation is close to being incredible. System reactivity is significantly reduced from what has generally been evaluated by CSER 80-021 for the LLBG retrievable (buried) storage. It is not reasonable to try to quantify uncertainty.

Liquid Process Operations:

For liquid processes (e.g., T Plant), fissile inventories may use a combination of process knowledge (method 3) and sampling (method 1). In many cases, only single point samples are possible based on the configuration or remote operations involved (high dose rates). The sampling operation attempted to provide reasonably homogenized samples, but measured isotopic concentrations and densities have to be combined with conservative estimates of mass, volume, and knowledge or assumptions about the material distribution. Direct measurements of fissile mass are difficult in canyon and tank operations because of background radiation, shielding, and geometry. Facility inventories are considered to be reasonably bounding, but uncertainty cannot be quantified for many measurements, which were taken at different times and with various analytical methods.

There are currently no plans for further liquid decontamination system operations in the canyon. Appendix C shows a methodology that has been used in the past to calculate the 221-T tank system inventory. The tank system inventory is currently static because of environmental concerns but is estimated to be 111.2 FGE. It is considered that conservative estimates of the mass and concentrations combined with a thorough evaluation of historical data provide a bounding inventory. Facility limits have recently been updated to allow only 200 FGE in any independent Unit Cell, rather than the previous 900 FGE total limit. 221-T Canyon liquid waste operations should be exempted from any requirements for quantifying the uncertainty provided conservative estimating techniques are demonstrated to have been followed.

2706-T facility liquid waste operations will require a fissile inventory tracking system before fissile material decontamination operations can begin. No fissile decontamination operations are currently planned. Appendix D was prepared for operations as an isolated facility, thus the entire inventory needed to be tracked, not just that in the tank system. Because individual Unit Cell operations are limited to 200 FGE, and are expected to be a fraction of this, quantified uncertainty will not normally be needed. As above for 221-T, 2706-T liquid waste operations should be exempted from any requirements for quantifying the uncertainty provided conservative estimating techniques are demonstrated to have been followed.

Mixed waste trench operations may also result in dilute fissile solutions in the sumps and storage tanks. Limits (CSER 03-014) are well below levels of concern such that there is no need to track uncertainty.

Radioactive Surface Contamination or Facility Holdup:

T Plant previously operated as a plutonium process facility. Holdup in the 221-T ductwork and ventilation system has been estimated as a maximum of 194 FGE based on extrapolation of worst case historical data, thus uncertainty cannot be quantified. Recent replacement of the 291-T HEPA prefilters identified negligible buildup. 2706-T has not previously operated as an alpha facility. There may also be limited holdup remaining in isolated process cells or piping that is not included in fissile inventories associated with the decontamination liquid waste system operations. Quantified uncertainty for these fixed Unit Cells and any associated contamination control buffer areas is not possible. Buildup on T Plant facility HEPA filters is monitored by dose rates following HNF-3845 and HEPA vacuum cleaners are controlled at levels that will make it unlikely to exceed even a few FGE, let alone 200 FGE. Quantified uncertainty is not normally possible for T Plant fixed Unit Cell operations or for HEPA filter monitoring in any SWOC facility.

Intrusive Operations:

WRAP Process Area Glovebox operations account for uncertainty and holdup, which is within the capability of the facility, with individual containers allowed up to 400 FGE under CSER 02-018 (HNF-13391). T Plant intrusive operations currently are limited to 200 FGE, but will usually be much less because of the radiological control considerations for alpha bearing material. Even for operations up to 450 FGE, the actual critical mass would be several times to orders of magnitude greater than what is actually being handled considering the form and distribution of the fissile material.

Before a container is moved into a WRAP Process Area Glovebox, it is assayed for isotopic makeup with an approved NDA system. The fissile mass and a value for measurement uncertainty is then calculated by WRAP assay Engineers. The container FGE, isotopic makeup, and TMU are entered into the WRAP facility DMS by the assay engineers. The WRAP DMS keeps a running inventory of FGE and TMU in each of the Process Area Gloveboxes. When a container (e.g., 55 gallon drum, 85 gallon overpack, 75 gallon overpack, transfer drum, Sample Transport Container [STC], and/or packet) is being added to a glovebox the container FGE and TMU amounts are added to the glovebox inventory. When a container is removed from a glovebox, DMS removes the FGE value of that container from the glovebox inventory.

Glovebox Total TMU is not decreased by the removal of a container from a glovebox. Each container TMU remains as a component of the Glovebox Total TMU even after the container itself is removed. Glovebox Total TMU can ONLY be updated (i.e., reduced) by performing an assay of the glovebox itself. Upon assay completion a new TMU may be calculated for the glovebox. This method of calculating each Glovebox Total TMU is to ensure a conservative FGE value for each glovebox is maintained.

In cases when a portion of a parent container will be removed from a glovebox (i.e., removal of non-compliant items or samples from a drum), a packet is used. All packets require an assay. But until an assay can be performed, DMS will assign a value of 15 FGE or the total of the parent container FGE (whichever is less) to the packet. The assigned fissile mass will be added to the glovebox inventory where the packet is located. Glovebox Total TMU will not be adjusted at this time. Once an assay of the packet is obtained, the measured FGE and TMU values are entered into DMS to replace the initial values assigned. This update may change the FGE inventory of the glovebox or limited control area in which the packet is currently located.

Transfer drums and STCs are used to transport packets between gloveboxes. Transfer drum and STC fissile inventories are tracked in DMS. Transfer drums and STCs do not accumulate a Total TMU. When packets are removed from a transfer drum or STC, the TMU of those packets will be transferred to the glovebox to which the packet is added.

Similar tracking will be performed for T Plant Unit Cell operations; however uncertainty data may not be available for operations up to 200 FGE. The limited nature of the activities normally will allow direct confirmation that there is no holdup, and only closed waste containers or whole equipment pieces cross the Unit Cell boundary. Holdup is tracked whenever the Unit Cell inventory is not confirmed to be zero at the completion of an activity.

6.0 WD/GRP PROGRAMMATIC REQUIREMENTS

In order to assure adequate consideration of uncertainty in assigning fissile mass, WD/GRP will commit to the following programmatic requirements.

1. Waste Services will continue to maintain waste acceptance criteria that generally follow Appendix A.

2. WD/GRP will at least annually compare NDA results with fissile mass from previous records, similar to that reported in HNF-18009. This applies to fixed NDA at WRAP and also NDA performed in mobile trailers whenever these trailers are routinely conducting assays. This comparison should place an emphasis on containers assigned a high fissile mass (those over 100 FGE) and may include random sampling techniques, i.e., it does not have to be a 100 percent sample.

3. NDA results that indicate significant differences with previously recorded values (e.g., greater than 50 percent increase for a high fissile mass container) will be investigated to determine if any additional actions should be taken. For example, there could be a particular problem with inventory values provided by a particular generator during a given time frame or for a particular waste stream, the hardcopy record may be incomplete or confusing, or data may have been entered incorrectly.

4. WD/GRP will perform a review of this methodology at least every two years. This document will be updated as needed.

These commitments and the specific processes that accomplish them will be implemented in facility and project administrative procedures.

REFERENCES

ARH-1842, 1970, *Specifications and Standards for the Burial of ARHCO Solid Wastes*, Atlantic Richfield Hanford Co, Richland, Washington.

ARH-3032, 1974, *Specifications and Standards for the Packaging, Storage and Disposal of Richland Operations Solid Wastes*, Atlantic Richfield Hanford Co, Richland, Washington.

DOE/CBFO-01-1005, 2001, *Performance Demonstration Program Plan for Nondestructive Assay of Drummed Wastes for the TRU Waste Characterization Program*, Rev 0.1, DOE Carlsbad Field Office, Carlsbad, New Mexico.

DOE/RL-96-68, 1998, *Hanford Analytical Services Quality Assurance Requirements Document*, DOE Richland Operations Office, Richland, Washington.

HNF-4050, 2002, *Total Measurement Uncertainty (TMU) for NDA of TRU Waste at the WRAP Facility*, Rev 8, Fluor Hanford, Inc., Richland, Washington.

HNF-3485, 1999, *Dose Rate to Activity Assay Calculations for T Plant HEPA Filters*, Fluor Daniel Northwest, Richland, Washington.

HNF-5134, 2000, *CSER 00-005: Determination of Fissile Gram Equivalence for Hanford Solid Waste Operations*, Fluor Hanford, Inc., Richland, Washington.

HNF-6747, 2003, *CSER 00-020: Waste Treatment, Storage, and Decontamination Operations in 221-T,* Rev. 1, Fluor Hanford, Inc., Richland, Washington.

HNF-7098, 2004, *Criticality Safety Program*, Rev. 5, Fluor Hanford, Inc., Richland, Washington.

HNF-8319, 2001, *CSER 01-006: Storage of 55-Gallon Drums for Direct Disposal of Plutonium Bearing Liquids*, Fluor Hanford, Inc, Richland, Washington.

HNF-8854, 2002, *CSER 01-010: Storage of 55-Gallon Drums with Concentrated Core Regions*, Fluor Hanford, Inc, Richland, Washington.

HNF-13391, 2004, *CSER 02-018: Designation of WRAP Process Area as a Limited Control Facility*, Fluor Hanford, Inc, Richland, Washington.

HNF-17340, 2004, *CSER 03-014: Disposal of Uranium in the Mixed Waste Trenches*, Fluor Hanford, Inc, Richland, Washington.

HNF-18009, 2003, *Comparison of WRAP NDA Fissile Grams Equivalent Data to Acceptable Knowledge*, Fluor Hanford, Inc, Richland, Washington.

HNF-18921, 2004, *CSER 03-026: Review of Drums Retrievably Stored in Vertical Configurations at the Low Level Burial Ground Transuranic Waste Trenches*, Fluor Hanford, Inc, Richland, Washington.

HNF-EP-0063, 2004, *Hanford Site Solid Waste Acceptance Criteria*, Rev. 10, Fluor Hanford, Inc, Richland, Washington.

PNNL-10910, 1996, *EBRII Cask Characterization Measurements*, Pacific Northwest National Laboratory, Richland, WA.

WHC-SD-SQA-CSA-20121, 2000, *CSAR 80-021: Packaging, Storage and Disposal of Solid Waste (55-Gallon Drums, Unrestricted H/Pu Only)*, Rev. 0A, Fluor Hanford, Inc, Richland, Washington.

WHC-SD-SQA-CSA-20130, 2000, *CSAR 82-003: Packaging, Storage and/or Disposal of Solid Wastes (Burial Containers and Uranic Burial)*, Rev. 0A, Fluor Hanford, Inc, Richland, Washington.

WHC-SD-SQA-CSA-20204, 2002, *CSAR 79-038: Out-of-Hood Plutonium Storage*, Rev. 0A, Fluor Hanford, Inc, Richland, Washington.

WHC-SD-SQA-CSA-20395, 1999, *CSER 95-007: Acceptability of Bettis Laboratory Waste Shipment to WHC Solid Waste*, Rev. 1, Fluor Daniel Northwest, Inc, Richland, Washington.

WHC-SD-SQA-CSA-20397, 2001, *CSAR 79-038 Addendum 6: Out-of-Hood Plutonium Storage (Burial Box)*, Rev. 0A, Fluor Hanford, Inc, Richland, Washington.

APPENDIX A

Portions of the current waste acceptance criteria that relate to measurement uncertainty have been extracted from HNF-EP-0063, as follows:

2.4 RADIOLOGICAL CHARACTERIZATION

The major radionuclides in the waste and the concentration of each major radionuclide must be established with sufficient sensitivity and accuracy to properly classify and manage the waste in accordance with the TSD unit-specific radiological limits (DOE M 435.1-1).

2.4.1 Identification of Major Radionuclides

For the purposes of the radiological criteria in this document, major radionuclides are defined as those radionuclides that meet any of the following conditions. Calculational methods for determining these limits are described in Appendix A.

- Any TRU radionuclide present in the waste in concentration exceeding 1 nanocurie per gram.

- Any fissionable radionuclide present in the waste in a quantity exceeding 0.1 FGE per container.

- Any radionuclide present in concentration exceeding 1 percent of its respective Category 1 limit (Appendix A, Table A-2. Note: this reporting limit does not apply to TRU waste).

- Any radionuclide that is reportable on shipping papers in accordance with 49 CFR 173.433.

- Any mobile radionuclide present in concentration that exceeds its reporting limit (Appendix A, Table A-2. Note: this reporting limit does not apply to TRU waste).

- For waste that has no detectable radiological activity but cannot be radiologically released, major radionuclides are those radionuclides believed to contribute more than 1 percent each of the radiological activity based on available process knowledge. The estimated concentration of the radionuclides should be based on the limit of detection of the analysis method used.

- The amount of U-235 and U-238 must be reported in each waste container that contains at least 0.1 grams of U-235, or if either isotope is a major radionuclide. The amount of U-233 must be reported in each waste container that contains at least 0.1 grams of U-233.

- Any radionuclide that accounts for more than 1 percent of the total radiological activity of the waste. However, a radionuclide in concentration less than 1.0 E-6 Ci per cubic meter, and not otherwise reportable, is exempt from reporting.

2.4.2 Methods for Establishing Radionuclide Inventory

The radionuclide inventory of a waste must be established using a method or combination of methods capable of identifying and quantifying the major radionuclides present. The methods chosen must provide adequate sensitivity and accuracy to ensure that the waste is categorized correctly (e.g., Category 1 and 3 limits for the LLBG, correct TRU determination). A graded approach (DOE M 435.1-1) should be applied when planning radiological characterization of waste streams. Using the graded approach, more frequent and detailed analysis is performed when a waste approaches one or more of the limits of these criteria. Conversely, waste that is far below applicable limits of these criteria would not require as extensive or frequent analysis. Use of the data quality objectives process (or an equivalent process) in accordance with DOE M 435.1-1, should help ensure that the appropriate type, quantity, and quality of radiological characterization data are obtained.

Both direct and indirect methods can be used for characterization (DOE G 435.1-1). When indirect methods are used, these methods must be corroborated periodically with direct measurements. The frequency of corroborative analysis should be based on the variability of the waste generating process, and the extent and consistency of previous analytical data. A graded approach should be applied when determining the appropriate type and frequency of corroborative analysis.

The following characterization methods can be used individually or in combination to establish the radionuclide inventory of the waste.

- Process knowledge – Process knowledge includes documented knowledge of the radioactive materials used and the processes that contributed to the radiological content of the waste, along with historical analysis of waste and radiological contamination from the process. Process knowledge can be used to establish the suspected major radionuclides in a waste stream. In addition, process knowledge can be used to eliminate from further consideration those radionuclides not present in sufficient concentration to be major radionuclides as defined in Section 2.4.1, as long as the basis of this determination is documented.

- Radionuclide material accountability - The content of a given radionuclide in a waste can be determined by documented logs detailing the mass or activity of that radionuclide added to and leaving the waste in a controlled process. In addition, data relating the total inventory of a radionuclide in a process or facility can be used to determine the radionuclide inventory, but must be corroborated periodically with direct measurement methods.

- Field and laboratory analysis methods - Field and laboratory analysis methods, such as NDA, radiochemical analysis, and surveys with field instruments, must be selected as appropriate to detect and quantify the major radionuclides with adequate sensitivity and accuracy for waste classification. Analysis methods that measure gross activity (i.e., not radionuclide specific) must be used in conjunction with other methods to determine the relative concentration (scaling factors) of each suspected radionuclide, and must be corroborated periodically with radionuclide-specific analysis.

- Computer modeling - Computer modeling, applied appropriately, could be used in conjunction with other methods for radiological characterization. An individual who is knowledgeable and experienced in the use and limitations of the model must perform the modeling. The assumptions and measurements used as inputs to computer modeling must be documented. The computer software must be controlled in a manner that meets conventional QA requirements. Computer models must be corroborated periodically with direct measurement methods.

- Scaling factors - Scaling factors can be used to relate the concentration of a readily-measured radionuclide to more difficult to measure radionuclides. Scaling factors must be developed from one of the previous methods, and must be corroborated periodically with radionuclide-specific analysis.

Other methods of radiological characterization could be used, but must be documented clearly and approved by the WMP acceptance organization. Documentation of the method must include a detailed description of the method, the radionuclides identifiable by the method, and a discussion of precision, accuracy, QA, and QC methods.

2.4.3 Additional Detail on Mobile Radionuclide Characterization

For low-level and low-level mixed waste, mobile radionuclide reporting is particularly critical for compliance with the LLBG performance assessments (WHC-EP-0645 and WHC-SD-WM-TI-730). Because of the low reporting limits and difficulty of analysis of certain mobile radionuclides, this section provides additional detail concerning acceptable knowledge and characterization.

The concentration of each mobile radionuclide must be established with respect to the Appendix A, Table A-2, reporting limit using process knowledge and/or analysis. If process knowledge alone is used to determine that a mobile radionuclide is not present in a waste stream at the reporting limit, the basis for this determination must be clearly documented. If available analysis techniques cannot detect a mobile radionuclide at its reporting limit, the concentration could be estimated using a combination of process knowledge, scaling factors, and analytical detection limits.

Mobile radionuclide reporting is intended to measure only the quantity of isotopes that exceeds Hanford Site natural background concentrations. For waste forms that contain uranium that originates from natural background on the Hanford Site, the background concentration of that radionuclide can be subtracted from the total concentration.

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APPENDIX B

The consideration of fissile mass uncertainty has been expressed in various terms in criticality safety documentation at Hanford. Some of this discussion has been extracted as follows:

ARH-1842, *Specifications and Standards for the Burial of ARHCO Solid Wastes*, December 1970:

3.4.2 [Personnel Protection Operation is responsible for providing] assistance in estimating the plutonium and/or other transuranium nuclide content of packages when radiation counting of packaged waste is not feasible.

4.1.1 [burial boxes]...shall be known beyond reasonable doubt to contain less than 1000 grams...

4.1.2 [miscellaneous wastes] ... < 250 g Pu, U-233, or U-235 (above natural)...

5.1.1.4 "All solid radioactive waste containers shall be surveyed at the facility generating the waste. The radiation readings shall be recorded and used for estimating the radioactive wastes contained. Waste containers generated by facilities where plutonium, uranium-233, protactinium-233 and uranium-235 could be present in significant quantities (234-5, 202-A) should be monitored by neutron counting or other methods which will provide a meaningful estimate of the fissile content of the waste."

5.4.1 A solid waste burial record form shall be completed by the facility generating the waste and shall accompany the shipment to the burial grounds.

ARH-3032, *Specifications and Standards for the Packaging, Storage and Disposal of Richland Operations Solid Wastes*, April 1974:

3.1.3 The total mass ... contained in a burial box shall be known beyond reasonable doubt (as determined by the best estimating methods) to be less than 1000 grams.

3.1.3.4 When the ^{235}U content of uranium present is greater than 1.15 but less than or equal to 1.97 percent, individual boxes containing miscellaneous equipment pieces ... shall be known beyond reasonable doubt to contain less than 340 grams total plutonium, ^{233}U, and ^{233}Pa, and less than 1,100 pounds of uranium.

4.1.4 "Waste containers generated by facilities where plutonium, uranium-233, protactinium-233 and uranium-235 could be present in significant quantities (234-5, 202-A) should be monitored by neutron counting or other methods which will provide a meaningful estimate of the fissile content of the waste.

4.4.1 A solid waste burial record form shall be completed by the facility generating the waste and shall accompany the shipment to the burial grounds. A transuranic dry waste storage form must also accompany the shipment if transuranic wastes are present.

CSAR 79-038 (WHC-SD-SQA-CSA-20204)

"The analysis for the HEPA filters [in the burial box] was based on maintaining k-infinity less than 1.0 under the worst credible conditions. …overbatching any filter by a factor of 2 in addition to the collapse of a burial box will not cause a k-infinity of 1.0 to be exceeded."

CSAR 80-021 (WHC-SD-SQA-CSA-20121)

"Overbatching of drums can occur but generally by minor amounts…. If the fissile material is believed to be well moderated material but actually is poorly moderated (e.g., plutonium oxide), an incorrect conversion table for converting radiation level to fissile material content can be selected which can underestimate the fissile mass. Generally, the better moderated the fissile material, the lower the fissile content is calculated to be for a given radiation level…. However, from the array reactivity standpoint there is a self-compensating aspect of this in that for arrays of drums with identical grams of plutonium per drum the arrays with unmoderated fissile cores have a much lower k-effective than arrays with moderated cores."

APPENDIX C

SAMPLE CALCULATIONS OF 221-T CANYON FISSIONABLE MATERIAL INVENTORY

The calculations discussed in this appendix are intended for the use of the CSR and inventory custodian. Deviations are approved by the CSR. Spreadsheets or databases may be used to enhance maintaining an up-to-date inventory subject to verification requirements.

1. Calculate Fissionable Material in Tank System Liquid.

NOTE - Tank system contents were previously transferred to tank 15-1 to prepare for a railcar shipment. Prior to the transfer to railcar, the liquid contained in tank 15-1 was sampled. The analysis of the tank 15-1 liquid sample was used as representative for calculating the amount of fissionable material in the entire waste tank system liquid. In the future, any transfers may be made directly to truck cargo tanks from several tanks, thus each liquid movement must be carefully evaluated to determine if or how the fissionable inventory will be calculated or adjusted.

a. Record Tank 15-1 sample analysis results in the canyon baseline logbook or spreadsheet.

b. Record in the canyon baseline spreadsheet, the liquid volumes of Tanks 15-1 and 5-7 from the operations daily report or daily surveillance data sheet from plant operating procedures for the day on which the samples were taken.

c. Calculate the mass of fissionable material using the following equation:

$$m_l = V_t * (c_{Pu,l} + c_{U,l})$$

where:

m_l = mass of fissionable material in tank system liquid (g)
V_t = total liquid volume in tank system (L)
$c_{Pu,l}$ = liquid concentration of total Pu (g/L)
$c_{U,l}$ = liquid concentration of ^{235}U (g/L).

3. Calculate Fissionable Material in Tank 15-1 Sludge

NOTE - A Tank 15-1 sludge sample is taken after a liquid transfer is performed. Sample results with an isotopic breakdown of uranium are preferred. However, if an isotopic breakdown can not be obtained for the sludge sample, then the isotopic break down from the liquid sample is used to determine the ^{235}U concentration.

a. Record Tank 15-1 sludge sample analysis results in the canyon baseline logbook or spreadsheet.

b. If necessary, calculate the ^{235}U enrichment using the liquid sample and following equation:

$$e = c_{U,l} / c_{t,l}$$

where:

e = ^{235}U enrichment (wt%)

$c_{t,l}$ = liquid concentration of total uranium (g/L).

c. If necessary, calculate the ^{235}U concentration using the sludge sample and following equation:

$$c_{U,s,15\text{-}1} = e * c_{t,s,15\text{-}1}$$

where:

$c_{U,s,15\text{-}1}$ = sludge concentration of ^{235}U (g/g)

$c_{t,s,15\text{-}1}$ = sludge concentration of total uranium (g/g).

d. Calculate the Pu (i.e. $^{239}Pu/^{240}Pu$) concentration using the sludge sample and following equation:

$$c_{Pu,s,15\text{-}1} = ac_{Pu,s,15\text{-}1} / SpA$$

where:

$c_{Pu,s,15\text{-}1}$ = sludge concentration of Pu (g/g)

$ac_{Pu,s,15\text{-}1}$ = activity concentration of Pu (Ci/g)

SpA = 0.072 = specific activity for Pu (Ci/g).

e. Calculate mass of fissionable material in Tank 15-1 using the following equation:

$$m_{s,15\text{-}1} = (c_{U,s,15\text{-}1} + c_{Pu,s,15\text{-}1}) * \rho * V_{15\text{-}1}$$

where:

$m_{s,15\text{-}1}$ = mass of fissionable material in Tank 15-1 (g)

ρ = 1500 = density of sludge (g/L)

$V_{15\text{-}1}$ = 4530 = sludge volume in Tank 15-1 (L).

4. Calculate Fissionable Material in Tanks 5-7, 5-6, and 5-9 Sludge

NOTE - A Tank 5-7 sludge sample was taken once every six months of operation to ensure concentration limits were not exceeded. Additional samples may be required for inventory purposes in order to update the inventory once a liquid waste shipment is completed. If an isotopic breakdown can not be obtained for the sludge sample, then the isotopic break down from the Tank 15-1 liquid sample is used to determine the ^{235}U *concentration.*

a. Record Tank 5-7 sludge sample results in the canyon baseline logbook or spreadsheet.

b. If necessary, calculate the ^{235}U enrichment using the liquid sample and following equation:

$$e = c_{U,l} / c_{t,l}$$

where:

$e = {}^{235}$U enrichment (wt%)

$c_{t,l}$ = liquid concentration of total uranium (g/L).

c. If necessary, calculate the ^{235}U concentration using the sludge sample and following equation:

$$c_{U,s,5\text{-}7} = e * c_{t,s,5\text{-}7}$$

where:

$c_{U,s,5\text{-}7}$ = sludge concentration of ^{235}U (g/g)

$c_{t,s,5\text{-}7}$ = sludge concentration of total uranium (g/g).

d. Calculate the Pu (i.e. ^{239}Pu/^{240}Pu) concentration using the sludge sample and following equation:

$$c_{Pu,s,5\text{-}7} = ac_{Pu,s,5\text{-}7} / SpA$$

where:

$c_{Pu,s,5\text{-}7}$ = sludge concentration of Pu (g/g)

$ac_{Pu,s,5\text{-}7}$ = activity concentration of Pu (Ci/g)

SpA = 0.072 = specific activity for Pu (Ci/g).

e. Calculate the mass of fissionable material in Tank 5-7 using the following equation:

$$m_{s,5\text{-}7} = (c_{U,s,5\text{-}7} + c_{Pu,s,5\text{-}7}) * \rho * V_{5\text{-}7}$$

where:

$m_{s,5\text{-}7}$ = mass of fissionable material in Tank 5-7 (g)
$\rho = 1500$ = density of sludge (g/L)
$V_{5\text{-}7} = 4670$ = sludge volume in Tank 5-7 (L).

NOTE - The contents of Tank 5-7 previously had to be transferred via either Tank 5-9, and may have passed through Tank 5-6 as well. The sludge concentration in Tanks 5-6 and 5-9 is assumed to be equivalent to that in Tank 5-7 at the time of the last transfer through these tanks (1994), rather than current values. This is a change from previous methods.

f. Calculate the mass of fissionable material in Tank 5-6 sludge using the following equation:

$$m_{s,5\text{-}6} = (c_{U,s,5\text{-}7} + c_{Pu,s,5\text{-}7}) * \rho * V_{5\text{-}6}$$

where:

$m_{s,5\text{-}6}$ = mass of fissionable material in Tank 5-6 (g)
$\rho = 1500$ = density of sludge (g/L)
$V_{5\text{-}6} = 950$ = sludge volume in Tank 5-6 (L).

g. Calculate the mass of fissionable material in Tank 5-9 sludge using the following equation:

$$m_{s,5\text{-}9} = (c_{U,s,5\text{-}7} + c_{Pu,s,5\text{-}7}) * \rho * V_{5\text{-}9}$$

where:

$m_{s,5\text{-}9}$ = mass of fissionable material in Tank 5-9 (g)
$\rho = 1500$ = density of sludge (g/L)
$V_{5\text{-}9} = 950$ = sludge volume in Tank 5-9 (L).

h. Calculate the total fissionable inventory in the Canyon.

i. Update the total fissionable inventory in the logbook or spreadsheet.

5. Tracking Fissionable Material in Containers and Equipment.

NOTE - The custodian must approve EACH acceptance and transfer into the facility of waste containers, cargo tanks, and equipment (for decontamination) with fissionable material, unless interim limits have been established in advance and FGE is verified to be within limits using SWITS or a similar equipment database.

a. Upon notification from operations management, prior to acceptance of containers or equipment, update the canyon running total logbook or spreadsheet with the fissionable content estimate from the shipper (validated by the custodian) as needed. Update the date and time upon receipt.

b. Upon notification from operations management concerning removal of containers or equipment, update the canyon running total logbook or spreadsheet with the date that the item is removed from the facility.

c. The inventory that is associated with equipment that is being decontaminated is added to the tank inventory. That inventory remains on the books until all affected tanks have been sampled and the tank inventory is updated based on the sample results.

6. Tracking Fissionable Material in Liquid Transfers.

   a. Record date of the transfer on the T-Plant liquid transfers out logbook or spreadsheet.

   b. Record the sending tank designation on the T-Plant liquid transfers out logbook or spreadsheet.

   c. Record the sending tank sample data on the T-Plant liquid transfers out logbook or spreadsheet.

   d. Record the starting and ending volumes on the T-Plant liquid transfers out logbook or spreadsheet.

   e. Record line hold-up volume on the T-Plant liquid transfers out logbook or spreadsheet.

   f. Calculate the mass of fissionable material in the transfer using the following equation:

$$m_t = (V_i - V_f)^* (c_{Pu,l} + c_{U,l})$$

   where:

   m_t = mass of fissionable material transferred to the cargo tanker (g).
   V_i = intial volume in the tank (L)
   V_f = final volume in the tank (L)
   $c_{U,l}$ = concentration of ^{235}U in the tank (g/L).
   $c_{Pu,l}$ = concentration of Pu in the tank (g/L).

   g. Record the mass of fissionable material in the transfer on the canyon running total logbook or spreadsheet.

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APPENDIX D

SAMPLE CALCULATIONS OF 2706-T FACILITY INVENTORY FOR ISOLATED FACILITY OPERATIONS

The calculations discussed in this appendix are intended for the use of the CSR and custodian. Deviations are approved by the CSR. Spreadsheets or databases may be prepared to enhance maintaining an up-to-date inventory subject to verification requirements.

Fissionable inventory in 2706-T/TA/TB unit cell shall be tracked as follows:

> *NOTE - Additions to Tank T-XX-2706-220/221 after sampling invalidate the data for this tank. No transfers into these tanks are allowed after sampling and prior to transfer to the tank car. Tank numbers are abbreviated hereafter without the "T-XX-" prefix.*

1. Subtract cargo tank shipment fissionable material from the inventory.

   a. Record Tank 2706-220/221 sample analysis results on the 2706 liquid transfers out logbook or spreadsheet.

   b. Record the starting liquid volume in the tank on the 2706 liquid transfers out logbook or spreadsheet.

   c. Record the volume in the tank after transferring to the tank car on the 2706 liquid transfers out spreadsheet.

   d. Calculate the volume of the tank car transfer using the following equation:

$$V_t = V_i - V_f$$

   Where:

   V_t = Total volume of tank car transfer (L)

   V_i = Initial volume of Tank 2706-220 or –221 (L)

   V_f= Final volume of Tank 2706-220 or –221 (L)

   e. Calculate the mass of fissionable material in the tank car using the following equation:

$$m_l = V_t * (c_{Pu,l} + c_{U,l})$$

where:

m_l = mass of fissionable material in tank car (g)
V_t = total volume of the tank car transfer (L)
$c_{Pu,l}$ = liquid concentration of total Pu (g/L)
$c_{U,l}$ = liquid concentration of ^{235}U (g/L).

f. Record the calculated mass of fissionable material in the transfer on the 2706-T running total logbook or spreadsheet.

g. Calculate a new facility inventory total using the following equation:

$$\text{New } m_f = \text{Old } m_f - m_l$$

where:
m_f = running total of fissionable material in 2706-T/TA/TB (g)

2. Track the fissionable content of equipment in the facility:

   a. Upon notification from Operations management, prior to the receipt of equipment for decontamination, record the equipment designation and fissionable content estimate on the 2706-T running total logbook or spreadsheet. Update date and time upon receipt.

   b. After removal of any equipment from the facility, record the date that the equipment was removed on the 2706 running total spreadsheet.

   c. Add the estimated fissionable content to the facility total when items are received.

   d. Maintain the estimated values in the facility inventory until the facility has been re-baselined following removal of the item.

NOTE - In order to subtract the estimated fissionable mass of equipment which has been removed from the facility, the total mass of fissionable material in the facility sumps and holding tanks must be calculated. This total is then added to the sum of the estimated fissionable content of all equipment in the facility to arrive at a new total. Step 4, below, is only performed to establish a new baseline (running total) of the facility fissionable inventory.

4. Calculate the fissionable material in the facility liquid handling systems.

   a. Record Tank 2706-220 sample analysis results on the 2706-T Baseline logbook or spreadsheet.

b. Record the liquid volume in the tank for the day on which the samples were taken on the 2706-T Baseline logbook or spreadsheet.

d. Calculate the mass of fissionable material in Tank 2706-220 using the following equation:

$$m_{l\text{-}220} = V_t * (c_{Pu,l} + c_{U,l})$$

where:

$m_{l\text{-}220}$ = mass of fissionable material in Tank 2706-220 (g)
V_t = total volume in Tank 2706-220 (L)
$c_{Pu,l}$ = concentration of total Pu (g/L)
$c_{U,l}$ = concentration of ^{235}U (g/L).

e. Record Tank 2706-221 sample analysis results.

f. Record the liquid volume in the tank for the day on which the samples were taken.

g. Calculate the mass of fissionable material in Tank 2706-221 using the following equation:

$$m_{l\text{-}221} = V_t * (c_{Pu,l} + c_{U,l})$$

where:

$m_{l\text{-}220}$ = mass of fissionable material in Tank 2706-221 (g)
V_t = total volume in Tank 2706-220 (L)
$c_{Pu,l}$ = concentration of total Pu (g/L)
$c_{U,l}$ = concentration of ^{235}U (g/L).

NOTE - Rinsing of the railroad pit and the sumps is required prior to establishing a new baseline inventory (running total) for the facility. Steps g through n, below, are included to provide guidance for emergency conditions, only. These steps assume that the railroad pit is completely drained, so if a baseline must be established when this pit is not drained, engineering must be contacted for further guidance. If rinsing of the railroad pit and the sumps has taken place, steps g through l, below may be omitted and ml-Ts and ml-TAs may be set equal to zero. If all the solids have been removed from these areas, step n, below may be omitted, and m_{sol} *may be set equal to zero*

h. Record Tank 2706-T sump sample analysis results.

i. Record the liquid volume in the 2706-T sump for the day on which the samples were taken.

j. Calculate the mass of fissionable material in the 2706-T sump using the following equation:

$$m_{l\text{-}Ts} = V_t * (c_{Pu,l} + c_{U,l})$$

where:

$m_{l\text{-}Ts}$ = mass of fissionable material in 2706-T sump (g)
V_t = total volume in Tank 2706-T sump (L)
$c_{Pu,l}$ = concentration of total Pu (g/L)
$c_{U,l}$ = concentration of ^{235}U (g/L).

k. Record Tank 2706-TA sump sample analysis results.

l. Record the liquid volume in the 2706-TA sump for the day on which the samples were taken.

m. Calculate the mass of fissionable material in the 2706-TA sump using the following equation:

$$m_{l\text{-}TAs} = V_t * (c_{Pu,l} + c_{U,l})$$

where:

$m_{l\text{-}TAs}$ = mass of fissionable material in 2706-TA sump (g)
V_t = total volume in Tank 2706-TA sump (L)
$c_{Pu,l}$ = concentration of total Pu (g/L)
$c_{U,l}$ = concentration of ^{235}U (g/L).

NOTE - It is advised that the liquid filters be changed out after obtaining the samples required for establishing the baseline. If this is completed, and the old filters are removed from the facility prior to calculating the new baseline, the fissionable inventory on the filters may be assumed to be zero ($m_{fil} = 0$).

n. Calculate the fissionable content on the liquid filters using the following equation:

To be determined by a new evaluation if required. (m_{fil})

o. If there are solids in the either the 2706-T or 2706-TB sumps, request Engineering to provide an estimate of the fissionable content of these solids (m_{sol}).

p. Calculate the total fissionable material in the liquid systems using the following equation:

$$m_{l\text{-}tot} = m_{l\text{-}220} + m_{l\text{-}221} + m_{l\text{-}Ts} + m_{l\text{-}TAs} + m_{fil} + m_{sol}$$

where:

$m_{l\text{-}tot}$ = total mass in the liquid systems (g)

q. Fissionable material buildup on the high efficiency particulate air (HEPA) filters attached to the tank vents will be evaluated every six months of operation. Fissionable material buildup on the HEPA filters of the ACT-1 and ACT-2 heating, ventilation and air conditioning (HVAC) system will also be evaluated based on data obtained using the tables in HNF-3485. Frequency may need to be adjusted based on tempo of operations and workplace monitoring.

NOTE - The summation of the facility equipment is taken when the baseline is calculated and not when the liquid samples are taken. This summary must include the estimates of the fissionable content of the equipment provided by the shipper for all equipment in the facility regardless of decontamination status. This may also include any cargo tanker fissionable material content which is not included in SWITS.

r. Calculate the total fissionable material in the facility by summing the total in the liquid system, the total for all equipment in the building, and that in HEPA filters using the following equation:

$$m_{total} = \boldsymbol{\Sigma}\, m_{ei} + m_{l\text{-}tot} + m_{vent} + m_{hvac}$$

where:

m_{total} = total mass in 2706-T/TA/TB (g)

$\boldsymbol{\Sigma}\, m_{ei}$ = summation of the fissionable material estimates of all equipment located in the facility.

m_{vent} = fissionable material in tank vent HEPAs

m_{hvac} = fissionable material in HVAC HEPAs

Record the facility total calculated above on the 2706-T running total logbook or spreadsheet.