X-SD-G-00008, Rev. 20

Waste Acceptance Criteria for Sludge, ARP, and MCU Process Transfers to 512-S and DWPF (U)

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WASTE ACCEPTANCE CRITERIA FOR SLUDGE, ARP, AND MCU PROCESS TRANSFERS TO 512-S AND DWPF (U)

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REVISION HISTORY

Revision 4 (February 2010)	**Revision bars used** - Added to distribution list - Added Revision History section - Changed SB4 to SB5 throughout the document - Section 5.3.3.1: Changed 512-S criticality safety criteria from single subcritical mass argument to an enrichment/concentration basis - Section 5.3.3.3: Revised to clarify the computational technique - Section 5.3.3.4: Revised section to clarify the background for nuclear criticality safety - Section 7.0: Deleted References 7.33, 7.50, 7.53, and 7.54 - Section 7.0: Updated References 7.1, 7.2, 7.48, 7.49, 7.55, and 7.56 to reflect the most current revisions
Revision 5 (June 2010)	**Revision bars used** - Added Sludge Batch 6 throughout the document - Section 5.4.6: Changed Fe to Pu-239(eq) weight ratio limit to greater than or equal to 160:1 - Section 5.4.10: Added Reduction of Constraints report (Reference 7.29) for replacement of homogeneity constraint - Section 5.4.17: Added Fissile concentration in glass limit of 897 g/m^3 glass - Section 7.0: Added Sludge Batch 6 References 7.33, 7.50, 7.53, and 7.54
Revision 6 (March 2011)	**Revision bars used** - Removed Implementation Checklist - Removed Sludge Batch 5 throughout the document - Added Sludge Batch 7A throughout the document - Section 7.0: Added Sludge Batch 7A References 7.34, 7.60, 7.61, and 7.62 - Increased the Isopar concentration allowable in the MCU transfer line to DWPF (Section 5.4.13) - Added reference for basis of particle size requirement
Revision 7 (June 2011)	**Revision bars used** - Changed the description of DWPF TSR 5.8.2.25 from Administrative to Specific Administrative Control in the Requirements and sections 5.3.3.2 and 5.3.6.2.
Revision 8 (September 2011)	**Revision bars used** - Removed Sludge Batch 6 throughout the document - Added Sludge Batch 7b throughout the document - Section 7.0: Added Sludge Batch 7b References 7.33, 7.53, 7.54 - Changed description from H Disposition Project to Tank Farm - Updated Reference 7.64 - Changed References 7.50 and 7.62 to initial ARP/MCU testing studies and added Reference 7.68 - Added new Melter feed TOC/nitrate ratio requirements for qualification of a new sludge batch in Section 5.5

REVISION HISTORY (continued)

Revision 9 **(April 2012)**	**Revision bars used** - Removed Sludge Batch 7a throughout the document and deleted References 7.34, 7.60, and 7.61 - Changed Liquid Waste Process Chemistry Program to Engineering Technology Integration - Section 5.3.3.1: Changed 512-S criticality safety by increasing the Pu concentration from 0.1 mg/L to 0.3 mg/L - Section 5.4.10: Added the nepheline requirement under Glass Quality and Processability - Updated Reference 7.1
Revision 10 **(September 2012)**	**Revision bars used** - Revised the 512-S Inhalation Dose Potential (IDP) criteria in Section 5.3.2 to delete the soluble Pu-238 limit of 3.0E-03 Ci/gal and add the new IDP limit for the 512-S MST/Sludge Solids at 6 wt% solids (1.24E+08 rem/gallon) - Updated References 7.2, 7.38, 7.48 and 7.55 and added Reference 7.71
Revision 11 **(April 2013)**	**Revision bars used** - Added Sludge Batch 8 (SB8) throughout the document - Updated organization names - Section 5.4.7: Added SB8 sulfate solubility discussion and new SB8 reference - Section 5.4.10: Revised variability study discussion - Section 5.4.12: Added more restrictive radiological hydrogen generation limit during 511-S purge modifications outage - Section 5.5: Updated the melter offgas flammability discussion - Section 7.0: Updated references accordingly
Revision 12 **(July 2013)**	**Revision bars used** - Section 5.4.14: Added new upper pH limit for Next Generation Solvent (NGS) and an associated concentration limit for boric acid - Section 7.0: Added new References 7.60 and 7.61 for NGS and corrected document number for Reference 7.63. Updated Reference 7.56 (NCSASR) and deleted References 7.48, 7.49 and 7.55 (individual NCSEs).
Revision 13 **(December 2013)**	**Revision bars used** - Removed Sludge Batch 7b throughout the document - Updated Engineering organization name - Section 5.4.6: Increased uranium enrichment limit to 5 wt% and added associated Mn safe mass ratio - Section 5.4.7: Added SB8 sulfate solubility limit to Table 5 and removed related SB7b limit - Section 5.4.12: Removed radiological hydrogen generation limit that was specific to 511-S purge modifications outage - Section 5.4.13: Changed Isopar L units from ppm to mg/L and updated strip effluent transfer line volume to 1689 gallons (Reference 7.66). Added new strip effluent specific gravity acceptance criterion. - Section 7.0: Updated references accordingly

REVISION HISTORY (continued)

Revision 14 (January 2014)	**Revision bars used** - Section 5.4.14: Revised upper pH limit for strip effluent stream under NGS/blend flowsheet. Additionally, added that compliance with upper pH limits is required prior to strip effluent batch entering DWPF Chemical Process Cell (CPC) - Section 5.4.14: Added new sodium limit for strip effluent transfers including that sodium compliance is required prior to strip effluent batch entering DWPF CPC - Section 7.0: Added References 7.74 and 7.75 as bases documents for new pH and sodium limits, respectively
Revision 15 (October 2014)	**Revision bars used for non-formatting technical changes only** - Reformatted entire document - Sections 5.1 and 5.3: Revised feed stream name in 512-S sections from MST/Sludge Solids to 512-S feed stream for consistency with DWPF FSAR - Section 5.4.2: Revised canister heat generation limit to reflect most restrictive limit from the thermal analyses of Glass Waste Storage Building (GWSBs) #1 and #2 - Section 5.4.3: Added direct analysis and/or process knowledge for compliance with Gamma Shielding limit (Cs-137 concentration) for MCU stream - Section 5.4.5: Added process knowledge for compliance with IDP limit (Cs-137 concentration) for MCU stream - Section 5.4.7: Revised background/basis for sulfate solubility limit to state that limit is dependent on glass composition and will be derived during sludge batch qualification - Section 5.4.14: Added process knowledge for compliance with pH limits for MCU stream - Section 7.0: Added GWSB #1 and #2 thermal calc references as well as renumbered all references sequentially
Revision 16 (February 2015)	**Revision bars used** - Modified Section 2 (Scope) to address the CPC Purge Modifications Outage - Revised acceptance criteria in Sections 5.4.11 (H_2 Generation/N_2O Concentration) and 5.4.12 (Radiolytic Hydrogen Generation Rate) to support the purge modifications outage - Section 7.0: Updated references accordingly and added Reference 7.39
Revision 17 (March 2015)	**Revision bars used** - All revisions implemented in Rev. 16 of the WAC related to CPC Purge Modifications were reverted back to the pre-CPC Purge Modifications wording in WAC Rev. 15
Revision 18 (June 2015)	**Revision bars used** - Revised Sections 1.0, 2.0, 5.1 and 5.3 to include Filter-Only option at 512-S - Section 7.0: Updated revision of Reference 7.10 (DWPF NCSASR)

REVISION HISTORY (continued)

Revision 19 (August 2015)	**Revision bars used** - Modified Section 2 (Scope) to address the WAC-related compensatory measures included in the JCO for the antifoam PISA - Section 5.4.5: Reduced the IDP limit to 8.0E+07 rem/gal in support of the JCO to meet the 5 rem offsite evaluation guideline - Sections 5.4.11 and 5.4.12: Added a note requiring hydrogen generation rates to be re-evaluated for SB9 and reported to DOE if higher than SB8 - Section 7.0: Updated Reference 7.24 and added References 7.60 and 7.61
Revision 20 (August 2015)	**Revision bars used** - Modified 512-S and DWPF acceptance criteria sections to specify whether it is required to include analytical uncertainty or if there is sufficient conservatism to use nominal values - Updated NOx emissions, corrosive species and glass quality to state that ARP stream contributions should be calculated and that MCU stream contribution are expected to be negligible. - Section 7.0: Updated Reference 7.2 to include the 2015 DWPF FSAR Annual Update and added Reference 7.62 - Minor editorial and formatting changes throughout

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Requirement: **This document meets the DWPF requirement of the following:**

- **DWPF Admin TSR 5.8.2.1**
- **DWPF Admin TSR 5.8.2.9**
- **DWPF TSR Specific Administrative Control (SAC) 5.8.2.11**
- **DWPF TSR SAC 5.8.2.25**
- **DWPF TSR SAC 5.8.2.31**
- **DWPF U-JCO-S-00002**

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1.0 PURPOSE

This document provides the waste acceptance criteria (WAC) for transfers to 512-S and the Defense Waste Processing Facility (DWPF). Transfers to DWPF consist of sludge from H-Tank Farm, monosodium titanate (MST)/Sludge Solids from the Actinide Removal Process (ARP), and Cesium Strip Effluent from the Modular CSSX Unit (MCU) for use in the Chemical Processing Cell (CPC) of the DWPF. Transfers to 512-S consist of feed from either 241-96H (MST-Strike option) or Tank 49 (Filter-Only option). MST/Sludge Solids refers to either MST/Sludge Solids from 241-96H or potential sludge solids entrainment in the salt solution from Tank 49, depending on whether ARP/MCU is in MST-Strike operations or Filter-Only operations. 512-S then filters the feed sending the collected MST/Sludge Solids to DWPF and the filtrate to MCU for cesium extraction and eventually to Saltstone for disposal.

2.0 SCOPE

This Waste Acceptance Criteria (WAC) document gives the chemical and radiological requirements for sludge, MST/Sludge Solids and cesium strip effluent to be transferred to 512-S and/or DWPF and applies to the period when Justification for Continued Operations U-JCO-S-00002 [7.60] amends the DWPF Documented Safety Analysis (DSA) for the antifoam degradation products Potential Inadequacy in the Safety Analysis (PISA) [7.61]. These requirements apply to Sludge Batch (SB) SB8 “sludge-only” operations as well as "coupled" operations (SB8 with ARP MST/Sludge Solids and MCU strip effluent) including both the MST-Strike option and the Filter-Only option.

3.0 TERMS AND DEFINITIONS

LIMIT: a type of acceptance criteria that, if not satisfied, will have an adverse impact on repository requirements (Waste Acceptance Product Specifications - WAPS) or DWPF Safety Basis (SB).

TARGET: a type of acceptance criteria that, if not satisfied, will have an adverse impact on cost or attainment.

PCT: Product Consistency Test - a glass leaching test developed at Savannah River National Laboratory (SRNL) for use in characterizing production glass samples. The method is formalized as American Society for Testing and Materials (ASTM) Designation C 1285-97.

4.0 RESPONSIBILITIES

4.1 DWPF & Saltstone Facility Engineering (D&S-FE) is responsible to:

- maintain the WAC, including reviews and revisions as needed

- co-approve Waste Compliance Plan (WCP) documents and conduct the Technical Review of the waste streams (characterization, controls, and any requests to deviate from the WAC requirements)

- review the Tank Farm self-assessment program for compliance with the WAC and WCP

- evaluate the impact of a WAC non-compliance and assist the investigation (e.g., Non-Conformance Report (NCR), Site Item Reportability & Issue Management (SIRIM))

- approve and document the acceptability of the waste stream with respect to the criteria provided in Section 5.4.1, NO_x Emissions; Section 5.4.2, Canister Heat Generation; Section 5.4.7, Glass Solubility; Section 5.4.10, Glass Quality and Processability; Section 5.4.11, H_2 Generation/N_2O Concentration; and Section 5.4.17, Fissile Concentration in Glass

4.2 Tank Farm Facility Engineering (TF-FE) is responsible to:

- develop, co-approve, and implement Waste Compliance Plan (WCP) documents. D&S-FE will provide description of compliance approach for Sections 5.4.1, 5.4.2, 5.4.7, 5.4.10, 5.4.11, and 5.4.17.

- provide DWPF a copy of documentation on all waste characterization data (and their bases) and maintain records demonstrating compliance with the WAC and WCP

- develop and conduct a self-assessment program that assures compliance with the WAC and WCP

- report a WAC non-compliance to DWPF and assist the investigation (e.g., NCR, SIRIM)

4.3 Tank Farm Operations is responsible to:

- prepare waste for transfer to 512-S/DWPF so that all WAC requirements are met

- perform sampling as required by the WAC

5.0 PROCEDURE

5.1 General Information

The primary function of the 512-S facility is to receive and filter the feed stream from either 241-96H (MST-Strike option) or Tank 49 (Filter-Only option). The 512-S Facility separates strontium, actinides and insoluble sludge solids from salt solutions by filtration in a cross flow filter. The solids collected in the Late Wash Precipitate Tank (LWPT) are transferred to the Low Point Pump Pit (LPPP) Precipitate Pump Tank (PPT) and then to the DWPF 221-S building for chemical processing. The filtrate collected in the Late Wash Hold Tank (LWHT) is transferred to the MCU facility for cesium extraction. The Decontaminated Salt Solution (DSS) from the MCU facility is then transferred to Tank 50H for disposal in the Saltstone Production Facility (SPF). The cesium-laden strip effluent is transferred from MCU to the DWPF.

The primary function of DWPF is to process high level waste sludge, MST/Sludge Solids, and cesium strip effluent into borosilicate glass. The Tank Farm and DWPF are responsible for ensuring that the WAC of the interim (241-96H, 512-S, MCU) and disposal (DWPF, SPF) facilities are met. The 512-S acceptance criteria ensures that 512-S feed will not exceed 512-S facility specific safety and processing constraints (gamma shielding, inhalation dose potential, nuclear criticality safety, radiolytic hydrogen generation) as well as waste acceptance requirements for downstream facilities (DWPF, MCU, SPF). The DWPF acceptance criteria ensures that the combination of sludge batches, ARP feed/effluents, and MCU feed/effluents used to make feed for DWPF results in a blend capable of producing acceptable glass (*e.g.*, liquidus, viscosity, durability, nepheline, insolubles, etc.) as determined by the Product Composition Control System (PCCS).

5.2 Prerequisite Programmatic Criteria

A WAC is an Interface Control Document (ICD) written by a waste receiving organization (DWPF) describing the parameters (e.g., flow, temperature, composition) that must be considered in receiving the waste and defining criteria for acceptance of the waste. The DOE Order on radioactive waste management, DOE Order 435.1 [7.1], requires that waste handling facilities have acceptance criteria.

A WCP is an ICD written by the sending organization (the Tank Farm) describing how the sending organization will control the parameters to ensure compliance with the WAC of the receiving organization. When the wastes being sent are known to be outside WAC criteria, a strategy must be developed for safe management and future processing. As soon as practical, the sending organization is to inform the receiving organization of any requirements that have not been satisfied. It will then be determined what actions are to be performed by the sending and/or receiving organizations before the waste can be accepted by the receiving organization. The WCP will document the agreement between the organizations for handling the wastes.

The Tank Farm may propose exceptions to any WAC specification. The Tank Farm WCP will document any deviations and provide a defensible rationale and/or alternative. DWPF's Tech Review of the WCP will evaluate any requested deviations.

5.3 512-S Acceptance Criteria

Sections 5.3.1 through 5.3.6 are 512-S facility specific safety and production requirements. 512-S is used to filter strontium and actinide solids for disposal in DWPF and salt filtrate to MCU and eventually Saltstone. Since 512-S is used for filtering only, any feed that is sent to 512-S must also meet the requirements of the downstream facilities. Meeting the requirements of sections 5.3.1 through 5.3.6 ensures that feed sent through 512-S meets the DWPF waste acceptance requirements. In addition to these requirements the Tank Farm sending facility shall ensure that feed sent to 512-S will result in filtrate meeting the requirements of the MCU WAC (see the TF WAC X-SD-G-00001 for Requirements) and the SPF WAC (see X-SD-Z-00001 for Requirements).

For transfers to 512-S the Tank Farm is responsible for demonstrating that the criteria in Sections 5.3.1 through 5.3.6 are not exceeded and filtrate from 512-S is in compliance with the MCU WAC and SPF WAC. The 512-S facility is included in the DWPF Technical Safety Requirements (TSRs). The requirements specified in the DWPF TSRs relating to WAC are tabulated below along with the corresponding WAC Section which fulfills the TSR commitment.

DWPF TSR Requirement	Topic	WAC Section	Topic
5.8.2.1	Radiation Protection Program	5.3.1	Gamma Shielding
5.8.2.9	Nuclear Criticality Safety Program	5.3.3	Nuclear Criticality Safety
5.8.2.11	Waste Acceptance Criteria **(SAC)**	5.3.2	Inhalation Dose Potential
		5.3.3	Nuclear Criticality Safety
		5.3.4	Radiolytic Hydrogen Generation
		5.3.5	Organic Concentration
		5.3.6	Temperature
5.8.2.25	Waste Compliance Plan **(SAC)**	5.3.3	Nuclear Criticality Safety

Radioactive waste to be received into 512-S exceeding the assumptions given in the DWPF SB shall not be accepted unless an Unreviewed Safety Question (USQ) review has been performed and approved [7.2, 7.3].

5.3.1 Gamma Shielding

5.3.1.1 Criteria: The 512-S feed stream shall not exceed a Cs-137 concentration of 1.11 Ci/gal [7.4].

5.3.1.2 Criteria Type: LIMIT (DWPF Administrative TSR – 5.8.2.1)

5.3.1.3 Computational Technique: Direct measurement.

5.3.1.4 Background: In order to maintain a dose rate that does not exceed 0.5 mrem/hr for continuous occupancy in the 512-S facility, the Cs-137 concentration cannot exceed 1.11 Ci/gal [7.4].

The shielding basis is part of the overall Radiation Protection Program - nominal radionuclide concentrations can be used without adding analytical uncertainty.

5.3.2 Inhalation Dose Potential

5.3.2.1 Criteria: The inhalation dose potential for the ARP streams shall have a:

a. Total rem/gallon value less than or equal to 3.00E+06 rem/gallon for the 512-S feed stream accounting for analytical uncertainty.

b. Cs-137 concentration less than or equal to 1.11 Ci/gallon for the 512-S feed stream accounting for analytical uncertainty.

c. Total rem/gallon value less than or equal to 1.24E+08 rem/gallon for the 512-S MST/Sludge Solids accounting for analytical uncertainty.

5.3.2.2 Criteria Type: LIMIT **(DWPF TSR SAC - 5.8.2.11)**

5.3.2.3 Computational Technique: For Criterion a. above, two methods will be used to calculate the rem/gallon source term for the 512-S feed stream and the more conservative result used to compare with the above rem/gallon limit. The first method for evaluating the dose source term is to simply analyze the alpha emitter content and the Sr-90 content of the 512-S feed [7.5]. The reported pCi/mL concentration values from the waste analysis are converted to Ci/gal and then multiplied by the respective dose conversion factor (DCF) (rem/Ci) (see Table 1) to obtain a final rem/gallon value. Reference 7.5 justifies the use of the Pu-238 rem/Ci value for the gross alpha dose conversion factor. The rem/gallon values for gross alpha and Sr-90 are then summed together.

The second method looks at the eleven major inhalation dose radionuclides in the 512-S feed - i.e., Sr-90, Ru-106, Cs-137, Ce-144, Pm-147, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, and Cm-244 [7.6].

Similar to the first method, rem/gallon values for each radionuclide are calculated using the DCFs in Table 1 and then summed together.

For Criterion b., the Cs-137 for the 512-S feed stream is determined by direct radionuclide analysis.

For Criterion c. above, a conservative Concentration Factor is determined and applied to the 512-S feed stream concentrations to get the 512-S MST/Sludge Solids in the LWPT to 6 wt% insoluble solids. N-ESR-S-00004 provides the methodology for calculating this Concentration Factor [7.7]. The concentrated radionuclide concentrations are then multiplied by the respective dose conversion factors and then summed to yield the total IDP of the 512-S MST/Sludge Solids. Both methods discussed above for the 512-S feed stream will also be used as the methods for calculating the 512-S MST/Sludge Solids total rem/gallon.

5.3.2.4 Background: Radiological consequences for 512-S have been determined using design basis compositions given in the DWPF Curie Balance [7.2]. Eleven isotopes (Sr-90, Ru-106, Cs-137, Ce-144, Pm-147, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, and Cm-244) account for 99.9% of the potential S-Area dose for accident scenarios analyzed in the DWPF DSA [7.6]. All other isotopes in the Curie Balance can be neglected from a dose perspective. The rem/gallon limit conservatively implements the curie balance restrictions for the 512-S feed stream and the 512-S MST/Sludge Solids stream (see Tables 1 and 1A, respectively). It is entirely possible that one or more of the isotopes in the 512-S feed and/or 512-S MST/Sludge Solids could significantly exceed the values listed below without affecting the conclusions of the DWPF accident analyses (i.e., still meet the requirements of DWPF TSR SAC 5.8.2.11). A lumped source term methodology has been developed for use in evaluating feed material for inhalation dose potential. The total rem/gallon limit was determined by summing the individual rem/gallon values for the eleven isotopes, which were calculated by multiplying the Ci/gallon concentration of the isotope by the dose conversion factor (rem/Ci) of the isotope [7.8]. Compliance with the 512-S/DWPF WAC and the Tank Farm WCP provides assurance that the DSA accident evaluations remain bounding.

Calculation X-CLC-S-00126 [7.9] documents the 512-S design basis radionuclide inventories for both the 512-S feed stream as well as the LWPT vessel heel following concentration to 6 wt% insoluble solids (i.e., 512-S MST/Sludge Solids). N-CLC-S-00099 [7.6] converts the feed stream concentrations to a total rem/gallon limit. Similarly, N-ESR-S-00004 [7.7] calculates the 512-S MST/Sludge Solids total rem/gal limit from the isotopic Ci/gal concentrations.

The Cs-137 limit of 1.11 Ci/gal protects the DSA accident analysis assumption of the salt stream portion of the total Cs-137 dose contribution in the melter explosion scenarios. See Section 5.4.5.4 for additional discussion on the impact of the volatile/semi-volatile radionuclides on melter-related events. Additionally, the Cs-137 Ci/gal limit protects the shielding design basis for 512-S.

An analytical uncertainty of 2 Sigma shall be accounted for in sample analyses used to determine IDP compliance [7.2].

TABLE 1

Species	**DSA Curie Balance Limit for 512-S Feed (Ci/gallon)**	**Dose Conversion Factor (rem/Ci) ***	**Dose for 512-S Feed (rem/gallon)**
Sr-90	3.05E-01	8.9E+04	2.71E+04
Ru-106	1.50E-02	2.4E+05	3.60E+03
Cs-137	**1.11E+00**	**1.9E+04**	**2.11E+04**
Ce-144	6.56E-02	2.0E+05	1.31E+04
Pm-147	1.61E-01	1.9E+04	3.06E+03
Pu-238	9.76E-03	1.7E+08	1.66E+06
Pu-239	1.46E-04	1.9E+08	2.77E+04
Pu-240	7.06E-05	1.9E+08	1.31E+04
Pu-241	1.12E-02	3.3E+06	3.70E+04
Am-241	7.08E-03	1.6E+08	1.13E+06
Cm-244	7.06E-04	1.0E+08	7.06E+04
Total			**3.00E+06**

* Dose Conversion Factors (DCFs) were obtained from Reference 7.8.

TABLE 1A

Species	**DSA Curie Balance Limit for 512-S MST/Sludge Solids (Ci/gallon)**	**Dose Conversion Factor (rem/Ci) ***	**Dose for 512-S MST/Sludge Solids (rem/gallon)**
Sr-90	2.02E+01	8.9E+04	1.80E+06
Ru-106	9.98E-01	2.4E+05	2.40E+05
Cs-137	1.77E+00	1.9E+04	3.36E+04
Ce-144	4.36E+00	2.0E+05	8.72E+05
Pm-147	1.07E+01	1.9E+04	2.03E+05
Pu-238	6.49E-01	1.7E+08	1.10E+08
Pu-239	5.70E-03	1.9E+08	1.08E+06
Pu-240	3.80E-03	1.9E+08	7.22E+05
Pu-241	7.29E-01	3.3E+06	2.41E+06
Am-241	1.17E-02	1.6E+08	1.87E+06
Cm-244	4.69E-02	1.0E+08	4.69E+06
Total			**1.24E+08**

* Dose Conversion Factors (DCFs) were obtained from Reference 7.8.

5.3.3 Nuclear Criticality Safety

5.3.3.1 Criteria: The 512-S feed stream shall have a:

a. Soluble uranium concentration in Tank 49 solution less than or equal to 50 mg/L accounting for analytical uncertainty.

b. Soluble plutonium concentration in Tank 49 solution less than or equal to 0.3 mg/L accounting for analytical uncertainty.

c. U-235 (eq_sol) enrichment in Tank 49 solution less than or equal to 3.0 wt% accounting for analytical uncertainty.

5.3.3.2 Criteria Type: LIMIT (DWPF TSR SACs 5.8.2.11 and 5.8.2.25, and DWPF Administrative TSR 5.8.2.9)

5.3.3.3 Computational Technique: Chemical analysis of soluble U and Pu and radionuclide analysis of U-233, U-235 and U (summation of all uranium isotopes (e.g., U-233, U-234, U-235, U-236, U-238)).

5.3.3.4 Background: The nuclear criticality safety position for the 512-S facility is that by preventing the sending of salt solution with soluble uranium concentrations greater than 50 mg/L, soluble plutonium concentrations greater than 0.3 mg/L, and U-235(eq_sol) enrichment greater than 3 wt% ensures a criticality accident will not occur in 512-S [7.10].

The U-235(eq_sol) enrichment will be determined using U-233, U-235 and U.

U-235(eq_sol) enrichment (wt%) = 100 * (U-235 + 1.4(U-233)) / U

An analytical uncertainty of 2 Sigma shall be accounted for in sample analyses used to determine criticality safety compliance [7.2].

5.3.4 Radiolytic Hydrogen Generation

5.3.4.1 Criteria: The radiolytic hydrogen generation rate (HGR) for the 512-S feed stream shall not exceed 1.64E-06 ft^3/hr/gal at 25ºC.

5.3.4.2 Criteria Type: LIMIT **(DWPF TSR SAC – 5.8.2.11)**

5.3.4.3 Computational Technique: The radiolytic hydrogen generation rate is based on the cumulative sum of a mixture of radionuclide hydrogen generation conversion factors multiplied by the radionuclide heat rate.

5.3.4.4 Background: In the 512-S process vessels hydrogen is produced radiolytically. The total radiolytic hydrogen generation rate ensures that the inputs used in selecting flammability controls used for each of the process vessels are protected. Table 2 identifies radionuclides that are significant (contribute 99.8% of total HGR) to radiolytic hydrogen generation [7.6].

Radiolytic HGRs can use nominal radionuclide concentrations without adding analytical uncertainty based on conservative R-Values used in determining the generation rate [7.2].

TABLE 2

Species	512-S Feed Bounding Heat Rate (BTU/hr/gal)	R-Value ($ft^3/10^6$ BTU)	512-S Feed HGR (ft^3/hr/gal)
Co-60	5.94E-05	48.36	2.87E-09
Y-90	5.94E-03	48.36	2.87E-07
Sr-90	1.21E-03	48.36	5.84E-08
Rh-106	9.74E-04	48.36	4.71E-08
Sb-125	6.34E-05	48.36	3.07E-09
Cs-134	3.69E-05	48.36	1.79E-09
Cs-137	3.83E-03	48.36	1.85E-07
Ba-137m	1.41E-02	48.36	6.83E-07
Ce-144	1.47E-04	48.36	7.13E-09
Pr-144	1.64E-03	48.36	7.95E-08
Pm-147	2.02E-04	48.36	9.76E-09
Eu-154	1.27E-04	48.36	6.16E-09
Pu-238	1.09E-03	134.7	1.46E-07
Pu-239	1.51E-05	134.7	2.03E-09
Pu-240	7.37E-06	134.7	9.92E-10
Am-241	7.94E-04	134.7	1.07E-07
Cm-244	8.29E-05	134.7	1.12E-08
Total			**1.64E-06**

5.3.5 Organic Concentration

5.3.5.1 Criteria: Organic material present in the 512-S feed stream shall contribute less than 0.1% to the hydrogen LFL.

5.3.5.2 Criteria Type: LIMIT **(DWPF TSR SAC – 5.8.2.11)**

5.3.5.3 Computational Technique: Direct chemical analysis and/or process knowledge of material used to make up the salt batch.

5.3.5.4 Background: The organic contribution to the hydrogen LFL Limit protects the assumptions in the DWPF DSA accident calculations which assume that time to LFL calculations, purge rates, etc. for sludge processing vessels are based on 100% hydrogen since the organic contribution in the incoming waste stream is considered negligible. Verifying that the organic concentration is insignificant during the salt batch qualification work provides assurance that the organic contribution to hydrogen LFL in 512-S vessels will be negligible.

The 0.1% value specified is utilized to quantify a negligible amount. Since these values are expected to be negligible, nominal values can be used without adding analytical uncertainty [7.2].

5.3.6 Temperature

5.3.6.1 Criteria: The temperature of the 512-S feed stream shall be less than or equal to 45ºC.

5.3.6.2 Criteria Type: LIMIT (DWPF TSR SACs 5.8.2.11 and 5.8.2.25)

5.3.6.3 Computational Technique: Direct measurement and/or process knowledge.

5.3.6.4 Background: The maximum temperature limit of 45ºC protects the assumptions in the DWPF DSA accident calculations. Transfers from Tank 49 or 241-96H to 512-S are required to be at or below 45ºC, which ensures that temperature assumptions used for spill and cell explosion accident calculations are protected [7.2, 7.11].

5.4 DWPF Acceptance Criteria

DWPF will receive three waste streams for processing: sludge, MST/Sludge Solids, and cesium strip effluent. The acceptance criteria in Section 5.4 applies to the combined receipt stream (sludge, MST/Sludge Solids, and cesium strip effluent) except where specific limits are set on a specific waste stream (i.e., Cs-137 limit for MCU stream). For example, NO_x Emissions (Section 5.4.1) are targeted at less than 103.52 tons/year. This requirement indicates that the combined waste streams entering DWPF shall not exceed 103.52 tons/year. If the sludge stream contributes 75 tons/year then material received from MCU and ARP may only contribute 28.52 tons/year.

The Tank Farm is responsible for demonstrating that the criteria in Sections 5.4.3 through 5.4.6, Section 5.4.8 and 5.4.9, and Sections 5.4.12 through 5.4.16 are not exceeded. DWPF will provide the evaluation necessary to demonstrate that the criteria in Sections 5.4.1, 5.4.2, 5.4.7, 5.4.10, 5.4.11, and 5.4.17 are not exceeded. SRNL Analytical Study Plans will ensure that the analyses needed to perform evaluations that demonstrate compliance with sections of this WAC are provided.

The requirements specified in the DWPF Technical Safety Requirements (TSRs) relating to WAC are tabulated below along with the corresponding WAC Section which fulfills the TSR commitment.

DWPF TSR Requirement	Topic	WAC Section	Topic
5.8.2.1	Radiation Protection Program	5.4.3 5.4.4	Gamma Shielding Neutron Shielding
5.8.2.9	Nuclear Criticality Safety Program	5.4.6	Nuclear Criticality Safety
5.8.2.11	Waste Acceptance Criteria **(SAC)**	5.4.2	Canister Heat Generation
		5.4.5	Inhalation Dose Potential
		5.4.6	Nuclear Criticality Safety
		5.4.7	Glass Solubility
		5.4.11	H_2 Generation/N_2O
		5.4.12	Radiolytic Hydrogen
		5.4.13	Organic Concentration
		5.4.14	pH
		5.4.15	Temperature
5.8.2.31	SEFT Dilution Program **(SAC)**	5.4.13	Organic Concentration

Radioactive waste to be received into DWPF exceeding the assumptions given in the DWPF SB shall not be accepted unless an Unreviewed Safety Question (USQ) review has been performed and approved [7.2, 7.3].

5.4.1 NO_x Emissions

5.4.1.1 Criteria: The estimated annual NO_X emissions from the DWPF shall not exceed 103.52 tons/year [7.12].

5.4.1.2 Criteria Type: TARGET

5.4.1.3 Computational Technique: Sludge concentrations are in gmoles/liter (M) slurry. Total estimated NO_X emissions (N_T) in tons/yr is:

$$N_T = 19.1\,(0.70[OH^-]_S + 1.40[CO_3^{=}]_S + 1.86[NO_2^-]_S + [NO_3^-]_S + 0.84[Mn^{+4}]_S + 0.70[Hg^{+2}]_S)$$

where: $[OH^-]_S$ = Hydroxide concentration

$[CO_3^{=}]_S$ = Carbonate concentration

$[NO_2^-]_S$ = Nitrite concentration

$[NO_3^-]_S$ = Nitrate concentration

$[Mn^{+4}]_S$ = Manganese concentration

$[Hg^{+2}]_S$ = Mercury concentration

All concentrations are moles per liter, slurry basis.

Reference 7.13 contains detailed information on the derivation of the algorithm. This information can be used to modify the algorithm to account for current feed rates and attainment. The algorithm presented in Reference 7.13 assumes that DWPF will produce 250 discrete canisters per year, an acid stoichiometry of 140%, and that at least 50% of the required acid in the SRAT is nitric acid. Although canister production will exceed 250 by 20% some years, the assumption of 50% nitric acid addition to the feed more than covers the NO_x produced because of the excess production. DWPF production and acid stoichiometry used in the derivation of the algorithm reflect nominal conditions. The assumption that 50% of the acid required is nitric acid is very conservative for SB8 as most of the acid to be added to these batches will be formic acid based on SRNL testing. The hydroxide concentration used for this calculation is the base equivalents added to titrate a slurry sample to a pH of 7. The carbonate is estimated from the Total Inorganic Carbon (TIC) analysis. Actual NO_x emissions may be calculated and tracked by the facility.

5.4.1.4 Background: The DWPF is permitted for annual NO_X emissions [7.12]. Many of the components in the sludge contribute either directly to emissions (for example, nitrite and nitrate) or indirectly (for example, hydroxide which requires the addition of nitric acid to neutralize; the nitric acid then contributes to NO_X emissions). Contributions to NOx emissions from the ARP stream should be calculated using the above algorithm similar to the sludge stream. The MCU stream contribution to NO_X emissions is expected to be negligible.

5.4.2 Canister Heat Generation

5.4.2.1 Criteria: The heat generation per canister produced in the DWPF shall not exceed 792 watts/canister as calculated from the radionuclide content of the glass.

5.4.2.2 Criteria Type: LIMIT (**DWPF TSR SAC - 5.8.2.11)**

5.4.2.3 Computational Technique:

$$\text{Canister Heat Generation} = 2200\,(0.00670[^{90}\text{Sr}] + 0.0195[^{106}\text{Ru}] + 0.00474[^{137}\text{Cs}] + 0.00800[^{144}\text{Ce}] + 0.0286[^{233}\text{U}] + 0.0326[^{238}\text{Pu}] + 0.0302[^{239}\text{Pu}] + 0.0306[^{240}\text{Pu}] + 0.0328[^{241}\text{Am}] + 0.0344[^{244}\text{Cm}])$$

Concentrations are in Ci/lb of calcined solids. [7.6, 7.14, 7.15, 7.16, 7.17, 7.18]

5.4.2.4 Background: The thermal analyses of the Glass Waste Storage Buildings #1 and #2 vaults concluded that if the natural circulation is interrupted for four days, then the threshold canister power to reach the vault ceiling lower surface temperature of 350 °F (the code requirement) is 836 W/canister and 834 W/canister, respectively [7.19, 7.20]. The canister heat generation limit, in place to protect the concrete vault strength, is based on the more restrictive value of the two vaults - 834 W/canister in GWSB #2 [7.2].

The equation for calculating canister heat generation comes from Reference 7.14. The factor of 2200 differs from the algorithm in Reference 7.14 because a revised fill level corresponding to 4400 pounds glass per canister is used instead of 3700 pounds glass [7.17] and a waste loading of 50 wt% instead of 30 wt% is also used [7.18]. Ten radionuclides and their short lived daughters contribute to over 95% of the heat load in sludge batches processed and are used to determine heat loads [7.6, 7.16]. As a result, the 834 W/canister DSA limit is reduced by 5% to 792 W/canister to account for any heat from unmeasured radionuclides using the above algorithm.

The radionuclides used for determining heat load are: Sr-90, Ru-106, Cs-137, Ce-144, U-233, Pu-238, Pu-239, Pu-240, Am-241, and Cm-244. The watts per curie value for each radionuclide includes the disintegration energies for any short-lived daughter products. The watts per curie values are from Reference 7.15. The methodology for determining the watts per curie value for radionuclides with short-lived daughter products is shown in Reference 7.14. Contributions to canister heat generation from the ARP and MCU streams should be calculated using the above algorithm similar to the sludge stream.

Nominal radionuclide concentrations can be used for canister heat generation without adding analytical uncertainty [7.2]. Reference 7.62 demonstrates based on past sludge and salt batch reports that heat generation rates assuming a bounding 50% waste loading and no uncertainty will yield a higher wattage value than an average 40% waste loading with a 2 Sigma analytical uncertainty added to the nominal concentrations.

5.4.3 Gamma Shielding

5.4.3.1 Criteria: The sludge to be transferred to DWPF shall not exceed specific gamma source strength values of 4070 mR/hr/gallon and 3.7 mR/hr/gram insoluble solids [7.21, 7.6]. Transfers from MCU are limited to 16.5 Ci/gallon Cs-137.

5.4.3.2 Criteria Type: LIMIT (DWPF Administrative TSR – 5.8.2.1)

5.4.3.3 Computational Technique: Direct analysis and/or process knowledge.

5.4.3.4 Background: The gamma source strength value provides a common means for comparing the radionuclide distribution assumed in the DWPF design basis and the variable radionuclide feed conditions in High Level Waste. This limit has been shown to be conservative to the composition detailed in the DWPF DSA Table 9.4-1 [7.2, 7.21]. Table 3 provides a list of significant (contributes 99.9% of the total gamma source strength) sludge gamma sources used for DWPF shielding criteria include Co-60, Ru-106, Sb-125, Cs-134, Cs-137, Ce-144, Eu-154, Eu-155, and Pu-238.

Transfers from MCU to DWPF are limited to 16.5 Ci/gallon, which is based on the MCU 15x concentration factor of the incoming Cs-137 concentration of 1.11 Ci/gal. N-CLC-S-00095 [7.22] evaluated strip effluent Cs-137 concentrations up to 19.8 Ci/gal and concluded that the effect of cesium content in the MCU transfers on DWPF facilities is bounded by previous analysis. In summary, the overall effect of the cesium concentration increase is negligible on the facility design dose rates.

The shielding basis is part of the overall Radiation Protection Program - nominal radionuclide concentrations can be used without adding analytical uncertainty.

TABLE 3

Species	**DSA Curie Balance Limit (Ci/gallon)**	**Dose Constant (mR/hr/µCi)**	**Gamma Source Strength (mR/hr/gal)**
Co-60	2.94E-01	1.37E-03	4.03E+02
Ru-106	2.69E+00	1.38E-04*	3.72E+02
Sb-125	1.43E-01	3.80E-04	5.44E+02
Cs-134	3.03E-01	9.99E-04	3.03E+02
Cs-137	**2.86E+00**	**3.82E-04***	**1.09E+03**
Ce-144	1.69E+00	2.33E-05*	3.94E+02
Eu-154	1.07E+00	7.56E-04	8.08E+02
Eu-155	8.21E-01	6.67E-05	5.48E+01
Pu-238	1.29E+00	7.90E-05	1.02E+02
Total			**4.07E+03**

* Daughter Product Gamma Source Strength included with the Parent

5.4.4 Neutron Shielding

5.4.4.1 Criteria: The total alpha curie per gram of solids value for the sludge feed to DWPF shall not exceed 1.5E-03 Ci/gram insoluble solids.

5.4.4.2 Criteria Type: LIMIT (DWPF Administrative TSR – 5.8.2.1)

5.4.4.3 Computational Technique: Direct radionuclide analysis.

5.4.4.4 Background: The neutron production rate in DWPF sludge waste feed has been evaluated due to exposure concerns involving the use of the Shielded Canister Transporter. The neutron energy and impact on dose is very minimal when hydrogenous materials are available to moderate the neutrons. The sludge slurry and the concrete shielding in the DWPF canyon provide sufficient moderation to limit the impact of neutron dose. However, when the sludge slurry solids are vitrified in the glass, the hydrogenous materials are no longer present and the moderation of the neutrons is minimal. Reference 7.21 recommends only a gross alpha curie value, 1.5E-03 Ci/gram of solids, be used to evaluate the neutron production rate. This value is derived from the assumed DWPF design basis, 152 neutrons per second per gram of insoluble sludge solids. The gross alpha curie value is developed in Table 4 of Reference 7.21. The basis for using the gross alpha determination of the neutron production rate is given in Reference 7.21. This limit has been shown to be conservative to the composition detailed in DWPF DSA Chapter 9 [7.21].

The shielding basis is part of the overall Radiation Protection Program - nominal radionuclide concentrations can be used without adding analytical uncertainty.

5.4.5 Inhalation Dose Potential

5.4.5.1 Criteria: The inhalation dose potential for the streams to be transferred to DWPF shall have a:

a. Total rem/gallon value less than or equal to 8.0E+07 rem/gallon for the sludge stream accounting for analytical uncertainty.

b. Cs-137 concentration less than or equal to 1.34 Ci/gallon for the sludge stream accounting for analytical uncertainty.

c. Cs-137 concentration less than or equal to 16.5 Ci/gallon for cesium strip effluent transfers accounting for analytical uncertainty.

5.4.5.2 Criteria Type: LIMIT **(DWPF TSR SAC - 5.8.2.11)**

5.4.5.3 Computational Technique: Two methods will be used to calculate the rem/gallon source term and the more conservative result used to compare with the above rem/gallon limit. The first method for evaluating the dose source term is to simply analyze the alpha emitter content and the Sr-90 content of the sludge feed [7.5]. The reported Ci/g values from the analysis are multiplied by a density factor and the respective dose conversion factor (rem/Ci) (see Table 4) to obtain a final rem/gallon value. Reference 7.5 justifies the use of the Pu-238 rem/Ci value for the gross alpha dose conversion factor. The rem/gallon values for gross alpha and Sr-90 are then summed together.

The second method looks at the eleven major inhalation dose radionuclides in the sludge feed - i.e., Sr-90, Ru-106, Cs-137, Ce-144, Pm-147, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, and Cm-244 [7.23, 7.6]. Similar to the first method, rem/gallon values for each radionuclide are calculated using the dose conversion factors in Table 4 and then summed together.

The Cs-137 concentration is determined by direct radionuclide analysis and/or process knowledge.

5.4.5.4 Background: DWPF's SB analyzes the risks and consequences of numerous accident scenarios for the S-Area DWPF. Radiological consequences for DWPF have been determined using design basis compositions given in the DWPF Curie Balance [7.2]. For all accidents in the DSA, except the Steam Explosion in the Melter and the Explosion in the Melter Offgas, radionuclides contributing to the inhalation dose limit are released at the same rate. However, for the two Melter Offgas events mentioned above, only the volatile or semi-volatile radionuclides at the melter operating temperatures are of interest. These offgas radionuclides include Cs-137, Ru-106, Te-125m, and Sb-125. For design basis sludge (i.e., 5 years out of the reactor), Cs-137 is the largest contributor to the unmitigated dose for the worst case scenario involving a melter steam explosion followed by an unfiltered 4-day offgas release [7.24]. Furthermore, since the sludge transferred to DWPF will be on the order of 40 to 50 years old, the dose contribution from Ru-106, Te-125m, and Sb-125 will even be less significant due to the short half-life of these radionuclides compared to Cs-137. For this reason, Cs-137 is the only radionuclide that must be evaluated for the Melter Explosion scenarios in the DSA [7.2]. Concentration limits are given for both the sludge (1.34 Ci/gal) and the strip effluent (16.5 Ci/gal).

For all other accident scenarios, eleven isotopes (Sr-90, Ru-106, Cs-137, Ce-144, Pm-147, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, and Cm-244) account for 99.8% of the potential S-Area dose [7.6]. All other isotopes in the Curie Balance can be neglected from a dose perspective. The 2.47E+08 rem/gallon limit conservatively implements the DSA curie balance restrictions (See Table 4).

U-JCO-S-00002 [7.60] was written in response to PISA PI-2015-0009 [7.61], which identified the presence of multiple degradation products of antifoam (e. g., hexamethyldisiloxane [HMDSO]). In the JCO a simple ratio of 1 : 2.47 was applied to the above 2.47E+08 rem/gallon limit to establish a new maximum IDP for the sludge stream (1.0E+08 rem/gal) that will not result in challenging the offsite evaluation guideline of 5 rem for the bounding Natural Phenomena Hazard (NPH) scenarios. The IDP limit is further reduced by 20% in the WAC to 8.0E+07 rem/gallon to ensure that the 5 rem evaluation guideline is met for the NPH scenarios.

It is entirely possible that one or more of the isotopes in the sludge stream could significantly exceed the values listed below without affecting the conclusions of the DWPF accident analyses (i.e., still meet the requirements of DWPF TSR SAC 5.8.2.11). A lumped source term methodology has been developed for use in evaluating feed material for inhalation dose potential. The total rem/gallon limit was determined by summing the individual rem/gallon values for the eleven isotopes, which were calculated by multiplying the Ci/gallon concentration of the isotope by the dose conversion factor (rem/Ci) of the isotope [7.8]. Compliance with the DWPF WAC and the Tank Farm WCP provides assurance that the JCO accident evaluations remain bounding.

An analytical uncertainty of 2 Sigma shall be accounted for in sample analyses used to determine IDP compliance [7.2].

TABLE 4

Species	DSA Curie Balance Conc. (Ci/gallon)	Dose Conversion Factor (rem/Ci) *	Dose (rem/gallon)
Sr-90	4.05E+01	8.9E+04	3.60E+06
Ru-106	2.00E+00	2.4E+05	4.80E+05
Cs-137	**1.34E+00**	**1.9E+04**	**2.55E+04**
Ce-144	8.74E+00	2.0E+05	1.75E+06
Pm-147	2.14E+01	1.9E+04	4.07E+05
Pu-238	1.30E+00	1.7E+08	2.21E+08
Pu-239	1.13E-02	1.9E+08	2.15E+06
Pu-240	7.59E-03	1.9E+08	1.44E+06
Pu-241	1.46E+00	3.3E+06	4.82E+06
Am-241	9.47E-03	1.6E+08	1.52E+06
Cm-244	9.40E-02	1.0E+08	9.40E+06
Total			**2.47E+08**

* Dose Conversion Factors (DCFs) were obtained from Reference 7.8.

5.4.6 Nuclear Criticality Safety

5.4.6.1 Criteria: Compliance to the Nuclear Criticality Safety Criteria 5.3.3 ensures that transfers from ARP and MCU will not challenge the nuclear criticality criteria for the DWPF facility as long as sludge transfers from the Tank Farm meet the following requirements [7.10]:

a. The Pu-240 concentration in sludge shall exceed the Pu-241 concentration accounting for analytical uncertainty.

b. The Fe:Pu-239(eq) mass ratio in sludge shall be ≥ 160:1 accounting for analytical uncertainty and only Fe from the Tank Farm material shall be included in the calculation of the ratio.

c. The Pu-239(eq) concentration in sludge [not including U-235(eq_{SLU})] shall be ≤ 0.59 g/gallon accounting for analytical uncertainty if non-Tank Farm Pu is included in the sludge batch. There is no Pu-239(eq) concentration limit if only Tank Farm Pu is included in the sludge batch.

d. The U-235(eq_{SLU}) enrichment in sludge shall be ≤ 0.93 wt% or ≤ 5 wt% with a Mn:U-235(eq_{SLU}) mass ratio of ≥ 70:1 accounting for analytical uncertainty.

5.4.6.2 Criteria Type: LIMIT (DWPF TSR SAC – 5.8.2.11 and DWPF Administrative TSR – 5.8.2.9)

5.4.6.3 Computational Technique: Chemical analysis of Fe and U and radionuclide analysis of U-233, U-235, Pu-239, Pu-240, Pu-241, Am-242m, Cm-244, and Cm-245.

5.4.6.4 Background: The nuclear criticality safety position for the DWPF process is that the high abundance of neutron absorbers in the sludge and the low concentration of fissile materials make criticality non-credible. There are seven fissile radionuclides of concern in the sludge stream: U-233, U-235, Pu-239, Pu-241, Am-242m, Cm-244, and Cm-245. The Pu-239(eq) and U-235(eq_{SLU}) concentrations shall be determined by the following equations [7.10]:

Pu-239(eq) = Pu-239 + Pu-241 + Cm-244 + 15(Cm-245) + 35(Am-242m) + 0.65(U-235(eq_{SLU}))

NOTE: U-235(eq_{SLU}) needs to be included in equation only if the uranium enrichment is greater than 0.93 wt%.

U-235(eq_{SLU}) = U-235 + 1.4(U-233)

where each isotope represents the mass, in grams, present in the sludge batch.

In the waste sludge, iron is present and is the most abundant neutron absorber. A safe mass ratio of 160:1 has been established for Fe in which a mixture of fissile materials and iron cannot achieve criticality. This safe mass ratio was developed for an infinite system and therefore is applicable for all geometries.

For sludge batches containing non-Tank Farm Pu (e.g., canyon Pu), there is an additional requirement that the Pu-239(eq) mass in the SRAT is less than or equal to 6,195 g. A WAC limit of less than or equal to 0.59 g/gallon was derived based on a sludge volume of 10,500 gallons in the SRAT. This limit does not apply if only Tank Farm Pu is included in the sludge batch.

Reference 7.10 specifies a DWPF uranium enrichment limit of ≤ 0.93% or ≤ 5 wt% with a Mn:U-235(eq_{SLU}) mass ratio of ≥ 70:1. An initial Mn mass ratio of 70:1 in sludge is sufficient to maintain a Mn:U-235(eq_{SLU}) mass ratio of 14:1 in both the solid and solution phase during normal DWPF processing (14:1 is the minimum Mn:U-235(eq_{SLU}) safe mass ratio for an infinite solution). The U-235 (eq_{SLU}) enrichment in sludge shall be determined as follows:

U-235(eq_{SLU}) Enrichment (wt%) = 100 x U-235(eq_{SLU}) / U

Where U is the summation of all uranium isotopes (U-233, U-234, U-235, U-236, U-238).

An analytical uncertainty of 2 Sigma shall be accounted for in sample analyses used to determine criticality safety compliance [7.2].

5.4.7 Glass Solubility

5.4.7.1 Criteria: The concentration of the species shown in Table 5 below shall not be exceeded.

TABLE 5

Species	Weight Percent in Glass [7.25, 7.26, 7.27]
TiO_2	2.00
Cr_2O_3	0.30
PO_4	3.00 [SAC]
NaF	1.00 [SAC]
NaCl	1.00 [SAC]
Cu	0.50
SO_4	0.65 [SAC]

5.4.7.2 Criteria Type: LIMIT **(DWPF TSR SAC – 5.8.2.11)**

5.4.7.3 Computational Technique: Direct chemical analysis.

5.4.7.4 Background: The maximum waste solubility of certain components (TiO_2, Na_2SO_4, Cr_2O_3, PO_4, NaF, NaCl, and Cu) is important to successful operation of the DWPF Melter [7.25]. If the concentration is exceeded, secondary glass phases or a salt layer may be created, adversely affecting melter operations, melter life, and/or safety. All solubility limits, except for sulfate and titanium oxide, have been documented in Reference 7.26. Reference 7.27 provides the bases for DWPF glass containing up to 2.00 wt% TiO_2. The SO_4 solubility limit applicable to SB8, 0.65 wt% in glass, was derived from Vitreous State Laboratory (VSL) testing [7.28]. The sulfate limit will need to be re-evaluated during each sludge batch qualification since it is dependent on glass composition. The glass composition is a function of the sludge composition (sludge only and/or coupled operations), frit, trim chemicals, and waste loading. The sulfate limit is implemented by determining a conservative waste loading for the batch based on the amount of sulfate in the sludge and salt [7.2].

NOTE: Titanium contribution from ARP processing will not exceed the glass solubility limit provided no more than two MST strikes are performed per batch in 241-96H (for MST-Strike option).

An analytical uncertainty of 2 Sigma shall be accounted for in the PO_4 analysis to demonstrate compliance. The NaF and NaCl limits are controlled by the DWPF PCCS at the 95% confidence level – nominal concentrations can be used without adding analytical uncertainty. As discussed above, the SO_4 limit is controlled by determining a conservative waste loading limit for the Slurry Mix Evaporator (SME) batch – therefore, nominal SO_4 analysis can be used without adding analytical uncertainty [7.2].

5.4.8 Corrosive Species

5.4.8.1 Criteria: The concentration of SO_4^{2-} in washed sludge shall not exceed 0.058 M [7.29] slurry and the concentration of Hg shall not exceed 21 g/l slurry [7.26].

5.4.8.2 Criteria Type: LIMIT

5.4.8.3 Computational Technique: Direct chemical analysis.

5.4.8.4 Background: Mercury and sulfate can lead to excessive rates of attack on the SRAT and the SME materials. The mercury limit is based on the upper bound of concentrations tested during the DWPF materials testing program and is corrected for concentrating in the SRAT [7.26]. The sulfate limit is based on testing done at SRNL. Coupon and electrochemical testing showed that sulfate concentrations in the range of 0.011M and 0.058M did not accelerate the corrosion of the DWPF materials of construction [7.29]. Fluoride and chloride are also corrosives, but the glass solubility limits are lower than the corrosive limits. Contributions from the ARP stream should also be calculated. The MCU stream contribution to corrosive species is expected to be negligible.

5.4.9 Sludge Solids Content

5.4.9.1 Criteria: The total weight percent solids content of sludge feed sent to DWPF shall be 12 - 19 wt% dry total solids [7.14].

5.4.9.2 Criteria Type: TARGET

5.4.9.3 Computational Technique: Direct chemical analysis.

5.4.9.4 Background: The solids content criteria are an attainment (low solids) and pump operability/line pluggage (high solids) issue. Low solids content feed reduces the solids content of each DWPF batch. This lower solids content requires DWPF to process more batches to produce the same number of canisters. Solids content feed outside of the ranges specified in this requirement would require additional evaluation to determine processability. The total solids weight percent is used as a basis for calculating actual isotopic volumetric concentrations in the waste for comparing the concentrations to the limits described in other sections of this WAC. If the sludge solids content increases during a batch after the batch has been qualified, the batch will have to be reevaluated against this WAC to ensure that Ci/gallon values specified elsewhere in this WAC have not been exceeded.

5.4.10 Glass Quality and Processability

5.4.10.1 Criteria: A sample of sludge must be transported to SRNL for analysis and processing in the Shielded Cells. The melter feed must be vitrified and the resulting glass tested using the PCT to confirm that an acceptable glass product can be produced (as required by the DWPF Glass Product Control Program (GPCP), WSRC-IM-91-116-6 [7.30, 7.31]). The vitrified product must be verified to meet the following leach rate limits:

Boron Leach Rate - ≤ 16.70 g/l
Lithium Leach Rate - ≤ 9.57 g/l
Sodium Leach Rate - ≤ 13.35 g/l

The melter feed must also be verified to meet the following predicted properties:

Liquidus Temperature - ≤ 1050° Celsius
High Viscosity - ≤ 110 poise
Low Viscosity - ≥ 20 poise

Homogeneity (Alumina/Alkali) Constraint - $Al_2O_3 \geq 4$ wt%
OR
$Al_2O_3 \geq 3$ wt% **AND** $\sum M_2O < 19.3$ wt%
where $\sum M_2O = Na_2O + Li_2O + Cs_2O + K_2O$ wt%

Nepheline > 0.62

where Nepheline = $SiO_2 / (SiO_2 + Na_2O + Al_2O_3)$

The GPCP also requires a variability study be performed using simulants which represent the anticipated variability for the sludge composition over the life of the sludge batch. This study confirms the applicability of the PCT/chemical composition correlation for the sludge batch.

5.4.10.2 Criteria Type: LIMIT

5.4.10.3 Computational Technique: D&S-FE will review and accept the results of the SRNL studies. D&S-FE will use the PCCS algorithms to calculate the properties of the requisite range of blends and the associated tolerance/confidence limits, based on the feed composition from sample and analyses described in Section 5.4.

5.4.10.4 Background: DWPF will determine properties of this feed and the feed acceptability. The basis for these calculations is discussed in References 7.25 and 7.31.

The WAPS [7.32] limits the release properties of the waste form to less than the boron, lithium, and sodium release from the Environmental Assessment (EA) glass as measured by the PCT [7.33].

The maximum acceptable liquidus temperature of 1050°C was based on the minimum design temperature for the DWPF Melter [7.34]. The algorithm to calculate the liquidus temperature from the glass composition was developed by Jantzen [7.35, 7.36]. If the liquidus temperature of the glass exceeds 1050°C, it is possible to form crystalline phases in the cooler portions of the melter. These crystalline phases may interfere with the melter operation and may lead to premature failure of the melter.

The maximum glass viscosity that will be allowed in the melter is 110 poise at 1150°C [7.25]. If the viscosity is too high, the heat transfer between the cold cap and the molten glass is reduced, which reduces the melt rate. High viscosities may also adversely affect the ability to pour the glass from the melter. The minimum allowable viscosity in the DWPF Melter is 20 poise at 1150°C. Low viscosities in the melter can lead to increased cesium volatility and excessive refractory corrosion [7.34]. The algorithm for viscosity at 1150°C was developed by Jantzen [7.35].

The homogeneity constraint used in DWPF's PCCS is used to discriminate compositions that are likely to result in glasses containing glass-in-glass amorphous phase separation from compositions that are likely to be homogeneous. However, implementation of the homogeneity constraint has resulted in an overly restrictive operating region for DWPF. Therefore, studies were conducted at SRNL to determine if the homogeneity constraint could be replaced by other constraint(s) that would prevent processing unpredictable glasses while still allowing processing flexibility. The testing performed concluded that the homogeneity constraint could be replaced during both sludge-only operations and coupled operations by an Al_2O_3 and/or sum of alkali constraint ($\sum M_2O$) without sacrificing glass durability [7.37].

The nepheline ($NaAlSiO_4$) constraint is used to ensure the formation of nepheline and/or other aluminum/silicon-containing crystalline structures are not formed that will affect the durability of the DWPF glass. The combination of high Al_2O_3 and high Na_2O concentrations, coupled with lower SiO_2 concentrations as waste loadings increase can increase the formation of nepheline. Nepheline tends not to precipitate when the SiO_2 mass fraction in the glass to Al_2O_3 and Na_2O is greater than 0.62 [7.31].

The glass variability study is one of the parameters required by the GPCP to confirm the applicability of the PCT/chemical composition correlation for the sludge batch [7.30].

The glass quality and processing constraints are controlled at the 95% confidence level [7.25] and, therefore, nominal concentrations can be used without adding analytical uncertainty. Contributions to glass quality from the ARP stream should also be evaluated. The MCU stream contribution to glass quality is expected to be negligible.

5.4.11 H_2 Generation/N_2O Concentration

5.4.11.1 Criteria: The hydrogen generation rate in the SRAT shall not exceed 0.65 lb/hr for 6000 gallons of SRAT product accounting for analytical uncertainty [7.2].

The hydrogen generation rate in the SME shall not exceed 0.223 lb/hr for 6000 gallons of SME product accounting for analytical uncertainty [7.2].

The nitrous oxide concentration in the SRAT vapor space shall not exceed 15 volume percent accounting for analytical uncertainty [7.38].

NOTE: The SRAT and SME hydrogen generation rates for Sludge Batch 9 (SB9) will be evaluated as part of the qualification process of Sludge Batch 9 (SB9). Per the JCO, if the SB9 SRAT/SME hydrogen generation rates are higher than SB8, these results will be communicated to DOE and a path forward will be developed to address the increase [7.60].

5.4.11.2 Criteria Type: LIMIT (**DWPF TSR SAC - 5.8.2.11)**

5.4.11.3 Computational Technique: The Tank Farm will sample sludge batches as described in Section 5.4 and the sample will be processed at SRNL in the Shielded Cells Facility. Hydrogen generation rates will be measured in the SRAT and the SME and verified to be lower than the values above. The nitrous oxide concentration in the SRAT will be measured and verified to be lower than the above value.

5.4.11.4 Background: TNX Run #PX-5 bounded the metal content and processing variables related to hydrogen generation in the DWPF Chemical Process Cell (CPC) and determined the Design Bases hydrogen generation rates given above [7.39]. This hydrogen generation rate was used to determine the minimum purge requirements necessary to maintain the SRAT vapor space at less than the CLFL for benzene and hydrogen and maintain the SME vapor space at less than the Lower Flammability Limit for hydrogen. The CLFL formula for the SRAT has been adjusted for 15 vol% nitrous oxide. Exceeding these criteria would challenge the maximum hydrogen generation rates in the CPC. The addition of MST/Sludge Solids from ARP and Strip Effluent from MCU will have negligible impact on hydrogen generation [7.40, and 7.41].

The direct measurements of hydrogen generation and nitrous oxide shall include analytical uncertainty [7.2].

5.4.12 Radiolytic Hydrogen Generation

5.4.12.1 Criteria: The radiolytic hydrogen generation rate (HGR) for sludge transferred to DWPF shall not exceed 8.95E-05 ft^3/hr/gal at 25ºC .

NOTE: The radiolytic hydrogen generation rate for Sludge Batch 9 (SB9) will be evaluated as part of the qualification process of Sludge Batch 9 (SB9). Per the JCO, if the SB9 radiolytic hydrogen generation rate is higher than SB8, this result will be communicated to DOE and a path forward will be developed to address the increase [7.60].

5.4.12.2 Criteria Type: LIMIT **(DWPF TSR SAC – 5.8.2.11)**

5.4.12.3 Computational Technique: The radiolytic hydrogen generation rate is based on the cumulative sum of a mixture of radionuclide hydrogen generation conversion factors multiplied by the radionuclide heat rate.

5.4.12.4 Background: Hydrogen is produced catalytically with formic acid additions in the SRAT and radiolytically in each of the DWPF vessels. The radiolytic hydrogen generation rate limit ensures that the inputs used in selecting flammability controls used for each of the process vessels are protected. Table 6 identifies radionuclides that are significant (contribute 99.9% of total HGR of 8.95E-05 ft^3/hr/gal at 25ºC) to radiolytic hydrogen generation [7.6].

Radiolytic HGRs can use nominal radionuclide concentrations without adding analytical uncertainty based on conservative R-Values used in determining the generation rate [7.2].

TABLE 6

Species	**Sludge Stream Bounding Heat Rate (BTU/hr/gal)**	**R-Value ($ft^3/10^6$ BTU)**	**Sludge Stream HGR (ft^3/hr/gal)**
Co-60	7.89E-03	48.36	3.81E-07
Y-90	7.87E-01	48.36	3.81E-05
Sr-90	1.60E-01	48.36	7.76E-06
Ru-106	4.06E-03	48.36	1.96E-07
Rh-106	1.30E-01	48.36	6.27E-06
Sb-125	8.45E-03	48.36	4.08E-07
Cs-134	4.91E-03	48.36	2.37E-07
Cs-137	4.62E-03	48.36	2.23E-07
Ba-137m	1.72E-02	48.36	8.33E-07
Ce-144	1.96E-02	48.36	9.50E-07
Pr-144	2.19E-01	48.36	1.06E-05
Pm-147	2.68E-02	48.36	1.30E-06
Eu-154	1.70E-02	48.36	8.22E-07
Pu-238	1.45E-01	134.7	1.95E-05
Pu-239	1.17E-03	134.7	1.57E-07
Pu-240	7.92E-04	134.7	1.07E-07
Am-241	1.06E-03	134.7	1.43E-07
Cm-244	1.10E-02	134.7	1.49E-06
Total			**8.95E-05**

5.4.13 Organic Concentration

5.4.13.1 Criteria: Organic material present in sludge feed transferred to DWPF shall contribute less than 0.1% to the hydrogen LFL except for transfers from MCU.

Transfers of strip effluent from MCU shall be tracked and characterized by the sending facility prior to entering the DWPF Chemical Process Cell (CPC):

a. Transfers of strip effluent from MCU shall not exceed 87 mg/L Isopar L accounting for analytical uncertainty.

b. In the event of a process upset, transfers of strip effluent from MCU may be greater than 87 mg/L Isopar L but shall not exceed 600 mg/L Isopar L accounting for analytical uncertainty [7.2, 7.3].

c. MCU may transfer a maximum of 1689 gallons of strip effluent prior to being characterized [7.42].

d. Transfers of strip effluent from MCU shall not result in a specific gravity exceeding 1.06 in the Strip Effluent Feed Tank (SEFT) [7.43].

5.4.13.2 Criteria Type: LIMIT **(DWPF TSR SAC – 5.8.2.11)**

5.4.13.3 Computational Technique: Direct chemical analysis and/or process knowledge.

Transfers of strip effluent from MCU greater than 87 mg/L but less than or equal to 600 mg/L Isopar L will require a Tank Farm Type 1 Engineering Calculation reviewed/approved by D&S-FE summarizing the transfers associated with the upset condition (e.g., Isopar L concentrations, transfer volumes, etc.).

5.4.13.4 Background: The organic contribution to the hydrogen LFL limit protects the assumptions in the DWPF DSA accident calculations which assume that time to LFL calculations, purge rates, etc. for sludge processing vessels are based on 100% hydrogen since the organic contribution in the incoming waste stream is considered negligible. Verifying that the organic concentration is insignificant provides assurance that the organic contribution to hydrogen LFL in DWPF vessels will be negligible.

The 0.1% value specified is utilized to quantify a negligible amount. Since these values are expected to be negligible, nominal values can be used without adding analytical uncertainty [7.2].

The purge flow requirements for controlling flammability in the DWPF Chemical Process Cell were developed assuming a mixed fuel system of hydrogen and benzene. The hydrogen is produced radiolytically and from the noble metal catalyzed decomposition of formic acid. The benzene vapor was from the residual organics (benzene and phenylboric acid) in the cesium bearing Precipitate Hydrolysis Aqueous (PHA) stream fed to the SRAT. The process for removing cesium from soluble waste and sending the cesium stream to the DWPF is now Caustic Side Solvent Extraction (CSSX). The extraction solvent for this process includes a flammable kerosene-like diluent – Isopar L – which is stripped out in the SRAT. The flammable contribution of the diluent was determined and compared to the contribution from benzene in the original flammability calculation [7.44]. The flammability of a mixed fuel system of hydrogen plus Isopar L is bounded by the flammability of the hydrogen plus benzene system, when the strip effluent concentration is below 87 ppm Isopar L. Since strip effluent was assumed to have a specific gravity greater than 1.0, the 87 ppm Isopar L concentration used in flammability calculations is bounding of actual inventories limited to 87 mg/L [7.2].

NOTE: For Criterion (a) the lower limit (Isopar ≤ 87 mg/L) is not part of SAC 5.8.2.11; however, this limit is expected during normal MCU processing for the required SRAT flammability limits.

The Isopar L concentration in the strip effluent from MCU is limited to 600 mg/L (Criterion (b)). A lower concentration (i.e., 87 mg/L) is required in the CPC than is allowed in the strip effluent transfer line and the LPPP. As a result, transfers into the CPC must be tracked and characterized by MCU prior to entering the CPC. The maximum uncharacterized volume of strip effluent in the transfer line shall not exceed 1689 gallons (Criterion (c)) to ensure the uncharacterized strip effluent does not enter the CPC [7.42]. When the concentration exceeds 87 mg/L in the transfer line, the SEFT Dilution Program (DWPF SAC 5.8.2.31) provides the actions necessary to ensure adequate dilution occurs in the SEFT to maintain the bulk concentration less than or equal to 87 mg/L. An analytical uncertainty of 2 Sigma shall be accounted for in Isopar L sample analyses used to determine organic concentration compliance [7.2].

For Criterion (d), a maximum specific gravity of 1.06 was assigned for the strip effluent in the SEFT that will be transferred to the SRAT in the determination of the minimum steam flow required to ensure that Isopar L does not accumulate in the SRAT vapor space, which could become a flammability concern [7.43]. As documented in the DWPF Safety Analysis Input Sheets for the MCU WTL Project, MCU historical data show an average of 1.009 for the specific gravity of the strip effluent with the highest reported specific gravity being at 1.037 [7.45]. NOTE: The specific gravity limit for strip effluent [SpG ≤ 1.06] is not part of TSR SAC 5.8.2.11.

5.4.14 pH

5.4.14.1 Criteria: Transfers from MCU must meet the following constraints:

a. Strip Effluent with the BOBCalix-based solvent (based on a nominal 0.001 M nitric acid concentration and a bounding 0.006 M nitric acid concentration) shall have a pH ≥ 2 and ≤ 4 accounting for analytical uncertainty. NOTE: Compliance with the upper pH limit of 4 shall be shown by the sending facility prior to the strip effluent batch entering the DWPF CPC.

b. Strip Effluent with the Next Generation Solvent (NGS) (based on a nominal 0.01 M boric acid concentration and a bounding 0.0125 M boric acid concentration) or Strip Effluent with a blend of the two solvents shall have a pH ≥ 2 and ≤ 11 accounting for analytical uncertainty. NOTE: Compliance with the upper pH limit of 11 shall be shown by the sending facility prior to the strip effluent batch entering the DWPF CPC.

c. The boric acid concentration for the Strip Effluent with NGS or a blend of the two solvents shall be ≤ 0.0125 M.

d. A full line volume water or Strip Effluent flush shall be transferred through the Strip Effluent Transfer Lines within 2 weeks after Contactor Cleaning Solution (nominally 3M HNO_3) is transferred [7.46, 7.47].

e. The sodium concentration for the Strip Effluent with either the BOBCalix-based solvent, NGS or a blend of the two solvents shall be ≤ 265 mg/L accounting for analytical uncertainty and shall be tracked and characterized by the sending facility prior to entering the DWPF CPC.

5.4.14.2 Criteria Type: LIMIT **(DWPF TSR SAC – 5.8.2.11)**

5.4.14.3 Computation Technique: Direct chemical analysis and/or process knowledge (Criteria a and b), procurement specification or chemical analysis (Criterion c), procedural measurement of flush volume (Criterion d) and direct chemical analysis and/or process knowledge (Criterion e).

5.4.14.4 Background: For Criteria (a) and (b), the transfer line and vessels contacting strip effluent are suitable. The dilute nitric and boric acids are insufficiently oxidizing to lead to significant corrosion of the HASTELLOY® C-276 (high molybdenum alloy). 304L/316L (Austenitic Stainless Steel) components are compatible with nitric acid [7.48], and 0.006 M nitric acid with a pH of 2 bounds 0.0125 M boric acid from a corrosion perspective. Additionally, a temperature of less than 50 °C is assumed [7.49], which is protected by the temperature requirements provided in Sections 5.3.6 and 5.4.15. NOTE: The upper pH limits [pH ≤ 4 for (a) and pH ≤ 11 for (b)] are not part of TSR SAC 5.8.2.11; however, these upper pH limits are required for SRAT processing purposes [7.50]. These higher pH limits are set to a level where the base added with the strip effluent is insignificant compared to the acids (both formic and nitric) added on SRAT processing. Similar to the Isopar L criteria in Section 5.4.13, strip effluent transfers must be characterized for pH by MCU and shown to be compliant with the upper pH limits prior to entering the CPC. An analytical uncertainty of 2 Sigma shall be accounted for in sample analyses used to determine pH compliance [7.2].

For Criterion (c) there is an upper limit for boric acid concentration. If the concentration of the boric acid is increased above 0.0125 M, the ramification on predicted glass properties and SME acceptability decisions could become more serious warranting additional evaluations [7.51]. NOTE: The boric acid concentration is not part of TSR SAC 5.8.2.11; this limit is required for glass quality (see Section 5.4.10).

For Criterion (d) the Contactor Cleaning Solution (with either nominally 0.001 M nitric acid solution, nominally 0.01 M boric acid solution or a blend) is sufficiently oxidizing to attack HASTELLOY® C-276. Stagnant acid solution can lead to the formation of concentration cells which cause localized corrosion. Flushing the line will leave solution which is benign [7.46, 7.47, 7.52].

For Criterion (e) exceeding the sodium limit for the Strip Effluent stream could impact the SME compositional blend and therefore could result in the remediation of a SME batch. Reference 7.53 documents that a strip effluent transfer of 10,500 gallons at a sodium concentration of 265 mg/L will have a negligible effect on the final sodium concentration in the SME. NOTE: The sodium concentration is not part of TSR SAC 5.8.2.11; this limit is related to glass quality (see Section 5.4.10). Similar to the Isopar L criteria in Section 5.4.13, strip effluent transfers must be characterized for sodium by MCU prior to entering the CPC.

An analytical uncertainty of 2 Sigma shall be accounted for in sample analyses used to determine sodium compliance [7.2].

5.4.15 Temperature

5.4.15.1 Criteria: Wastes entering the DWPF facilities shall meet the following temperature Limits:

a. Sludge transfers from Tank 40 shall be ≤ 45ºC

b. Strip Effluent transfers from MCU shall be ≤ 40ºC

5.4.15.2 Criteria Type: LIMIT **(DWPF TSR SAC – 5.8.2.11)**

5.4.15.3 Computational Technique: Direct measurement and/or process knowledge.

5.4.15.4 Background: The maximum temperature limits protect the assumptions in the DWPF DSA accident calculations [7.2, 7.11].

5.4.16 Particle Size

5.4.16.1 Criteria: New product streams entering the DWPF facilities shall have a maximum particle size of 80 mesh sieve or equivalent.

5.4.16.2 Criteria Type: LIMIT

5.4.16.3 Computational Technique: Direct chemical analysis and/or process knowledge.

5.4.16.4 Background: In the future non-sludge and non-salt streams (e.g., product stream from treatment of Tank 48H material) may be transferred to DWPF for processing. Hydragard samplers are used with DWPF processing vessels to obtain representative samples from the tanks. These samples are analyzed in the DWPF Laboratory to ensure that the tank contents meet acceptability and processability requirements.

Particle sizes greater than 80 mesh, the maximum particle size of frit given in the frit procurement specification [7.54], can adversely impact operation of the Hydragard sampler via pluggage and therefore could prevent a representative sample from being taken from a tank. The basis for the DWPF particle size requirement including tolerances is given in Reference 7.55.

5.4.17 Fissile Concentration in Glass

5.4.17.1 Criterion: The sum of the concentrations of ^{233}U, ^{235}U, ^{239}Pu and ^{241}Pu shall not exceed 897 grams per cubic meter of glass.

5.4.17.2 Criterion Type: LIMIT

5.4.17.3 Computation Technique: Chemical analysis of Fe, radionuclide analysis of ^{233}U, ^{235}U, ^{239}Pu and ^{241}Pu in WAPS sample and glass density measurement. Prior to WAPS sample analysis D&S-FE will use sludge batch qualification data and previous sludge batch heel data to demonstrate that the fissile limit is met assuming conservative waste loadings. During this initial period, production data will be collected, and an algorithm written with associated tolerance/confidence limits for the sludge data. Reference 7.56 contains detailed information on the derivation of the algorithm for reporting fissile loading in DWPF canisters for a specific sludge batch.

5.4.17.4 Background: The Department of Energy required that DWPF control waste loading such that the total concentration of the specified radionuclides be less than 897 grams per cubic meter glass [7.57]. This limit was set to be consistent with the License Application for the Geological Repository at Yucca Mountain. Sludge batch planning will limit plutonium discards from H Canyon to ensure 897 grams per cubic meter is met for future sludge batches given projected DWPF production rates and target waste loadings. The Savannah River National Laboratory has developed a method by calculation that insures that this criterion is met at the 95% confidence level (2 Sigma), allowing for uncertainties in the analytical measurements and the density of the glass [7.56]. Note: The method used is applicable to all sludge batches, but the specific inputs must be determined analytically for each batch.

5.5 Administrative Controls

Prior to the Tank Farm processing of a sludge batch, TF-FE and D&S-FE will agree upon and document the extent of aluminum dissolution necessary, if any, and the amount of sludge washing required prior to and during the Tank Farm activities.

Prior to acceptance by DWPF, a sludge or salt batch must be qualified. Following receipt of all feed for a particular batch, a sample representative of the batch shall be taken and transported to SRNL. The sample must be analyzed and processed in the Shielded Cells using the DWPF process. The sludge sample may be washed at SRNL prior to characterization and processing if it was obtained before washing evolutions were completed. Washing of the sample at SRNL may occur in parallel with the actual washing in the waste tank. The analytical results will either be compared directly with the WAC or be used with the appropriate algorithm to calculate a composite value that will be compared with the WAC requirement.

No additional high level waste or chemicals (except for uninhibited/inhibited water, corrosion prevention inhibitors, or approved processing chemicals such as MST, MCU solvent, etc.) will be transferred to the accepted sludge or salt batch or to the sludge or salt batch after the qualification sample has been taken without requalifying the batch. If an addition other than uninhibited/inhibited water or corrosion prevention inhibitors is to be made to a batch after the qualification sample has been obtained or after the batch has been qualified, the addition must be evaluated by TF-FE and D&S-FE. This evaluation must be formally documented by these organizations. The addition may be qualified as part of the sludge or salt batch qualification if the addition is replicated at SRNL during the qualification process. If the addition is to be made to a previously qualified batch, the process documented in Reference 7.58 may be followed. It may be possible to use a different source of wash water, other than inhibited water, to wash the sludge after the qualification sample has been obtained as long as the washing process is replicated in the Shielded Cells. TF-FE and D&S-FE must document the evaluation of this evolution prior to making the additions. The newly accepted batch may then be transferred into a previously accepted sludge or salt batch. Multiple transfers of the newly accepted batch into the previously accepted batch are permissible as long as no additional high level waste (unless previously qualified and accepted) or chemicals (except for corrosion prevention inhibitors and uninhibited/inhibited water) have been added to the newly accepted batch. Following this transfer(s), the receiving tank will be sampled for radionuclides to meet Waste Acceptance Reporting Requirements [7.32].

Prior to intentional adjustment with corrosion prevention inhibitors (sodium hydroxide or sodium nitrite) into a completed washed and sampled batch or a previously accepted batch, TF-FE shall analyze the expected new composition for the batch and provide the results to D&S-FE. D&S-FE shall determine the potential impact of the addition on DWPF. D&S-FE will then notify TF-FE if it will be necessary to terminate new transfers to DWPF until additional sampling and requalification of the batch has been performed.

NOTE: For corrosion inhibitor additions determined to have only minor impacts, verification of the new composition can be determined by samples taken in the DWPF SRAT or by sampling the Tank Farm batch feed tank while continuing to perform transfers to DWPF.

Radionuclide data from the qualification sample analysis shall be used to evaluate radiological requirements in support of batch qualification efforts. Radiological Technology is to perform the following evaluations based on sample results prior to transfer of the sludge and salt batch to DWPF: (1) Personnel alpha monitoring program at DWPF, (2) Continuous Air Monitor (CAM) setpoints at DWPF, (3) DWPF Bioassay program, (4) Use of Thermoluminescent Dosimeters (TLDs) at DWPF, and (5) Photon energy emission spectrum (vs. design basis).

Radionuclides and hazardous metals required for Solid Waste Characterization and solids and elemental content greater than 1 wt% shall be measured in the qualification sample. Qualification of the feed for solid waste characterization is not required prior to acceptance of the batch for feed to DWPF/512-S but is required prior to shipment of job control waste to the Solid Waste Facility.

Prior to receiving a new sludge batch, the melter off-gas flammability model needs to be evaluated to determine if the existing TSR and feed interlock limits are still valid for the new sludge batch. The three equation sets below are valid for SB8 [7.59].

Equation Set A

A.1 = Carbon From Antifoam Concentration Limit (ppm)

$$\text{A.1} = \sqrt{\left(\mathbf{5117745.1} + (\mathbf{-35.869438} \times \boldsymbol{x})\right)}$$

A.2 = TOC Concentration Limit (ppm)

$$\text{A.2} = \mathbf{7557.6474} + \mathbf{0.50526028}(\boldsymbol{x}) + [\mathbf{-9.2573423E\text{-}06}(\boldsymbol{x})^{\mathbf{2}}] + \mathbf{2.3456397E\text{-}10}(\boldsymbol{x})^{\mathbf{3}} + [\mathbf{-1.6391746E\text{-}15}(\boldsymbol{x})^{\mathbf{4}}]$$

Equation Set B

B.1 = Carbon From Antifoam Concentration Limit (ppm)

$$\text{B.1} = \sqrt{\left(\mathbf{7884790.5} + (\mathbf{-55.545316} \times \boldsymbol{x})\right)}$$

B.2 = TOC Concentration Limit (ppm)

$$\text{B.2} = \mathbf{9422.0849} + \mathbf{0.07089545}(\boldsymbol{x}) + \mathbf{9.1468028E\text{-}06}(\boldsymbol{x})^{\mathbf{2}} + [\mathbf{-6.620362E\text{-}11}(\boldsymbol{x})^{\mathbf{3}}] + \mathbf{5.7959687E\text{-}17}(\boldsymbol{x})^{\mathbf{4}}$$

Equation Set C

C.1 = Carbon From Antifoam Concentration Limit (ppm)

$$\text{C.1} = \sqrt{\left(\mathbf{10373798} + (\mathbf{-73.602487} \times \boldsymbol{x})\right)}$$

C.2 = TOC Concentration Limit (ppm)

$$\text{C.2} = \mathbf{10556.47} + [\mathbf{-0.2167157}(\boldsymbol{x})] + \mathbf{2.0961912E\text{-}05}(\boldsymbol{x})^{\mathbf{2}} + [\mathbf{-2.5179967E\text{-}10}(\boldsymbol{x})^{\mathbf{3}}] + \mathbf{1.0703826E\text{-}15}(\boldsymbol{x})^{\mathbf{4}}$$

Where x = nitrate concentration in ppm

In addition, if a sludge batch is believed to contain a new carbon species or a species that could contribute to flammability in the melter, D&S-FE (with support from SRNL) must perform an evaluation to determine the impact of the projected component on melter off-gas flammability.

6.0 RECORDS

Documentation of the SRNL analysis and Shielded Cells processing, this WAC for Tank Farm transfers to 512-S and DWPF, and the evaluation of feed compliance associated with this WAC will be retained as lifetime records.

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8.0 ATTACHMENTS

None