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12/31/2007– December, 2007 Curie and Volume Inventory Report

Introduction

The Waste Characterization System (WCS) is an electronic information system that tracks waste tank data, including projected radionuclide inventories based on sample analyses, process histories, composition studies and theoretical relationships. In addition, several recent studies have established characterization methodologies that expand on the information found in WCS. This information is used to aid the planning and scheduling of Closure Business Unit activities. The purpose of this memorandum is to document the information as of December 2007 for the curie inventory phase partition (supernate, sludge, salt) for radionuclides tracked in waste (including phase subtotals). This information is provided in Table A1 and reflects the tank farm inventories as of 12/31/2007. Phase curies and volumes inventories reported by tank are provided in Table A2 and A3 respectively. General methods and computations performed within WCS used to generate curie inventory projections are documented in References 1 and 2.

Inputs and Assumptions

1. Reference date for sludge decay calculations: 12/31/2007
2. Tank Farm Transfer Receipt Sludge 1.5 Update Status:

   Tank 26: 1/31/2005 Tank 39: 11/30/2006
3. Tank Farm Effluent Transfer Sludge 1.5 Update Status:

   Tank 40: 5/17/2007
4. Evaporator Tanks (26, 27, 32, 37, 38, and 43) assumed to be at level when samples were taken for Curie inventory estimates. Total supernate Curie inventory is affected accordingly due to the level changes in the tanks.
5. Morning Report reference date for tank levels: 12/31/2007, Ref. 3.
6. Closed Tank Sludge Volume included in Phase Volume Sludge Total.
7. Zeolite, Coal, Sand Volumes not accounted in volumes (impacts Supernate Total). Interstitial Supernate Volumes accounted for in Sludge/Salt Volumes, Salt Volume for Salt Ci content calculations, and in Total Supernate Volume for Supernate Ci content calculations.

8. Algorithms from Waste Characterization System (WCS) Supernate Baseline Composition Development in Support of Integrated Flowsheet Modeling Efforts (Ref. 4) are used to estimate the supernate inventories of ^{3}H, ^{14}C, ^{60}Co, ^{63}Ni, ^{90}Sr, and ^{90}Y, except for the values of Tank 23, Tank 49 for which results of supernate sample analysis are used (Ref. 5, 6) and Tank 50 for which results of Tank 50 material balance is used (Tank 50 material balance Tab in WCS1.5) . The ^{90}Sr supernate concentration of Tank 28 is taken form free liquid sample results of the Tank saltcake (Ref. 7). These algorithms project conservative (high) estimates for supernate inventory of these isotopes.

9. ^{3}H curies are adjusted for Tank 26, 27 based on recent overhead sampling [Ref. 8]. ^{3}H inventories for Tank 7, 8, and 33 are based on current sample data as recorded in WCS. ^{3}H inventory of Tank 6 is based on the value of Tank 7 due to transfer supernate from this Tank.

10. Additional sludge inventories are identified for ^{126}Sb, ^{126m}Sb, ^{125m}Te, ^{151}Sm, ^{152}Eu, ^{155}Eu, ^{243}Am, ^{243}Cm, ^{226}Ra, ^{228}Ra, ^{227}Ac, ^{229}Th, ^{230}Th, ^{231}Pa, and ^{244}Pu (Refs. 9, 10, and 11). An assumed 30 year-old waste is utilized in the inventory estimates.

11. Additional supernate inventories are identified for ^{126}Sb, ^{126m}Sb, ^{125m}Te, ^{151}Sm, ^{152}Eu, ^{155}Eu, ^{243}Am, ^{243}Cm, ^{226}Ra, ^{228}Ra, ^{227}Ac, ^{229}Th, ^{230}Th, ^{231}Pa, and ^{244}Pu (Refs. 9, 10, and 11). An assumed 30 year-old waste is utilized in the inventory estimates.

12. ^{22}Na inventory is added as determined from Ref. 12 and the partitions of Na between the supernate, sludge and salt phases which are 42.1%, 0.3%, and 57.6%, respectively. The phase breakdown is determined from the ratio of sodium compounds' quantities contained in WCS 1.5.

13. ^{26}Al inventory is added as determined from Ref. 13 and the partitions of Al between the supernate, sludge and salt phases are 41.9%, 20.2%, and 37.9%, respectively. The phase breakdown is determined from the ratio of aluminum compounds' quantities contained in WCS 1.5.

14. ^{129}I supernate inventory is added, Ref. 14.

15. Supernate inventories for ^{79}Se and ^{99}Tc are, respectively, 8.9E+01 and 3.3E+04 curies, Ref. 15.

16. ^{242}Cm total inventory is set equal to 82% of the corresponding ^{242m}Am inventory, Ref 9.

17. ^{246}Cm sludge inventory is added, Ref. 16.

18. Inventories distributed to each Tank as detailing in reference 17

19. To determine soluble inventories for isotopes listed in Table 1, the solubility factor is multiplied by the corresponding total tank farm sludge inventory. Since, the chemistry of the transplutonium elements is very similar to the rare earths (Ref.18), their solubility factor is assumed to be 0.001.

Table 1: Soluble Inventory Estimates Based on Solubility

Nuclide	Solubility Factor (Ref. 19)
Ni-59	(a)
Nb-94	1.00E-03
Ru-106	2.50E-01
Rh-106 (f)	2.50E-01
Sn-126	2.00E-01 (b)
Sb-125	5.00E-02
Sb-126	5.00E-02 (c)
Sb-126m	5.00E-02 (c)
Te-125m	5.00E-02 (c)
Cs-134	(d)
Cs-135	(d)
Ce-144	1.00E-03
Pr-144 (g)	1.00E-03
Pm-147	1.00E-03
Eu-154	1.00E-03
Sm-151	1.00E-03 (e)
Eu-152	1.00E-03 (e)
Eu-155	1.00E-03 (e)
Am-241	1.00E-03 (e)
iAm-241	1.00E-03 (e)
Am-242m	1.00E-03 (e)
Am-243	1.00E-03 (e)
Cm-242	1.00E-03 (e)
Cm-243	1.00E-03 (e)
Cm-244	1.00E-03 (e)
Cm-245	1.00E-03 (e)
Cm-246	1.00E-03 (e)

Note: (a) Based on ^{63}Ni ratio between sludge and supernate inventories
(b) Based on ref. 15
(c) Based on ^{125}Sb solubility
(d) Based on ^{137}Cs ratio between sludge and supernate inventories
(e) Based on rare earths solubility
(f) Assumed same as Ru-106
(g) Assumed same as Ce-144

20. Adjustments Made to Sludge 1.5:

- ^{63}Ni sludge inventory is added, Ref. 20, Although to be consistent with all other isotopes within PUREX waste, the mixed waste stream is assumed to be 50% LHW and 50% HHW.
- ^{94}Nb sludge inventory is added, Ref. 21
- Add Am/Cm additions to Sludge 1.5 for Tank 33 and 39, Ref. 22 (Not decay adjusted)
- Tank 50 sludge inventories are set to zero since Tank 50 is operated on Supernate-Only mode.

21. Adjustments Made to WCS:

a) **Sludge Volume:** These values listed below reflect sludge volume corrections for the sludge volume equation. The Sludge Volume changes do not affect the total sludge curie inventory because those values are extracted directly from Sludge 1.5.

Tank 7 (Removed the sludge exposed selection, and no sludge volume input) – The sludge level change is based on a recent sounding (Ref. 23) and recent sludge transfers. Given the liquid level from the morning report, the sludge is no longer exposed.

Tank 12 (No sludge input) - Estimated sludge level (51 inches) from Ref 24 is used.

Tank 13 (81.75 to 72.75 inches) – The level used is the average the two sludge sounding recorded in Ref. 23.

Tank 15 (89.0 inches to 42.8 inches) – The Tank 15 level is reported as either visual level (61 inches, 2/26/1998), or sludge sounding depth (89 inches, date unknown), or morning report level (42.8 inches, on 12/31/2007). The total tank waste volume reported in WCS is based on an outdated visual level and built in algorithms that chose the total tank waste volume for the sludge volume in case of a greater sludge volume based on sounding. Since the recent morning report level is more recent and was verified via camera, this value is also used as the salt and sludge levels.

Tank 39 (30.0 inches to 32.5 inches) - Updated to match recent sludge sounding recorded in Ref. 23.

Tank 43 (68.60 to 66.68 inches) – The level used is based on an average of the two soundings recorded in Ref. 23.

b) **Salt Volume:** Changes in Salt Volume will change the corresponding insoluble curies inventory. Therefore, additional salt formation from reducing evaporator tank supernate volumes in Tank 15 is also accounted for.

Tank 12H (60,000 gallons to 52,000 gallons) – WCS currently maintains a salt volume in Tank 12 based on an evaluation prior to the re-wet of the tank contents. After the re-wet, a portion of the salt has been dissolved (Ref. 24).

Tank 15H – As supernate evaporates in the tank, salt begins to crystallize and fill in the void space of the sludge. The salt volume is adjusted in dry sludge tanks to account for this evaporation effect. Tank 15 is the only tank where this is taken into account.

Tank 37H (314.4 to 307.07 inches) – The salt depth is based on soundings from risers B1, B3, B5 (10/13/2005), and H (4/10/2007). The most recent sounding, in H riser, showed an increase of 25 inches over sounding level after the last dissolution. H riser is the highest level of the four risers. This suggests there is not a uniform salt level in the tank. Therefore, using only this measurement would not yield the best estimated level. Also, using the older sounding from risers B1, B3 and B5 would be expected to yield a lower level than actually believed. Therefore, based on the 25 inches increase in salt level in H riser, 25 inches of salt was added to the sounding in risers B1, B3 and B5 (Ref. 23) to provide the best estimate of salt level in the tank. The salt depth is the average of the adjusted sounding levels from all four risers.

Tank 41H (no change to WCS recorded salt level) – The current salt level recorded in WCS is 252", and the level reported in Ref. 22 is 312". Based on video observation of Tank 41, the salt level is estimated to be 252 in. based on the elevation of taller cooling coil horizontal supports (Ref 25) which were observed to be partially buried in salt.

Tank 46H (329.75 to 326.13 inches) – The salt depth is based on soundings from risers G (10/20/07) and H (2/11/03 – revision 0 of Ref.23) (Ref. 23). The sounding from riser H must be adjusted before using to estimate salt level. Since 2/11/03, there was 87.89" increase in salt level in G riser (329.75" - 241.86"). Therefore, 87.89" of salt was added to the sounding in riser H to adjust the level. The salt depth is the average of the adjusted value of H riser and G riser sounding.

c) **Tank 48**: The tank contents are accounted for as sludge in Sludge 1.5. Although, the volume and curie inventory will be treated as a slurry. The unanalyzed supernate nuclide inventory is determined in the same manner as for other tanks.

d) **Tank 23:** Supernate sample data from a recent WAC analysis is used in place of WCS assumptions (Ref. 5). The ^{232}U supernate concentration was not measured in this data set. Therefore, it is estimated by subtracting the actual measured (i.e., no detection limit values) alpha emitters from the gross alpha measurement.

e) **Tank 28:** Free Liquid sample data from a recent saltcake core sample analysis is used in place of WCS for supernate concentration of gamma and ^{238}U (Ref. 7)

f) **Tank 49:** Supernate sample data is used in place of WCS assumptions (Ref. 6)

g) **Tank 50:** Data is taken from WCS1.5 , Tank 50 material balance Tab.

Appendix A

Table A1 – December-2007 Curie Inventory

Nuclide Data	Total Supernate (Ci)	Sludge (Ci)	Insoluble (Ci) (Including Tk 15 Interstitial Salt)
H-3	8.11E+03	-	-
C-14	1.66E+02	3.12E+00	3.79E+02
Na-22	2.09E+03	1.77E+01	2.95E+03
Al-26	1.22E+01	5.79E+00	1.14E+01
Co-60	8.33E+01	2.50E+05	-
Ni-59	2.36E+00	2.61E+03	-
Ni-63	2.02E+02	2.23E+05	-
Se-79	8.90E+01	1.55E+03	-
Sr-90	2.44E+04	8.18E+07	4.15E+06
Y-90	2.44E+04	8.18E+07	4.15E+06
Nb-94	6.88E-04	6.88E-01	-
Tc-99	3.30E+04	2.64E+04	-
Ru-106	5.11E+02	1.53E+03	-
Rh-106	5.11E+02	1.53E+03	-
Sn-126	5.02E+02	2.01E+03	-
Sb-125	5.28E+03	1.00E+05	-
Sb-126	1.76E+01	3.34E+02	-
Sb-126m	1.26E+02	2.39E+03	-
Te-125m	1.29E+03	2.45E+04	-
I-129	1.74E+01	1.06E-01	-
Cs-134	8.33E+04	4.41E+03	-
Cs-135	3.33E+02	1.77E+01	-
Cs-137	1.02E+08	5.39E+06	1.86E+05
Ba-137m	9.61E+07	4.71E+06	1.76E+05
Ce-144	6.72E-01	6.71E+02	-
Pr-144	6.71E-01	6.71E+02	-
Pm-147	2.11E+03	2.11E+06	-
Sm-151	4.30E+03	4.29E+06	-
Eu-152	2.08E+01	2.07E+04	-
Eu-154	7.45E+02	7.45E+05	-
Eu-155	2.43E+02	2.43E+05	-
Ra-226	7.71E-06	1.05E-04	-
Ra-228	9.33E-02	2.80E+00	-
Ac-227	2.43E-05	4.04E-04	-
Th-229	6.30E-03	2.86E-01	-
Th-230	9.43E-04	1.29E-02	-
Th-232	9.33E-02	2.80E+00	-
Pa-231	6.76E-05	1.12E-03	-
U-232	6.24E-01	5.41E-01	-
U-233	2.22E+00	1.01E+02	-
U-234	3.42E+00	4.67E+01	-
U-235	1.07E-01	1.60E+00	1.63E-01
U-236	3.42E-01	7.16E+00	-
U-238	8.58E+00	6.26E+01	3.67E+00
Np-237	3.93E+00	8.77E+01	-
Pu-238	7.99E+04	1.97E+06	5.30E+04
Pu-239	5.51E+03	4.45E+04	1.77E+03
Pu-240	1.43E+03	1.95E+04	-
Pu-241	5.16E+04	1.09E+06	-
Pu-242	2.01E+00	3.30E+01	-
Pu-244	9.18E-03	1.51E-01	-
Am-241	2.97E+02	2.97E+05	-
iAm-241	7.58E+01	7.58E+04	-
Am-242m	1.99E-01	1.99E+02	-
Am-243	6.95E-02	6.94E+01	-
Cm-242	1.63E-01	1.63E+02	-
Cm-243	4.07E-02	4.06E+01	-
Cm-244	9.52E+01	9.51E+04	-
Cm-245	3.18E+02	3.18E+05	-
Cm-246	1.28E-05	1.28E-02	-
Subtotal	1.98E+08	1.86E+08	8.72E+06
Total	**3.96E+08**		

Table A2 – December-2007 Waste Tanks Curie Inventory

Tank	Total Supernate Curies (Ci) *	Sludge Curies (Ci)	Insoluble salt curies (Ci)
1	6.41E+06	1.08E+06	2.51E+05
2	2.34E+06	1.47E+05	2.80E+05
3	2.38E+06	1.29E+05	2.80E+05
4	4.08E+06	6.62E+06	1.24E+04
5	4.74E+04	2.55E+06	
6	1.26E+04	1.36E+06	
7	7.99E+05	7.56E+06	
8	3.49E+05	5.91E+04	
9	2.46E+06	1.59E+05	2.79E+05
10	1.60E+05	1.66E+04	1.11E+05
11	1.44E+02	1.33E+06	
12	1.43E+06	1.60E+07	2.72E+04
13	1.85E+07	1.42E+07	
14	1.90E+06	3.62E+05	6.78E+04
15		1.39E+07	5.38E+04
16			
17		1.47E+03	
18	2.73E+02	3.76E+04	
19	4.20E+02	1.37E+05	
20			
21	3.03E+03	1.16E+05	
22	3.25E+03	2.18E+05	
23	1.31E+02	1.11E+03	
24	9.23E+05		
25	9.48E+05		5.75E+05
26	5.78E+06	4.01E+05	
27	4.33E+06		6.06E+05
28	4.80E+06		5.39E+05
29	1.18E+06		5.35E+05
30	2.52E+07	8.44E+04	1.33E+05
31	9.98E+06		6.00E+05
32	9.27E+06	2.01E+07	
33	4.36E+06	1.89E+07	1.54E+05
34	1.26E+07	1.57E+07	1.00E+05
35	6.40E+06	1.81E+07	0.00E+00
36	1.84E+07	2.01E+04	5.42E+05
37	9.42E+06		5.64E+05
38	2.93E+05		4.40E+05
39	1.24E+06	2.67E+07	
40	3.66E+04	6.91E+06	
41	4.57E+05	2.41E+04	4.61E+05
42	2.23E+07	5.87E+05	
43	3.61E+05	4.00E+06	
44	4.21E+06		5.28E+05
45	4.27E+06		5.78E+05
46	8.75E+06		5.99E+05
47	6.37E+05	3.02E+05	4.06E+05
48	1.25E+02	7.60E+05	
49	1.07E+06		1.56E+02
50	3.57E+03		
51	8.45E+04	7.26E+06	
Phase Totals	**1.98E+08**	**1.86E+08**	**8.72E+06**

Note:

(*)Total supernate curies include interstitial supernate.

(**) Insoluble curies include interstitial salt in Tank 15

Table A3 –December-2007 Waste Tank Phase Volume Inventory

Tank	Free Supernate Volume (gal)	Sludge Volume (incl. Interstitial Liquid) (gal)	Salt Volume (incl. Interstitial Liquid) (gal)
1	1.71E+04	7.05E+03	4.80E+05
2		4.07E+03	5.36E+05
3		4.07E+03	5.36E+05
4	3.18E+05	9.49E+04	2.37E+04
5	1.34E+04	1.61E+04	
6	2.96E+03	5.98E+03	
7	3.94E+05	8.47E+04	
8	2.73E+04	4.10E+03	
9	1.30E+04	2.71E+03	5.34E+05
10		2.71E+03	2.11E+05
11	2.90E+04	1.81E+04	
12	5.74E+02	1.38E+05	5.20E+04
13	5.53E+05	2.55E+05	
14		2.80E+04	1.30E+05
15*		1.50E+05	7.19E+04
16			
17		2.20E+03	
18	4.20E+03	4.30E+03	
19	5.76E+02	1.50E+04	
20		1.00E+03	
21	1.25E+06	1.10E+04	
22	9.73E+05	5.03E+04	
23	2.76E+05	1.00E+05	
24	8.41E+05	3.54E+03	
25	1.93E+04		1.10E+06
26	5.42E+05	3.11E+05	
27	7.76E+04	3.86E+03	1.16E+06
28	1.90E+05		1.03E+06
29	1.74E+05		1.02E+06
30	8.00E+05	6.32E+02	2.55E+05
31	1.17E+05		1.15E+06
32	7.51E+05	1.21E+05	
33	8.05E+05	8.01E+04	2.94E+05
34	9.04E+05	1.26E+04	1.91E+05
35	1.10E+06	6.32E+04	
36	2.14E+05	1.86E+02	1.04E+06
37	1.63E+05		1.08E+06
38	3.69E+05		8.41E+05
39	7.72E+05	1.14E+05	
40	3.06E+05	1.41E+05	
41		2.67E+03	8.82E+05
42	1.02E+06	1.76E+04	
43	8.80E+05	2.34E+05	
44	2.63E+05		1.01E+06
45	1.54E+05		1.10E+06
46	1.26E+05		1.14E+06
47	1.22E+05	2.48E+05	7.76E+05
48**	2.44E+05		
49	1.19E+06		2.99E+02
50	5.23E+05		
51	3.68E+05	3.06E+05	
Phase Totals	1.69E+07	2.66E+06	1.66E+07
Interstitial Volumes	NA	1.79E+06	4.97E+06
Total Volume***	**3.61E+07**		
F Tank Farm Total	1.43E+07 gal	5.40E+04 m^3	
H Tank Farm Total	2.19E+07 gal	8.30E+04 m^3	

Note: * Salt volume is interstitial salt from the evaporation of the interstitial supernate ** Slurry volume
*** Total volume does not include Tank 15 interstitial salt

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