

WSMS Calculation-Quality Assurance Package

Calculation Title: Vitrification Melter Waste Classification		Page 1 of 7
Calculation No: WSMS-WV-08-CAL002		
Associated Document Title: <i>Basis for Waste Incidental to Reprocessing Determination for the Vitrification Melter</i>		Associated Document Number: None
<p>Purpose: To document how calculations were performed for Table 6-1 of the subject document and to calculate the plutonium-equivalent grams in the melter.</p> <p>Contents:</p> <ul style="list-style-type: none"> 1. Purpose 2 2. Background 2 3. Information Used in the Table 6-1 Calculations 2 4. Assumptions Made in the Table 6-1 Calculations 3 5 Results of the Table 6-1 Calculations 3 5 Estimating the Plutonium Equivalent Grams in the Melter 4 6. References 4 Attachment A – Copy of Excel Spreadsheet Used in the Calculations 5 		
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1. PURPOSE

The purposes of this calculation – quality assurance package is to document how calculations were performed (1) for Table 6-1 of the Waste Incidental to Reprocessing Determination for the Vitrification Melter and (2) to determine the plutonium equivalent grams (PE-g) in the Melter. Table 6-1 is entitled Melter Waste Classification Results.

2. BACKGROUND

The *Basis for Waste Incidental to Reprocessing Determination for the Vitrification Melter* was prepared using information from a waste determination prepared for the melter in 2004 (WVNSCO 2004). Table 4 of that report provided the results of a comparison of the residual radioactivity in the melter with criteria in Tables 1 and 2 of 10 CFR 61.55.

During preparation of the new waste determination basis document, it was determined that values in the second column of Table 4 of the 2004 report for curies were actually radioactivity concentrations in the waste stream in $\mu\text{Ci/g}$. Consequently, a new calculation was performed.

In review of the draft basis document it was determined that the PE-g value for the melter should be included.

3. INFORMATION USED IN THE TABLE 6-1 CALCULATIONS

The melter weight of $4.81\text{E}+07$ g comes from report DOE/NE/441399-73 of June 1997 (Vance, et al., 1997), which uses the value approximately 48.1 Mg. This is approximately 106,000 pounds.

The melter volume is based on dimensions shown in drawings 900D-2780 Rev 1. This drawing shows the melter to be box shaped. The average height from sheet 1 is approximately 7.5 feet. The width on the electrode side is 115.38 inches (9.6 feet) from sheet 2. The width on the other side is 124.5 inches (10.4 feet) from sheet 3. The approximately volume is therefore $7.5 \times 9.6 \times 10.4 = 748.8$ cubic feet. A volume of 750 cubic feet was used in the calculation. This volume is the same as that recommended by West Valley Environmental Services (WVES 2008).

Descriptions of the melter generally give the size as approximately as 10 feet by 10 feet by 10 feet, which equates to a volume of 1000 cubic feet. Use of the smaller 750 cubic feet is more conservative than use of 1000 cubic feet because the calculations produce values in Ci/m^3 that are compared to limits in Tables 1 and 2 of 10 CFR 61.55.

The estimated activity is taken from the fifth column (10/1/2004 Activity in Curies) of Table 3 of WMG Report 4005-RE-024, Rev 3 (WMG 2004a).

The values in Table 1 and 2 of 10 CFR 61.55 were used in the calculations. These tables are reproduced in the *Basis for Waste Incidental to Reprocessing Determination for the Vitrification Melter* as Tables 4-1 and 4-2.

4. ASSUMPTIONS MADE IN THE TABLE 6-1 CALCULATIONS

The estimated weight of the residual glass (425 kg or approximately 937 pounds) was neglected in the calculations even though essentially all of the radioactivity in the melter resides in the residual glass (WMG 2004a). This assumption is conservative.

The external portions of the three melter electrodes were removed before the melter was placed in its shipping container. The weight of the removed electrodes was not subtracted from the 106,000 pounds because it is obviously a small fraction of the total melter weight. This assumption is not conservative.

The weight of the grout and the shipping container was not taken into account. It has been estimated that the grouted container bearing the melter will weigh approximately 360,000 pounds (WMG 2004b).

The estimated activity on the outside of the melter was not taken into account because it represents only 0.11% of the total estimated activity (WMG 2004a). This assumption is not conservative, but the activity on the outside of the melter is trivial compared to the estimated activity inside.

5. RESULTS OF THE TABLE 6-1 CALCULATIONS

The calculations were made using a Microsoft Excel 2007 spreadsheet, which is reproduced as Attachment A. Table 1 shows the results.

Table 1. Melter Waste Classification Results

Isotope	Estimated Activity (Ci)	Class C Limit (Ci/m ³)	Class C Limit (nCi/g)	Melter Concentration (Ci/m ³)	Melter Concentration (nCi/g)	Table 1 Fraction	Table 2 Fraction
C-14	2.12E-02	8.00E+00		1.00E-03		1.25E-04	
Ni-63	1.01E+00	7.00E+02		4.76E-02			6.81E-05
Sr-90	2.47E+02	7.00E+03		1.17E+01			1.66E-03
Tc-99	1.11E-02	3.00E+00		5.24E-04		1.75E-04	
I-129	5.64E-03	8.00E-02		2.66E-04		3.33E-03	
Cs-137	4.31E+03	4.60E+03		2.03E+02			4.42E-02
Np-237	6.20E-03		1.00E+02		1.29E-01	1.29E-03	
Pu-238	6.84E-01		1.00E+02		1.42E+01	1.42E-01	
Pu-239	1.59E-01		1.00E+02		3.31E+00	3.31E-02	
Pu-240	1.21E-01		1.00E+02		2.52E+00	2.52E-02	
Pu-241	3.12E+00		3.50E+03		6.49E+01	1.85E-02	
Am-241	3.00E+00		1.00E+02		6.24E+01	6.24E-01	
Am-243	3.50E-02		1.00E+02		7.28E-01	7.28E-03	
Cm-242	7.33E-02		2.00E+04		1.52E+00	7.62E-05	
Cm-243	1.68E-02		1.00E+02		3.49E-01	3.49E-03	
Cm-244	4.35E-01		1.00E+02		9.04E+00	9.04E-02	
Sums of fractions						9.49E-01	4.59E-02

To determine the sensitivity of the results to the melter volume used in the calculation, the calculation was repeated using 50 percent of the calculated volume (375 cubic feet) to account for the void spaces inside the melter. The results showed a Table 1 sum of fractions of 9.52E-01 and a Table 2 sum of fractions of 9.19E-02.

6. ESTIMATING THE PLUTONIUM EQUIVALENT GRAMS IN THE MELTER

The Nevada Test Site provides specific radionuclide waste acceptance criteria for LLW (DOE 2006) that are expressed primarily in terms of waste package activity limitations based on plutonium 239 equivalent grams (PE-g). This quantity relates the amount of a particular radionuclide to plutonium 239. Appendix B to the criteria document contains a table of PE-g radionuclide conversion factors. These conversion factors relate amounts of an individual radionuclide to plutonium 239.

Table 2-2 of the draft basis document provides the estimated activity in the melter for radionuclides of interest. Using these values, the PE-g value for the melter was calculated for the melter using the spreadsheet shown in Attachment A. The resulting value was 78.5 PE-g as of October 1, 2004. This value is much less than the 300 PE-g package limit identified in Table 3.1 of the Nevada Test Site Waste Acceptance Criteria (DOE 2006). Since the estimated melter PE-g value is significantly less than the allowable package limit, the potential contribution of other minor radionuclides not estimated by WMG can reasonably be ignored.

7. REFERENCES

- DOE 2006, *Nevada Test Site Waste Acceptance Criteria*, DOE/NV-325-Rev. 6-02. U.S. Department of Energy, National Nuclear Security Administration, Nevada Site Office, Waste Management Project, Las Vegas, Nevada, October 2006.
- Vance, et al., 1997 *Design of Equipment Used for High-Level Waste Vitrification at the West Valley Demonstration Project*, Topical Report DOE/NE/44139-73. Vance, R.F, B.A. Brill, D.E. Carl, H.S. Dhingra, R.A. Meigs, and M.G. Studd, West Valley Nuclear Services Company, West Valley, New York, June 1997.
- WMG 2004a, *West Valley Nuclear Services Company (WVNSCO) Melter Characterization Results*, Report 4005-RE-024, Revision 3. WMG, Inc. Peekskill, New York, May 2004.
- WMG 2004b, *WVDP Package Description Report*, Report 4005-RE-030, Revision 2. WMG, Inc. Peekskill, New York, May 2004.
- WVES 2008, E-mail from Dave Kurasch (WVES) to Jim McNeil (WSMS) dated March 7, 2008.
- WVNSCO 2004, *Waste Incidental to reprocessing (WIR) Evaluation for the Vitrification Melter*, West Valley Nuclear Services Company, West Valley, New York, 2004.

ATTACHMENTS

- A. Copy of Excel Spreadsheet

ATTACHMENT A – COPY OF EXCEL SPREADSHEET USED IN THE CALCULATIONS

These calculations were performed for the Melter WIR Determination on 3/8/08. They are part of Calculation Package WSMS-WV-08-CAL002.

Table 6-1 Calculation

Melter weight = 4.81E+07 g

Melter volume = 750 ft³ or 21.2 m³

In the table below, the activity is from the 5th column of Table 3 of WMG Report 4005-RE-024, Rev 3, 10/1/04 activity in Ci. The limits are from Tables 1 and 2 of 10 CFR 61.55.

Isotope	Activity (Ci)	Limit (Ci/m ³)	Limit (nCi/g)	Concen. (Ci/m ³)	Concen. (nCi/g)	Table 1 Fraction	Table 2 Fraction
C-14	2.12E-02	8.00E+00		1.00E-03		1.25E-04	0
Ni-63	1.01E+00	7.00E+02		4.76E-02		0	6.81E-05
Sr-90	2.47E+02	7.00E+03		1.17E+01		0	1.66E-03
Tc-99	1.11E-02	3.00E+00		5.24E-04		1.75E-04	0
I-129	5.64E-03	8.00E-02		2.66E-04		3.33E-03	0
Cs-137	4.31E+03	4.60E+03		2.03E+02		0	4.42E-02
Np-237	6.20E-03		1.00E+02		1.29E-01	1.29E-03	0
Pu-238	6.84E-01		1.00E+02		1.42E+01	1.42E-01	0
Pu-239	1.59E-01		1.00E+02		3.31E+00	3.31E-02	0
Pu-240	1.21E-01		1.00E+02		2.52E+00	2.52E-02	0
Pu-241	3.12E+00		3.50E+03		6.49E+01	1.85E-02	0
Am-241	3.00E+00		1.00E+02		6.24E+01	6.24E-01	0
Am-243	3.50E-02		1.00E+02		7.28E-01	7.28E-03	0
Cm-242	7.33E-02		2.00E+04		1.52E+00	7.62E-05	0
Cm-243	1.68E-02		1.00E+02		3.49E-01	3.49E-03	0
Cm-244	4.35E-01		1.00E+02		9.04E+00	9.04E-02	0
Sums of fractions						9.49E-01	4.59E-02

ATTACHMENT A – COPY OF EXCEL SPREADSHEET USED IN THE CALCULATIONS

As a measure of the sensitivity to the melter volume, this calculation was repeated using 50% of the 750 ft 3 value to account for the void spaces inside the melter.

Melter weight = 4.81E+07 g

Melter volume = 375 ft3 or 10.6 m3

In the table below, the activity is from the 5th column of Table 3 of WMG Report 4005-RE-024, Rev 3, 10/1/04 activity in Ci. The limits are from Tables 1 and 2 of 10 CFR 61.55.

Isotope	Activity (Ci)	Limit (Ci/m3)	Limit (nCi/g)	Concen. (Ci/m3)	Concen. (nCi/g)	Table 1 Fraction	Table 2 Fraction
C-14	2.12E-02	8.00E+00		2.00E-03		2.50E-04	0
Ni-63	1.01E+00	7.00E+02		9.53E-02		0	1.36E-04
Sr-90	2.47E+02	7.00E+03		2.33E+01		0	3.33E-03
Tc-99	1.11E-02	3.00E+00		1.05E-03		3.49E-04	0
I-129	5.64E-03	8.00E-02		5.32E-04		6.65E-03	0
Cs-137	4.31E+03	4.60E+03		4.07E+02		0	8.84E-02
Np-237	6.20E-03		1.00E+02		1.29E-01	1.29E-03	0
Pu-238	6.84E-01		1.00E+02		1.42E+01	1.42E-01	0
Pu-239	1.59E-01		1.00E+02		3.31E+00	3.31E-02	0
Pu-240	1.21E-01		1.00E+02		2.52E+00	2.52E-02	0
Pu-241	3.12E+00		3.50E+03		6.49E+01	1.85E-02	0
Am-241	3.00E+00		1.00E+02		6.24E+01	6.24E-01	0
Am-243	3.50E-02		1.00E+02		7.28E-01	7.28E-03	0
Cm-242	7.33E-02		2.00E+04		1.52E+00	7.62E-05	0
Cm-243	1.68E-02		1.00E+02		3.49E-01	3.49E-03	0
Cm-244	4.35E-01		1.00E+02		9.04E+00	9.04E-02	0
Sums of fractions						9.52E-01	9.19E-02

ATTACHMENT A – COPY OF EXCEL SPREADSHEET USED IN THE CALCULATIONS

PE-g Calculation

The conversion factors in the WAC are in PE-g/Bq. One Ci = 3.700E+10 Bq

Nuclide	Activity (Ci)	Activity (Bq)	Conversion Factor	PE-g
C-14	2.12E-02	7.84E+08	1.79E-15	1.40E-06
K-40	8.19E-02	3.03E+09	1.05E-14	3.18E-05
Mn-54	8.57E-02	3.17E+09	5.70E-15	1.81E-05
Co-60	8.33E-02	3.08E+09	1.86E-13	5.73E-04
Sr-90	2.47E+02	9.14E+12	1.11E-12	1.01E+01
Zr-95	1.65E+00	6.11E+10	2.01E-14	1.23E-03
Tc-99	1.11E-02	4.11E+08	7.08E-15	2.91E-06
Cs-137	4.31E+03	1.59E+14	2.72E-14	4.34E+00
Eu-154	1.21E+00	4.48E+10	2.43E-13	1.09E-02
Th-228	4.09E-02	1.51E+09	2.13E-10	3.22E-01
Th-230	3.65E-04	1.35E+07	2.77E-10	3.74E-03
Th-232	4.01E-04	1.48E+07	1.39E-09	2.06E-02
U-232	5.01E-04	1.85E+07	5.60E-10	1.04E-02
U-234	9.81E-03	3.63E+08	1.13E-10	4.10E-02
U-235	3.76E-04	1.39E+07	1.05E-10	1.46E-03
U-238	2.25E-03	8.33E+07	1.02E-10	8.49E-03
Np-237	6.20E-03	2.29E+08	4.60E-10	1.06E-01
Pu-238	6.84E-01	2.53E+10	3.90E-10	9.87E+00
Pu-239	1.59E-01	5.88E+09	4.35E-10	2.56E+00
Pu-241 ⁽²⁾	3.12E+00	1.15E+11	8.50E-12	9.81E-01
Am-241	3.00E+00	1.11E+11	4.44E-10	4.93E+01
Am-243	3.50E-02	1.30E+09	4.44E-10	5.75E-01
Cm-242	7.33E-02	2.71E+09	1.47E-11	3.99E-02
Cm-243	1.68E-02	6.22E+08	2.61E-10	1.62E-01
				<u>7.85E+01</u> as of 10/1/04