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SAVANNAH RIVER NATIONAL LABORATORY
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CALCULATION OF RADIATION HEAT LOADS AND DOSE RATES IN SRS TANKS 18 AND 19 RESIDUAL WASTES

Introduction and Summary

Per your request I have calculated the radiation heat loads and radiation dose rates in the residual wastes in Tanks 18 and 19. These two tanks are currently being evaluated for permanent closing by adding grout to solidify the residual radioactive slurries that are still in the tanks. Knowing the heat loads is necessary to assess if temperatures caused by the radiation will affect the grout. Knowing the dose rates is necessary to assess if the radiation itself will affect the grout. This memorandum describes how the radiation heat loads and dose rates were calculated. Results are summarized in Table 1.

Table 1. Calculated Radiation Heat Loads and Maximum Dose Rates in Tank 18 and 19 Residual Wastes

	Total Watts in Solids	Total Watts in Liquids	Maximum Dose Rate (rads/hr)
Tank 18	83	0.034	1.8×10^3
Tank 19	230	1.3	1.5×10^3

Calculation of Radiation Heat Loads in the Residual Wastes in Tanks 18 and 19

The residual wastes in Tanks 18 and 19 have been characterized and results published.[1,2] These characterizations included an estimate of radionuclide inventories in the wastes and the amounts of liquid and solids remaining in each tank. The radionuclide inventories were based on measured values for some radionuclides and estimates from the SRS Waste Characterization System[3] when measured values were not available. Since some of the inventory is based on estimates, this calculation used only two significant figures for the inventory rather than three as given in References 1 and 2.

The radiation heat loads were calculated for each tank in terms of total watts in the residual solids and liquids as well as the watts per kilogram of residual solids and residual liquids. Results are given in Tables 2 through 5. The curies of each radionuclide in the residual solids and liquids was taken from References 1 and 2. For some radionuclides the curies were not given in References 1 and 2 even though the radionuclide was included in the inventories given in References 1 and 2. These radionuclides were also entered in Tables 2-5 but listed as having no data available (NDA). The decay energies in terms of watts per curie were taken from Reference 4. The tables also present the fraction of total watts contributed by each radionuclide. The watts per kilogram of residual solids and per liter of residual liquids were calculated in order to calculate the radiation dose rates to the wastes. It was estimated that Tank 18 contains 36,062 pounds or 1.64×10^4 kilograms of residual solids.[1] The total volume of residual liquids in Tank 18 was estimated to be 6,094 gallons or 2.31×10^4 liters.[1] For Tank 19 the values were 121,480 pounds or 5.51×10^4 kilograms and 14,635 gallons or 5.50×10^4 liters, respectively.[2] For the calculations in this memorandum, three significant figures are sufficient for the weights and volumes of the residual wastes since the curies of the radionuclides are given to only two significant figures..

Table 2. Radiation Heat Loading and Wattage Distribution in Tank 18 Residual Solids

Radionuclide In Tank 18	Curies in Solids	W/Ci	Watts	Fraction of Total Watts	Watts per Kilogram Solids
C-14	1.6E-02	2.9E-04	4.5E-06	5.5E-08	2.8E-10
Co-60	4.3E+00	1.5E-02	6.7E-02	8.0E-04	4.1E-06
Ni-59	9.1E-01	4.0E-05	3.6E-05	4.4E-07	2.2E-09
Ni-63	8.0E+01	1.0E-04	8.1E-03	9.8E-05	5.0E-07
Se-79	5.0E-02	3.1E-04	1.6E-05	1.9E-07	9.6E-10
Sr-90	1.4E+03	1.2E-03	1.6E+00	2.0E-02	1.0E-04
Y-90	1.4E+03	5.5E-03	7.8E+00	9.4E-02	4.8E-04
Nb-94	4.0E-05	1.0E-02	4.1E-07	4.9E-09	2.5E-11
Tc-99	1.5E+00	5.0E-04	7.4E-04	8.9E-06	4.5E-08
Ru-106	9.7E-05	6.0E-04	5.8E-08	7.0E-10	3.5E-12
Rh-106	9.7E-05	1.9E-02	1.8E-06	2.2E-08	1.1E-10
Sn-126	1.4E-01	1.1E-03	1.5E-04	1.8E-06	9.2E-09
Sb-125	1.2E+00	3.4E-03	3.9E-03	4.7E-05	2.4E-07
Sb-126	2.0E-02	1.8E-02	3.6E-04	4.3E-06	2.2E-08
Sb-126m	1.4E-01	1.3E-02	1.8E-03	2.2E-05	1.1E-07
Te-125m	2.9E-01	8.7E-04	2.5E-04	3.0E-06	1.5E-08
I-129	6.2E-06	4.8E-04	3.0E-09	3.6E-11	1.8E-13
Cs-134	3.1E-03	1.0E-02	3.1E-05	3.7E-07	1.9E-09
Cs-135	8.7E-04	3.3E-04	2.9E-07	3.5E-09	1.8E-11
Cs-137	1.2E+04	1.0E-03	1.2E+01	1.5E-01	7.6E-04
Ba-137m	1.2E+04	3.9E-03	4.6E+01	5.5E-01	2.8E-03

Radionuclide In Tank 18	Curies in Solids	W/Ci	Watts	Fraction of Total Watts	Watts per Kilogram Solids
Ce-144	1.4E-06	6.6E-04	9.5E-10	1.1E-11	5.8E-14
Pr-144	1.4E-06	7.3E-03	1.1E-08	1.3E-10	6.5E-13
Pm-147	1.9E+01	3.7E-04	6.8E-03	8.2E-05	4.2E-07
Sm-151	4.6E+01	7.4E-04	3.4E-02	4.1E-04	2.1E-06
Eu-152	2.0E-01	7.7E-03	1.5E-03	1.8E-05	9.3E-08
Eu-154	1.1E+01	9.1E-03	9.6E-02	1.2E-03	5.9E-06
Eu-155	2.7E+00	7.6E-04	2.0E-03	2.4E-05	1.2E-07
Ra-226	4.9E-07	2.8E-02	1.4E-08	1.7E-10	8.5E-13
Ra-228	NDA	6.9E-05	0.0E+00	0.0E+00	0.0E+00
Ac-227	1.6E-06	4.7E-04	7.8E-10	9.3E-12	4.8E-14
Th-229	2.3E-03	2.9E-02	6.6E-05	7.9E-07	4.0E-09
Th-230	6.0E-05	2.8E-02	1.7E-06	2.0E-08	1.0E-10
Th-232	NDA	2.4E-02	-	-	-
Pa-231	4.6E-06	3.0E-02	1.4E-07	1.6E-09	8.3E-12
U-232	2.2E-04	3.2E-02	6.8E-06	8.2E-08	4.2E-10
U-233	8.0E-01	2.9E-02	2.3E-02	2.7E-04	1.4E-06
U-234	2.2E-01	2.8E-02	6.2E-03	7.4E-05	3.8E-07
U-235	7.2E-03	2.7E-02	2.0E-04	2.3E-06	1.2E-08
U-236	7.4E-03	2.7E-02	2.0E-04	2.4E-06	1.2E-08
U-238	1.8E-01	2.5E-02	4.6E-03	5.5E-05	2.8E-07
Np-237	8.4E-02	2.9E-02	2.4E-03	2.9E-05	1.5E-07
Pu-238	7.0E+01	3.3E-02	2.3E+00	2.7E-02	1.4E-04
Pu-239	1.3E+02	3.0E-02	4.0E+00	4.8E-02	2.4E-04
Pu-240	3.0E+01	3.1E-02	9.1E-01	1.1E-02	5.6E-05
Pu-241	2.5E+02	3.2E-05	8.1E-03	9.7E-05	4.9E-07
Pu-242	7.4E-02	2.9E-02	2.1E-03	2.6E-05	1.3E-07
Pu-244	3.4E-04	2.7E-02	9.2E-06	1.1E-07	5.6E-10
Am-241	7.2E+01	3.3E-02	2.4E+00	2.9E-02	1.5E-04
Am-242m	NDA	4.1E-04	-	-	-
Am-243	6.2E-06	3.2E-02	1.9E-07	2.3E-09	1.2E-11
Cm-242	3.2E-20	3.6E-02	1.1E-21	1.4E-23	7.0E-26
Cm-243	9.5E-05	3.6E-02	3.4E-06	4.1E-08	2.1E-10
Cm-244	1.7E+02	3.4E-02	5.8E+00	7.0E-02	3.6E-04
Cm-245	2.2E-09	3.3E-02	7.2E-11	8.7E-13	4.4E-15
Cm-247	2.2E-18	3.1E-02	6.8E-20	8.1E-22	4.1E-24
Cm-248	5.0E-19	2.8E-02	1.4E-20	1.7E-22	8.5E-25
Bk-249	1.9E-28	1.96EE-04	-	-	-
Cf-249	1.4E-20	3.4E-02	-	-	-
Total			**8.3E+01**		**5.1E-03**

In the Tank 18 solids note that 8 radionuclides contribute greater than 98% of the wattage. These are ^{90}Sr, ^{90}Y, ^{137}Cs, ^{137m}Ba, ^{238}Pu, ^{239}Pu, ^{241}Am, and ^{244}Cm. Of these, only ^{239}Pu and ^{241}Am have half lives grater than 100 years. The other 6 contribute 91% of the energy to the residual waste solids in Tank 18. The radionuclides ^{90}Sr and ^{137}Cs (and their radioactive daughters ^{90}Y and ^{137m}Ba) along with ^{244}Cm contribute 88% of the heat loading to the solids. These radionuclides have half lives less than 31 years.

Results for the heat loading calculation for the residual liquids in Tank18 are given in Table 3. Data for fewer radionuclides was listed Reference 1 because the liquids are caustic. Many of the radionuclides are insoluble in caustic and thus are only in the solids.

Table 3. Radiation Heat Loading and Wattage Distribution in Tank 18 Residual Liquids

Radionuclide In Tank 18	Curies in Liquid	W/Ci	Watts	Fraction of Total Watts	Watts per Liter Liquid
H-3	6.2E-02	3.4E-05	2.1E-06	6.2E-05	9.0E-11
C-14	4.1E-02	2.9E-04	1.2E-05	3.5E-04	5.2E-10
Co-60	2.4E-02	1.5E-02	3.7E-04	1.1E-02	1.6E-08
Ni-59	NDA	4.0E-05	-	-	-
Ni-63	5.8E-02	1.0E-04	5.8E-06	1.7E-04	2.5E-10
Se-79	NDA	3.1E-04	-	-	-
Sr-90	2.9E-02	1.2E-03	3.3E-05	9.9E-04	1.4E-09
Y-90	2.9E-02	5.5E-03	1.6E-04	4.7E-03	6.9E-09
Nb-94	4.0E-08	1.0E-02	4.1E-10	1.2E-08	1.8E-14
Tc-99	9.4E-03	5.0E-04	4.7E-06	1.4E-04	2.0E-10
Ru-106	NDA	6.0E-04	-	-	-
Rh-106	NDA	1.9E-02	-	-	-
Sn-126	NDA	1.1E-03	-	-	-
Sb-125	NDA	3.4E-03	-	-	-
Sb-126	NDA	1.8E-02			
Sb-126m	NDA	1.3E-02	-	-	-
Te-125m	NDA	8.7E-04			
I-129	2.1E-07	4.8E-04	9.9E-11	3.0E-09	4.3E-15
Cs-134	NDA	1.0E-02	-	-	-
Cs-135	NDA	3.3E-04	-	-	-
Cs-137	1.3E+00	1.0E-03	1.3E-03	4.0E-02	5.8E-08
Ba-137m	1.3E+00	3.9E-03	4.9E-03	1.5E-01	2.1E-07
Ce-144	NDA	6.6E-04	-	-	-
Pr-144	NDA	7.3E-03	-	-	-
Pm-147	NDA	3.7E-04	-	-	-
Sm-151	NDA	7.4E-04	-	-	-
Eu-152	NDA	7.7E-03	-	-	-
Eu-154	NDA	9.1E-03	-	-	-
Eu-155	NDA	7.6E-04	-	-	-
Ra-226	NDA	2.8E-02	-	-	-
Ra-228	NDA	6.9E-05	-	-	-
Ac-227	NDA	4.7E-04	-	-	-
Th-229	NDA	2.9E-02	-	-	-
Th-230	NDA	2.8E-02	-	-	-
Th-232	NDA	2.4E-02	-	-	-
Pa-231	NDA	3.0E-02	-	-	-
U-232	4.0E-07	3.2E-02	1.3E-08	3.8E-07	5.5E-13
U-233	1.4E-02	2.9E-02	4.1E-04	1.2E-02	1.8E-08

Radionuclide In Tank 18	Curies in Liquid	W/Ci	Watts	Fraction of Total Watts	Watts per Liter Liquid
U-234	9.3E-03	2.8E-02	2.6E-04	7.9E-03	1.1E-08
U-235	8.3E-06	2.7E-02	2.2E-07	6.7E-06	9.8E-12
U-236	9.6E-05	2.7E-02	2.6E-06	7.6E-05	1.1E-10
U-238	2.1E-04	2.5E-02	5.2E-06	1.6E-04	2.3E-10
Np-237	1.1E-03	2.9E-02	3.0E-05	9.0E-04	1.3E-09
Pu-238	3.8E-03	3.3E-02	1.2E-04	3.7E-03	5.4E-09
Pu-239	9.3E-02	3.0E-02	2.8E-03	8.3E-02	1.2E-07
Pu-240	3.4E-01	3.1E-02	1.0E-02	3.1E-01	4.5E-07
Pu-241	1.7E-02	3.2E-05	5.3E-07	1.6E-05	2.3E-11
Pu-242	5.7E-03	2.9E-02	1.6E-04	4.9E-03	7.1E-09
Pu-244	NDA	2.7E-02	-	-	-
Am-241	1.2E-02	3.3E-02	3.8E-04	1.1E-02	1.6E-08
Am-242m	8.0E-01	4.1E-04	3.3E-04	9.7E-03	1.4E-08
Am-243	NDA	3.2E-02	-	-	-
Cm-242	NDA	3.6E-02	-	-	-
Cm-243	NDA	3.6E-02	-	-	-
Cm-244	3.4E-01	3.4E-02	1.2E-02	3.5E-01	5.1E-07
Cm-245	4.0E-12	3.3E-02	1.3E-13	3.9E-12	5.7E-18
Cm-247	NDA	3.1E-02	-	-	-
Cm-248	NDA	2.8E-02	-	-	-
Bk-249	NDA	2.0E-04	-	-	-
Cf-249	NDA				
Total	**-**	**-**	**3.4E-02**		**1.5E-06**

In the liquids note that 50% of the heat load comes from decay of ^{137}Cs, ^{137m}Ba and ^{244}Cm which have half lives less than 31 years.

Results for the heat loading calculation for the residual solids in Tank19 are given in Table 4.

Table 4. Radiation Heat Loading and Wattage Distribution in Tank 19 Residual Solids

Radionuclide In Tank 19	Curies in Solids	W/Ci	Watts	Fraction of Total Watts	Watts per Kilogram Solids
C-14	1.4E-02	2.9E-04	4.1E-06	1.8E-08	7.4E-11
Co-60	7.2E+00	1.5E-02	1.1E-01	4.8E-04	2.0E-06
Ni-59	8.3E-01	4.0E-05	3.3E-05	1.4E-07	6.0E-10
Ni-63	7.6E+01	1.0E-04	7.7E-03	3.3E-05	1.4E-07
Se-79	5.6E-02	3.1E-04	1.7E-05	7.4E-08	3.2E-10
Sr-90	4.0E+01	1.2E-03	4.6E-02	2.0E-04	8.4E-07
Y-90	4.0E+01	5.5E-03	2.2E-01	9.5E-04	4.0E-06
Nb-94	3.6E-05	1.0E-02	3.7E-07	1.6E-09	6.7E-12
Tc-99	6.4E+00	5.0E-04	3.2E-03	1.4E-05	5.8E-08

Radionuclide In Tank 19	Curies in Solids	W/Ci	Watts	Fraction of Total Watts	Watts per Kilogram Solids
Ru-106	2.7E-04	6.0E-04	1.6E-07	6.9E-10	2.9E-12
Rh-106	2.7E-04	1.9E-02	5.1E-06	2.2E-08	9.3E-11
Sn-126	1.3E-01	1.1E-03	1.4E-04	5.9E-07	2.5E-09
Sb-125	2.6E+00	3.4E-03	8.7E-03	3.7E-05	1.6E-07
Sb-126	1.8E-02	1.8E-02	3.3E-04	1.4E-06	5.9E-09
Sb-126m	1.3E-01	1.3E-02	1.6E-03	7.0E-06	3.0E-08
Te-125m	6.3E-01	8.7E-04	5.5E-04	2.3E-06	1.0E-08
I-129	5.6E-06	4.8E-04	2.7E-09	1.1E-11	4.9E-14
Cs-134	7.5E-03	1.0E-02	7.6E-05	3.3E-07	1.4E-09
Cs-135	7.9E-04	3.3E-04	2.6E-07	1.1E-09	4.8E-12
Cs-137	4.9E+04	1.0E-03	4.9E+01	2.1E-01	8.9E-04
Ba-137m	4.6E+04	3.9E-03	1.8E+02	7.8E-01	3.3E-03
Ce-144	3.7E-06	6.6E-04	2.4E-09	1.0E-11	4.4E-14
Pr-144	3.7E-06	7.3E-03	2.7E-08	1.2E-10	4.9E-13
Pm-147	4.2E+01	3.7E-04	1.5E-02	6.5E-05	2.8E-07
Sm-151	1.3E+00	7.4E-04	9.6E-04	4.1E-06	1.7E-08
Eu-152	5.6E-03	7.7E-03	4.3E-05	1.8E-07	7.8E-10
Eu-154	1.5E+01	9.1E-03	1.3E-01	5.7E-04	2.4E-06
Eu-155	7.6E-02	7.6E-04	5.7E-05	2.5E-07	1.0E-09
Ra-226	1.1E-07	2.8E-02	3.0E-09	1.3E-11	5.5E-14
Ra-228	NDA	6.9E-05	-	-	-
Ac-227	2.9E-07	4.7E-04	1.4E-10	5.8E-13	2.5E-15
Th-229	2.6E-03	2.9E-02	7.6E-05	3.2E-07	1.4E-09
Th-230	1.3E-05	2.8E-02	3.6E-07	1.5E-09	6.5E-12
Th-232	NDA	2.4E-02	-	-	-
Pa-231	7.9E-07	3.0E-02	2.3E-08	1.0E-10	4.3E-13
U-232	2.1E-04	3.2E-02	6.6E-06	2.8E-08	1.2E-10
U-233	9.2E-01	2.9E-02	2.6E-02	1.1E-04	4.8E-07
U-234	4.7E-02	2.8E-02	1.3E-03	5.7E-06	2.4E-08
U-235	1.3E-03	2.7E-02	3.4E-05	1.4E-07	6.1E-10
U-236	2.8E-03	2.7E-02	7.5E-05	3.2E-07	1.4E-09
U-238	4.2E-02	2.5E-02	1.1E-03	4.5E-06	1.9E-08
Np-237	1.1E-02	2.9E-02	3.0E-04	1.3E-06	5.5E-09
Pu-238	2.3E+01	3.3E-02	7.4E-01	3.2E-03	1.3E-05
Pu-239	3.0E+01	3.0E-02	9.1E-01	3.9E-03	1.7E-05
Pu-240	1.1E+01	3.1E-02	3.2E-01	1.4E-03	5.9E-06
Pu-241	5.4E+01	3.2E-05	1.7E-03	7.4E-06	3.1E-08
Pu-242	3.6E-01	2.9E-02	1.1E-02	4.5E-05	1.9E-07
Pu-244	1.7E-03	2.7E-02	4.5E-05	1.9E-07	8.2E-10
Am-241	1.2E+01	3.3E-02	3.8E-01	1.6E-03	6.9E-06
Am-242m	NDA	4.1E-04	-	-	-
Am-243	1.8E-07	3.2E-02	5.5E-09	2.4E-11	1.0E-13
Cm-242	9.1E-22	3.6E-02	3.3E-23	1.4E-25	5.9E-28
Cm-243	2.7E-06	3.6E-02	9.7E-08	4.2E-10	1.8E-12
Cm-244	3.0E-03	3.4E-02	1.0E-04	4.5E-07	1.9E-09
Cm-245	2.0E-09	3.3E-02	6.5E-11	2.8E-13	1.2E-15

Radionuclide In Tank 19	Curies in Solids	W/Ci	Watts	Fraction of Total Watts	Watts per Kilogram Solids
Cm-247	6.2E-20	3.1E-02	1.9E-21	8.2E-24	3.5E-26
Cm-248	1.4E-20	2.8E-02	3.9E-22	1.7E-24	7.1E-27
Bk-249	5.4E-30	2.0E-04			
Cf-249	4.0E-22	3.4E-02	1.4E-23	5.8E-26	2.5E-28
Total Watts	-	-	**2.3E+02**		**4.2E-03**

In the Tank 19 residual solids, 99% of the heat load is due to ^{137}Cs and its daughter ^{137m}Ba. Both these radionuclides have half lives less than 31 years.
Results for the heat loading calculation for the residual liquids in Tank 19 are given in Table 5. Data for fewer radionuclides was listed in Reference 2 because the liquids are caustic. Many of the radionuclides are insoluble in caustic and thus are essentially only in the solids.

Table 5. Radiation Heat Loading and Wattage Distribution in Tank 19 Residual Liquids

Radionuclide In Tank 19	Curies in Liquid	W/Ci	Watts	Fraction of Total Watts	Watts per Liter Liquid
H-3	3.8E-01	3.4E-05	1.3E-05	9.5E-06	2.3E-10
C-14	9.8E-02	2.9E-04	2.9E-05	2.1E-05	5.2E-10
Co-60	5.7E-02	1.5E-02	8.8E-04	6.6E-04	1.6E-08
Ni-59	NDA	4.0E-05		-	-
Ni-63	1.4E-01	1.0E-04	1.4E-05	1.0E-05	2.5E-10
Se-79	1.3E-03	3.1E-04		-	-
Sr-90	6.9E-02	1.2E-03	8.0E-05	6.0E-05	1.4E-09
Y-90	6.9E-02	5.5E-03	3.8E-04		
Nb-94	3.6E-08	1.0E-02	3.7E-10		
Tc-99	4.0E-01	5.0E-04	2.0E-04		
Ru-106	NDA	6.0E-04	-	-	-
Rh-106	NDA	1.9E-02	-	-	-
Sn-126	NDA	1.1E-03	-	-	-
Sb-125	NDA	3.4E-03	-	-	-
Sb-126	NDA	1.8E-02			
Sb-126m	NDA	1.3E-02	-	-	-
Te-125m	NDA	8.7E-04		-	-
I-129	4.4E-05	4.8E-04	2.1E-08	1.6E-08	3.8E-13
Cs-134	NDA	1.0E-02		-	-
Cs-135	NDA	3.3E-04		-	-
Cs-137	2.8E+02	1.0E-03	2.8E-01	2.1E-01	5.1E-06
Ba-137m	2.7E+02	3.9E-03	1.0E+00	7.8E-01	1.9E-05
Ce-144	NDA	6.6E-04	-	-	-
Pr-144	NDA	7.3E-03	-	-	-
Pm-147	NDA	3.7E-04	-	-	-
Sm-151	NDA	7.4E-04	-	-	-

Radionuclide In Tank 19	Curies in Liquid	W/Ci	Watts	Fraction of Total Watts	Watts per Liter Liquid
Eu-152	NDA	7.7E-03	-	-	-
Eu-154	NDA	9.1E-03	-	-	-
Eu-155	NDA	7.6E-04	-	-	-
Ra-226	NDA	2.8E-02	-	-	-
Ra-228	NDA	6.9E-05	-	-	-
Ac-227	NDA	4.7E-04	-	-	-
Th-229	NDA	2.9E-02	-	-	-
Th-230	NDA	2.8E-02	-	-	-
Th-232	NDA	2.4E-02	-	-	-
Pa-231	NDA	3.0E-02	-	-	-
U-232	8.0E-07	3.2E-02	2.5E-08	1.9E-08	4.5E-13
U-233	2.6E-03	2.9E-02	7.4E-05	5.5E-05	1.3E-09
U-234	1.7E-03	2.8E-02	4.7E-05	3.5E-05	8.5E-10
U-235	4.3E-06	2.7E-02	1.2E-07	8.8E-08	2.1E-12
U-236	1.7E-05	2.7E-02	4.6E-07	3.4E-07	8.3E-12
U-238	1.2E-04	2.5E-02	3.0E-06	2.3E-06	5.4E-11
Np-237	1.9E-04	2.9E-02	5.4E-06	4.1E-06	9.8E-11
Pu-238	5.3E-02	3.3E-02	1.7E-03	1.3E-03	3.1E-08
Pu-239	2.4E-02	3.0E-02	7.2E-04	5.4E-04	1.3E-08
Pu-240	6.1E-02	3.1E-02	1.9E-03	1.4E-03	3.4E-08
Pu-241	7.3E-02	3.2E-05	2.3E-06	1.8E-06	4.2E-11
Pu-242	1.0E-03	2.9E-02	3.0E-05	2.2E-05	5.3E-10
Pu-244	NDA	2.7E-02	-	-	-
Am-241	8.5E-03	3.3E-02	2.8E-04	2.1E-04	5.1E-09
Am-242m	1.9E+00	4.1E-04	7.8E-04	5.9E-04	1.4E-08
Am-243	NDA	3.2E-02	-	-	-
Cm-242	NDA	3.6E-02	-	-	-
Cm-243	NDA	3.6E-02	-	-	-
Cm-244	1.2E-05	3.4E-02	4.0E-07	3.0E-07	7.1E-12
Cm-245	7.5E-12	3.3E-02	2.5E-13	1.9E-13	4.5E-18
Cm-247	NDA	3.1E-02	-	-	-
Cm-248	NDA	2.8E-02	-	-	-
Bk-249	NDA	2.0E-04	-	-	-
Cf-249	NDA	3.4E-02	-	-	-
Total			**1.3E+00**		**2.4E-05**

As with the solids in Tank 19, 99% of the heat load comes from decay of ^{137}Cs and ^{137m}Ba which have half lives less than 31 years.

Calculation of Radiation Dose Rates in the Residual Wastes Tanks 18 and 19

As shown in column 6 of Tables 2 and 3, Tank 18 contains 5.1 x 10^{-3} watts per kilogram of solids and 1.5 x 10^{-6} watts per liter of liquid. As shown in Tables 4 and 5 the values for Tank 19 are 4.2 x 10^{-3} watts per kilogram of solids and 2.4 x 10^{-5} watts per liter of liquid. The measured densities of the liquids were 1.02 kg/L for Tank 18[1] and 1.19 kg/L for Tank 19[2], consequently the heat loading per unit mass for the liquids is <99% of the heat loading per unit mass for the solids.

To calculate the maximum dose rate to the grout it was assumed that the residual wastes in each tank could be solidified without the addition of cement or water to the wastes. This dose rate is conservatively high because the cement and water would dilute the dose rate in terms of watts per kilograms. These heat loads per unit mass can be converted to rads per hour with the conversion factor of 1 watt/kilogram = 3.60×10^5 rads per hour[5]. When this is done the dose rate in Tank 18 is 1.8×10^3 rads/h and 1.5×10^3 rads/h in Tank 19. These dose rates would decrease significantly with time. For example, as shown in Table 2, 88% of the initial dose rate in Tank 18 is due to $^{90}Sr/^{90}Y$, $^{137}Cs/^{137m}Ba$ and ^{244}Cm. Each of these has a half life less than 31 years.[4] As shown in Table 4, 99% of the initial dose rate is due to $^{137}Cs/^{137m}Ba$.

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