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CRWMS/M&O

# Calculation Cover Sheet

*Complete only applicable items.*

1. QA: L

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| 2. Calculation Title<br>Definition of the Radionuclide Inventory for the DOE Spent Nuclear Fuel used in the TSPA-VA Base Case. | |
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| 7. Originator | Anthony J. Smith | | 20 October 98 |
| 8. Checker | Robert L. Howard | | October 13, 1998 |
| 9. Lead Design Engineer | Jerry A. NcNeish | | 10/13/98 |

10. Remarks

This calculation contains TBV-463

ADDED ACCESSION NUMBER TO DISK IN SECTION 7 23Dec98 23-Dec'98

**Revision History**

| 11. Revision No. | 12. Date Approved | 13. Description of Revision |
|---|---|---|
| 00 | 10-13-98 | Initial Issue |

## Table of Contents:



## 1.0 Purpose

The purpose of this document is to present the details of the calculations used to define the radionuclide inventory for the Department of Energy (DOE) spent nuclear fuel (SNF) used in the TSPA-VA calculations.

## 2.0 Method

The method used in the calculation is that of simple averaging over those categories of DOE spent nuclear fuels that have been demonstrated, by previous analyses (Figures 4.3-5 and 4.3-6 on page 4-38 of M&O 1997b), to be the major contributors to dose. The complete inventory in each of the DOE spent nuclear fuels categories is given in the formal DOE transmission of this information (INEEL 1998). The combined activity inventory for each radionuclide and the total mass (in units of metric tons of uranium (MTU)) in the selected waste categories was calculated. From these numbers the inventory per unit mass of each radionuclide was calculated. The inventory destined for disposal in the repository in the base case was then determined by multiplying the inventory per unit mass by the total mass allocation for DOE SNF (one third of the total 7,000 MTU regulatory limit for noncommercial radioactive waste as per Table ES-1 of M&O 1997a). The average radionuclide inventory per waste package for a DOE SNF was

calculated by dividing the total inventory allocated to the repository by the total number of wastes packages destined to contain DOE SNF.

The following is an outline of the method:

(1) The DOE SNF categories and anticipated inventory as defined in INEEL 1998, were obtain from an electronic transmission of the data in an Excel file.

(2) The total mass of the nominated categories (1, 4, 5, 6, 8, & 11 as defined in M&O 1997b) was calculated. To assist in this simple calculation, the columns were rearranged so that the categories of interest were contiguous at the left hand side of the data.

(3) The total radionuclide activities for each radionuclides in the nominated categories (1, 4, 5, 6, 8, & 11) were calculated.

(4) A list of the required 39 radionuclides nominated for consideration in TSPA-VA was copied onto a new work sheet from TSPA-95 (M&O 1995).

(5) The "VLOOKUP" function of Excel spreadsheet program was used to copy the appropriate total inventory values for the categories considered into a column adjacent to the radionuclide symbol.

(6) The total mass (MTU) of the waste categories being considered was copied to the space above the radionuclide list.

(7) The total mass allowed for the DOE SNF was entered into the spreadsheet. This value came from table 2-5 of (M&O 1997a) (one third of the 7,000 MTU allocated to non-commercial SNF was to be used for DOE SNF).

(8) The number of waste packages allocated to the DOE SNF (2546) was entered onto the spreadsheet. This number was obtained from M&O 1997a

(9) The inventory per waste package for each radionuclide was calculated from the total inventory as arrived at in step (5), by successive application of the following steps. (a) dividing by the total mass of DOE SNF from step (6), (b) multiplying by the defined maximum mass of the DOE SNF in step (7) and (c) dividing by the total number of waste packages allocated to DOE SNF as given in step (8).

(10) A hard and electronic copy of the final inventory data was produced from this effort.

## 3.0 Assumptions

### *3.1. Averaging over Waste Categories and Waste Packages*

Because of mass and volume characteristics, it is know that the details of the disposal of DOE SNF will be category dependent. Some (such as N-reactor fuel in category 1) will be disposed alone in a waste package. Some other categories where the waste is in smaller individual quantities will be disposed in waste packages with other DOE SNF categories and radioactive High Level Wastes. To avoid generating more detail in the waste stream definition than can be handled by the TSPA code, the averaging approach described in Section 2 above was assumed to be valid and does not need to be verified.

# 4.0 Use of Computer Software

### *4.1. Commercial Software*

The Microsoft Excel 97 spreadsheet program was used to perform data look up and the averaging calculations reported. The values of the parameters used in the spreadsheet are documented in section 5.2.

# 5.0 Calculation Inputs

### *5.1. DOE SNF Inventory by Category*

The details of the inventory as supplied by INEEL (INEEL 1998) are shown in Table 1 for the categories of waste used. The data used is unqualified (TBV-463).

**Table 1 Inventory Data as supplied by INEEL**

| DOE TSPA Category | 1 | 4 | 5 | 6 | 8 | 11 |
|---|---|---|---|---|---|---|
| | MTHM | MTHM | MTHM | MTHM | MTHM | MTHM |
| Hanford | 2103.5898 | 18.28473 | 0.15736 | 0 | 0 | 10.225651 |
| INEEL | 1.68153 | 80.395664 | 83.638451 | 0 | 24.667361 | 2.0942616 |
| SRS | 16.992107 | 0 | 3.2248996 | 8.7402845 | 0 | 0 |
| Total | 2122.2634 | 98.680394 | 87.02071 | 8.7402845 | 24.667361 | 12.319913 |
| | packages | packages | Packages | packages | packages | packages |
| Hanford | 101 | 19 | 1 | 0 | 0 | 324 |
| INEEL | 6 | 195 | 406 | 0 | 503 | 43 |
| SRS | 0 | 0 | 279 | 706 | 0 | 0 |
| Total | 107 | 214 | 686 | 706 | 503 | 367 |
| | total curies | total curies | total curies | total curies | total curies | total curies |
| AC227 | 1.01E-02 | 3.88E-02 | 1.13E-02 | 2.57E-04 | 0.00E+00 | 5.51E-07 |
| AM241 | 5.16E+05 | 3.55E+05 | 6.08E+03 | 2.48E+03 | 1.87E+03 | 1.58E+05 |
| AM242M | 2.99E+01 | 5.97E+02 | 1.18E+01 | 1.70E+00 | 5.06E-01 | 2.74E+02 |
| AM243 | 1.27E+02 | 1.90E+03 | 1.86E+01 | 1.84E+00 | 1.33E+01 | 6.61E+01 |
| C14 | 6.63E+02 | 2.34E+01 | 8.98E-01 | 7.45E-04 | 1.08E+02 | 3.64E-01 |
| CL36 | 0.00E+00 | 7.91E-02 | 1.41E-02 | 0.00E+00 | 1.36E+00 | 3.84E-03 |
| CM244 | 3.84E+03 | 8.03E+04 | 7.73E+02 | 1.57E+01 | 4.19E+02 | 2.78E+03 |
| CM245 | 1.63E+00 | 3.27E+01 | 3.14E-01 | 1.33E-03 | 7.01E-02 | 1.14E+00 |
| CM246 | 2.41E-01 | 5.55E+00 | 5.32E-02 | 6.43E-05 | 3.48E-02 | 1.93E-01 |
| CO60 | 6.23E+01 | 4.03E+03 | 1.34E-09 | 8.97E-09 | 0.00E+00 | 5.03E+02 |
| CS134 | 1.21E+02 | 2.20E+01 | 6.90E+00 | 1.30E+02 | 3.80E+00 | 2.75E+00 |
| CS135 | 8.00E+01 | 4.04E+01 | 1.81E+01 | 2.11E+01 | 8.68E+00 | 1.17E+00 |
| CS137 | 8.97E+06 | 6.60E+06 | 2.99E+06 | 2.88E+06 | 1.21E+06 | 1.47E+06 |
| H3 | 1.03E+04 | 8.32E+03 | 1.05E+03 | 4.43E+02 | 9.97E+02 | 1.04E+03 |
| I129 | 7.35E+00 | 4.06E+00 | 6.25E-01 | 1.37E+00 | 1.04E+00 | 1.32E-01 |
| KR85 | 1.64E+05 | 7.03E+04 | 2.28E+04 | 9.56E+04 | 3.03E+04 | 8.77E+03 |
| NB93M | 3.64E+02 | 1.54E+02 | 9.18E+00 | 1.16E+01 | 4.64E+00 | 4.63E+00 |
| NB94 | 2.57E-03 | 1.68E+00 | 3.49E-02 | 2.32E-03 | 6.66E-02 | 6.98E-03 |
| NI59 | 3.72E+01 | 2.15E+01 | 1.94E-01 | 0.00E+00 | 8.66E+00 | 7.51E-01 |
| NI63 | 3.51E+03 | 6.77E+04 | 2.11E+01 | 1.71E-19 | 2.08E+02 | 3.18E+03 |

| | | | | | | |
|---|---|---|---|---|---|---|
| NP237 | 7.75E+01 | 4.09E+01 | 2.54E+00 | 8.74E+00 | 8.16E+00 | 2.37E+00 |
| PA231 | 2.62E-02 | 6.81E-02 | 2.12E-02 | 3.12E-03 | 9.35E+00 | 4.56E-05 |
| PB210 | 1.46E-07 | 2.05E-05 | 4.36E-06 | 1.56E-08 | 2.30E-03 | 1.14E-07 |
| PD107 | 1.50E+01 | 1.10E+01 | 6.87E-01 | 6.94E-01 | 4.37E-01 | 3.75E-01 |
| PU238 | 1.13E+05 | 2.63E+05 | 4.79E+03 | 1.29E+04 | 4.07E+04 | 2.90E+04 |
| PU239 | 2.33E+05 | 3.52E+04 | 1.04E+04 | 1.79E+03 | 1.13E+02 | 1.17E+05 |
| PU240 | 1.38E+05 | 5.46E+04 | 3.67E+03 | 9.31E+02 | 1.90E+02 | 1.02E+05 |
| PU241 | 1.74E+06 | 3.20E+06 | 2.43E+05 | 4.70E+04 | 0.00E+00 | 9.49E+05 |
| PU242 | 7.28E+01 | 2.09E+02 | 2.52E+00 | 7.38E-01 | 0.00E+00 | 7.27E+00 |
| RA226 | 2.10E-03 | 5.96E-05 | 1.65E-05 | 2.85E-07 | 2.44E-03 | 1.95E-06 |
| RA228 | 1.70E-07 | 3.07E-02 | 9.21E-03 | 5.48E-10 | 3.28E+00 | 7.39E-09 |
| RU106 | 1.40E-02 | 9.00E-05 | 1.03E-03 | 9.50E-03 | 1.58E-06 | 1.12E-05 |
| SE79 | 1.17E+02 | 4.35E+01 | 1.34E+01 | 3.72E+01 | 1.48E+01 | 1.34E+00 |
| SM151 | 1.48E+05 | 1.20E+05 | 2.05E+04 | 3.12E+04 | 2.26E+04 | 8.87E+04 |
| SN126 | 1.58E+02 | 5.49E+01 | 9.69E+00 | 1.24E+01 | 6.96E+00 | 1.75E+00 |
| SR90 | 7.16E+06 | 4.86E+06 | 2.69E+06 | 2.77E+06 | 1.13E+06 | 5.73E+05 |
| TC99 | 3.50E+03 | 1.50E+03 | 3.46E+02 | 7.72E+02 | 3.72E+02 | 4.65E+01 |
| TH229 | 1.77E-05 | 9.14E-02 | 2.65E-02 | 1.64E-06 | 1.39E+01 | 6.20E-07 |
| TH230 | 1.98E-03 | 8.46E-03 | 2.43E-03 | 1.35E-04 | 9.55E-01 | 4.26E-04 |
| TH232 | 2.32E-07 | 3.24E-02 | 9.71E-03 | 1.41E-08 | 2.54E+00 | 2.00E-08 |
| U232 | 4.49E-02 | 0.00E+00 | 1.83E-02 | 1.29E-01 | 1.14E+03 | 0.00E+00 |
| U233 | 1.12E-02 | 3.54E+01 | 1.01E+01 | 1.98E-03 | 3.45E+03 | 3.40E-04 |
| U234 | 8.89E+02 | 3.80E+01 | 8.79E+00 | 1.63E+00 | 2.81E+02 | 2.92E+00 |
| U235 | 3.81E+01 | 3.88E+00 | 1.00E+01 | 1.35E+01 | 1.09E+00 | 7.88E-02 |
| U236 | 1.49E+02 | 3.14E+01 | 9.66E+00 | 2.75E+01 | 1.07E+01 | 1.51E+00 |
| U238 | 7.04E+02 | 2.96E+01 | 2.81E+01 | 6.67E-01 | 2.69E-02 | 9.96E-01 |
| ZR93 | 4.58E+02 | 2.09E+02 | 4.18E+01 | 7.59E+01 | 5.40E+02 | 6.22E+00 |

### *5.2. Repository Constraints on DOE SNF*

The parameters imposed at the repository on the DOE SNF are given in Table 2.

**Table 2 Other Parameters used in Calculation**

| | |
|---|---|
| DOE SNF mass allocation (MTU) | 2333.333 |
| Number of Waste Packages for DOE SNF | 2,546 |

## 6.0 Results

The results of the simple averaging calculation in the Excel spreadsheet (M&O 1998) are shown in Table 3.

**Table 3. Average Radionuclide Content of the Waste Package containing DOE SNF as used in RIP for TSPA-VA**

| Nuclide | Ci/WP | Nuclide | Ci/WP | Nuclide | Ci/WP |
|---|---|---|---|---|---|
| Ac227 | 2.35E-05 | Ni59 | 2.66E-02 | Se79 | 8.85E-02 |
| Am241 | 4.04E+02 | Ni63 | 2.91E+01 | Sm151 | 1.68E+02 |
| Am242m | 3.56E-01 | Np237 | 5.46E-02 | Sn126 | 9.48E-02 |
| Am243 | 8.28E-01 | Pa231 | 3.69E-03 | Tc99 | 2.55E+00 |
| C14 | 3.10E-01 | Pb210 | 9.05E-07 | Th229 | 5.47E-03 |
| Cl36 | 5.67E-04 | Pd107 | 1.10E-02 | Th230 | 3.77E-04 |
| Cm244 | 3.43E+01 | Pu238 | 1.81E+02 | Th232 | 1.01E-03 |
| Cm245 | 1.40E-02 | Pu239 | 1.55E+02 | U233 | 1.36E+00 |
| Cm246 | 2.36E-03 | Pu240 | 1.16E+02 | U234 | 4.76E-01 |
| Cs135 | 6.60E-02 | Pu241 | 2.40E+03 | U235 | 2.59E-02 |
| I129 | 5.67E-03 | Pu242 | 1.14E-01 | U236 | 8.93E-02 |
| Nb93m | 2.13E-01 | Ra226 | 1.80E-06 | U238 | 2.97E-01 |
| Nb94 | 6.98E-04 | Ra228 | 1.29E-03 | Zr93 | 5.18E-01 |

## 7.0 References

INEEL 1998. Letter from E. P. Stroupe, Manager National Spent Nuclear Fuel Program to Dr. Robert W. Andrews, titled *Transmittal of Revised Information to Support the TSPA-VA Analyses – ESP-23-98*, May 4, 1998. (MOL.19980616.0308)

M&O 1995. *Total System Performance Assessment – 1995 An Evaluation of the Potential Yucca Mountain Repository.* B00000000-01717-2200-00136, Rev. 01. November 1995. (MOL. 19960724.0188)

M&O 1997a. *Waste Quantity, Mix, and Throughput Study Report.* B00000000-01717- 5705-00059 REV 01. CRWMW M&O August 15, 1997. (MOL. 19971210.0628)

M&O 1997b. *Total System Performance Assessment of U.S. Department of Energy Spent Nuclear Fuel.* A00000000-01717-5705-00017, Rev. 01. September 30, 1997 (MOL.19980618.0474)

M&O 1998. Electronic File for: Definition of the Radionuclide Inventory for DOE Spent Nuclear Fuel used in the TSPA-VA Base Case. B00000000-01717-0210-00020 REV 00.

Microsoft Excel 97 file "DOE SNF TSPA-VA Base Case.xls" Size 329 kB
Date 5/21/98. Time 11:46 am. MOL. 19981221.0223 23DEC98

## 8.0 Attachments

There are no attachments to this document