AUSTRALIAN NUCLEAR SCIENCE AND TECHNOLOGY ORGANISATION

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COMPARISON OF MAIN CHARACTERISTICS BETWEEN PROPOSED WASTE FROM AREVA AND HIFAR SPENT FUEL

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1 ABSTRACT

1. Historic spent fuel from the operation of HIFAR was sent to COGEMA in four shipments during 1999, 2001, 2003 and 2004.
2. This spent fuel is to be reprocessed and the vitrified waste returned to Australia in the form of Intermediate Level Waste (ILW) for long term storage within Australia.
3. The proposed return waste is not the original HIFAR spent fuel but rather waste from the reprocessing of UMo-MoSnAl fuels. A total of 20 canisters of vitrified waste (i.e. CSD-U) are to be returned in a TN 81Transport/Storage Container. *(Note: maximum capacity of the TN 81container is 28 vitrified waste canisters).*
4. The activity and inventory of the most relevant nuclides of the proposed waste are compared to that of the HIFAR spent fuel. The results of that comparison are presented in this note.

2 INVOLVED AREAS

1. Spent fuel.
2. Waste equivalence.

3 METHOD

1. Calculations were performed using the original data [1]-[4] sent as part of the COGEMA spent fuel shipments. The data contains information for each individual fuel assembly specifying the initial uranium masses, accumulated burnup, time in reactor, date removed from reactor and various nuclide (mainly uranium and transuranics) masses post irradiation.
2. This data was used to estimate the fission yield for each fuel assembly and then the inventory for the main fission products expected in the waste Cs137, Sr90 and Y90. These fission products not only have a high yield but also a relatively long half-life to be present at appreciable levels in the waste.
3. The masses of the various uranium, plutonium and americium nuclides was also estimated extrapolating from the original post irradiation masses accounting for decay up to the processing time (taken as 18/11/13).
4. The alpha activity was calculated using the masses of the various plutonium and americium isotopes. All other alpha emitters have either too short a half-life (and have decayed) or too long (low activity) to make an appreciable contribution.
5. An estimate of the heat was calculated based on the beta and alpha activities and the associated decay energies of Cs137, Sr90, Y90 and the plutonium and americium isotopes. It was assumed that all the energy associated with gamma radiation was deposited in the CSD-U.
6. The data for the proposed waste was obtained from the Declaration of Conformity [5] for each CSD-U as provided by AREVA. The methods and techniques adopted to sample, measure and deduce the composition and other characteristics of the waste is outlined in [6].
7. The quantity of waste to be returned is calculated based on the equivalence of neodymium mass in the HIFAR waste and that in the processed waste. Neodymium is

a high yield stable fission product isotope that remains as part of the processed waste form. It is therefore, an ideal normalisation factor for the total fission product inventory.

8. The mass of neodymium expected in the HIFAR spent fuel was estimated based on the fuel burnup and fission yield of the isotopes Nd143, Nd144, Nd145, Nd146, Nd148 and Nd150.

4 RESULTS

1. The activities and masses of the relevant nuclides are presented in Table 1 for both the HIFAR spent fuel projected to 18/11/13 and the total from the Declaration of Conformity for each CSD-U.
2. Although the data for each CSD-U provides activities for other beta emitters these make up less than 1% of the total and so were ignored in this comparison.
3. Detailed comparison of the isotopic composition of uranium and plutonium was also neglected as the initial enrichment levels of the two sources of spent fuel are expected to be significantly different (HIFAR fuel highly enriched and processed waste likely low or natural) and this will result in discrepancies for specific isotopes. In this case it is more instructive to compare total masses for the given elements.
4. A comparison is also provided for the total heat in the waste. The value for the CSD-U is obtained using the average value in [7] from a sample of 34 CSD-U and multiplying by 20 (number of canisters).

Characteristic	HIFAR spent fuel	Declaration of Conformity Data from AREVA
Cs137 [TBq]	5340	1275
(Sr90+Y90) [TBq]	10100	8559
Am241 [g]	23.1	340.6
Total alpha [TBq]	51.14	49.82
Total Uranium [kg]	198.2	18.36
Total Plutonium [g]	1111.9	391.8
Heat [W]	2101	950†
Nd [g]	10825	11070

Table 1. Comparison of HIFAR spent fuel and proposed waste characteristic data.
† deduced using data from [7].

5. It is clear the activity of Cs137 in the proposed waste is significantly less than that expected in the HIFAR spent fuel. This must be a consequence of the reprocessing chemistry. The fission yield of Cs137 is similar to that of Sr90 and the half-lives are also similar so the expected activities are very similar. This is not evident in the activities of the waste (Cs137 activity should be approximately half that for (Sr90+Y90)).
6. The activity in the waste for (Sr90+Y90) is slightly less than that estimated for HIFAR spent fuel. This is expected as the waste has slightly longer decay time than the HIFAR fuel by approximately 10 years on average. This means the activity of (Sr90+Y90) will

be lower by a factor of about 0.79 yielding an activity of 7940 TBq, in close agreement to the waste data and within the uncertainty for this parameter.

7. The mass of Am241 is significantly different due mostly likely to differences in the initial uranium enrichment between the HIFAR and processed fuels. This leads to different rates of transuranic production relative to fuel burnup.
8. The total alpha activity is similar but this is coincidental as the relative nuclide components are completely different.
9. The total uranium and plutonium masses in the waste are significantly lower than in the HFAR spent fuel due to the chemical process and preparation of the solution prior to vitrification. At any rate the equivalence methodology implemented is only relevant in terms of mass of fission products not uranium and plutonium masses.
10. The total heat in the proposed waste is less than in the estimated HIFAR waste as the Cs137 and (Sr90+Y90) activities are lower and these are the main sources of heat.
11. The mass of neodymium estimated for the HIFAR spent fuel is slightly less than the total measured mass of neodymium in the proposed waste but this difference is well within the uncertainty of the calculated HIFAR value and measured waste value. The agreement is therefore very good and gives confidence that the fission product mass in the proposed waste is a good match for the HIFAR spent fuel.

5 CONCLUSIONS

1. The main inventory of the proposed return waste and the HIFAR spent fuel were compared.
2. The activity of the main beta decay nuclides (and hence the total beta activity and total heat) is less in the proposed return waste than in the HIFAR spent fuel. The total alpha activity is also less in the proposed return waste than in the HIFAR spent fuel.
3. The total mass of uranium and plutonium in the proposed return waste is much less than in the HIFAR spent fuel.
4. The neodymium mass in the proposed waste is in good agreement with that expected in the HIFAR spent fuel and hence also the total fission product mass.

6 REFERENCES

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4. SHIPMENT 2004 FUEL INFORMATION, COG11 (2004).
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