Post Closure Safety Assessment for Electrolytic Reduction Process Waste

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1. Introduction

KAERI has developed the KIEP-21 (Korean, Innovative, Environmentally Friendly, and Proliferation Resistant System for the 21st Century). It is an advanced nuclear fuel cycle option with a pyro-process and a GEN-IV SFR. A pyro-process consists of two distinctive processes, an electrolytic reduction process and an electro-refining and winning process. When the electrolytic reduction process is applied, it generates two streams of products, metals and solidified fission products. The electro-refining and winning process with these products produces five different waste streams. To compare pyro-process advantage over the direct disposal of Spent Nuclear Fuel (SNF), the PWR SNF of the 45,000 MWD burn-up has been assumed. A safety assessment model for electrolytic reduction process wastes and representative results are presented in this paper.

2. Models and Numerical Illustrations

KAERI has developed a safety assessment program for the disposal of waste streams from the electrolytic reduction process in pyro-process by utilizing Goldsim [1]. This new program is a user friendly program and very flexible for a complex repository system. Figure 2 shows the EBS part in this program.

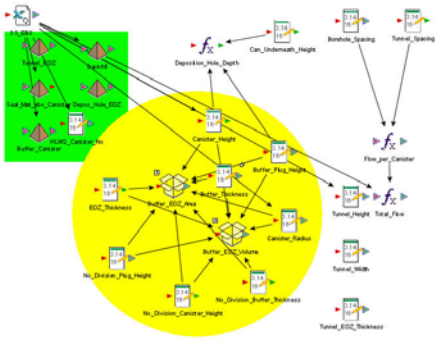

Figure 1. EBS modeling scheme

The mass balance assuming 4.5 wt% U-235, 45,000 MWD/MTU, 5 years cooling through the entire pyro-process has been estimated [2]. Figure 2 and 3 illustrate the annual individual doses when the dissolution rate of a solid waste is 10^{-4} 1/yr and 10^{-6} 1/yr, respectively. Figure 4 shows the estimation of annual individual doses for direct disposal of PWR SNF as a reference case.

As shown in these Figures, results show that the environmental impact of the electrolytic reduction process depends on the dissolution rate of waste form. If the dissolution rate is high, e.g. 10^{-4} 1/yr, the environmental impact is even higher than the direct disposal of SNF. The dissolution rate becomes small then the effects of the fission products decrease. However, the annual doses from TRU waste do not change until the dissolution rate of a waste form is similar to that of uranium dioxide of SNF.

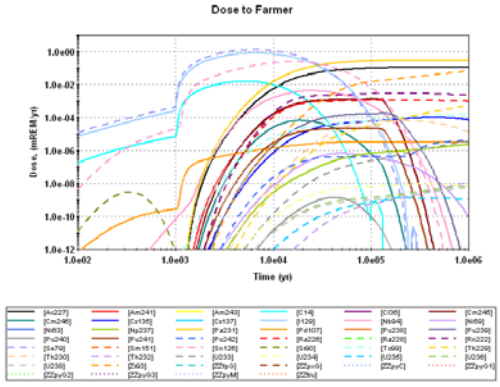

Figure 2. Estimation of Annual Individual Doses for Direct Disposal of PWR SNF

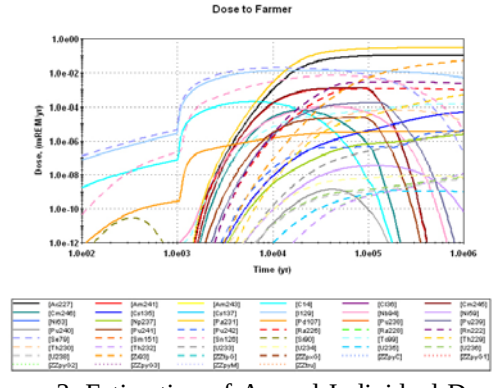

Figure 3. Estimation of Annual Individual Doses for Direct Disposal of PWR SNF

Figure 5 shows total annual individual doses as a function of the dissolution rate of a waste form. If the dissolution rate of a waste form is smaller than that of uranium dioxide of SNF, the annual individual dose from the electrolytic process decreases significantly. However, if the dissolution rate is relatively high, there is no real advantage of the electrolytic reduction in terms of disposal.

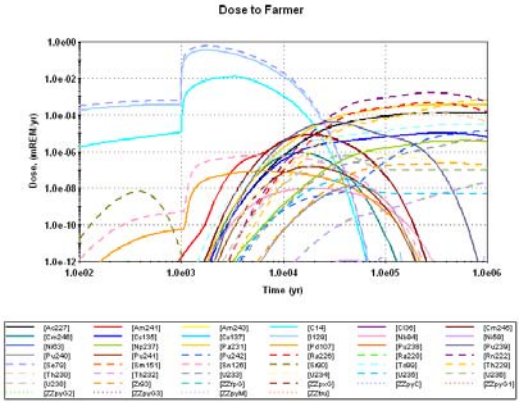

Figure 4. Estimation of Annual Individual Doses for Direct Disposal of PWR SNF

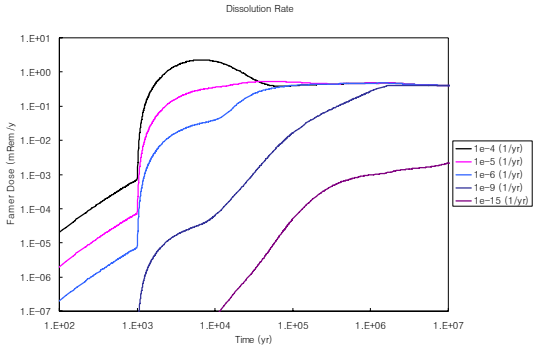

Figure 5. Estimation of Annual Individual Doses for Direct Disposal of PWR SNF

3. Conclusions

A safety assessment model for electrolytic reduction process wastes and representative results are presented. If the dissolution rate of a waste form is relatively high, there is no real advantage of the electrolytic reduction in terms of disposal. However, if the dissolution rate of a waste form is smaller the annual individual dose from the electrolytic process decreases. This suggests the importance of developing a waste form of low dissolution rate in a waste disposal project.

REFERENCES

[1] Goldsim, Goldsim Contaminant Transport Module, User's Guide, Goldsim Technology Group, 2006.
[2] Personal Communication, the 19th Material Balance, KAERI, 2008.

Acknowledgement

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