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Probabilistic Safety Assessment of Waste from PyroGreen Processes

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1. Introduction

PyroGreen processes is decontamination technology using pyro-chemical process developed by Seoul National University in collaboration with KAERI, Chungnam University, Korea Hydro-Nuclear Power and Yonsei University [1]. The main object of PyroGreen processes is decontaminating SNFs into intermediate level waste meeting U.S. WIPP contact-handled (CH) waste characteristics to achieve long-term radiological safety of waste disposal.

In this paper, radiological impact of PyroGreen waste disposal is probabilistically assessed using domestic input parameters for safety assessment of disposal. Advanced Korean Reference Disposal System (A-KRS) design for vitrified waste is applied to develop safety assessment model using GoldSim software.

2. PyroGreen Process

PyroGreen processes is fundamentally based on pyro-chemical processes developed by KAERI. Three additional processes, however, are added for recycling Zr-alloy (Zr Hull electrorefining), transmuting of Tc and I, and increasing decontamination factor (DF) of TRU (PyroRedSox) [1]. By adding these processes PyroGreen aims to get rid of all high level waste from pyro-chemical processes. Table 1 shows the target DF of radionuclides of overall PyroGreen processes.

Table 1: Target decontamination factor of radio nuclides of overall PyroGreen processes

Target Nuclides	Target DF
Cs, Sr	300
I, Tc	50
U	20,000
TRU	20,000

3. Waste Inventory

The final waste from PyroGreen processes is vitrified using glass named PG-14 developed by KHNP [2]. Acceptable waste loading for PG-14 is 20 wt%, but to meet the WIPP CH waste characteristics only 2.5 wt% of waste is loaded. We assumed 25,000 MTU of PWR fuels with 45 GWD/MTU and 100-year cooling time are recycled. Applying DFs in table 1, waste inventory in table 2 is used for safety assessment of disposal.

Table 2. Inventory of PyroGreen vitrified intermediate waste

Nuclides	Inventory (g/canister)	Nuclides	Inventory (g/canister)
Ac_227	0.00E+00	Pu_241	2.87E-04
Am_241	2.82E-03	Pu-242	1.26E-03
Am_243	2.63E-04	Ra_226	0.00E+00
C_14	1.07E-01	Ra_228	0.00E+00
Cl_36	1.15E-01	Rn_222	0.00E+00
Cm_245	3.78E-06	Se_79	9.87E-01
Cm_246	4.68E-07	Sm_151	8.09E-01
Cs_135	1.08E-01	Sn_126	2.74E+00
Cs_137	1.21E-01	Sr_90	8.17E-02
I_129	3.56E-01	Tc_99	2.00E+00
Nb_94	9.76E-05	Th_229	0.00E+00
Ni_59	2.80E-02	Th_230	1.30E-03
Ni_63	3.50E-03	Th_232	3.68E-04
Np_237	1.55E-03	U_233	2.69E-08
Pa_231	3.55E-05	U_234	5.13E-04
Pd_107	0.00E+00	U_235	2.09E-02
Pu_238	3.34E-04	U_236	1.20E-02
Pu_239	1.17E-02	U_238	1.89E+00
Pu_240	5.08E-03	Zr_93	1.04E+02
PG14	1.28E+04		

4. Model

4.1. Conceptual Model

Nuclides transportation from waste to human biosphere is divided into five compartments model which constitute the transport pathway (figure 1). Engineering barrier system (waste, package, buffer/backfill) design is based on A-KRS for vitrified waste [3]. For conservative we assume that the waste matrix dissolve in groundwater with constant dissolution rate after package failure time. Because the buffer/backfill material is expected to assure very low hydraulic conductivity, only diffusion mechanism is considered in buffer/backfill compartment. For rock compartment, granite system with discrete fracture network and main water conducting feature (MWCF) is modeled. For biosphere compartment model, JAEA's report H-12 model is adopted.

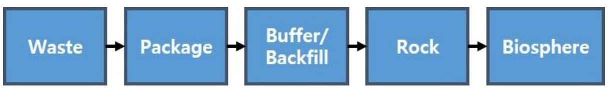

Figure 1. Nuclides trasport pathway

4.2. Computational Model

GoldSim software is used to build computational model [4]. GoldSim provides solution for contaminant transport problem and has been used to assess long-term radiological impact of nuclear waste repository by various institutes. It is specialized code to simulate in Monte Carlo simulation so that we can easily analyze the uncertainty and risk of the assessment result.

4.3. Input Parameters

Domestic data for radioactive waste disposal are used in this study [5]. Among various parameters, solubility, distribution coefficients data are inputted as stochastic value because their significance impact on safety assessment result. Parameter used in human biosphere modeling (farmer group) are referred from H-12 report [6]. For the other input parameters, deterministic values are used in this study.

5. Result

Probabilistic simulation is conducted using 100 realizations times with Latin Hypercube Sampling. Figure 2 shows the total radiological dose to farmer group. The maximum mean exposure dose rate to farmer is calculated to be about 7.8E-4 mSv/yr at 36,000 years after repository closure.

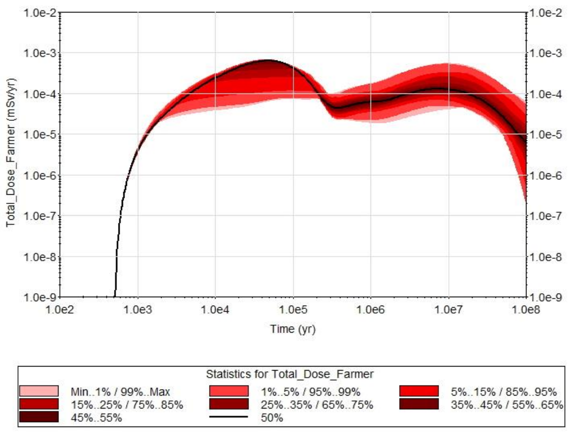

Figure 2. Radiological impact to farmer group

6. Discussion and Conclusion

The simulation result shows that PyroGreen vitrified waste is expected to satisfy the regulatory dose limit criteria, 0.1 mSv/yr. With small probability, however, radiological impact to public can be higher than the expected value after 2E5-year. Although the result implies 100 times safety margin even in that case, further study will be needed to assess the sensitivity of other input parameters which can affect the radiological impact for long-term.

Acknowledgements

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REFERENCES

[1] Il Soon Hwang et. al., A study on the process verification for conversion of spent nuclear fuel into intermediate level waste based on PyroGreen, 2011-0031839, Ministry of Science, ICT and Future Planning, 2013.
[2] Cheon-Wee Kim et. al., Feasibility study on vitrification for rare earth wastes of PyroGreen process, J. Korean Radioact. Waste Soc. Vol.11 No.1 p.1-9, March 2013.
[3] Jihae Yoon et. al., A system assessment for the Korean advanced nuclear fuel cycle concept from the perspective of radiological impact, Nuclear Engineering and Technology, Vol. 42 No.1 p. 17-36, Feburary 2010
[4] GoldSim User's Guide Version 11.1, GoldSim Technology Group, 2014
[5] Chung-Kyun Park et. al., Production and application of domestic input data for safety assessment of disposal, J. Korean Radioact. Waste Soc. Vol.10(3) p161-170, September 2012.
[6] JNC, H12: project to establish the scientific and technical basis for HLW disposal in Japan, JNC TN1410 2000-001, April 2000.