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Preliminary Risk Assessments for Spent Nuclear Fuel (SNF) Transportation From Kori-site To The Hypothetical SNF Storage Facility

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1. INTRODUCTION

Since 1990s, in order to secure the storage capacity of spent nuclear fuel (SNF) in the NPP, SNF assemblies has been on-site transported from one unit to nearby another unit at Kori-site.

In the foreseeable future, as the amount of the spent fuel generated at Kori unit approach its capability, some of them will have to transport to the other spent fuel storage facility. Therefore, due to the transportation of many SNFs, the additional risk will be encountered. So, in order to evaluate the transport risk, RADTRAN5.5 computer code was used in this work. [1]

The RADTRAN5.5 code models the radiological consequences of the transportation of radioactive materials, both the exposures that will occur if the transport performs without incident, and the exposures that may occur if the transport vehicle should be involved in an accident while en route. Because accidents might occur at any point along a transportation route, RADTRAN divides the route into segments (links) and uses a uniform population density and constant meteorological conditions (wind speed and atmospheric stability, etc) to represent the population and weather characteristics of each route segment. [2]

This paper describes and validates a way to use RADTRAN to model a route segment that has an unpopulated coastal region, and then illustratively applies the method to the transport of SNF from Kori-site to the hypothetical spent fuel storage facility.

2. DATA PREPARATION

So far, our country didn't accomplish the off-site SNF transportation. Therefore, some of the site-specific data are acquired from the authorized person for SNF transportation and the others are acquired from relevant authorities for required input data or derived from arithmetic calculation based on some conservative assumption.

2.1 Source Terms

The calculations assumed that the spent fuels with maximum initial enrichment of 5.0wt.%, maximum average burn-up of 50000MWD/MTU and minimum cooling time of 7 years are loaded and subsequently transported. Table1 presents the radioactive inventory calculated by the ORIGEN-ARP code.

Radionuclide	Inventory (Ci)	Radionuclide	Inventory (Ci)	Radionuclide	Inventory (Ci)
Co58	9.71E-01	Ru103	4.31E-02	Ce141	8.21E-04
Co60	9.22E01	Ru106	1.62E04	Ce144	1.22E04
Kr85	6.11E03	Te127	9.25E01	Pu238	2.97E03
Sr89	1.77E00	Te127M	9.45E01	Pu239	4.10E02
Sr90	5.97E04	Te129M	4.36E-05	Pu240	4.67E02
Y91	1.78E01	Cs134	2.73E04	Pu241	1.27E05
Zr95	8.14E01	Cs137	8.76E04	Am241	1.29E03
Nb95	1.80E02	Ba140	1.25E-19	Cm244	1.79E03

Table1. Details of Source Terms

2.2 Package Release data

Radionuclides are released from the inside of breached fuel rods and from the detachment of radioactive material from the outside surfaces of fuel rods and other components of fuel assemblies.

The elements in this inventory were assigned to five chemical element classes. Eighteen of the elements were assigned to the Particulate chemical element class. Because during a severe transportation accident they would each be released as constituents of fuel fines. Other element, Co, would also be released as a constituent of particles. However, because these particles would be formed by spallation of the chemical deposits that form on the surface of fuel rods during reactor operation, they are assigned to a separate chemical element class, termed CRUD (Sandoval et al. 1991). One element in the inventory, Kr, will always transport as a gas and therefore is assigned to the Noble Gases chemical element class. Finally, two elements in the inventory, Cs and Ru, may be released from spent fuel as vapors during fire accident scenarios that heat the fuel to temperatures above 800 C. [3]

Release fractions were estimated for two severe accident scenarios, a ship collision that leads to small failure of the cask seal but not to a fire, and an extremely severe collision that initiates a fire and also causes a double failure of the cask. [4]

Chemical Element Class	Scenario	
	Collision-Only	Collision-plus-Fire
Noble Gases	0.16	0.2
CRUD	3E-03	0.3
Volatile	2E-08	1.6E-03
Ruthenium	2E-08	1.6E-06
Particulates	2E-08	2E-06

Table2. Release Fractions

2.3 Vehicle and Link

Because the vehicle information is insufficient, the specific data of vehicle were referred to the Rokuei Maru from Japanese Nuclear Fuel Transport Co., LTD.

The transporting vehicle is a specially prepared ship, which carries 20 packages per shipment. The dose rate at 1 [m] from package surface was measured as 4.2 [mrem/h]. Overall vehicle length is approximately 100 [m] and breath is about 16.5 [m]. Dead weight of ship is about 3,000 tons and the crew size is about 20 people. This ship specially designed to transport SNF, and the Rokuei Maru is equipped with robust lashings that prevent the movement or rollover of transport packages even if the vessel is rocked by an external force. [5] In future, if our country conduct the off-site SNF transportation by maritime, these kind of ship will be used.

The transporting route is assumed as a straight line and located in a rural area. The length of the route was estimated as 9.5km, 43.8km, and 53.37km respectively. The average speed of the ship was derived as 22.2 km/h.

To capture the effect of the each route, three RADTRAN calculations were performed; one 0 to 9.5 km calculation, and one 0 to 43.8 km calculation, one 0 to 53.37km calculation and their results were difference, thereby obtaining the results from 9.5 to 43.8km and from 43.8 to 53.37km. By subtracting the 0-to-9.5km results from the 0-to-43.8 km results, the 9.5-to-43.8km results were obtained.

3. RESULT OF THE RISK ASSESSMENT

Modeling of a coastal region that is devoid of population by three RADTRAN calculations was illustrated by estimating the consequences of SNF transportation.

Radiological effects due to the off-site transportation of SNF are expected to be very small because of the relatively low population and traffic density area. All radiological impacts are calculated in terms of dose and associated health effects in the exposed populations.

The health effect end point typically is used radiation-induced latent cancer fatalities (LCFs), which are estimated by multiplying the dose [person-rem] by health risk conversion factors.

	Crew	Link	Totals	LCFs
0 to 9.5 km	5.94E-06	1.80E-04	1.86E-04	9.30E-08
0 to 43.8 km	2.74E-05	8.28E-04	8.56E-04	4.28E-07
0 to 53.37 km	3.34E-05	1.01E-03	1.04E-03	5.20E-07
9.5 to 43.8 km	2.15E-05	6.48E-04	6.70E-04	3.35E-07
43.8 to 53.37 km	6.0E-06	1.82E-04	1.84E-04	9.20E-08

Table3. In-Transit Population Exposure (ITPE) [Rem] and Latent Cancer Fatalities (LCFs)

4. CONCLUSION.

The risk associated with the transportation of highly radioactive SNF from NPP to an interim storage facility or to a permanent repository is important to both the relevant authorities and the public because the number of spent fuel shipment is expected to increase significantly if these facilities begin operating.

In this paper, differencing three RADTRAN calculations is an appropriate way to model a transportation route segment with an unpopulated coastal region.

The results of the risk assessments demonstrate that the radiation dose from Kori-site to the hypothetical spent fuel facility is much lower than the dose limits required by regulatory standards. (The dose limits for general public, handler, and vehicle crew are 0.1 [rem/yr], 5 [rem/yr], and 1.2 [rem/yr], respectively). The scope of this paper is the risk assessment for off-site SNF transport. More detail approach will be performed based on the methodology presented in this paper within near future.

REFERENCE

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