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Preliminary Risk Assessments for On-site Spent Nuclear Fuel(SNF) Transportation in Wolsong NPPs

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1. INTRODUCTION

In South-Korea, on-site transportation of SNF started in 1980s at Kori site. As the amount of the spent fuel generated at Wolsong unit approached its capability, some of them have been transported to the adjacent dry storage site. As a result, due to the transportation of SNF, the additional risk was encountered. In order to evaluate the risk, RADTRAN 5.5 computer code was used in this work. RADTRAN 5.5 is a computer code system for the assessment of radiological consequences and risks for the transport of radioactive material including SNF. It allows to study incident-free and accident conditions of transport separately. It can be applicable to all modes of transport [1].

In this work, assessments have been made for road transportation of short distance between Wolsong unit 3 and dry storage site. Many of specific data to Wolsong-site were used for the risk assessment. But, in case there is no site-specific data, some conservative input data were assumed for preliminary risk assessments [2]. The work consisted of a preparation of input data and the calculation of the risk due to SNF transportation in Wolsong-site.

2. DATA PREPARATION

In this work, many of site-specific data were used for the risk assessments. Some of the site-specific data are acquired from the authorized person for SNF on-site transportation and the others are acquired from relevant authorities for required input data or derived from arithmetic calculation based on some conservative assumption [3]. However in case where there is no site-specific data available, some conservative default data provided by RADTRAN 5.5 were also used.

2.1 Package

The long dimension for package was estimated as 5.4 [m]. Radiation dose rate at 1m from surface of the package was measured as 12 [mrem/h].

2.2 Radionuclides

This package contains various radionuclides and the source terms were acquired by report relevant to CANDU Spent Fuel[4]. The important radionuclides for the risk assessment were selected as shown in Table 1.

C14	Kr85	Co60	Sr90	Ru106	Cs134	Cs137
1.11E-04	2.97E+01	1.76E-01	9.32E-10	3.32E-13	3.76E01	4.27E02
Pu238	Pu239	Pu240	Pu 241	Am241	Am243	Cm244
1.69E+00	3.19E+00	4.43E00	3.30E02	3.81E00	9.97E-03	2.69E-01

Table 1. Details of Radionuclides

2.3 Vehicle

The transporting vehicle is a specially prepared truck, which carries four packages per shipment. The dose rate at 1 [m] from package surface was measured as 4.2 [mrem/h]. Vehicle size is 14m and the crew size was 2 people. The average number of shipment per year is assumed as 40.

2.4 Link

The transporting route is assumed as a straight line and located in a rural area. The characteristics of the route are summarized in Table 2. The length of the route was estimated as 1500[m]. The average speed of the vehicle was derived as 18 [km/h].

link	Population Density [persons /Km²]	Vehicle Density [#/Km]	Persons/ Vehicle	Accident Rate [#/Km]	Zone
Wolsong-site	196	25	2	0.1×10^{-6}	Rural

Table 2. Characteristics of Route

The link model of RADTRAN 5.5 was prepared for this route. Only one link was used for the assessment, because the transporting route was very short. There is no site-specific accident data for Wolsong-site transportation. The accident rate for the link is assumed to be 0.1×10^{-6}[accidents/vehicle-Km], which is based on the typical accident rates on road and rail [5]. Consequently the value of 0.1×10^{-6} [accidents /Km] is conservatively used for the accident analysis.

2.5 Stop and Handling

The value of Min distance and Max distance are 30 [m] and 800 [m] respectively. And the number of handlers is 8 people and the average distance from the radioactive cargo to the handler group is assumed as 10[m].

2.6 Accident and Parameters

The default values are used for the dispersibility of radioactive materials, the isotope P, aerosol fraction, release, and deposition velocity, which are provided by RADTRAN 5.5. User-defined values were used for the isopleth area so that the wind speed of Wolsong-site is distributed between 2.5[m/s] and 4.0[m/s] on yearly average. The risk assessments were performed with respect to relevant Pasquill categories to the wind speeds such as C, D and E categories.

3. RESULT OF THE RISK ASSESSMENT

Radiological effects due to the on-site transportation of SNF are expected to be very small because of the relatively short distance of the shipment and low population and traffic density area. All radiological impacts are calculated in terms of dose and associated health effects in the exposed populations. The radiation dose calculated is the total effective dose equivalent (TEDE), as specified in 10 CFR Part 20 ("Standards for Protection against Radiation"), which is the sum of the effective dose equivalent (EDE) from exposure to external radiation and the 50-year committed effective dose equivalent (CEDE) from exposure to internal radiation [6]. Doses of radiation are typically calculated in units of rem for individuals and in units of person-rem for collective populations. In this study, In-Transit Population Exposures (ITPE) for the transporting link are evaluated as summarized in Table 3

	Crew	Off Link	On Link	Totals
Wolsong-site	8.64×10^{-4}	1.71×10^{-3}	6.52×10^{-4}	3.23×10^{-3}

Table 3. In-Transit Population Exposure (ITPE) in Person-Rem

Also Maximum Individual In-Transit Off-link Dose (MIITOD) to a member of the public was evaluated as 1.93×10^{-5} [rem/yr].

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 [7]. These factors relate the radiation dose to the potential number of expected LCFs based on comprehensive studies of people historically exposed to large doses of radiation, such as the Japanese atomic bomb survivors. In this study, the Latent Cancer Fatalities (LCFs) with respect to MIITOD, Dose to Member Of Public (DMOP), Dose To Crew (DTC), and Expected Values of Population Risk (EVPR) are evaluated with 0.0005 [LCF/person-rem] and summarized in Table 4. EVPR was derived from groundshine, inhalation, resuspension and cloudshine according to each wind speed.

	MIITOD	DMOP	DTC	EVPR (2.5m/s)	EVPR (3m/s)	EVPR (4m/s)
LCFs	9.65×10^{-9}	1.18×10^{-6}	4.32×10^{-7}	2.40×10^{-11}	2.55×10^{-11}	2.43×10^{-11}

Table 4. The Latent Cancer Fatalities (LCFs) in each population exposure

4. CONCLUSION.

The results of the risk assessments demonstrate that the radiation dose due to Wolsong-site SNF transportation is much lower than the dose limits required by regulatory standards, even though some conservative input data were used. (The dose limits for general public, handler, and vehicle crew are 0.1 [rem/yr], 5 [rem/yr], and 1.2 [rem/yr], respectively). Therefore if the conservative input data are replaced with the site-specific input data, which may be evaluated as lower than the conservative input data, the lower risk from Wolsong-site transportation of SNF is expected to be evaluated.

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