Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 18-19, 2017

Feasibility Study of Spent Fuel Transportation Risk Assessment using INTERTRAN2 Code

Minchul Kim, Kyoon-ho Cha
KHNP CRI, Spent Fuel Technology Team, 70, 1312-gil, 34101
Corresponding author: kim.minchul@khnp.co.kr

1. Introduction

Spent fuels for PWRs have been routinely transported and stored to the neighboring NPPs and to the dry storage facilities for PHWRs. Because spent fuel transportation may involve potential radiological risks such as dose risk and health effects for the public and the workers, both on-site and off-site spent fuel transportation need to be radiologically safety analyzed.

Studies of SNF transportation risk assessment to Yucca Mountain have conducted by mainly Sandia National Laboratories using RADTRAN code since 1970s. RADTRAN code is no longer service and distributable due to their internal QA problems.

As a preliminary study for SNF transportation risk assessment, this study benchmark some of the technical reports [1,2,3] to briefly verify and validate INTERTRAN2 code as a substitute of RADTRAN code.

2. Methods and Results

In this section some of the benchmark procedures to conduct INTERTRAN2 code V&V are described.

2.1 RADTRAN4 and INTERTRAN2

RADTRAN code is capable of leading incident-free consequences, accident dose risk and health effects risk through 9 main modules as shown in figure 1. INTERTRAN code performs probabilistic safety techniques related to the safe transport of radioactive material as RADTRAN code leads. INTERTRAN2 code was chosen in this study as a transport risk assessment program because it is still available.

2.2 Benchmark of RADTRAN4

An example, sets of input and it's result, from a RADTRAN4 user's guide was chosen to compare consequence of INTERTRAN with the same input of RADTRAN4 [2]. Under the transportation condition and activities for package as shown in Table 1 and Table 2, INTERTRAN2's expected collective dose for an exclusive transport cask for 610 km transport distance is compared with RADTRAN4. Incident free collective dose for the public and workers is described in table 3 and figure 2 according to exposure pathway.

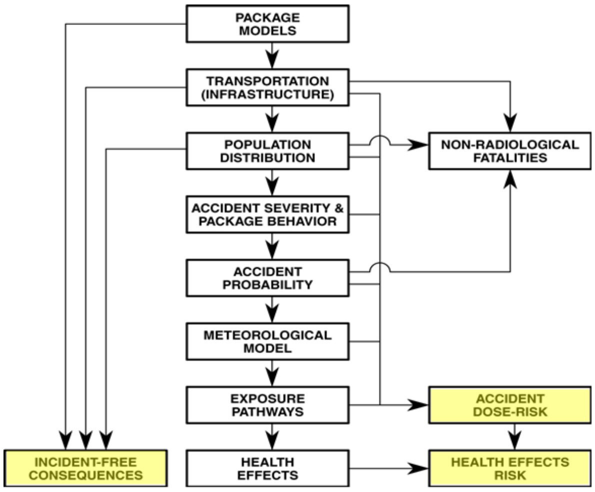

Fig. 1. RADTRAN5 Component models and interrelationship

In addition, accident radiological risk by isotopes is shown in table 4 and figure 3.

Table 1: Primary inputs of INTERTRAN2

Parameter	default value
Shielding eff. factor (rural)	1
Shielding eff. factor (suburban)	0.87
Shielding eff. factor (urban)	0.018
Building dose factor	8.6E-03
Fraction of land under cultivation	0.5
Breathing rate (m^3/s)	3.30E-04
Evacuation time (days)	1
Fraction of travel in rural	7.96E-01
Fraction of travel in suburban	1.76E-01
Fraction of travel in urban	2.80E-02
Velocity in rural zone (km/h)	8.86E+01
Velocity in urban (km/h)	2.41E+01
Number of crew on a shipment	2

Table 2: Activities for package

Nuclide	Activity (Bq)	Nuclide	Activity (Bq)
Co-60	3.41E+12	Pu-238	1.10E+14
Kr-85	2.26E+14	Pu-239	1.52E+13
Sr-90	2.21E+15	Pu-240	1.73E+13
Ru-106	5.99E+14	Pu-241	4.69E+15
Cs-134	1.01E+15	Am-241	4.78E+13
Cs-137	3.24E+15	Am-243	7.36E+11
Ce-144	4.51E+14	Cm-244	6.62E+13
Eu-154	2.59E+14	-	-

Table 3: Comparison of Incident-free collective dose

Collective dose (man-Sv)	RADTRAN 4	INTERTRAN2
Off-link	2.42E-05	2.42E-05
On-link	6.36E-05	6.36E-05
Stop	1.21E-03	1.21E-03
Crew	2.72E-04	2.72E-04
Total	1.57E-03	1.57E-03

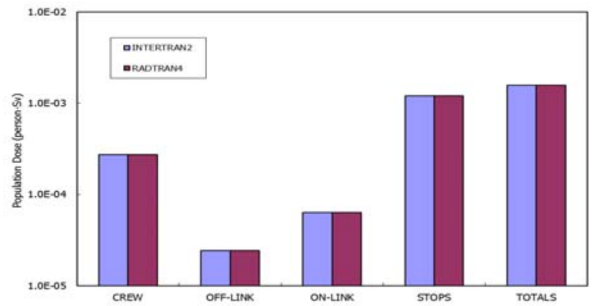

Fig. 2. Incident-free Collective dose

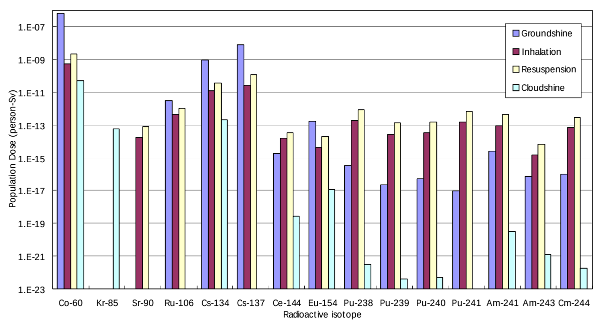

Fig. 3. Collective dose contribution by isotopes via exposure pathway

Table 4: INTERTRAN2 Incident-free collective dose compared with RADTRAN4

Isotope	Exposure pathway				
	Groundshine	Inhalation	Resuspension	Cloudshine	Total
Co-60	6.77E-07 (100.0%)	5.69E-10 (100.0%)	2.18E-09 (100.0%)	5.06E-11 (99.6%)	6.80E-07 (100.0%)
Kr-85	-	-	-	5.96E-14 (100.2%)	5.96E-14 (100.2%)
Sr-90	-	1.84E-14 (100.5%)	8.10E-14 (100.2%)	-	9.94E-14 (100.2%)
Ru-106	3.14E-12 (100.0%)	4.83E-13 (99.8%)	1.10E-12 (99.1%)	-	4.73E-12 (100.0%)
Cs-134	9.78E-10 (99.6%)	1.27E-11 (99.2%)	3.90E-11 (99.2%)	2.13E-13 (99.5%)	1.03E-09 (100.0%)
Cs-137	8.13E-09 (100.0%)	2.85E-11 (100.0%)	1.26E-10 (100.0%)	-	8.28E-09 (100.0%)
Ce-144	1.87E-15 (100.0%)	1.70E-14 (100.0%)	3.38E-14 (99.7%)	2.73E-19 (100.0%)	5.27E-14 (99.8%)
Eu-154	1.68E-13 (100.0%)	4.81E-15 (100.0%)	1.97E-14 (100.0%)	1.12E-17 (100.0%)	1.92E-13 (100.0%)
Pu-238	3.00E-16 (100.3%)	2.02E-13 (100.5%)	9.10E-13 (100.3%)	3.23E-22 (100.3%)	1.11E-12 (100.0%)
Pu-239	2.16E-17 (100.0%)	3.00E-14 (100.0%)	1.37E-13 (100.0%)	4.15E-23 (100.2%)	1.67E-13 (100.0%)
Pu-240	5.34E-17 (99.8%)	3.42E-14 (100.0%)	1.56E-13 (100.0%)	4.97E-23 (99.8%)	1.90E-13 (100.0%)
Pu-241	9.02E-18 (100.6%)	1.61E-13 (100.6%)	6.87E-13 (100.9%)	-	8.48E-13 (100.8%)
Am-241	2.67E-15 (100.0%)	9.74E-14 (99.8%)	4.44E-13 (100.0%)	3.02E-20 (100.0%)	5.44E-13 (99.8%)
Am-243	7.35E-17 (100.0%)	1.50E-15 (99.3%)	6.85E-15 (99.7%)	1.25E-21 (100.0%)	8.42E-15 (99.6%)
Cm-244	9.83E-17 (100.0%)	7.11E-14 (100.0%)	3.07E-13 (100.0%)	1.85E-22 (100.0%)	3.78E-13 (100.0%)
Total	6.86E-07 (100.0%)	6.12E-10 (100.0%)	2.35E-09 (100.0%)	5.09E-11 (99.6%)	6.89E-07 (100.0%)

3. Conclusions

Radiological transport risk assessment using INTERTRAN2 to benchmark RADTRAN4 was conducted and turned out no significant different between 2 codes. Risk assessment with on-site information in Korean NPPs will be made using INTERTRAN2 code in the near future.

REFERENCES

[1] K. S. Neuhauser. RADTRAN 5 Technical Manual SAND2000-1256, 2000.
[2] K. S. Neuhauser, RADTRAN 4: VOLUME 3 USER GUIDE, SAND89-2370, 1992.
[3] D. M. Osborn, Verification and Validation of RADTRAN 5.5, SAND2005-1274, 2005.