RADSHIP-3--A New Version of the Radwaste Transportation Radiological Impact Assessment Code

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ABSTRACT

RADSHIP-3 is a new version of the radwaste transportation radiological impact assessment code of RADSHIP-2. As compared with RADSHIP-2 code which was presented in the Waste Management '86 Symposium, the major improvement in RADSHIP-3 involves the following additional considerations: the exposure pathway to the pedestrians, the shielding effect of housing, the use of the experimental data of doses to replace the original calculation model for handlers and crewmen, and the extension of the functional mode for analyzing the radiological impact from spent fuel transportation. Besides, RADSHIP-3 code also involves a new dispersion model in sea, modifies the resuspension dose factor, and adds nuclides for the analysis of radioactive material transportation. Based on the Taipower's radwaste transportation data and with the aid of FACOM-M200 computer system, the results calculated from both RADSHIP-3 and RADSHIP-2 are compared. The comparison reveals that the annual doses computed from RADSHIP-3 are much more reasonable and acceptable than those from RADSHIP-2, particularly under the operational and environmental conditions in Taiwan.

INTRODUCTION

The evaluation of the radiological impact from radwaste transportation has been highly concerned by the public in Taiwan since the nuclear power was generated in 1977. Under the policy of storing radwaste on off-shore island, the radwaste generated from the existing nuclear power plants are shipped to the national Lan-Yu storage site for interim storage in Taiwan. The transport modes include track transportation, pier operation and sea shipment. To evaluate the radiological impact to the environment from the radwaste transportation in Taiwan area, a computer code RADSHIP-2 was developed and presented in the Waste Management '86 Symposium. The methodology used in RADSHIP-2 code covers shipment model, transportation model, population distribution model, Radiological impact under normal transportation, accident severity and package release model, meterological dispersion model, health effects model, radiological impact due to accident, and dispersion model in sea.

Recently, some significant improvement on RADSHIP-2 have been achieved by the Institute of Nuclear Energy Research (INER) under a subsequent contracted program with Radwaste Administration of ROC-AEC and Taiwan Power Company (TPC). This revised version of the computer code is named RADSHIP-3, which is much more reasonable and acceptable in the analysis of the radiological impact under the transportation conditions in Taiwan.

Besides retaining previous considerations in RADSHIP-2, the code RADSHIP-3 includes some additional considerations, particularly the effects on the annual doses to be computed for pedestrians and residents in shielded housing through the application of building transmission factors, the three-dimensional dispersion model in sea, the annual doses for handlers and crewmen to be estimated through experimentally measured data, etc.

RADSHIP-3 is written in FORTRAN-IV language and has been testified to be operational on the FACOM-M200 computer system successfully since May 1986.

MODEL IMPROVEMENT

The development of the RADSHIP-3 code was based on the RADSHIP-2 code but ultilizing more effective and reasonable methodology to evaluate the radiological impact to the environment from the radwaste transportation in Taiwan area. The submodels which have been added or improved by RADSHIP-3 will be described briefly hereafter, including the consideration of the shielding effect of housing, the addition of nuclides, the expansion of the functional mode for analyzing the radiological impact from spent fuel transportation, the modification of the resuspension dose factor, the addition of a new dispersion model in sea, and the estimation of the exposure for handlers and crewmen through experimentally measured data. Besides, RADSHIP-3 was also written by using FIDO system to allow the input data preparation more convenient and flexible.

(A) Shielding effect of housing

In this part two important improvements have been achieved. One is the addition of the exposure pathway to the pedestrians, and the other is that three options in the shielding consideration are made available for the users. The first option in the analysis assumes that all housing constructions provide excellent shielding effect so that all doses are accumulated by pedestrians. The second option assumes that unshielded pedestrians accept the exposure but the exposure to the residents is reducible due to the shielding effect. The third option is the most conservative which ignores the shielding effect entirely so that all pedestrians and residents accept the exposure.

(B) The addition of nuclides

In RADSHIP-2 code, there are only twenty radioisotopes to be handled in the shipment model. In order to enable us for analyzing the transportation of all radioactive material, the number of radioisotopes to be handled in RADSHIP-3 are extended to 32.

(C) The expansion of the functional mode for analyzing the spent fuel transportation

For actual considerations, RADSHIP-3 adds the functional mode for analyzing the spent fuel transportation. The evaluation mode for spent fuel transportation is complicated because there are so many kinds of spent fuel casks with different design features. If the correction factor doesn't be considered in the evaluation of the spent fuel transportation, the computed result will be conservative. So different calculations between radwaste transportation and spent fuel transportation are only based on whether or not using the correction factor. The correction factor is used in both RADSHIP-2 and RADSHIP-3 for the evaluation of radwaste transportation in order to yield a better result. However, owing to the complexity of using a correction factor for the evaluation of spent fuel transportation by RADSHIP-3, we have ignored the correction factor in the spent fuel transportation so that the computed result becomes conservative.

(D) The modification of the resuspension dose factor

To analyze latent cancer fatalities under accident, instead of using the resuspension dose factor as input data in RADSHIP-2, the calculations in RADSHIP-3 are based on nuclides.

(E) The addition of a new dispersion model in sea

In RADSHIP-2 the concentration of radionuclides in sea water through the release of radionuclides from container under sea-shipment accident is computed by using one-dimensional dispersion model as described in IAEA Safety Series NO.5. In order to yield a more realistic result, a three-dimensional dispersion model and the dose calculation model suggested by the Nuclear Safety Bureau, Science & Technology Agency, and Nuclear Safety Commission, Japan, have been taken into consideration in RADSHIP-3 as an alternative model.

(F) The estimation of the exposure for handlers and crewmen through experimentally measured data

Although the inverse square-distance law applied in RADSHIP-2 is simple, it seems over-conservative when estimating the exposure doses of handlers and crewmen, because of the complexity of their actual operation. In order to eliminate such over-conservative estimations of doses, RADSHIP-3 applies the experimentally measured doses instead of the calculations. In such a manner, disadvantages in RADSHIP-2 are improved and the dose estimations of handlers and crewmen are made to be more practical and reasonable.

RADIOLOGICAL ASSESSMENT IN TAIWAN AREA

Based on the actual considerations the radwaste transportation of 19 shipments in Taipower's Kuo-Sheng Nuclear Power Plant transported to Lan-Yu storage site during the year of 1985 have been evaluated by using the code RADSHIP-3. Table I gives some of the transportation conditions: transport index using 13 mrem/yr and curie per package using 5.6 Ci are both based on certain conservative data within the limitation of package surface dose rate in the safety guide. the nuclide of radwaste is assumed to be Co-60, and population density in emergency anchoring port is assumed to be 611 person/km**2. Based on the same transport conditions, analyses have also been performed by RADSHIP-2 for comparison. Table II shows the annual doses calculated from both RADSHIP-3 and RADSHIP-2. It can be found that under normal truck transportation , since the exposure to the pedestrians has been added to RADSHIP-3, the results for residents calculated from RADSHIP-3 are larger than those from RADSHIP-2. Under pier normal operation and emergency anchoring port, the exposures for residents calculated by RADSHIP-3 are smaller than those by RADSHIP-2 because of the addition of the shielding effects of housing. For handlers and crewmen, because of using experimentally measured data, RADSHIP-3 also provides the more reasonable results of exposure than those by RADSHIP-2 . And, under contaminated accident in sea shipment, RADSHIP-3 can also yield the more acceptable results than those from RADSHIP-2 due to the application of three-dimensional dispersion model in sea.

TABLE I

Typical Data Used in RADSHIP-3

Parameter	Value
Transport Index (mrem/hr)	13
Distance per Shipment (km), Land	2
Sea	370.4
Package per Shipment	6
Shipment per Year	19
Velocity (km/hr), Land	30
Sea	17
Curie per Package (Ci)	5.6
Nuclide	Co-60
Population Density (people/km**2),	100
Distance between Pier Operation Supervisor and Container (m)	3
Minimum Distance between Resident and Truck Transport Route (m)	30
Population Density in Emergency Anchoring Port (person/km**2)	611

TABLE II

Results of the RADSHIP-2 and RADSHIP-3 Codes

	Annual Dose (man-rem)	
	RADSHIP-2	RADSHIP-3
1. Land Normal Transportation		
. Resident	1.203E-4	1.254E-4
. People on Guided Vehicle	1.059E-2	1.059E-2
. Driver	1.296E-2	1.296E-2
. Traffic Control Patrol	1.334E-4	1.334E-4
2. Pier Operation		
. Normal Operation		
--- Resident	3.182E-3	2.768E-3
--- Handler	1.338E+1	1.647E+0
--- Crew	6.158E-1	5.199E-2
--- Supervisor	2.728E+0	3.294E-1
. Cargo Fall on Ground or Ship		
--- Handler	2.591E-5	2.591E-5
. Cargo Fall into the Sea		
--- Handler	2.591E-6	2.591E-6
--- Diver	6.423E-15	6.423E-15
3. Sea Transportation		
. Normal Condition		
--- Crew	1.001E+1	8.454E-1
. Aground		
--- Crew	2.428E-4	2.428E-4
. Small Accident		
--- Crew	5.059E-4	5.059E-4
. Non-Scheduled Anchoring		
--- Crew	1.214E-2	1.214E-2
--- Resident	8.981E-4	7.813E-4
4. Truck Contaminated Accident		
. Resident	6.411E-12 *	6.411E-12 *
5. Pier Contaminated Accident		
. Resident	1.808E-6 *	1.808E-6 *
6. Ship Contaminated Accident		
. Resident	1.312E-10 *	1.171E-10 *

* : Unit in (Latent Cancer Fatalities/yr)

The representation of this paper reveals that the annual doses computed from RADSHIP-3 are more reliable than those from RADSHIP-2, particularly under the operational and environmental conditions in Taiwan.

The extension of our present research work on the way includes reloading RADSHIP-3 code on a personal computer, analyzing different kinds of transportation accident, evaluating the personnel dose rate during severe accident, etc. Besides, a code named RAMDA which simulates the dose assessment from radwaste drums manipulation in plant and at Lan-Yu storage site has been achieved. The final target of our whole project is to develop a linkage of RADSHIP-3 and RAMDA to evaluate the radiological impact during the radwaste transportation in Taiwan.

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