Radiological Assessment of Spent Resin Treatment Device for Disposal Safety

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1. Introduction

At a nuclear power plant (NPP), resins are used to purify liquid radioactive waste generated from operating NPP. In the case of pressurized heavy water reactor, resin is used in deuteration and de-deuteration, liquid waste disposal system etc. The spent resin is stored in a resin storage tank and processed in accordance with the decommissioning plans. Resins generated from pressurized heavy water reactors contain various radioactive nuclides and are classified as an intermediate level radioactive waste (ILW), especially due to high concentration of long-lived radioactive C-14 (half-life of 5,730 years). In case of Wolsong unit 1,2,3,4, disposal costs of about 80 billion Won are required to dispose without treating the spent resin [1]. To solve this problem, a spent resin treatment device has been developed which able of recovering and recycling the C-14 from spent resin. In this paper, VISIPLAN code was used to evaluate the external exposure dose [2].

2. Method

The spent resin will be treated through a heat desorption process using a treatment device such as a microwave.

The VISIPLAN exposure dose assessment code was used to confirm the radiation safety of radiation workers on the spent resin treatment device.

2.1 Modeling of spent resin treatment device

The actual spent resin treatment device is modeled based on the basic structure of box, cylinder, sphere, cap, cone etc. supported by VISIPALN code. The space with the device was defined as a concrete wall with a length of 4 m and the device was located at the center of the space. The device was modeled with stainless steel material. In the case of the main process part, the sphere cap model was used for the upper and lower structures, and the tube model was used for the middle part. For the tube connecting the main process part, the tube model was used as the basis and bending part was modeled using the torus model. The cone model was used to model the connection between the upper part of the process part for desorbing C-14 in the resin and the transfer pipe using a microwave.

2.2 The source information of the spent resin treatment device

The radioactivity of the radionuclides in the resin was checked to evaluate the exposure dose to the spent resin treatment device. As shown in Table 1, based on the radioactivity concentration in the resin derived from the experiment, the maximum value of the radioactive concentration for each nuclear species was used, and the radioactivity values corresponding to 1,000 g of the input dose at the time of the device operation was derived.

Table 1. Radioactivity concentration of resin and radiation of the spent resin treatment device

Nuclide	Radioactivity Concentration (Bq/g)	Radioactivity (Bq)
H-3	3.75E+04	3.75E+07
C-14	2.23E+05	2.23E+08
Co-57	2.91E+01	2.91E+04
Co-60	4.94E+02	4.94E+05
Cr-51	2.58E+02	2.58E+05
Cs-134	1.57E+01	1.57E+04
Cs-137	9.09E+03	9.09E+06
Mn-54	2.67E+01	2.67E+04
Nb-95	4.39E+01	4.39E+04
Sb-125	4.25E+02	4.25E+05
Zr-95	2.75E+01	2.75E+04
Eu-152	5.12E+02	5.12E+05
Eu-154	4.33E+01	4.33E+04

2.3 Exposure scenario for radiation worker

Based on the worker scenario, the radiation exposure dose of the workers was calculated. In order to operate the spent resin treatment device, it is assumed that the time required to put the spent resin into the device and operate the device is 1 hour. The deviation of the working time was set to 10 minutes, and the dose was evaluated for the working time of 50 minutes and 70 minutes. The position of the worker was set at a distance of 20 cm from the center surface of the device and the height was set at 120 cm, which is the height from the ground to the worker's chest. The main internal exposure pathway was considered as respiration and ingestion. The 1 % outflow from treatment device was assumed.

3. Result and discussion

3.1 Dose rate distribution by the spent resin treatment device

As shown in Fig. 1, based on the structural modeling of the spent resin treatment device and the definition of the source, the radiation dose rate distribution in the space where the device is located was confirmed.

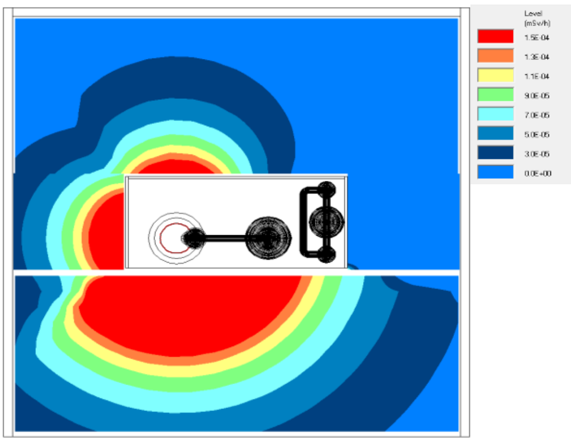

Fig. 1. The distribution of the exposure dose rate due to the spent resin treatment device derived by VISIPLAN (Z-view).

For the dose distribution rate, the highest value was found to be 1.1E-03 mSv/h. It was confirmed that the nuclide which has the largest influence on the dose distribution rate was Cs-137.

3.2 Dose assessment of radiation worker

As shown in Table 2, for 1 hour of working time, the received dose was calculated as 5.3E-05 mSv/h. In order to derive the annual worker dose based on the received dose per hour, 2,000 hours which is the annual working hours of a typical radiation worker was used. The derived dose value is 0.106 mSv. It can be checked that the annual dose received from the spent resin treatment device doesn't reach the 100 mSv limit for 5 years and 50 mSv limits for 1 year in maximum, the annual worker dose. The internal dose was evaluated as 3.22 mSv in terms of committed effective dose.

Table 2. Dose assessment result of radiation worker

Working Time (min)	Exposure Dose (mSv)
50	4.4E-05
60	5.3E-05
70	6.1E-05

4. Conclusion

The radiological assessment for radiation worker of spent resin treatment process was conducted based on VISIPLAN. The internal dose was evaluated about 30 times higher than the external dose. It is thought to be due to beta-emitting nuclides such as C-14. This result shows that the annual dose due to spent resin treatment device does not reach the annual worker's dose limitation. Therefore, the radiological safety of the workers in the spent resin treatment process is secured.

REFERENCES

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