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Radiation Shielding Evaluation of IP-2 Packages for Low and Intermediate Level Radioactive Waste

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1. Introduction

KHNP is developing two kinds of IP-2 packages to transport low and intermediate level radioactive waste (LILW) steel drums from the on-site temporary storage facilities of nuclear power plants to the disposal facility in accordance with IAEA and domestic transport regulations. This paper describes radiation shielding evaluation to determine dose rate limits of LILW steel drums to be containable in the packages by using MCNP code.

2. Description of IP-2 Package

Two kinds of IP-2 packages with the same external dimension of 1.6mW×3.4mL×1.2mH are designed to transport 8 LILW steel drums of 200L and 320L, and to comply with the regulatory requirements of IAEA SSS No.TS-R-1[1] and Korea Atomic Energy Act[2][3] for IP-2 package. The weight of each package is about 6 tons including 8 steel drums. The body of packages is made of carbon steel of SS400 and the shielding thickness of body and lid of packages is 12mm. A fabricated package model is shown in Fig.1. The content contained in the packages is 14 kinds of LILW drums as classified in Table 1. The packages are so designed that the radiation level does not exceed 2mSv/h at any point on, and 0.1mSv/h at 2m from, the external surface of the packages.

Fig.1 IP-2 package

Table 1 LILW drum classification

Dry active waste	Concentrated waste	Spent resin	Spent filter
General	Cement solid.	Cement solid.	Concrete
1) 200L drum	5) 200L drum	9) 200L drum	13) 200L drum
2)320L drum	6) 320L drum	10) 320L drum	14) 320L drum
Shielded	Paraffin solid.	Dried	
3) 200L drum	7) 200L drum	11) 200L drum	
Super. comp.	8) 320L drum	12) 320L drum	
4) 320L drum			

3. Radiation Shielding Evaluation

In order to evaluate radiation shielding integrity of the packages and determine dose rate limits of LILW drums to be containable in the packages, radiation shielding evaluation was carried out by using MCNP computer code[4] with PHYS card and MCPLIB042 library. To convert the flux at tally points with respective energy bands to actual dose rate, flux-to-dose conversion factor, ANSI/ANS-6.1.1[5] was applied.

200L and 320L drums were modeled and average radioactivity of nuclides according to each kind of radioactive waste at temporary storage facilities of nuclear power plants as a source term was considered to be homogeneous[6]. Various tally positions to evaluate dose rate on and at 2m from the external surface of the top and side of package are shown in Fig.2. To find out the positions presenting the maximum dose rate, multiple dose assessment was conducted. It was found that dose rate at 2m from the external surface of package was more dominant than on the surface and dose rate over the top of package was higher than from the side. Dose rates at 2m from the external surface of the top and the side of each package were calculated.

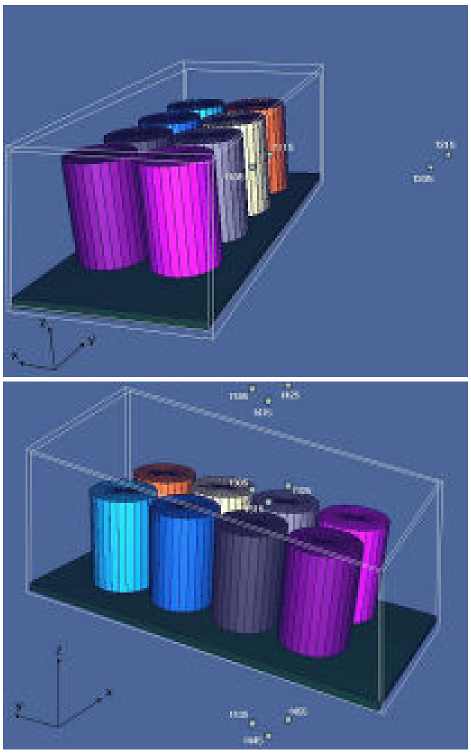

Fig.2 Positions to assess dose rate

On the basis of the calculated dose rates at 2m from the external surface of the top and the side of package, dose rate limits of each LILW drum to be containable in the packages were tabulated in Table 2.

Table 2 Containable dose rate limits for single package

LILW	200L drum (mSv/h)		320L drum (mSv/h)	
	top	side	top	side
Spent resin (Cement)	1.200	1.200	1.023	0.8444
Spent resin (Dried)	1.035	1.035	0.8906	0.8151
CW[1] (Cement)	1.234	1.234	1.046	0.8568
CW (Paraffin)	1.089	1.089	0.9606	0.8579
Spent filter	1.177	1.177	1.016	0.8616
DAW[2] (General)	0.7095	0.7095	0.6224	0.6314
DAW (Shielded)	0.8929	0.8929	-	-
DAW (Super. comp.)	-	-	0.6333	0.6385

[1] Concentrated waste ; [2] Dry active waste

In practice, 2 IP-2 packages will be loaded on a vehicle and transported by the transport mode as shown in Fig.3 in the sites of nuclear power plants and disposal facility. Hence radiation shielding evaluation for 2 serial packages was carried out as shown in Fig.4. A space of at least 22cm between packages on the vehicle was assumed. The method of radiation shielding evaluation for 2 serial packages was identical to one for the single package. Containable dose rate limits for 2 serial packages are tabulated in Table 3.

Fig.3 Vehicle transport mode with 2 packages

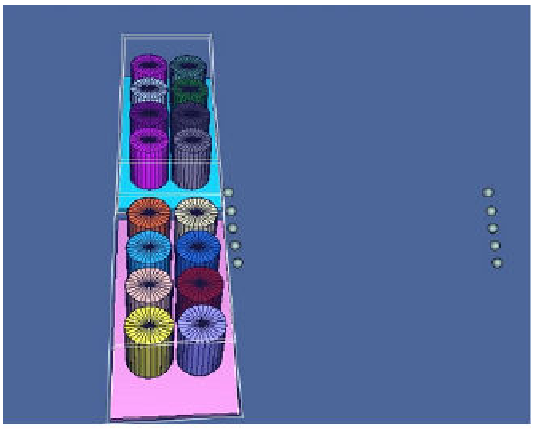

Fig. 4 Positions to assess dose rate for 2 serial packages

Table 3 Containable dose rate limits for 2 serial packages

LILW	200L drum (mSv/h)		320L drum (mSv/h)	
	top	side	top	side
Spent resin (Cement)	0.8729	0.7911	0.8033	0.6648
Spent resin (Dried)	0.7883	0.7519	0.8493	0.7773
CW (Cement)	0.9103	0.7735	0.8407	0.6886
CW (Paraffin)	0.8382	0.7810	0.7734	0.6907
Spent filter	0.8809	0.7911	0.7768	0.6588
DAW (General)	0.5119	0.5448	0.4683	0.4750
DAW (Shielded)	0.7397	0.7748	-	-
DAW (Super. comp.)	-	-	0.5008	0.5049

[1] Concentrated waste ; [2] Dry active waste

4. Conclusion

From the distribution of dose rate of LILW drums stored in the temporary storage facility of nuclear power plants as shown in Fig.5[7], it is estimated that about 65% of 200L LILW drums and about 95% of 320L LILW drums are to be transportable with the 12mm thick-walled IP-2 packages being currently developed. Therefore, new packages with thicker wall than 12mm to transport all LILW drums stored in the temporary storage facility of nuclear power plants are needed to be developed, and KHNP intends to design new packages for LILW drums.

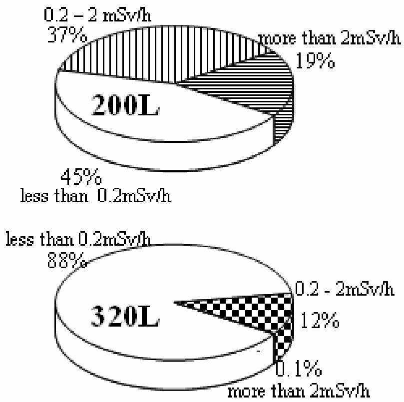

Fig.5 Distribution of dose rate of LILW drums

REFERENCES

[1] IAEA Safety Standards Series No.TS-R-1, "Regulation for safe Transport of Radioactive material," 2005
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[7] KHNP-NETEC, "Basic Design Report of Packages for LILW," 2007