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Preliminary Shielding Evaluation of IP-2 Type Transport Container

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1. Introduction

Considering workers and public safety, the low and intermediate-level waste (LILW), which is generated from nuclear power plants (NPPs), should be transported with the codes related with domestic and international regulations [1,2]. Transport container of IP-2 Type should be also designed to meet the technical standard from the related codes. In this article, radiation shielding evaluation for the transport container, in which the wastes in the interim storage facilities of NPPs could be transported, is introduced briefly. From the analysis surface dose rate of the waste drum that could be carried through the container was evaluated.

2. Design Criteria

The technical standards related with radiation safety assessment of the transport container are addressed in Regulations for Technical Standard for Radiation Safety Management and etc. [3] and Notification from Ministry of Science and Technology No. 2001-23, Regulations for the Packaging and Transport for Radioactive materials, 2001 [4]. Based on these regulations the following technical standards were established.

■ Surface dose rate of the container: 2mSv/hr
■ Dose rate at 2 m separation distance from the surface: 0.1mSv/hr

3. Shielding Analysis

3.1 Source Specification

There are various radioactive nuclides in LILW generated from the plants and because of various gamma rays dependent with the nuclides, it is important to identify clearly the nuclides to ensure the safe transportation.

The average categorized radioactivity for each isotopes in LILW generated from domestic nuclear reactors are referred in this article. From the above data, several radioisotopes yield radioactivity, but for the conservatism, it is assumed that there is only Co-60 in the radioactive waste and it is used as whole radiation source in the calculation. Co-60 is a gamma source which produces two different energy level of gamma rays that are 1.17MeV, 50% and 1.33MeV, 50%. By preceding calculation using MCNP for source term in the LILW and accompanying with the dose rate limit for a transport container, the acceptable dose rate value per drum for transport is acquired. This acceptable dose rate value per drum for transport is the criteria for determining which drum can be transported by container (IP-2 type) or not. In this calculation, the acceptable dose rate value per drum for transport is 1.1204E9 photon/sec.

3.2 Modeling

In this study 3-D radiation shielding analysis was performed through MCNPX using Monte Carlo method. The transport containers of 200 and 320 L drums were simulated as a medium with homogeneous density source. Figure 1 shows vertical and horizontal schematics of analytical model for shielding evaluation. As shown in Figure 1, 8 drums (200 or 320 L) are located in an IP-2 Type container. Even the out-size of the container at any choice of 200 or 320 L is same, but there is difference in the inner geometry of the container. Composition of 200 and 320 L drums are shown in Table 2. And specification of the container is listed in Table 3. Because density, composition, and composition ratio in radiation shielding analysis are principal factors affecting directly on dose rate assessment, density and material compositions of carbon steel SS400, of which 200 and 320 L drums and IP-2 containers are consisted with, are listed in Table 4. Fifteen kinds of LILW were modeled with densities and compositions of each waste drum as shown in Table 5 [4]. There is an assumption that constitution of all drums is consisted homogeneously with the exception of miscellaneous waste drums. Miscellaneous waste drums were modeled with shielding material of concrete in 0.1 m thickness as shown in Figure 2. All wastes that are considered in this study mean solid state.

3.3 Shielding Analysis

In this study 3-D radiation shielding analysis for the transport container was also performed through MCNPX. Eight drums of radioactive wastes with the same composition are loaded in the container. For detection of radioactive dose rate, detectors were located on outside surface of the container and at 2 m separation point. To calculate a point with maximum dose rate from the container, there were many evaluations at various points for dose rate analysis. Through the evaluation of outside dose rate on the surface of the container, maximum radioactivity inside of the container, radioactivity per drum, and surface dose rate per drum were calculated.

MCNP calculation results show a flux distribution with specific energy level according to the detection points of dose rate. But to convert the flux into real radioactivity, Flux-to-Dose conversion factor should be multiplied to it. Flux-to-Dose conversion factor is determined by ANSI/ANS-6.1.1 (1991) of MCNPX code and dose evaluation was performed for all possible cases through 200,000 numbers of histories.

3.4 Result

From the radiation evaluation results, we could conclude that it would be much more conservative to restrict radioactivity at 2 m separation point instead of the surface on the container and, moreover, high radioactivity would be detected at the upper points of the container instead of the surface.

4. Conclusion

In this study, surface dose rate on the surface of LILW drum with the kind of wastes, which could be carried by using IP-2 Type transport container with carbon steel plate of 15 mm in thickness, was evaluated through 3-D simulation and its results are listed in Table 6 and 7.

REFERENCES

[1] International Atomic Energy Agency, IAEA Safety Standard Series, Regulations for the Safe Transport of Radioactive Material, Safety Requirements No. TS-R-1, 2005 Edition

[2] Ministry of Science and Technology, Regulations for Technical Standard for Radiation Safety Management and etc., 2001

[3] Ministry of Science and Technology, Notification from ministry of Science and Technology No. 2001-23, Regulations for the Packaging and Transport for Radioactive materials, 2001

[4] Kanguk Lee, et al., Shielding analysis for IP type transport container, Korea Radioactive Waste Society, 2005.

Table 1. Averaged radioactivity of miscellaneous materials

unit : Ci/drum

Nuclide	Normal/con. (200L)	Normal (320L)	Shielding (200L)	Shielding (320L)	HIC (320L)
H-3	6.67E-04	6.67E-04	1.76E-02	1.76E-02	1.33E-03
C-14	2.65E-05	2.65E-05	7.40E-04	7.40E-04	5.30E-05
Fe-55	3.85E-03	3.85E-03	1.08E-01	1.08E-01	7.70E-03
Co-58	1.74E-03	1.74E-03	4.89E-02	4.89E-02	3.48E-03
Co-60	1.96E-03	1.96E-03	5.49E-02	5.49E-02	3.92E-03
Ni-59	9.81E-05	9.81E-05	2.43E-03	2.43E-03	1.96E-04
Ni-63	5.02E-04	5.02E-04	1.40E-02	1.40E-02	1.00E-03
Sr-90	3.81E-06	3.81E-06	1.06E-04	1.06E-04	7.63E-06
Nb-94	1.41E-05	1.41E-05	1.43E-04	1.43E-04	2.83E-05
Tc-99	2.60E-06	2.60E-06	6.36E-05	6.36E-05	5.20E-06
I-129	2.06E-07	2.06E-07	4.70E-06	4.70E-06	4.13E-07
Cs-137	3.84E-04	3.84E-04	1.07E-02	1.07E-02	7.67E-04
Ce-144	2.68E-04	2.68E-04	7.50E-03	7.50E-03	5.36E-04
전알파	7.43E-07	7.43E-07	2.08E-05	2.08E-05	1.49E-06

Table 2. Specification of 200 and 320 L drums

		200L	320L
Material		Carbon Steel(SS400)	
Size	I-Diameter.(mm)	567.6	717.6
	O-Diameter (mm)	570.0	720.0
	High (mm)	884.0	1,000.0
	Thickness(mm)	1.2	1.2

Table 3. Composition of IP-2 Type Package

Material			Carbon Steel(SS400)
Dimension	Inside of drum	length(mm)	3.380
		width(mm)	1.740
		high(mm)	1.020
	Inside of drum	length (mm)	3.400
		width (mm)	1.760
		high (mm)	1.040
	thickness(mm)		15

Table 4. Composition of carbon steel(SS400)

Material	Density(g/cm^3)	Element	Weight Percent [wt%]
SS400	7.85	C	0.30
		Si	0.28
		S	0.05
		Mn	1.03
		Fe	98.00
		Cu	0.30
		Pt	0.04

Table 5. Density and composition of LILW

Density (g/cm^3)	Composition rate[wt%]			
2.3	O(53.2)	Si(33.7)	Ca(4.4)	Al(3.4)
	Na(2.9)	Fe(1.4)	H(1.0)	
1.1	C(95.91)	H(4.09)		
2.3	O(53.2)	Si(33.7)	Ca(4.4)	Al(3.4)
	Na(2.9)	Fe(1.4)	H(1.0)	
1.2	C(21.29)	H(3.72)	B(23.30)	O(51.71)
2.3	Si(35.06)	Na(10.39)	Mg(3.02)	Ca(4.29)
	O947.25)			
0.2	C(57.48)	H(8.52)	O(7.58)	Cl(20.43)
	F(4.49)	N(1.52)		
0.2	C(57.48)	H(8.52)	O(7.58)	Cl(20.43)
	F(4.49)	N(1.52)		
2.3	O(53.2)	Si(33.7)	Ca(4.4)	Al(3.4)
	Na(2.9)	Fe(1.4)	H(1.0)	
0.25	C(57.48)	H(8.52)	O(7.58)	Cl(20.43)
	F(4.49)	N(1.52)		

Table 6. Surface dose rate of spent resin/concentrated waste drums

Waste	Resin cement solidification		Dried resin		Concentrated waste cement solidification
	200L	320L	200L	320L	200L
Surface dose rate(mSv/hr)	1.06	0.72	1	0.75	1.06

Table 7. Surface dose rate of spent filter/ miscellaneous waste drums

Waste	Resin cement solidification		Dried resin		Concentrated waste cement solidification
	200L	320L	200L	320L	200L
Surface dose rate(mSv/hr)	1.06	0.72	1	0.75	1.06

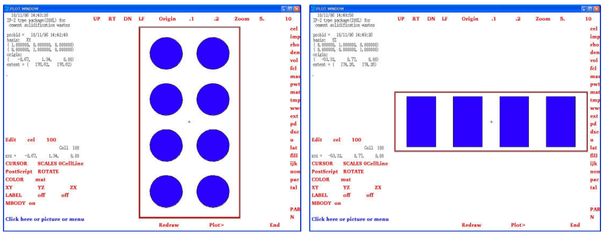

Figure 1. Vertical & horizontal schematics of MCNP analysis

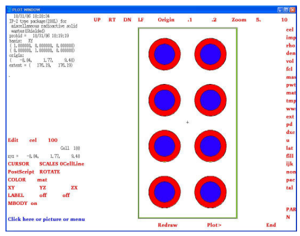

Figure 2. Horizontal schematic of 200 L drum