Shielding Analysis for Development of Type A and Type B packages for On-site Transportation in Domestic NPPs

Jeong-Hyoun Yoon, Sung-Hwan Kim, Kyung-Ho Lee, Byung-Il Choi, Chun-Hyung Cho and Heung-Young Lee

Korea Hydro and Nuclear Power Co., Ltd. Nuclear Environmental Technology Institute Daejon, Korea
Tel : 82-42-870-0372, Fax 82-42-870-0354, Email: jhyoon@khnp.co.kr

1. Introduction

There are many kinds of radioactive wastes generated from nuclear power plants. On-site, within Site boundaries where public access is restricted and controlled, transportation of radioactive wastes is a part of routine radiation works in each NPPs and various packages are being used for it. This paper describes radiation shielding analysis assessments for a development of package for on-site transportation, especially for Type A and Type B packages. Especially , this analysis is intended for use in the selection of the package shield material and for an estimate of shielding thickness as well. The results are intended to provide a technical basis for determining an optimal design for each types of the packages.

2. Background

In most cases, regulations of transportation of radioactive wastes such as IAEA Safety Standard Series TS-R-2[1] is applied for only off-site transportations. However, scoping provisions of Type A and Type B packages to on-site transportation of radioactive wastes implicates that it provides an equivalent degree of safety to onsite workers, the general public, and the environment as would be achieved by meeting international and domestic standards. For radiological assessment, there are always a lot of requirement to keep dose rates lower than the allowable in accordance with regulations. On the other hands, to prevent the site workers' potential exposure dose rates from the radiation due to the transportation works, most conservative requirement shall be chosen within ALARA concept. Followings are allowable radiation dose rates described in the domestic regulation[2] which was fully reflected the IAEA regulation since 2001. There are three shielding limits that were considered as part of this study:

1) In accordance with MOST notice 2001-13, the dose rate at any surface of the package for exclusive use only must be less than 2mSv/hr.
2) In accordance with MOST notice 2001-13, the dose rate at any surface of the package for non-exclusive use must be less than 2mSv/hr.
3) In accordance with MOST notice 2001-13, the dose rate at two meters from the transportation vehicle surface must be less than 0.1 mSv/hr.

Among those three shielding limits, design criterion considering package handling is that the radiation dose rates less than 0.1mSv/hr 0 mSv/hr at two meters from the transportation vehicle surface, although on-site transportation can be treated as exclusive-use which is allowable dose of a package surface is 10mSv/hr.

3. Radiation Sources

Table 1. shows for radionuclides contained each wastes content, which are obtained by radiological assay of wastes drums performed at Kori NPP in late 1990s'. Most of short live nuclides in waste content decay out soon after the wastes generated from each wastes stream so only relatively long lived radionuclides is used for the shielding analysis. Even though there are many type of wastes from wastes streams in NPPs, spent filter waste shielded solid waste have been chosen as source region material for shielding calculation purpose. Despite most of wastes generated from NPPs can be classified by LSA(Low Specific Activity Material)which can be transported by IP packages as described in the IAEA regulations, those type of wastes are chosen for content of Type A and Type B package for shielding calculation purpose only, Especially highly activated waste that is beyond Type A limits is assumed to belong to Type B package category.

Table 1. Nuclides inside wastes normalized to one

Nuclide	Spent Resin (cemented)	Spent Resin (dried)	Concentrate (cemented)	Spent filter	DAW	Highly Compressed DAW
C-14	4.4E-04	4.3E-03	1.9E-02	5.4E-03	9.6E-03	9.6E-03
Co-60	6.9E-01	6.9E-01	5.1E-01	7.7E-01	6.0E-01	6.0E-01
Cs-135	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Cs-137	1.3E-02	1.3E-02	6.2E-02	1.7E-04	1.0E-01	1.0E-01
I-129	1.4E-06	1.4E-06	3.1E-07	2.4E-08	2.6E-04	2.6E-04
Nb-94	1.6E-04	1.6E-04	1.2E-04	1.8E-04	1.9E-06	1.9E-06
Ni-59	8.0E-03	8.0E-03	5.9E-03	8.9E-03	9.4E-05	9.4E-05
Ni-63	2.9E-01	2.9E-01	4.0E-01	2.2E-01	2.9E-01	2.9E-01
Sr-90	5.7E-05	5.6E-05	4.2E-05	1.7E-06	4.6E-04	4.6E-04
Tc-99	8.8E-07	8.8E-07	8.7E-04	7.7E-07	8.9E-05	8.9E-05
Total	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00	1.0E+00

4. Shielding Analysis Modeling

Figure 1. and Figure 2 shows conceptual illustrations for Type A and Type B packages, which can accommodate 9 drums of waste content and 4drums

inside, respectively. As shown in the Figures, the design for the packages used in the shielding analyses is constructed waste meat region and 4 cm thick carbon steel for Type A and 5cm lead in 1cm carbon steel casing for Type B. So the shielding model for the packages is comprised of simple two zones for Type A and four zones for Type B. The overall dimensions of the packages are 2.06 m in length and width 1.0 m in height for Type A and 1.85m in length and width 1.52m in height for Type B. Since the radiation source is assumed to be homogenously distributed for shielding calculation purpose, only one-dimensional shielding calculation concept is enough to investigate the maximum radiation dose rates outside of the packages, normally represented in the right middle position in each dimension. Thus the variations in radiation field along the length and width of the packages can be neglected for conservatism and do not take part in the calculations. A computer program Micro-SHIELD was employed to calculate the dose rates. The shielding calculations were performed only for gamma radiation because betas and alphas would not penetrate the steel liners or lead that surround the radiation shielding material. They typically have a dose equivalent rate that is about order of magnitudes(four or five) less than that from gammas. It can be thus negligible

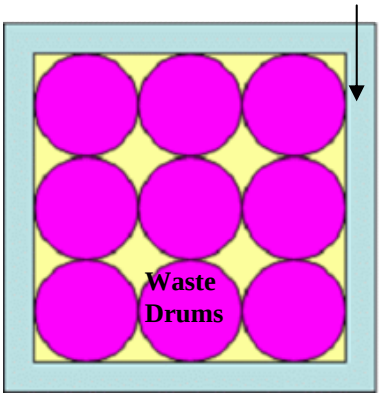

Figure 1. Conceptual Illustration of Type A package

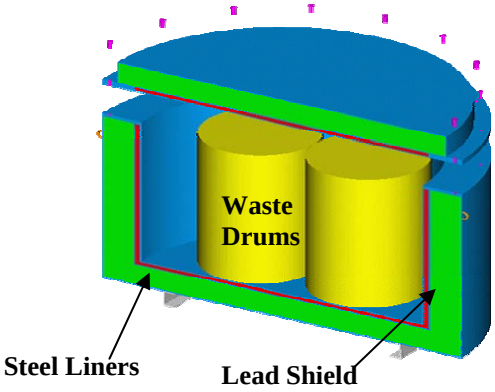

Figure 2. Conceptual Illustration of Type B package

Result s

Results from shielding analysis for the Type A and Type B packages are summarized in Table 2. Dose rates at 2m from the package surface is design criteria of shielding limit. Those dose rates represented described in Table that Type A package is based on assumptions accommodating 9 solidified waste drums dose rate upto 3.5mSv/hr on its surface and Type B is 4 spent filters dose rate upto 2.2 Sv/hr on its surface.

Table 2. Summary of dose rates obtained by shielding calculations comparing to allowable limis exclusive-use package

Package Type	Dose rates(mSv/hr)		
	Surface	1m	2m
Type A	3.5	-	0.098
Type B	2.8	-	0.097
Allowable	10.0	-	0.1*

***** Design criteria for consideration of package handling

Conclusions

The results obtained from the shielding calculations in this study indicate the following major findings:

1) A shielding thicknesses of 4cm steel for Type A and 5cm lead included the stainless steel liners for Type B are suitably chosen for shielding criteria.

2) In terms of shielding Type A and Type B packages being developed through the project can deal with transportation most of non-uniformed wastes generated from NPPs which can not be classified by LSA or SCO.

3) The required shielding thickness is updated dependent upon the gamma-ray spectra by more accurate determination of the source term in the future. Then we may preclude an overly conservative or under estimation.

References

[1] IAEA Safety standard Series No. TS-R-1, "Regulations for Packaging and Transportation of Radioactive Material", 2000 Ed.