A Study on Opening Displacement of Lid and Decrease in Shielding Thickness of a Type IP-2 Transport Package in Drop Events

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1. Introduction

Radioactive waste generated from nuclear power plants shall be transported in accordance with designated regulations, which is to protect radiation workers and the public against potential radiation exposure caused by the transportations. Each transport package of radioactive waste is to be designed to have enough safety to fulfill with the regulations and technical standards in domestic and foreign regulations.[1~3] In accordance with IAEA safety standard series TS-R-1 which is widely accepted by most of its member states, industrial package can be divided into IP-1, IP-2 and IP-3 along with other Type A and Type B packages, a conventional clarification. IP-2 package shall be designed to meet the designated requirements in addition to those for type IP-1 package. IP-2 package is subject to the free drop and stacking tests under normal conditions of transport as regulated in the regulation. In this paper, opening displacement of lid and body and decrease in shielding thickness of an IP-2 package are analytically evaluated, which is proposed for on-site transportation in domestic nuclear power plants. The results of the analysis is compared with design requirements of the package that loss or dispersal of the radioactive contents should be prevented and total loss of shielding effect from free drop shall be less than 20%.

2. Methods and Results

2.1 Finite Element Analysis(FEA)

Carbon steel was employed as a main structural material of the transport packages. The material properties of carbon steel and waste drum inside were shown in Table 2. The plastic deformation of carbon steel was considered. Waste drum was including drum and radioactive waste. The average weight of each waste drum was assumed by 450 kg and a number of drum was 16. It was used for total mass of inside content of the package.

Four dropping directions which were vertical, horizontal, side and corner drop were considered. The external dimension of the package are 4,580mm(L) x 1,080mm(H) x 2340mm(W) and 4,500mm(L) x 1,000mm (H) x 2,260mm(W) for the internal dimension. The thickness of lid and side wall is 40mm and that of bottom 50mm. To reinforce the strength and to avoid steaming radiation in shielding path, 10mm step in lid zone is made. The size of waste drum is 720mm(D) x 960mm(H). The clearance between drums is 25mm.

3D full modeling was used for Finite element analysis which is shown as Figure 1. The model employed C3D8R(8-node linear brick, reduced integration with hourglass control). The number of elements was 10,844 and 16,901 for the number of nodes. ABAQUS/Explicit is used for a finite element code for this analysis. As total weight of the full-loaded package is 18,955 kg, the drop height is 0.3m which is proposed in MOST Act. 2001-23 for the weight of transport package is heavier than 15,000kg. The initial velocity, 2,426mm/sec, which was obtained by the height of drop analysis, and an acceleration of gravity, 9,810mm/sec^2, were applied.

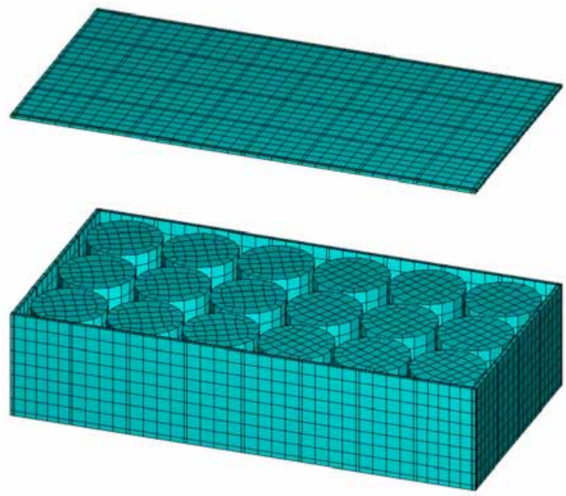

Figure 1.A finite element analysis modeling for vertical drop of the transport package.

Table 2. Mechanical properties used in FEA.

Mechanical properties	Carbon steel	Waste drum
Density (ton/mm^3)	8.02717E-9	1.1513E-9
Elastic modulus(MPa)	194,493	2E+9
Poisson’s ratio	0.3	0.01

2.2 Opening Displacement of lid

To ensure containment of the radioactive waste after drop events, opening displacement behaviors of lid and body were studied. Fig. 2 shows the displacement occurred at contact surface of lid and body for vertical drop analysis. The maximum displacements at contact surface of lid and body which are 10.21mm and 10.18mm, respectively. The maximum opening displacement of lid was 0.418mm from the analysis. Meanwhile, the height of step, 10mm is higher than the displacement of lid obtained from the analysis so there is no breach of containment to cause any loss or dispersal of the radioactive contents due to vertical drop analysis. The maximum opening displacements of lid for the other drop analyses are shown in Table 3.

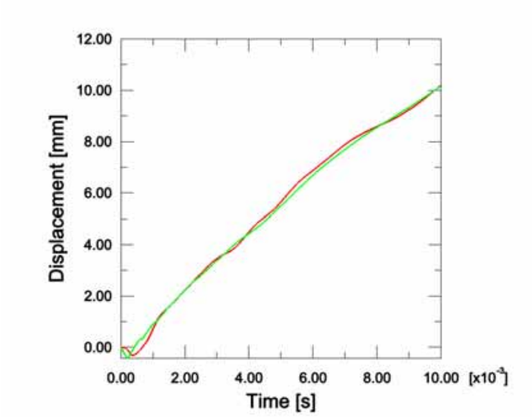

Figure 2. Opening displacement of lid as a function of time for vertical drop analysis.

Table 3. Maximum opening displacements of lid.

Drop direction	Vertical	Horizontal	Side	Corner
Max OPL	0.418 mm	0.249 mm	0.589 mm	0.501 mm

2.3 The decrease in thickness of shielding material

To investigate the loss of shielding integrity, the size of decrease in shielding thickness of the packages is calculated. Fig. 3 shows the displacements in upper and lower surface of shielding material for vertical drop analysis. The decreases in thickness of shielding material are shown in Fig. 4. The maximum decreases in thickness of shielding material for vertical, horizontal, side and corner drop analyses are 0.064mm, 0.03mm, 0.125mm, 1.09mm, respectively. The shielding analysis must be carried out. But the decreases are so small that losses of integrity are very low.

3. Conclusion

To evaluate the drop analysis for type IP-2 transport package an opening displacement of lid and a decrease in thickness of shielding material were studied. The maximum opening displacement of lid was 0.589 mm for vertical analysis for side drop analysis. So the containment of package to prevent loss or dispersal of radioactive material from the drop is expected to be achieved. The maximum possible decrease in thickness of shielding material was 1.09mm for corner drop analysis so that loss of shielding integrity is negligible in terms of shielding integrity.

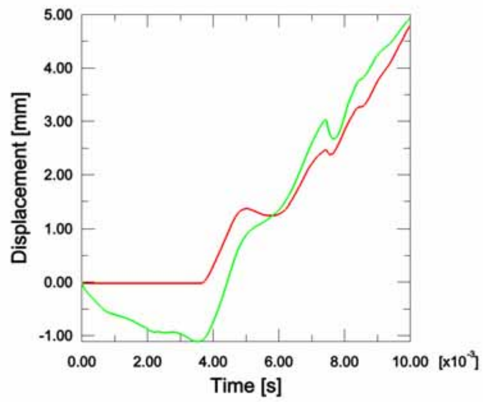

Figure 3. Displacements at upper and lower part of shielding material for corner drop analysis.

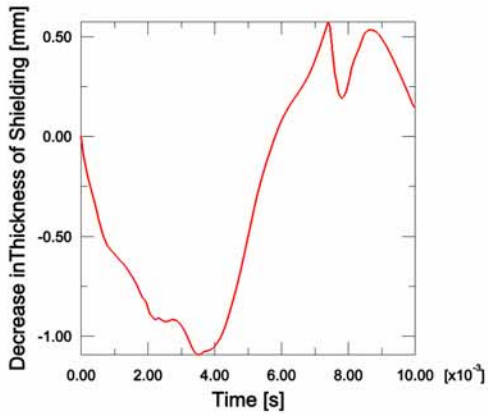

Figure 4. The decrease in thickness of shielding material for corner drop analysis.

REFERENCES

[1] KOREA MOST Act. 2001-23, “Regulations for the Safe Transport of Radioactive Material”, 2001.

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

[3] U.S. Code of Federal Regulations, Title 10, Part 71, "Packaging and Transportation of Radioactive Material”, 2004 Ed.