

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

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Introduction

Korea Hydro and Nuclear Power Co., Ltd.(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. The packages are designed to comply with the requirements of IAEA Safety Standards Series No.TS-R-1[1] and Korea Atomic Energy Act[2][3] for Type IP-2 packages. One package is able to contain eight 200-liter steel waste drums and also another package eight 320-liter steel waste drums. Both packages including waste drums do not exceed six tons of total weight and their structure and external dimensions are identical. Performance of the packages is demonstrated by analyses and confirmed by safety tests. This paper describes the evaluation carried out to demonstrate the structural performance of two IP-2 packages and their compliance with the regulatory requirements.

IP-2 Packages

Two kinds of IP-2 packages with the same external dimension of 1.6mWx3.4mLx1.2mH are designed to transport eight LILW steel waste drums of 200-liter and 320-liter. The package as shown in Fig.1 consists of a body, a lid, lid bolts and internal drums. The body of packages is made of carbon steel of SS400 and shielding wall thickness of the body and the lid is 12mm. The lid is securely fastened down with lid bolts and waste steel drums are secured firmly by internal supports shown in Fig.2 to ensure that they do not move during transport. The packages including eight steel drums do not exceed six tons of total weight due to the capacity of the on-board crane of the purpose-built transport vessel. The design of the package incorporates criteria based on IAEA Safety Standards Series No.TS-R-1 and Korea Atomic Energy Act for Type IP-2 packages.

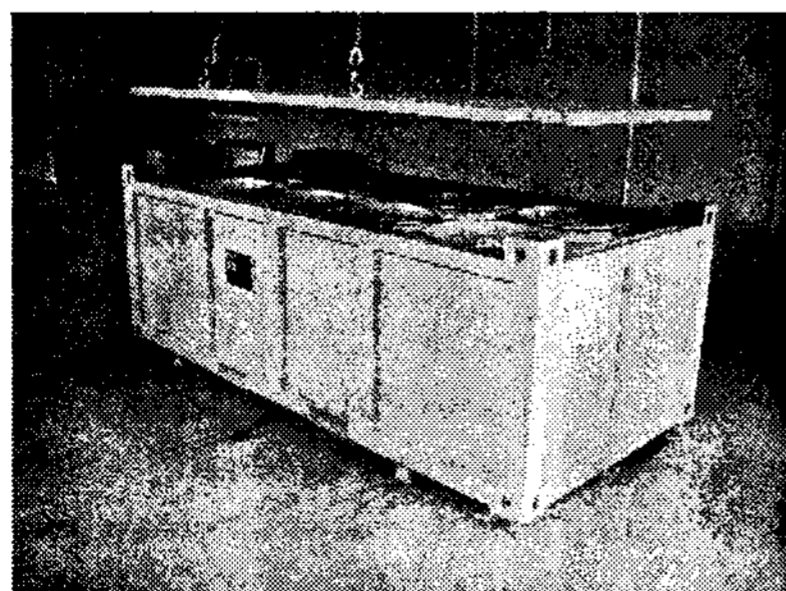


Fig.1 Overview of IP-2 package

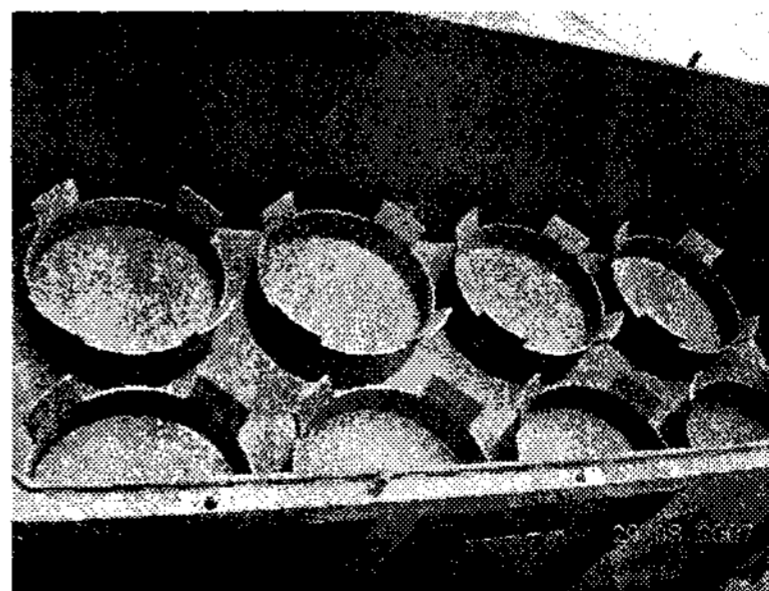


Fig.2 Drum supports inside the package

Structural Analyses

Structural analyses to ensure that the integrity of packages is maintained under all credible loads for free drop conditions specified in the regulations were performed using the LS-DYNA explicit transient finite element analysis code. Analyses for 0.9m free drop conditions were carried out for a total of 15 drop directions as shown in Fig.3 and Fig.4 such as vertical, horizontal, corner and oblique because it is difficult to define the impact direction for which maximum damage is expected. The analysis result for corner drop impact(direction 7) causing maximum stress is shown in Fig.5 and Fig.6.

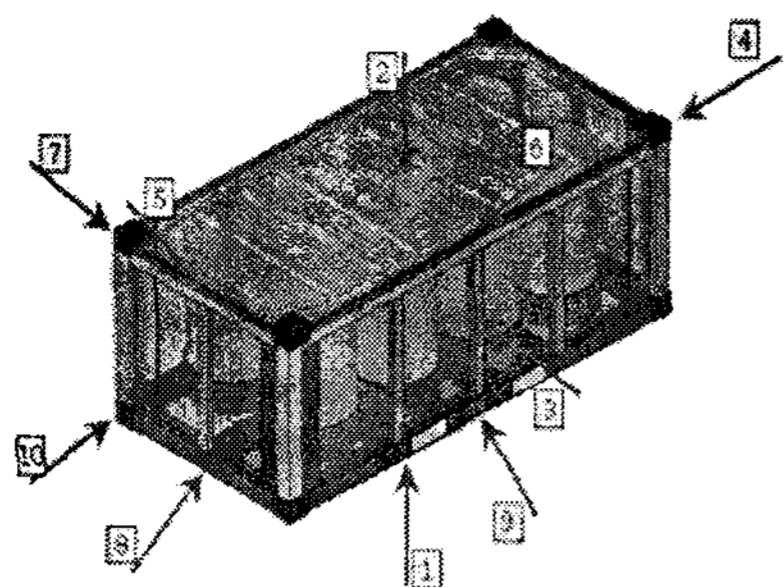


Fig.3 Drop directions for 200-liter drum package

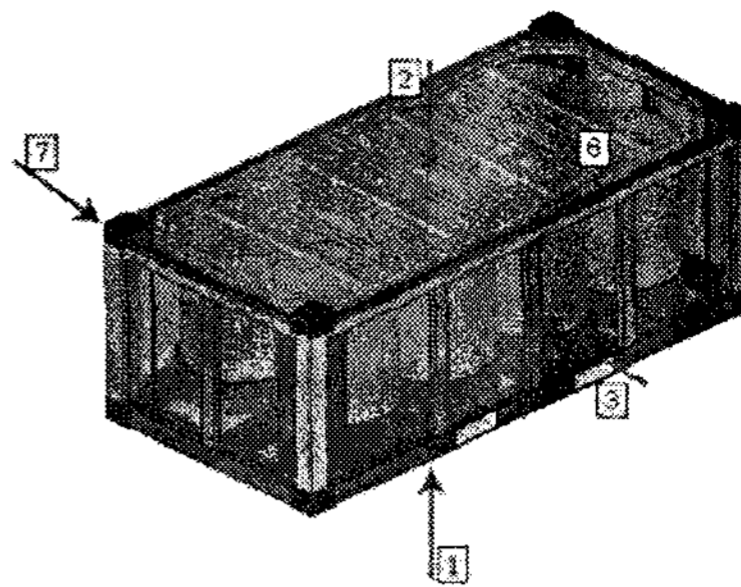


Fig.4 Drop directions for 320-liter drum package

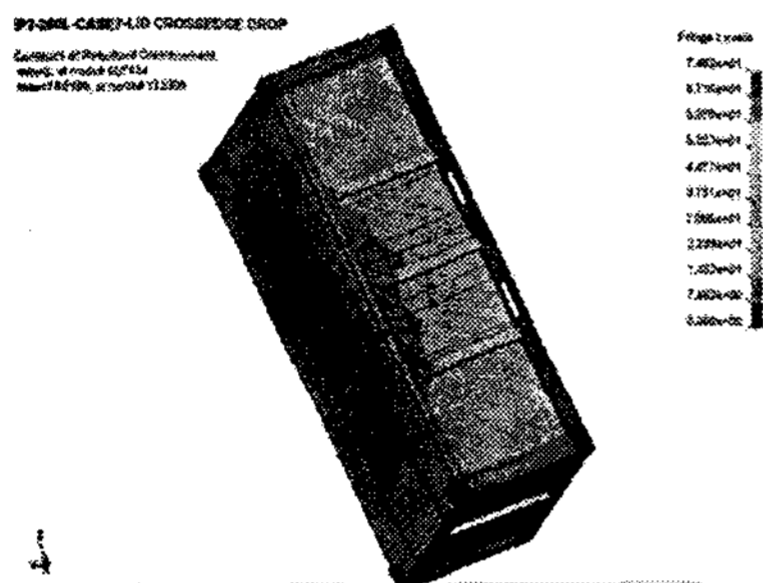


Fig.5 Corner drop analysis

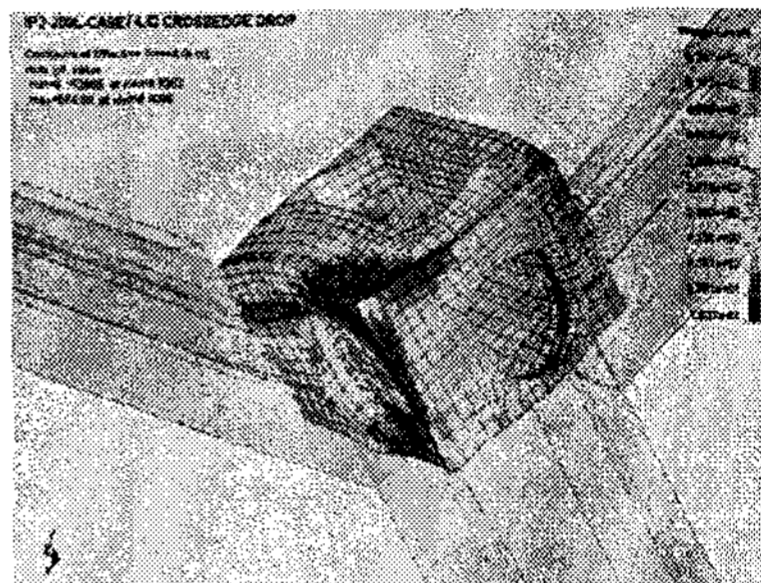


Fig.6 Deformation of corner fitting

Safety Tests

For confirmation and verification of the analysis results, a total of five free drop tests from 0.9m height onto a rigid target in different drop positions using two prototype package models. Figure 7 shows a vertical drop test of 200-liter drum package and Fig.8 shows the measured acceleration data.

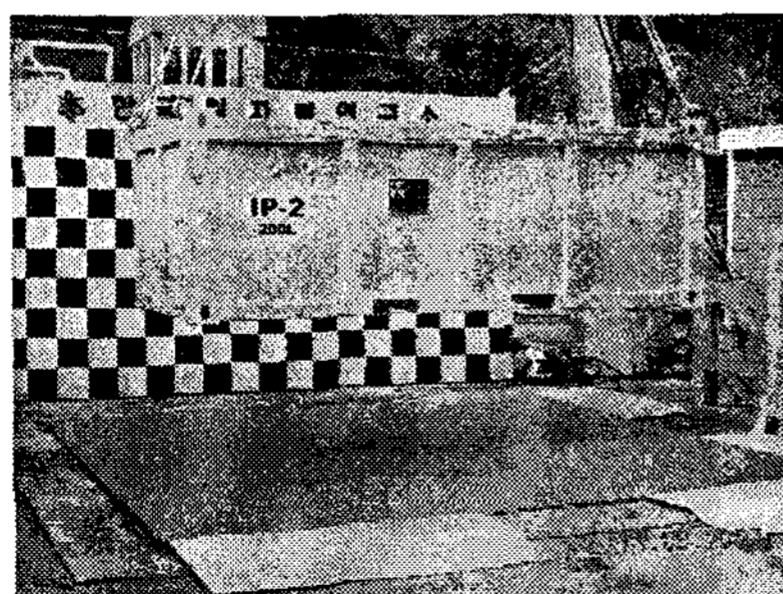


Fig.7 0.9m vertical drop test

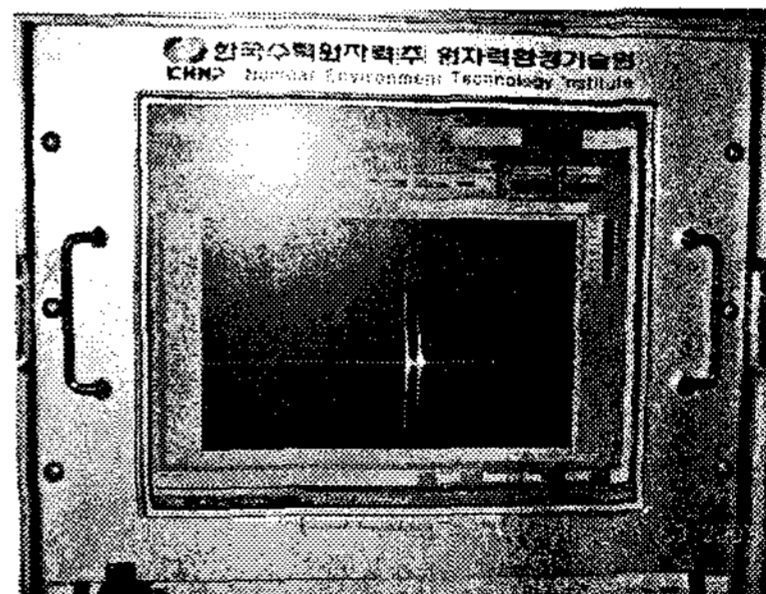


Fig.8 Measured acceleration

Conclusion

Structural performance of two IP-2 packages in normal conditions of transport was demonstrated by a combination of analyses using the verified code LS-DYNA and safety tests carried out on two prototype test models. The structural analyses and safety tests demonstrated that the packages comply with the regulatory requirements.

References

- [1] IAEA Safety Standards Series No.TS-R-1, "Regulation for Safe Transport of Radioactive Material", 2005
- [2] MOST Ordinance No.93, "Regulation on Technical Standards for Radiation Safety Management", 2006
- [3] MOST Notice No.2001-23, "Regulation for Packaging and Transport of Radioactive Material", 2001