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An Approach to the Localization of Technology for a Transport and Storage Container for Very Low-Level Radioactive Liquid Waste

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The structural safety of prototype transport and storage containers for very low-level radioactive liquid waste was experimentally estimated for its localization development. Transport containers for radioactive liquid waste have been researched and developed, however, there are no standardized commercial containers for very low-level radioactive waste in Korea. In this study, the structural safety of the designated IP-2 type container capable of transporting and temporarily storing large amounts of very low-level liquid waste, which is generated during the operation and decommissioning of nuclear power plants, was demonstrated. The stacking and drop tests, which were conducted to determine the structural integrity of the container, verified that there was no external leakage of the contents in spite of its structural deformation due to the drop impact. This study shows the effort required for the localization of the technology used in manufacturing transport and storage containers for very low-level radioactive liquid waste, and the additional structural reinforcement of the container in which the commercial intermediate bulk container (IBC) external frame was coupled.

Keywords: Radioactive waste container, Decommissioning, Nuclear power plant, Radioactive liquid waste

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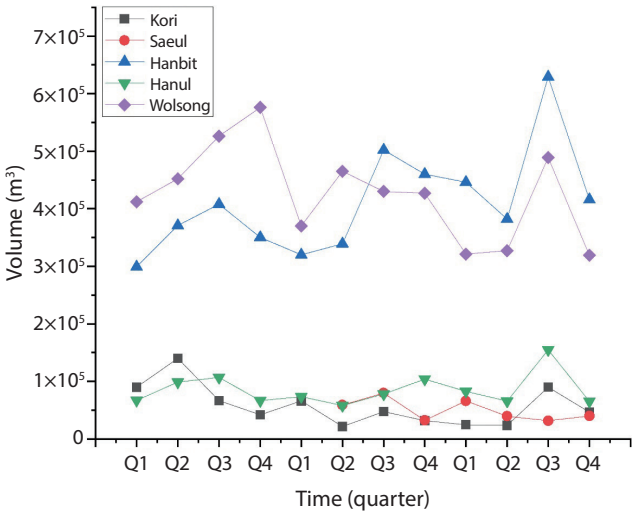


Fig. 1. The generation of radioactive liquid waste for each nuclear power plant site in Korea for 2018–2020.

1. Introduction

Decommissioning of nuclear power plants (NPPs) generates radioactive wastes in solid and liquid states contaminated by radioactive nuclides from nuclear fissions and neutron activations. For the safety of personnel, the public, and the environment, these wastes shall be safely transported within the NPP site or to a radioactive waste disposal facility.

National research institutes such as the Korea Atomic Energy Research Institute (KAERI) and Korea Hydro & Nuclear Power (KHNP) are already conducting transport container research and development focusing on their intended usage. However, there are no standardized commercial transport containers for very low level radioactive waste in Korea.

The liquid radioactive waste is generated during the decommissioning of an NPP from following procedures; cleaning the controlled area to reduce dust, decontaminating dismantled material, and washing the protective clothing used in the controlled area [1]. Furthermore, the liquid radioactive waste is continuously generated and treated by the operation of an NPP, as shown in Fig. 1, where liquid effluent is discharged into the environment after being treated via ion exchange, precipitation, evaporation, reverse osmosis, or filtration to reduce the radioactivity during the operation of NPPs [2].

Therefore, very low-level radioactive liquid waste (1 or more and less than 100 times limit concentration of clearance) is generated from the treatment of liquid waste during operation and decommissioning of a NPP, which requires a container capable of transporting and storing such a liquid waste. In this study, the effort to the localization of a container for transporting and storing very low level radioactive liquid waste is made.

2. Experimental

As shown in Fig. 2 and Table 1, a prototype IP-2 type IBC for transporting and temporal storing very low-level liquid waste was designed and manufactured. In addition, field tests such as stacking and drop tests were conducted in

Fig. 2. IP-2 type IBC (HDPE-$BaSO_4$) Prototype.

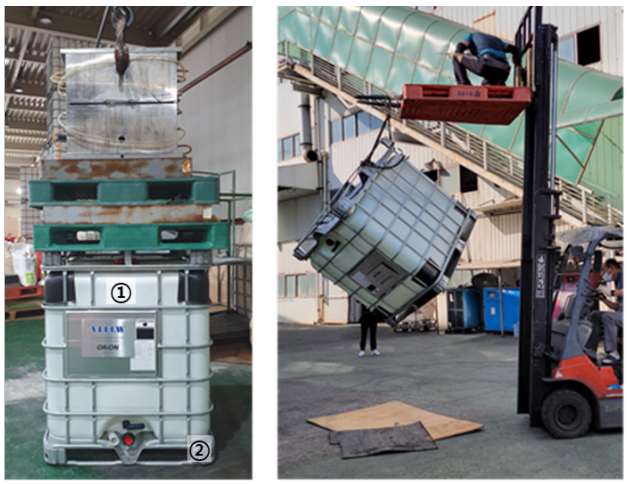
Table 1. Specification of IP-2 type IBC for transport and storage of very low-level liquid waste

Component		Specification		
		Size (mm)	Weight (kg)	
Inner container (Screw cap, drain valve)		1,180 (L) × 980 (W) × 940 (H) (Ø144, Ø56)	18	76 (1,080)[a]
External frame	Top cover	1,200 (L) × 1,000 (W) × 100 (H)*	23	
	Cage	1,200 (L) × 1,000 (W) × 1,045 (H)	15	
	Pallet	1,200 (L) × 1,000 (W) × 100 (H)	20	

* L: length, W: width, H: height
[a] Package weight

Table 2. Technical standard for testing IP-2 type transport container [4]

Test type	Criteria
Drop test	1.2 m height free-fall
Staking test	5 times the weight of the package or 13 kPa pressure



① Inner container ② External frame

(a) (b)

Fig. 3. IP-2 type IBC (HDPE-$BaSO_4$) staking and drop field test.

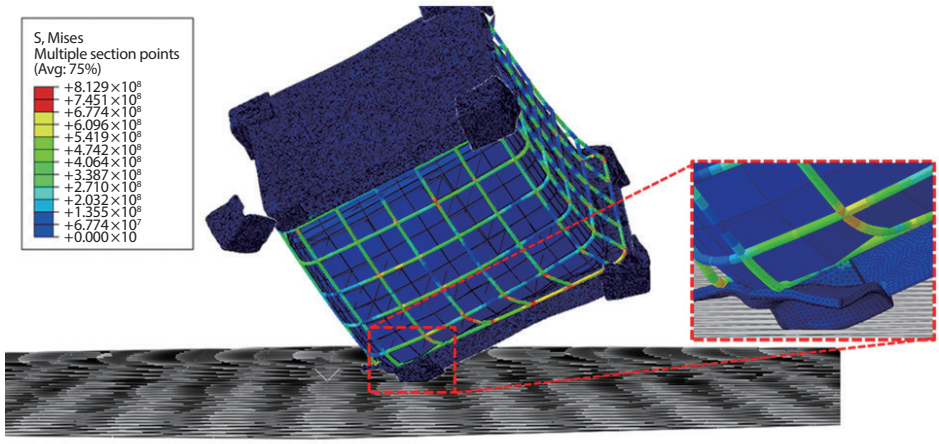
accordance with the technical standards for IP-2 type transport containers which are described in Table 2 in order to certify the integrity and structural safety of the transport container.

The IP-2 type IBC components are composed with top cover, inner container, cage and pallet, as shown in Table 1. The inner container comprises high density polyethylene (HDPE) pellets containing 20% of barium sulfate (HDPE-$BaSO_4$) that performs as an additional radiation shield [3].

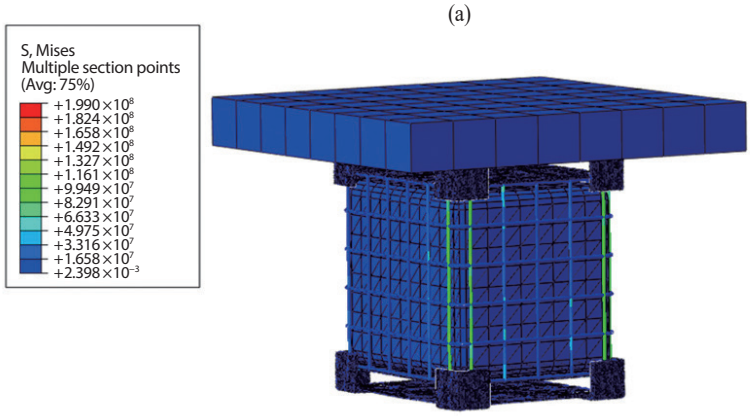
A field test and the structure analysis using ABAQUS/Explicit were conducted to evaluate the transport container structural safety, as shown in Figs. 3 and 4, using the normal transport condition test for the IP-2 type transport container. In the stacking test, 5,500 kg, which is more than five times the package weight of 1,080 kg, was stacked on the top of the container, and the test was carried out for 24 hours. In addition, IP-2 type container drop test was evaluated by a 45˚ incline drop and a free fall from a height of 1.2 m.

3. Result and Discussion

The structural analysis of the drop test in Fig. 4(a) shows that when the ground impacts, plastic deformation occurs in the top cover and cage, and there is no deformation due to stress within the elastic limit of the inner



(a)



(b)

Fig. 4. IP-2 type IBC (HDPE-$BaSO_4$) stacking and drop test structure stress distribution.

container. Furthermore, no plastic deformation was seen as a result of the structural analysis of the stacking test in Fig. 4(b). The stacking and drop tests demonstrated no leakage or loss of contents, as required by the IP-2 type transport container technical standard test. There was no deformation of the container or loss of contents during the stacking test, even though the load was more than 5 times the mass of the package layered on the top for 24 hours. In the drop test, however, the inner container and external frame were bent owing to the drop impact, but no leakage or loss of the package occurred, indicating the prototype container structural safety. In the IP-2 type drop test, the external frame of a commercial IBC container was deformed, requiring an additional design complement of the external frame.

4. Conclusion

The structural safety of the prototype container for very-low-level radioactive liquid waste was proven through the stacking and drop test, which showed the integrity of the container through no external leakage of the contents despite its structural deformation in terms of function. The study established the basis of localization of a container capable of transporting and storing very low-level radioactive

liquid waste produced during the decommissioning process and operation of an NPP. Further approach to the development of standardization of containers is thought to make it possible to apply to actually on-site temporary storage and transportation of very low-level radioactive liquid wastes in the nuclear installations such as nuclear power plants and disposal facilities.

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