Thermal characterization of Insulation of the Hot Cell Cask

K. S. Bang, J. C. Lee, W. S. Choi, K. O. Nam, K. S. Seo
Korea Atomic Energy Research Institute, 150 Dukjin-Dong, Yuseung-gu, Daejeon, Korea 305-353
nksbang@kaeri.re.kr

1. Introduction

In order to safely transport the radioactive waste arising from the hot test of ACP(Advanced Spent Fuel Conditioning Process) a shipping package is required. Therefore KAERI is developing a shipping package to transport the radioactive waste arising in the ACPF during a hot test.

Regulatory requirements for a Type B package are specified in the Korea MOST Act 2001-23, IAEA Safety Standard Series No. TS-R-1, US 10 CFR Part 71 and the US 49 CFR Part 173 [1~4].

These regulatory guidelines classify the hot cell cask as a Type B package, and state that the Type B package for transporting radioactive materials should be able to withstand for a period of 30 minutes under a thermal condition of 800 ℃. However, polyurethane, which is to be used as the filling within the impact limiter of the hot cell cask, has a very weak characteristic in a high temperature. Therefore it is difficult for resin or lead, which is used as a shielding material, to be protected under a thermal condition of 800 ℃.

Accordingly, thermal tests were carried out on specimens for 30 minutes under a thermal condition of 800 ℃.

2. Thermal Tests

2.1 Description of the Hot Cell Cask

The hot cell cask is to transport the radioactive waste arising in the ACPF during a hot test.

The hot cell cask, shown in figure 1, consists of an outer shell, an intermediate shell, an inner shell, a neutron shield, a gamma shield and a shock absorber.

The outer shell, intermediate shell and inner shell is made of stainless steel. The inner cavity between the outer shell and intermediate shell is filled with resin, which acts as a neutron shield. The inner cavity between the intermediate shell and inner shell is filled with lead, which acts as a gamma shield.

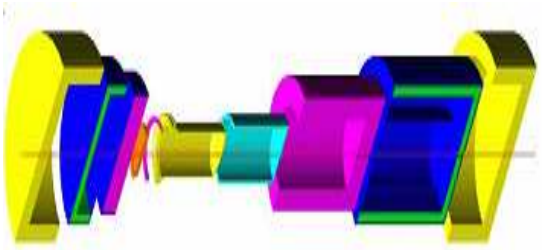

Figure 1. Configuration of the hot cell cask.

2.2 Measurement System

The temperature data acquisition system, which is to be used in the thermal test, consists of the thermo-couple scanner, the signal conditioner, the A/D converter and the P/C.

The signal, which is detected in the thermocouple scanner, is filtered and amplified through the signal conditioner, and converts the analog signal to the digital signal through the A/D converter. This signal is stored and analyzed by means of the software that is installed in the P/C.

2.3 Thermal Tests

As shown in figure 2, the thermal test was carried out in an thermal characterization test equipment with chamber dimensions of Φ 61 mm x 100 mm.

Table 1 shows the test specimens. Thermocouple was placed in the end of the specimen as shown in figure 3.

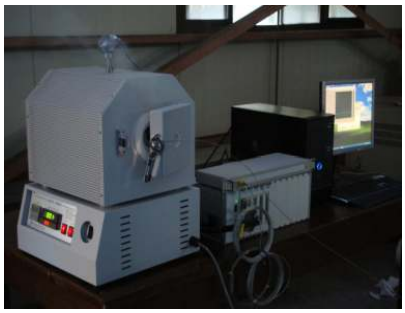

Figure 2. Thermal characterization test equipment.

Table 1. Specimens for Thermal Test

Specimens	Density (kg/m³)	Diameter (㎜)	Thickness (㎜)	ID
Non-combustible Poly-urethane	220	58	10	NU21~24
			20	NU17~20
			30	NU13~16
			40	NU09~12
			50	NU05~08
			100	NU01~04
Balsa Wood	100	58	10	BW21~24
			20	BW17~20
			30	BW13~16
			40	BW09~12
			50	BW05~08
			100	BW01~04

Figure 3. Specimens for Thermal Test.

The intent of the thermal tests was to provide a comparison of the ability of the materials to limit the heat flux into the package.

The thermal tests were performed as follows:

- The chamber of the thermal characterization test equipment was heated at 800℃.
- The specimen was inserted within the specimen chamber.
- The specimen was allowed to stand for a period at least 30 minutes under a thermal environment with an average temperature of at least 800℃.

2.3 Test Results and Discussion

The temperature profile for the non-combustible polyurethane and the balsa wood is shown in figure 4~5. The temperature data for the thermal tests are shown in table 2.

In the case of the non-combustible polyurethane, the specimen with 10 mm thickness was measured at 316 ℃ after 30 minutes under 800 ℃. The specimen with 50 mm thickness was measured at 117 °C after 30 minutes under 800 ℃.

In the case of the balsa wood, the temperature of the specimen with 10 mm thickness was over 300℃ after 5 minutes had passed under 800℃. The temperature of the specimens with 20, 30, 40 mm thickness was over 300℃ under 800℃ after 16 minutes, 21 minutes and 27 minutes had passed, respectively. Only the temperature of the specimen with 50 mm thickness was over 134℃ after 30 minutes had passed under 800℃.

These results indicate that the material with high-density and more thickness can provide a good thermal resistance.

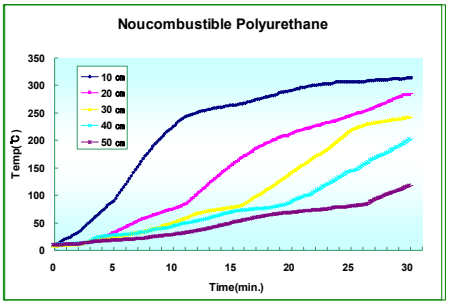

Figure 4. Temperature profile of Noncombustible Polyurethane.

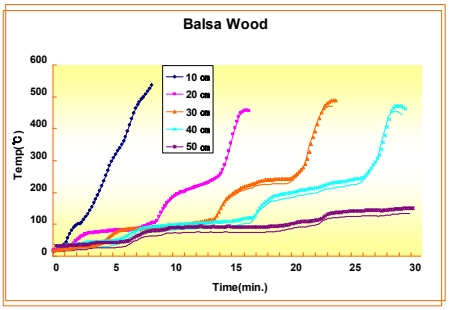

Figure 5. Temperature profile of Balsa Wood

Table 2. Thermal Test Results

Specimens	Thickness(㎜)	Temp.(℃)	Remarks
Noncombustible Polyurethane	10	316	After 30 min.
	20	285	After 30 min.
	30	242	After 30 min.
	40	200	After 30 min.
	50	117	After 30 min.
Balsa Wood	10	300	After 5 min.
	20	300	After 16 min.
	30	300	After 21 min.
	40	300	After 27 min.
	50	134	After 30 min.

3. Conclusion

The thermal tests were carried out to evaluate the ability of the materials to limit the heat flux into the package.

The main results were as follows:

ⅰ) The material with a high-density and more thickness can provide a good thermal resistance.

ⅱ) In the case of a use of lead as the gamma shield, to maintain the thermal integrity of the hot cell cask under a thermal condition of 800 ℃, the thickness of the non-combustible polyurethane must be more than 30 mm, and the thickness of the balsa wood must be more than 50 mm.

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.

[4] U.S. Code of Federal Regulations, Title 49, Part 173, "Shippers—General Requirements for Shipments and Packagings”, 2003 Ed.