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# Thermal Evaluation of a KRI-BGM Shipping Cask

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## 1. Introduction

Radioactive isotopes are used extensively in the fields of industry, medical treatment, food and agriculture. Use of radioactive isotopes is expected to increase continuously with the growth of each field.

In order to safely transport radioactive isotopes from the place of manufacture to the place of use, a shipping package is required. Therefore KAERI is developing the KRI-BGM shipping cask to transport the Ir-192 bulk radioactive material, which is produced at the HANARO research reactor.

The shipping package should satisfy the requirements which are prescribed 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 classify the KRI-BGM shipping cask as a Type B package, and their regulatory guidelines state that the Type B package for transporting radioactive materials should be able to withstand a period of 30 minutes under a thermal condition of 800 ℃. However, the polyurethane, which is to be used as the filling within the cavity of the KRI-BGM shipping cask, has a very weak characteristic in a high temperature. Therefore it is difficult for the depleted uranium(hereafter DU), which is used as shielding material, to be protected under a thermal condition of 800 ℃.

Accordingly, the KRI-BGM shipping cask, which applied non-combustible polyurethane and fireproof materials as the filling, was fabricated. The thermal tests by using prototype cask have been performed to estimate the thermal integrity of the KRI-BGM shipping cask under a thermal condition of 800 ℃.

## 2. Thermal Test

### *2.1 Description of the KRI-BGM shipping cask*

The KRI-BGM shipping cask, which is to transport Ir-192 radioactive isotopes, has a maximum capacity of 10,000 Curies. It weighs approximately 170 kg.

The KRI-BGM shipping cask, shown in figure 1, consists of an over-pack and a shielded package. The structural strength part of the over-pack, which is to protect the shielded package, is made of carbon steel, and the inner cavity of the structural strength part is filled with noncombustible polyurethane with a density of 200 kg/cm$^3$ and fireproof materials. The structural strength part of the shielded package is made of stainless steel. The shields of the shielded package consist of a main-shield and sub-shield. The main-shield is DU which is classified as a radioactive material. To perform the test by using DU, the test facility must receive approval as a Material Balance Area from the IAEA as well as a Nuclear Material Use Facility from MOST. However it is very difficult to receive such approval, because the test facility is an open space. Therefore, the main-shield of the test models was made of lead instead of DU.

The sub-shield is made of tungsten.

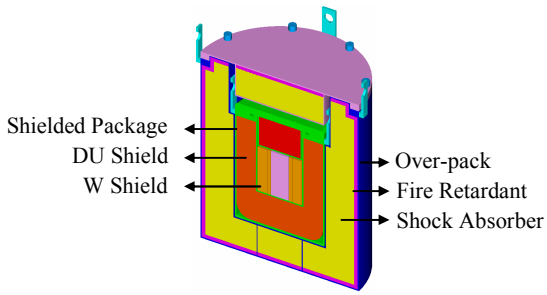


Fig. 1. Configuration of KRI-BGM Shipping Cask..

### *2.2 Thermal Test*

As shown in figure 2, the thermal tests were carried out in an insulated test chamber with the dimensions of 1.0 m x 1.0 m x 1.0 m.

The thermal tests were performed as follows:

- The supporter to set the test model within the test chamber was installed.
- The test model was set onto the supporter.
- The thermocouples for measuring the flame temperature inside the test chamber were installed.
- The water was filled with a height of 5 cm in the test chamber.
- The kerosene was filled with a height of 10 cm from the surface of the water.

Fig. 2. Test model in the test chamber.

- The test model was allowed to stand for a period of at least 30 minutes under a fully engulfed thermal

environment with an average flame temperature of at least 800℃.

- After the thermal test was finished, the test model was left in order to be cooled naturally.

### *2.3 Test Results and Discussion*

The K type thermocouples were used to monitor the temperature of the flame and the test model. The Thermo Labels, which be able to evaluate a change of temperature from 100 °C to 150 °C, were attached to identify the integrity of the O-ring, which was installed on the lid of the shielded package. No insolation was applied.

In the first thermal test, prior to the ignition of the fire, the environmental temperature in the test chamber was maintained at approximately 6 °C. Figure 3 shows the shape of the fully engulfed flame. Figure 4 shows the flame temperature during the thermal test. The average flame temperature measured in the thermal test was 865 °C. The maximum surface temperature of the shielded package was measured as 241 °C. The test model was disassembled in order to identify the state of the O-ring. The color of the Thermo Labels did not change and the O-ring maintained its original shape.

Fig. 3. The shape of the engulfed flame.

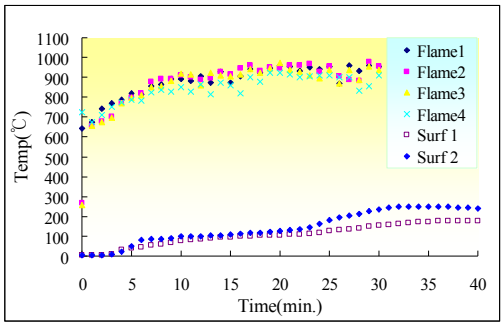


Fig. 4. Temperature profile in the first thermal test

In the second thermal test, the environmental temperature in the test chamber was maintained at approximately 16 °C before the ignition of the fire. The fire was applied for approximately 37 minutes, because the fire did not extinguish easily. Figure 5 shows the flame temperature during the thermal test. The average flame temperature measured during the thermal test was 728 °C. The maximum surface temperature of the shielded package was measured at 134 °C after the fire was extinguished and 1.7 hours had passed. The color of the Thermo Labels did not change like the first thermal test. The O-ring maintained its original shape also. From the results of the two thermal tests, the thermal integrity of the KRI-BGM shipping cask can be maintained under a thermal condition of 800 ℃.

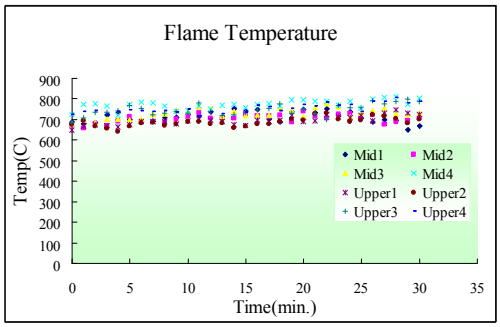


Fig. 5. Flame Temperature in the second thermal test.

## 3. Conclusion

As a part of the safety tests, a thermal test was carried out to evaluate the thermal integrity of the KRI-BGM shipping cask, which is to transport Ir-192 radioactive isotopes.

The main results were as follows:

ⅰ) The maximum surface temperature of the shielded package was measured as 241 ℃. Accordingly, the integrity of the depleted uranium shield is estimated to be maintained.

ⅱ) The color of the Thermo Labels did not change and the O-ring maintained its original shape. Therefore, the containment of the KRI-BGM shipping cask is safe under a thermal condition of 800 ℃.

ⅲ) Therefore, the thermal integrity of the KRI-BGM shipping cask is safe enough under a thermal condition of 800 ℃.

## 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.