Thermal Test of the Irradiator for Ir-192 110 Ci

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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 irradiator to transport the Ir-192 special form 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 guidelines classify the irradiator 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, the polyurethane, which is to be used as the filling within the cavity of the irradiator, has a very weak characteristic in a high temperature. Therefore it is difficult for depleted uranium, which is used as shielding material, to be protected under a thermal condition of 800 ℃.

Accordingly, the irradiator, which applied non-combustible polyurethane and fireproof materials as the filling, was made. The thermal test was carried out on the irradiator for 30 minutes under a thermal condition of 800 ℃.

2. Thermal Test

2.1 Description of the Irradiator

The irradiator, which is to transport Ir-192 radio-active material in a special form, is the shipping package for use as an industrial radiography exposure device. The irradiator has a maximum capacity of 110 Curies. It weighs approximately 21.1 kg.

The irradiator, shown in figure 1, consists of a cylindrical body, a shield, a front plate, a rear plate, a locking system, a tube and a shock absorber. Except for the shield, tube and shock absorber, all the components of the irradiator were made of stainless steel.

The shield was made of depleted uranium. The depleted uranium shield weighs approximately 16.4 kg.

The shock absorber was filled with noncombustible polyurethane with a density 200 kg/cm^3. The cavity between the cylindrical body and the deplete uranium shield was filled with noncombustible polyurethane with a density 200 kg/cm^3 and fireproof materials.

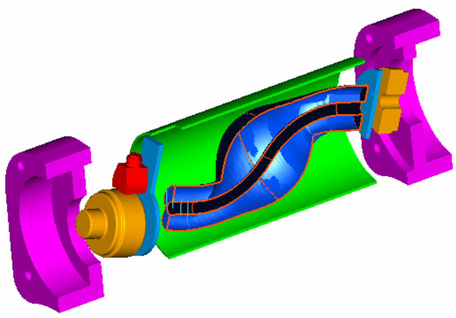

Figure 1. Configuration of the Irradiator.

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 thermocouple scanner can connect thirty-two thermocouples. 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. Also, the change of the temperature according to transient is monitored through the P/C.

2.3 Thermal Test

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

The thermal test was performed as follows:

- The supporter to set the irradiator within the test chamber was installed.

Figure 2. Irradiator in the test chamber.

- The irradiator 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.
- The irradiator was allowed to stand for a period at least 30 minutes under a fully engulfed thermal environment with an average flame temperature of at least 800℃.
- After the thermal test is finished, the irradiator is left in order to be cooled naturally.

2.3 Test Results and Discussion

Prior to the ignition of the fire, the environmental temperature in the test chamber was maintained at 6°C approximately. No insolation was applied. The K type thermocouples were used to monitor the temperature of the flame and the tube space of the irradiator.

The fire was applied for approximately 40 minutes, because the fire did not extinguish easily.

Figure 3 shows the shape of the fully engulfed flame. The average flame temperature measured in the thermal test was 807 °C. Therefore, the thermal condition, which is prescribed in the regulatory guide-lines, was satisfied.

Figure 3. The shape of the engulfed flame.

The maximum temperature of the tube space was measured at 343 °C after the fire was extinguished and the 30 minutes had passed. It is to say that the special form, which was located in the tube space, is safe under the thermal condition of 800 ℃.

The irradiator was disassembled in order to identify the state of the depleted uranium and noncombustible polyurethane.

As shown in figure 4, the surface of the depleted uranium was not burned by the fire. Also, the noncombustible polyurethane was not completely burnt. Its central appearance maintained its original color without changing into a black color.

It showed that the irradiator is sufficiently safe from the fire. Therefore, the thermal integrity of the irradiator can be maintained under a thermal condition of 800 ℃.

Figure 4. The depleted uranium shield after the thermal test.

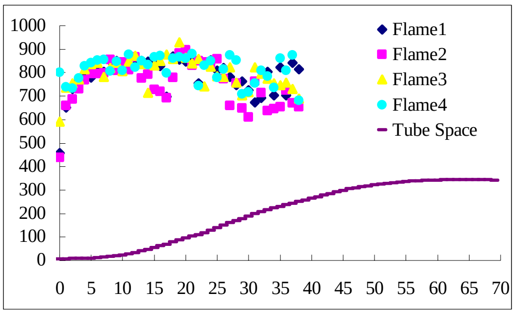

Figure 5. Temperature profile according to transient.

3. Conclusion

As a part of the safety tests, a thermal test was carried out to evaluate the thermal integrity of the irradiator, which is to transport Ir-192 radioactive material in a special form.

The main results were as follows:

i) The depleted uranium was not burned by the fire. Also, the noncombustible polyurethane was not completely burnt. Accordingly, the integrity of the depleted uranium shield is estimated to be maintained.

ii) The maximum temperature of the tube space was measured at 343 ℃. Therefore, the special form, which is transported by means of the irradiator, is safe under a thermal condition of 800 ℃.

iii) Therefore, the thermal integrity of the irradiator 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.