Development of Fresh Fuel Packaging for a Prototype Fast Breeder Reactor "MONJU"

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1. Introduction

Power Reactor and Nuclear Fuel Development Corporation (PNC) is now making an integrated function test of prototype fast breeder reactor "MONJU" in a reactor site and fabricating fresh fuel assemblies in Plutonium Fuel Production Facility (PFPF), aiming to put "MONJU" in criticality in the spring of 1993.

PNC has developed the packaging to transport fresh fuel assemblies from PFPF to the reactor site. The paper describes general specifications and characteristics of the packaging and the summary of prototype packaging tests.

2. General Specifications

The packaging is designed as type BU fissile package, and can accommodate "MONJU" fresh fuel assemblies. As shown in Photo 1, the packaging is cylindrical in shape and mainly consists of fuel holder, containment vessel and overpack. The summary of general specifications of the packaging is shown in Table 1.

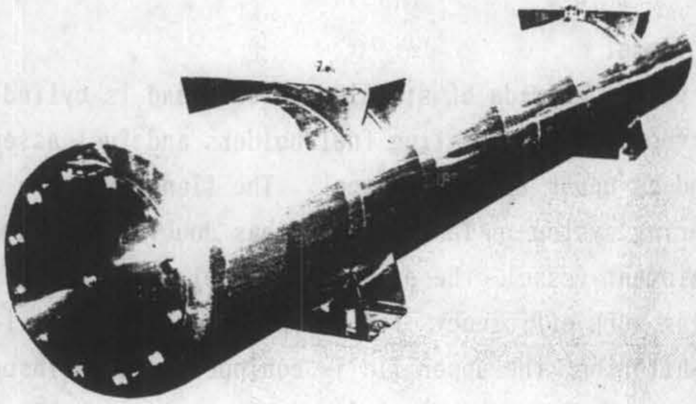

Photo 1 Outside View of Packaging

Table 1 General Specifications of Packaging

Type of Package	Type BU Fissile Package
Weight of Packaging	Approx. 2.26 ton
Size of Packaging • Length • Outer Diameter • Height	 Approx. 5,000 mm Approx. 630 mm Approx. 730 mm

2.1 Fuel Holder

The fuel holder is mainly made of stainless steel and it is equipped with the mechanism that automatically holds the fuel assembly during insertion of the assembly.

2.2 Containment Vessel

The containment vessel is made of stainless steel, and is cylindrical in shape. The containment vessel, accommodating fuel holders and fuel assemblies, is provided with a flange and an upper lid at its top. The flange and the upper lid are sealed with a double O-ring system. The packaging has double containment boundaries. One is the containment vessel, the other is fuel elements which are sealed with welding. Considering work efficiency, for the purpose of an easy leaktight test and α contamination monitoring, the upper lid is equipped with an inspection hole leading to the space between O-rings and also with a valve and a penetration hole which leads to the inside of containment vessel.

2.3 Overpack

The overpack is connected with the containment vessel at both ends. The overpack has neutron shielding material at the middle part of the containment vessel to shield the neutron from core fuel. Disk-type heat transfer fins are inserted in the shielding material at regular intervals to transfer the heat from fuel outwards.
A thermal insulator surrounds the neutron shielding material to prevent heat from coming in during the fire accident. The shock absorber to absorb a impact energy upon drop accident is installed at both ends.

3. General Characteristics

The packaging has the following characteristics as compared with traditional fresh MOX fuel packagings.

3.1 Neutron Shielding Material

It is necessary to efficiently shield the radiation emitted from fuel and to effectively transfer the heat discharged from fuel outward because the radiation and the heat from fuel is higher. The neutron shielding material heightened with the hydrogen content has developed to obtain good moldability, machinability and heat-resistance. The development makes it possible that neutron shielding material of a doughnut shape sandwiches heat transfer fins in between.

3.2 Automatic Holding System

The work to hold the fuel assembly has been performed by manual operation. The packaging, at the first time, incorporates the automatic holding system in the fuel holder to reduce the radiation exposure to worker. In the system, the fuel assembly is automatically fixed when the fuel assembly had been vertically loaded into the fuel holder by remote operation. The function of the automatic holding system are mechanically performed through spring, rod and cam kicked on by the inserted assembly. The fuel assembly is laterally supported with resin-made pads for holding.

3.3 Direct Tie Down System

In general, a shock absorbing device, together with tie-down device, is used in fresh fuel transportation from a fuel production plant to a reactor site to assure the integrity of fuel assemblies. The packaging adopted a direct tie-down device to facilitate the tie-down work and to lighten the weight. The direct tie-down device is directly fixed on a truck floor through rubber-vibration insulator mats instead of sophisticated shock absorbing devices.

4. Results of Prototype Packaging Tests

Shielding tests, handling tests, land cruising tests and sequential tests were executed using prototype packagings in order to experimentally confirm the performance of packaging and validity of design technique. Sequential tests were carried out in accordance with accident conditions specified in a domestic regulation.

4.1 Shielding Tests

The shielding tests was carried out using the "MONJU" fuel assembly. The radiation dose level was about 1/27 and about 1/8 as compared with criteria specified in the domestic regulation: 2 mSv/hr at the surface of package and 100 μSv/hr at a point one meter away from the surface. The test demonstrated that the packaging satisfied criteria sufficiently.

4.2 Handling Tests

In order to confirm function of automatic holding system, handling tests were carried out by remote operation using dummy assembly. The test demonstrated that the dummy assembly could be loaded into the fuel holder and unloaded from it, and the automatic holding system could be operated smoothly and easily.

4.3 Land Cruising Tests

Land cruising tests for the direct tie down system were carried out on test courses with the rugged road surface and on a general road and an expressway. As the results of this tests, the soundness of fuel assembly in land transport was confirmed.

4.4 Prototype Packaging Tests

In order to experimentally confirm the validity of design technique, 9-meter dropping and 1-meter puncture tests in horizontal and corner postures were executed using two prototype packagings. Furthermore, a prototype packaging dropped horizontally was applied to fire test of 800 ℃ for 30 minutes and immersion test of the hydraulic pressure of 1.5 kgf/cm^2 for 8 hours.

In the dropping tests, all of impact energy were absorbed by the overpack, and its deformation did not reach the containment vessel, and there was no crack on the surface of outer shell.

In the fire test, temperature of several points of inside packaging were measured. From results of measurement, the temperature at the double O-ring forming containment boundary of this packaging was within its usable temperature. Therefore, the required performance of containment was confirmed to be maintained.

In the immersion test, the containment vessel was undeformed by hydraulic pressure, and the there was no invasion to the containment vessel.

Leak tests of containment vessel and dummy assembly accommodated in the prototype packagings demonstrated that there was no significant difference between before and after the sequential tests and the leak rate was below permissible leakage specified in the regulation.

5. Conclusion

The packaging is developed to transport "MONJU" fuel assembly from PFPF to the reactor site. From the results of prototype packaging tests, it is confirmed that the package has expected integrity and meets all requirements of the domestic and IAEA regulations.

As compared with the traditional fresh MOX fuel packagings, the packaging has the following improvements.

① Development of the neutron shielding material with high shielding power, moldability and machinability leads to easy fabrication of complicated structure such as sandwich of shielding material and heat transfer fins.

② Development of the automatic fuel holding system, facilitating remote loading and unloading operations of fuel assembly by watching ITV, introduces reduction of radiation exposure to workers and efficient handling operations.

③ Adoption of the direct tie-down system, together with weight reduction of the whole transportation system, makes it possible that efficiency of the transportation is much improved as compared with the transportation using traditional MOX fuel packages.