Transport of Fresh MOX Fuel Assemblies for MONJU Initial Core

J. Kurakami, Y. Ohuchi, M. Usami
Power Reactor and Nuclear Fuel Development Corporation

INTRODUCTION

Shipment of fresh MOX fuel assemblies for prototype MONJU core started in July 1992 and ended in March 1994. MONJU is a prototype Fast Breeder Reactor in Japan. As many as 205 fresh MOX fuel assemblies were transported in nine shipment missions. This paper describes a summary of shipment and packaging.

GENERAL SPECIFICATIONS OF FUEL ASSEMBLY

The fuel assembly contains plutonium-uranium mixed oxide fuel, MOX fuel. The fuel assembly is approximately 4.2m in length and 185kg in weight. A cross-section of the fuel assembly is hexagonal in shape and its face-to-face distance is approximately 11cm. There are two types of fuel assemblies from the viewpoint of plutonium fissile content: One type, which contains 15% fissile plutonium, is used for the inner core of the reactor; the other type contains 20% fissile plutonium and is used for an outer core. The fuel assembly contains plutonium of about 7 to 9kg in metal.

SUMMARY OF SHIPMENT

The summary of shipment of fresh MOX fuel assemblies for MONJU initial core is shown in Table 1. As many as 205 fresh MOX fuel assemblies fabricated in the Plutonium Fuel Production Facility (PFPF) (109 assemblies for the inner core of the reactor, 91 assemblies for the outer core of the reactor, and 5 assemblies for the testing operation) and 65 neutron detection elements were transported from the PFPF in Ibaraki prefecture to the reactor site in Fukui prefecture. We fabricated and used 12 packagings for each transport. As the packaging can accommodate two fuel assemblies, 24 fuel assemblies are one unit of shipment.

Table 1. Summary of MOX Fuel Assemblies for MONJU Initial Core

Number of Shipment	Date of Transport	Number of Fuel Assemblies Transported	Number of Packagings Used	Type of Transport
1	Jul. 7, 1992	24 for Inner Core	12	Land
2	Sep. 4, 1992	24 for Inner Core	12	〃
3	Nov. 13, 1992	24 for Inner Core	12	〃
4	Dec. 16, 1992	24 for Inner Core	12	〃
5	Mar. 19, 1993	13 for Inner Core & 11 for Outer Core	12	〃
6	May. 18, 1993	17 for Outer Core & 3 for Testing	11	〃
7	Oct. 8, 1993	24 for Outer Core	12	〃
8	Dec. 21, 1993	20 for Outer Core & 65 Neutron Detection Elements	12	〃
9	Mar. 4, 1994	19 for Outer Core & 2 for Testing	11	〃
		Total : 205 Assemblies & 65 Neutron Detection Elements		

SUMMARY OF TRANSPORT CONVOY

A transport convoy consisted of trucks loaded with packages and escort-cars when the MOX fuels were transported. Three packages were loaded onto an 11-ton truck and fixed to the truck floor by means of a tie-down device. The tie-down device has three hinged harnesses to fix packages to the floor. The tie-down device can resist 10 times the weight of the packaging. The escort-cars were located in front of and behind the trucks. The purpose of the escort-cars was to take command of the transport convoy and to keep guard. All cars were equipped with a communication system to communicate with each other. In principle, the transport convoy ran in a line when other vehicles disturbed the formation or a traffic signal divided the line into parts, the transport convoy took time to resume the original formation.

SUMMARY OF PACKAGE

The cross-section view of a package for MONJU is shown in Figure 1. This package has been developed as the third generation of a fresh MOX fuel packaging on the basis of successful results of two packagings for a prototype ATR "FUGEN" and an experimental FBR "JOYO." The packaging is cylindrical in shape; approximately 5m in length, approximately 0.6m in diameter, and 2.2 tons in weight. The structure of the package consists mainly of an outer shell, neutron shielding material, shock absorbers, a containment vessel, and a fuel holder.

The package is in a vertical position when a fuel assembly is loaded or unloaded. It is designed as a type B(U)F package, and it meets national safety regulations which include IAEA regulations. In the process of package development we fabricated prototyped models and carried out the demonstration tests in accordance with the test standards of type B(U)F package in IAEA regulations.

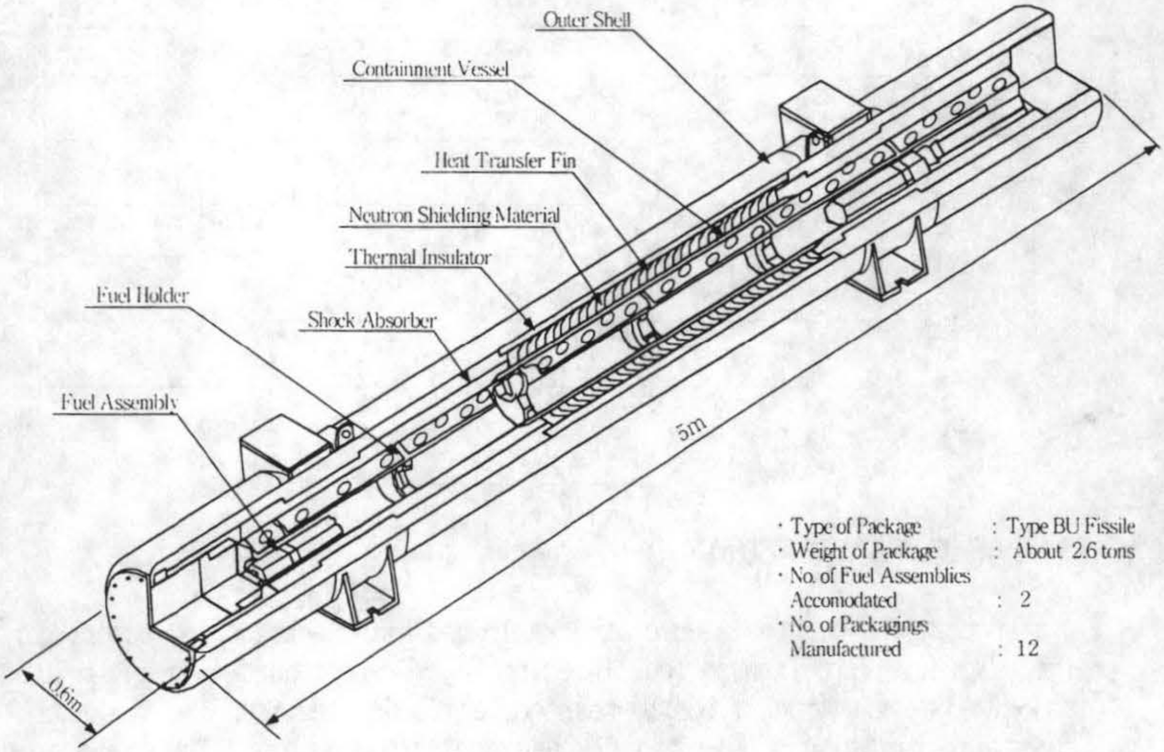


Figure 1. Cross Section View of Package for MONJU.

CHARACTERISTICS OF PACKAGING

The packaging has been designed using such advanced technologies as effective neutron shielding material and an automatic tie-down mechanism for the fuel assembly.

Development of Neutron Shielding Material

It is necessary to efficiently shield radiation emitted from MOX fuel and to effectively transfer heat discharged from MOX fuel outward, because the radiation and the heat from the fuel is higher. Material of the neutron shielding was originally based on epoxy resin and has a higher hydrogen content than that of epoxy resins. Moreover, the materials have good fabricability and machinability in the process of manufacturing and the materials also have good heat resistance. Development made it possible that neutron shielding material of a doughnut-shape sandwiches heat transfer fins in between. The actual maximum radiation dose equivalent rates measured were 105μSv/hr at the surface of the package and 17μSv/hr at 1m from the package. These values meet our domestic regulations criteria; 2,000μSv/hr at the surface and 100μSv/hr at 1m from the surface of the package.

Employment of Automatic Tie-down Mechanism

The automatic tie-down mechanism for fuel subassembly was adopted to avoid operators' unnecessary exposure to radiation. As shown in Figure 2, the mechanism consists of a spring, rods, cams, and pads. And the mechanism starts functioning when the loaded fuel assembly pushes the spring placed at the bottom of the fuel holder in the packaging. When the spring is compressed, the rod moves downward, and the pads close to fix the fuel assembly with the help of cams. The mechanism brought about a substantial reduction of loading operation time.

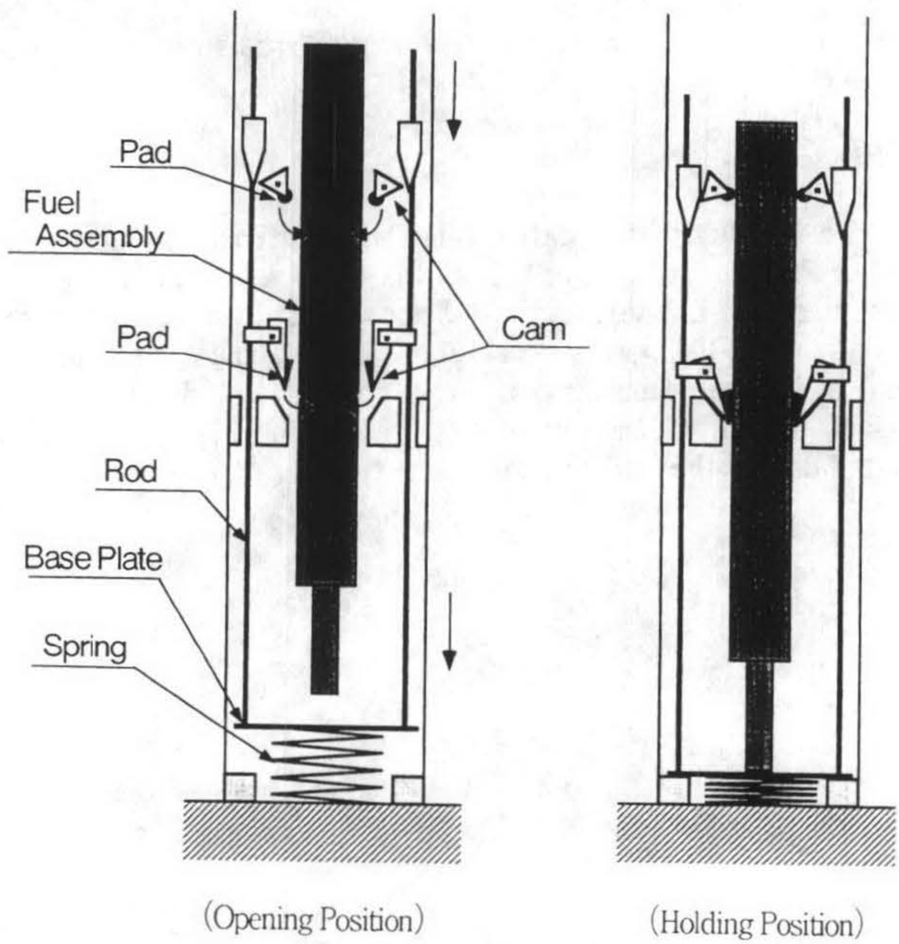


Figure 2. Automatic Tie-down Mechanism of Fuel Holder.

MEASURES OF SAFE TRANSPORT

We took several measures to ensure the safe transport of MOX fuel.

- A group as task force in PNC for public acceptance was established before the first shipment. The group made an extensive effort to gain a better understanding by the public about safety of the shipment.

- Transport control centers were established during each shipment at the departure site, the Tokyo head office, and the reactor site, in order to communicate closely with the transport convoy all the time on the 24 hours basis.

- Communication systems were reviewed between PNC and the Competent Authorities to make immediate and close contact, especially, in the hypothetical case of an emergency.

- A vehicle ran ahead of the transport convoy to gather traffic information along the route.

- A trial-run was also carried out before the first shipment to decide a route.

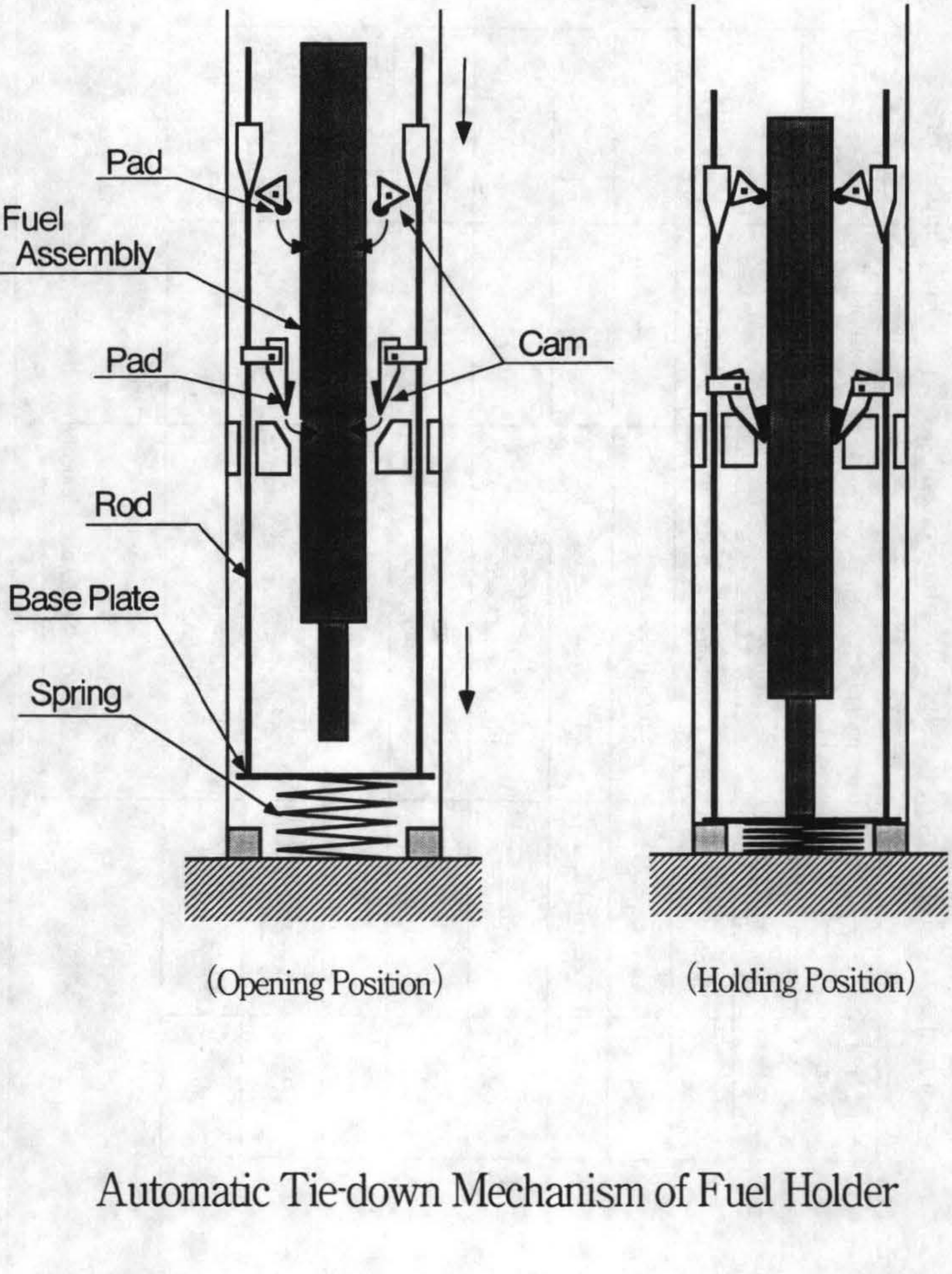
CONCLUSION

We finished nine shipments safely without any trouble. Neither accident nor trouble occurred during all shipments. The total weight of plutonium transported was approximately 1.5 metric tons. When we received plutonium returned from France in January 1993, we successfully employed the same transport system to carry out a domestic transport of the plutonium from a Japanese port to PFPF. We continue the safe transport of MOX fuel by putting to good use experiences accumulated during the MONJU initial core transport.

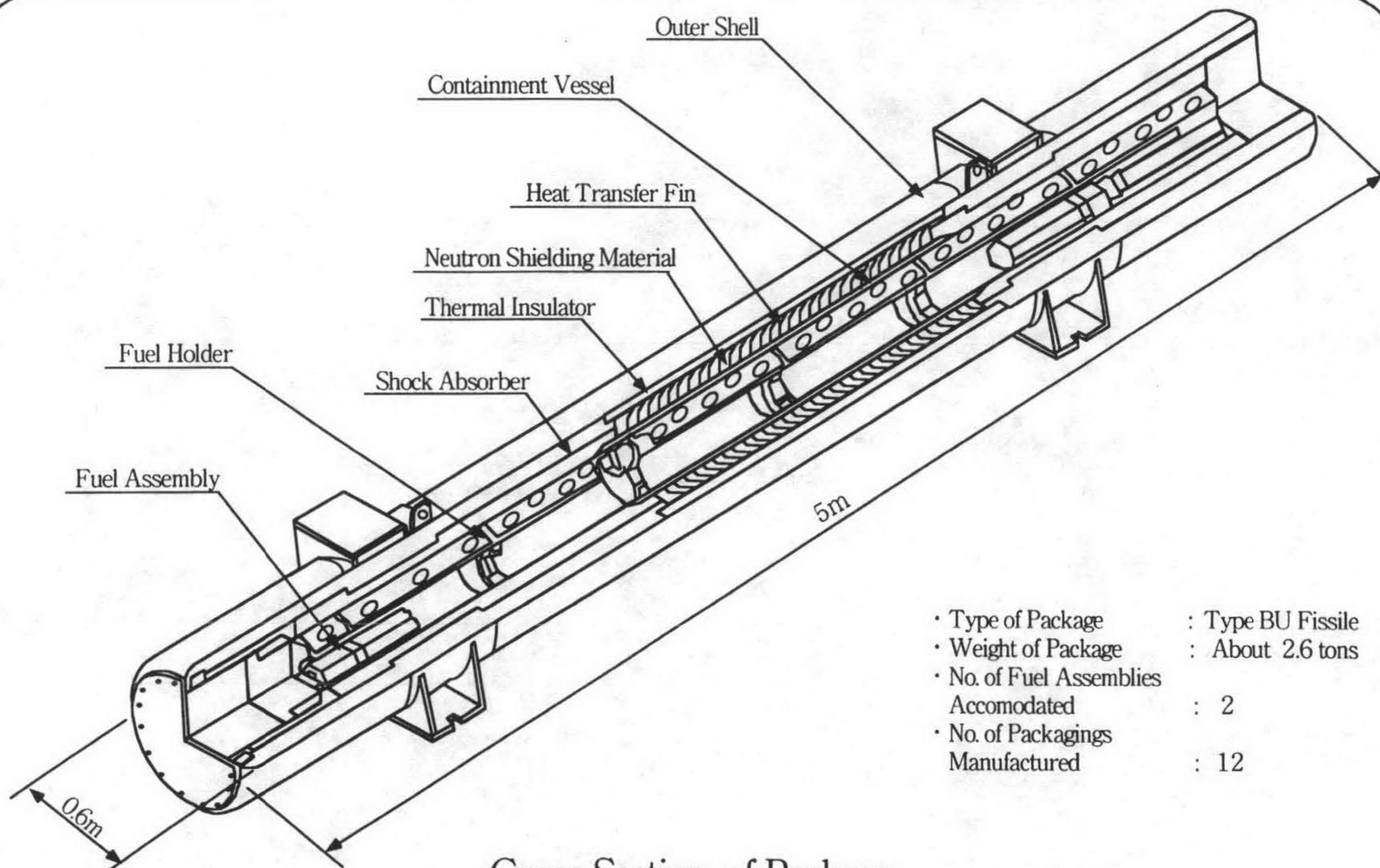
PNC

Summary of Shipment of Fresh MOX Fuel Assemblies for MONJU Initial Core

Number of Shipment	Date of Transport	Number of Fuel Assemblies Transported	Number of Packagings Used	Type of Transport
1	Jul. 7, 1992	24 for Inner Core	12	Land
2	Sep. 4, 1992	24 for Inner Core	12	〃
3	Nov. 13, 1992	24 for Inner Core	12	〃
4	Dec. 16, 1992	24 for Inner Core	12	〃
5	Mar. 19, 1993	13 for Inner Core & 11 for Outer Core	12	〃
6	May. 18, 1993	17 for Outer Core & 3 for Testing	11	〃
7	Oct. 8, 1993	24 for Outer Core	12	〃
8	Dec. 21, 1993	20 for Outer Core & 65 Neutron Detection Elements	12	〃
9	Mar. 4, 1994	19 for Outer Core & 2 for Testing	11	〃
		Total : 205 Assemblies & 65 Neutron Detection Elements		



Automatic Tie-down Mechanism of Fuel Holder



- Type of Package : Type BU Fissile
- Weight of Package : About 2.6 tons
- No. of Fuel Assemblies Accomodated : 2
- No. of Packagings Manufactured : 12

Cross Section of Package