Sea Transport of Plutonium by the Akatsuki Maru

M. Kubo, H. Matsushima, T. Kitamura, T. Ito
Power Reactor and Nuclear Fuel Development Corporation

1. Introduction

The dedicated plutonium transport ship Akatsuki-Maru which left Cherbourg port in France in November, 1992 and then sailed down the Atlantic with the Japanese Maritime Safety Agency's Escort Vessel, safely arrived at a port in Tokai in Japan in January the following year after a 30,000-kilometer non-stop voyage of a little less than 2 months around the Cape of Good Hope and via the Indian Ocean, the Tasman Sea, and the Pacific.

The transport was planned and carried out by Power Reactor and Nuclear Fuel Development Corporation (PNC) according to a policy for the transport of returned plutonium defined by the Atomic Energy Commission of Japan by which the sea transport should conform to the Annex 5, Guidelines for the International Transportation of Recovered Plutonium, Implementing the Agreement between Japan and the US pursuant to Article 11 of the Agreement for Cooperation Concerning Peaceful Uses of Nuclear Material. It was a large-scale international project with close cooperation among the governments and related organizations of the countries concerned including the United States, France, the United Kingdom, and Japan, extending over a relatively long period if the preparatory stage is included. The successful completion of this transport was due substantially to the cooperation and understanding of these countries and others.

The amount of plutonium carried was about 1.7 tons in the form of plutonium dioxide (equivalent to about 1 ton of fissile plutonium). About 30 tons of plutonium in total will be recovered from overseas reprocessing of the spent fuels of Japanese electric utility companies. The initial plutonium returned by PNC has been used at the Plutonium Fuel Production Facility of PNC's Tokai Works as a raw material to fabricate new reload-fuel assemblies for the prototype fast breeder reactor Monju, which reached its initial criticality in April 1994.

The following explains the careful preparations undertaken to ensure the safety measures for the hardware including packaging, the ship and transport operations.

2. Principal measures to secure the safety of sea transport

Prior to the sea transport, PNC carried out the necessary procedures to conform with a number of international conventions and rules including the IAEA Requirements for the Safe Transport of Radioactive Materials (Safety Series No. 6), the International Convention for the Safety of Life at Sea (SOLAS), the International Maritime Dangerous Goods Code (IMDG Code), the Convention on the Physical Protection of Nuclear Material and INFCIRC/225/Rev. 2, Agreement for Cooperation between Japan and the USA concerning Peaceful Uses of Nuclear Energy and the Annex 5, Guidelines for the International Transportation of Recovered Plutonium and the Japan-France Atomic Energy Cooperation Agreement, the domestic laws of each country, and the like.

(1) FS-47 packaging

The FS-47 packaging was designed by COGEMA in France and satisfies the requirements for type-B fissile packaging stipulated in the IAEA requirements and has already been used many times in the transport of plutonium in Europe with the approval of not only France but also Germany and Belgium. This packaging obtained the approval of the Science and Technology Agency (STA) of Japan after a rigorous safety examination.

A FS-47 package weighs approx. 1.5 ton in total. It is approx. 0.8 m in outer diameter and approx. 2 m in height, and has a multi-containment structure. The main body of the packaging is composed of an outer cylindrical shell made of steel and an inner one made of stainless steel, and contains thermal insulating material and neutron shielding material inside. The cans containing the plutonium dioxide are tightly sealed by welding and are put into a cartridge, which is then put in a container. These receptacles compose the contents of the package.

Structural strength, thermal performance, containment performance, shielding performance, and sub-criticality performance were analyzed beforehand and a number of tests were carried out on prototype packages : Drop test-I onto an unyielding target from a height of 9 m, Drop test-II onto a protruding object from a height of 1 m and a fire test with an ambient temperature of 800 ℃ for 30 minutes. It was confirmed that all the results conformed to the criteria and were then approved by the competent authorities.

A total of 133 packages were used in this transport. These were packed into 15 transport containers and then fixed into the cargo holds of the transport ship.

Meanwhile, in order to test the hypothetical case of accidental submergence the STA carried out in February, 1992 at the Nuclear Safety Technology Center a demonstration test for hydrostatic pressure resistance of the package equivalent to a sea depth of 10,000 meters, using the containment vessel of the packaging in order to confirm its containment performance. The test was implemented in the Marine Science and Technology Center's high-pressure experimental tank unit. The test results showed that the deformation of the containment vessel was elastic under a pressure equivalent to that at a depth of 5,000 m and there was no change in the containment performance. Furthermore, partial deformation occurred to the vessel body at a pressure equivalent to a depth of 10,000 m but this deformation ceased during the test of 20 minutes. This test clearly demonstrated that the packages containment performance was unimpaired even under such conditions.

(2) Plutonium transport ship Akatsuki-Maru

The transport ship Akatsuki-Maru satisfies not only the International Convention for the Safety of Life at Sea (SOLAS), the International Maritime Dangerous Goods Code (IMDG Code), and the Ship Safety Law and other rules but also the special requirements of the Ministry of Transport of Japan for the structure and equipment of a plutonium transport ship, so it has the following structure and equipment.

(1) Ship's structure
- (a) Stability of the transport ship if damaged:
  The ship retains adequate stability to resist capsizing even if the cargo hold was damaged and flooded with sea water and the ship listed as a result.
- (b) Cargo hold structure:
  The walls of the cargo holds are of double construction.
- (c) Anti-collision structure:
  The cargo is structurally protected from an impact into the side hull by another ship.

(2) Equipment
- (a) Tie-down devices:
  These devices keep the cargo from shifting.
- (b) Radiation measurement equipment:
  The necessary radiation measurement equipment to measure the radiation dose rate and surface contamination are installed.
- (c) Drainage equipment in the cargo hold:
  Any bilge water generated in the cargo holds would be pumped into a storage tank.
- (d) Emergency flooding device:
  As a last resort means of fire extinguishing, the cargo holds can be flooded with water.
- (e) Emergency power supply unit:
  Additional electric power could be supplied for a sustained period during an emergency.
- (f) Navigation equipment:
  In addition to the navigation equipment normally required, additional radar and automatic anti-collision aid devices and location measurement devices for ships are installed for navigational safety purposes.
- (g) Structures and equipment related to physical protection
  The transport ship, equipped with two propellers driven by two diesel engines, can sail from France to Japan without any port-call en route.

These special requirements as domestic standards were introduced at the conference of the IMO in 1979 for subsequent deliberation, resulting in the adoption of the INF Code (Code for the Safe Carriage of Irradiated Nuclear Fuels, Plutonium, and High-level Radioactive Wastes in Flasks on Board Ships) at the IMO general conference in November 1993.

The transport ship Akatsuki-Maru, originally one of the spent fuel carriers owned by PNTL of the United Kingdom, was selected since it satisfied the above stringent standards and had already been used more than a hundred times for the sea transport of spent fuels. The ship was subsequently modified as required under the Japan-US Atomic Energy Cooperation Agreement, and in accordance with MOT regulations. Finally, the ship was inspected by the relevant authorities and registered under the Japanese flag.

3. Transport route measures

In accordance with the above-mentioned guidelines, the route and departure/arrival times were carefully selected to avoid possible areas of natural disaster or civil disorder and to secure the safety of the cargo and the ship itself. A plan was made for a non-stop voyage from France to Japan, in principle. The route was established so that the ship would sail as far away as possible from the shore, in principle, and to avoid encountering other ships en route from the viewpoint of security and safety.

During the voyage of the transport ship, information such as the situation of the cargo in the hold and the location of the ship were automatically transferred to the operations center in Japan via the INMARSAT communication satellite. The information was appropriately processed by the operations center and directions when needed were sent from the center to the transport ship.

4. External circumstances

The plutonium transport of the Akatsuki-Maru undeniably generated world wide concern and attentions. PNC believes one of these major causes of such concerns was a lack of accurate informations. The Japanese government, Japanese embassies abroad and the PNC sincerely responded to these questions and concerns according to Japanese policy that we will provide appropriate information regarding the safety of the transport, while keeping under control information that should be kept confidential from the viewpoint of security. It is necessary for us to continue these activities for public acceptance, based on the above policy, and to obtain public understanding.

5. Conclusions

The movement of the plutonium returned from France by the transport ship Akatsuki-Maru demonstrated that the sea transport of plutonium could be safely and securely executed in accordance with current stringent international and domestic safety standards, with close cooperation with the appropriate countries. The shipped plutonium has been supplied to the Japanese prototype fast breeder reactor Monju for fuel.

PNC learned a great deal through this sea transport plan. Our lessons should be utilized appropriately for future plans, with suitable improvements if necessary, and we expect to obtain a higher degree of understanding and confidence internationally and domestically.