Experiences on Domestic Transportation of Spent Nuclear Fuels in Japan

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INTRODUCTION

Currently, most of the spent fuel from nuclear power stations in Japan is transported to oversea's reprocessing plants (COGEMA, BNFL), although part of it is reprocessed by Power Reactor and Nuclear Fuel Development Corp., (Hereafter called PNC) at Tokai-mura in Ibaraki Prefecture. This spent nuclear fuel is transported by sea to this domestic reprocessing plant on a exclusive use ship the Hinouramaru.

This year is the fourteenth year since the first shipment held in January 1978. During that period some 550 MTU was transported in about 100 trips, using a total of about 200 casks. (These figures do not include irradiated test-use nuclear fuel.)

Nuclear Fuel Transport Co, Ltd. was originally set up as Nuclear Transport Services Company (hereaftercalled NTS) to transport nuclear fuel, the investment being provided by power companies, transport companies, and trading companies. At that time, as a contractor for spent nuclear fuels, it provided technical guidance concerning spent nuclear fuel transportation to transport companies. Subsequently in line with the development of domestic nuclear fuel cycle planning, the company strengthened its organization and changed its name in 1986 from NTS to Nuclear Fuel Transport Co., Ltd.. (hereafter called NFT) in order to perform overall transportation of spent nuclear fuel, low-level radioactive waste, returned waste, etc., in place of the each electric power company. It now plays a central role in the transportation of downstream part of the domestic nuclear fuel cycle.

Maritime transportation of spent fuel in Japan was introduced in 1980 at PATRAM '80 by NTS. The following is a report of the results of transportation in the ten years following that date and of expected future trends.

OUTLINE OF DOMESTIC MARITIME TRANSPORTATION

(1) Outline and Locations of Nuclear Facilities

(a) Nuclear Power Stations

As of the end of March 1992, there were 41 nuclear power stations in Japan, with an operating capacity of 33,239 MW. The spent nuclear fuels from nine of these power stations are transported to the reprocessing plant inside Japan.

The locations of the nuclear power stations and the reprocessing plant are shown in Figure 1.

(b)Reprocessing Plant

Currently, reprocessing of spent nuclear fuel in Japan is carried out at the reprocessing plant of the PNC's Tokai facility at Tokai-mura in Ibaraki Prefecture.

This plant has an original design reprocessing capacity of 0.7 MTU per day, or 210 MTU per year, although it is currently operating at 60 to 90 MTU per year.

(2) Spent Nuclear Fuel Transportation Ship Hinouramaru

The Hinouramaru has been specially adapted for the transportation of spent nuclear fuel. It can carry up to 4 spent nuclear fuel casks at the same time. The ship's technical standards are in accordance with those laid down by the Ministry of Transport.

An outline of the special structure and of the facilities of the Hinouramaru is given below.

An external view of the Hinouramaru is shown in Figure 2. Table 1 shows the outline of the Hinouramaru.

1) Special Structure

(a) Impact Resistance

If another ship collides with the Hinouramaru, the double-hull construction with longitudinal bulkheads in the sides protects the package in the hold from the bow of the other ship and also minimizes the possibility of sea water entering the hold.

(b) Stranding-resistance

The inner bottom plating has a double structure and is raised in such a way as to prevent the amount of water entering the hold if the ship strands.

(c) Stability characteristic

The Hinouramaru has a recovery capability that will prevent it from listing more than 25° under normal sailing conditions and even if sea water simultaneously enters two subdivisions separated by a transverse bulkhead in the unlikely event of the outer plating being damaged.

(d) Shield Structure

The hold has a shielding tank with water around it and a shield cover on the ceiling. The shielding tank and the shielding cover are designed so that the crew members are exposed to the same annual dose of radiation as is the general public.

2) Special Equipment

(a) Cargo Cooling Equipment

The Hinouramaru is equipped with a cooling system to prevent the temperature inside the hold from rising above 38° C.

(b) Restraining Equipment

The Hinouramaru is equipped with restraining devices to prevent the casks HZ-75T, NH-25 and MSF-1 in the hold from moving around or tipping over.

All of the devices are designed to maintain the casks securely in place even if the ship rolls 45° and/or pitches 10° .

(c) Hold Flooding Equipment

The Hinouramaru has flooding equipment for each of the holds in case the temperature in a hold rises abnormally.

(3) Navigation Routes and Required Hours between Nuclear Power Stations and Reprocessing Plant

The navigation routes from each nuclear power station to the Tokai reprocessing plant can be broadly divided into northern routes and southern routes.

The northern routes are used for power stations to the north of the Shimane power station on the Sea of Japan, while the southern routes are used for power stations to the south of the Genkai power station.

The longest route is that from Genkai power station to the Tokai port, a navigation of about 4 days and 3 nights.

The shortest route is that from Fukushima No. 1 power station, a single overnight navigation.

(4) Meteorological Conditions

Surrounded by sea, Japan is ideally suited to maritime transportation. However, because this mode of transportation is dependent upon sea weather conditions, transportation is sometimes delayed by stormy weather and other phenomena, and these ever-changing weather and sea conditions must therefore be taken into consideration when the schedule is prepared.

Winter (roughly, November to March)

During this period, a high atmospheric pressure region is located over the Chinese mainland and a low-pressure region is located over the sea to the northeast of Japan Islands. This arrangement of atmospheric pressures causes Japan to receive strong northwesterly winds, and high swells are generated along the coast of the Sea of Japan. As a result, transportation from power stations situated on the Sea of Japan side is not normally carried out during this period, although transportation from power stations on the Pacific coast is usually carried out.

Summer (roughly June to September)

During this period, the Pacific high atmospheric pressure region over the seas around Japan extends southwards and weather conditions become relatively stable. However, in the latter half of summer, typhoons develop further to the south over the central Pacific and frequently pass over Japan, causing the seas around the archipelago to become very stormy. At this time of year, therefore, although the preparation of transportation plans should proceed with caution, especially in the latter half, efforts are centred on transportation from the power stations on the Sea of Japan coast, which cannot be performed in winter.

(5) Spent Fuel Casks

EXCELLOX-3A casks were used first, when transportation operations began. However, HZ-75T casks, with their increased loading capability, were subsequently introduced and are now the only ones used for spent fuels from power stations, although irradiated test fuel is sometimes transported in small casks exclusively designed such as NH-25 and MSF-1 types. The outline of each type of cask is shown in Table 2.

TRANSPORTATION PROCESS

The transportation of spent fuels begins with the dispatching of empty casks from the reprocessing plant to the nuclear power station by way of overland and maritime routes. At the power station, the spent fuels are loaded into the casks, which are then transported by maritime and overland routes back to the reprocessing plant.

The main steps involved in the transportation and the number of days required are shown below. Figure 3 is a schematic drawing of the transportation process for loaded casks.

(1) Dispatch of empty casks from reprocessing plant
(2) Overland transportation at Tokai — 1 day
(3) Loading onto the vessel at Tokai port
(4) Maritime transportation of empty casks — 1-3 days
(5) Unloading of empty casks from the vessel at power station port — 1 day
(6) Transportation on power station premises
(7) Loading of spent fuel inside fuel handling facility — 20-30 days
(8) Inspection of loaded casks before shipment
(9) Transportation of loaded casks on power station premises — 1 days
(10) Loading onto the ship at power station port
(11) Maritime transportation of loaded casks — 1-3 days
(12) Unloading of loaded casks from the vessel at Tokai port
(13) Overland transportation at Tokai — 1 day
(14) Carrying-in to reprocessing plant

TRANSPORTATION RESULTS

Since her first transportation of spent nuclear fuel from Fukushima No.1 Nuclear Power Station to the Tokai Reprocessing Plant January 1978, Hinouramaru has carried about 200 casks containing about 550 tons of uranium in total, by 100 navigations service from 9 power stations until end of March 1992.
Transported quantities by year are summarized Table 3 and Figure 4.

FUTURE TRENDS OF DOMESTIC TRANSPORTATION OF SPENT NUCLEAR FUEL

With the aim of establishing a nuclear fuel cycle in Japan, progress is being made by Japan Nuclear Fuel Ltd. on construction plans for a uranium enrichment facility, a spent fuel reprocessing plant, a low-level radioactive waste disposal centre, and other nuclear fuel cycle facilities at Rokkasho-mura in Aomori Prefecture.
The uranium enrichment facility began operation in March 1992, and the low-level radioactive wastes disposal centre is expected to begin accepting low-level radioactive wastes in December 1992. Preparations for construction of the spent fuel reprocessing facility are also under way.
NFT handles the transportation of nuclear spent fuel and low-level waste as part of the domestic nuclear fuel cycle plan and has already completed the procurement of a specialized ship and transportation containers and other means required for transportation of low-level waste.
The acceptance of spent nuclear fuels at the reprocessing plant is expected to begin in 1995, and, with this objective in view, progress is being made on the development of a new transportation ship, newly designed casks for high burn-up spent nuclear fuels, and other equipment.

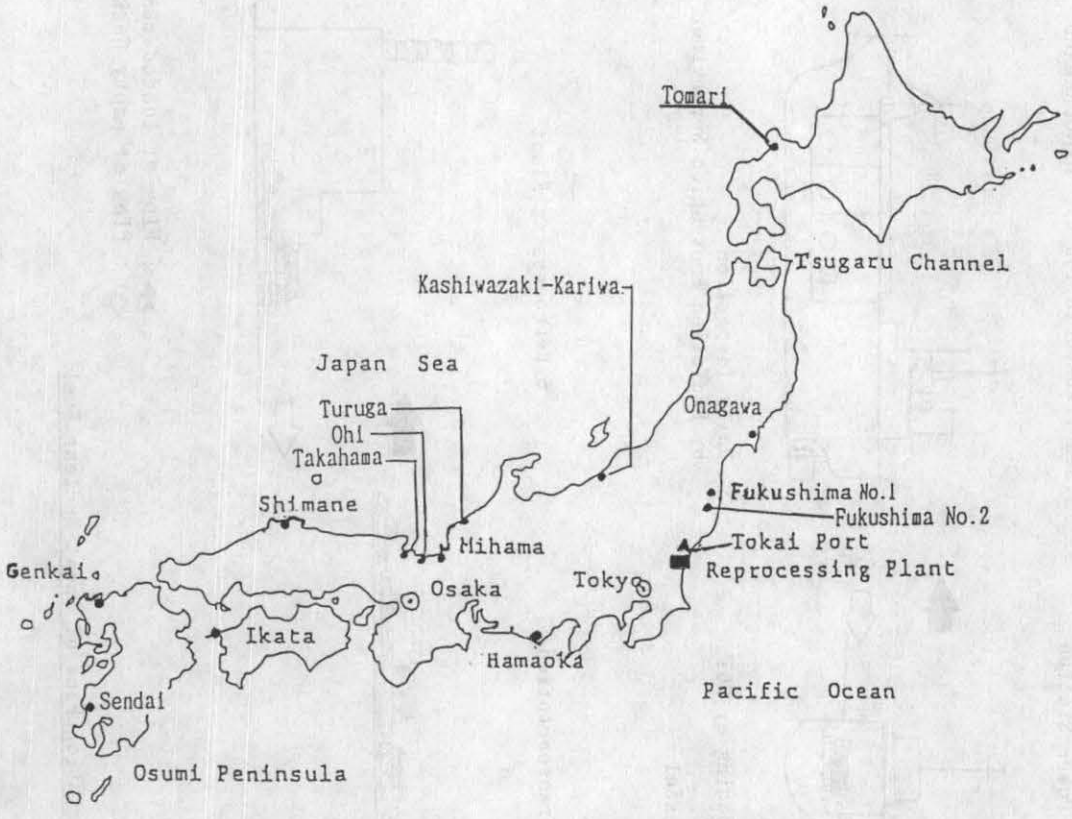

Fig. 1 Locaition of Nuclear Fcilities

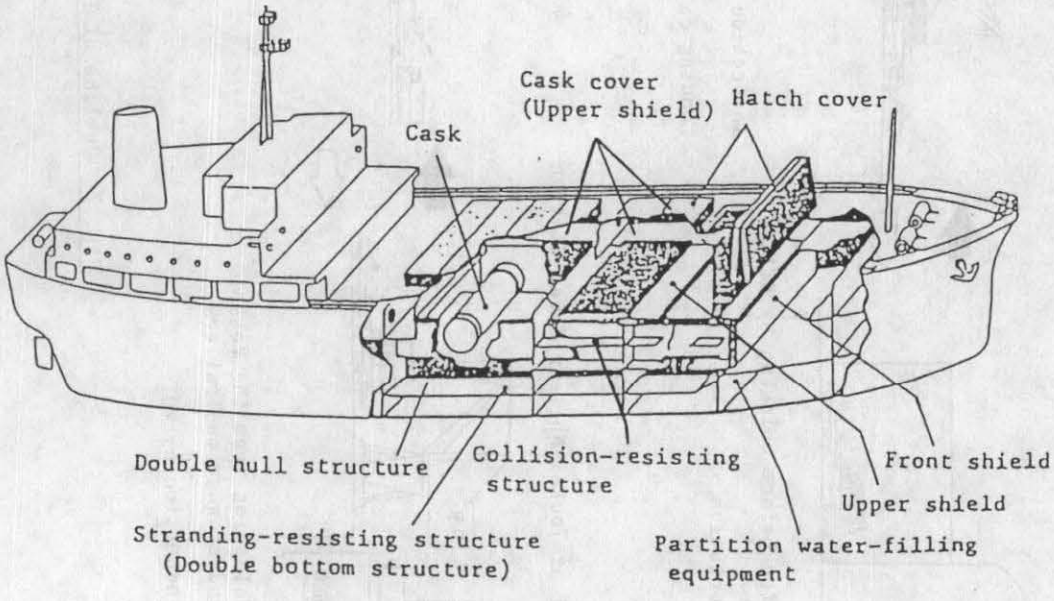

Fig. 2 Structure of 'HINOURA MARU'

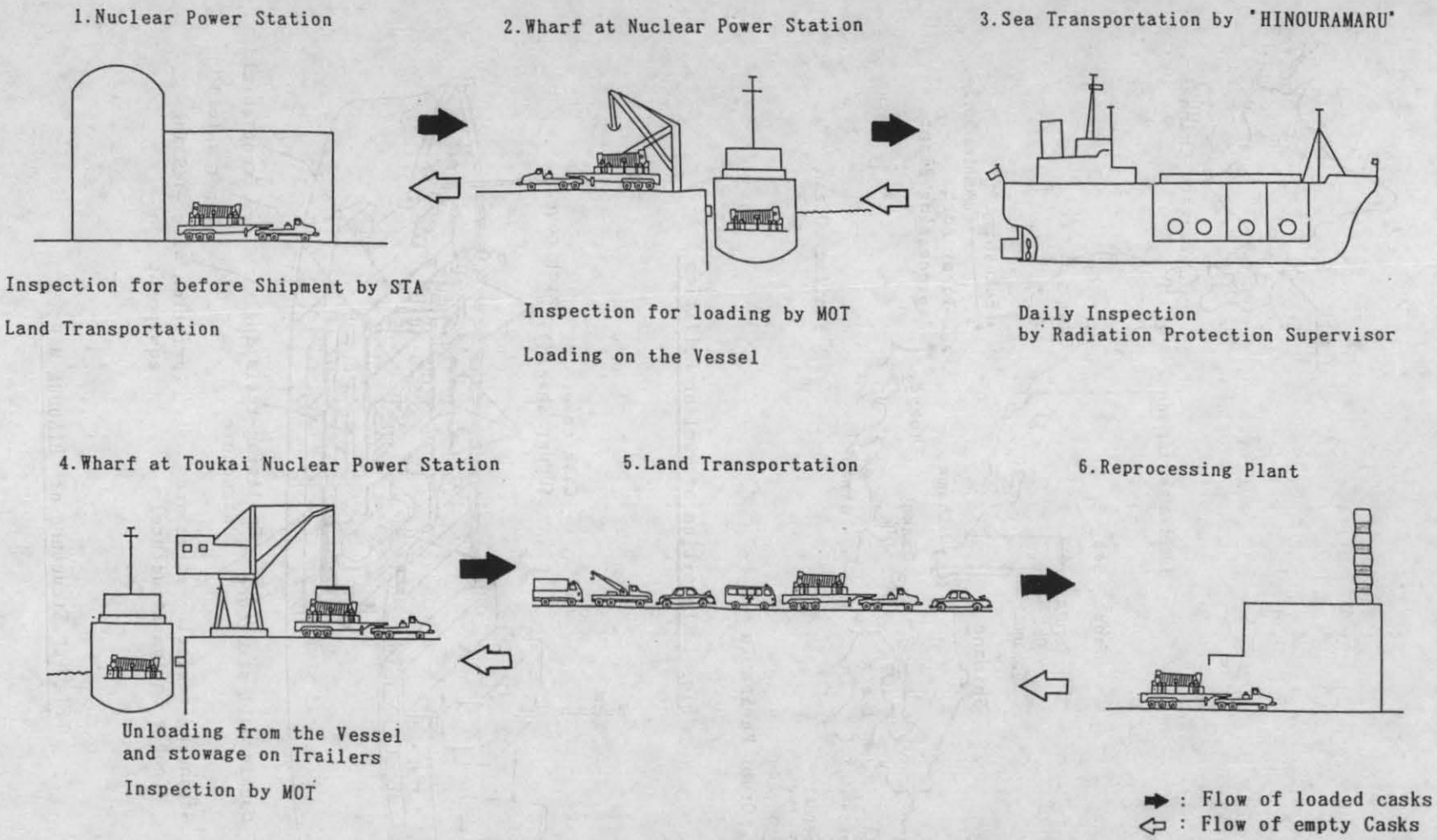

Fig. 3 Outline of Transportation Flow of Spent Nuclear Fuel

Table 1. Outline of 'HINOURAMARU'

Item		Spec.
Gross ton	:	1,290 tons
Dead Weight	:	1,242 tons
Length Overall	:	78.25 m
Width	:	12.20 m
Depth (to upper deck)	:	5.85 m
Draft	:	4.20 m
Full Load Service Speed	:	abt. 11 Knots
Main Engine	:	2,500 PS
Loaded Casks	:	4 Casks

Table 2. Outline of Casks Used in JAPAN

	HZ-75T	NH-25*1	MSF-I*1
Dimension			
Length(m)	5.9	5.8	6.2
Diameter(m)	2.3	1.5	1.8
weight(ton)*2	91	33	53
Loading Capacity			
BWR No. of Assemblies	17	2	---
Weight(MTU)	3.4	0.4	---
PWR No. of Assemblies	7	1	1
Weight(MTU)	3.3	0.5	0.5
Cooling	Natural	Natural	Natural

*1 The Cask Use for the PIE(Post-Irradiation Examination) Fuel Transport.
*2 Including Fuel and Skid.

Table 3. Amounts of Spent Nuclear Fuels Transported

Fiscal Year	No. of Casks	Fuel (MTU)	accum. (MTU)
1977	6	13.3	13.3
1978	8	16.8	30.1
1979	16	43.8	73.9
1980	24	66.8	140.7
1981	20	58.6	199.3
1982	10	29.8	229.1
1983	0	0.0	229.1
1984	0	0.0	229.1
1985	18	50.0	279.1
1986	22	60.6	339.7
1987	16	45.9	385.6
1988	16	43.4	429.0
1989	10	30.2	459.2
1990	18	48.0	507.2
1991	20	57.3	564.5

* end of March 1992

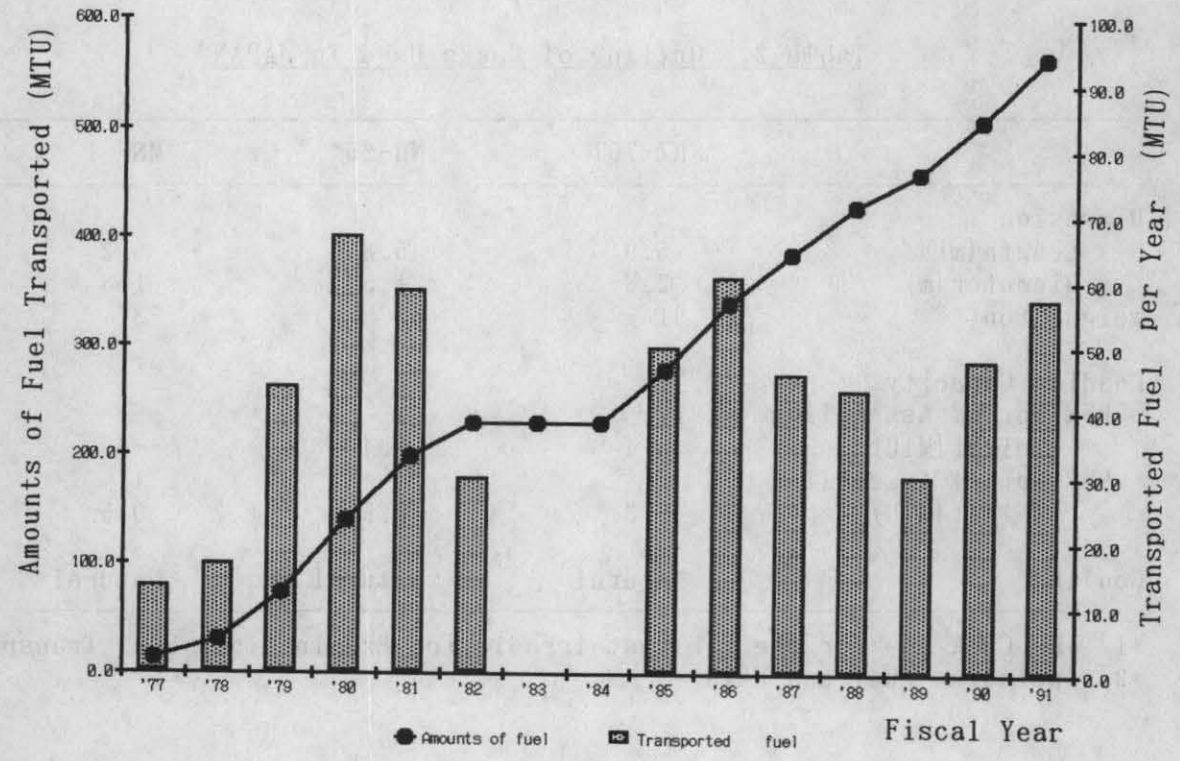

Fig. 4 Amounts of Fuel Transported