MARINE TRANSPORTATION FOR LOW LEVEL RADIOACTIVE WASTE

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ABSTRACT

As each Japanese nuclear power plant is located on the seaside, the marine transportation is the most suitable way to carry safely various types of radioactive materials.

Nuclear Fuel Transport Co. (NFT) is to be in charge of the marine transportation of the spent fuel and the low level radioactive waste (LLW) from the nuclear power plants to the nuclear fuel cycle facilities in "Rokkasho Mura" including land transportation.

The urgent LLW transportation is scheduled to be commenced at the end of 1992 and NFT has already been providing the necessary transport means; an exclusive use vessel, a bridge type crane, transport packages, etc.

NFT puts a great emphasis on "the concept of safe transport" in developing a new transport system. This concept has been implemented in the design of mechanical structure, radiation shieldings and automation systems.

NUCLEAR FUEL CYCLE IN JAPAN

In today's Japan the peaceful use of nuclear power is becoming important, due to the poor condition in domestic energy resources, one of the most significant issue and its importance will be increased considering the efforts made in preventing temperature rise caused by fossile fuel burning.

41 units in 16 nuclear power plants are in operation producing about 30% of the total electric energy in Japan.

In order to keep the nuclear power generation reliable in the future, it is indispensable to establish a so-called "nuclear fuel cycle" as soon as possible.

For this purpose an important project which consists of three major facilities is now under way as a private enterprise in "Rokkasho Mura", located in Aomori Prefecture, in the northern part of Honshu Island.

Among these facilities the "Uranium enrichment plant" is under operational test, the "LLW final repository" is also under construction expected to be completed in December, 1992 and the "Reprocessing plant" is at the stage of safety examination by the competent authority.

Figure 1 shows the locations of each nuclear power plant and the nuclear fuel cycle facilities.

PRESENT CONDITION OF LLW STORAGE

LLW arising at the nuclear power plants are usually packed in regular size drums, some of them are solidified by cement or bitumen. They are stored temporarily in the warehouse at each nuclear power plant. However, the available storage capacity is becoming smaller with the years. In Japan, the accumulated number of drums has reached approximately 470,000.

Various measures such as incineration and concentration have been taken to reduce the volume of LLW. But the basic solution is to transport LLW to the final repository.

This final repository of LLW in "Rokkasho Mura" is a ground burial type as shown in Fig. 2, where drums are stored in the concrete pit. The space in the pit is filled up with mortar and its top is covered with soil. The repository shall be institutionally controlled over 300 years.

OUTLINE OF LLW TRANSPORT SYSTEM

The LLW transportation system includes marine transportation from the nuclear power plants to the "Mutsu Ogawara Port" located in "Rokkasho Mura" and the subsequent land transportation from the port to the final repository.

A special type container vessel is used exclusively for the marine transportation of LLW and conventional type trucks are used for land transportation.

The necessary time for one journey along the Japanese Islands sea coast is estimated at 2 to 4 days depending on the location of the nuclear power plants.

As for land transportation, there is a 9 km road from the port to the repository, where the major part of the transport route is inside the premises of the nuclear fuel cycle facilities except the public port and its adjacent area.

Considering safety and convenience of LLW handling, a special transport package has been developed by NFT. It is a closed type container able to pack 8 drums.

As the method of loading and unloading the package, a gantry type crane mounted on the LLW vessel is used on the pier of each nuclear power plant and on the other hand a bridge type crane installed on the wharf is used at "Mutsu Ogawara Port".

According to the repository program, 25,000 drums are to be buried every year and NFT estimates that at least 10 trips will be necessary per year assuming that 2,500 drums are stowed each time in the vessel. (Maximum stow capacity of the vessel is 3,072 drums in seven holds)

Figure 3 shows the outline of the LLW transport system.

SPECIAL FEATURES OF TRANSPORT FACILITIES

LLW Vessel

Considering, among other factors, the particularity of LLW and other factors, NFT has decided to use an exclusive container vessel (approx. 3000 tons dead weight) for the marine transportation.

The name of the vessel, "SEIEI MARU", has the Japanese meaning of "promising future" symbolizing the prosperity of Aomori Prefecture where the LLW repository is located.

She has launched in January 1991 and completed in September 1991 at the Kobe Shipyard, Mitsubishi Heavy Industries Ltd.

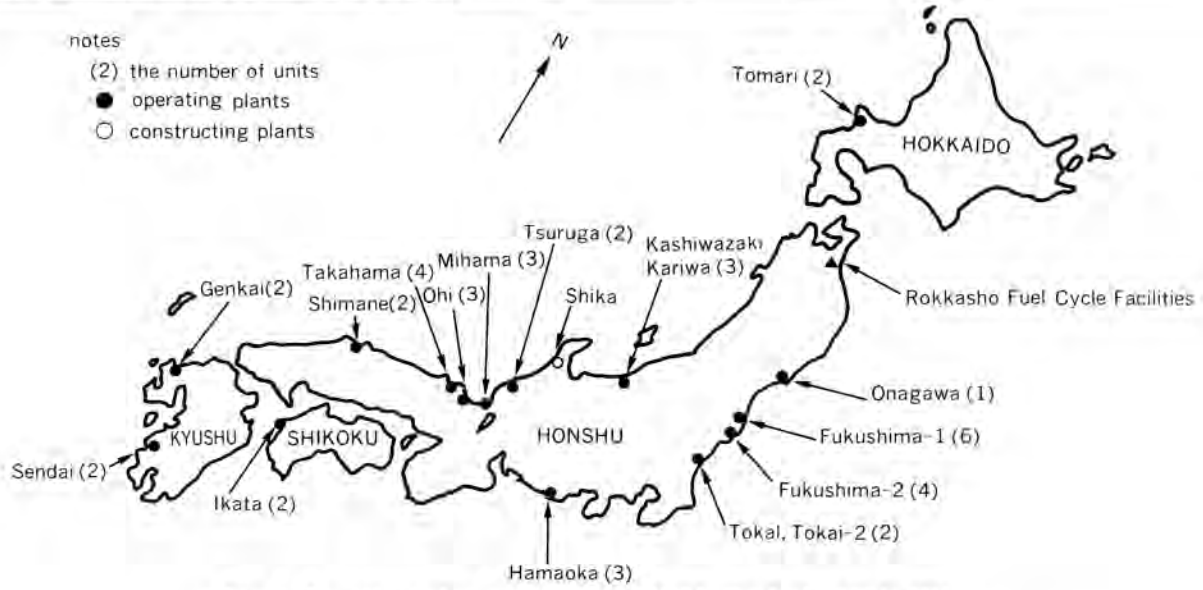

Fig. 1. Locations of power plants and Rokkasho fuel cycle facilities.

Every possible safety design has been applied to the vessel base on "Structure and Equipment Guide" issued by Japanese Ministry of Transportation.

Figure 4 and Table I show a "cutaway view" of the vessel and the main specification.

Comparing with a conventional cargo ship, "SEIEI MARU" has the following special features.

- Double hull and double bottom
  ... to reduce sinking possibilities and to improve the structure against collision and stranding
- Radiation shield with concrete and steel wall
  ... to keep dose rate below 1 mSv per year for the crew
- Ship mounting gantry crane
  ... to open hatch cover and to lift package (semi automatic control)
- Special navigation instruments
  ... such as special radar for anti-collision support and satellite positioning system and others

Transport Package

A specially designed closed type container which can load 8 drums is used as a transport package. This is the most adequate size as far as handling in the warehouse at each nuclear power plant is concerned.

The package has been designed so as to meet the requirement of IP-2 as specified in IAEA Standard, for instance 1.2 m drop test.

As shown in Fig. 5, a package lid with 4 fastening bolts can be open and close by remote control tool.

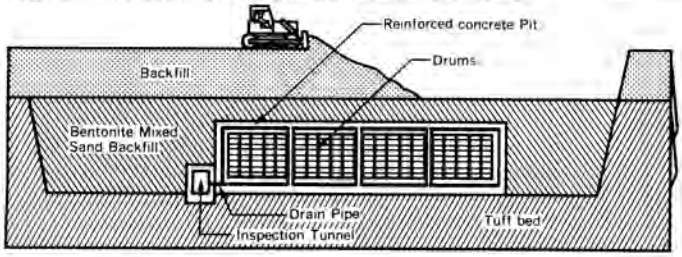

Fig. 2. Disposal of LLW drum at LLW storage center.

Each package identification number can be read automatically by means of a radio frequency identification instrument attached to each package body. (data carrier system)

NFT has ordered 3,000 packages to an iron work factory in "Rokkasho Mura".

Bridge Type Crane

A bridge type crane with 25 tons lifting capacity has been installed on the public wharf of "Mutsu Ogawara Port".

The crane can move on the rails (16 m wide) extended along the wharf and also move to the parking place by the curved side track.

As a large size crane with the curved rail is comparatively rare case in the world, 1/5 scale model test have been conducted prior to the manufacturing in order to assess the design pertinency.

The crane can be controlled automatically the same way as the gantry crane on the "SEIEI MARU".

As the loading and the unloading of the packages are carried out using computer program, the crane operator sits at a remote console watching televisions screens and only a few manual operations are required for each handling cycle.

Figure 6 shows a picture of the bridge type crane.

Other Facilities

- A large size truck with 11 tons capacity is use to carry two transport packages (5 tons each) at the same time. The bed of the truck is removed to reduce the empty load and a steel wall is installed to protect drivers from radiation. An anti-locking and anti-spinning breaking systems are installed on the truck driving mechanism specially for snowy roads. The packages can be fixed on the body frame using "twist lock" mechanism, which are remotely operated by the driver from his seat.
- A large "Gate Monitor" has been developed to automatically measure the dose rate and to verify relevant requirements before the loaded truck departs from the port. It measures several points at the surface as well as at 1 m position apart from the truck. The

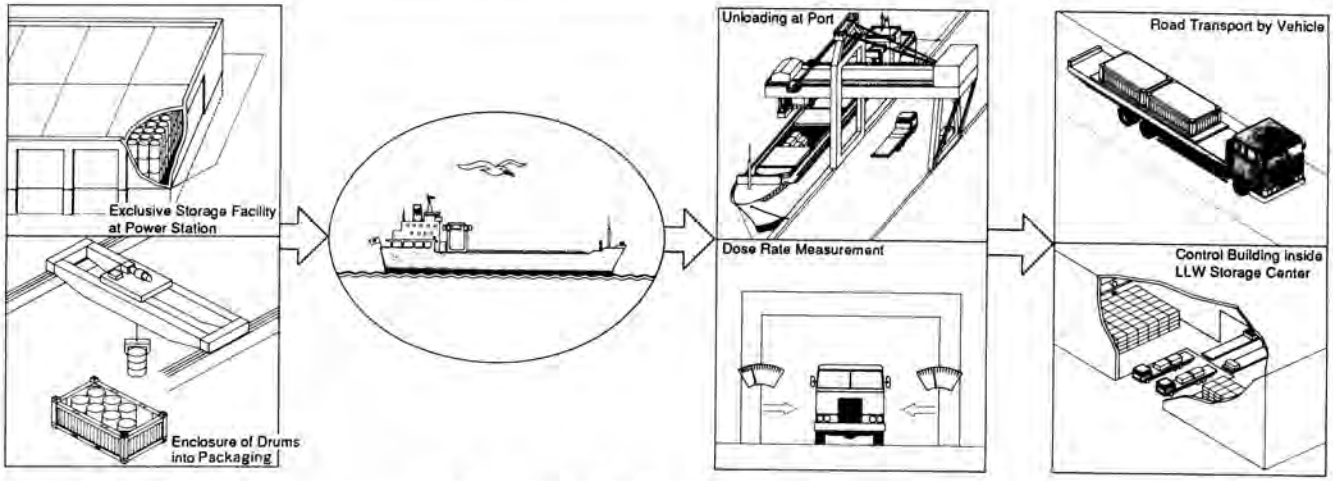

Fig. 3. Outline of LLW transport system.

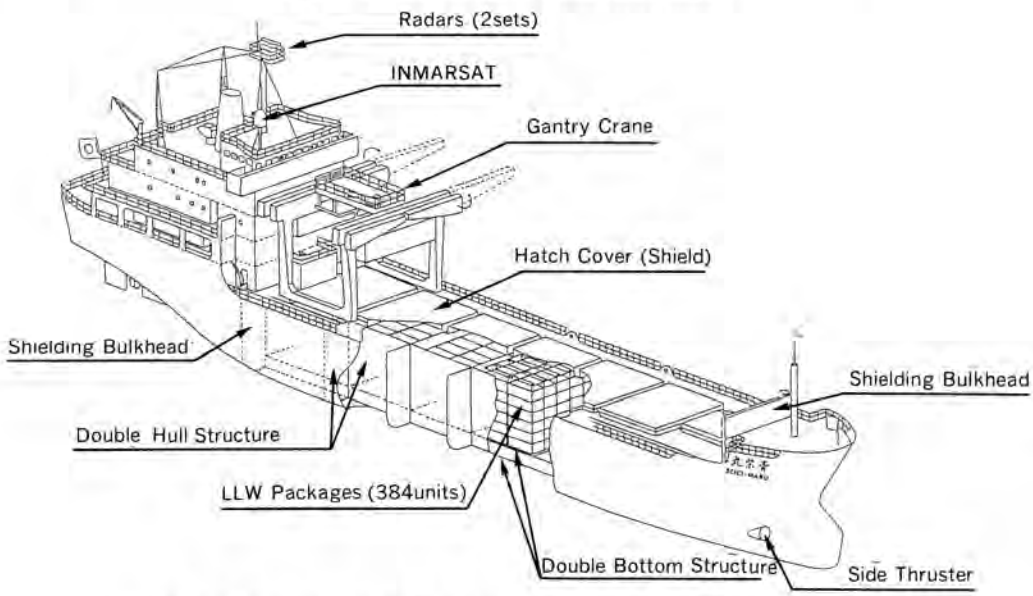

Fig. 4. Cutaway view of exclusive transport vessel "Seiei-Maru".

package number is recorded by a data carrier system receiving a signal from each package as mentioned before.

- Each emptied package must be inspected, cleaned and repaired, if necessary, before it is to be sent back to the nuclear power plant preparing for the next transportation. NFT is constructing a package store house for this purpose in the premise of the LLW repository.

COMPUTER SYSTEM

NFT has developed an integrated computer system to fit the mass transportation of LLW with efficiency and reliability. The system consists of two major parts, planning and management.

Using the "Planning System" an efficient navigation schedule can be obtained immediately considering different restricting conditions of each port. The planning system will also be effective for changing the schedule in case of bad weather conditions or other occurrences.

The "Management System" has several functions to monitor on line transportation; such as LLW data tracking, radiation monitoring, vessel loading calculation, supervising of vessel position, crane program control, package flow management and etc.

As shown in Fig. 7, the work stations of the system are installed at the main office (Tokyo) as well as at the branch office (Rokkasho). They will enable operators to input and output data from both stations.

Aiming at a successful LLW transportation, NFT intends to take all possible measures.

In addition to the above mentioned items, important factors, needless to say, are preparation of operating manuals, education and training of personnel and also promotion of NFT activity to public acceptance.

TABLE I

Main Specification of Exclusive Vessel "SEIEI-MARU"

General	
Navigation Area	Greater Coasting Area
Classification	NK (Nippon Kaiji Kyokai)
Principal Particular	
Length (overall)	99.89 m
Length (between perpendiculars)	95.00 m
Breadth (mold)	16.00 m
Depth (mold)	8.00 m
Design draft	5.40 m
Gross tonnage	4,053 tons
Dead weight	3,206 tons
Main engine (Diesel 3,900ps)	1 set
Service speed	13.0 knots
Fuel number of persons on board	25 persons
Cargo	
Package	384 units (3,072 drums)
(L: 3.2 m x W: 1.6 m x H: 1.1 m)	
Hull Structure	Double-hull
Main Fittings	
Radiation shielding	Steel and Concrete
Max. accommodation radiation level	(Less than 1.8 μSv/h)
Radiation monitoring equipment	1 set
Propeller	C.P.P. (Control Pitch Propeller)
Rudder	Schilling rudder
Thruster	Bow (5 t)
Gantry crane	1 set
Echo sounder	Depth range abt. 400 m
Radar	2 sets
Automatic Radar Plotting Aids	1 set
Communication System	Radiotelegraph and Radiotelephone
	VHF radiotelephone
	INMARSAT system
Positioning System	Global Positioning System
	Loran C

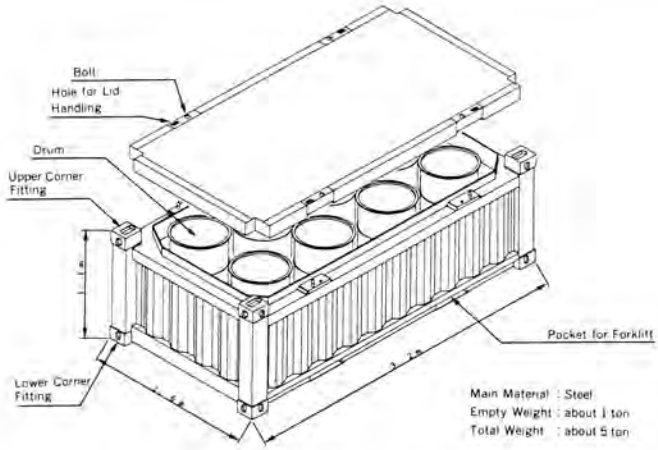

Fig. 5. Low level waste transport package.

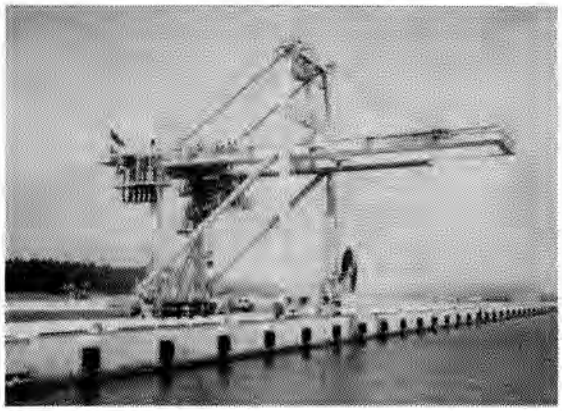

Fig. 6. 25 ton bridge type crane at Mutsu Ogawara Port.

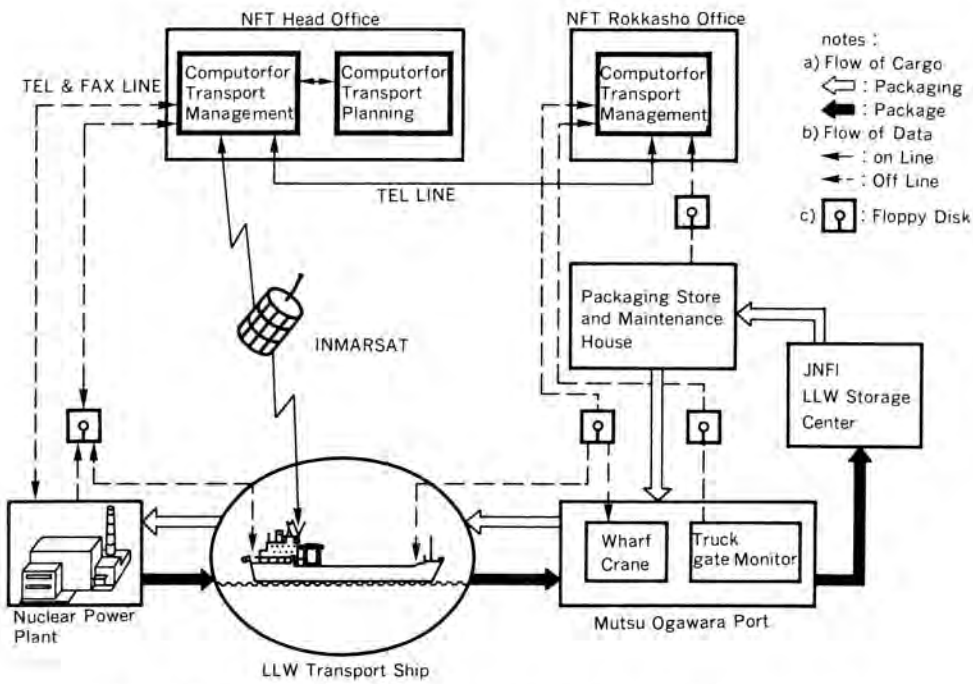

Fig. 7. Concept of LLW transport planning & management system.