SEIEI - MARU
Japan's First Low - Level Radioactive Waste Transport Ship

M. Hirano[*1], T. Sasao[*1], and T. Sanui[*1] K. Kondo[*2], T. Kan[*2], and H. Kihara [*2]

Nuclear Fuel Transport Co., Ltd., Tokyo, Japan [*1]
Kobe Shipyard and Machinery Works, Mitsubishi Heavy Industries, Ltd., Kobe, Japan [*2]

INTRODUCTION

The low - level radioactive waste (LLW) generated at the nuclear power stations throughout Japan is tightly sealed in drums and stored at these power stations.

In order to transport such waste to the Low - Level Radioactive Waste Disposal Center in Rokkasho - Mura, Aomori Prefecture, which is scheduled to start operation in December 1992, Japan's first exclusive LLW transport ship, the Seiei - Maru, was built for the Nuclear Fuel Transport Co., Ltd. at the Kobe Shipyard and Machinery Works, Mitsubishi Heavy Industries, Ltd. in September, 1991. (See Fig.1)

SPECIAL PROVISIONS FOR SAFE TRANSPORTATION

For safe sea transportation of LLW, the Seiei - Maru has been built in accordance not only with the usual rules and regulations applicable to ships but also with the "Regulations for the Carriage and Storage of Dangerous Goods" and the "Design Criteria for Seagoing Vessels Carrying Low - Level Radioactive Waste" (to be referred to as Ship Inspection Regulation 450) of the Ministry of Transport, Japan.

The "Regulations for the Carriage and Storage of Dangerous Goods" were instituted in accordance with the "IAEA Safety Standard, Safety Series No.6 Regulations for the Safe Transport of Radioactive Material, 1985 Edition", while Ship Inspection Regulation 450 has special provisions for damaged stability, hold arrangement, securing cargo, on - board radiation monitoring equipment, fire fighting system for cargo holds, water drainage, communication, navigational equipment, and so on.

PRINCIPAL PARTICULARS

The principal particulars of the ship are given in Table 1.

OUTLINE OF THE SHIP

General Arrangement

Figure 2 shows a general arrangement of the ship. The ship is divided by eleven transverse watertight bulkheads into the engine room, cargo holds, bow thruster room, and so on. The cargo holds are separated from the outside shell plating by longitudinal watertight bulkheads, side tanks being provided between the shell plating and the bulkheads.

Table 1. Principal Particulars

Registered government	: Japan
Classification	: Nippon Kaiji Kyokai (NK) NS *, MNS*(MO)
Principal dimensions	
Overall length	: approx. 100 m
Length b.p.	: 95.0 m
Breadth mld.	: 16.0 m
Depth mld	: 8.0 m
Summer draft	: 5.4 m
Deadweight	: approx. 3,000 metric tons
Cargo loading capacity	: 384 LLW packages (3,072 drums)
Service speed	: 13.0 knots
Bow thruster	
Type & number	: Controllable pitch type X 1 set
Thrust	: 5 metric tons
Rudder	: Schilling Rudder X 1 set
Gantry crane	
Type & number	: Electric motor driven X 1 set
Safety working load	: 10 metric tons
Main engine	
Type	: 2-cycle crosshead, diesel engine
Model & number	: Mitsubishi 6UEC37LA X 1 set
Maximum output	: 3,900 PS X 200 rpm
Propeller	: 4 bladed controllable pitch propeller X 1 set
Electric power generator	
Main diesel generator	: 462.5 kVA X 2 sets
Aux. diesel generator	: 250.0 kVA X 1 set
Port use diesel generator	: 132.5 kVA X 1 set
Emergency diesel generator	: 65.0 kVA X 1 set

Fig.1 "SEIEI-MARU"

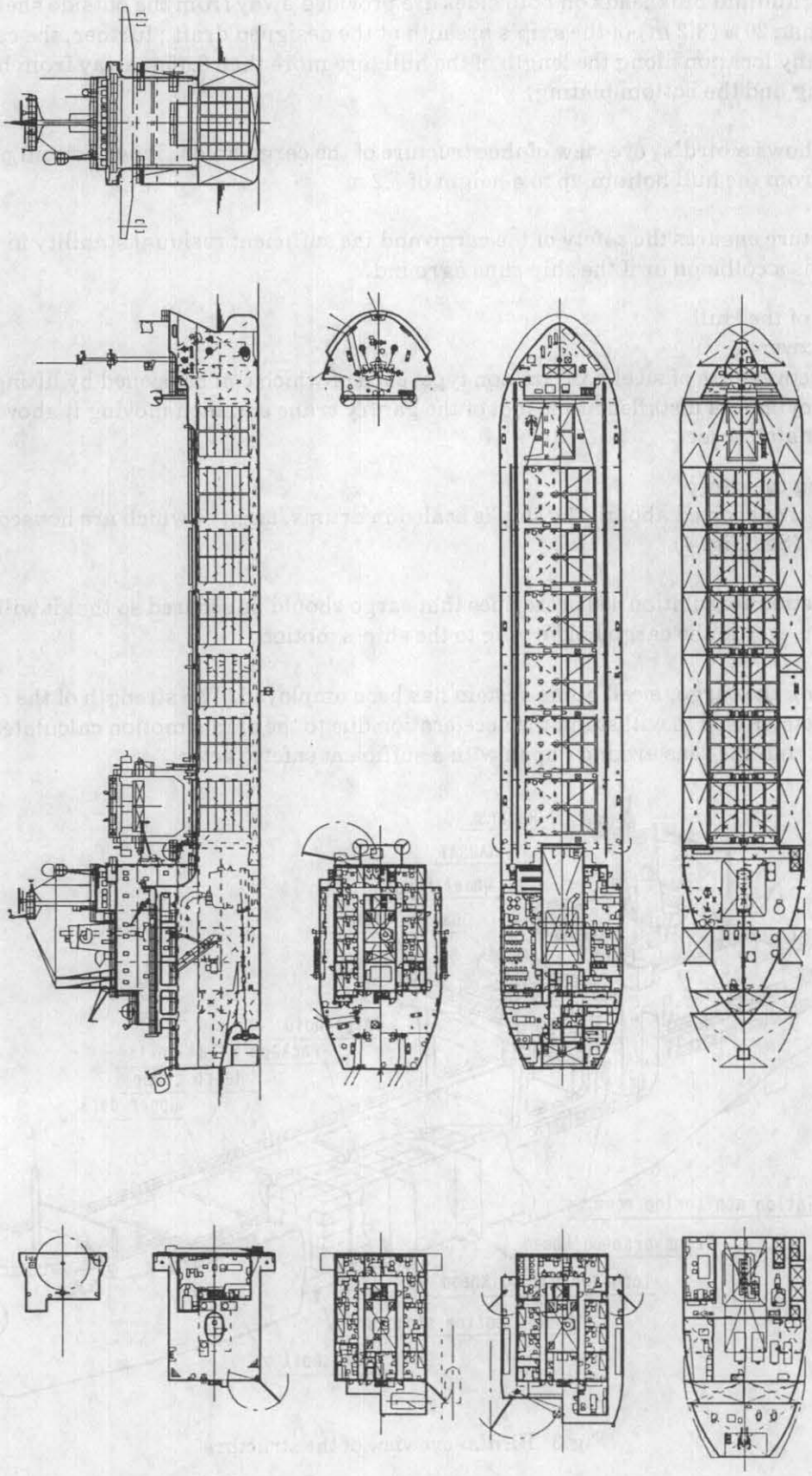

Fig.2 General Arrangement

These longitudinal bulkheads on both sides are provided away from the outside shell plating by more than 20 % (3.2 m) of the ship's breadth at the designed draft ; further, the cargo holds, at any location along the length of the hull, are more than 0.76m away from both the side plating and the bottom plating.

Figure 3 shows a bird's - eye view of the structure of the cargo holds. Inner bottom plating is provided from the hull bottom up to a height of 1.2 m.

This structure ensures the safety of the cargo and the sufficient residual stability in the event that there is a collision or if the ship runs aground.

Outfitting of the Hull

(1) Hatch cover

The hatch covers are of steel box pontoon type, each of which can be opened by lifting it by hydraulic cylinders installed at the foot of the gantry crane and then moving it above the adjoining hatch cover.

(2) Securing the cargo

LLW to be transported aboard the ship is sealed in drums, eight of which are housed in a packaging.(See Fig. 4)

Ship Inspection Regulation 450 prescribes that cargo should be secured so that it will neither shift nor tip over in the cargo hold owing to the ship's motion.

For securing the cargo, a cell guide system has been employed. The strength of the cell guide has been determined to withstand the acceleration due to the ship's motion calculated on wave data from the seas around Japan with a sufficient safety factor.

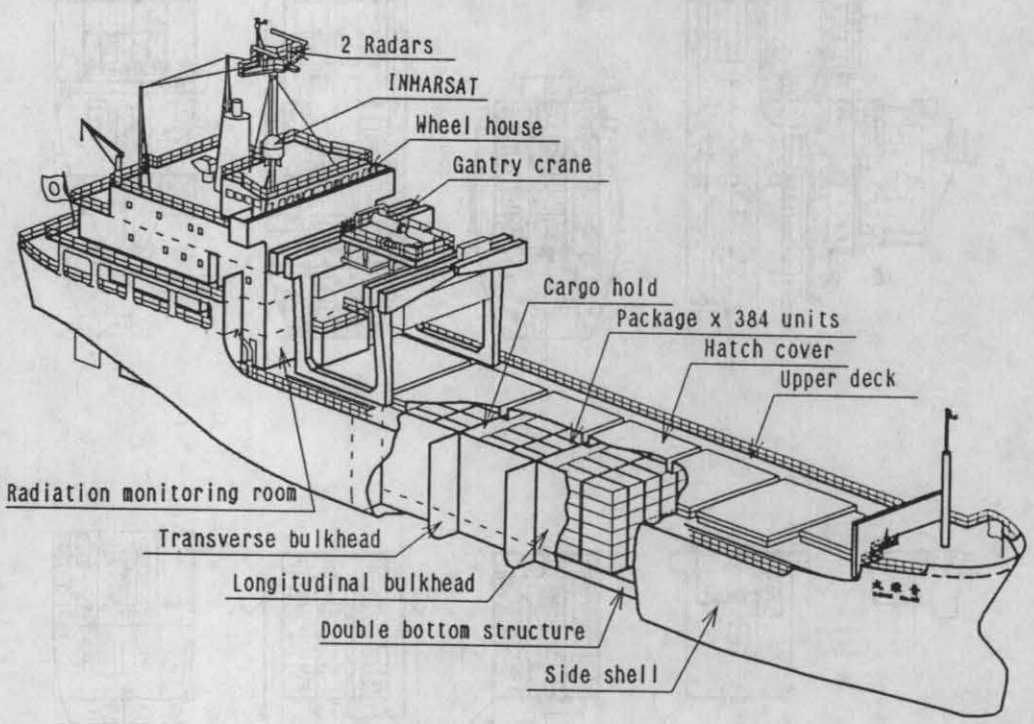

Fig.3 Bird's - eye view of the structure

(3) Rudder and bow thruster
For better maneuvering ability, the ship is equipped with what is called the Schilling rudder with a maximum steering angle of 70 degrees to one side and a bow thruster.

By a combined operation of this Schilling rudder, a controllable - pitch propeller and the bow thruster, sidewise movement of the ship is possible with hardly any forward or backward movement.

(4) Water drainage and fire fighting facilities for the cargo holds
The bilge in the cargo holds is stored in hold bilge tanks without being released outside the ship. The bilge line valves are remote - controllable from the wheelhouse.

To prevent the rapid rise of temperature of the cargo during a fire at sea, four nozzles have been installed to spray water on the upper deck and the hatch covers. The nozzle discharge angle can be remote - controlled from the wheelhouse.

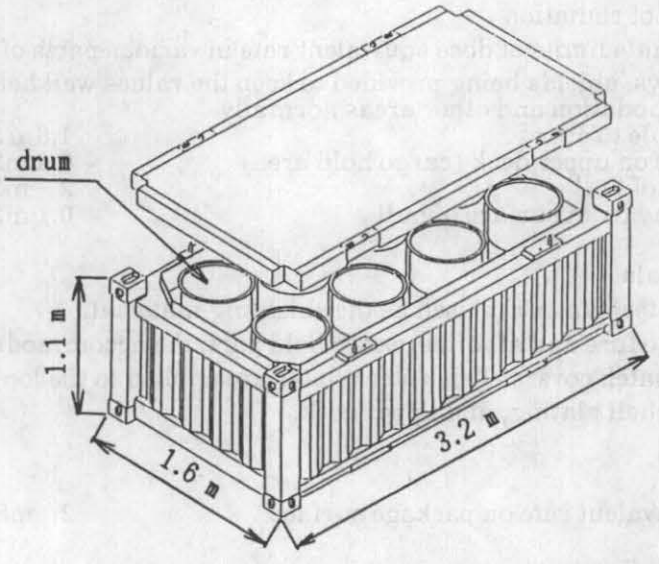

Fig.4 Packaging and drums

Outfitting of the Engine
The ship has been qualified by the Nippon Kaiji Kyokai for Notation (MO) for Unmanned Engine Operation. The main engine, generator engines, and auxiliary machinery in the engine room are automatically controlled and also remote - controllable for improving the working environment and maintaining security in the entire engine room.

By such measures, the safety and reliability of the ship's operation can be ensured.

Electrical Outfitting
(1) Generators
Taking the different electric power demands during navigation and cargo handling into consideration, the ship is equipped with various generators as shown in Table 1.

The emergency generator and generator engine used aboard the ship satisfy the requirements of Ship Inspection Regulation 450.

(2) Navigational equipment and communication facilities
The navigational equipment consists of two radars, and echo sounder, an automatic collision prevention system (ARPA), a gyrocompass, and a Doppler speed log as required by Ship Inspection Regulation 450. Furthermore, the ship is equipped with two ship positioning systems, a GPS1 (Global Positioning System) and a LORAN C receiver.

As for communication facilities, the ship is equipped with an international VHF radio telephone system, a marine radio telephone system, and international marine satellite communication system (Inmarsat).

These navigational aids and communication systems together contribute to the safe operation of the ship.

RADIATION SHIELDING AND RADIATION MONITORING FACILITIES

Radiation Shielding

(1) Allowable limits of radiation
The designed allowable limits of dose equivalent rate in various parts of the ship have been determined as follows, shields being provided to keep the values well below the limits.

(a) accommodation and other areas normally accessible to crew	1.8 μSv/hr max
(b) passage on upper deck (cargo hold area)	0.2 mSv/hr max
(c) surface of hull	2 mSv/hr max
(d) 2 m away from surface of hull	0.1 mSv/hr max

(2) Shielding materials
Concrete and thick steel plates are used as the shielding material.
Concrete is applied to fore and aft of the cargo hold part, the accommodation, part of the upper deck and the hatch covers. Thick steel plates are applied to the longitudinal watertight bulkheads, outside shell plating, and upper deck.

(3) Radiation source

Dose equivalent rate on package surface	2 mSv/hr max

Radiation Monitoring Facilities

(1) Radiation monitoring room
The radiation monitoring room and the changing room are both provided in the fore end of the accommodation so that access to the deck exposed to radiation can be controlled there.

(2) Radiation monitoring equipment
The radiation monitoring equipment on board is shown in Table 2.

(3) Centralized radiation monitoring system
The radiation monitoring computer on board is capable of

(a) exchanging information with control center on land (the Nuclear Fuel Transport Center).
(b) centralized management of all the information related to the radiation monitoring of packages on board.
(c) centralized management of information on the exposure of each crew member.
(d) centralized monitoring of dose equivalent rate in the ship with the aid of twelve gamm a - ray area monitors.

Table 2. Radiation Measuring Equipment

Type of equipment	Name of equipment	Quantity	Place of installation or storage
Personal external exposure monitor	Film badge		Worn by each crew member Spare badges in lead box in Changing Room
	Pocket type alarm dosimeter (APD) APD checker, charger	25	Monitoring Room
Spatial radiation measuring equipment	Area monitor	12	Various locations in ship Monitoring panel in Radiation Monitoring Room
	Scintillation type survey meter (for gamma ray)	2	Changing Room
	Ionization - chamber type survey meter	3	Changing Room
Surface contamination measuring equipment	Hand - foot - clothing monitor	1	Changing Room
	Scintillation type survey meter (for alpha ray)	2	Changing Room
	Geiger - Muller type survey meter	2	Changing Room
	Automatic smear measuring equipment	1set	Changing Room
Measuring equipment for concentration of radioactive matter in air and water	Automatic measuring equipment for radiation from bilge in carge hold (scintillation type)	1set	Changing Room
	Dust sampler	2	Changing Room
	Automatic smear measuring equipment	1set	Changing Room
Others	Radiation source for calibration	1set	Changing Room

GANTRY CRANE

The large gantry crane on the upper deck, which is driven by electric motors, is a major feature of the ship .(See Fig. 5)

The crane is a highly intelligent one, its operation being possible in the operator's booth on the crane, the wheelhouse, a portable radio control panel, and by program control. Each mode of operation will be explained below.

Operation in Operator's Booth
The operator can control the crane with a joystick in the operator's booth on the crane.

Remote Operation
The operator can control the crane with a joystick in the wheelhouse by watching its operation on a monitoring television screen and a graphic panel.
The joystick is on the remote/automatic operation console.

Operation is also possible by the portable radio control panel if the operator is within 20 m of the hull.
Ten television cameras in total are mounted on the crane, and any of them can be monitored on four monitoring screens.

Programmed Operation
Three work patterns have been programmed : "loading operation", "unloading operation", and "simultaneous loading/unloading operations".

By specifying one of these patterns, automatic operation is possible according to cargo handling plan prepared in advance.

CARGO MANAGEMENT SYSTEM

The radiation monitoring computer, the loading computer, and the crane operating computer on board are interconnected on line, so that integrated management of all the information related to the radiation monitoring of LLW loaded at the nuclear power stations, the location of each of the packages at these power stations, and the cargo handling schedule at each port is possible.

The gantry crane is automatically operated at the instruction of this integrated system, and the information on the radiation monitoring of packages and their locations is sent to the Nuclear Fuel Transport Center via a communication satellite for total management there.

CONCLUSION

As described in the preceding sections, the Seiei - Maru has been built with the newest equipment and technology, and we take pride in her as being a ship fully capable of safely transporting LLW.

The Seiei - Maru has been undergoing various training and transporting empty packagings since June 1992 in preparation for the transportation of radioactive waste to start in December 1992.

Fig.5 Gantry crane