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Building of the new low level radioactive-waste transporting ship

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Abstract

The Nuclear Fuel Transport Co., Ltd. ("NFT") owns three ships for transporting low-level radioactive waste ("LLW") and spent fuel ("SF"). NFT has been transporting such cargo safely without accident thanks to the crew's sailing ability and navigation management groups' earnest efforts to enhance safety. The Seiei-Maru, an LLW transport ship, has transported over 300,000 LLW drums over 27 years.

NFT decided to retire the Seiei-Maru from service no later than September 2019, and construct a new LLW transport ship. Based on lessons learned from the tsunami strike triggered by the Great East Japan Earthquake and NFT's operational knowledge, we have no doubt that our new ship will have the highest level of safety because NFT attended almost every inspection for verifying rule compliance and performance satisfaction. In addition, we reused Clearance Level Material (CL) from nuclear plants for this first initiative in Japan.

In March 2019, NFT completed construction of a successor ship capable of providing even safer transportation than the Seiei-Maru, and is striving to continue to transport cargo safely.

Introduction

LLW, which is generated at nuclear power stations throughout Japan, is sealed tightly in drums and stored temporarily at the power stations. Transport containers, which hold eight LLW drums, are of heavy-duty construction that is stronger than large cargo containers in order to ensure safe transport with stable drum placement and protection. Therefore, there is little risk involving radioactive materials during LLW transport.

NFT transports the LLW packages from nuclear power stations to the LLW Disposal Center in Rokkasho Village, Aomori Prefecture, and the Seiei-Maru is used for marine transportation portion of this process.

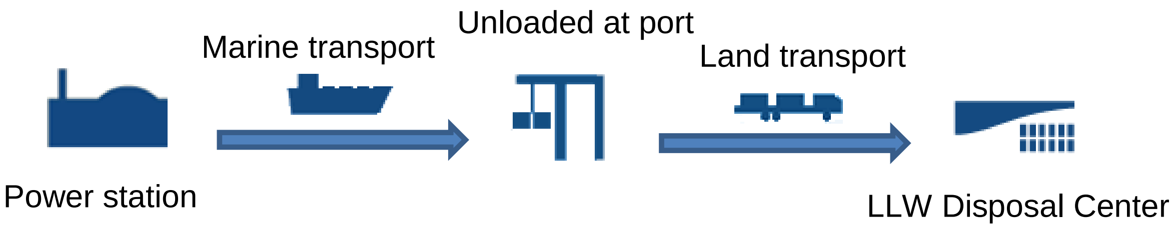
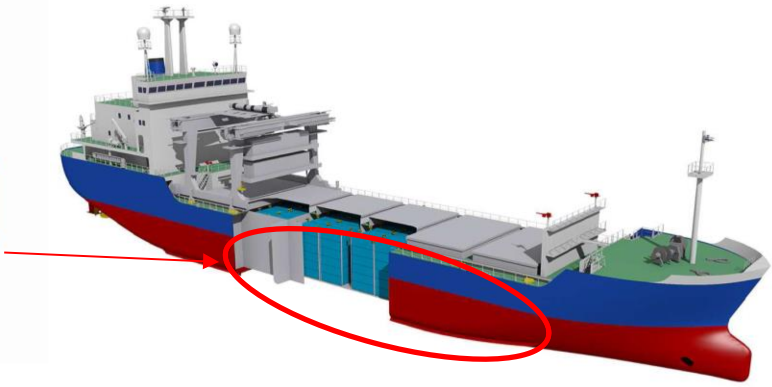


Figure 1. Flowchart of LLW transport

LLW container



LLW transport ship

Figure 2. Diagram of LLW transport ship and LLW container

NFT ordered the construction of a successor ship from a shipbuilding company so that NFT would be able to continue to fulfil its duty to safely transport LLW after retirement of the Seiei-Maru from service. NFT was completed on schedule in March 2019.

This paper presents the construction and inspections, to which particular effort was given, in constructing the new LLW transport ship, which was christened the Seiei-Maru, the same name as the predecessor vessel.

Construction of successor ship

<u>(1) Inspections during construction</u>

NFT attended almost every inspection from the start of block construction to ship completion so as to ensure that the quality of the new ship was reliably assured. In particular, NFT verified that block and tank inspections were conducted reliably by reconciling the activities performed with markings on the following drawings.

- Block division diagram
- Block installation schedule
- Tank layout diagram

LLW transport ships must conform to the KAISA 450 requirements, which are specific Japanese government requirements for LLW transport ships, in addition to regulations for general cargo ships. Table 1 provides an overview of the requirement prescribed in KAISA 450 and specification for LLW transport ships.

Table 1. Overview of KAISA 450 requirements and LLW transport ship specifications

KAISA 450 requirements	LLW ship specifications
Hull structure	Double-hull structure
*For damage stability	Clear assessment developed using a probabilistic method (corresponds to INF Code Class 3)
Firefighting system	Equipped with a water discharge nozzle
Life-saving devices	Two sets of life rafts
Emergency power supplies	Equipped with an emergency generator that can supply electricity for over 18 hours
Drainage system	Install an independent polluted water facility
Cargo fastening equipment	LLW packages are fastened in place by means of cell guides in the hold.
Radiation measurement instrument	Equipped with a dose measuring instrument, protective equipment, etc.

*Damage stability means the capability to maintain ship buoyancy without sinking when there is an inrush of sea water due to a collision or the ship runs aground.

NFT has attended all inspections verifying conformance with KAISA 450 requirements. Therefore, NFT has no doubt that our new ship has a markedly higher level of safety.

(2) Reuse of clearance level material (CL) from nuclear plants

CL is generated in the operation and dismantlement of nuclear plants, yet the level of radioactivity is very low. Moreover, there is no effect on human health. CL has already obtained government approval and may be reused just as ordinary waste is.

In Japan, there are examples of CL being reused for benches or fences at a nuclear power plant, but it has never been reused in general industry.

Initially, the use of clearance material was not planned, but, during construction of the ship, NFT received a request from the power company to use CL. After positively considering the adoption of CL, NFT decided to adopt CL for the ship inclination reduction device (counterweight) utilized when the loading crane is used. Table 2 shows the details of the review on adopting CL. A diagram of the counterweight is shown in Figure 3.

Table 2. Details of the review on adopting CL

Part of ship	Details	Outcome
Body material	・At the time of review, steel plates had already been ordered. Consideration had also advanced on steel plate cutting, so it would be difficult to use new materials. ・Delivery time of the material was about 3 months and, considering the construction time, it would have been a very tight process.	N
Inclination reduction device (counterweight)	・CL may be used because the quality requirements for counterweights are weight and volume, and there are no concerns about material embrittlement. ・The counterweight is constructed as a integral component of the ship and may be manufactured by the start of construction of the ship.	Y
Ballast fixing	・In constructing the new ship, pachinko balls are used as fixed ballast, and a method of hardening them with concrete was adopted. ・At the processing plant, CL cannot be processed into pachinko balls.	N
Test dummy container	・At the processing plant, CL can be processed into dummy containers. ・It is processed as the same type as LLW transport container, but time is required because of the number needed.	N

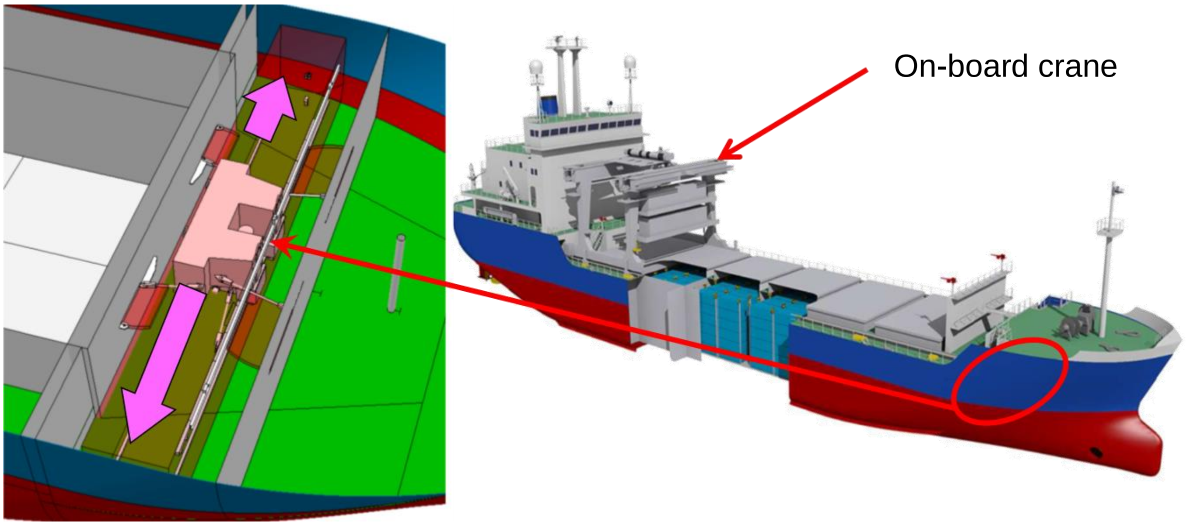


Figure 3. Illustration of a counterweight

(3) Shielding construction

In the Regulations for the Carriage and Storage of Dangerous Goods by Ships which is an ordinance issued by the Ministry of Land, Infrastructure and Transport pursuant to the Ship Safety Act, management is required of the dose equivalent rate of the hull outer plate surface and the crew members on the ship.

We adopted a method of filling the area between steel walls with concrete to serve as shielding material. In order to ensure shielding performance, concrete should be uniformly constructed without defects such as gaps and holes in the poured concrete.

Filling conditions inside and the properties of the actual concrete after curing are not able to be confirmed directly, therefore a mock-up was fabricated of the concrete fill of the ship was produced in order to confirm the validity of the construction method. The mock-up model is described below.

-Model 1: Model of the highest superstructure front wall
-Model 2: Model of a structure that is a tiered structure in the middle
-Model 3: Model of a structure as on an actual ship

NFT confirmed the validity of the concrete construction method for the No. 1 and 2 models, and verified the effectiveness of inspections conducted on actual ships with the No. 3 model. From the test results, a concrete construction method was established that took into account the following points.

1) Uniform concrete filling
   In order to ensure uniform filling when pouring concrete from the top, one wall was divided into blocks and the concrete cast hose gradually pulled up during filling to control the drop interval.
2) Measures to eliminate gaps during concrete filling

During concrete filling, a high frequency vibrator was used to compact the concrete so that gaps would not form due to air bubbles, thereby affecting shielding performance.

3) Temperature control during construction
Concrete has different properties depending on the ambient temperature at the time of use. In consideration of various conditions, we set a construction period that does not impair concrete performance or fluidity, and implemented high temperature construction measures.

4) Concrete injection
In anticipation of work interruption due to bad weather during work, we implemented pile-up measures when resuming concrete placement work.

During new LLW transport ship construction, we confirmed that construction was carried out according to the construction method established with the mock-up. Furthermore, shielding performance was assured by conducting attenuation factor evaluations using permeation tests with γ rays at 177 points on the ship. As a result, we confirmed through the series of shielding construction processes and inspections that the 16 months and much labour were spent to fully satisfy the regulations.

(4) Technical Tradition

NFT constructs a ship about once every 10 years and the newly assembled ship construction group will be disbanded after ship completion. It is necessary to ensure a technical tradition by taking into consideration future personnel transfers of experienced engineers. These things were recognized during the early stages of ship construction work, and many technical materials prepared.

-Glossary of ship technical terms appearing in specifications and drawings
-Videos of inspections conducting from ship construction start to completion
-Notes summarizing main points and other points noticed in the inspections that the inspectors attended
-Collection of cases of problems during construction
-Chronology of the entire process from start to finish

NFT's ship building group has prepared a construction report that included the above, which will not only be preserved until the next ship construction, but also passed on to offices and divisions operating the ships to ensure a technical tradition.

Overview of new ship

Principal dimensions of the new ship are given in Table 3 and a bird’s-eye view in Figure 4. The new ship takes into account the condition of power station ports, and is equivalent in size to the Seiei-Maru. The new ship has been designed so that it can transport some of the waste from the dismantled reactor units in addition to LLW drums, which have been previously transported.

Table 3. Principal Dimensions of the New Ship

Overall length	Approx. 100m
Breadth	Approx. 16.5m
Depth	Approx. 8.2m
Draft	Approx. 5.4m
Deadweight	Approx. 3000 metric tons
Gross tonnage	Under 5000 metric tons

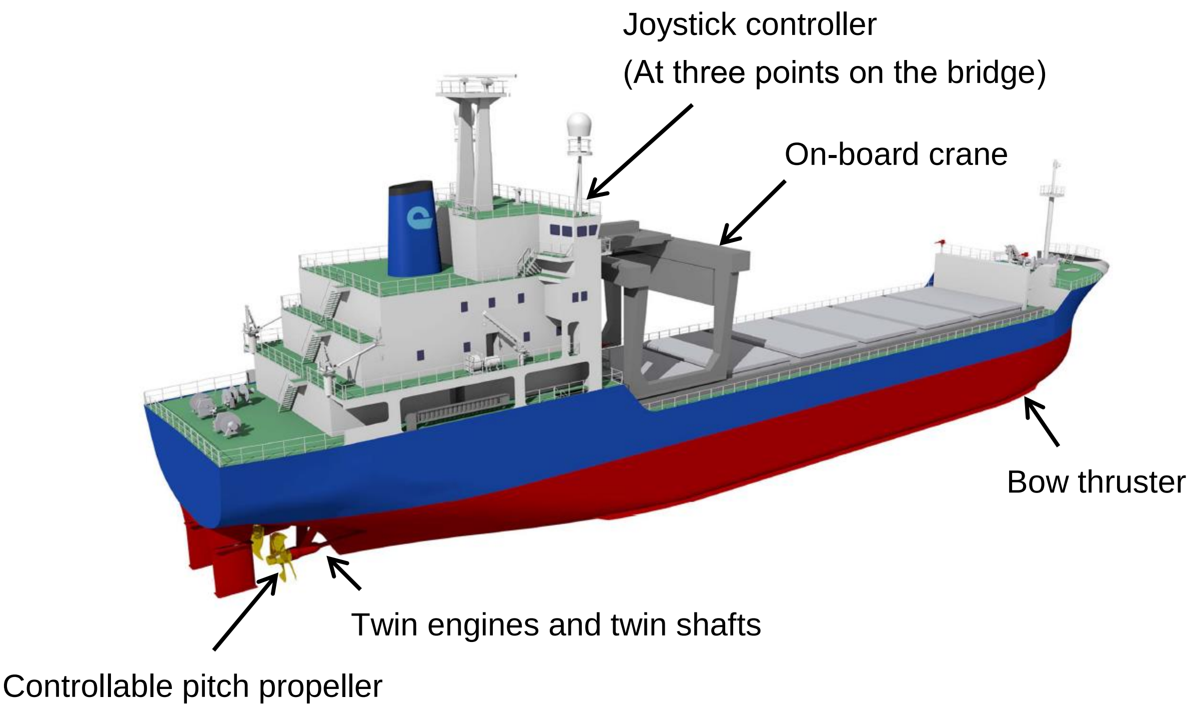


Figure 4. Bird's-eye View of the New Ship

The following equipment has been improved on the new ship to provide for emergency measures so that the ship is able to set sail. These measures are based on the experience of ships urgently leaving quays after the Great East Japan Earthquake, and the equipment has been demonstrated to confirm performance and make further improvements.

- Increase in bow thruster thrust
- Use of joystick for steering
- Reduction in time for quay separation with improved automatic operation of gangway
- Redundancy is achieved by two-machine / two-shaft, and improved maneuverability at the time of departure by combination of variable-pitch propeller and schilling rudder

As Seiei-Maru had one-machine and one-shaft, but the new ship has two machines and two shafts, which were factors in its increased cost. However, NFT stated that top priority was given to tsunami countermeasures, and carefully explained to the power companies that there is no difference between new and old ships in the continuous sailing distance due to improved diesel engine fuel efficiency over almost 30 years, and the power companies understood.

In addition, NFT has achieved cost reductions in specification preparation, detailed design, and operation stages by implementing specification changes to the extent at them they do not affect safe operation.

Specification preparation: Abolished crane aircraft side operator's cab, transportation boat, infrared monitoring equipment, etc.
Detailed design: Listened to opinions from the Seiei-Maru crew and clarified the detailed specifications so as to streamline some of the specifications
Operation: Transferred common measuring instruments, materials, and other items from the Seiei-Maru to streamline some specifications

Even during construction, flexibly responding to the shipyard's request for streamlining further reduced costs.

Conclusion

NFT has confirmed that it attended almost every inspections during construction of the successor ship to the Seiei-Maru through which the company fully complied with rules and verified performance. Moreover, NFT has implemented a number of initiatives for future nuclear transport in Japan, such as the use of clearance materials and the creation of documentation for maintaining a technical tradition. The specifications of the successor ship are not only adapted to Japan's unique KAISA 450, but also take into account the lessons learned from the tsunami strike triggered by the Great East Japan Earthquake as well as knowledge gained during operation of the Seiei-Maru. Therefore, in comparison to the previous Seiei-Maru, the successor ship is much safer.

NFT intends to continue to provide safe transportation in the future with the Seiei-Maru's successor.

References

Hirohito Ito, "Improved Safety Plan of New LLW Transport Ship," PATRAM2016

Acknowledgments

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