# THE PLANNING, LICENSING, MODIFICATIONS, AND USE OF A RUSSIAN VESSEL FOR SHIPPING SPENT NUCLEAR FUEL BY SEA IN SUPPORT OF THE DOE RRRFR PROGRAM[1]

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## ABSTRACT

The Russian Research Reactor Fuel Return (RRRFR) Program, under the U.S. Department of Energy's Global Threat Reduction Initiative, began returning Russian-supplied high-enriched uranium (HEU) spent nuclear fuel (SNF), stored at Russian-designed research reactors throughout the world, to Russia in January 2006. During the first years of making HEU SNF shipments, it became clear that the modes of transportation needed to be expanded from highway and railroad to include sea and air to meet the extremely aggressive commitment of completing the first series of shipments by the end of 2010. The first shipment using sea transport was made in October 2008 and used a non-Russian flagged vessel. The Russian government reluctantly allowed a one-time use of the foreign-owned vessel into their highly secured seaport, with the understanding that any future shipments would be made using a vessel owned and operated by a Russian company. ASPOL-Baltic of St. Petersburg, Russia, owns and operates a small fleet of vessels and has a history of shipping nuclear materials. ASPOL-Baltic's vessels were licensed for shipping nuclear materials; however, they were not licensed to transport SNF materials. After a thorough review of ASPOL-Baltic's capabilities and detailed negotiations, it was agreed that a contract would be let with ASPOL-Baltic to license and refit their MCL Trader vessel for hauling SNF in support of the RRRFR Program. This effort was funded through a contract between the RRRFR Program, Idaho National Laboratory, and Radioactive Waste Management Plant of Świerk, Poland. This paper discusses planning, Russian and international maritime regulations and requirements, Russian authorities' reviews and approvals, licensing, design, and modifications made to the vessel in preparation for SNF shipments. A brief summary of actual shipments using this vessel, experiences, and lessons learned also are described.

## INTRODUCTION

The Russian Research Reactor Fuel Return (RRRFR) Program, which is part of the U.S. Department of Energy's Global Threat Reduction Initiative, began returning Soviet or Russian-supplied high-enriched uranium (HEU) spent nuclear fuel (SNF) that is stored at Russian-designed research reactors throughout the world to Russia in January 2006. By the time this paper is presented, it is anticipated that over 20 shipments of HEU SNF will have been made by the RRRFR Program. During the first few years of making HEU SNF shipments, it became clear that the program needed modes of transportation other than highway and railroad to meet the extremely aggressive commitment of completing the first series of shipments by the end of 2010. The RRRFR Program expanded its modes of transportation to include sea and air transport.

The first shipment using sea transport was made in October 2008 and involved a shipment of HEU SNF from Hungary to Russia. The shipment was made using an American company who leased a Danish-flagged vessel. In order to meet the restrictions imposed by the destination port in Russia, the Danish-flagged vessel was used under management of the ASPOL-Baltic Corporation of St. Petersburg, Russia, who specializes in transporting nuclear cargo by sea. The Russian government reluctantly allowed this one-time use of a foreign-owned vessel into their highly secured seaport in northern Russian, with the understanding that any future shipments to the seaport would have to be made using a vessel owned and operated by a Russian company.

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ASPOL-Baltic owns and operates a small fleet of vessels; they have shipped nuclear materials for customers in the United States and other nations throughout the world. The ASPOL-Baltic vessels were already licensed for shipping nuclear materials; however, they were not licensed for transporting SNF materials. After thoroughly reviewing ASPOL-Baltic's capabilities, the RRRFR Program negotiated a fair and reasonable price to license and refit the MCL Trader vessel (Photo 1) to haul HEU SNF in support of the RRRFR Program.

**Photo 1. Photograph of the Russian Vessel MCL Trader.**

ASPOL-Baltic and its team of technical experts began the process of licensing the MCL Trader for transport of SNF in February 2009. They successfully finished modifying the vessel, obtaining the appropriate certificates and licensing, and having the vessel in place to transport the first shipment of SNF from Poland in September 2009. This was an extraordinary accomplishment that was accomplished in a very short amount of time and would not have been possible without the dedication and commitment of all involved. The purpose of this paper is to share the experiences gained from this process. This paper describes (1) the MCL Trader vessel; (2) vessel refitting (regulatory requirements/ authorities, design, modifications, supporting documentation, and licensing); (3) a brief summary of the shipping experiences; and (4) conclusions.

## DISCUSSION

### <u>Description of the MCL Trader</u>

The MCL-Trader was built in Singapore in 1990. It was designed for the Russian military to haul nuclear missiles to the northern areas of Russia. The vessel has been converted into a cargo vessel (Figure 1). It has a navigation deck with special tracking systems (e.g., global positioning system and special U.S. Department of Energy tracking system), communications (e.g., radios, radio telex, and satellite), emergency response capabilities, and other navigations equipment; it has living areas, a kitchen dining room, and a common area for the crew; it has two cranes for loading and unloading cargo from the two cargo holds; it has a double-walled hull and multiple backup systems; and it has two main engines and one backup engine. Table 1 provides the overall specifications for the vessel.

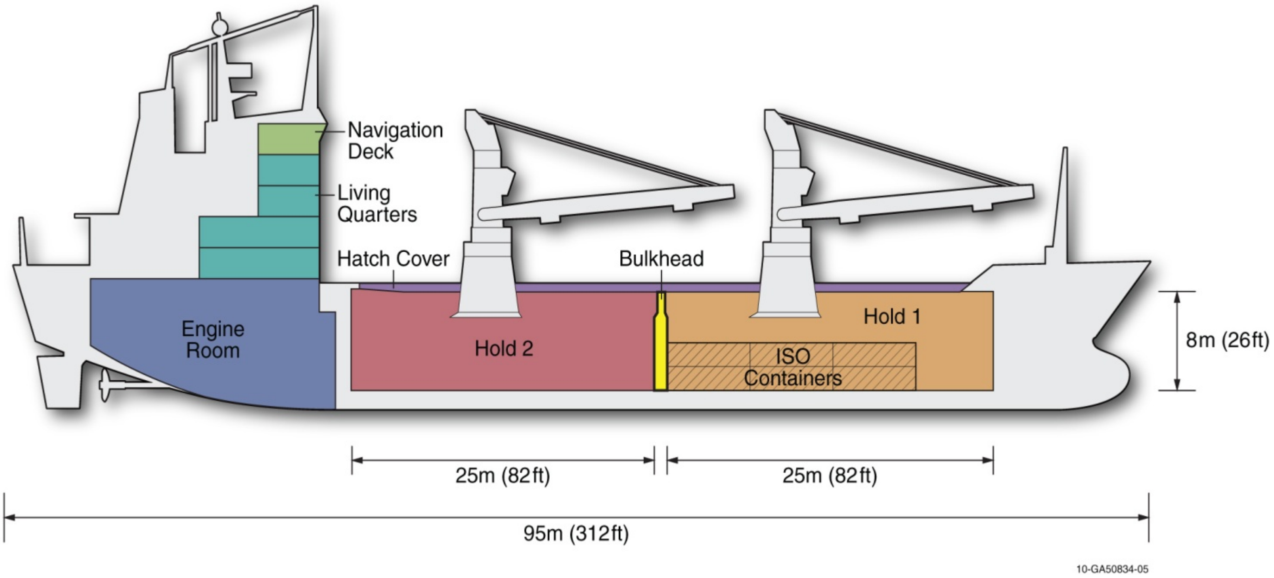


**Figure 1. Schematic of the MCL Trader vessel, including the vessel holds.**

**Table 1. Overall specifications for the MCL Trader vessel.**

| Main Dimensions of the Ship | | |
|---|---|---|
| Length overall | 95.00 m | |
| Length between perpendiculars | 87.00 m | |
| Breadth | 15.80 m | |
| Depth | 7.80 m | |
| Draught up to the load line ($\gamma$ =1.025 t/$m^3$) | 6.31 m | |
| Displacement up to the load line ($\gamma$ =1.025 t/$m^3$) | 6,325 t | |
| Deadweight | 4,195 t | |
| Full speed in calm deep water | 15.0 kn | |
| Main engine capacity | 2 × 1765 kW | |
| **Light Ship** | | |
| Displacement | 2,130 t | |
| Vertical center of gravity Zg | 7.61 m | |
| Longitudinal center of gravity Xg | -8.98 m | |
| Ordinate of center of gravity Yg | 0.42 m | |
| Allowed specific loads for double bottom flooring | 8.0 t/$m^2$ | |
| Allowed specific loads for hatch covers | 1.5 t/$m^2$ | |
| Allow specific loads for main deck | 2.2 t/$m^2$ | |
| Allowed load for axle of wheel-based cargos | 16 t | |
| Allowed load for container sockets | 65 t | |
| **Cargo Hold Capacity** | | |
| Bow hold | 2,203 $m^3$ of grain | 2,090 $m^3$ of bales |
| Aft hold | 2,426 $m^3$ of grain | 2,305 $m^3$ of bales |
| Modship | fr. $68^{+250}$ | |
| Volume of ballast tanks | 1,277 $m^3$ | |

The vessel has a special cooling ventilation system for the cargo hold area that maintains the temperature below 55°C. The vessel has 35 tanks/compartments capable of holding approximately 2,014 tons (i.e., in the hull, under the hold and engine room floors, and at the back of the vessel). These tanks are used for a variety of contents (e.g., sea water for ballast, fresh water, feed water, bunker/fuel oil, engine lubrication oil, sludge, dirty oil, sewer, and bilge water). Table 2 provides a list of the vessel's fluid storage capacity.

**Table 2. Fluid storage capacity for the MCL Trader vessel.**

| Description | Number of Tanks | Total Capacity (tons) |
|---|---|---|
| Ballast (sea) water | 13 | 1,191.3 |
| Bunker (fuel oil)[a] | 10 | 517.0 |
| Lubricant engine oil | 4 | 22.4 |
| Fresh (drinking) water | 2 | 133.2 |
| Feed water | 1 | 6.9 |
| Miscellaneous (sludge, dirty oil, sewer, bilget water) | 4 | 44.9 |
| Totals | 34 | 1,915.7 |

a. The total amount of vessel bunker/fuel can be increased to 800 tons by using the tanks in the cofferdam if more fuel is needed for longer voyages without access to refueling. This increase in fuel can extend the time at sea up to 100 days.

The vessel uses approximately 8 to 10 tons of fuel a day and has been used to haul a wide variety of cargo from various countries and customers.

**Vessel Refitting**

Transforming a Russian vessel from being authorized for transport of regular freight and dangerous goods to being authorized to haul SNF is a complicated and integrated process (Figure 2). The process consists of four major steps. First, regulatory requirements and approval authorities were clearly identified; second, the design was prepared and approved to bring the vessel into compliance with the regulatory requirements; third, the vessel was refitted and approved in accordance with the design; and, fourth, a documentation package, containing all of the design, analysis, operations, and inspection documentation, was prepared. This package was submitted for review and approval to the appropriate regulatory authorities, who issued the vessel license after confirming it met the regulatory requirements for hauling SNF in compliance with INF-2 (Figure 3) [IMO Resolution MSC.88 (71)].

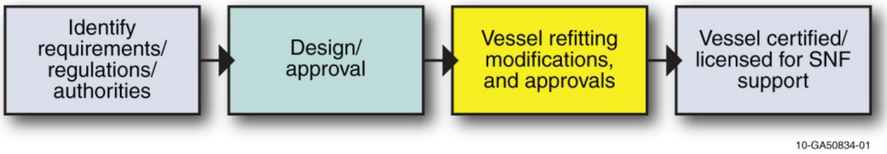


**Figure 2. The process for licensing the MCL Trader for transport of SNF materials.**

The schedule for completing the design, refitting, and licensing was so tight that it was not possible to perform each part of the process in sequence as it is normally done. Final design review and approval by the authorities was performed in parallel with the actual refitting and refurbishment of the vessel at the shipyard. This involved some risk to the program because parts were ordered and refitting and refurbishment of the vessel began without first having the appropriate approval from the Russian authorities. However, this risk was minimized by using a team of highly qualified and respected individuals and organizations at the beginning of the process. This team defined the requirements and prepared the designs, analysis, and other supporting documentation in preparation for the refitting. The following sections provide more detail on the steps taken to refit the MCL Trader for transport of SNF.

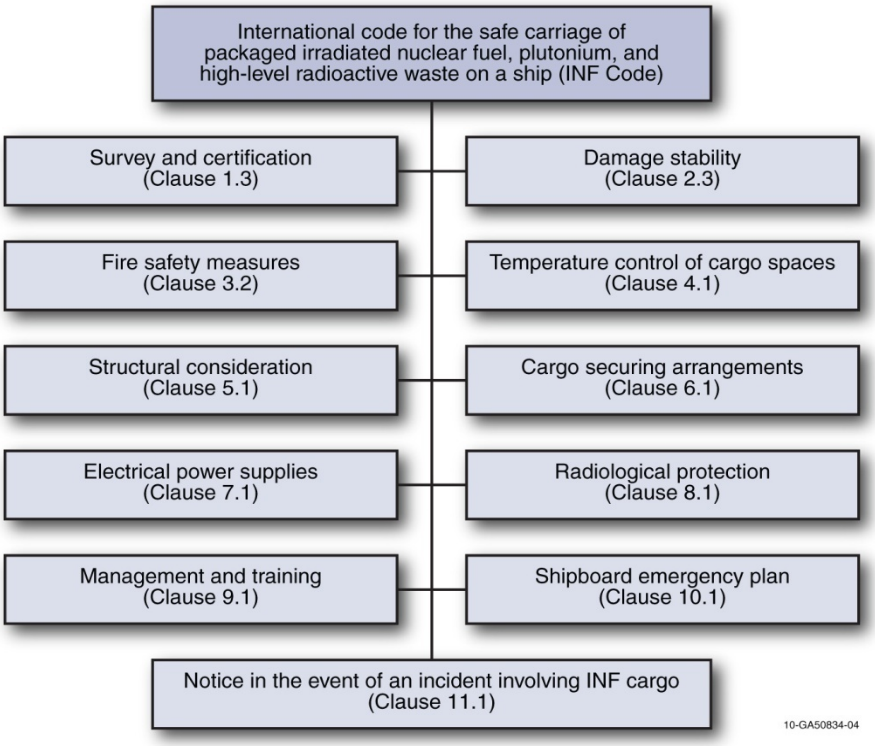


**Figure 3. INF Code for licensing/certifying a vessel to haul SNF.**

**Regulatory Requirements**

Because the MCL Trader is a Russian-flagged vessel, it had to meet Russian and international regulatory requirements and be approved by the appropriate Russian authorities. The vessel had to meet the following codes and regulations:

- Class INF-2 [IMO Resolution MSC.88 (71)]
- IMDC International Code Rules (radioactive materials), Class 7 (dangerous cargo)
- International Convention for Safety of Life at Sea (SOLAS-73/78)
  - Part B-1, Head II-1 (stability in a damaged condition)
  - Head II-2 (water fire-control unit, stationary fire-control unit in the machine premises of Category A, and stationary devices for cooling of the cargo premises)
  - Chapter II (the vessel holds a drainage system, fire alarm system, and carbon dioxide firefighting system that should be modified to be appropriated to the INF code requirements)
- Russian International Register of Shipping Rules, 2007.

As a world leader in sea transport, Russia has a very sophisticated and experienced regulatory authority system that covers all aspects of vessel design, analysis, verification, and licensing. Table 3 lists the Russian authorities and their areas of expertise and authority for licensing a Russian-flagged vessel for use in transporting SNF.

**Table 3. List of authorities involved in review and licensing of the vessel.**

| Authority | Area of Expertise/Authority |
|---|---|
| The Russian Maritime Register of Shipping (RMRS) | Supervision over the technical conditions of the vessels, including SNF sea carriers and approval of the vessel's modifications into an SNF carrier. |
| Krylov Shipbuilding Research Institute | The authorized scientific organization making the project design for modification of the vessels carrying SNF. |
| Rostechnadzor | The competent-state Russian entity for supervision over nuclear and radiation safety and physical protection and licensing of vessels, including SNF sea carriers. |
| Federal Medical and Biological Agency | The federal authorized medical and research institution for evaluation of various medical and ecological aspects that issues recommendations for safe carriage of SNF. |
| Sanitary and Epidemiological Control Center | The regional authorized medical and research institution for control over medical aspects onboard a vessel, including SNF sea carriers and the issue of the sanitary and epidemiological conclusions. |
| St. Petersburg Administration of the Federal Supervision Service for Rights Protection of the Consumers and Inhabitants Well-Being | The regional authorized institution entitled to evaluate the vessel's refitting for conformity to the various rules and hygienic safety requirements. |
| St. Petersburg Center of Hygiene and Epidemiology for Transport | The regional authorized medical institution that affects practical control for sanitary safety onboard the vessels. |
| Scientific Research Institute of Industrial and Sea Medicine | Performs calculations to specify the maximum permissible emissions and waste as a result of a vessel's refitting. |
| Murmansk Sea Biological Institute | Performs environmental impact assessment. |

**Refitting Design**

The process for designing and approving a vessel to transport SNF is shown in Figure 4. A team of the highest-qualified technical experts were pulled together to inspect, evaluate, calculate, and provide technical support to evaluate the current condition of the vessel and identify what was needed to bring the vessel into compliance with INF-2's SNF requirements. The members of the team included ASPOL-Baltic, Sosny R&D Company, Krylov Shipbuilding Research Institute, RMRS, Branch Scientifically-Methodical Center for Labor Safety on Sea Transport, St. Petersburg Administration of Federal Supervision Service for Right Protection of the Consumer and Inhabitants Well Being, St. Petersburg Center of Hygiene and Epidemiology for Transport, Scientific Research Institute of Industrial and Sea Medicine, Murmansk Medical Biological Institute, and the Federal Medical and Biological Agency.

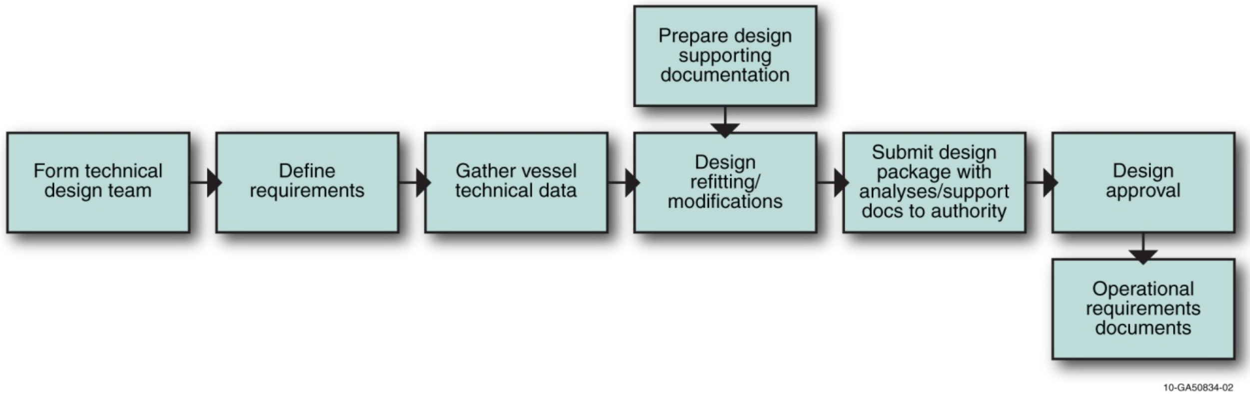


**Figure 4. The process for designing and approving a vessel for transporting SNF.**

**Design Criteria**

A complete set of the vessel documents (greater than 400 documents), including drawings and specifications, were gathered and given to the team of experts for review and evaluation. The team also performed a physical examination of the vessel. The experts concluded that the MCL Trader was in good condition and suitable for refitting to meet the requirements of Class INF-2 for transport of SNF. The team prepared a list of design criteria needed to refit the vessel to bring it into compliance with INF-2. Those criteria included the following:

1. Stability in a damaged condition that meets the requirements of International Convention for Safety of Life at Sea (SOLAS-73/78), meaning the vessel should have at least one-compartment floatability that is provided with the cross section, water-proof partition dividing the cargo hold.
2. The vessel should be equipped with a water fire-control unit, stationary fire-control unit in the premises of Category A machinery, and stationary devices for cooling of cargo.
3. The vessel should be provided with sufficient, independent, and duplicated systems of ventilation and cooling of the closed cargo premises, so that, at any time, the ambient temperature does not exceed 55°C.
4. Constructional durability of the deck and supporting devices should be sufficient for prospective loading.
5. Sufficient devices for fastening should be provided to prevent displacement of the containers in the cargo premises during a sea trip.
6. The second (i.e., emergency) source of electric power that is sufficient for supplying power to all emergency services on the vessel for at least 36 hours should be provided; it also should supply the equipment for emergency systems of flooding and cooling of a cargo premise that is transporting SNF cargo.
7. According to the conservative characteristics of transporting SNF cargo, additional devices and equipment for radioactive protection that meet the requirements of the International Code for the Safe Carriage of Packaged Irritated Nuclear Fuel should be provided.
8. Physical barriers complicating unauthorized penetration into a cargo premise and a means of detection, supervision, and a disturbance-calling alarm system should be provided.
9. An environmental impact assessment should be developed to reveal dangerous and risk factors that are capable of affecting a population's state of health during vessel modification.
10. The ship's emergency response plan of action in extreme situations should be developed and approved by supervising bodies.

**Vessel Design**

Once the design criteria were identified, the team established an approach for refitting the vessel. This approach involved dividing the vessel into two zones (i.e., the controllable zone or Hold No. 1 and the non-controllable zone or Hold No. 2) (see Figure 1). Hold No.1 is located in the nasal/front of the vessel and is designed to store the INF-2 Class SNF cargo (i.e., up to sixteen 20-ft International Shipping Organization [ISO] containers loaded with SNF casks) during sea transport. Hold No. 1 is designed to buffer the vessel's inhabitants/crew from the cargo's radiation exposure. All of the design and refitting of the vessel was focused on Hold No. 1. Hold No. 2 was deliberately left unchanged and required no design, refitting, or licensing. Hold No. 2 is nearest the navigation deck, crew living area, and engine room, and can be used to haul regular freight. In accordance with the Rules for the Classification and Construction of Sea-Going Ships, Edition XIII, each cargo hold was required to have two exits around the established cross-section, water-proof partition in the vessel case structures. In addition, a drainage system was designed for Hold No. 1 that is independent from the ship's drainage system. This was done so that in the unlikely event of radioactive contamination getting into the wastewater, the radioactive contamination will not be mixed with the vessel's other wastewater. Water from Hold No. 1 needs to be captured in an independent ballast tank that can be emptied into special hazardous material tanks at seaport if necessary.

Hold No. 1 has special design features, which includes stability in a damaged condition that is provided by a double-walled bulkhead that was made of 10 to 12-mm thick PCA-32 steel plates welded together to form two walls, with a 650 mm space between Hold No. 1 and Hold No. 2. This bulkhead extends from the vessel floor, up both sides of the vessel hold, to the main deck hatch, forming a leak tight seal between the two holds and a seal under the hold area hatch cover. Other features include a permanent water sprinkler system used for fire suppression and cooling the SNF cargo if the ambient temperature in the hold exceeds 55$^{o}$C; two ventilations fans connected to the cargo area, independent of each other, to provide cooling of the closed cargo area so that ambient temperature never exceeds 55$^{o}$C; floor reinforcement provided to ensure sufficient support for prospective loading; tiedown system that uses standard Mac Gregor latching fixtures built into the cargo hold floor to latch the ISO containers to the floor and double stoppers for additional tiedowns; radiation protection provided by the bulkhead wall between the two holds and filled with sea water and a special environmental shielding placed on top of the ISO containers and the hold; unauthorized access physical barriers controlled from the navigation bridge and the engine control room and by tamper seals secured on the personnel entrance hatches into the cargo hold; backup electric power system used to provide enough emergency power to supply all emergency services on the vessel, including power for flooding and cooling the SNF cargo area, for at least 36 hours.

## Design Documentation

Over one hundred documents were prepared in support of the vessel refitting design. Those documents are divided into 13 categories and examples of documents within each category are provided: (1) *general* – modifications to the vessel specifications, list of equipment and materials, and radiation safety justification report; (2) *vessel* – overall strength calculations and drawing of transition of pipes, ventilation, and cable ducts through bulkheads, decks, inner bottom, water-tight floors, and frame couplings; (3) *devices and equipment* – layout of holes in the vessel, superstructures and deckhouses; (4) *stability* – hydrostatic curve, and curves for frame and static moments; (5) *compartment* – diagram of vessel subdivisions showing all water-tight structures and holes, type of hole closures, and location of list-leveling and trim difference devices; (6) *fire protection* – fire alarm circuits and fire plan; (7) *automation equipment* – functional and principal diagrams of control automation of drainage and ballast systems, power supply, alarm, and indication; (8) *piping and systems* – diagram and list of elements of ballast and drainage systems; (9) *electrical equipment* – calculations of cable section with indication of their types, voltage, and protection; (10) *special issues* – ecological expertise documentation and biological shield diagram; (11) *communications and navigation* – secure lighting system and electric circuit; (12) *operations* – procedures for loading, unloading, and ballast operations; and (13) *others* – explanatory note on implementation of MARPOL 73/78.

## Design Approval

Once all of the documentation, (e.g., analysis, specifications, and engineering drawings) were completed, a vessel reconditioning design package was prepared, including a set of all documentation needed to substantiate/validate the changes in the MCL Trader vessel in order to be licensed to transport SNF. The vessel reconditioning design required approval by Russian authorities and ratification by the RMRS. The Russian authorities focused on four major areas when reviewing and approving the vessel reconditioning design package. Those areas were crew working conditions; general vessel characteristics; vessel sanitary status; and SNF cargo, radiation safety, and construction durability. The RMRS required 2 months to examine and ratify the design to be in full compliance with the rules of Russian International Register of Shipping. Ratification of the vessel reconditioning design was the first step in the procedure for obtaining the

International Certificate of Fitness for carriage of SNF cargo. The INF Certificate was issued by the RMRS after completion of the shipyard's formal acceptance of the work results.

**Operation Requirements Documentation**

Design involved preparation of a series of operational requirements documents. Ten documents were prepared, approved, and ratified by the RMRS and included documents on stability information, a manual for shipping SNF casks, document on the Radiation Security Program, regulations and instructions for fixing and lashing containers and fixing loads, a manual on securing cargo, a feasibility study on radiation protection, and an Environmental Impact Declaration.

**Final Authorization**

The handling of nuclear materials, including transportation and loading of SNF, is regulated at the state level in the Russian Federation by Rostechnadzor [Regulations for ships and other vessels on leaving Russian Federation ports with nuclear materials and radioactive matters (R 31.2.12-04)]. Rostechnadzor issued final permission for the MCL Trader to transport ISO containers loaded with SNF casks. Documents used by Rostechnadzor to give permission and determine transport included a report on safety, reports on the radiation protection program and quality control program, a shipboard emergency plan, personal right to work, a security certificate and certificates of approval for SKODA and TUK-19 packaging, an agreement between the government of the Russian Federation and the government of the Republic of Poland, the Foreign Trade Contract, the universal time-charter (Baltime 1939), a procedure for SNF physical protection, a constitution on physical protection of sea vessels, an emergency card for nuclear materials and radioactive substances, and documents of crew training and testing.

**Refitting/Refurbishment**

The vessel needed to be finished to make the first shipment from Poland by early September 2009, meaning ASPOL-Baltic had only 5 months for refitting (Figure 5). The schedule was very aggressive and would normally take 8 months, minimum, to complete. Refitting work began using designs that had not been approved by the RMRS. There was risk to the program that was minimized by using a team of highly qualified and skilled individuals and organizations. The team prepared design technical specifications based on a thorough review and inspection of the vessel and documentation and on a superior understanding of the regulatory requirements.

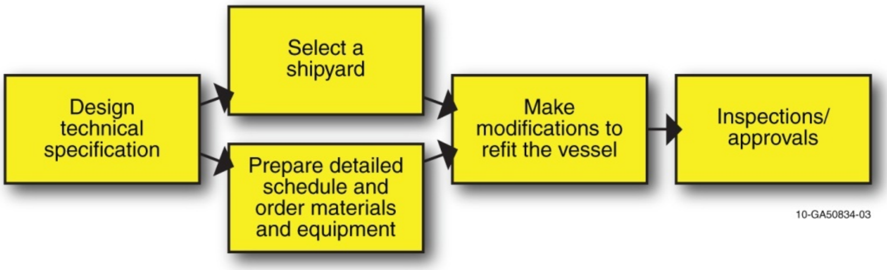


**Figure 5. The process for refitting the vessel.**

ASPOL-Baltic sent out a request for bids to shipyards throughout Europe and Russia for the refitting and refurbishment of the MCL Trader vessel. Ten shipyards responded to the request and only five submitted bids that met the schedule: (1) Netaman in Tallinn, Estonia, (2) Kanonersky Ship Repair Yard in St. Petersburg, Russia, (3) Nauta Shipyard in Poland, (4) Tallinn Shipyard in Tallinn, Estonia; and (5) Niestern Sanders in Holland. The bids included the following scope of work:

- Refitting the vessel per ASPOL-Baltic specifications
- Refitting the vessel hatch covers and building a patrician/bulkhead wall that divided the vessel hold in half in accordance with INF-2 standards
- Cleaning and painting the vessel and storage tanks (Photo 2)
- Disposal of tank sludge, sand, old paint, and rust removed from the vessel
- Classification Society to provide oversight and inspection of the refitting operations
- Dry docking the vessel and performing requirements in accordance with the Classification Society

- Materials and spare parts for refitting the vessel per ASPOL-Baltic specifications
- Providing a surveyor.

Netaman Shipyard in Tallinn, Estonia was chosen based on their bid price and reputation throughout the industry for being an excellent shipyard. They have highly skilled and qualified craftsmen that use approved materials and procedures and provide continuous monitoring and inspections by qualified inspectors during vessel refurbishments.

The vessel arrived at Tallinn Shipyard on April 22, 2009 (Photo 3). A detailed schedule was developed that included all work needed for every new and modified piece of equipment, vessel modification, and refurbishment. Materials were ordered, some of which took several months for delivery. Netaman Shipyard craftsman did the majority of the work; however, the MCL Trader crew overhauled two main engines, one auxiliary engine, all pumps, and performed other maintenance operations, as needed.

**Photo 2. MCL Trader crane being cleaned and painted.**

Upon arrival at the Netaman Shipyard, the vessel was immediately moved into dry dock and the refitting/refurbishment work began. The vessel bow was cleaned, scrapped, sand blasted, and painted. It took several months to paint the rest of the vessel, using the same painting process. All vessel tanks were emptied, waste removed, and equipment disassembled to be refurbished. Long-lead procurement items were identified and ordered.


**Photo 3. MCL Trader docked at the Netaman Shipyard in Tallinn, Estonia.**

Work on Hold No. 1 began and involved (1) reinforcing the deck under the bulkhead and in other areas of the deck; (2) building the bulkhead divider wall (Photo 4); (3) building an emergency personnel exit; (4) installing the fire protection system, including a sprinkler system, $CO_2$ system, monitoring capabilities in the navigation bridge, controls in the engine room, and automatic vent closures; (4) installing special Mac Gregor latching to the deck for tying down eight ISO containers; (5) installing a water drain system, with a water level detector and alarm in the navigation bridge, and piping and pump capabilities to direct discharge if the water is clean or pump into a special tank if the water is possibly contaminated; (6) refurbishing independent and duplicate ventilation and cooling systems; (7) backing up the power generator to supply emergency power for all emergency systems for greater than 36 hours; (8) installing radiation protection equipment; (9) installing special security devices to prevent unauthorized penetration into the SNF storage area; and (10) modifying the hatch cover with special seals to prevent water leakage.

Eight special radiation and biological protection covers were built for covering the top of the ISO containers in Hold No. 1. Each cover is constructed of a metal plate and frame filled with special concrete. Each cover weighs approximately 30 tons (Photo 5).

There were three levels of supervision, verification, and quality assurance (i.e., ASPOL-Baltic superintendent, Netaman Shipyard inspector, and an RMRS representative). Also, several times throughout the refitting process, representatives from the

**Photo 4. Bulkhead being built to separate vessel Hold No. 1 from Hold No. 2.**

**Photo 5. Special radiation and biological protection covers for the ISO containers.**

Radioactive Waste Management Plant and the RRRFR Program visited the vessel to see the completed work, review the schedule to identify problems, and confirm the vessel was still on schedule.

Vessel refitting was completed on September 2, 2009, and the MCL Trader license for transporting SNF material was issued September 3, 2009.

**Vessel Use Experience**

The MCL Trader was delivered to the Polish seaport on September 13, 2009, in time to make the first shipment. Since September 2009, the MCL Trader has been used successfully to make five HEU SNF shipments from Poland.

Prior to each shipment, ASPOL-Baltic confirmed that the vessel and crew were ready to make the shipment. The vessel was filled with bunker (fuel oil), fresh water, and supplies and food for the crew. Crew training was verified and updated if needed, and several days before shipment, the seaport agent began prearranging all seaport activities. A list of authorized personal needing access to the pier area during receipt and transfer operations was identified. Access to the pier was strictly controlled for security reasons. Arrangements were made for security, pier workers, the stevedore, and the lift operator to remove the ISO container from the railcars. The MCL Trader left in time to arrive at the Polish seaport 1 day before the shipment arrived at the seaport.

On the day of the shipment, the MCL Trader was moved to the pier and readied for loading. The deck cover to Hold No. 1 was opened and the hold was prepared for loading. The SNF arrived at the seaport by train. The shipment was highly guarded upon arrival and additional port guards were used to secure the pier area during port operations. The train was moved into place on the pier and the ISO containers, loaded with casks filled with SNF, were offloaded from the railcars and placed near the pier gantry crane. Each ISO container was placed into Hold No. 1. The bottom eight ISO containers were latched to the hold deck by the special Mac Gregor locking devices built into the vessel. A second layer of ISO containers were stacked on the first layer using standard equipment for stacking ISO containers. The top layer of the ISO containers was tied together with double-stoppers. Up to 16 ISO containers can be stored in the hold. The biological protection plates were placed on top of the ISO containers and latched into place (Photo 6). A final radiation survey of the hold area was performed, all workers were evacuated, the hold deck cover was closed, and the personnel access/exit covers were shut and tamper seals attached.

**Photo 6. MCL Trader Hold No. 1 loaded with SNF cargo.**

In the captain's quarters, all of the shipping papers were finalized and signed. Customs and immigration officers completed the final inspections, stamped the appropriate documentation, and authorized the vessel to leave. It took between 6 hours from the time the train arrived at the pier to the time the vessel was ready to leave.

A harbor pilot boarded the vessel, two tugboats were connected to the port (front) and stern (rear), and the vessel was slowly pulled away from the dock. The tugboats alternated pulling each end of the vessel while the other held its end of the vessel steady until the vessel was safely in the center of the harbor channel and could leave the seaport. The rear tugboat was released and the front tugboat pulled the vessel out of the harbor per the directions of the harbor pilot. The harbor pilot disembarked the vessel when outside the harbor area. The captain of the MCL Trader took control of the vessel, and the Polish Coast Guard escorted the vessel to international waters.


**Photo 7. MCL Trader anchored in the Russian harbor.**

The voyage to Russia took 9 days depending on the wind, currents, and storms conditions. The vessel travelled in international waters for the majority of the voyage.

At the Russian seaport, the vessel was driven by a local harbor pilot to a designated location where it was anchored in place (Photo 7). Russian customs and immigration agents boarded the vessel and checked all arrival documentation, personnel paperwork, and information for discharging the cargo. Once all of the documentation had been checked and confirmed to be in order and acceptable, and the ownership of the SNF had been transferred to the Russians, the non-Russian passengers (e.g., the Polish representative on board) left the vessel.

The vessel was moved to the pier, the seals to the personnel exit were cut, and the hold cover was opened. The biological protection covers were removed and the cargo was offloaded from the vessel and placed onto the railcars. The train left the seaport for Mayak.

The MCL Trader was reassembled, the biological covers were loaded back into the hold, and the hold cover was closed. The vessel was moved back into the harbor and anchored. Customs and immigrations agents boarded the vessel, rechecked all of the vessel and crew documentation, and released the vessel to leave Russia. The vessel departed and headed for the temporary docking area, pending the next shipment.

## CONCLUSIONS/LESSONS LEARNED

The following conclusions and lessons learned are from planning, licensing, modifying, and using a Russian vessel for shipping SNF by sea in support of the RRRFR Program:

1. Forming a team of highly qualified and respected individuals and organizations at the beginning of the refitting and licensing process of converting a vessel for transport of SNF in accordance with INF-2 is critical and can greatly reduce the time it takes to complete refitting and licensing.
2. Transportation of SNF by sea using a special, refitted, sea-going vessel represents a reliable and safe way of SNF delivery to the destination country within an existing schedule and avoiding any complications with transit countries.
3. In order to keep the highest level of safety and reliability of such shipments, it is essential to use permanent, experienced, and well trained personnel and subcontractors that have practice working with this type of materials.
4. All participants of such shipments should be able to contact each other on a permanent basis in order to verify and resolve the technical and other tasks arising out of practical implementation.
5. The special regime of confidentiality and other protective measures should be maintained throughout all stages of preparation and implementation of the sea shipment in order to maintain the physical protection of SNF and to avoid obstacles that could appear as a result of noncompliance to this requirement.
6. Preparation of each of the shipments should be started well in advance in order to ensure all participants and subcontractors are aware of their own tasks and are ready to follow the agreed on organization and technical procedures.
7. All factors that could have negative influence on the schedule of a particular shipment should be taken into account in advance to be able to elaborate the proper counter-measures, allowing achievement of the final goal and maintenance of the existing national and international requirements and maritime standards.
8. The vessel to be used for sea transport of SNF always should be kept in permanent readiness for forthcoming voyages, enabling all parties concerned to be assured of its performance.
9. It is critical that an adequate number of crew members are on a vessel during transportation of SNF and that the crew is provided with good accommodations, food, and reasonable work hours. The crew must be well fed and rested to ensure they are able to perform their duties effectively and safely.