MULTIMODAL SHIPMENTS UNDER PROGRAM ON RUSSIAN-ORIGIN RESEARCH REACTOR SFA RETURN TO RUSSIAN FEDERATION

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ABSTRACT

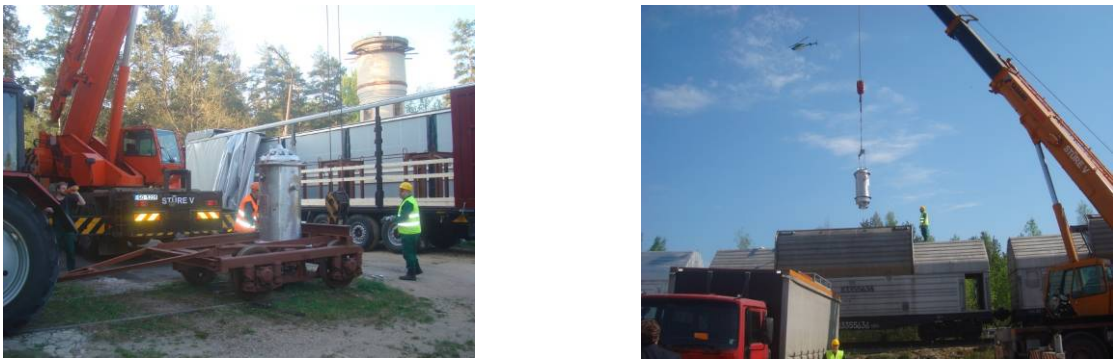
The paper describes experience in preparation and organization of research reactor nuclear material import under the Program on Russian-Origin Highly Enriched Uranium Return to the Russian Federation. It also summarizes evolution of transport equipment, conveyances and routes and describes types of packages, their adaptation and certification, safety issues, peculiarities and prospective use of the packagings and conveyances.

Introduction

Spent fuel assemblies of the research reactors (RR) constructed in European, Asian and African countries with the assistance of the Soviet Union are returned to the RF under the Russian Research Reactor Fuel Return (RRRFR) Program. A U.S. / Russian Government-to-Government Agreement concerning cooperation to return the Russian produced nuclear fuel to the Russian Federation signed in May 2004 established the legal framework for the cooperation between the RF and the USA. Fifteen counties out of seventeen having Soviet-design research reactors supported the terms and principles of the HEU return to the RF.
The RRRFR Program has given remarkable experience in multi-modal shipments of RR SFAs. The International RRRFR Program has reached its heights giving a chance to summarize the acquired experience and to sum up interim results. By now, the program has completed shipments of Russian-origin SFAs from Uzbekistan, Latvia, Kazakhstan, the Czech Republic, Bulgaria, Hungary, Romania, and Libya.

Evolution of Logistical Solutions for RR SFA Transportation

When the RRRFR program was started, the Russian fleet of RR SFA packagings included TUK-19, TUK-32 casks. In fact, the TUK-19 cask was the only that could be used. This was due to simplicity of its handling, a lesser mass (4.5 t), a sufficient quantity available, and correspondingly, few organizational and technical activities for receipt and handling of the TUK-19 casks on the SFA consignor's site.
The first experience in the RRRFR shipments was gained from RR spent fuel removal from Uzbekistan in 2006. The RR SFAs were transported to the Radiochemical Plant in Russian-made TUK-19 casks by the standard method, i.e. in TK-5 container railcars. From the Institute of Nuclear Physics to the railway station, the spent fuel was transported by road. Similar transportation plans were used for the RR SFA shipments from Latvia (2008) and Kazakhstan (2008-2009). Each of the shipments of the TUK-19 casks required development of special devices (Fig.1) that were not universal and could not be used in further projects.



a b

Fig. 1. Loading of TUK-19 casks on a truck (a) and a TK-5 container railcar (b)

It is evident that one type of casks for such a large-scale program on fuel return to the Russian Federation was insufficient. Specially for the RRRFR purposes, DOE financed development and fabrication of 16 SKODA VPVR/M casks.

The Czech-made SKODA VPVR/M cask was designed for multimodal shipments, since it fits a freight 20-ft ISO-container (Fig.2), and handling operations with the ISO-container are unified for almost all conveyances. The use of the SKODA VPVR/M cask for the RR SFA shipments in the Russian Federation required that a certificate for the package design and shipment be issued and the cask receipt procedure at PA "Mayak" be adapted.

Fig.2. Arrangement of the SKODA VPVR/M cask in an ISO-container

The effort on obtaining a Russian certificate of approval for SKODA VPVR/M cask design was divided into two stages. At stage I, the Russian technical experts reviewed the certification design safety documentation provided by SKODA JS a.s., the cask designer, to determine if they were sufficient to meet the requirements of the Russian regulations.

Stage II involved developing a Russian application for certifying the SKODA VPVR/M package design that was submitted to Rosatom, the Russian competent authority. The expert organizations, VNIIEF and IPPE, performed calculations of the package design safety under normal and accident transportation conditions; the calculation results verified the designer's data. After getting all required concurrences, on the 23rd of January, 2006, Rosatom approved certificate RUS/3065/B(U)F-96 for SKODA VPVR/M package design for transportation of research reactor SFAs.

Preparatory work for the receipt of the SKODA VPVR/M casks at PA "Mayak" required that additional equipment be fabricated or procured, necessary technological documents be prepared, the personnel be trained, and the handling procedure at the Radiochemical Plant be adapted.

The Czech-made SKODA VPVR/M casks were used to remove spent fuel from Nuclear Research Institute (NRI Rez), the Czech Republic, in 2007. The SFA-containing SKODA VPVR/M casks in ISO-containers were transported to the railway station by road; then, they were delivered to the Radiochemical Plant in Russia by rail through Slovakia and Ukraine (Fig.3). A similar scheme is planned for RR SFA transportation from Ukraine.

The first experience in shipments of SKODA VPVR/M casks by water transport was obtained from the RR SFA removal from Bulgaria in 2008. The water section of the route ran down the Danube River and involved a river/sea barge (Fig.4). The SFA-containing SKODA VPVR/M casks were transported from the Institute for Nuclear Research and Nuclear Energy to the Port of Kozloduy by road and reloaded to the barge. The containers were delivered to the Ukrainian Port of Izmail down the Danube river first, and then to the Russian reprocessing plant by rail.

a

b

Fig.3. Transportation of ISO-containers with SKODA VPVR/M casks by road (a) and rail (b)

The Check-made SKODA VPVR/M casks were also used to remove RR SNF from KFKI Atomic Energy Research Institute of the Hungarian Academy of Sciences in 2008. That was the first use of a sea transport for the RRRFR program.

The Danish LYNX vessel, a Class INF2 ship, (Fig.5) was used on the sea section of the route. The ship is equipped to comply with requirements of the INF Code. ASPOL-Baltic Corporation, a Russian sea carrier, that has relevant experience was in charge of compliance with the requirements. Since the major part of the sea route was out of the Russian maritime belt, the Russian Certificate of Approval required that International Emergency Cards should be used in compliance with the IMDG Code. Physical protection issues required particular attention. A special procedure for physical protection responsibility transfer was developed and approved.

The SFA-containing SKODA VPVR/M casks in ISO-containers were transported from the Research Institute to a Hungarian railway station by road and reloaded onto flat railcars. The ISO-containers were shipped to the Slovenian Port of Koper by rail (Fig.6). The sea route lied across Europe to the Russian Port of Murmansk, from where the ISO-containers were shipped to the Radiochemical Plant by rail.

Fig.4. Loading of an ISO-container with SKODA VPVR/M casks on the river/sea barge

Fig.5. The Danish LYNX vessel used to ship RR SNF from Hungary

The task of unification of handling operations with the TUK-19 casks was resolved under the project on SFA removal from the Romania VVR-S reactor by creating a transport overpack (Fig.7). A special freight 20-ft large-capacity ISO-container (a special ISO-container) satisfying international conventions and industry standards for transport of dangerous goods by various conveyances formed the basis for the overpack. The special ISO-container has a set of tie-downs to fasten the TUK-19 casks.

In 2008, the first (prototype) container was fabricated and tested, and the Russian Maritime Register of Shipping issued a certificate of approval.

a

b

Fig.6. Transportation of ISO-containers with SKODA VPVR/M casks by rail across Slovenia (a) and loading of the ISO-containers on the LYNX ship (b)

The new overpack significantly extended the TUK-19 cask handling and carriage capabilities for various conveyances including aircraft and ships. The overpack was used to ship the VVR-S reactor SFAs from Romania by air. For certification of the TUK-19 cask for RR SNF air shipment, VNIIEF experts calculated dynamic deformation and strength of the TUK-19 package under impacts simulating normal and accident transport conditions including an air crash. Additional calculations were made to substantiate that the individual package maintains sub-criticality under enhanced tests.

Fig.7. A freight ISO-container overpack for transportation of TUK-19 casks

The RR SFAs were removed from Romania in June 2009. The SFA-containing TUK-19 casks in ISO-containers were delivered from IFIN-HH Institute to the Romanian airport by trucks. Volga-Dnepr Airlines' AN-124-100 aircraft was used for the air shipment (Fig.8). The flight route lied over the Black Sea to minimize the time of crossing the airspace of third countries; over the land, it avoided large populated localities and hazardous industrial facilities. After an interim refueling stop in Ulyanovsk, the aircraft landed at the Koltsovo airport, from where the consignment was delivered to PA "Mayak" by trucks.

A similar transport plan involving air transport was used for removal of the RR SFA from Libya in December 2009.

a

b

Fig.8. AN-124-100 aircraft (a) and overpacks with TUK-19 casks in the hold

It would be logical to involve a Russian sea carrier in such a large-scale fuel repatriation program. With this purpose on and with direct involvement of R&D "Sosny", the Krylov Shipbuilding Research Institute (St.Petersburg) designed modifications to the *MCL Trader* ship (Fig.9) of ASPOL-Baltic Corporation. After the design was developed and approved, the Estonian Netaman Oy shipyard remodeled the *MCL Trader* supervised by local

representatives of the Russian Maritime Register of Shipping and certified it as Class INF2. In September 2009, the remodeled *MCL Trader* was commissioned for the Ewa and Maria SNF removal from Poland.

a

b

Fig.9. Russian Class INF *MCL Trader* ship (a) and loading of ISO-containers with SKODA VPVR/M casks in the hold (b)

Removal of the Polish reactor SFAs will require five shipments in SKODA VPVR/M and TUK-19 casks packaged in ISO-containers. The route includes a road section from Institute of Atomic Energy to a Polish railway station, a rail section across Poland to the Polish Post of Gdynya, a sea section around Scandinavia to the Russian Port of Murmansk, and a rail section across Russia to the Radiochemical Plant. The first shipment in SKODA VPVR/M casks has already been completed.
It is planned to use the *MCL Trader* for the RR SNF shipment from Germany and Serbia.
Before 2008, the RRRFR shipments employed road and rail transport. Water transport has been used for the shipments since 2008, and aircraft – since 2009. The returned amount totals 600 kg of HEU in SFAs.

Prospective

In 2009, development of a SKODA VPVR/M Type C package was started. As opposed to the Type B package certified for air shipment, the Type C package does not have any additional activity requirements for the radioactive contents, it is not required to load SFAs into airtight canisters, but the cask design shall maintain integrity and containment under enhanced tests. According to the data available, there are no certified SNF packagings that would comply with the Type C package requirements.
VNIIEF made a preliminary evaluation of the SKODA VPVR/M Type C package feasibility. The modification to the SKODA VPVR/M cask at hand will enhance efficiency of the energy absorption system through enclosing the cask in a “cocoon”. In case the efforts are successful, a universal packaging will be developed for air transportation of fissile materials without any additional activity or radioactive contents limits.

Conclusions

The RRRFR program has become a catalyst for enhancement of the fleet of casks, development of equipment for loading SFAs into casks, and the use of new transport modes and routes.
The experience gained in the multimodal shipments and the engineering developments have significantly extended capabilities for RR SFA transportation and have been successfully used for the RRRFR shipments. This experience has not only practical value for the RRRFR program, but is also universal for any other projects associated with management of research reactor nuclear fuel.