RESEARCH REACTOR PREPARATIONS FOR THE AIR SHIPMENT OF HIGHLY ENRICHED URANIUM FROM ROMANIA[1]

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ABSTRACT

In June 2009 two air shipments transported both unirradiated (fresh) and irradiated (spent) Russian-origin highly enriched uranium (HEU) nuclear fuel from two research reactors in Romania to the Russian Federation (RF) for conversion to low enriched uranium (LEU). The Institute for Nuclear Research at Pitesti (SCN Pitesti) shipped 30.1 kg of HEU fresh fuel pellets to Dimitrovgrad, Russia and the Horia Hulubei National Institute of Physics and Nuclear Engineering (IFIN-HH) shipped 23.7 kilograms of HEU spent fuel assemblies from the VVR-S research reactor at Magurele, Romania, to Ozersk, Russia. Both HEU shipments were coordinated by the Russian Research Reactor Fuel Return Program (RRRFR) as part of the U.S. Department of Energy Global Threat Reduction Initiative (GTRI), were managed in Romania by the National Commission for Nuclear Activities Control (CNCAN), and were conducted in cooperation with the Russian Federation State Corporation for Atomic Energy Rosatom and the International Atomic Energy Agency (IAEA). Both shipments were transported by truck to and from respective commercial airports in Romania and the Russian Federation and stored at secure nuclear facilities in Russia until the material is converted into low enriched uranium. These shipments resulted in Romania becoming the 3rd country under the RRRFR program and the 14th country under the GTRI program to remove all HEU. This paper describes the research reactor preparations and license approvals that were necessary to safely and securely complete these air shipments of nuclear fuel.

1. Introduction

1.1 GTRI and RRRFR Programs

In cooperation with the IAEA, the United States Department of Energy National Nuclear Security Administration (NNSA) created the RRRFR Program as part of GTRI to assist with the transfer of Russian-origin highly enriched uranium (HEU) research reactor fuel from third countries to the Russian Federation to reduce proliferation risks associated with HEU in research reactors. The United States (US) and the RF signed an agreement in 2004 to assist countries with these transports. GTRI and RRRFR work in close cooperation with the IAEA and Rosatom to safely and securely complete these HEU transfers. As of January 2010, RRRFR has helped safely transport over 1051 kg of HEU to Russia.

Fig 1. Loading spent fuel in ISO container into AN-124-100 cargo aircraft

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1.2 Romania Participation in GTRI

In 2003 Romania agreed to transport 14.3 kg of HEU unirradiated (fresh) fuel to Russia making it the second country to ship HEU under the RRRFR program. All Romania HEU shipments under RRRFR were managed by CNCAN, in conjunction with SCN Pitesti, and IFIN-HH. Planning began in 2004 for shipment of the HEU spent fuel from the VVR-S research reactor and shipment was completed in June 2009. SCN Pitesti also shipped US-origin HEU spent fuel under another GTRI program in 2008, not discussed in this paper. In June 2009, RRRFR assisted with the SCN Pitesti shipment of their remaining HEU fresh fuel and with the IFIN-HH shipment of all HEU spent fuel from the VVR-S reactor. The VVR-S shipment was the world's first air shipment of spent nuclear fuel under existing international laws that did not require special exceptions to obtain the air shipment licenses. As the result of these fresh and spent fuel shipments, all HEU has now been removed from Romania.

1.3 Facility Descriptions

1.3.1 VVR-S Research Reactor (IFIN-HH)

The VVR-S reactor is a light water moderated research reactor that began operation in 1957 with EK-10 fuel assemblies (10% enriched), converted in 1984 to type C-36 fuel assemblies (36.6% enriched), and was shut down in 1997. IFIN-HH performed nuclear physics research and radioisotope production during 40 years of VVR-S operation. Decommissioning is now in progress and all HEU C-36 fuel assemblies were removed in June 2009.

Fig 2. VVR-S reactor

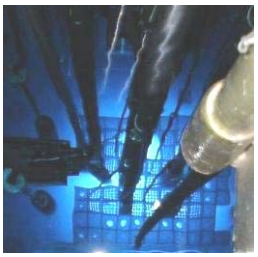

Fig 3. TRIGA reactor

1.3.2 TRIGA Research Reactor (SCN Pitesti)

The Institute for Nuclear Research at Pitesti was founded in 1971 to foster peaceful uses of nuclear power and has developed technologies, computer codes, and experiments for nuclear power plant applications. SCN Pitesti operates a TRIGA 14 MW reactor and provides technical support for the Cernavoda nuclear power plant. The TRIGA reactor was fully converted to use LEU in 2006 and the last HEU was removed in June 2009.

1.4 HEU Fuel Quantities Shipped by RRRFR

Two HEU fresh fuel shipments and one HEU spent fuel shipment were completed under the RRRFR program. Additional HEU shipped under another GTRI program is not included in these totals.

Date	Type	Quantity (kg)		Description
September 30, 2003	Fresh	14.3	44.4	150 type C-36 fuel rods (36.6% enriched)
June 28, 2009	Fresh	30.1		182 uranium metallic pellets (20.1% enriched)
June 29, 2009	Spent	23.7		70 type C-36 fuel assemblies (36.6% enriched)
	Total HEU	68.1		

Table 1. HEU fuel quantities

2. Shipment Preparations

Significant preparations were required for each HEU shipment to assure safe and secure handling and transport of the material. The first fresh fuel shipment required about 4 months of preparation and the last shipment, significantly expedited, was completed in only 23 days. Preparations for the spent fuel air shipment were more extensive and required 4-1/2 years.

2.1 VVR-S Research Reactor Preparations

2.1.1 Spent Fuel Cask Selection

Spent fuel casks available for shipping type C-36 fuel assemblies were assessed for suitability, including the TUK-19, VPVR/M, and LWT casks. In early 2006, CNCAN and

IFIN-HH selected the TUK-19 cask and all subsequent facility modifications, equipment designs, preparations, and licensing activities followed from this choice. The 70 HEU spent fuel assemblies were loaded into 18 TUK-19 casks secured inside 6 ISO containers.

Fig 4. Loading TUK-19 cask

2.1.2 VVR-S Facility Modifications

The existing reactor hall overhead crane was sufficient to lift fully loaded TUK-19 casks and the reactor hall floor was structurally adequate to transport the casks by truck into and out of the hall and store the loaded casks on the reactor hall floor. Both the inside and outside truck lock access doors and two truck lock floor hatches were replaced. The reactor hall floor was refurbished with an easily decontaminable epoxy surface. A new small cantilever crane was mounted in the cask loading area to install the TUK-19 cask lids. IFIN-HH installed new reactor hall personnel access doors and repaved roads to support the truck weights during shipment. IFIN-HH also installed a secondary fence, guard post, and security devices around the reactor building and cask storage area to increase security during loading.

Fig 5. VVR-S spent fuel in storage pool

2.1.3 Spent Fuel Inspections

Inspections and burn up calculations of the HEU spent fuel were completed in 2007. Storage pool records indicated there were no leaking C-36 assemblies and dimensional tests confirmed that all C-36 assemblies could be loaded into the TUK-19 casks. Mayak representatives reviewed and accepted all inspection data. IAEA and EURATOM safeguards inspectors witnessed the cask loading operations, verified the fuel documentation, and applied tamper indicating seals on each loaded TUK-19 cask.

2.1.4 Spent Fuel Air Shipment Planning

The initial plan was to transport the HEU spent fuel by rail in TUK-19 casks but in late 2006, the Sosny R&D Company proposed that the IAEA *Regulations for the Safe Transport of Radioactive Material* (TS-R-1) and the Russian Federation *Safety Rules in Transportation of Radioactive Material* (NP-053-04) allowed the air shipment of spent fuel in Type B(U) casks if the radioactive content did not exceed 3000 times the "A_2" radionuclide values in Table 1 of TS-R-1 and the equivalent table in NP-053-04. Sosny preliminary calculations suggested the total VVR-S HEU spent fuel activity would be less than $3000A_2$ and proposed to license and use the TUK-19 casks for air shipment of the Romanian HEU spent fuel. CNCAN, as the nuclear regulatory authority for Romania, agreed that if the Russian Federation issued an air shipment license for the HEU spent fuel and if the Russian licensing documentation also met Romanian requirements, then CNCAN would issue a Romanian air shipment license. The RRRFR program agreed with this air shipment proposal.

Fig 6. Loaded TUK-19 casks in ISO container

2.1.5 TUK-19 Air Shipment Equipment

Air shipment of the TUK-19 casks required new freight containers and cask tiedowns to allow multi-modal transport of the TUK-19 casks. Sosny R&D Company designed a special ISO container and cask tiedown system that was fabricated and tested in the Russian Federation to hold one, two, or three TUK-19 casks in each ISO container. The containers and tiedowns were certified for land, rail, water, and air modes of transport. The air carrier, Volga-Dnepr Airlines Company, participated in the design and testing to assure the cask ISO containers would meet all Russian and international air transport requirements.


Fig 7. Spent fuel transfer cask

2.1.6 Spent Fuel Transfer Cask

The TUK-19 casks could not be submerged in the spent fuel storage pool and loading in air by remote crane was not authorized. To assure radiologically safe cask loading operations, Sosny R&D Company designed a lead shielded transfer cask to load the cask baskets in the pool and transfer the loaded baskets into the TUK-19 casks positioned on the reactor hall floor. SCN Pitesti fabricated and tested the equipment which worked well and maintained personnel radiation exposure well below allowable limits.

2.1.7 Procedures and Training

Transfer cask handling procedures, TUK-19 cask loading procedures, and ISO container handling procedures were developed and approved as IFIN-HH documents. Mayak concurred with the procedures and assisted Sosny with training the IFIN-HH operators at the VVR-S reactor. The IFIN-HH operators passed written examinations by CNCAN before being qualified for cask loading. Before the empty TUK-19 casks were delivered to VVR-S, IFIN-HH operators used the transfer cask equipment, a mock-up of a TUK-19 cask, and mock-up fuel assemblies to train operators to load the TUK-19 casks.

2.1.8 Equipment Demonstration

The transfer cask equipment was operationally tested at SCN Pitesti and later demonstrated in VVR-S with mock-up fuel assemblies to validate the operating procedures and safety of operations. The demonstration identified the need to add a small cantilever crane to position the TUK-19 cask lid quickly on the cask body after loading to reduce personnel radiation exposure and this crane was installed prior to loading. Truck tests were conducted with empty ISO containers to assure adequate access to the reactor hall and resulted in minor modifications along the access route. ISO containers with empty VPVR/M shipping casks were loaded and unloaded from an AN-124-100 cargo aircraft to demonstrate the ISO containers could be loaded into the cargo aircraft. The dimensional and mass similarities between the VPVR/M and the TUK-19 cask ISO containers validated this test as an acceptable demonstration of the aircraft loading procedures for the TUK-19 ISO containers.

2.2 SCN Pitesti Shipment Preparations

2.2.1 Fresh Fuel Cask Selection

Two type IP-2 Russian TK-S16 shipping containers were used for the fresh fuel transport. Because the fuel was in pellet form, rather than in fuel assembly form, the 182 pellets were placed inside 14 plastic containers and 7 plastic containers were placed inside each TK-S16 shipping container. The canisters were transported on an IL-76 cargo aircraft.


Fig 8. Fresh fuel in TK-S16 containers


Fig 9. Inspecting fresh fuel

2.2.2 Fresh Fuel Inspections

IAEA and Euratom safeguards inspectors verified each fuel pellet serial number, weighed all material, and applied tamper indicating seals on each loaded TK-S16 shipping container.

3. License Approvals

More than 23 licenses, permits, government decrees, and other legal documents were required for Romanian and Russian authorities to approve the fresh and spent fuel shipments.

Experience from other RRRFR shipments helped minimize the time and effort required for the fresh fuel shipment licenses so their preparations and approvals were relatively quick. CNCAN issued a "*Shipping Certificate for Radioactive Materials R/402/IF-96T*," and a "*Validation Certificate for the Approval of Transport Casks Model Intended to Transport Radioactive Materials, No. R/402/IF-96*," for the fresh fuel shipment. The Russian Federation issued a "*Certificate of Approval of TK-S16 Package Design and Shipment RUS/3116/IF-96T*" and Import License No. L6439732060854 to authorize the fresh fuel shipment.

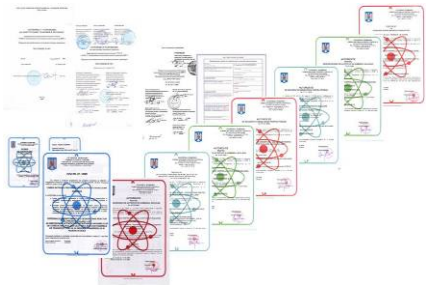

Fig 10. Russian and Romanian permits and licenses

The spent fuel shipment took significantly more effort in both Romania and Russia because no license had ever been granted for air shipment of spent fuel in a Type B(U) cask without special exceptions. Although the existing regulations allowed it, air shipment of spent fuel was a new licensing activity that required careful and thorough review by all parties to assure the transport could be performed safely and securely.

The most significant spent fuel license was the combined cask and transportation license *"Certificate of Approval for Package Design and Shipment, TUK-19 Transport Packaging with S-36 SFAs of Romanian VVR-S Research Reactor, Shipment by Road and Air,* document number RUS/3104/B(U)F-96T" issued by the Russian Federation. Russian organizations authorized by Rosatom performed safety analyses, security evaluations, and expert reviews to provide all supporting documentation for the license application. After Rosatom approved the license for the Russian Federation, CNCAN reviewed all supporting documents to assure they complied with Romanian law and issued a "*Road and Air Shipment Certificate R/400/B(U)F-96T(1/2009)*" authorizing air shipment within Romania. No transit country was in the flight path so no transit country licenses were required.

Russian Federation law required the completion of an environmental assessment, known as the Unified Project, before allowing the Romanian spent fuel to be imported. Several other Russian licenses and permits were also required, such as a flight permit to transport Class 7 dangerous cargo by air. Mayak obtained permits and transport licenses to move the spent fuel by truck from the airport in Yekaterinburg to the Mayak facility in Ozersk. The TUK-19 cask ISO containers were certified by the *Russian Maritime Register of Shipping* as meeting requirements of the *International Convention for Safe Containers*, 1972 (CSC). The tiedowns were certified by the Russian manufacturer to be in compliance with the requirements of TS-R-1 and NP-053-04.

In addition to the road and air shipment licenses, IFIN-HH and SCN Pitesti applied for, and CNCAN approved, multiple other Romanian licenses and permits for radiation protection programs, physical protection and safeguards programs, operator qualifications for fuel handling, truck equipment and carrier licenses, fuel handling equipment licenses, and export licenses.

4. Conclusions

The shipments of HEU fresh and spent fuel from Romania to the Russian Federation were completed safely, securely, and on schedule. Through the very cooperative efforts of many international governments and organizations, these shipments successfully achieved a significant nuclear non-proliferation goal by helping Romania become free of all HEU.

Fig 11. Fresh fuel departing Bucharest