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AIR SHIPMENT OF HIGHLY ENRICHED URANIUM SPENT NUCLEAR FUEL FROM ROMANIA AND LIBYA

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ABSTRACT

In June 2009 Romania successfully completed the world's first air shipment of highly enriched uranium (HEU) spent nuclear fuel transported in Type B(U) casks under existing international laws and without special exceptions for the air transport licenses. Special 20-foot ISO shipping containers and cask tie-down supports were designed to transport Russian TUK-19 shipping casks for the Romanian air shipment and the equipment was certified for all modes of transport including road, rail, water, and air. In December 2009 Libya successfully used this same equipment for a second air shipment of HEU spent nuclear fuel. Both spent fuel shipments were transported by truck from the originating nuclear facilities to nearby commercial airports, were flown by commercial cargo aircraft to a commercial airport in Yekaterinburg, Russia, and then transported by truck to their final destinations at the Production Association Mayak facility in Chelyabinsk Region, Russia. Both air shipments were performed under the Russian Research Reactor Fuel Return Program (RRRFR) as part of the U.S. National Nuclear Security Administration's Global Threat Reduction Initiative (GTRI). The Romania air shipment of 23.7 kilograms (kg) of HEU spent fuel from the VVR-S research reactor was the last of three HEU fresh and spent fuel shipments that resulted in Romania becoming the 3rd country to remove all of its Russian-origin HEU. Libya had previously completed three shipments of HEU fresh fuel so the 5.2 kg of HEU spent fuel air shipped from the IRT-1 research reactor in December made Libya the 4th country to remove all Russian-origin HEU. This paper describes the equipment, preparations, and license approvals required to safely and securely complete these two air shipments of spent nuclear fuel.

INTRODUCTION

The U.S. Department of Energy's National Nuclear Security Administration (NNSA) established the Global Threat Reduction Initiative (GTRI) to help reduce and protect vulnerable nuclear and radiological material located at civilian sites worldwide. In cooperation with the International Atomic Energy Agency (IAEA), NNSA created the Russian Research Reactor Fuel Return Program (RRRFR) to reduce nuclear proliferation risks by assisting with the transfer of Russian-origin HEU research reactor fuel from participating countries to the Russian Federation. The United States and the Russian Federation (RF) signed an agreement in 2004 to assist countries

Figure 1: Loading TUK-19 cask ISO container into AN-124-100 aircraft in Romania

with shipments of HEU nuclear fuel to Russia. GTRI works closely with the IAEA and the RF State Corporation for Atomic Energy (Rosatom) to transport this material safely and securely. By the end of May 2010, the RRRFR program had transported over 1,339 kg of HEU to Russia. Additional shipments are planned for 2010 and several second shipments of spent fuel are planned over the next several years as research reactors complete their conversions to use low enriched uranium (LEU) fuel.

The HEU shipment was managed in Romania by the National Commission for Nuclear Activities Control (CNCAN), the nuclear regulator for Romania. The consigner of the spent fuel was the Horia Hulubei National Institute of Physics and Nuclear Energy (IFIN-HH). In Libya, the Russian HEU shipment was managed by the Atomic Energy Establishment and the consignor of their spent fuel was the Tajoura Nuclear Research Center.

HEU SPENT FUEL QUANTITIES

Romania shipped seventy (70) type C-36 (36.6% enriched) spent fuel assemblies containing 23.7 kg of HEU. The spent fuel was loaded into 18 Russian TUK-19 shipping casks with 4 assemblies per cask. The casks were secured inside specially designed containers that complied with International Organization for Standardization (ISO) rules for freight containers. Three casks were loaded into each ISO container for a total of six ISO containers in the shipment. All six ISO containers were loaded into one AN-124-100 commercial cargo aircraft and transported 'in commerce' to the RF by the Volga-Dnepr Airlines Company.

Figure 2: TUK-19 cask

Libya shipped twenty six (26) type IRT-2M (80% enriched) spent fuel assemblies containing 5.2 kg of HEU. The assemblies were loaded into 7 TUK-19 casks which were secured inside 3 ISO containers. The containers were loaded into one AN-124-100 cargo aircraft and transported 'in commerce' to the RF by the Volga-Dnepr Airlines Company. Table 1 summarizes these shipments.

Table 1: HEU Shipment Quantities

Country	HEU	Date	Type	Assemblies	Casks	ISO Containers
Romania	23.7 kg	29 June 2009	C-36 (36.6%)	70	18	6
Libya	5.2 kg	20 December 2009	IRT-2M (80.0%)	26	7	3

PLANNING FOR SPENT FUEL AIR SHIPMENT

Before the Romania air shipment the Russian TUK-19 casks were certified for shipment only in specialized Russian TK-5 railcars. When the TUK-19 cask was selected by CNCAN and IFIN-HH in early 2006 as their preferred shipping cask, the plan was to ship them by rail from the VVR-S reactor site, through Ukraine, to the final destination in Russia. In late 2006, the Russian R&D Company Sosny (Sosny) proposed that a recent change in IAEA and RF regulations might allow the VVR-S spent fuel to be transported by air in the TUK-19 Type B(U) casks. Three international

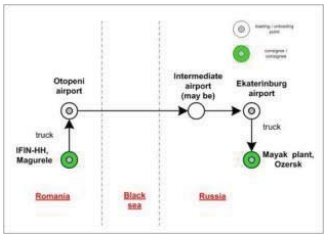

Figure 3: Proposed Romania air shipment route

air shipments of spent fuel in other Type B(U) casks had been previously completed under non-GTRI programs, but those shipments used military aircraft and required special arrangements for the transportation licenses. Sosny pointed out that both 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 air shipment of spent fuel in Type B(U) casks if the radioactive content did not exceed 3000 times the 'A_2' radionuclide values listed in the regulations for the content mixture. Preliminary calculations by Sosny showed the total VVR-S HEU spent fuel activity would be less than $3000A_2$ so air shipment in civilian aircraft would theoretically be possible without a special arrangement.

Figure 4: Loading TUK-19 cask in Romania

Since no licenses had been previously granted under the new regulations, there was uncertainty that the RF would issue a license for air shipment; although Sosny's preliminary discussions with Rosatom had indicated a realistic possibility. As the Competent Authority for Romania, CNCAN agreed that if the RF issued an air shipment transportation license for the VVR-S spent fuel and if the Russian licensing documents met Romanian requirements, then CNCAN would also issue an air shipment license for Romania. After some hesitation and multiple discussions, the RRRFR program agreed to proceed with the proposal to ship the VVR-S spent fuel by air in parallel with the planned rail shipment. GTRI agreed to fund the safety analyses and license application efforts to gain confidence that the air shipment license could be issued. When the safety analyses showed that license approval was highly probable, all efforts for rail shipment were terminated and all work was redirected toward assuring a safe air shipment.

The IAEA and Russian regulations have design and test requirements for the certification of a Type C cask specifically for the air shipment of spent fuel without the activity limitation of $3000A_2$. At present, no Type C casks are available; consequently, the air shipment from Romania had to rely on the successful issuance of a Type B cask air shipment license.

AIR SHIPMENT EQUIPMENT

Because TUK-19 casks had always been shipped in railcars, a new handling gear or freight container was needed with multi-modal transport to allow them to be transported by truck to the airport and to be loaded into and secured in an aircraft. It was decided to design and certify the freight containers in accordance with ISO regulations to allow the flexibility of multi-modal transport of the casks. Freight containers were designed as standard sized 20-foot containers and cask tiedowns were designed and fabricated to secure the casks inside the containers. By complying with ISO rules, the cask containers could be handled by most transportation carriers worldwide and could make use of common carrier equipment anywhere shipping was normally performed. Sosny had the containers and cask tiedown system designed to hold one, two, or three casks per container. The floor and wall structure were modified to support the total weight of three loaded casks and the external dimensions were kept within the ISO requirements. The tiedowns were designed to support the casks in an upright

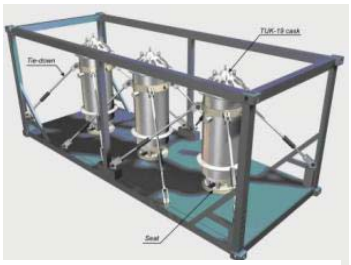

Figure 5: ISO container and tiedowns

Figure 6: Casks in ISO container

position and securely fastened to the container floor. The containers and tie-downs were fabricated and certified in Russia for road, rail, water, and air modes of transport. The planned air carrier, Volga-Dnepr Airlines Company, participated in the design and testing to assure the containers would meet all international and Russian air transportation requirements.

After the design was complete the cask and container handling procedures were developed by Sosny to assure that the limits of the design were not exceeded. These procedures were converted by IFIN-HH to meet its specific facility requirements and were approved by CNCAN. Sosny and Mayak personnel trained IFIN-HH operators on cask handling and ISO container handling procedures to assure they could load and secure the equipment properly.

All of the equipment developed and certified for the Romania shipment is reusable for subsequent air shipments and all of the handling procedures developed by Sosny are generic enough to use in other facilities. Consequently, when the decision was made to ship the Libyan spent fuel by air, no new equipment was required and the handling procedures required very little modification to meet the specific facility requirements for use in the Tajoura research reactor in Tripoli, Libya.

TRANSPORTATION LICENSES

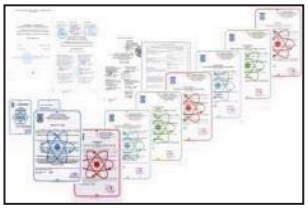

Figure 7: Licenses for Romania shipment

There was no precedent for issuing a license to ship spent fuel by air in a Type B(U) cask so considerable effort was required in both Romania and Russia to approve the air shipment licenses. This new licensing activity was given very careful review by all parties in both countries. Safety analyses were performed by authorized Russian agencies and multiple formal expert reviews were conducted by Russian authorities before the Russian license was issued. Particular attention was given to modelling the cask behavior under all assumed accident conditions, to assure there would be no criticality accident, no release of the radioactive contents above the limits imposed by IAEA guidelines, and minimal impact to the general public if there was any release to the environment. Although the regulations allowed air shipment in a Type B(U) cask, the safety analyses modelled the far more restrictive IAEA test requirements for a Type C package, specifically a 90 m/s impact into a hard surface to simulate an air crash, which is specifically identified in the IAEA regulations for transport of spent fuel by air. When all concerns were resolved, Rosatom issued a RF 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".

Figure 8: Romania convoy

After Russia issued its air shipment license, CNCAN reviewed the Russian license and documents to assure they complied with Romanian law. After completing the Romanian reviews, CNCAN issued a "*Road and Air Shipment Certificate R/400/B(U)F-96T(1/2009)*" authorizing road shipment from the VVR-S reactor to the airport and air shipment within Romania.

The successful Romanian air shipment established a precedent for other air shipment license applications. Russia subsequently issued an air shipment license for the Libyan fuel shipment based on their specific fuel type and quantity. The Libyan fuel activity was also less than $3000A_2$ so

approval of this license was similar to approval of the Romanian license. No specific problems were encountered when licensing the Libyan shipment.

AIR SHIPMENTS

Figure 9: Romania shipment ISO containers inside AN-124-100 aircraft

The Romanian shipment of 18 casks inside 6 ISO containers began on 28 June 2010 with road transport on 6 trucks from the VVR-S facility to the Bucharest commercial Henri Coanda (Otopeni) airport. The containers were transferred from the trucks into one AN-124-100 commercial aircraft in the early morning of 29 June. The aircraft departed the same day and flew over Romanian territory, across international airspace over the Black Sea, and into Russian territory to a refuelling stop in a commercial airport in Ulyanovsk, Russia. The air route avoided all populated areas to assure that if an air accident occurred, it would not affect any major populated area. Transit of Romanian airspace was closely monitored by CNCAN and transit over the Black Sea and Russian airspace was closely monitored by Rosatom. Both countries had emergency actions planned and personnel on alert to respond quickly if an incident should occur. After refuelling, the plane continued to the Yekaterinburg airport where the ISO containers were unloaded onto trucks and transported by road to the Mayak facility in Ozersk, Russia. The fuel was received at Mayak for reprocessing into commercial nuclear fuel.

The Libyan air shipment left Libya and entered international airspace over the Mediterranean Sea where it proceeded into Russian airspace with routing away from all major populated areas as was done for the Romanian air shipment. The spent fuel was unloaded onto trucks at the Yekaterinburg airport and transported by road to the Mayak facility in Ozersk, Russia, where it was unloaded for reprocessing into commercial nuclear fuel.

FINAL DISPOSITION OF FUEL

At the Mayak RT-1 complex, the spent nuclear fuel assemblies are remotely removed from the packaging and placed into temporary storage for up to 20 years. When the production schedule allows, the fuel assemblies are chopped and fed to reprocessing equipment to recover the usable fissile materials. The fissile materials are returned to the uranium fuel cycle and become commercial nuclear fuel. The non-fissile materials become vitrified waste and are placed into a geological repository for permanent disposal.

Figure 10: Unloading Romanian casks from aircraft in Russia

CONCLUSION

The world's first air shipment of spent nuclear fuel in Type B(U) casks under existing international laws 'in commerce' was safely and securely completed when Romania shipped all of the VVR-S research reactor HEU spent fuel to the RF on 29 June 2009. Because of the success of the Romania shipment and with the equipment and procedures developed for Romania, the Libyan air shipment was also completed safely and securely on 20 December 2009. These two successful shipments show that, with the cooperation of the participating countries, air shipment of spent fuel from Russian research reactors can be completed safely and securely in commerce.