THE EXPERIENCE OF SHIPPING SPENT NUCLEAR FUEL FROM UZBEKISTAN TO THE RUSSIAN FEDERATION

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ABSTRACT

In April 2006 the last of four shipments of spent nuclear fuel left the Institute of Nuclear Physics outside of Tashkent, Uzbekistan and traveled to the Mayak site in the Russian Federation. The shipment marked the completion of the first campaign under the National Nuclear Security Administration's Russian Research Reactor Fuel Return (RRRFR) Program to return highly enriched spent nuclear fuel to its country of origin. In total, 252 spent fuel assemblies containing over 63 kg of highly enriched uranium were returned. The project proved to be an excellent example of cooperation as four countries, Uzbekistan, Russia, Kazakhstan and the United States, were involved in its planning and implementation. This paper will describe the shipment process from planning to completion with emphasis placed on the critical activities. Specifically the paper will discuss: the activities performed to prepare for the shipments; the roles and responsibilities of each country; the shipment details; the lessons learned; and the future plans of the Institute and the RRRFR program.

Introduction

In January 2006, Uzbekistan became the first country in fifteen years to return spent nuclear fuel (SNF) to the Russian Federation and the first under the Russian Research Reactor Fuel Return (RRRFR) Program. The RRRFR Program was created in 1999 from a tri-partite initiative between the Russian Federation, United States, and the International Atomic Energy Agency

(IAEA) to return Russian-origin research reactor fuel containing high enriched uranium (HEU) from countries of the former Soviet Union. After the signing of the Implementing Agreement between the Government of Uzbekistan and the United States Department of Energy (DOE) in March 2002, the Institute of Nuclear Physics (INP) began the initial planning for the return of SNF from its WWR-SM research reactor[1]. Progress of the project was slow at first until the signing of the, '*Agreement Between the Government of the United States of America and the Government of the Russian Federation Concerning Cooperation for the Transfer of Russian-Produced Research Reactor Nuclear Fuel to the Russian Federation*' in May 2004, which gave the project the legal basis to proceed. The project experienced frequent challenges due to the fact that many of the laws, regulations, and procedures had changed dramatically since the last shipments of spent fuel in 1991. Through persistence and commitment to support the goals of the Global Threat Reduction Initiative (GTRI) and the RRRFR Program, the Russian Federation, Uzbekistan, Kazakhstan and the United States successfully coordinated the completion of the required preparation activities and shipped 252 SNF assemblies containing 63 kg of HEU. The timeline below (Figure 1) highlights the major milestones of the project.

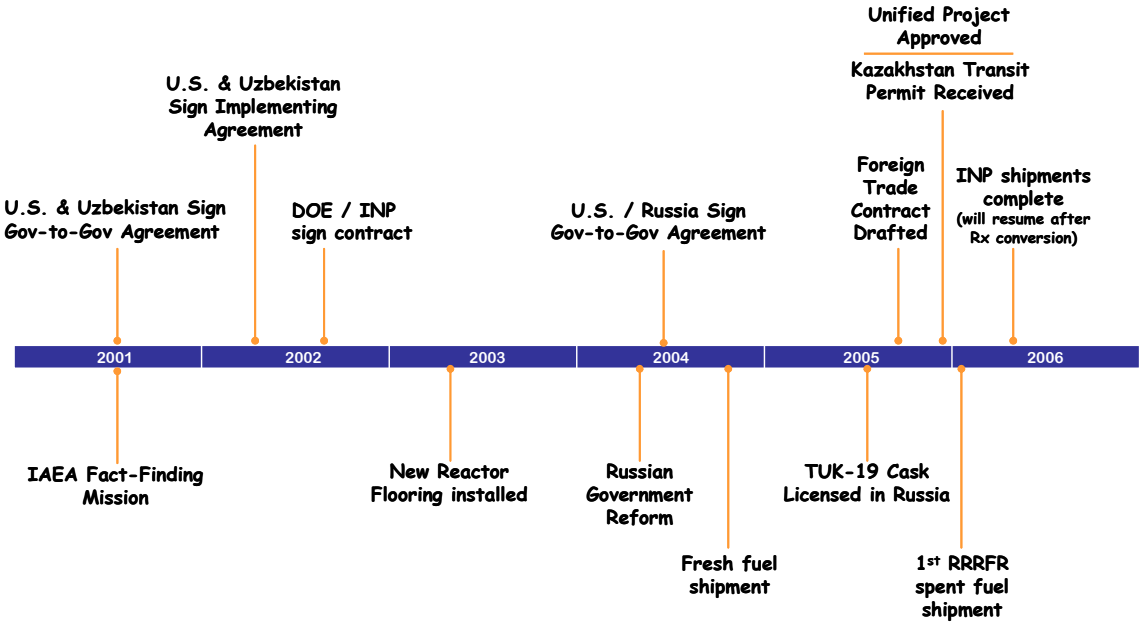

Figure 1 Milestone Timeline

This paper will not attempt to discuss all of the activities completed over the past two years but will focus on providing the details of the critical preparation activities and the actual shipment. The critical preparation activities were: Government-to-Government Agreements; Unified Project; TUK-19 cask licensing; Kazakhstan transit requirements; and facility preparations. The organizations who were involved will also be identified along with a brief description of their responsibilities. The details of the shipments (i.e. cask loading, logistics) will be described followed by the lessons learned and future plans of the reactor.

[1] The reactor operated from 1959 (initial criticality) to 1977 at 2MWt. After upgrades, the reactor operated at 10MWt with 90% enriched IRT-3M fuels from 1977 to 1997. Since conversion in 1997, the reactor has been using 36% IRT-3M fuel assemblies.

Critical Preparation Activities

Before the critical preparation activities are highlighted and discussed, it is important to identify the major organizations who were involved with the shipments and their roles and responsibilities. Table 1 includes the information on these organizations.

Organization	Country	Description and Responsibilities
NNSA	United States	National Nuclear Security Administration – division of the DOE that manages and funds the RRRFR Program.
INP	Uzbekistan	Primary contractor with NNSA and primary contractor with Mayak. INP provided project management and was responsible for all of the activities within Uzbekistan.
Rosatom	Russian Federation	Federal Atomic Energy Agency – responsible for regulating the import of research reactor fuel.
Mayak	Russian Federation	Prime contractor with INP. Mayak was the shipper of record, provided the shipping containers and rail cars, unloaded the fuel, and is responsible for reprocessing and interim storage.
Techsnabexport (TENEX)	Russian Federation	TENEX – one of the two companies in the Russian Federation authorized by the Russian Government to import spent nuclear fuel. TENEX was subcontracted by Mayak to complete the Unified Project and authorize the import of the SNF.
VNIPIET and VNIIEF	Russian Federation	Subcontracted by TENEX to perform the safety analyses, prepare the required documentation, and obtain the licenses for the TUK-19.
KATEP	Kazakhstan	Company authorized to manage spent fuel shipments in Kazakhstan. KATEP coordinated all activities for the transit of the spent fuel.
KAEC	Kazakhstan	Kazakhstan Atomic Energy Committee – nuclear regulator for Kazakhstan. Approved the transit permits and cask license.

Table 1: Project Team

Government-to-Government Agreements (GTGA)

The first critical activity and major prerequisite for the preparation activities was the establishment of the government-to-government agreements between Uzbekistan and the United States and Uzbekistan and the Russian Federation. Two GTGAs provided the legal framework between the U.S. and Uzbekistan. They were: the "US/Uzbekistan Non-Proliferation Agreement" signed in June 2001; and the "DOE/Ministry of Foreign Affairs (MFA) Non-Proliferation Agreement" signed in March 2002. The first agreement provided liability protection and tax exemption for non-proliferation activities and the second delegated the DOE and the MFA as agents with permission to enter into a contract for the spent fuel return. The

Governments of Uzbekistan and the Russian Federation agreed upon and signed an agreement (1997) on the peaceful use of atomic energy in which the focus was the dedication of the management of spent fuel. This GTGA was important because it served as the legal basis for the importation of spent nuclear fuel and the basis for the development of the Unified Project (to be discussed later), which was another critical path activity. With the government-to-government agreement in place, INP was permitted to contract with Mayak for the return of the spent fuel. This contract called the Foreign Trade Contract and discussed later in this paper, specifically addressed the following issues:

1. The scope of services to be provided by the Russian Federation. Services included temporary storage of SNF, SNF processing, interim storage, and radioactive waste return.
2. The contract defined the owner of the SNF after their importation and the owner of the reprocessing products after SNF reprocessing.
3. The contract included confirmations from Uzbekistan regarding the acceptance of the radioactive waste after a period of twenty years and assurances that all requirements are and will be met for the safe transportation of the SNF. The issue of the return of the radioactive waste after reprocessing is important because if the country decides to have the waste remain in the Russian Federation, additional costs (sometimes substantial) would result.

For future shipments of spent fuel, Rosatom has stated that the legal issues above should be included as part of the government-to-government agreement with the Russian Federation. The negotiation and approval of the government-to-government agreements are a lengthy evolution. Experience dictates that at least one year should be allotted for planning purposes.

Unified Project

A Unified Project was required for the importation of spent nuclear fuel into the Russian Federation per Russian Law [1]. The Unified Project was basically an overall assessment of the radiological, economical, social, and environmental impacts to the Russian Federation, particularly the areas surrounding the Mayak Plant (Chelyabinsk Region) [2]. The various elements that are included in the Unified Project are briefly discussed in the following paragraphs.

The first part of the Unified Project included the documents that make up the Special Ecological Programs (SEPs). The SEPs are used to rehabilitate the radioactive contaminated areas of the territory surrounding Mayak and are financed by the receipt of the SNF from foreign customers. In this case, the programs provided support to activities associated with the V-9 Industrial Water Basin and the development of systems for dosimetry, radiometry, and spectrometry monitoring. The SEPs went through a vigorous review process, with reviews by Rosatom, the Ministry of Economic Development and Commerce, and Medbiokestrem, culminating in a State Environmental Expert Review (SEER) by Rostechnadzor. A positive outcome from Rostechnadzor meant that the SEPs could be included in the final Unified Project package.

The second part of the Unified Project was the draft Foreign Trade Contract for the processing and storage of the SNF. The draft Foreign Trade Contract contained:

1. The number of SNF assemblies to be shipped
2. The scope and cost of the services provided
3. Confirmation of the decision by the originating country to accept the return of the high level waste
4. Total project cost
5. Durations of temporary and interim storage

The third part comprised of a set of documents that substantiate an overall radiation risk reduction and environmental safety increase as a result of the Unified Project implementation. These documents also address the storage durations and hazards associated with the products of the reprocessing activities. An additional document titled 'Assessment of Environmental Impact (AEI)', not required at the time of the Uzbekistan shipment Unified Project, has been recommended by the SEER to be included in future Unified Projects.

The fourth and final part of the Unified Project was the set of materials used to discuss the SNF importation project with the community members and public organizations in the areas affected by the shipments. In this case, the records of discussions included people of the Chelyabinsk Region, city of Ozersk, and Mayak employees.

Once all of the required documents were collected into the final Unified Project package, it was submitted to Rostechnadzor for the State Ecological Expert Review. Positive results were transmitted to Rosatom, the Foreign Trade Contract was signed, and the Russian Government issued the declaration authorizing the importation of the SNF from Uzbekistan. Based on this experience, a duration of 15 months is recommended to develop and obtain SEER approval of the Unified Project.

TUK-19 Cask Licensing

In the Russian Federation, casks transporting radiological materials must be licensed for both design and transportation [3]. The design license for the TUK-19 (Figure 2, right) had been allowed to expire in 2000 due to its inactivity. The transportation license, which is shipment specific and issued for each shipment campaign, required development. The transportation license included information such as: duration of the shipment; actual radioactive content; mode of transport; emergency card information; and proposed shipment category to name a few. Both the design and transportation licenses were analyzed and prepared by VNIPIET in less than five months with approval by Rosatom following shortly thereafter.

Figure 2 TUK-19 Casks

The Kazakhstan license for the design and transportation of the TUK-19 cask was issued by the Competent Authority, Kazakhstan Atomic Energy Committee (KAEC) of the Ministry of Energy and Mineral Resources (MEMR). The approval process involved reviews from both independent and state experts. The TUK-19 license in the Russian Federation was issued according to the regulatory guidelines developed in Russia, not the IAEA TS-R-1 guidelines adopted by the KAEC. Therefore, KAEC requested that VNIPIET prepare a comparative analysis that confirmed the compliance of the TUK-19 safety analysis to the IAEA TS-R-1 guidelines. KATEP was chosen to coordinate all of the TUK-19 licensing activities and the license was issued by the KAEC in less than four months.

The TUK-19 license validation in Uzbekistan was issued by the State Inspectorate on Safety in Industry Mining using the Russian license. This activity was completed within two months.

Kazakhstan Transit Requirements

As with the TUK-19 cask license, KATEP coordinated all of the transit activities for this shipment. This included the following main activities:

- Development of 'Assessment of Radiation Impact of SNF Transit to Environment and Population (EIA)' and receiving the State ecological conclusion.
- Purchase of the required insurance (obligatory and voluntary) policies for the SNF transit.
- Development and approval of the SNF Transit Program.
- Obtaining the permission to transit through Kazakhstan
- Signing of the contracts for: rail transportation; physical protection; emergency preparedness; and customs.

The transit program was quite extensive and included provisions for liability, route selection, security, physical protection, and emergency preparedness. All competent authority approvals were coordinated by KATEP and received in less than three months.

Facility Preparations

A number of facility and equipment enhancements were completed to support the loading and shipping of the TUK-19 casks. The major activities completed were:

- New reactor hall flooring was installed to increase safety and help prevent the spread of contamination.
- New reactor hall lighting and remote cameras were installed to improve the conditions for fuel and cask handling. Previously, the crane operator used mirrors and visual cues to assist with the alignment of the basket and cask. The new remote cameras improved the loading operations (Figure 3, right), making loading quicker and safer.
- A backup generator was installed to provide emergency power if electrical power was lost during the loading operations.

Figure 3 Remote Crane Camera

- New transport racks were fabricated to secure the TUK-19 casks to the trucks during transport from the reactor to the rail yard.
- New trucks were procured to ensure the safe transport of the SNF and to reduce the number of road transports.
- Additional radiological monitoring and communications equipment was purchased.
- A self-releasing grapple was designed, fabricated and used to load the basket containing fuel assemblies into the cask.

The reactor staff and support organizations received extensive training on the operations and procedures of every aspect of the fuel shipments. Many practice exercises were performed on: fuel loading; cask handling and loading; cask preparation; criticality and personnel safety; radiological safety; and security.

Shipment Details

The shipment consisted of the transport of 252 IRT-3M spent fuel assemblies enriched to 36% and 90% ^{235}U. The IRT-3M assembly is shown in Figure 5 below. Several months prior to the shipment, the fuel assemblies were inspected by Mayak experts. All of the spent fuel assemblies met the acceptance criteria [4] for shipment and receipt with none requiring encapsulation. The TUK-19 cask was chosen because it was designed for Russian research reactor fuel and for use in the Russian designed reactors. The TUK-19 has the capacity to hold 4 IRT-3M assemblies and a total of 16 casks were available for each shipment. The casks were transported to Mayak by rail in 2 TK-5 railcars. Each TK-5 railcar holds 8 TUK-19 casks and has a roof that can be opened for loading and unloading operations (Figure 5). With a maximum of 64 IRT-3M fuel assemblies transported in each shipment, four shipments were needed to return the 252 spent fuel assemblies to Mayak.

Figure 4 IRT-3M Assembly

Figure 5 TUK-19 Loading into TK-5 railcar

The shipment process was identical for each shipment. The TK-5 railcars transported the empty TUK-19 casks from Mayak, through Kazakhstan to a rail yard near INP. The casks were off-loaded and transported to the reactor hall and staged for loading. The casks were allowed to acclimate for 24 hours before opening. Detailed cask loading plans were prepared in advance to ensure that none of the cask license contents limits (i.e. decay heat, activity, cooling time) were

exceeded. IAEA inspectors were present and verified the presence of ^{137}Cs in 100% of the spent fuel assemblies. Each of the measurements was taken during the basket loading process and did not significantly affect the loading process. Once the four spent fuel assemblies were placed in the basket, the basket was remotely raised out of the spent fuel pool by the overhead crane and allowed to drip dry (removal of most of the water) for 15 minutes. After the drying period, the basket was placed into the cask (Figure 6). The cameras at this point proved to be a tremendous improvement to historical loading operations. Due to the in-air loading the grapple was designed to self-release once the basket was fully lowered in the cask. This grapple worked flawlessly during all 64 cask loading operations. One reactor operator along with two radiological protection operators entered the reactor hall carefully monitoring the radiation levels. The operators were able to approach the cask and connect the crane hook to the cask lid. The cask lid was then installed on the cask and secured with two bolts prior to movement to its assigned storage spot. The remaining bolts were installed and torqued and the cask prepared for hermetic seal testing. A helium detector was used to confirm a proper seal per the TUK-19 handling instructions. The time to load a TUK-19 cask averaged less than one hour per cask.

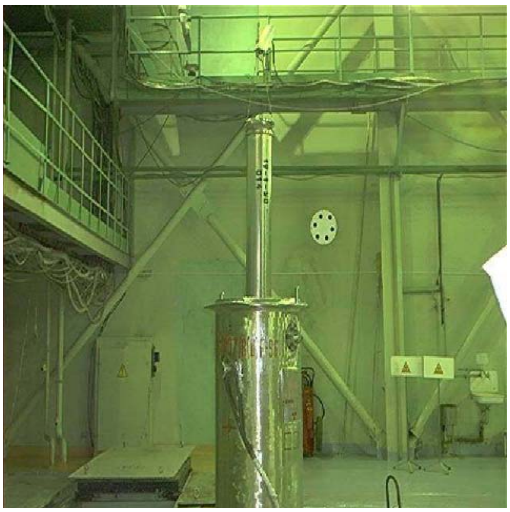

Figure 4 Basket in the TUK-19 Cask

On the day of the shipment, the TUK-19 casks were transported to the rail yard and loaded into the TK-5 railcars while under constant security surveillance. Final surveys were conducted and the shipment left by a dedicated train at the predetermined time specified by the authorities. The transit time from Tashkent to Mayak was less than four days and the total turnaround time to return the empty casks was approximately three weeks. All four shipments were completed in less than four months, four months ahead of the baseline schedule. There were no incidences reported during the loading of the casks at INP and unloading of the fuel at Mayak.

Future Plans

As reported earlier, the reactor currently operates with 36% enriched IRT-3M fuel assemblies. The Government of Uzbekistan and INP have decided to convert the reactor to use low enriched fuel, specifically, 19.7% IRT-4M fuel assemblies. Reactor conversion analyses with assistance from Argonne National Laboratory under the Reduced Enrichment for Research and Test Reactors (RERTR) program have been performed and final reactor parameters are being reviewed. There is a possibility that the reactor's power level may be increased to approximately 11 or 12 MW in order to preserve previous flux values. Other projects such as the refurbishment of the secondary cooling loop piping and the reactor control system are planned with their completion contingent upon funding support.

Lessons Learned

Because this was the first shipment of research reactor spent fuel to the Russian Federation, a significant amount of information was learned that would apply to future shipments from other RRRFR Program countries. At the time this paper was written, the Uzbekistan shipment project team and the IAEA were finalizing the plans for a lessons learned workshop to be held in early October. The focus of this workshop is to transfer knowledge and information regarding the necessary technical and administrative preparations to institutions planning future shipments. Ultimately, this information will be collected and published in a guideline document and intended for use as a reference tool. Sample passport and receipt documents, agreements, and contracts will be shared at this workshop. This experience demonstrated the need to identify all of the legal and technical requirements as soon as possible. It is also recommended that a dedicated project manager or team be appointed due to the significant work load. Lastly, it is important to have Mayak experts characterize and inspect the fuel to be shipped well in advance of the shipment to help reduce delays associated with suspect or deformed fuel assemblies.

Conclusion

The completion of the four shipments of spent HEU fuel from the Institute of Nuclear Physics of the Uzbekistan Academy of Sciences to the Russian Federation was a tremendous accomplishment for the Russian Research Reactor Fuel Return Program and the Global Threat Reduction Initiative. It marked the first return of spent research reactor fuel to the Russian Federation in over fifteen years and the first under the RRRFR program. Much was learned during the preparations phase, with many of the challenges requiring the development of new procedures to meet the updated regulations. In the end, the project proved to be an excellent example of international cooperation between the Russian Federation, Uzbekistan, Kazakhstan, and the United States in the area of nonproliferation.

The authors would like to extend their appreciation to Rosatom, the Governments of Uzbekistan and Kazakhstan, and the U.S. Department of Energy for their support of these spent fuel shipments and the RRRFR Program. Special thanks are also expressed to the team of experts from INP, Mayak, KATEP, TENEX, INL, SRS, the IAEA and others for their professionalism and excellent work.

References

[1] Decree #418, ‘Government of the Russian Federation on the Procedure for Importation of Irradiated Nuclear Reactor Fuel Assemblies Into the Russian Federation’, July 11, 2003.

[2] Lebedev, A.E., ‘Unified Project, Importation of Irradiated Fuel Assemblies (IFA) from Foreign Research Reactors to Russian Federation’, presented at the RRRFR Transport Options Workshop, Varna, Bulgaria, September 21, 2005.

[3] PVSR-92, ‘On the Procedure for Issuing Certificates/Permits for Special Type Radioactive Substances, and For the Design and Transportation of Packing Sets with Radioactive Substances’ (modified based on Amendment 2 and Amendment 3 established by the Orders No. 448 of 07/17/98 and No. 663 of 10/25/99).

[4] OST 95 10297-95, ‘Spent Nuclear Fuel Assemblies of Nuclear Research Reactors, General Requirements for Delivery’.