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Planning, Preparation, and Transport of the High-Enriched Uranium Spent Nuclear Fuel From the Czech Republic to the Russian Federation

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PLANNING, PREPARATION, AND TRANSPORT OF THE HIGH-ENRICHED URANIUM SPENT NUCLEAR FUEL FROM THE CZECH REPUBLIC TO THE RUSSIAN FEDERATION

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ABSTRACT

The United States, Russian Federation, and the International Atomic Energy Agency have been working together on a program called the Russian Research Reactor Fuel Return (RRRFR) Program, which is part of the Global Threat Reduction Initiative. The purpose of this program is to return Soviet or Russian-supplied high-enriched uranium (HEU) fuel, currently stored at Russian-designed research reactors throughout the world, to Russia. In February 2003, the RRRFR Program began discussions with the Nuclear Research Institute (NRI) in Řež, Czech Republic, about returning their HEU spent nuclear fuel to the Russian Federation for reprocessing. In March 2005, the U.S. Department of Energy signed a contract with NRI to perform all activities needed for transporting their HEU spent nuclear fuel to Russia. After 2 years of intense planning, preparations, and coordination at NRI and with three other countries, numerous organizations and agencies, and a Russian facility, this shipment is scheduled for completion before the end of 2007. This paper will provide a summary of activities completed for making this international shipment. This paper contains an introduction and background of the RRRFR Program and the NRI shipment project. It summarizes activities completed in preparation for the shipment, including facility preparations at NRI in Řež and FSUE "Mayak" in Ozyorsk, Russia; a new transportation cask system; regulatory approvals; transportation planning and preparation in the Czech Republic, Slovakia, Ukraine, and the Russian Federation though completion of the Unified Project and Special Ecological Programs. The paper also describes fuel loading and cask preparations at NRI and final preparations/approvals for transporting the shipment across the Czech Republic, Slovakia, Ukraine, and the Russian Federation to FSUE Mayak where the HEU spent nuclear fuel will be processed, the uranium will be downblended and made into low-enriched uranium fuel for commercial reactor use, and the high-level waste from the processing will be stabilized and stored for less than 20 years before being sent back to the Czech Republic for final disposition. Finally, the paper contains a section for the summary and conclusions.

INTRODUCTION AND BACKGROUND

Starting in December 1999, representatives from the United States, Russian Federation, and International Atomic Energy Agency (IAEA) began working on a program to return Soviet and Russian-supplied high-enriched uranium (HEU) fuel currently stored at foreign research reactors to Russia. This effort is being funded under the Russian Research Reactor Fuel Return (RRRFR) Program, a nuclear nonproliferation initiative for eliminating stockpiles of HEU nuclear materials by encouraging eligible countries to convert their research reactors from HEU to low-enriched uranium (LEU) fuel upon availability, qualification, and licensing of suitable LEU fuel.

In May 2004, 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" was signed. This agreement provides legal authority for the RRRFR Program and establishes parameters whereby eligible countries may return fresh and spent HEU fuel assemblies and fissile materials to Russia.

In February 2003, a team of technical representatives from the United States, Russian Federation, and the IAEA conducted a fact-finding mission of the Nuclear Research Institute (NRI) in Řež, Czech Republic, which is about 20 km north of Prague along the banks of the Vltava River (see Figure 1). The purpose of this mission was to discuss the RRRFR Program with NRI and to obtain preliminary information about the physical and mechanical state of their fresh and HEU SNF, their facilities, and their transportation capabilities and experiences. During this mission, NRI expressed a desire to participate in the RRRFR Program.

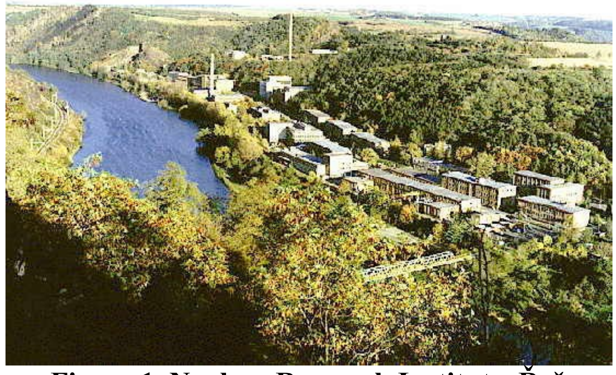

Figure 1. Nuclear Research Institute, Řež.

NRI owns and operates a LVR-15 Russian-designed type research reactor (see Figure 2). The reactor is a light-water moderated and cooled tank nuclear reactor with forced cooling. A combined water-beryllium reflector is used. The reactor was placed in operation in 1957 and operated until 1974 when it was upgraded to 10 MWt and the fuel was changed to the IRT-2M configuration with 80 weight percent 235U. It then operated until the core was converted in 1996 to IRT-2M fuel with 36 weight percent 235U with 3 or 4 tubes. Plans exist for further reducing the enrichment of the core to 19.7 weight percent 235U fuel of the IRT-4M. NRI has 299 HEU SNF and 206 LEU SNF assemblies available for return to the Russian Federation.

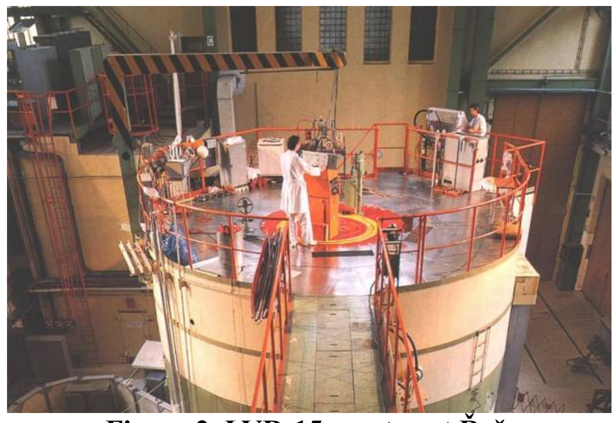

Figure 2. LVR-15 reactor at Řež.

In 2004, the U.S. Department of Energy (DOE) began negotiating NRI's participation in the RRRFR Program. In March 2005, an umbrella contract was signed for NRI to perform all activities needed to prepare for transporting their HEU SNF to the Russian Federation. In May 2007, the contract was amended to include actual HEU SNF handling, transport, and disposition.

NRI is responsible for the entire project, including overall project management. DOE provides funding and oversight of NRI. A task assignment process is used to authorize and pay for the work. Specific activities are proposed by NRI to DOE. DOE prepares a task description for the activity and sends it to NRI. The scope, cost, and schedule for the activity is negotiated and NRI issues a task plan. Once the task plan is agreed to by DOE, a task assignment is issued that authorizes the scope of work, deliverables, schedule, and a fixed price.

NRI assigned a highly qualified senior technical person with extensive management experience to manage the project. The project manager is responsible for (1) planning, managing, and coordinating all activities; (2) developing and maintaining a detailed baseline cost and schedule for the project; (3) negotiating and managing all subcontracts; (4) preparing project status and other reports; and (5) coordinating and conducting meetings. The success of this project can be attributed to the excellent planning, scheduling, cost estimating, managing, and communications skills of the project manager. Being fluent in Czech, Russian, Slovak, and English also was a significant attribute.

NRI requested that their LEU SNF be allowed to be included in the DOE shipment to the Russian Federation. DOE agreed, conditional upon NRI being responsible for all costs associated with the LEU SNF activities and that it does not delay the HEU SNF shipment.

The NRI SNF Shipping and Disposition Project required a significant amount of planning and coordination, including obtaining a new transportation cask system, preparing both shipping and receiving facilities, participation of four countries, and involvement of numerous organizations, regulatory agencies, and contractors.

TRANSPORTATION CASK SYSTEM

To accommodate the need for a large-capacity cask system to haul HEU SNF in support of the RRRFR Program, the IAEA, funded by DOE, competitively bid and selected the ŠKODA VPVR/M cask by ŠKODA JS a.s. of Plzeň, Czech Republic. A tripartite contract was negotiated and signed between IAEA, ŠKODA JS a.s., and NRI for the cask system. ŠKODA provided 10 VPVR/M casks and ancillary equipment and agreed to maintain and store the casks for 10 years (the life of the RRRFR Program). NRI took ownership of these casks in exchange for allowing DOE to use the six casks they procured for hauling their LEU SNF. The IAEA, with support from DOE, performed quality audits and inspections of ŠKODA to ensure that regulatory requirements and design and fabrication specifications in the contract were satisfied.

The VPVR/M cask (see Figure 3) has a unique top or bottom loading/unloading design. The cask consists of a massive, cast steel, cylindrical body that is 300-mm (12-in.) thick. The upper and lower parts of the body are tapered to minimize the total cask weight, which is needed to better accommodate the limited overhead crane capacities in the research reactor facilities. The cask's external dimensions are 1,505 mm (59-in.) high (without shock absorbers) by 1,200-mm (47-in.) diameter. Its cavity is 885-mm (35-in.) high by 600-mm (24-in.) diameter. Internal cask walls have a hot aluminum spray coating for cask internal decontamination. The cask SNF basket is made of Atabor (i.e., 1.5% boron-treated) steel sheets that are 3.63-mm (0.14-in.) thick. The basket is 833-mm (33-in.) high by 553-mm (22-in.) wide and has a 36-square port for the fuel assemblies. A central suspension/hanger rod, running down the middle of the basket, is used to raise or lower the basket in and out of the cask.

Ancillary equipment for the VPVR/M cask system includes a basket alignment tool, cask manipulating frame, cask tiedown system, drying/leak-testing equipment, a cask lift fixture, fuel-handling tools, and specially designed and certified International Shipping Organization (ISO) containers.

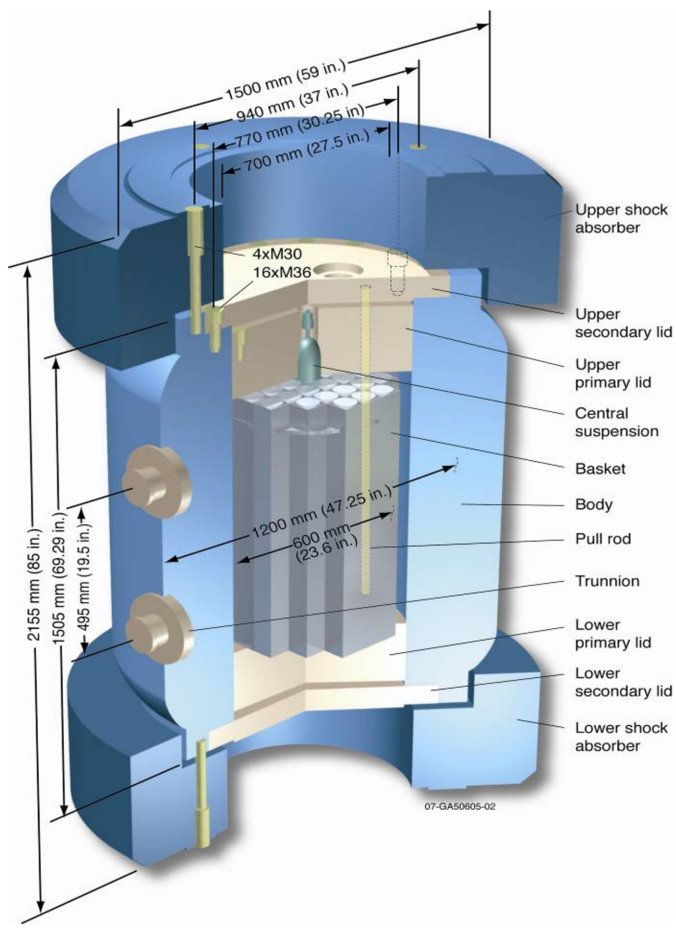

Figure 3. Schematic of the VPVR/M transport and storage cask.

The VPVR/M cask is licensed in four countries (i.e., Czech Republic, Russian Federation, Slovakia, and Ukraine). The State Office for Nuclear Safety (SONS) of the Czech Republic issued the original license (CZ/048/B(U)F-96 [Revision 1]), for both transport and storage. The cask is licensed for transport by road, railway, river, and sea. It is also licensed to transport 10 fuel types and store three types of Russian-origin research reactors fuels.

In January 2006, Rosatom issued certificate RUS/3065/B(U)F-96 for the VPVR/M. It is the first foreign cask to be licensed for multiple uses in the Russian Federation. Obtaining this license involved the efforts of numerous Russian companies and organizations, including Sosny R&D Company, a privately owned Russian company who coordinated the licensing effort in Russia; FSUE "VNIIEF," a government company who performed safety analysis and confirmed the structural, thermal, leak tightness, radiation, and nuclear safety of the cask design under normal and hypothetical accident conditions; FSUE "IPPE," a government company who provided safety analysis that demonstrated the radiation and nuclear safety for the cask design under normal and hypothetical accident transportation conditions; Mayak, a government company who is the user and responsible for the cask system in Russia; and Rosatom and Rostechnadzor, the Russian regulators who licensed the casks in Russia. The certificate is valid until January 23, 2009.

Obtaining competent authority certification for transport of the VPVR/M cask through Slovakia and Ukraine was fairly simple because the design meets the IAEA TS-R-1 international transportation requirements and is already licensed by the Czech Republic and the Russian Federation. Both countries approved use of the cask within their territory without performing a detailed evaluation.

The cask system, with all features, has been thoroughly demonstrated at the SKODA JS a.s. manufacturing facilities in Plzen, Czech Republic; NRI facilities at Řež; and the Mayak facilities in Ozyorsk, Russia. Improvements, deficiencies, and lessons learned from those demonstrations have been incorporated into the casks design and operations.

Poster session paper titled, "Development of a New Transportation/Storage Cask System for Use by the DOE Russian Research Reactor Fuel Return Program," can be referenced for a more detailed discussion of the cask, ancillary equipment, licensing, demonstrations and operations, procurement, quality assurance inspections, fabrication, and delivery [1].

NUCLEAR RESEARCH INSTITUTE PREPARATIONS

NRI has three spent fuel storage facilities that need to be prepared for fuel and cask-handling operations. Those facilities are the At Reactor Pool (ARP), the Reactor Annex Pool (RAP), and the Away from Reactor (AFR) or High-Level Waste Storage Facility (HLWSF).

The ARP and RAP are both located within the research reactor building. The ARP is connected to the research reactor vessel inside the main reactor building (see Figure 4), whereas the RAP is located in a room connected to the main reactor building, which is accessible by a special rail system (see Figure 5).

Figure 4. LVR-15 reactor At Reactor Pool for spent nuclear fuel storage.

Figure 5. The VPVR/M cask being moved into the Away from Reactor storage area.

Preparations for handling the fuel assemblies and cask in both storage pool areas involved overhead crane upgrades (adding a nomadic load cell and speed controls); setting up the ŠKODA VPVR/M cask manipulation frame; installing specially designed cask basket support in the RAP; modifying the AFR pool cask transport device; adding special shielding around the cask pool, support/fuel loading stand; setting up numerous specialized tools and equipment for handling the fuel and transport cask; and setting up cask drying and leak tightness testing equipment. NRI also modified their ŠKODA 1 × IRTM transfer cask needed to transfer two damaged SNF assemblies from the reactor building to the HLWSF.

Figure 6. Cask transfer device on rails into the High-Level Waste Storage Facility entrance hall.

The HLWSF (see Figure 6) is located on a hill overlooking the main NRI complex. Preparing the HLWSF for fuel and cask-handling operations involved upgrading the overhead crane (adding a nomadic load cell and speed controls), setting up a specially designed cask manipulation frame, and installing a cask loading support bridge over the storage pool. Miscellaneous tools and equipment, including a cask drying and leak tightness testing machine, were installed.

NRI made two major facility modifications to the HLWSF not funded by DOE. A state-of-the-art, semiportable, modular hot cell was installed with specially designed remote-handling cutting and welding equipment and a cask basket loading and storing system. The hot cell was used primarily for repackaging and loading the EK-10 LEU SNF assemblies and the damaged IRT-2M fuel assemblies into specially designed stainless-steel canisters. The canisters were hermetically sealed (i.e., welded closed), loaded into a cask basket, and stored in a designated location inside the hot cells, pending loading into the casks.

An extension was built onto the front of the HLWSF for handling and storing the transport casks. A cask transfer device on rails was installed in this extension (see Figure 7). A specially designed cask storage vault, used for storing both the loaded and empty VPVR/M casks, was installed on one side of the extension. This vault is designed to protect, isolate, and provide physical protection for the casks during storage at NRI (see Figure 8).

Figure 7. Cask transfer device on rails into the High-Level Waste Storage Facility entrance hall.

Figure 8. High-Level Waste Storage Facility extension cask storage vault.

Every NRI operation, procedure, new piece of equipment, and facility modification required special analysis and documentation. Examples of the documentation include (1) operational manual, (2) operation condition/limitation plan, (3) quality assurance manual, (4) emergency plan, (5) hot cell inspection and test plan, (6) permission for hot cell construction, (7) list of equipment to be controlled by SONS, (8) decommissioning plan, (9) list of controlled actions, (10) cask and SNF-handling operations procedures, and (11) safeguards and security plan, including the IAEA design information questionnaire. Many of these documents were provided to SONS (i.e., the Czech regulator) for obtaining facilities and operations licenses.

NRI conducted two demonstrations that tested the procedures, operations, equipment, and facility modifications. One demonstration used dummy fuel assemblies and the second demonstration used real HEU SNF assemblies. Both demonstrations confirmed NRI's preparedness, provided training for the operators, and were used to obtain approval from SONS for actual fuel and cask-handling and loading operations.

NRI loaded the first cask with SNF in March 2007 to confirm adequacy for the VPVR/M shielding. All 16 casks were loaded and placed in the HLWSF extension cask storage vault by the end of August 2007. Cask loading operations went smoothly with no significant problems. It took about 3 days to load, seal, and prepare each cask for shipment.

RUSSIAN FEDERATION PREPARATIONS

Russian Federation law requires that thorough planning, reviews and evaluations of the environmental impacts for importing nuclear materials be performed. The evaluation must show that the importation will have a positive impact on the environment. A formal process called the Unified Project is required to evaluate the impact of transporting the nuclear material within the Russian territory, including; identifying potential emergencies, consequences, and responses; nuclear and radiation risks and mitigation of the impact on the public and environment; anti-terrorist planning and training; reprocessing the SNF, stabilizing the high level waste and storing it in Russia for less than 20 years. The law also requires that the total cost of performing this activity in Russia be identified and a 30% surcharge be added to the project. The added funds are to be used for "Special Environmental Programs" that will have a positive impact on the public and/or environment at Mayak and/or the Chelyabinsk Region.

Approval to make the shipment into the Russian Federation is obtained after completion of the following: (1) the Unified Project and Special Environmental Programs; (2) the Foreign Trade Contract between Russia and Czech Republic; (3) the Russian transport and cask licenses; (4) the Transport Conditions Plan between Czech, Slovak, Ukraine, and Russian governments; (5) Mayak preparations; and (6) the Russian Transport Decree.

The SNF from NRI will be shipped to FSUE "Mayak" Production Association, located near Ozyorsk, Russia, the largest city in northern Chelyabinsk region and southern part of the Urals mountain range. Mayak is one of the largest nuclear fuel reprocessing facilities in the world and is central to all RRRFR Program activities in the Russian Federation. Upon arrival at Mayak, the HEU SNF will be unloaded from the casks and stored until it is reprocessed to separate out the HEU. The HEU will be downblended and made into LEU fuel for commercial reactor use. The high-level waste from the reprocessing will be stabilized (vitrified) and stored for less than 20 years before being sent back to the Czech Republic for final disposition.

Preparing Mayak for the NRI shipment involved two facilities (i.e., Buildings 855 and 101A) and modifying a specially designed rail car. Mayak's fuel reprocessing, high-level waste vitrification process, and waste storage systems already existed and did not need to be changed to handle the NRI fuels.

Upon arrival at Mayak, the ISO containers, loaded with VPVR/M casks, are received by rail in Building 855, a large rail/truck high-bay area with a heavy capacity overhead crane (see Figure 9). This building was equipped with interim storage for the ISO container; a 32-ton handling beam and slings for lifting and handling the ISO container; a handling beam to remove the cask shock absorbers; the cask manipulation frame; guiding rods to remove/install the shock absorbers; and scaffolding for both the ISO containers and VPVR/M cask. Specialized tools provided included a hand hoist with weighting equipment, pneumatic torque wrench, polymeric protector for the lid sealing surfaces, guide rods to remove the secondary lid, support for the secondary lid, and numerous wrenches.

Figure 9. Cask unloading from the International Shipping Organization container in Building 855.

Building 101A is a larger hot shop with remote operations capabilities for handling casks and SNF assemblies (see Figure 10). Specialized remote-handling equipment and tools were installed for handling the VPVR/M cask system and NRI SNF. Examples include cameras and lighting, a special fuel basket loading/unloading grapple, and a special basket on a modified storage pool fuel-handling cart. A high-pressure heated water decontamination facility was setup for cleaning the cask baskets before reinstallation into the casks. Finally, tools and equipment needed to reassemble, seal, and leak test the casks in preparation for transport were provided.

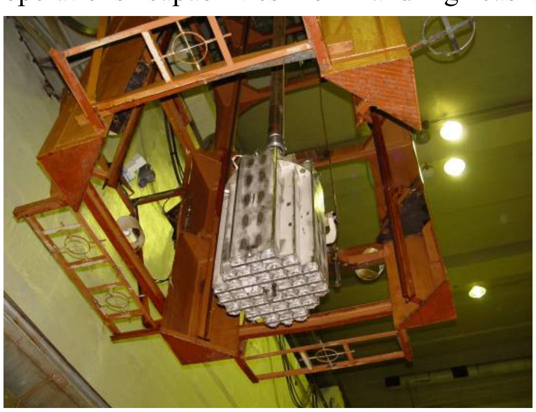

Figure 10. Loaded VPVR/M cask basket being transferred into the Building 101A hot shop/pool area.

Transporting the loaded and empty casks between Buildings 855 and 101A is performed by rail using a specially designed railcar. This railcar was modified to hold two VPVR/M casks.

Mayak prepared numerous documents, designs, and analyses for receiving the NRI shipment. Examples include the following: (1) a "Technical Description and Operation Manual for the ŠKODA

VPVR/M Cask at Mayak;" (2) design drawings, sketches, and descriptions of tools and equipment used to handle the casks and SNF assemblies; (3) detailed operating procedures; and (4) a safety analysis.

Mayak successfully completed a "dry run" of the cask and fuel-handling operations from May 30 through June 2, 2006. The dry run demonstrated that the equipment, tools, operating procedures, and personnel are prepared to receive and handle the NRI shipment. Some of the improvements identified during the dry run include the following: (1) information provided to the Russian customs needs to be accurate to minimize delays in acceptance and release of the shipment; (2) load cells are needed for most lifts to prevent overloading and damaging cask components and handling tools; (3) the cask lid seal holders design needed changed to prevent the seals from falling out during lid handling; (4) cask tiedowns and bolts needed to attach the bottom shock absorber to the cask body needed to be evaluated and redesigned to prevent loosening of the tiedowns and the bolts falling out during the cross continent transport between the research reactor facilities and Mayak; and (5) minor changes to the ISO container lift fixture needed to eliminate interferences.

SHIPMENT PREPARATIONS

All shipping preparations have been completed in the Czech Republic, Slovakia, Ukraine, and Russian Federation. Final loading of the casks into the ISO containers and transport by truck to the rail station for loading onto a special train is arranged. All shipment permits and licenses are in place and most of the approvals have been received. Contracts with rail carriers and security are in place. Shipping papers have been drafted and preliminary reviews have been completed. The shipment nuclear liability insurance has been procured from the Kancelar Ceskeho Jadernoho Pool for the Czech Republic, Slovakia, and Ukraine. Nuclear liability protection insurance in Russia is provided under the Foreign Trade Contract. Special arrangements and equipment are in place for switching the train from the European to Russian rail system.

SHIPMENT APPROVALS

Some of the most difficult, time-consuming, and sometimes frustrating activities required for making the shipment involved obtaining the numerous government agreements and approvals. Because these activities are not under the control of the project, it was difficult to influence timely and favorable completion. Table 1 identifies major agreements, contracts and licenses needed to obtain approval for making the shipment. The participating government for each activity is marked by "X." It is anticipated that all approvals will be received and the shipment completed by the end of 2007.

Table 1. List of activities needing finalized before making Nuclear Research Institute shipment [2].

Activity	U.S. DOE	Czech Republic	Russian Federation	Slovakia	Ukraine	Euratom
USA-RF GTRI agreement	X		X			
NRI-DOE (NNSA) contract	X	X				
CR-USA DipNote exchange	X	X				
CR-USA implementing agreement	X	X				
Gov-to-gov agreement		X	X			
Gov-to-gov transport Agreement		X	X	X	X	
NRI-MAYAK Unified Project contract		X	X			
Transportation technical conditions plan		X	X	X	X	
NRI-Russian (TENEX) foreign trade contract		X	X			X
Package/cask design license		X	X	X	X	

Activity	U.S. DOE	Czech Republic	Russian Federation	Slovakia	Ukraine	Euratom
Country transport license		X	X	X	X	
SK-UA physical protection border exchange agreement				X	X	
UA-RF physical protection border exchange agreement			X		X	
Carrier contracts		X	X	X	X	
Nuclear damage liability insurance		X	X	X	X	
Czech export license		X				
Russian import license			X			
Russian prime minister shipment decree			X			
Czech letter to Russia government guaranteeing HLW return		X				
Russian letter to Czech government guaranteeing nonproliferation of SNF		X				
Shipping papers completed		X	X	X	X	
Shipment notification to Mayak		30 days before the shipment, Mayak is informed all documentation is complete				

SUMMARY AND CONCLUSIONS

Preparing to transport the NRI SNF to Mayak for reprocessing and waste stabilization and storage required a significant amount of planning and coordination. Sixteen new VPVR/M transport/storage casks and ancillary equipment were obtained and licensed in four countries. Three NRI SNF storage pool facilities were prepared, tested, and used to load the 16 casks. Two facilities at Mayak were prepared and tested for handling the VPVR/M casks and NRI SNF. The cask system has been thoroughly demonstrated at NRI and Mayak. All preparations have been completed for transporting the loaded casks through the Czech Republic, Slovakia, Ukraine, and the Russian Federation. Once all final approvals are received, the shipment will be made, which is expected to be completed by the end of 2007.

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