TECHNICAL, ECONOMICAL AND LEGAL ASPECTS OF REPATRIATION OF RUSSIAN-ORIGIN RESEARCH REACTOR SNF TO RUSSIA

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Abstract

The aim of the report is to find some principal decisions to implement an Agreement between the Governments of the Russian Federation and the USA on repatriation of the research reactor spent nuclear fuel (RR SNF) to the Russian Federation. The report presents some ideas and approaches to the transportation of the Russian-origin RR SNF from the technical, economical and legal viewpoints. The report summarizes the Russian experience and possibilities to fulfill the program under the Agreement. Some decisions are proposed related to application of the international transportation experience and the most advanced technologies for the RR SNF handling. At present, there is no any unified SNF transportation technology that is capable to implement the transportation program schedule set by the Agreement. The decision is in the comprehensive approach as well as in the development of mobile and flexible schemes and in implementation of parallel and combined shipments.

Introduction.

On the 28th of May 2004 the Government of the Russian Federation and the Government of the USA signed the Agreement on repatriation of the research reactor spent nuclear fuel generated in Russia. It made us revise the approaches to the transportation of RR SNF back to Russia.

To fulfill the Agreement, the top heads of Russian and American Nuclear Departments have to ship the spent nuclear fuel from all research centers of Europe, Asia and Africa till the 31st of December 2010. Due to this task, the necessity arose to revise all the aspects of the international shipments of Russian-origin RR SNF. The most important aspects that determine a successful transportation are as follows:

- Spent Fuel geography and Conveyance Preferences
- SNF acceptance Criteria and Fuel Preparation
- Fuel Inspection
- Cask selection and Transportation Logistics
- Technical Issues, Certification and Security
- Costs
- Legal Guideline and Contract Issues
- Scheduling
- Public Relations.

The international experience on the transportation of fresh highly-enriched Russian fuel from Serbian, Romanian, Bulgarian and Libyan research reactors gained during the last three years evidences that the majority of problems can be successfully avoided in case of close cooperation, mutual confidence and unified schedule of each transportation. This report pays great attention to compliance with the Russian legal regulation basis as well as to issues of selection of transport means, containers and SNF handling technologies.

1. Spent Nuclear Fuel Geography and Conveyance Preferences.

The analysis of location of different types of RR SNF in countries and continents is made in Review /1/. However, it will be reasonable to divide the geography analysis into four groups corresponding to four directions of possible transportations (Fig.1):

- Europe,
- Middle Asia,
- Africa,
- South-East Asia.

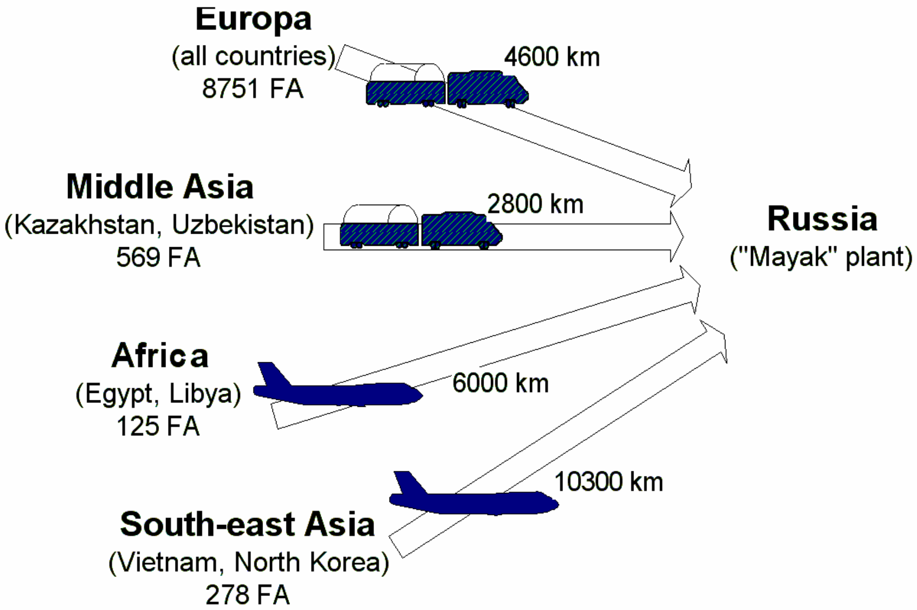

Fig. 1. The geography of the Russian-origin RR SNF location

The figure shows that the geography of the RR SNF location determines the conveyance preferences. Thus, it is reasonable to perform air or sea transportation of SNF from countries that are far from Russia or separated from it by seas. This way is economically profitable even special tests are needed as well as certification of containers for air transportation of fuel from these countries.

2. SNF Acceptance Criteria and Fuel Inspection.

The nomenclature of spent fuel stored in the research reactor pools is known very well. The level of fuel enrichment in U-235 is from the lowest value (<20%) up to the highest one. The burn-up ranges from 10% to 50%. The time period of the fuel storage is from 5 years to 50 years. These parameters determine, to a great extent, the mass characteristics of fuel, its activity, residual energy release and fuel physical condition as well.

The Russian criteria for fuel acceptance are more liberal than, for instance, the American ones /2/. It is allowed to specify the SNF acceptance terms in a contract. These terms are determined by the “IAEA regulations on export and import of nuclear material” INFCIRC/207. This document states that all the accompanying documents for SNF should comply with the data of the IAEA Safeguards Department.

Fuel mass characteristics. Russia has a governmental NM registration system. Its main principles are stated in "The main regulations for the nuclear material registration and control" No NP-030-01-2001. These principals are the basic for the "Mayak" plant activities and they are implemented in the form of two-stage system for uranium acceptance. First of all, the preliminary NM acceptance is performed based on the accompanying documents issued by the consignor. At the second stage the nuclear materials are accepted on the balance of the plant according to the results of the spent FA dissolution analysis and a special Act is issued. As for plutonium and neptunium, they are accepted after their extraction in the form of nitric acid solutions and their further analysis. Thus, a foreign supplier should indicate the registered quantity of NM in an invoice (according to the IAEA Safeguards Department data). All the spent FAs should have "Certificate of Spent Fuel Assembly loaded into the XXX basket of the YYY cask" (Annex 5 to OST 95 10297-95).

Shipments of material may be better coordinated when detailed information is promptly provided to include a comprehensive Appendix A "Spent Nuclear Fuel Acceptance Criteria". An Appendix A is an appendix to the contract between the consignor of goods and "Mayak" plant in which the reactor operator provides detailed information regarding their spent nuclear fuel. Appendix B "Transport Package Acceptance Criteria" is also an important condition of successful fuel acceptance on the consignee' territory.

Fuel burn-up. Since the fuel burn-up range is very wide, the differences in the U-235 content after irradiation can be significant. This fact causes some serious problems in elaboration of the fuel acceptance criteria. To solve this problem, a mutually approved technique is needed to determine the fuel burn-up even in the case when the irradiation history of each FA is unknown (for instance, TVR-S slugs from Serbia or ball-type fuel rods from Byelorussia).

Leaky and damaged spent fuel assemblies. The problem of transportation of leaky and damaged spent FAs is a peculiar one. First of all, it is necessary to identify leak-tight and leaky fuel assemblies. The Russian document OST 95 10297-95 allows transportation of leak-tight FAs and those with gas leakage without cans (in open baskets) or in non-hermetic cans. In case of direct contact of the fuel composition with pool water, the sealing of cans should be provided. The sipping methods should be of great attention during fulfillment of the SNF shipment program under the

Agreement. The scope of works on the fuel preparation will be determined by the number of leaky spent FAs.

Cooling period and SNF conditions. The Russian experience on examination of RR SNF with aluminum cladding shows that after a long-term storage (more than 30 years) in high-quality water the state of such fuel tends to a critical one. It means that the spent FA can be leak-tight but careless spent FA handling during reloading works can lead to its damage. In this case, the procedure of the spent FA preparation to the transportation (for instance, reloading into wrappers or cans) is a very complicated one. Work on fuel preparation to the transportation should be performed at each research center so as to comply the fuel acceptance criteria.

Distribution of spent FA of different types is Europe, Asia and Africa is presented in Fig.2. Undoubtedly, the nomenclature and design peculiarities of the Russian-origin fuel /3/ limit the handling means and fuel transportation technology. However, from the transportation viewpoint, all the variety of spent FAs can be brought to a certain number of types.

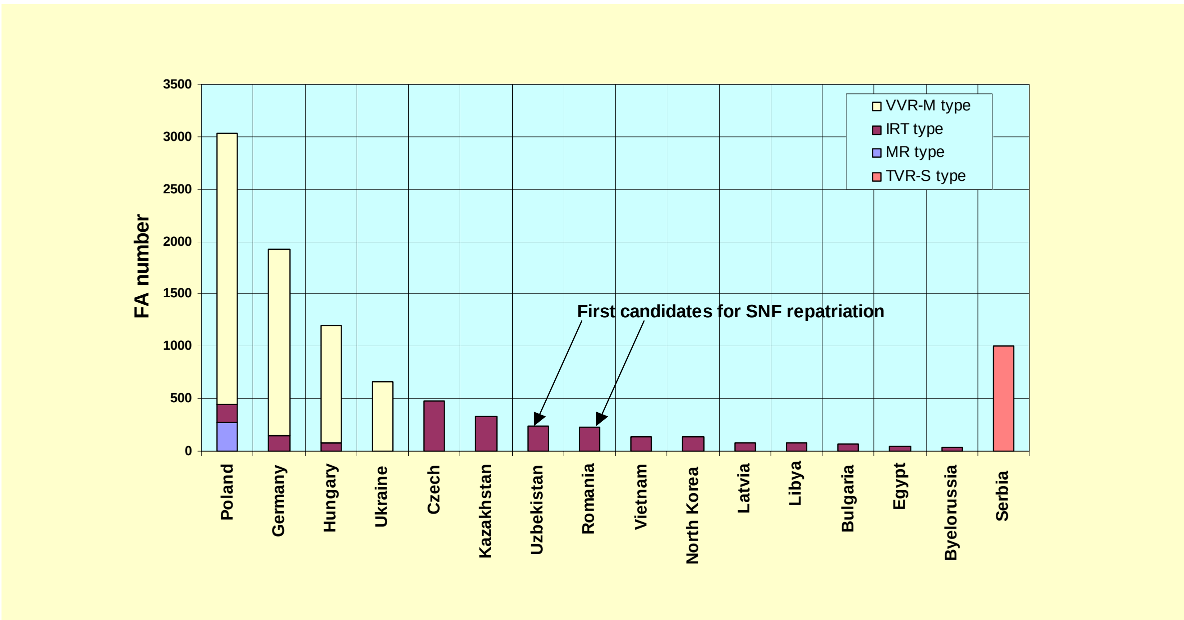

Fig.2. Russian-origin SNF distribution in countries

Several conclusions follow from the analysis of Fig.2:

- The largest amount of irradiated fuel (both in the FA quantity and U mass) is in Poland, Germany, Hungary and Ukraine. In all four countries the percentage of highly enriched fuel is rather high. The most part of spent FAs is of VVP-M type, i.e. small-size fuel assemblies. The rest of the fuel is fuel rods and FAs of EK-10 type;

- Large-size fuel assemblies of IRT, EK-10, S-36 and VVR-K type are, mainly, in Check Republic, Kazakhstan, Uzbekistan and Romania. The percentage of FA containing highly-enriched uranium is significantly lower as compared to the first four countries;
- Yugoslavian SNF storage facility is a peculiar case, since a large amount of the TVR-S type slugs is stored there. The total amount of slugs is 8030 pcs and 20% of them are highly enriched. Since the slugs have a unique design that differs from the standard RR FAs and the period and storage conditions of these slugs are also non-standard, the transportation of fuel from this storage facility is a complicated problem;
- Transportation of 275 FAs of MP type from the MARIA reactor (Poland) is also non-typical due to the non-standard design of FAs;
- As for Asian research reactors, they have, mainly, highly-enriched fuel (803 FAs with HEU and 44 FAs with LEU). All the 44 FA of EK-10 type with low-enriched uranium are in North Korea. All the Asian spent AFs are of IRT and VVR-K type, i.e. large-size fuel assemblies;
- African research reactors have EK-10 type FAs (Egypt) and IRT-2M type FAs (Libya).

3. Cask Selection and Transportation Logistics.

Cask selection. The fleet of transport casks and variety of technologies used by Russian and foreign companies for the SNF transportation have a wide scope of characteristics /4/. As in case with spent FAs, the whole variety of containers and technologies can be brought to several types. Such approach allows some new solutions to be found in the problem of the SNF transportation, which haven’t been considered by the researchers before.

Due to the limited possibilities of the research centers in organizing of the SNF transportation, only so called LWT containers should be used (weight is up to 30 tones). Table 1 presents a list and characteristics of the LWT transport casks used for the RR SNF transportation performed by Russian, American, German, French and Czech companies.

Table 1

Characteristic of different containers sets, type LWT

Cask type	Country	Active quantity of cask, units	Capacity (for IRT FA type), units.	Capacity (for VVR-M FA type), units.
TUK-19	Russia	20	4	16
NAC-LWT	USA	8	42	112
VPVR Skoda	Czech	1 (12 casks will be fabricated)	36	108
CASTOR MTR 2	Germany	18	32	96
NCS-15	Germany	1	4	16
NCS-45	Germany	1	16	48
GNS11	Germany	2	32	96
GNS16	Germany	2	32	96
TN 7-2	Germany	2	64	200
TN-MTR	France	4	52	150
TN-106	France	1	8	32

Only one set of the LWT casks is available in Russia for the RR SNF transportation. It’s a TUK-19 cask. These casks are of a simple design and they are very convenient for Russian home shipments. It is expedient to use the TK-19 casks when all the fuel can be transported at a single railway shipment from the research center (for instance, Bulgaria, Byelorussia, Latvia and, probably, Romania).

The comparative analysis of the efficiency of different casks, readiness of the technologies for fuel reloading under complicated conditions, analysis of costs on various variants of container applications and account of preparatory work scope allow the following conclusions to be made:

1. There is no any unified type of cask that makes it possible to fulfill the whole program of the SNF repatriation within the schedule set by the Russian-American Agreement. That is why it is necessary to use some combined variants with the most convenient characteristics of different types of casks as well as to widen the sphere of their application taking into account the peculiarities of the research center geographical disposals.
2. Russian TUK-19 casks can be used to ship SNF from those European countries, where the amount of fuel is not large and can be transported at a single shipment.

3. Significant volume of transportations can be made using American containers of the NAC-LWT type. The advantages of this variant are in high efficiency of the park of capacious containers and in flexibility of the reloading technology. In addition, the design of these casks allows, if necessary, for certification of air shipment that is of great importance for the SNF transportation from distant countries.
4. To perform the program of the RR SNF transportation within the set schedule, containers and technologies of the NCS-GNS company can be used sometimes. But in this case, the costs for adaptation of the “Mayak” plant acceptance technology to different types of containers can be rather high.
5. VPVR casks of the Czech company Skoda that have a peculiar loading/unloading technology (top and bottom) can be accepted at the “Mayak” plant and the adaptation costs will be insignificant.

Transportation means. The selection of the transportation means is determined by the following factors.

- Location of the Russian-origin RR SNF is of a continental character. Hence, the transportation will be performed, mainly, by the railway transport.
- Air shipment is inevitable during the fuel transportation from Africa and South-Eastern Asia. Besides, widening of application area of one of the above casks during air shipmen will allow the used container fleet to be brought to a new high level.
- The necessity to use river and sea transport means arises if there are some transit difficulties during the SNF transportation from countries situated on the Danube. Such transportations have been already performed (Kozloduy, 2001). The analysis of capacities of ports located on the Danube, through which packagings with SNF can be shipped, shows that they are ready to deal with the LWT type containers. The Russian port in the Barents Sea (Murmansk) is going to get licenses for the SNF handling.

4. Technical Issues, Certification and Security.

Loading and unloading technologies. To accept the Russian-origin RR SNF at the "Mayak" plant, two technologies are used to load irradiated FAs into the transport casks:

- Underwater loading of spent FAs into the transport cask basket using its own cranes. This type of technology is applied at the research centers with highly developed infrastructure.
- "Dry" reloading of spent FAs into the transport cask using intermediate transfer container. This technology is used at the reactors, where fuel transportations are very rare and possibilities of lifting equipment are very weak.

Since the first type of technology is not convenient for the majority of research centers, it follows that only those casks must be selected that can be used in the "dry" transfer technology. At present, the following casks can be used for the SNF transportation from the research centers with weak possibilities of lifting equipment: TUK-19, NAC-LWT, GNS-16 and TN-MTR. In this case no additional significant costs are required.

Thus, it is economically profitable to improve the transportation equipment and technologies, which do not depend on the capacities of the research center. Adaptation of the transport-technological equipment of the research centers to the containers is not reasonable.

Certification. There are no any difficulties in the certification of the package design and transportation by means of railway transport.

Certification of packages for their transportation by air is more difficult task. To solve this problem, testing of the casks is necessary according to article 734 "Regulations for Safe Transportation of Radioactive Materials" TS-R-1. The most complicated test is a crash test at a speed of 90 m/s. These tests are considered to be very expensive but the investigation show that the costs could be much lower if the tests are performed in Russia instead of the USA. As it was already mentioned, if this obstacle is overcome, the international container fleet will achieve a new level so as to solve RF-USA Agreement tasks.

Physical protection and security. There is a fundamental difference between Russian and foreign casks. The Russian casks are shipped, as a rule, in special railway carriages, of which design is intended only for one type of cask. In this case, track and sea transportations of these casks become a serious problem. Foreign casks are transported, as a rule, in 20-feet transport containers that meet the ISO standards.

Other aspects of the secure transportation are as follows:

- Transportation means is accompanied by the necessary force ministers of the country, on which territory transportation is carried out;
- Rosatom Crisis Center provides the insurance and information support during the whole shipment period;
- Date of any shipment is confidential. The details of any shipment are available only for those who deal with;
- Responsibility for the product should be strictly shared till the rout is over;

The above problems have been already solved in Russia.

5. Costs

To compare different variants of the SNF transportation from the cost viewpoint, the following costs should be taken into account:

- Management of project and logistics of shipment;
- Development, designing and fabrication of DTT components;
- Fabrication of new containers and their rent;
- Certification of package design and shipment;
- Personnel training and preparation of the consignor technical means for cask acceptance;
- Preparation of fuel for shipment and fuel loading into casks;
- Transportation and provision of physical protection;
- Insurance and customs costs;
- Ecological expertise of the project;
- Unloading at the “Mayak” plant and SNF acceptance.

In any case the costs should comply the requirements of the Russian laws (Fig.3)

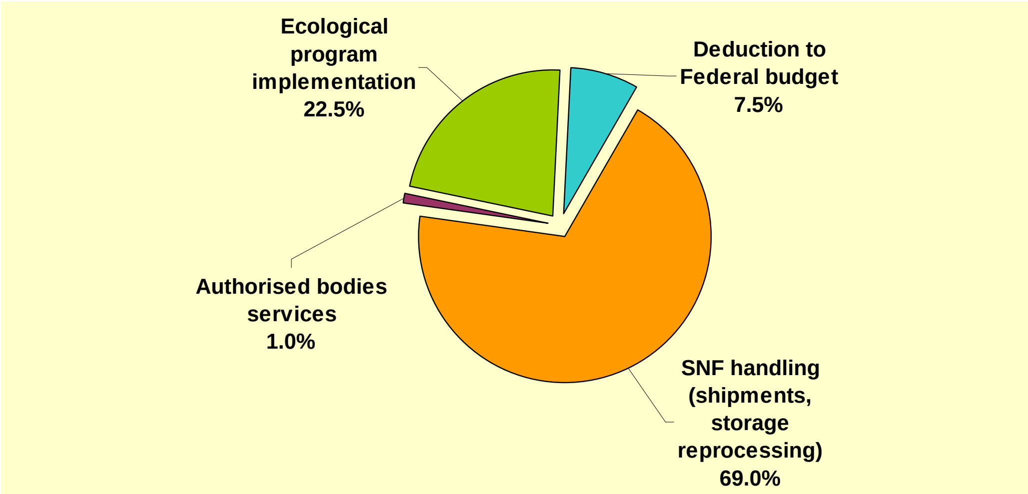

Fig.3. Total SNF repatriation cost distribution
(according to the requirements of the Russian laws)

6. Legal Guideline, Contract Issues and Scheduling

Legal guideline. The repatriation of SNF to the Russian Federation is performed on the basis of international Agreements of the Russian Federation and foreign trade contracts concluded to fulfill the above Agreements by organizations authorized by the Government of the Russian Federation. A Gov-to-Gov Agreement for import of irradiated fuel assemblies between Russia and the Supplier country as well as contracts with transit countries are mandatory.

The key point of the SNF import to the Russian Federation is a Unified Project (foreign trade contract + a set of verifying documents). This Unified Project specifies the import conditions, determines main executors and their role in the Project and regulates necessary and obligatory conditions for the Project implementation related to fulfillment of special ecological programs on improving of contaminated areas for the SNF handling. The mandatory condition for international Agreements and Contract on the spent FA import is the availability of positive conclusions of the State Ecological Expertise about the Unified Project.

Contract Issues. Selection of an organizational and financial scheme is the most important stage of the implementation of the Project for the RR SNF shipment to Russia. Russia has strictly determined organizations responsible for conclusions of foreign trade agreements on the NM supply (TENEX and TVEL) and nuclear and radiation safety during the NM transportation (Rosatom, former Minatom). Nevertheless, standard schemes are not always effective. The experience on return of the fresh Russian-origin fuel of research reactors shows that non-traditional schemes with the participation of private companies are more effective.

The contract determines the cost of the spent FA import that includes:

- All customs fees;
- Costs of services rendered by organizations authorized by the RF Government to conclude foreign trade agreements related to the import of spent fuel assemblies to the Russian Federation;
- Costs of services rendered by organizations dealing with handling of spent fuel assemblies and products of their reprocessing (including transportation, interim storage, reprocessing and radwaste handling).

Scheduling. According to the current Russian legislation, the following stages of the spent FAs transportation to the Russian Federation are supposed:

- Signing of Gov-to-Gov Agreement on the spent FAs import to the Russian Federation;
- Signing of transit agreements;
- Preparation and expertise of the Unified Project;
- Signing of foreign trade contract on the spent FA import;
- Delivery of empty casks to a facility;
- Loading of spent FAs;
- Transportation of loaded packages to Russia and their acceptance at the “Mayak” plant.

If necessary, Russian specialist can carry out the SNF inspection prior to the delivery of transport casks. Taking into account the fact that the most part of the research reactor fuel is stored in water within several decades, this inspection is of great importance. According to the inspection results, the decision can be taken about the SNF preparation for the transportation and provision of the shipment safety (for example, fabrication of leak-tight transport cans).

The preparatory phase performed by the governmental bodies influences greatly the time of project implementation. Thus, the time period for signing of Gov-to-Gov Agreement can make up about 6-12 months. Depending on the conditions and quantity of fuel, the time for fuel preparation for transportation can make up from 6 months up to 18 months. The preparation of the Unified Project will take no less than 4 months. The shipment of spent FAs will take 45-60 days. Thus the whole import project will take 15-24 months.

7. Public Relations.

Public relations is an important part of the successful implementation of the program to return USSR-origin spent nuclear fuel to the Russian Federation. Russia does not have enough experience in public relations during the RR SNF transportation since all the transportations of spent FAs (from power reactors) are carried out according to the old legislation that does not provide issues of public relations. The current legislation has the regulation of the RF Government No 418 signed on 11th of July, 2003 concerning the procedure of the import of irradiated fuel assemblies of nuclear reactors. This regulation allows for easier solving of the transportation problems. Thus, Russia has an experience of intensive public collaboration during preparing for import of the spent FA of the VVR-SM research reactor (Uzbekistan). In particular, during the conference with the participation of the representatives of public bodies and people hold in summer 2004 in Chelyabinsk, the project of the spent FA transportation was fully approved. The transportation was approved because information was available as well as justification of costs for the spent FA handling and ecological activities.

Conclusion.

The report covers the issues of the Russian-origin SNF transportation from Europe, Asia and Africa to Russia. In fact, the problem of the SNF transportation is more complicated. Not only spent nuclear fuel is transported to Russia but also all the technical, economical, legal and ecological problems related to the SNF handling. The analysis shows that the Russian legislation is ready enough to solve these problems.

At the same time, we should admit that from the viewpoint of efficiency, the Russian cask fleet intended for the spent FA transportation is not ready yet for such tasks. To solve this problem, a comprehensive approach is necessary including application of foreign casks of different types.

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