# Operating Experience and Lessons

# Learned on Managing Non-Standard

# Legacy Spent Fuel from Power and

# Research Reactors in Russia

L. BELINSKIY

Rosatom

Moscow, Russia

Email: LeLBelinsky@rosatom.ru

**Extended Abstract**

Since the beginning of nuclear energy in Russia, a huge number of different types of reactors have been developed. Some became serial, and many remained in single copies. As a result of the operation of such reactors, SNF was formed. Some types of this SNF have extremely unusual characteristics:

dimensions

fuel composition

FA construction

defects of FA and fuel composition.

All this required separate approaches to the management of this SNF. And if, as a rule, the handling of spent fuel at the reactor site has been thought out, then the removal of spent fuel from the site and further handling of it is an extremely difficult engineering task.

The strategy of closed nuclear fuel cycle has been implemented in Russia. Thus, all types of SNF have to be reprocessed. The most non-standard SNF for reprocessing are SNF of AMB reactors, uranium-zirconium SNF of the atomic ice-breaker and liquid SNF of research reactors.

The AMB-100 and AMB-200 reactors (Atom Mirniy Bolshoy) in Beloyarskaya NPP became prototypes for RBMK-1000, 1500 and EGP-6 reactors. SNF of AMB reactors has a huge size. The length of the FA exceeds 13.5 m. The fuel rod length is more than 6 m. It is not divided into segments. Five or six fuel rods have a ring shape, filled with fuel composition. The coolant circulates inside the fuel rods. The fuel rods are inserted into graphite bushings that do not have a durable shell. There are more than 21 types of fuel compositions and enrichments from units to tens of percent.

Fuel compositions are mainly represented by grains of uranium-molybdenum of various ratios and uranium dioxide in the calcium and magnesium sublayer. At the same time significant part of the FAs (estimated at more than 30 %) was damaged due to the fragility of the structure during operation in active zone and storage. Since the AMB reactors were shut down in 1981 and 1990, there is currently a need to decommission them. To begin decommissioning it is required to free the NPP site from nuclear materials.

This required the development a technological scheme for the transportation of this SNF to the reprocessing plant, the development of technology for preparing and reprocessing this type of SNF.

A third of the AMB spent nuclear fuel was transported from the NPP site to the RT-1 plant in the 70-80s of the 20th century. As time passed, the previously used transport scheme was lost. Regulatory requirements have changed to improve transportation safety. It took developing everything all over again. For the transportation AMB’s FA from NPP to the reprocessing plant special cask TUK-84/1 was developed. From 17 to 35 FA can be placed in the TUK-84/1 at a time, depending on the storage case. The transportation cask has been certified according to all requirements.

Due to the large FA length, it had to be fixed in a railway wagon. At the same time, the design of the car provides for the tilting of the cask, with the lowering of a part of it below the level of the track. For this purpose, reinforced structures of the railway track and special receiving cavities for lowering the cask between the rails are made in the places of tipping. Cask maintenance is performed from special platforms that cover the cask from all sides above the car. The requirements for cranes carrying out loading and unloading of cask have also been increased, since the fuel rise from the floor level exceeds 25 m.

Now the transport and technological scheme is functioning successfully. 2/3 of the total spent SNF was transported to the site of the radiochemical plant.

To prepare the AMB FAs at the reprocessing plant, a technology for take FAs apart into an active part and a structural components was developed. The AMB FAs preparation workshop is currently under construction. The technology of the complex involves underwater layered cutting of FAs. After cutting, the FAs is divided into fuel and structural components. The fuel component is packed and sent for drying. After drying, the spent nuclear fuel is transferred to an operating storage pool for storage before radiochemical reprocessing. The FAs structural elements are placed in the primary package and sent for defining RAW characteristics. After determining and checking for the content of nuclear materials, the radioactive waste is sent for temporary storage and disposal. Due to FAs cutting under water and cuts are made directly through the fuel composition, special requirements are placed on the pool-cutting water purification system. A special water treatment system was designed. It makes it possible to purify water from metal shavings, graphite, nuclear materials and radioactivity. The system has passed successful bench tests.

A radiochemical technology for reprocessing all types of fuel compositions was developed in preparation for the AMB SNF reprocessing. The technology was developed for the operations of dissolution, extraction separation and radioactive waste treatment. Experimental SNF reprocessing operations of similar SNF fuel compositions of the AM reactor have been successfully carried out. The AM fuel was used at the world's first NPP located in the city of Obninsk.

After construction of the workshop and testing of all technological solutions, the AMB SNF reprocessing will start.

The uranium-zirconium SNF used on nuclear icebreakers was accumulated at the Atomflot base in Murmansk. SNF is stored in 50 casks TUK-120. It was packed as a result of the work carried out with the UK within the framework of the Global Partnership programme. SNF is a complex alloy of uranium and zirconium that cannot be reprocessed using the standard technology of the reprocessing plant. The main difficulty is the dissolution of the uranium-zirconium fuel composition. Common types of SNF are dissolved in nitric acid, sometimes with the use of fluoride ions. However, uranium-zirconium SNF does not dissolve in any of the commercially available radiochemical acids or alkalis, such as those whose solutions would later allow the use of a standard extraction system based on TBP.

It was necessary to create a reprocessing technology for this type of SNF, design, manufacture and test nuclear-safe equipment for the dissolution process. As a result of the analysis, it was decided to test the technology of electrochemical dissolution. The dissolution process technology has been developed. Laboratory, bench and full-size tests of the proposed technology have been carried out. The tests were successful. Dissolver unit designed to dissolve only this type of SNF was made. The device was installed in a hot cell of the radiochemical plant RT-1. Successful dissolutions of dozens of FAs have been carried out.

Liquid SNF from IIN-3M type reactors is the most atypical type of the spent nuclear fuel. LSNF is solution of uranyl sulfate of various concentrations (it depends on reactor). At the same time, the concentration of fissile material is low, and reactor operation does not lead to high SNF burnout. Despite the low activity and small volume of spent nuclear fuel in the core, transportation and reprocessing of liquid spent nuclear fuel is an extremely difficult task from the point of view of equipment development and safety justification at all stages of treatment.

For the first time, Russia faced the task of transportation this SNF type as part of the The Russian Research Reactor Fuel Repatriation (RRRFR) programme. To return this type of spent nuclear fuel to Russia, a technological scheme for pumping SNF from the reactor into transport cask, packaging for transporting spent nuclear fuel, an installation for unloading SNF from a cask, and a technology for SNF reprocessing at the radiochemical plant were developed. The uniqueness of the developed technological scheme was also that the fuel had to be transported by air. For this purpose, the TUK-145/C was developed on the basis of the ŠKODA VPVR/M container, packaged in an external protective capsule. As a result, a successful transportation of LSNF from the Republic of Uzbekistan was carried out. Unloading from the cask into a technological tank was carried with a double level of safety –through a pipeline completely placed in another, security pipeline. The SNF reprocessing technology has also been pre-tested at a radiochemical plant. The reprocessing of SNF did not cause any difficulties.

Based on the developed technology, the liquid SNF also was transported from the Russian reactor. The essence of the technological scheme was preserved, but the Russian cask TUK-19 was used and transportation was carried out by rail. The new packaging has been certified according to all requirements. The unloading and reprocessing of spent nuclear fuel passed without incidents. The SNF discharge system has undergone significant modernization. The security level has also been significantly increased. A stationary SNF transfer line from the TUK to the technological tank was installed, which will allow receiving SNF from other reactors with a high level of safety in the future. Due to repeated use of the equipment, a smaller amount of RAW will be generated.

These types of SNF are not the only ones whose characteristics are unique and require special treatment. 99% of such nuclear fuel accumulated in Russia has already been recycled, is being recycled, or there are technologies for handling it, including reprocessing.

It is planned that all types of atypical SNF will be recycled in the medium term. Russia has accumulated extensive experience in handling non-standard legacy SNF at reactor sites, in transportation, reprocessing, and RAW management. This experience can be useful for organizing the management of non-standard SNF around the world.