Preparation for Transportation of Damaged SNF from Serbian Research Reactor RA

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The heavy-water reactor RA at the Vinca Institute of Nuclear Science, Serbia (since 2009 Public Company "Nuclear Facilities of Serbia") was commissioned in the middle of the last century and shut down more than 20 year ago. The fuel had never been removed from the reactor being left for storage in the SNF storage pool adjacent to the reactor. For various reasons, the SNF storage conditions could never meet standards and regulations resulting in an unsatisfactory state of the fuel. The observations of the water activity in the storage pool suggested that the situation had been getting worse from year to year.

To resolve the problem, a technology for SNF preparation and loading into canisters for further transportation or interim storage had to be developed. Since the project involved radiation hazardous operations right in the middle of Europe, the fuel repackaging campaign had to be organized and performed at a high technological level adhering to all international safety standards and regulations.

Preparatory Work

In 2003-2006, Sosny specialists took several missions to investigate the SNF health and the reactor safety and made sure that the Company's competence is sufficient to deal with the scope and complexity of the SNF preparation tasks.

The project participants prepared technical proposals on the SNF repackaging into canisters, loading into casks, transportation to Mayak PA, performed feasibility studies and developed the project schedule. In June 2006, Sosny R&D Company participated in the international tender in cooperation with Mayak PA and Techsnabexport and won it.

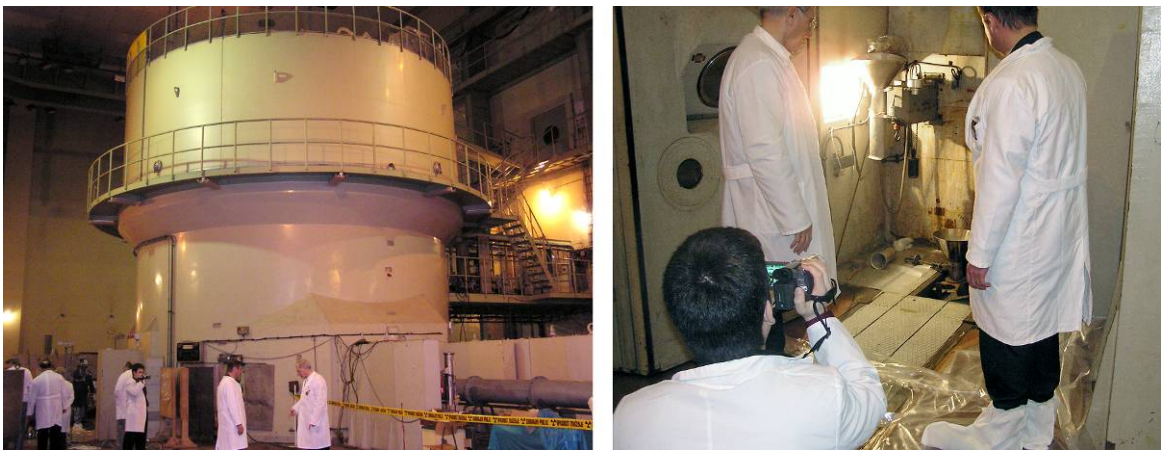

Fig. 1. Sosny specialists at Vinca Institute

Development of Technologies for SNF Preparation for the Safe Transport to Russia

Once the contract was signed, development of possible options of the RA reactor SNF preparation for the transportation was started. Since a big scope of preparatory work had been done before signing the contract, an SNF removal concept was developed before March, 2007; the concept became a starting point for further development of procedures and equipment, safety analysis and getting authorizations. The SNF removal concept development stage was devoted to analyzing the Russian and international regulatory and legal framework and justifying the feasibility to transport leaky SNF to Mayak PA.

The year 2008 was spent on the development of the procedure for SNF repackaging and loading into casks, as well as safety analysis. All main safety issues regarding the SNF preparation for the shipment and the shipment itself were considered including nuclear and radiation safety, design analysis, thermal conditions, explosion and fire safety. VNIIEF calculations demonstrated that transportation of the failed spent fuel could be safe, if loaded in special untight canisters for TUK-19 and SKODA VPVR/M casks; the canisters were developed with regard to Mayak's reprocessing requirements. In preparing, the following engineering solutions were taken.

1 All operations of the SNF preparation and loading into canisters would be performed remotely using special equipment and tools. The operations would be carried out in two areas:

– shielding room 099 inside the RA reactor vessel for cutting off the fuel-free upper parts of the reactor channels (RC);

– a working frame installed above basin 4 of the SNF storage pool for loading the SNF from aluminum barrels (ALB) and RC fuel sections into canisters.

All the operations in the basin were performed remotely under a layer of water. To facilitate the operators'

work, the working frame was equipped with underwater TV cameras transmitting the process to the operators' workstations. The dispatcher could observe the operations on his monitor, too to control and record the SNF repackaging process.

2 Russian TUK-19 and Czech SKODA VPRM casks were selected for the shipment. Sixteen TUK-19 casks and sixteen SKODA VPVR/M casks were required to transport the fuel as a single run.

3 The SNF was repackaged into special untight canisters of unified design, but differing in height and mass. The TUK-19 cask accommodates a Type 51 basket with the partitions removed. The SKODA VPVR/M cask incorporates a specially developed basket (Fig.2).

Fig.2. Untight canisters with SNF and baskets for the SKODA VPVR/M cask

4 Repackaging the SNF from ALB was the first operation. Opening the ALB was performed on the working frame. The SNF was repackaged into 75 untight canisters for the SKODA VPVR/M casks.

5 Repackaging the SNF from the aluminum barrels was followed by repackaging the fuel from the reactor channels. Once the long fuel-free upper part of the reactor channel was cut off, the RC fuel column was delivered to the Basin 4 working frame and repackaged into an untight canister for TUK-19 (16 canisters) and SKODA VPVR/M (19 canisters).

6 Fuel-free ALB parts and RC fragments were loaded into solid radwaste (SRW) vessels. During the operation, an SRW vessel was installed on the working frame under water. Once the vessel was filled up with the SRW, it was put into a standard storage barrel, which was remotely sealed and transferred to the storage facility.

7 Until loaded into the casks, the SNF-containing canisters were stored under water on the main rack in the Basin 4 and on additional racks in Basins 1-3. The total capacity of the racks allowed storing all the Vinca SNF repackaged into the canisters.

8 A system for water treatment from cesium-137 maintained the allowed volumetric water activity to ensure safety of underwater repackaging and interim SNF storage.

9 Since the TUK-19 cask design provides for the top loading only, the safe loading of the SNF-containing canisters was ensured by the transfer cask developed by Sosny R&D Company under the Romanian SNF removal project and adapted for operations at the RA reactor. The canisters were loaded into the TUK-19 casks in the reactor hall. The canisters for the SKODA VPVR/M casks or the transfer cask for the TUK-19 casks were loaded in the SNF storage room.

10 A special frame was used to install the casks on above the basin. To load the SKODA VPVR/M cask with the fuel, its lower lid with a basked installed on it was put at the bottom of the basin, the canisters were loaded with the fuel underwater using a special grapple, and the lid with the basket was pulled back into the cask. Loading the canister into the transfer cask for the TUK-19 cask was carried out in the same way.

11 Special areas were allocated in the reactor hall for arranging and handling empty and loaded SKODA VPVR/M and TUK-19 casks.

12 A rail trolley was used to transfer the empty or loaded SKODA VPVR/M, TUK-19 or transfer casks between the reactor hall, room 141 and the ground at the vehicle gate. Inside the reactor hall, the casks and special equipment were transferred by the 20 t capacity bridge crane available.

13 Since the storage pool has a 2 t capacity crane only, the SKODA VPVR/M casks and the transfer cask for the TUK-19 casks were moved by a 15 t capacity forklift. To provide free maneuvering of the forklift in the SNF storage room, a part of the rails was dismantled.

14 The SNF was dried inside the TUK-19 and SKODA VPVR/M casks.

15 Loading and unloading the TUK-19 and SKODA VPVR/M casks into/out of ISO containers were carried out on the ground at the vehicle entry to the reactor building.

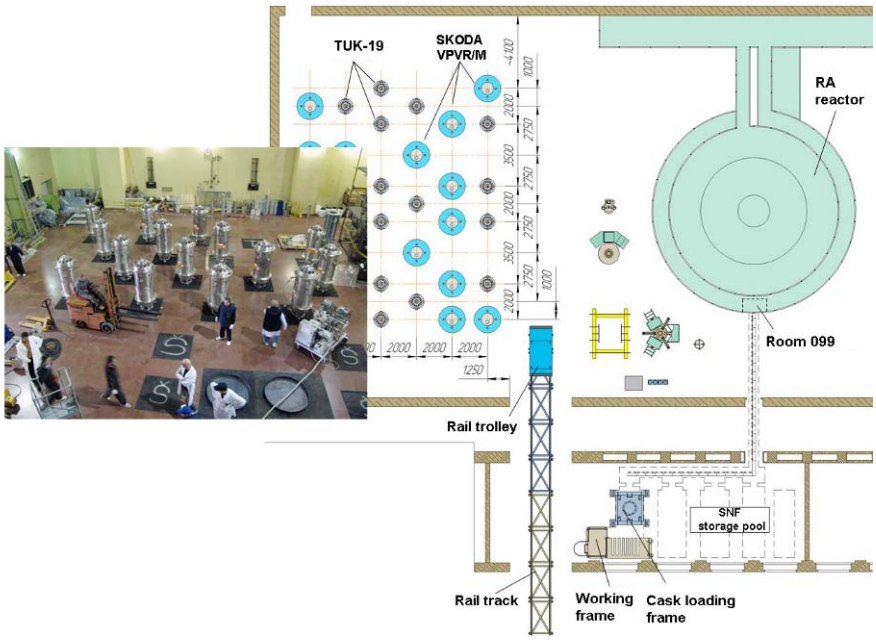

Fig.3. Layout of the reactor hall and the SNF storage room

The Vinca site had never witnessed such large-scale operations with SNF and casks; moreover, the design of the reactor and the SNF storage room did not provide any. A part of the equipment and systems had not been in use and operation since the reactor was shut down in 1984. So, the operations required modifications to the Vinca infrastructure. The preparatory work was done by Serbian specialists in compliance with Sosny's requirements and included modifications and repair of operational equipment and radiation monitoring systems. Unnecessary metalwares hampering installation of the working frame were removed.

In 2008, the SNF preparation procedure was approved by the Serbian regulatory authority. After that, the Sosny experts started developing and fabricating the equipment.

Operations

Over a year and a half, more than 120 items (more than 580 pieces of equipment) were developed and fabricated. All the equipment was fabricated at Russian plants including Ozersk Non-Standard Equipment Plant and SSC RIAR. In June, 2009, the equipment was delivered to Vinca Institute.

Fig.4. Mounting the equipment

In July 2009, the Vinca personnel started mounting the equipment and training to handle it under the guidance of Sosny experts. The SNF repackaging campaign was started in December 2009 and took six months. Over that period, no incidents happened to cause the personnel overdose or a radioactive release into the environment. The radiation doses received by the personnel were many factors of ten lower than the values allowed by Russian and Serbian

standards.

Fig.5. SNF repackaging operations on the working frame

In late July 2010, Vinca Institute received SKODA VPVR/M casks, and the final stage of the campaign was started. Under the guidance of the Sosny experts, the Serbian personnel received training in handling the SKODA VPVR/M and TUK-19 casks and loaded the SNF-containing canisters into them. The, the casks were loaded into ISO containers. That event happened in November 2010. Preparation of the RA research reactor SNF for the shipment to Russian was completed.

Fig. 6. Loading the containers on the Vinca site and at the port of Koper, Slovenia

The safety, feasibility and cost analysis found the multimodal shipment to be optimum; the route included combined road and railway transit through Serbia, Hungary and Slovenia followed by a sea shipment from the port of Koper to the port of Murmansk and the railway transportation to the reprocessing plant at Mayak PA. Licensing the shipment required a safety analysis with respect to national peculiarities of each country of transit and took 8 months in total. Ten carries from five countries participated in the shipment. The road shipment involved 15 large-capacity trucks; the special train consisted of 19 railcars.

The fuel started from Vinca Institute late at night on 18 December 2010. The fuel was shipped in full compliance with the schedule and the transport plan. The way from Vinca Institute to the reprocessing plant took more than 30 days and became the ever longest one under the RRRFR program.

It is no exaggeration to call the Vinca SNF removal the hardest RRRFR project. Its implementation required solutions to multiple unique technological and managerial challenges, most of which will undoubtedly be demanded in the future.