Technological Challenges in the Retrieval of Spent Fuel from Storage in Sea Vessels

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In condition of the nuclear opposition of 1950-80's Russia, as well as other nuclear powers, had been creating powerful nuclear shield, one of the basic element were nuclear submarines (NS). The problem which Russian Navy faced required to use floating technical platform for reloading and intermediate storage of spent nuclear fuel (SNF) from NS. The similar technology was established for SNF of nuclear icebreaker fleet.

At contemporary conditions of maintenance of a reasonable sufficiency of the defense arms and in accordance with its international agreements, Russia is carrying out a considerable reduction in number of the Navy's NS. At the same time decommissioning proceeds of the naval nuclear-powered ships with expired service life. Both factors have caused a peak in accumulation of out-service NS. Civil and military shipyards have failed to deal with recovery of the increased number of NS and service ships. However, the existing technical possibilities are presently not used at full because the financial means are insufficient not only for decommission, but for maintenance of the decommission infrastructure as well. Projects of creating additional decommission capacities at the shipyards were halted. Land-based facilities for long-term storage and disposal of SNF and Radioactive waste (RW), including the reactor compartments, were not built.

Therefore, a big number of NS intended for decommission are now laid up with the non-unloaded nuclear fuel. Such position does not satisfy neither Russia nor its neighbours, first of all because of high potential risks for population and environment, exerted by the moored submarines and the floating storage facilities with SNF. The RF President and Government have taken very important decisions aimed at acceleration of loading the spent fuel out of the floating units.

Below I shortly inform you about the urgent tasks set at the Russian industry, and principal technical solutions to be performed to terminate the practice of storing the dangerous radiation objects on water.

The decommission infrastructure consists of seven main elements (Structural Scheme No. 1):

(1) - Maintenance of nuclear submarines laid up on float (performed by the Navy and the shipyard);
(2) - Preparation of NS for discharge of SNF (Performed by Shipyard);
(3) - Discharge and temporary storage of SNF, treatment and storage of RW (performed by a naval technical base or a specialized civil industrial enterprise);
(4) - Packing of SNF into transport containers (performed by shipyard or specialized civil industrial enterprise);
(5) - Delivery of the containers to the plant for regenerating SNF (performed by the regeneration plant or the specialized civil industrial enterprise);
(6) - Decommission of NS including separation of three- or one-compartment units (performed by shipyard);

(7) - On-float storing of a three-compartment unit or dry storing of one-compartment unit (performed by the Navy or the specialized civil industrial enterprise).

The infrastructure established simultaneously with building of the first nuclear submarines was intended only for technical servicing of the war ships. Inadequacy of the infrastructure for massive decommission has resulted in that some decommissioned naval NS and storage facilities are laid up during 10-15 years or more, and the floating and coastal storage facilities for RW and SNF are filled up. Now the discharge of SNF is the narrowest bottle neck in the decommission process. The naval fleets have three floating storage facilities to discharge fuel from the laid-up submarines. Without an increase of the fuel discharge capacities, the decommission will take more than 30 years. In planning of decommission we proceed from a consideration that the discharge of floating facilities and NS should exceed the rates of their decommission. Such an approach admits to essentially reduce risks of large-scale radiation accidents. It is primarily true for floating storage facilities.

To implement the decommission plans, capacities of the individual elements could be enlarged by ordinary building them in more quantities. For this capacities of civil enterprises can be used. However, for other systems an essentially different approach shall be used. Special technical solutions are needed, aimed at discharging the floating facilities where damaged and accident fuels are stored for a long time. At present, such fuels can not be taken for regeneration.

The structural diagram shows that the Navy performs a large volume of technological operations for decommission. These functions are excessive and inappropriate to it and should be transferred to shipyards and specialized civil industrial enterprises. Such function transfer to civil specialist would essentially simplify the institutional structure and lower the decommission costs.

To discharge fuel, it is planned to create coastal complexes at larger shipyards on the North and the Pacific regions of Russia. These complexes will provide two- or three- times higher rates of discharge. Additionally, in the North region the Nuclear icebreaker fleet's floating storage facility is planned to use for discharge. The coastal complexes will be equipped with the accumulating pads for temporary storage of containers with spent fuel. The idle time of the rail transport delivering the fuel to "Mayak" will be more short. The coastal complexes are built with the US technical and financial support in the frame of Cooperative Threat Reduction (CTR), and we expect a considerable success in this direction.

To transport fuel to "Mayak" there are used stainless containers TK-18 that have proved their advantage (Fig.1). But the existing containers are insufficient to implement the whole decommission programme. At present, the development of double purpose metal-concrete containers for storage and transport (Fig. 2) is near to end. The development should be completed this year. In 1999 comprehensive tests on a specially built unique test facility and certification of the container should be fulfilled, and manufacture of containers would be launched at Izjora Plant in Saint-Petersburg. The metal-concrete container is 3-4 times cheaper than a metallic one. The containers are intended primarily to enlarge the existing stock of transport containers. Another object to resolve with the metal-concrete container will be a backing coastal container storage of damaged and other untreatable fuel that is still stored in the expired floating facilities. In further, when the rate of fuel discharge from submarines

exceeds "Mayak" processing capacity, the metal-concrete containers with fuel will be placed on the accumulating pads in the surface expedite storage facilities.

Increase of fuel unloading must be provided with adequate increase of opportunities of the fuel for reprocessing. In frameworks Russian-Norwegian cooperation in a near future the construction of 4 rail cars for transport containers with fuel is planned.

Owing to their low cost and possibility of being produced in quantities at the machine-building plants, the metal-concrete containers give an opportunity to increase the capacities for discharge, storage and transport of spent fuel at minimal coats and in the shortest times. The metal-concrete container programme is executed in line with the Arctic Environmental and Military Cooperation between Norway, Russia and USA, and the CTR stipulates to use the containers at the coastal discharge complexes.

A matter of topical interest is the creation of additional capacities for long-term storage of spent nuclear fuel. "Mayak" does not have such capacities, and its capability of regeneration at the peak stage of discharge is obviously inadequate. Two options are planned. The first one, as I said, considers the build-up of temporary container storage facilities on the North and the Pacific regions where metal-concrete containers would be used. The second option is a temporary storage facility at "Mayak". This dry storage facility had been designed by a consortium of enterprises of Norway, Sweden, United Kingdom and France. Russia is interested to complete a water storage facility. It is the element of the technological scheme of processing the SNF. The CTR programme and the Russia-Norway agreement suppose forwarding of the project in accordance with the Russian accepted technological scheme.

Russia has yet mastered decommission of the nuclear submarines by an intermediate variant. A three- or multicompartment unit is formed for further storing on float. The need is assumed to change for one-compartment variant and, at the same time, to finish the design of land facilities for long-term storage of reactor compartments. We agree that this task is a priority, and it is a focus of efforts of a few research and design entities of MINATOM. These land facilities are planned to be used for long-term storage of the proper floating storage compartments. The CTR programme provides for funds for this work. The one-compartment variant requires creation of a transport ship. The ship would perform delivery of reactor compartments from shipyards to the long-term storage facility. We are also planning to reconstruct a ship to have a container carrier for transportation of containers with fuel and RW between enterprises. Here we expect cooperation of Norway.

It should be separately said about the laid-up floating storage facilities. It is most complex to discharge SNF from the first generation ships. The damaged fuel is disposed without additional canisters at such storage. Russian designers and firms of France and United Kingdom have examined different options of discharge of such facilities, referring to "Lepse", a ship of the nuclear icebreaker fleet (Fig. 3). Specialists recommend to discharge such facilities by mechanical cutting of the facility's canals together with thermal fuel assemblies. Russian enterprises are now ending testing of the relevant equipment to be applied to discharge military floating facilities. We expect a successful implementation of an international project for decommission of the floating base "Lepse". The assurance of success is fed by an agreement signed in May between Norway and Russia and by an agreement with the European Community. Russia considers this project as a pilot one. In further it will be extended for similar naval ships.

In general, the problems of civil nuclear fleets repeat those of the Navy. Besides "Lepse", the icebreaker fleet has been using for a long time a floating facility "Lotta" for passive accumulation. The facility is completely filled up with untreatable fuel. We are planning to discharge the facility into metal-concrete containers of other modification and to site them on shore, a nd to use the ship for active loading out of the floating and coastal storage facilities.

At the beginning of this report I have said that technical decommission initiatives are accompanied by a structural change. At present Minatom that is charged with not only leading functions in the spent nuclear fuel and radioactive waste management, but also to direct decommission, is establishing an appropriate management system On the base of leading enterprises of Minatom, a concern RosRAO is created to be properly a specialized civil industrial enterprise which will perform all the functions of decommissioning of the nuclear objects, and of managing the dangerous man-made waste. On the base of former naval technical bases for management of SNF and RW, civil enterprises are being established to deal with the spent nuclear fuel, radioactive waste and reactor compartments produced from decommission of nuclear submarines. Such enterprises will appear in the North and the Pacific regions.

For financial support of the newly established enterprises, an accumulating Interregional Ecological Fund "Radioactive waste and decommission of weapons" is created, having regional divisions. The specialization of the fund will be consolidation of the amounts recycling the valuable components of decommissioned nuclear objects, decommission of nuclear weapons. deductions from enterprises using nuclear technologies, deductions from nuclear assurance, etc.

Scheme 1.

	Technological stage	Current performer	Planned performer
1.	Maintenance of nuclear submarines laid up on float	Navy	Shipyard
2.	Preparation of nuclear submarines for discharge of spent nuclear fuel	Shipyard	Shipyard
3.	Discharge and temporary storage of spent nuclear fuel, treatment and storage of radioactive waste	Naval floating technical base	Specialized civil industrial enterprise
4.	Packing of spent nuclear fuel into transport containers	Shipyard	Specialized civil industrial enterprise
5.	Delivery of the containers to the plant for regenerating spent nuclear fuel	Regeneration plant	Specialized civil industrial enterprise
6.	Decommission of nuclear submarines including separation of three- or one-compartment units	Shipyard	Shipyard
7.	On-float storing of a three-compartment unit or dry storing of a one-compartment unit	Navy	Specialized civil industrial enterprise