The Shipment of Russian-Origin Highly Enriched Uranium Spent and Fresh Nuclear Fuel from Belarus and Delivery of Fresh Low Enriched Nuclear Fuel to Belarus

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1. Introduction

In 2010 under the Global Threat Reduction Initiative, the Joint Institute for Power and Nuclear Research – “Sosny” (JIPNR-Sosny) of the National Academy of Sciences of Belarus repatriated highly enriched uranium (HEU) fresh and spent nuclear fuels to the Russian Federation. The fresh and the spent nuclear fuels were from the decommissioned Pamir-630D mobile reactor and IRT-M research reactor. These fuel shipments marked the complete removal of all HEU spent nuclear fuel from Belarus. The HEU fresh nuclear fuel of Pamir-630D mobile reactor has been replaced with new low enriched uranium (LEU) fresh nuclear fuel for “Giacint” critical facility.

2. HEU Spent and Fresh Nuclear Fuel of Pamir-630D reactor

The Pamir-630D mobile NPP had 630 kW electrical output power. The reactor consisted of five basic modules: the reactor; turbine generator set; two modules of control and protection systems; and auxiliary module. All the modules were installed on semi-trailers that could be transported by trucks.

The coolant of reactor was nitrogen dioxide (N₂O + O₂ ↔ 2NO + O). The Pamir-630D reactor core included 106 fuel assemblies. Each fuel assembly included seven fuel rods. The fuel was UO₂ spherical particles enriched to 45% ²³⁵U in a nickel/chromium matrix (UO₂-Ni-Cr). Volume content of UO₂ in the fuel core is near 60%.

3. Shipment of Spent and Fresh Nuclear Fuel

Planning, preparations, coordination of the HEU repatriation and of the LEU delivery include facility preparations, safety arrangements, casks management and train/plane shipping/delivery logistics. Safety arrangements considered the radiation exposure and the steps for unloading and loading the fuels. Calculations and analyses have been performed to validate the developed procedure for transporting the fuels and the amount loaded per cask/train and plane.

SCODA VPVR/M casks have been selected for transportation of spent HEU nuclear fuel. This casks with spent fuel was transported from the JIPNR - Sosny to the railway station by trucks and further to Russian Federation by railway.

TK-S16 containers have been selected for transportation of the fresh HEU nuclear fuel and fresh LEU nuclear fuel. This fresh nuclear fuel has been transported by air.

At first TK-S16 containers with fresh HEU nuclear fuel have been transported from the JIPNR - Sosny to the (Belarus) airport by truck. Simultaneously TK-S16 containers with fresh HEU nuclear fuel have arrived from Russian Federation to the airport. At the airport TK-S16 containers with fresh LEU fuel have exchanged for TK-S16 containers with fresh HEU fuel. Then TK-S16 containers with fresh LEU nuclear fuel have been transported by truck from the airport to the JIPNR - Sosny, and TK-S16 containers with fresh HEU nuclear fuel have been transported by air from the airport to the Russian Federation.

4. LEU Fresh Nuclear Fuel for “Giacint” Critical Facility

Critical facility “Giacint” of the JIPNR-Sosny of NAS Belarus is destined for basic research on the physics and safety of neutron-multiplying systems and applied research in a substantiation of development of new generation of different nuclear energy sources. It provides the experimental base for the development of fundamental and applied nuclear power engineering, including research in a substantiation of development of new generation of reactor facilities of different destination.

The LEU fuel replacement will be created for research purposes at the critical facility “Giacint” on development of perspective cores for research and power nuclear reactors. This fuel has been developed by FSUE “BRI SIA ‘LUCH” and JIPNR-Sosny. The LEU fuel consists of uranium-zirconium carbon nitride U₃ZrₓCᵧNₓ with 19.75% enrichment by U-235. Density of a fuel composition is not less than 12 g/sm³, porosity less than 12%, density of uranium - more than 10.5 g/sm³, diameter of a pellet – 10.7 mm. Length of the fuel core - 500 mm, diameter of the fuel rod 12 mm, length of the fuel rod - 620 mm. Thickness of clad is 0.6 mm. The fuel rod clad material is stainless steel or niobium. This fuel will be used for developing new reactor configurations cooled by gas or water at low power. In particular, this nuclear fuel can be used at conversion HEU on liquid and solid hydrogenous moderator.

5. Conclusions

The shipment of highly enriched uranium nuclear fuel from the Joint Institute for Power and Nuclear Research – “Sosny” marked the end of a successful project that removed all of the spent HEU from Belarus. LEU fresh fuel was design and produced for “Giacint” critical facility under Belarus-Russian-American cooperation on nuclear fuel research reactor conversion programs. Exchange of HEU/LEU nuclear fuel was realized with uranium-235 equivalent amount in frame of international project. This project was an excellent example of international cooperation between the various organizations of Belarus, Russian Federation, United States of America and the IAEA.