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Support of ÚJV Řež, a. s. for Shipments of Spent Nuclear Fuel within the M^3 program

J. Podlaha and K. Svoboda
ÚJV Řež, a. s., Hlavní 130, Husinec-Řež, 25068, Czechia

ABSTRACT

In 2005, ÚJV Řež, a. s. (ÚJV), Czechia joined the Russian Research Reactor Fuel Return (RRRFR) program under the US-Russian Global Threat Reduction Initiative (GTRI) and started the process of spent nuclear fuel (SNF) shipment from the LVR-15 research reactor to Russia using the high capacity ŠKODA VPVR/M casks. Two SNF shipments from ÚJV were carried out in 2007 and 2013. The LVR-15 converted to the use of IRT-4M LEU fuel in 2010.
ÚJV also participates in shipments of SNF from other countries providing the ŠKODA casks, training of personnel in cask use and technical oversight and expertise during the cask handling. Seventeen shipments from twelve countries using a total of 110 ŠKODA casks have already been completed without any incident or accident and more than 3500 fuel assemblies or cores have been shipped to Russia and China.

1 Introduction

ÚJV Řež, a. s. (formerly Ústav jaderného výzkumu Řež a.s., Nuclear Research Institute Řež) is a leading institution in all areas of nuclear R&D in Czechia. ÚJV has had a dominant position in the nuclear field since it was established in 1955. The main issues addressed in past decades have included research, development and services for nuclear power plants operating VVER reactors, development of chemical technologies for the fuel cycle, and irradiation services for research and development in the industrial sector, agriculture, food processing and medicine.

ÚJV`s daughter company, Research Centre Řež, operates the LVR-15 research reactor, which has been in operation since 1957. After more than 50 years of operation of this reactor, a large amount of SNF of Russian origin has been accumulated.

In 2005, ÚJV joined the RRRFR program under the US-Russian GTRI initiative (now Material Management and Minimization program, M^3). With significant technical and financial aid from the US administration and US DOE (total of approximately 31 mil. USD), Czechia became a pilot country, carrying out the first shipment from ÚJV to the Russian Federation (RF) by means of

specially developed casks, which are compatible with the technology of research reactors of Russian design as well as the technology of the reprocessing plant in the RF. The Ministry of Finance of the Czech Republic paid approx. 15 mil. USD, within the framework of eliminating ÚJV`s old environmental liabilities.

The VVR-S research reactor began operations in 1957. The original EK-10 fuel assembly (FA) was made up of 16 rods of a 10 % enriched uranium dioxide-magnesium alloy in aluminum cladding. The reactor was operated at 2 MWth maximum output until 1969, when the power was increased to 4 MWth. In 1974, IRT-2M fuel with 80 % enrichment was introduced. This consisted of 3 or 4 concentric square tubes of uranium/aluminum alloy fuel/metal clad on either side with aluminum. The power output of the reactor was increased to 10 MWth. In the years 1988 – 1989 the reactor was completely reconstructed into the LVR-15 reactor (see Fig. 1), with maximum output of 10 MWth. In 1996, IRT-2M fuel with 36 % enrichment using uranium dioxide was introduced. As a result of the Reduced Enrichment for Research and Test Reactors (RERTR) Program, the LEU IRT-4M fuel with enrichment below 20% has been used since 2010 [1].

Fig. 1. LVR-15 research reactor

2 ŠKODA VPVR/M Transport Packaging System (TPS)

The ŠKODA VPVR/M TPS is a type B(U) and S cask system designed and licensed for the transport and storage of SNF from research reactors of Russian origin. The unique design of the cask (see Fig. 2) allows for easy use at almost any research reactor facility. The cask is closed by means of a system of two upper and two lower lids. The cask is loaded from the bottom, being placed above the SNF storage pool. It eliminates the need for a transfer cask, thereby reducing the number of manipulations and increasing the level of nuclear safety and radiation protection.

A specially designed basket handling tool suspended from a crane is connected to the central suspension of the basket and is used for lowering the basket from the cask into the storage pool. The basket is filled manually with FA by a special manipulation rod. The crane and the basket handling tool are equipped with a digital dynamometer that is used to monitor the weight of the basket during reinstallation into the cask. It prevents the disruption of the central suspension.

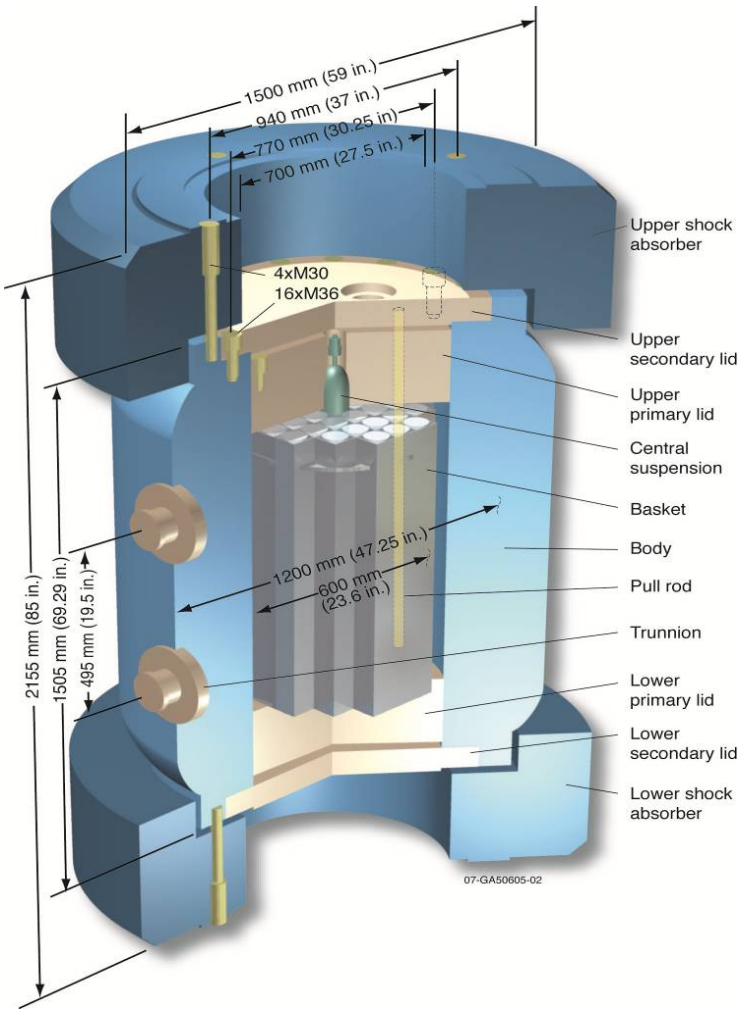

Fig. 2. Diagram of the ŠKODA VPVR/M cask

The cask has a capacity of 36 FA, and 16 casks are now available. This means that 576 FA can be transported in one shipment. Detailed design information of the cask is provided in [2].

The TPS consists of:

- ŠKODA VPVR/M casks
- Special ISO containers for cask shipment
- Auxiliary equipment sets for cask handling
- Drying and He-leak testing equipment sets for cask testing after loading
- Service ISO containers for shipment of auxiliary equipment

The ŠKODA VPVR/M cask loading procedure is divided into the following activities:

- Cask transport to the SNF loading site and its dismounting
- Transport of the cask to the SNF storage facility (pool, hot cell)
- Putting the basket inside the loading facility (pool, hot cell)
- Loading the SNF into the basket, basket retraction into the cask
- Cask flushing with hot air, desiccation of the cask, cask completion, helium leak test
- Cask sealing with IAEA and EURATOM seals

Photographs of the loading procedure are provided in Fig. 3 - 5.

Fig. 3. Cask prepared for loading onto the storage pool

Fig. 4. Loading SNF in the basket in the pool

Fig. 5. Cask drying, helium leak test

Special equipment for the loading of SNF at a facility which does not allow for the disposition of the cask on the storage pool was designed and developed by the SOSNY company (RF) and financed by the US DOE. It consists of transfer casks, serving for the transfer of single FA from a storage pool to the ŠKODA VPVR/M casks, and auxiliary equipment. The FA is then reloaded from the transfer cask into the ŠKODA VPVR/M cask. In Fig. 6, the scheme for reloading FA from the transfer cask to the ŠKODA VPVR/M cask is provided. More information about the special equipment is provided in [2]. The equipment was used for the first time for loading SNF at the Dalat research reactor, Vietnam (see Fig. 7).

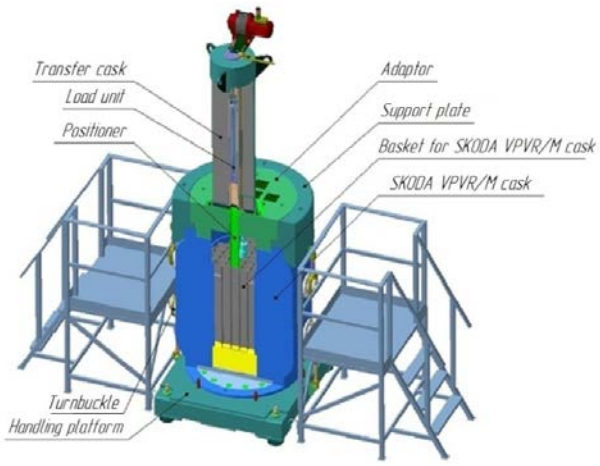

Fig. 6. Scheme of reloading FA from the transfer cask

Fig. 7. Reloading of FA from the transfer cask, Vietnam

The ŠKODA VPVR/M TPS can be used for not only road, railway, river and marine transport but, with the energy absorption container (EAC) which forms the TUK-145/C Type C package, also air transport. The TUK-145/C Type C package was designed and developed by the SOSNY company (RF) and financed by the US DOE.

The Type C package is designed for transportation of radioactive material without any restrictions on activity through different transport modes. It is a vertical cylinder made of two titanium halves with a flange joint and filled with hollow titanium spheres (see Fig. 8). The package is described in detail in [3]. In Fig. 9, a photograph of the forming of the Type C package is provided.

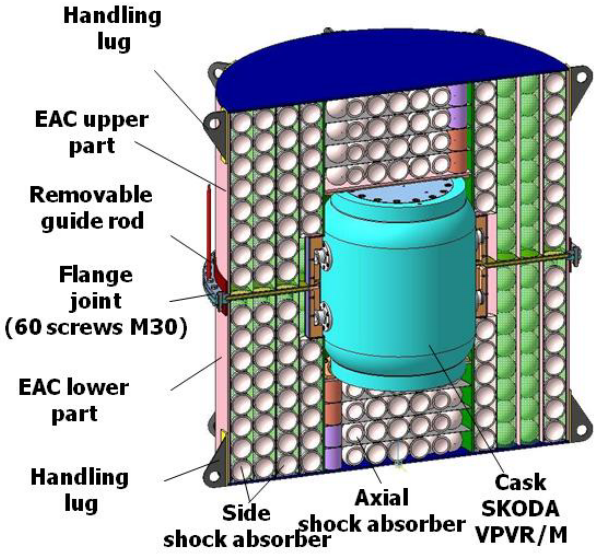

Fig. 8. TUK-145 / C Type C transport package

Fig. 9. Forming the TUK-145 / C transport package (Vietnam)

3 Shipment of SNF from Czechia to Russia

The first SNF shipment was carried out in December 2007 under several specific conditions:

1. It was the first time high capacity ŠKODA VPVR/M casks were used, which allowed for the transport of both HEU and LEU SNF (568 FA in 16 casks) in one shipment, resulting in a substantially reduced risk.
2. It was the first time that HEU SNF from a research reactor had been sent to the RF from a European Union country.
3. The combined road and railway transport of the dangerous material (Czechia – Slovakia – Ukraine – RF) took place using several reloadings of goods.

A second shipment of the residue of HEU SNF (112 FA in 6 casks) was carried out in 2013. Combined road, railway and marine transport (Czechia – Poland – RF) was used. The shipments are described in detail in [4, 5]. Photographs from the shipments are provided in Fig. 10 - 15.

Fig. 10. Cask inside the ISO container prepared for shipment

Fig. 11. Truck with ISO container ready for transportation

Fig. 12. Railway shipment of SNF

Fig. 13. Reloading of the ISO container in port

Fig. 14. Marine transportation

Fig. 15. Reloading of SNF in Murmansk (RF)

4 ÚJV's Participation in Shipments of SNF from Other Countries

As a result of the successful performance of the first Czech shipment, ÚJV is also participating in shipments from other countries (see Table I). The services of ÚJV comprise: ŠKODA VPVR/M TPS leasing, maintenance and transportation, training of personnel in TPS use and SNF loading, technical oversight and expertise during cask handling, SNF loading and cask closing and sealing, drying and helium leak testing of casks, and return transportation of the empty TPS. A detailed description of the participation of ÚJV is provided in [2, 5].

Table I. Performed SNF shipments

Country (Facility)	Shipment date	No. of casks	No. of FA	Route
Czechia 1 (LVR-15)	12/2007	16	568	Road, rail
Bulgaria (IRT-2000)	07/2008	3	108	Road, rail, river
Hungary 1 (BRR)	08/2008	16	576	Road, rail, sea
Poland 1 (EWA)	09/2009	16	864	Road, rail, sea
Poland 2 (EWA)	02/2010	8		
Ukraine 1 (VVR-M)	05/2010	7	252	Road, rail
Belarus (PAMIR-630D, IRT-M)	08/2010	4	144	Road, rail
Serbia (RA)	11/2010	16	576	Road, rail, sea
Ukraine 2 (VVR-M)	03/2012	4	98	Road, rail
Poland 6 (EWA)	08/2012	3	90	Road, rail, sea
Czechia 2 (LVR-15)	03/2013	6	112	Road, rail, sea
Vietnam (DNRR)	07/2013	1	36	Road, air, rail
Hungary 2 (BRR)	11/2013	6	144	Road, air, rail
Uzbekistan (Foton)	09/2015	1	16 (liquid fuel)	Road, air, rail
Georgia (Breeder-1)	12/2015	1	1 (active core)	Road, air
Ghana (GHARR-1)	09/2017	1	1 (active core)	Road, air
Nigeria (NIRR-1)	10/2018	1	1 (active core)	Road, air
Total		**110**	**3587**	

Photographs from selected shipments are provided in Fig. 16 - 21.

Fig. 16. Loading of SNF in Poland

Fig. 17. Loading of SNF in Belarus

Fig. 18. Casks ready for loading in Serbia

Fig. 19. TUK-145/C Type C packages inside the airplane (Hungary)

Fig. 20. Loading of fuel (liquid fuel in canisters) in Uzbekistan

Fig. 21. Mounting of TUK-145/C package

5 Shipment of Irradiated MNSR Cores to China

The experience and results gained are applied to the repatriation of irradiated HEU cores from Chinese Miniature Neutron Source Reactors (MNSR), see Fig. 22.

In 2016, the new ŠKODA MNSR casks were developed on the base of the ŠKODA VPVR/M casks in Czechia and currently are being employed in the shipments of HEU MNSR cores to China. The TUK-145/C-MNSR cask system developed in Russia is used for air transportation. The shipments from Ghana and Nigeria were carried out in 2016 and 2018. Shipments from Pakistan, Iran and Syria are planned.

Special equipment for the loading of HEU cores was designed and developed by the SOSNY company (RF) and financed by the US DOE. It consists of a transfer cask, serving for the transfer of the irradiated core from the MNSR reactors to the ŠKODA MNSR cask, and auxiliary equipment. The core is then reloaded from the transfer cask into the ŠKODA VPVR/M cask (see Fig 23).

Fig. 22. GHAR-1 MNSR reactor in Ghana

Fig. 23. ŠKODA MNSR cask with transfer cask

6 Conclusions

All SNF produced after more than 50 years of operation of the LVR-15 (or VVR-S) research reactor has already been shipped to the RF within the framework of the GTRI initiative.

ÚJV is also participating in shipments of SNF from other countries. The ŠKODA VPVR/M casks were used for SNF shipment from nine other countries to the RF for reprocessing within the framework of the GTRI project. The ŠKODA MNSR cask is used for shipment of irradiated MNSR core to China

Seventeen shipments of more than 3500 fuel assemblies or cores from twelve countries using a total of 110 ŠKODA casks have already been completed without any incident.

7 Acknowledgments

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- Ghana (NNRI, GAEC, NRA)
- China (CIAE, CNEIC, C-NNSA, Everclean)
- Nigeria (CERT, NNRA)
- Czechia (ÚJV Řež, a. s., ŠKODA JS, DMS)
- Research reactor operators
- State administrations and regulators in the respective or transit countries

8 References

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