

ŠKODA VPVR/M TRANSPORT PACKAGING SYSTEM AND ITS USE FOR TRANSPORT OF SPENT FUEL FROM RESEARCH REACTORS

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ABSTRACT

The ŠKODA VPVR/M transport packaging system (TPS), owned and operated by ÚJV Řež, a. s., Czech Republic, is widely used in the Russian Research Reactor Fuel Return (RRRFR) program.

The TPS consists of the ŠKODA VPVR/M cask, transport ISO containers and auxiliary equipment. The ŠKODA VPVR/M cask is a type B(U) and S cask designed and licensed for the transport and storage of spent nuclear fuel (SNF) from research reactors. The cask is compatible with the technology of research reactors of Russian design as well as the technology of the reprocessing plant in the Russian Federation (RF).

The unique design of the cask allows for easy use at almost any research reactor facility. Since 2007, ŠKODA VPVR/M TPS has been used for shipment of SNF within the framework of the Global Threat Reduction Initiative (GTRI) from research reactors from the following countries: Czech Republic, Bulgaria, Hungary, Poland, Ukraine, Belarus, Serbia and Vietnam; and more than 3,400 fuel assemblies were shipped to the RF for reprocessing using a total of 100 casks.

The ŠKODA VPVR/M TPS can be used not only for road, railway, river and marine transport but, with the energy absorption container which forms the TUK-145/C Type C package, also for air transport. The TUK-145/C Type C package was designed and developed by the SOSNY company (RF) and was used for the first time for shipment of SNF from Vietnam to the RF in 2013.

The experience proved that ŠKODA VPVR/M TPS is an excellent and very sophisticated system for SNF transport. It is expected that the experience and results gained will be applied to the preparation and completion of SNF repatriation from Chinese Miniature Neutron Source Reactors (MNSR) in the near future.

INTRODUCTION

ÚJV Řež, a. s.

The ÚJV Řež, a. s. (formerly Ústav jaderného výzkumu Řež a.s., Nuclear Research Institute Řež, NRI) is a leading institution in all areas of nuclear R&D in the Czech Republic. The ÚJV has had a dominant position in the nuclear field since it was established in 1955 as a state-owned research organization, and has subsequently developed to its current status.

The activities of ÚJV encompass nuclear physics, chemistry, nuclear power and many other topics. The main issues addressed at ÚJV 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, Centre of Research 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.

Joining the Global Threat Reduction Initiative (GTRI)

The Czech Republic was included in the GTRI program in 2004. In 2005, a contract between the US Department of Energy (US DOE) and ÚJV was signed. With significant technical and financial aid from the US administration and US DOE (total of approximately 27 mil. USD), the Czech Republic became a pilot country, carrying out this shipment from ÚJV to the 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.

A tender for the shipment casks took place under the auspices of the IAEA. High capacity ŠKODA VPVR/M Casks, made by ŠKODA JS a. s., were chosen. Six casks, suitable for shipment of low enriched (LEU) SNF, were purchased by ÚJV. Ten casks, suitable for shipment of high enriched (HEU) SNF, were purchased by the US administration (approximately USD 4 mil.) as a gift to ÚJV, provided that ÚJV make these as well as its own casks available for the RRRFR program. Once the shipment of SNF from ÚJV has been carried out, all 16 casks are to be further used for return shipments of SNF from other countries to the RF, by an agreement between ÚJV and the US DOE, taking into account ÚJV's experience preparing and implementing the transport from the Czech Republic to the RF.

ŠKODA VPVR/M TRANSPORT PACKAGING SYSTEM

The ŠKODA VPVR/M cask (see Fig. 1) 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.

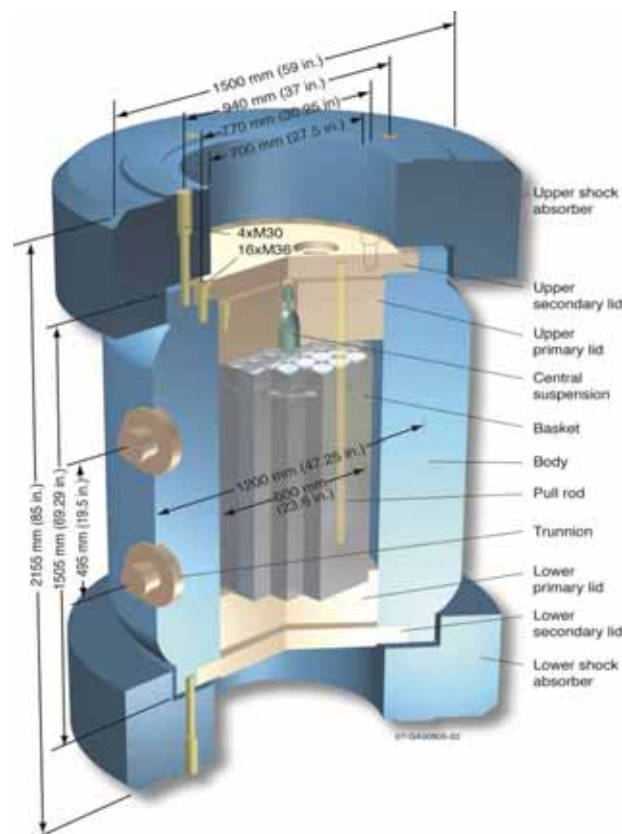


Figure 1. Scheme of the ŠKODAVPVR/M cask

The unique design of the cask 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. The cask has a capacity of 36 fuel assemblies, and 16 casks are now available. This means that 576 fuel assemblies can be transported in one shipment.

The TPS consists of (see Figures No. 2 - 6):

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



Figure 2. ŠKODA VPVR/M cask and cask basket



Figure 3. Special ISO containers, with the cask inside



Figure 4. Auxiliary equipment sets for cask handling, in action



Figure 5. Service ISO container with auxiliary equipment



Figure 6. Drying and He-leak testing equipment sets

The list of available parts of the TPS is provided in the Table 1.

Table 1. List of TPS equipment

Description	Total Number
ŠKODA VPVR/M casks	16
Cask baskets	17
Special ISO containers for cask shipment	12
Auxiliary equipment sets for cask handling	3
Service ISO containers for shipment of auxiliary equipment	2
Drying and He-leak testing equipment sets	3+2
Service ISO containers for drying and He-leak testing equipment	2

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

- Cask transport to the SNF loading site, dismantling the cask
- 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

A specially designed basket handling tool is used for lowering the basket from the cask into the storage pool. The basket is filled manually with the FAs by a special manipulation rod. The crane and lift fixtures are equipped with a digital dynamometer that is used to monitor the weight of the basket during reinstallation into the cask. This prevents the disruption of the central suspension/hanger. Photographs from the loading procedure are provided in Figures 7 - 9.



Figure 7. ŠKODA VPVR/M cask prepared for loading onto the storage pool



Figure 8. Loading SNF inside the pool into the basket



Figure 9. 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 a transfer cask, serving for the transfer of single FA from a storage pool to the ŠKODA VPVR/M casks, and auxiliary equipment. In Figure 10, the scheme of reloading FA from the transfer cask to the ŠKODA VPVR/M cask is provided.

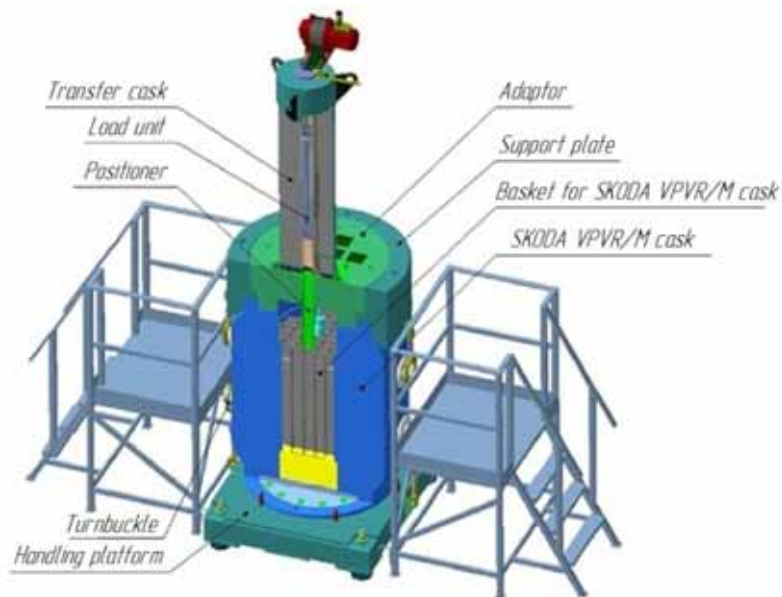


Figure 10. Scheme of reloading FA from the transfer cask

The ŠKODA VPVR/M (TPS) can now be used at any research reactor facility. The equipment was used for the first time for loading SNF at the Dalat research reactor in Vietnam (see Figure 11).



Figure 11. Reloading of FA from the transfer cask, Vietnam

TUK-145/C TYPE C PACKAGE

The ŠKODA VPVR/M TPS can be used not only for road, railway, river and marine transport but, with the energy absorption container (EAC) which forms the TUK-145/C Type C package, also for 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, including aircraft. It is a vertical cylinder made of two halves with a flange joint and filled with hollow titanium spheres (see Figure 12).

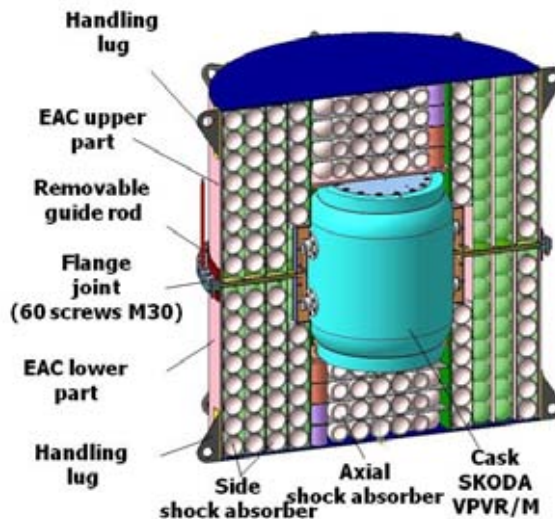


Figure 12. TUK-145 / C Type C transport package

The cask was used for the first time for shipment of SNF from Vietnam (see Figure 13), and will next be used for shipment of SNF from Hungary to the RF.



Figure 13. Forming the TUK-145 / C transport package (Vietnam)

SHIPMENT OF SNF FROM THE CZECH REPUBLIC TO RUSSIA

The first SNF shipment in December 2007 was carried out 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 high- and low-enriched SNF (576 fuel assemblies in 16 casks) in one shipment, resulting in a substantially reduced risk.
2. It was the first time that high-enriched uranium SNF from a research reactor had been sent to the RF from a European Union country under the appropriate intergovernmental agreements, legal regulations and conditions.
3. The combined road and railway transport of the dangerous material (Czech Republic – Slovakia – Ukraine – Russian Federation) took place using several reloadings of goods.

The second shipment of the residue of high-enriched SNF from ÚJV (112 fuel assemblies in 6 casks) was carried out in 2013. Combined road, railway and marine transport (Czech Republic – Poland – Russian Federation) was used. Photographs from the shipments are provided in Figures 14 - 19.



Figure 14. Cask inside the ISO container prepared for shipment



Figure 15. Truck with ISO container ready for transportation



Figure 16. Railway shipment of SNF



Figure 17. Reloading of the ISO container in port



Figure 18. Marine transportation



Figure 19. Reloading of spent fuel in Murmansk (RF)

After the shipment was completed, only low-enriched nuclear fuel remained on the territory of the Czech Republic for LVR-15 research reactor operation. It contained a maximum of 20% U-235, which is the conventionally recognized limit between low- and high-enriched nuclear materials.

ÚJV'S PARTICIPATION IN SHIPMENTS OF SNF FROM OTHER COUNTRIES

As a result of the successful performance of the first shipment from the Czech Republic, ÚJV is also participating in shipments of SNF from other countries. The services of ÚJV comprise: ŠKODA VPVR/M TPS leasing, providing service and maintenance inspections of the TPS, transportation of the TPS, providing TPS documentation, training of personnel in TPS use and SNF loading, technical oversight and expertise during cask handling, fuel loading and cask closing and sealing, drying and helium leak testing of casks, and return transportation of the empty casks and auxiliary equipment to ÚJV. A review of the performed shipments, including shipments from the Czech Republic, is shown in Table 2.

Table 2. Shipments of SNF under the RRRFR program performed by ÚJV

Country (Facility)	Shipment date	No. of casks used	SNF Data	No. of shipped FA (basket cells)	Transport Route
Czech Republic 1 (LVR-15)	Dec 2007	16	HEU: IRT-2M LEU: EK-10	576	Road, rail
Bulgaria (IRT-2000)	Jul 2008	3	HEU: S-36 LEU: EK-10	108	Road, rail, river
Hungary 1 (BRR)	Oct 2008	16	HEU: VVR-M, VVR-M2 LEU: EK-10	576	Road, rail, sea
Poland 1 (EWA)	Sept 2009	16	HEU: VVR-M2	864	Road, rail, sea
Poland 2 (EWA)	Feb 2010	8	HEU: VVR-M2		Road, rail
Ukraine 1 (VVR-M)	May 2010	7	HEU: VVR-M2	252	Road, rail
Belarus (PAMIR-630D, IRT-M)	Oct 2010	4	HEU	144	Road, rail, sea
Serbia (RA)	Nov 2010	16	HEU: TVR-S LEU: TVR-S	576	Road, rail, sea
Ukraine 2 (VVR-M)	Mar 2012	4	HEU: VVR-M2	98	Road, rail
Poland 6 (EWA)	Oct 2012	3	LEU: EK-10	90	Road, rail, sea
Czech Republic 2 (LVR-15)	Mar 2013	6	HEU: IRT-2M	112	Road, rail, sea
Vietnam (DNRR)	Jul 2013	1	HEU: VVR-M2	36	Road, air, rail

Photographs from the shipments are provided in Figures 20 - 24.



Figure 20. Loading of SNF in Hungary



Figure 21. Loading of SNF in Ukraine



Figure 22. Loading of SNF in Poland



Figure 23. Loading of SNF in Belarus



Figure 24. Casks ready for loading of SNF in Serbia

A second shipment of HEU from Hungary is planned in 2013. Six casks will be used for a combined road, air and railway transport. The shipment of SNF from Uzbekistan is planned in 2014. One cask will be used for shipment of liquid SNF in special canisters.

It is expected that the experience and results gained will be applied to the preparation and completion of SNF repatriation from Chinese Miniature Neutron Source Reactors (MNSR) in the near future. The SNF is planned to be shipped from Ghana, Nigeria, Pakistan, Iran and Syria to China. ÚJV will be responsible for project management and service activities. New cask internals will be developed and manufactured by CIAE (China Institute of Atomic Energy) and ŠKODA JS (Czech Republic).

ŠKODA VPVR/M TPS INSPECTION AND MAINTENANCE

A comprehensive document control system was developed and is being applied to ensure a high level of safety and functionality for the ŠKODA VPVR/M TPS. This system maintains the quality documents for the fabrication, use, inspection, maintenance and repair of each of the casks, as well as other quality records. The system also controls the issuance of all the cask and auxiliary equipment documents, such as operational and maintenance manuals, safety analyses, checklists, instructions, procedures and drawings, including changes affecting

quality. It ensures that documents, including changes, are reviewed for adequacy, approved for release by authorized personnel, and distributed and used at the location where the prescribed activity is performed. The system also maintains sufficient written records to describe the activities which affect quality.

The document control system is linked with the Quality Assurance System of ÚJV, an integrated management system combining several management systems:

- Quality management system EN ISO 9001:2000;
- Environmental management system EN ISO 14001:2004;
- Management system for employee safety and health protection BS OHSAS 18001:2007.

After each use of the ŠKODA VPVR/M transport packaging system, a system receipt inspection must be done. Its result is documented and reported to the regulatory body. The inspection is performed by ÚJV and TPS producers. The inspection includes:

- Disassembly of equipment, a radiation contamination survey and decontamination
- Inspection for non-conformances and repairs (visual inspection, use of volume gauges, capillary tests)
- Cleaning, checking of parts, change of worn-out parts and service media
- Assembly and testing

In addition, after five years of use, a five-year preventive maintenance has to be performed. As the system has been in use since 2007, preventive maintenance was done in 2012. The five-year maintenance included not only standard inspections, but also an extended inspection involving total disassembly of each cask and change-out of all bolts in the lids, trunnions, test ports, etc. In addition, an extended inspection of the ISO containers and auxiliary equipment has already been performed. The lessons learned from the five-year maintenance proved that the ŠKODA VPVR/M transport packaging system is one that has been designed and manufactured well.



Figure 25. TPS during inspection

CONCLUSIONS

The ŠKODA VPVR/M transport packaging system is a system designed and licensed for the transport and storage of SNF from research reactors. The unique design of the cask allows for easy use at almost any research reactor facility.

The ŠKODA VPVR/M TPS was used for shipment of spent fuel from the Czech Republic and eight other countries to the Russian Federation for reprocessing within the framework of the

GTRI project. Twelve shipments using a total of 100 casks have already been completed without any incident or accident. Two other shipments will be carried out. A project for repatriation of SNF from Chinese Miniature Neutron Source Reactors (MNSR) is currently being prepared.

Practical experience has proven that the ŠKODA VPVR/M TPS is an excellent and very sophisticated system for SNF transportation. On the basis of the experience gained, the system has been improved to enhance its safety and efficiency of use. Combining it with the energy absorption container which forms the TUK-145/C Type C package significantly increases the potential uses of the system, because the Type C package is designed for transportation of radioactive material without any restrictions on activity from different modes of transport, including aircraft.

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- EUROATOM
- Russian Federation (Rosatom, FCNRS, MAYAK, R&D Sosny company)
- Ukraine (Izotop)
- Czech Republic (ÚJV Řež, a. s., ŠKODA JS, DMS)
- Research reactor operators
- State administrations, regulators in respective or transit countries

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