SHIPMENT OF VINČA INSTITUTE'S HEU FRESH FUEL TO RUSSIA

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ABSTRACT

This paper shows, for the first time, the basic data related to the recent shipment of the fresh HEU fuel elements from Yugoslavia back to Russia for uranium down blending. In this way, Yugoslavia gives its contribution to the RERTR program and to the world's joint efforts to prevent possible terrorist action against nuclear material potentially usable for production of nuclear weapon

1. INTRODUCTION

After negotiations with government and non-government organisations from USA, and with Minatom and responsible expert organisations from the Russian Federation, that took part during spring and summer of 2002, Yugoslav government had made the agreement for returning of all unused HEU fuel elements back to the country of origin - Russian Federation. Appropriate decisions on final shutdown and decommissioning of the RA research reactor and the HEU fresh fuel shipment, were made by the governments of Republic of Serbia and the Federal Republics of Yugoslavia during the last two weeks of July 2002. Preparations for the shipment of more than 5000 HEU fuel elements were done in the "Vinča" Institute of nuclear sciences, Belgrade, Yugoslavia and in the Branch Federal State Institute "Safe Transportation of Nuclear Materials" (STNM Institute), Dimitrovgrad, Russian Federation. Safeguards department of the International Atomic Energy Agency, Vienna (IAEA), Austria and non-proliferation specialists from the Oak Ridge National Laboratory, USA, took part during the preparation and transport of the HEU fuel elements, as well. The shipment was realised during mid-August under highest physical protection available in the Vinča Institute and, especially, during the transport of the fuel from the Vinča Institute to the Belgrade airport.

2. FUEL DESCRIPTION

All the fresh HEU fuel elements at the Vinča Institute were bought in ex-USSR during 1976-1985. These elements have been used for the operation of 6.5 MW heavy water research reactor RA [1] and for experiments at the RB heavy water critical assembly [2]. The same fuel elements were also used at the TVR heavy water research reactor [3], operated by the Institute for Theoretical and Experimental Physics (ITEP) in Moscow, in the period from 1964 to 1986

(when the reactor was shut down permanently). The TVR reactor was, in fact, the genetic one for the other two similar reactors built in Beijing (People Republic of China) and in the Vinča near Belgrade (Federal Republic of Yugoslavia) by end of fifties. The reactor in Beijing has been put in the operation in 1958, and after modernization, it is still operational. The reactor in the Vinča reached the first criticality in December 1959.

The HEU fuel elements, known as the TVR-S type of fuel element ("slug") [4], were produced in the Novosibirsk Chemical Concentrates Plant (NCCP). The TVR-S fuel element is 11.30 cm long cylinder with 3.72 cm outer diameter (Figure 1). The fuel layer of the TVR-S HEU element contains 80 % enriched uranium in form of UO_2 dispersed in Al matrix and has length 100 mm and inner/outer diameter of 31/35 mm. Mass of ^{235}U nuclide in TVR-S fuel element is 7.7 g ± 0.3 g. The fuel layer is covered by 1 mm thick aluminium cladding. Inner tube, made of aluminium (known as the "expeller" or "ejector") within the slug serves to adjust the coolant flow rate. Top and bottom of the slug are covered by the 3 mm thick (aluminium) "stars" with sprockets, so that the total length of the slug is 11.30 cm. The aluminium, used in the construction of the TVR-S slugs, is known as the SAV-1 alloy (0.985 weight fraction of aluminium with very low contents of neutron high-absorbing impurities, e.g., boron and cadmium). Average mass of the TVR-S slug is 162 g. Detailed material composition of the TVR-S HEU fuel element is given in [5].

During the operation of the RA reactor, about 1400 HEU slugs were spent by the end of 1984. The total amount of the fresh HEU fuel elements at the RB and RA reactors at Vinča Institute was 5046. The fresh and spent nuclear fuel elements at the Vinča Institute are under regular safeguards control of the IAEA. The HEU fresh fuel elements were stored in original, Russian made, packages (containers) used for transport and storage (Figure 2). Beside police guards engaged for physical protection of the reactors' building, the storage rooms for the fresh HEU elements at the RA and RB reactors were also under surveillance by the automatic electronic alarm system applied since 1996, according to the USA DOE recommendations.

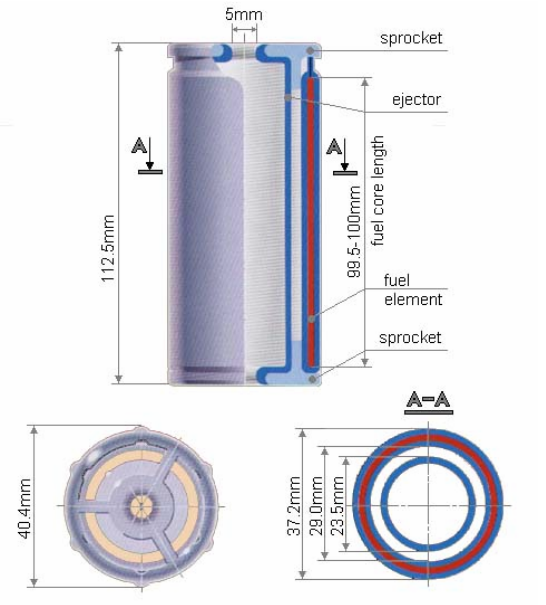

FIG. 1. Sketch of TVR-S fuel element

FIG. 2. Packages for TVR-S fuel elements designed in Russia in 1970-ties

3. TRANSPORT PACKAGES

Inspection of the existing packages, (i.e., original Russian made transport containers), in which the HEU slugs were stored at the Vinča Institute, has been carried out by the DOE experts from the ORNL and the LANL USA and experts from the Minatom, the Atomspectrans and the STNM Institute in spring 2002. They found out that these containers do not fulfil the modern standards and requirements [6] for the planned shipment. Russian counterpart, STNM Institute, proposed the use of Russian industrial package IP-2 type TK-S15 and TK-S16 for the shipment. The TK-S15 and TK-S16 containers are designed and used for transport of fresh fuel assemblies (FA) that are used nowadays for operation of MR, MIR, i.e., IRT-2M, IRT-3M and IVV-10 type of Russian research reactors, respectively.

New packaging procedures were proposed by the STNM Institute according to the available space within TK-S15 and TK-S16 containers, and according to the safety requirements in respect to the criticality safety index. These containers, and packaging procedure for transport of the TVR-S type HEU fuel elements were certified by the Russian certificates, licensed on July 1, 2002, with validity up to December 31, 2002. The criticality calculations, according requirements given in [6], were carried out independently in the SSC RF FEI Russia and in the Vinča Institute. Results of calculations showed that unlimited number of the TK-S15 and TK-S16 packages, filled with the proposed number of 80% HEU fuel slugs of TVR-S type, can be used in the transportation by truck or by aircraft.

The TK-S15 packaging assembly includes: a container, the inner equipment and accessories. The container consists of a steel case, two covers, heat insulation and wrapper. The container case is welded. The container is hermetic by means of two rubber gaskets. The inner equipment is a welded construction of seven aluminium tubes. Capacity of the TK-S15 is seven FA. Mass of the TK-S15 is 240 kg. Mass of the cover itself is 11 kg. Dimensions of the TK-S15 package are: length 1650 mm, width 400 mm, and height 420 mm.

The TK-S16 packaging assembly includes: a container, the inner equipment and accessories. The container consists of a steel case and a cover. The container case is a welded construction as a barrel with double walls. The gap between the walls is filled with heat-insulating material. Inner equipment is a welded construction of seven aluminium tubes welded to spacer grids. Capacity of TK-S16 is also seven FA. Mass of the TK-S16 is 160 kg. Mass of the cover is 48 kg. Dimensions of the TK-S15 package are: diameter 655 mm, maximum width 740 mm, and height 1200 mm.

In each tube of TK-S15 packaging, 13 couples of two TVR-S slugs (the total of 26 slugs, tied together by Scotch tape) can be stored. In such a way, in one TK-S15 package, the total of 7*26 = 182 TVR-S slugs may be stored. The total mass of ^{235}U per TK-S15 package is 1401.4 g. The total of 20 TK-S15 packages were delivered to the Vinča Institute for the shipment (17 were used, while three were the spare ones).

In each tube of the TK-S16 packaging eight bundles of four TVR-S slugs (the total of 32 slugs, tied together by Scotch tape), were placed one above another. In such a way, in one TK – S16 package, the 7*32 = 224 TVR-S slugs may be stored. The total mass of ^{235}U per TK-S16 container is 1724.8 g. The total number of TK-S16 packages, delivered to the Vinča Institute to be used for fresh HEU fuel shipment was 10.

4. PREPARATORY ACTIVITIES

All preparatory activities related to packaging procedures were carried out in the Vinča Institute during July and in the beginning of August 2002, in close cooperation with the safeguards inspectors of the IAEA and experts from the STNM Institute. These activities included:

- Establishing the management structure and the executive Transport Program Team
- Elaboration of the repackaging procedures, preparation of the repackaging area, organisation of necessary logistics support and personnel training
- Providing increased physical protection in the Institute and appropriate police escort during the transport of the fresh fuel elements from the Institute to the airport in Belgrade
- After all necessary decisions were made by the governments of the Federal Republic of Yugoslavia and the Republic of Serbia, and the Steering board of the Vinča Institute, all documents, required permissions and certificates issued in Yugoslavia are provided
- Providing appropriate transport vehicle and close cooperation with the Customs at the airport in Belgrade
- Introduction with the task and training of the members of various supporting teams (e.g., health physics department, medical protection department, fire department, etc.) for the regular and possible incidental situations that may happen during realisation of the activities
- Preparation of necessary equipment for packaging, radiological measurements, marking and sealing of the packages

The whole task was kept as a secret in order to reduce the possibility of a terrorist attack or of any conflicts with the green-peace members during the transport.

As the first step, all HEU fuel elements used at the RB reactor were unloaded from the core. They were returned to the storage containers placed at the RB reactor room. These containers were verified for the fuel type and number by the RB staff. The IAEA safeguards inspectors verified the contents of the containers. The containers were closed and were sealed by the safeguards inspectors from the IAEA too. At the same time, in presence of the IAEA safeguards inspectors, the storage containers with the fresh HEU fuel elements at the RA reactor storage site, were unsealed and opened, one by one. In that way, the total of about 4000 fuel slugs were released from their original protection packaging (paper and plastic foils) and returned back to their positions in the containers. The reason for this preparatory activity was fact that only “naked” fuel elements could be inserted inside tubes of the TK-S15 and TK-S16 containers. Every container was closed and sealed by the safeguards inspectors of the IAEA again, as soon as the procedure mentioned above, was finished.

The repackaging area, i.e., TK-S15 and TK-S16 loading area, was prepared within the RA reactor room. Three additional areas (arrays) were also marked for the locations of 51 existing storage containers, and for the 20 TK-S15 and 10 TK-S16 new transport packages. Two working (packaging) lines were set, including all necessary tools and supporting material needed for repackaging. A place for sample control measurements by the IAEA safeguards inspectors was arranged, as well as a place for gamma-ray dose rate measurement, sealing and marking of the loaded containers. Records forms for all procedures were prepared too. The requested radiation control included contamination monitoring of the area, used equipment and packages and gamma-ray dose rate measurements For all the staff personnel engaged in the work within the reactor room, appropriate protective clothes, gloves, overshoes and TLD were provided, although

the gamma-ray dose rate from the fresh fuel elements was very low. A special metal detector gate was set at the only allowed exit/entrance of the RA reactor room in order to prevent any deliberate removal of fuel slugs from the room. Entrance to the reactor room was allowed only to personnel wearing special badges approved and allowed by the managers of the Transport Program Team. Unless few exceptions, mobile phones and cameras were not allowed inside the RA reactor room during repackaging activities.

All storage containers loaded with the HEU fuel elements were transferred from their regular storage place at the RA and RB reactors, to the RA reactor room, one day before the aircraft with transport packages TK-S15 and TK-S16 arrived from STNM Institute, Dimitrovgrad, Russia, to the Belgrade airport.

5. PACKAGING AND TRANSPORT

The aircraft was unloaded at the airport immediately after lending and all TK-S15 and TK-S16 packages were loaded into the transport vehicle in few hours, including radiation and contamination control and customs procedures. The transport vehicle was escorted by police cars, during its way from the airport to the Vinča Institute. After arrival of the vehicle at the parking place in front of the RA reactor building, the TK-S15 and TK-S16 packages were unloaded, one by one, using lifting carriage, and transferred to the transport entrance of the RA reactor room. There, the packages were loaded to the transport chart and carried to marked positions in the reactor room. The existing crane in the reactor room was used to unload the chart and locate the package at the desired position within the marked array area. This activity took about 3 hours.

The next day, all ten TK-S16 packages were fully loaded, closed, sealed, measured for the transport index, labelled and moved back to their position in the reactor room. The HEU fuel slugs were prepared according to the proposed procedure – four in a bundle, and eight bundles connected in a row, using strong nylon string that was pulled through central axial holes of any two slugs in each bundle by the aid of the special needle prepared. The nylon string was used for moving the whole row of eight bundles from repackaging table to the aluminium tubes in the TK-S16 package. Nylon string also enabled unloading the fuel elements from the containers.

In the next two days, all seventeen TK-S15 packages were fully loaded, closed, sealed, measured for the transport index, labelled and moved back to their position in the reactor room. The HEU fuel slugs were prepared according proposed procedure – two in a bundle, and 13 bundles connected in a row, using strong nylon string that was passed through the central axial holes of both slugs of each bundle by using prepared needle. The nylon string and plastic supporter designed as a long semi-tube was used for moving whole row of 13 bundles from repackaging table to the aluminium tubes in the TK-S16 package. Nylon string also enabled unloading the fuel elements from the containers.

Figures 3 and 4 show the top view of TK-S15 and TK-S16 opened package completely filled by TVR-S fuel elements, before closing by the top cover.

The IAEA safeguards inspectors monitored repackaging activities in the reactor room and carried out measurements of random selected HEU fuel slugs according to the, in advance, prepared procedures. About 1 % of all HEU fuel slugs were verified without any remark or objection by the safeguards inspectors. Due to the well-trained staff and using some additional supporting tools for packaging, these activities were finished about 50 % faster than expected

during planning. The activity was completely monitored by two transportation experts from STNM Institute, and by two representatives from the DOE ORNL, one being the non-proliferation and the other being the transportation expert. Yugoslav customs officers also reviewed the activity in the RA reactor room and put their seals on the containers.

FIG. 3. TK-S15 loading

FIG. 4. TK-S16 loading

The TK-S15 and TK-S16 packages filled with HEU fuel slugs, including the three spare empty ones, were moved from the reactor room to the room transport entrance by using the crane in the reactor room and the chart. The lifting carriage accepted the package there and loaded it into the transport truck. This activity took about 2.5 hours, including measuring the transport index of the packages loaded on the vehicle.

The core of the Transport Program Team include about 30 persons from operation staff of RA and RB reactors, while in the whole activities at the Vinča site were engaged about 50 persons including two IAEA safeguards experts, two STNM Institute experts and two DOE ORNL monitoring experts. About 1200 policemen, including members of the Special Antiterrorist Unit, were engaged during loading of the packages on the vehicle at the Vinča Institute, transport of the fuel elements from the Vinča Institute to the Belgrade airport and during loading of the aircraft at the airport.

The transport itself took place after midnight, when police forces closed for traffic the lines in both directions along the whole route and blocked all intersections on the way from the Vinča Institute to the Belgrade airport. The aircraft was loaded in about 3 hours including fixing packages in their locations in the aircraft, measuring the transport index and preparing the final export documents. The aircraft departed the Belgrade airport the same morning, on August 22 at 08:05 and landed to the Uljanovsk airport near Dimitrovgrad after about 4 hours of flight time. The successful landing of the aircraft with fuel cargo was immediately reported by Russian experts escorted the shipment. The same day at 12:15 in Belgrade, the Ministry of Science, Technologies and Development of the Republic of Serbia and the Director General of the Vinča Institute held the Press Conference about these activities and the success of the whole operation.

6. CONCLUSION

To carry out the whole fresh HEU fuel shipment operation at the Vinča Institute, about 50 persons were engaged, including the safeguards inspectors from the IAEA, STNM Institute experts and monitoring experts from DOE ORNL. The executive team consists of 30 experts from the operation staff members of the RA and RB research reactors. In order to provide adequate security measures during the whole shipment operation, about 1200 policemen, including special task forces were engaged.

This operation was very useful experience for various government and non-government institutions and management personnel in all the three countries being involved in this, the first, planned and realized, shipment of the fresh HEU fuel of the Russian origin from one research reactor, back to the Russia for down blending. This paper shows the experiences gathered in the organization, planning and undertaking such task. For Yugoslav side, the successful conduct of the operation is considered as a trial step for performing the much more complex task – the shipment of the spent nuclear fuel from the RA research reactor back to the Russia fro reprocessing.

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