

TRIGA MARK II LJUBLJANA – SPENT FUEL TRANSPORTATION

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ABSTRACT

The most important activity in 1999 was shipment of the spent fuel elements back to the United States for final disposal. This activity started already in 1998 with some governmental support. In July 1999 all spent fuel elements (219 pieces) from the TRIGA research reactor in Ljubljana were shipped back to the United States by the ship from the port Koper in Slovenia. At the same time shipment of the spent fuel from the research reactor in Pitesti, Romania, and the research reactor in Rome, Italy, was conducted. During the loading the radiation exposure to the workers was rather low. The loading and shipment of the spent nuclear fuel went very smoothly and according the accepted time table.

During the last two years the TRIGA research reactor in Ljubljana has been in operation about 1100 hours per year and without any undesired shut-down.

1. Operating experiences

The 250 kW TRIGA Mark II research reactor of the “J. Stefan” Institute in Ljubljana, Slovenia, was critical on May 30, 1966. It is a light water reactor, with solid fuel elements in which zirconium hydride moderator is homogeneously distributed between 20% enriched uranium. The reactor core consists of about 70 fuel elements, which are arranged in an annular lattice. The maximum neutron flux in the central thimble is 10^{13} n/cm²sec. A 40 position rotary specimen rack around the fuel elements, a pneumatic transfer rabbit system, as well as a central thimble and three extra positions in the core are used for irradiation of samples. Other experimental facilities include two radial and two tangential beam tubes, a graphite thermal column and a thermalizing column.

From 1966 to 1980 the reactor was in operation about 2400 hours per year. In the next decade (1981 – 1990) the reactor was in operation of about 4000 hours per year because an extensive production of radioactive isotopes like ¹⁸F and ^{99m}Tc was carried out. Technetium-99m is namely today the most widely used radionuclide in diagnostic medicine, therefore in our hospitals the demand for this isotope has been very high. At present the hospitals in Slovenia are using Technetium generators as a source of this isotope, therefore the production of ^{99m}Tc in our reactor is not in progress anymore.

In autumn 1990 the operation of the reactor was discontinued for two years. During this time the reactor was almost completely reconstructed and upgraded. The reconstruction consisted mainly of replacing the grid plates, the control console and the driving units of

the control rods. Also a new PC based system was adopted and developed to collect the operational radiation data of the reactor. The spent fuel storage pool was modified in order to store about 600 spent fuel elements. New wiring of the electric power supply system and a new air-exchange system in the control room were installed recently. However, the main novelty in the reactor physics and operational features of the reactor was the installation of a pulse rod, therefore the reactor can be operated also in a pulse mode. After reconstruction, the reactor core was loaded with fresh 20% enriched stainless steel fuel elements.

The facility is expected to operate without major investment at least until 2006. During the last 8 years (after the reconstruction) the reactor has been in operation without any undesired shut-down. An average operational time has been around 1600 hours per year. In 1998 the reactor was in operation 1200 hours and the last year 1100 hours. The reactor is regularly inspected and supervised by the Slovenian Nuclear Administration and has the same safety and quality standards as required for the nuclear power station operation.

2. Spent fuel transport to the United States

The most important activity in 1999 was shipment of the spent fuel elements from TRIGA reactor in Ljubljana back to the United States for final disposal. The preparation for this shipment operation started already in 1998. The United States has not accepted spent nuclear fuel since 1988 when an old programme of acceptance expired. In 1996 the US government accepted a new policy for the management of foreign research reactor spent nuclear fuel containing uranium enriched in the United States. This decision was part of the Reduced Enrichment for Research and Test Reactors (RERTR) programme, which was aimed at reducing the use of high enriched uranium in civilian programmes by promoting the conversion of foreign research reactors from high enriched to low enriched uranium. According to this new policy accepted in 1996 the US will accept and manage research reactor spent nuclear fuel containing uranium enriched in the United States. Actual shipment of spent fuel to the US could be made until 2009, as long as spent nuclear fuel was generated within the 10-years policy period.

Because of very extensive use of the research reactor TRIGA in Ljubljana between 1975 and 1990 we had in the spent fuel storage pool more than 200 spent fuel elements, therefore it was our big interest to send all spent fuel elements back to the USA as soon as possible. It is clear that take-back programme of foreign research reactor fuel will not continue indefinitely. Shipment of the spent fuel elements was implemented in July 1999 when all 20 % enriched spent fuel elements and 70 % enriched fuel elements (FLIP), all together 219 pieces, were shipped back to the United States. The shipment operation was organized and carried out by the Nuclear Assurance Company (NAC) of the US, under surveillance of the US Department of Energy (DOE). The transport containers were provided by the NAC ("NAC Legal Weight Truck Cask") and the cost of shipment was covered by the DOE because Slovenia was treated at that time as a low income country. The contribution of the Institute staff to the project was the preparation of the safety analysis of shipment and loading the containers with the spent fuel. The Institute team also provided radiological monitoring of the loading and shipment operation. Shipment was carried out by truck on July 27, 1999 to the shipping port Koper (near Trieste),

Slovenia, together with the spent fuel from the research reactor in Romania without abnormal events. The spent fuel from the TRIGA reactor in Pitesti, Romania, arrived by truck to Ljubljana on July 27. At the same time shipment of the spent fuel from research reactor in Rome, Italy, was conducted. This fuel arrived by truck from Rome directly to the shipping port Koper on July 28, when the ship Sea Bird depart to the United States.

The loading was initiated on July 7, 1999, and completed on July 15. During the loading the radiation exposure to the workers was rather low. The total amount of radiation received for 15 workers was 0,468 mSv or 0,031 mSv per worker. The maximum dose of 0,088 mSv received a worker dealing with a crane. The cooling time for all spent fuel elements was rather high (from 3 to 17 years), therefore the dose rate on the surface of the transport container was very low (from 0,9 μ Sv/h to 0,5 μ Sv/h).

Before the transportation careful examination of all spent fuel elements was performed. It was found that some fuel elements were damaged, therefore 6 spent fuel elements with Al cladding were canned in leak-tight containers and 60 others elements were placed in special containers with 4 pieces in each. It can be concluded that the cladding of the fuel element could be damage after a long storage time in spite of keeping water in the spent storage pit very clean.

3. Conclusions

The shipment operation went very smoothly in spite of the international cooperation and according to the accepted time-table because all shipment procedures were prepared with a great care. The loading and shipment of the spent nuclear fuel from the TRIGA reactor in Ljubljana was conducted without any public comment or opposition.