RERTR 2008 — 30th INTERNATIONAL MEETING ON REDUCED ENRICHMENT FOR RESEARCH AND TEST REACTORS

October 5-9, 2008
Hamilton Crowne Plaza Hotel
Washington, D.C. USA

EXPORTATION CAMPAIGN OF SPENT NUCLEAR FUEL FROM THE RA-6 REACTOR

Osvaldo Calzetta, Carlos Díaz, Guillermo Facchini, Carlos Fernandez, Oscar Novara, Fernando Orlando, Marcos Ratner, Nestor Rico and Horacio Taboada

Comisión Nacional de Energía Atómica
Av. del Libertador 8250 (1429), Buenos Aires - ARGENTINA

ABSTRACT

RA-6 reactor is located in Bariloche Atomic Center (CAB), in the city of San Carlos de Bariloche, in the south of Argentina. In 2005, CNEA and DOE signed a contract for the conversion of the RA-6 reactor to LEU and for shipping back in a single shipment the HEU spent fuel inventory that consisted of 42 MTR - type fuel assemblies. The SNF exportation was performed in the framework of the DOE Spent Fuel Acceptance Program and the GTRI. The shipment campaign took place in the last quarter of 2007 and the receiving facility for the RA-6 fuel was the L-Basin at the Savannah River Site.

One unit of a NAC - LWT shipping cask was used to ship the fuel. In order to place inside it all the fuel assemblies, cropping of their non active parts (structural parts) was required. In order to provide adequate shielding to the operators, fuel cropping was performed under water. Transfer of baskets loaded with conditioned fuel to the transport cask was made by shielded intermediate transfer systems.

Package check-out consisted of activity leak test, helium leak test, dose rate measurement to verify package self-protection, superficial contamination and transport index determination.

The typical daily staff that participated in the loading campaign was about twelve people and the collective dose was approximately 0.70 mSv.man.

Transportation to the exit port was carefully designed. It demanded one overnight stop in transit and potential routes had been previously assessed. The convoy was formed by four transport trucks and vehicles with security force. More recently, as part of the RA-6 core conversion planning, the first consignment of locally manufactured fresh fuel was carried out with similar features regarding transport design.

1. Introduction

In 2005, the National Commission of Atomic Energy (CNEA) of Argentina and the National Nuclear Security Administration (NNSA) of the United States Department of Energy (DOE) signed a contract for the conversion of the RA-6 reactor to low enrichment uranium (LEU) and for shipping to the USA the fuel the reactor had been working with since its start-up. This fuel was manufactured in Argentina with high enrichment uranium (HEU) of American origin and therefore, it was eligible to be taken back in the framework of the DOE Foreign Research Reactor/Domestic Research Reactor (FRR/DRR) Spent Nuclear Fuel (SNF) Acceptance

Program. Additionally, the ongoing RA-6 conversion is supported by the Global Threat Reduction Initiative (GTRI) whose objective is minimizing the use of HEU worldwide.

The RA-6 SNF exportation campaign consisted of the shipment of 42 MTR-type fuel assemblies. The fuel was dispatched from the RA-6 reactor, located at the Bariloche Atomic Center (CAB) in the city of San Carlos de Bariloche, in November 2007 and arrived to the receiving facility, the L-Basin at the Savannah River Site (SRS), in December of the same year.

The 42 MTR-type fuels had an U-235 remnant quantity of 5.167 Kg in total and they were manufactured in Argentina with American HEU (about 90%). There were 37 standard assemblies and 5 control assemblies, all them with fuel cladding and most of their structural parts in aluminum. Average burn-up was 19.5 % for the standard assemblies and 6.7 % for the control ones. The fuel inventory was stored in the decay pool inside the reactor building at the time of the shipping preparations.

2. Description of the Activity

One NAC - LWT transport cask was used to ship the RA-6 fuel to the USA. Each cask holds up to six stacked transport baskets containing a maximum of 42 assemblies. Therefore, only one LWT cask (5 m tall, about 21 TN) was necessary to transport the whole fuel inventory. In order to accommodate the fuel into the shipping basket, the nozzle of every fuel assembly as well as the upper structural part of the control assemblies were cropped. Due to its large dimensions and weight, the LWT had to be placed outside the reactor building with the aid of a mobile crane. Additionally to setting the LWT cask up right, the outdoors operation area was prepared to receive and place the ISO shipping containers the transport cask and the auxiliary equipment came in. Once the LWT was fully loaded, the cask check-out was also performed in that area. To move the transport baskets loaded with spent fuel to the LWT cask, NAC also provided the well known shielded containers called Intermediate Transfer System (ITS, formed by the inner shield - IS - and the outer shield - OS -) and Dry Transfer System (DTS).

Inside the reactor building, the fuel conditioning and its loading in the ITS was done by CNEA personnel. In order to provide adequate shielding to the operators, fuel cropping was performed under water in the decay pool, which was placed in the basement. The cropping device consisted of an electrically powered underwater saw mounted on a submergible structure. The cropping stage was completed with the removal of the cropped parts, the removal of the saw, and the cleaning of the aluminum filings by means of a vacuum suction pump.

After completion of the cropping stage, the ITS-IS with an empty transport basket inside were placed underwater with the aid of the facility 5 TN bridge crane. Seven assemblies were loaded in each basket with the help of the appropriate handling tool (Fig. 1). Once the lid was secured, the IS was raised from the decay pool and lifted through a hatch to the ground floor of the reactor building (Fig. 2), where the OS, mounted on a palletized base, was placed. To enhance the radiation protection during outdoors operations, the IS was positioned on the OS and then nested inside it (Fig. 3). The whole ITS was moved and placed outdoors, close to the LWT cask, by means of a 8 TN forklift.

The mobile crane placed the empty DTS on top of the ITS. The gates were opened to provide an internal hoisting path for the fuel transport basket. The pneumatically actuated grapple was lowered into the ITS to engage the basket. The basket was raised into the DTS and its bottom shield gate was closed. The loaded DTS was lifted from the ITS and was lowered onto the upright LWT cask. NAC personnel used scissors-type lifts and elevated platforms to access the shielded gates (Fig. 4). After the pneumatic lines were reconnected to actuate the DTS grapple and hoist, the basket was lowered into the LWT cask until seated. After the LWT was fully loaded with the six baskets, the cask lid was fitted and bolted.

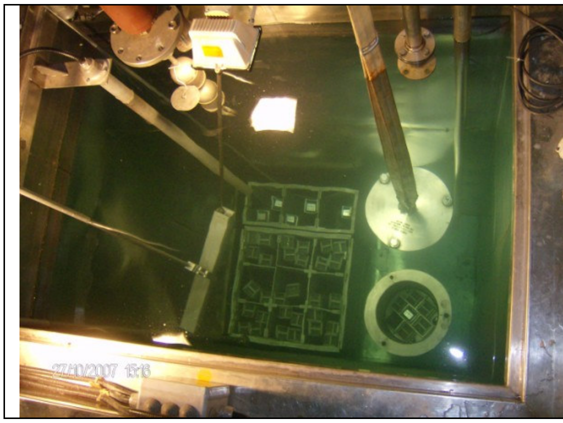

Figure 1: View of the decay pool. Loading of transport basket (inside the ITS-IS)

Figure 2: Raising loaded IS through the hatch

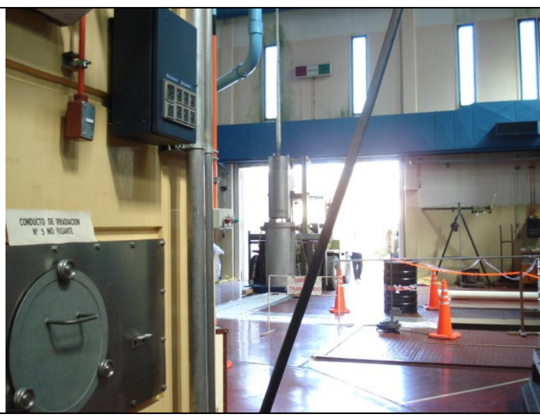

Figure 3: View of ground floor of the reactor building. Nesting of ITS-IS inside OS

Figure 4: Mounting of DTS on to the LWT at the RA-6 outdoors operation area

3. Check-out and testing of loaded LWT

Before closing the loaded LWT, determination of self-protection was required to verify that the fuel inventory was Category II regarding physical protection. This was done in a quick maneuver, where the cask lid was slightly raised from its seating to let the probe of a telescopic radiometer measure the dose rate (at about 1 m) without any shielding. Measured dose rate was 1.54 Sv/h.

Fuel integrity was verified to fulfill the requirements of the receiving facility. For this, the loaded LWT was subjected to a radionuclide sampling test, consisting of the measurement of the Cs-137 activity increase in samples from deionized water that occupied the free volume of the loaded cask (filled with water for this test). Activity increase detected in the 12-hour sample was 0.30 Bq/cm^3, which represented 1.36 % of the acceptable limit (1325 dpm/ml). After this test, a controlled water removal and vacuum were performed in the cask.

To ensure safe transport conditions, the package was subjected to containment verification by filling the cask with helium and monitoring gas releases through the cask seals (helium leak test).

Superficial contamination (α and β/γ emitters) and the dose rate in contact and at 1 m were exhaustively measured on the loaded transport cask. Sweep-tests results were < 0.01 for β/γ and < 9.10-3 Bq/cm2 for α particles. Maximum dose rate in contact was 0.28 mSv/h and the transport index (TI) was 1.5. The ISO shipping container inside which the LWT cask was placed was also subjected to an equivalent radiological control. Identical measurements were taken on the transfer systems, the cropping device and their respective shipping containers. This task was completed with the corresponding labeling of transport cask and shipping containers.

3. Safety Aspects

Based on the experience gained in previous shipping experiences [1], the on-site activity was thoroughly designed. In order to minimize the number of workers involved, specific roles were defined and distributed among a total of twelve individuals.

Personnel wore TLD badges in the work time. Furthermore, they wore electronic dosimeters as well as clothing for protection against contamination (shoe-covers, gloves, etc.) whenever they were in the reactor building controlled area. The decay pool surroundings were delimited as a controlled zone and the operators that handled the fuel wore overalls of impermeable material.

From the radiological protection point of view, the following were identified as sensitive tasks:
i) Transference of the loaded ITS inner shield from the decay pool to the point where the ITS outer shield was placed.
ii) Removal from the pool of the bucket containing the cropped structural parts: These parts showed significant radioactivity that came from some of their components made of stainless steel with cobalt (eventually activated during irradiation). After being lifted and allowed to drain water for a short time, the bucket was moved into an especially designed shielded storage drum.
iii) Determination of self-protection for the loaded LWT cask
iv) Saw blade decontamination.
v) Pool cleaning: After cropping but prior to loading the fuel baskets, it was necessary to clean up the aluminum filings by means of a vacuum suction pump. Due to these filings, some activity was found along the vacuum hose surface and in the filter.

The estimated whole-body collective dose from penetrating radiation was 2.84 mSv.man, while the collective dose taken from personal electronic dosimeters readings was 0.72. Dose rates rapidly estimated by means of a linear code for shielding calculation considering a simple model for the fuel were conservative and led to expect greater dose values. Nevertheless, good practice and permanent control contributed to minimizing dose absorption. Dose values from TLD films, when detected, were consistent with the readings from electronic dosimeters.

4. Spent Fuel Transport

To dispatch the RA-6 SNF, two means of transportation were utilized. The in-land transport was carried out by trucks that drove about 1000 km of national routes across Patagonia to reach the exit port situated on the Atlantic coast. Consequently, this stage was the responsibility of CNEA and other Argentine authorities. The maritime transportation was done by an exclusive-use vessel contracted by DOE that met the requirements to transport INF Class 2 cargo.

The fuel transport was carried out following national and international rules. In fact, national legislation that regulates the transport and transit of dangerous merchandises is based on UN recommendations (issued in the commonly known “orange guide”) and, specifically regarding the transport of radioactive material, the requirements from the Argentine regulatory body strictly follow the IAEA safety standard TS-R-1 Ed. 1996 (Rev.)

Transportation to the exit port was carefully designed. Several potential routes had been previously assessed on the field. Evaluation included the shape and status of the road, availability of side roads to avoid cities, availability of services and facilities for programmed and non-programmed stops if required, etc. The assessment was complemented with a deep study of the local rules regarding the transit of radioactive material in jurisdictions on the selected way.

Exit from CAB was an important aspect to analyze: the main access is a paved road that borders the Nahuel Huapi lake about 10 km on the way. Since this narrow road is sinuous, frequently close to steep slopes leading to the lake, and traffic on it is heavy, it was not considered safe enough for the transport of such heavy loads. A combination of secondary roads was considered to be safer. This alternative also maid it possible to leave the zone without passing through Bariloche City.

The selected routes to reach the exit port were about 1000 km long and therefore, one overnight stop was planned. A short way from Bariloche the route runs sinuously across mountains and edges, becoming difficult for approximately 150 km. Route conditions get worse in winter due to snow and the formation of “black ice”, a slippery thin layer of ice covering the paved road. Therefore, transport was constrained to the warm season (October to March).

The consignment consisted of four ISO containers, one for the LWT cask and three for the shielded transfer systems, the cropping machine and the auxiliary equipment. Therefore, four trucks, each one transporting one ISO container, formed the convoy, which was completed by escort vehicles with security forces and two more vehicles with CNEA personnel responsible for the transport.

As it is usual for nuclear activity in Argentina, security was provided by Gendarmería Nacional (national frontline police). The overnight stop took place in a military site to provide adequate security environment. Occasionally, when close to urban zones, the security agents directed the traffic as necessary to let the convoy pass or turn to other roads.

The transport vessel was escorted by Argentine Navy ships up to the limit of the maritime exclusion zone 200 miles away from the coast.

5. Supply of fresh fuel

More recently, as part of the RA-6 core conversion planning, the first consignment of locally manufactured fresh fuel was carried out. Twenty two MTR-type LEU fuel assemblies with 7.023 Kg of U-235 in total were transported in five INVAP - GURI 100 transport casks from Constituyentes Atomic Center in Buenos Aires to CAB in May 2008.

One transport truck was enough to carry all the casks. As usual, the truck was escorted by security forces as well as CNEA personnel in separate vehicles. Itinerary by selected routes took about 1700 Km to reach CAB and required two overnight stops in military facilities to complete the journey.

A complementary consignment to the RA-6 of about 10 fuel assemblies is scheduled for October 2008.

6. Conclusion

Forty two MTR-type HEU fuel assemblies that constituted the RA-6 reactor core for 25 years were successfully shipped in a NAC-LWT transport cask to SRS in 2007. Preliminary inspection of the fuel inventory and the final check-out of loaded LWT casks concluded the fuel met the acceptance criteria for its shipment and storage in the SRS basins. The transport was carried out following national and international rules for the transport of dangerous materials Class 7.

Preparations in the reactor site demanded two weeks of intense technical work and administrative arrangements. The number of staff that participated in the spent fuel conditioning and loading campaign was typically twelve. The collective dose was 0.72 mSv.man. Since preliminary dose rate calculations were conservative, the actual collective dose was 1/4 of the expected one. Sensitive tasks did not represent much contribution to dose. Good practice and permanent control contributed to minimizing dose absorption.

The SNF was dispatched from CAB on 6 Nov 2007. The convoy was formed by 4 trucks each one transporting one ISO container, one for the LWT cask and three for the shielded transfer systems, the cropping machine and the auxiliary equipment. The convoy included escort vehicles with security forces plus two vehicles with CNEA personnel responsible for the transport. There was an overnight stop in a military site to provide adequate security environment. The following day, the convoy arrived to the exit port and the ISO containers were loaded on to an exclusive-use transport vessel that departed that evening. After a stop at Sao Paulo, Brazil, to collect a cargo of spent fuel and radioactive sources used in that country, the vessel arrived in Charleston on 11 Dec 2007 and the spent fuel entered SRS the same day.

7. References

[1] O. E. Novara, "Argentine Experience in Shipping Irradiated Fuel to the United States of America". Return of Research Reactor Spent Fuel to the Country of Origin: National Experiences and Requirements for Technical and Administrative Preparations, Proceedings of a Technical Meeting Held in Vienna, August 28 to 31, 2006, IAEA TECDOC # 1593, Vienna (2008).