PREPARATIONS FOR THE SHIPMENT OF RA-3 REACTOR IRRADIATED FUEL

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INTRODUCTION

Along the last quarter of 2000, in the Radioactive Waste Management Area of the Argentine National Commission of Atomic Energy (CNEA), located at Ezeiza Atomic Center (CAE), activities associated to the shipment of 207 MTR spent fuels containing high enrichment uranium were carried out within the Foreign Research Reactor / Domestic Research Reactor Receipt Program launched by the US Department of Energy (DOE).

The MTR spent fuel shipped to Savannah River Site (SRS) was fabricated in Argentina with 90 % enriched uranium of US origin and it was utilized in the operation of the research and radioisotope production reactor RA-3 from 1968 until 1987. After a cooling period at the reactor, the spent fuel was transferred to the Central Storage Facility (CSF) located in the waste management area of CAE for interim storage.

The spent fuel (SF) inventory consisted of 166 standard assemblies (SA) and 41 control assemblies (CA).

Basically, the activities performed were the fuel conditioning operations inside the storage facility (remote transference of the assemblies to the operation pool, fuel cropping, fuel re-identification, loading in transport baskets, etc.) conducted by CNEA. The loading of the filled baskets in the transport casks (NAC–LWT) by means of intermediate transfer systems and loaded casks final preparations were conducted by NAC personnel (DOE's contractor) with the support of CNEA personnel.

VISUAL INSPECTION: CHARACTERIZATION OF THE RA-3 SF INVENTORY

In 1998, experiments based on the installation of aluminum coupon racks were launched to monitor the corrosion of the CSF, in the frame of a IAEA CRP on Corrosion of Aluminum-Clad Spent Fuel in Water. The results indicated that the conditions of storage in the CSF generated aluminum corrosion.

A preliminary visual inspection in June 1999 led DOE to decide to inspect all 207 HEU assemblies prior to shipping them back to the US.

In October 1999, an inspection team from Westinghouse Savannah River Company (WSRC), with the cooperation of CNEA personnel, performed a detailed inspection of the SF stored at the CSF. The purpose of this inspection was to characterize the fuel condition (structural damage, corrosion degree, etc.) in order to meet acceptance criteria for transportation compliance (i.e., containment) and provide assurance that the SF could be safely handled and stored in SRS basins. The configuration of the storage facility required that the inspections be performed remotely via a video viewing and control system. Digital videotapes were extensively reviewed upon completion of the inspection effort.

Assemblies were categorized by the extent of penetrating corrosion visible on the two outer fuel plates and/or structural damage, as shown in Table 1.

Table 1

Number of Fuel Assemblies	Severity Index	Exposed Fuel Area
67	0	No corrosion product nodules or general corrosion
24	1	< 0.1 cm^2
48	2	≥ 0.1 cm^2 to < 0.5 cm^2
33	3	≥ 0.5 cm^2 to 1.0 cm^2
16	4	≥ 1.0 cm^2 to 1.5 cm^2
19	5	≥ 1.5 cm^2

Corrosion nodules less than 3 mm in diameter were assumed not to penetrate the fuel plate cladding. About 45% of the fuel assemblies exhibited minimal or no corrosion damage, and only 10% of the inventory showed significant corrosion indications. The reviews concluded that the SF inventory condition was generally satisfactory for handling, shipment, and storage in the SRS basins.

DESCRIPTION OF STORAGE FACILITY AND MODIFICATIONS

The Central Storage Facility (CSF) is a wet storage facility for research reactor spent fuel located at the waste management area of CAE about two kilometers from the RA-3 reactor. The CSF building is 35.2 meters long, 11.5 m wide and 4 m high. The structure is primarily concrete block walls with an iron plate roof and sliding bay doors at each end.

The CSF contains two sectors of in-ground storage tubes for SNF (Fig 1). The front sector has 6 rows with 16 storage tubes per row. The back sector has 6 rows with 17 tubes per row. The storage rows, which are 0.5 m apart, have raised curbs at ground level with a lead-filled plug at the top of each storage tube. Total capacity is 198 storage tubes holding a maximum of two standard assemblies per tube.

Each storage hole is lined with a 316 series stainless steel tube that is 2.1 m deep and 15 centimeters in diameter. Each tube can hold two standard MTR assemblies or one control assembly. There is about 15 cm of water shielding above two stacked standard assemblies or 30 cm of water shielding above a control assembly.

The storage tubes and rows are interconnected via a water recirculation system, not currently in operation. An inspection pit between the storage sectors contains valves and piping for the mentioned system. The CSF was not designed to accommodate commercial SF shipping casks and did not have a water–filled basin. CNEA modified a number of systems inside the facility to support the planned conditioning of the SF for its loading into shipping casks (Fig. 2). The original 1 TN overhead crane used to handle the storage tube shield plugs was replaced by a new 2 TN overhead crane with a dual beam bridge, capable of handling a shielded transfer cask for SF baskets, and the bridge rail supports were strengthened. Besides, a small auxiliary hoist attached to the bridge was used to handle individual fuel assemblies. Both the crane and the auxiliary hoist could be operated either remotely or via a tethered pendant controller. The valve pit was converted to a temporary basin for underwater SF conditioning operations by installing a stainless steel pool. The temporary basin was 0.85 m wide, 5 m long and 2.5 m deep, holding about 10 cubic meters of deionized water, permanently treated with a water filtering system.

Two shielded stations were located inside the CSF. The three-sided walls were constructed of 10-centimeter thick lead bricks inside a steel frame. The front walls were approximately 2 m wide by 2.75 m high with two lead-glass view-ports.
A monitoring station was set in the adjoining building about 10 m from the CSF to follow the in-air transfer operations with the aid of cameras conveniently distributed inside the facility. The LCD displays that received the camera signals and the pan-tilt-zoom control boxes of the cameras were installed in the station, which was sheltered by walls built with high density concrete bricks.

Fig. 1: Central Storage Facility

Fig. 2: CSF modified for SF conditioning

NAC TRANSFER COMPONENTS AND TRANSPORT CASKS

NAC supplied the fuel baskets (NAC-MTR42) and the transport casks (NAC-LWT) for the shipment of the RA-3 SF to the US. Each cask holds six stacked MTR42 baskets containing a maximum of 42 assemblies. Five NAC-LWT casks (5 m long, ~21 TN) were necessary to transport the 207 items.
NAC also provided a multistage SF transfer system to enable cask loading outside the facility. The transfer systems were the Intermediate Transfer System (ITS) and the Dry Transfer System (DTS). The ITS (Fig. 3) was utilized to move a fuel basket outside the CSF. ITS main components were two separated shielding containers, the inner shield (IS), a 1.3 TN stainless steel vessel that held one MTR42 and was placed in the operation basin, and the outer shield (OS). The IS nested inside the OS after the being removed from the basin with the loaded SF basket. The OS weighed 2.6 TN and was mounted on a palletized base to facilitate handling with a standard forklift.
The DTS is a 6 TN dry transfer cask with pneumatically driven grapple and hoist for lifting the SF basket from the ITS and lowering it into the upright LWT cask.

Fig. 3: ITS inner and outer shields

SPENT FUEL CONDITIONING AND LOADING ACTIVITIES

The fuel conditioning operations were performed by CNEA personnel inside the storage facility. These activities were: remote transference of the assemblies to the operation pool, fuel cropping, fuel re-identification (when necessary), loading of the cropped assemblies in transport baskets and loading of the filled baskets in the ITS.

The assemblies were processed in lots of seven (capacity of the NAC-MTR42 basket).
CNEA had already established a list of assemblies to be loaded into each transport basket. The loading sequence was designed to: i) Gather the assemblies classified with severity index 4 and 5 in only two transport casks. ii) Ensure an elevated radiation rate in each sixth basket (the one allocated inside the cask closest to the cask lid) to comply with the physical protection requirement that the loaded LWT be Class II (self-protected; > 1 Sv/h measured on top with the cask lid open). iii) Store a CA in the central slot of every basket, since the shorter length of those cropped assemblies helped to minimize the possibility of incorrect grasping of the DTS grapple during the basket transfer.

1) Remote transfer of SF from in-ground tubes to the operation basin

The first step was to remove the shielded plug from the selected storage tube with the aid of the bridge crane hook. Then, the assembly was manually grasped (Fig. 4) with special handling tools provided by WSRC. Different grappling tools were available to engage standard assemblies, control assemblies or cropped assemblies. When removing a standard assembly from the bottom of the tube, a longer grappling tool with an underwater camera attached to the shaft was utilized. The camera was connected to a goggle-type video display worn by the tool operator.

Fig. 4: SF grasping from in-ground tube

Once the assembly was grappled and the tool was hanged on to the auxiliary hoist, the assembly was remotely lifted until it was entirely out of the tube and then transferred to the operation basin, where it was lowered into the water.

2) SF cropping

The first underwater operation was fuel cropping. All the SF inventory was cropped to reduce the length of the assemblies (to 0.69 m for CA and to 0.72 m for SA) and thereby reduce the required number of LWT casks. The nozzle was cropped from every fuel assembly. Besides, the top control plate guide box was cropped from every CA.
The cropping device (Fig. 5) was supplied by NAC and was modified for an optimum functioning by a local contractor.
The cropping device consisted of an underwater band saw actuated by compressed air flux on a stainless steel plate that served as cropping table. A pneumatic actuator drove the blade downwards along the cutting section at low constant speed producing straight cuts. The table had adjustable stops to control cropping length and three clamps pneumatically actuated to hold the assembly in position against a guide rail during cutting.

Fig 5. Submerging the cropping device

3) Re-identification of control assemblies

Since control assemblies lost their ID number when their top extremes were cut, it was necessary to re-identify them. Holding the cropped assembly upright, an aluminum flat bar was inserted between two fuel plates and slid along the assembly. One extreme of this bar was bent at 90º and the ID # engraved on it. The other extreme finished in a bending tab that protruded and was bent to fasten the ID bar to the assembly. The CA was loaded in the basket with ID # facing the top.

4) Loading of conditioned SF in the ITS

The empty NAC-MTR42 transport basket lay underwater inside the ITS-IS (Fig. 6). After the lot of seven assemblies was cropped, the personnel loaded each assembly in the basket with the help of the appropriate handling tool. The IS lifting lid was subsequently placed on the shielding with the overhead crane and the bolts secured. The IS was remotely raised from the basin and suspended over it for a few minutes to let drain water. The IS was then remotely transferred across the facility to the ITS outer shield (OS) that lay close to the facility rear door and lowered into it.

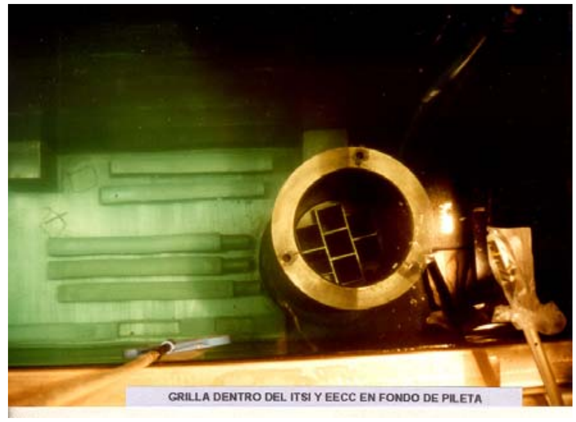

Fig. 6: Basket inside the IS and SF assemblies

The loaded ITS was removed from the storage facility with a forklift and placed outdoors about 15 meters from the LWT cask.

NAC personnel performed all subsequent SF basket handling operations and conducted the mobile crane movements.

5) Transference of the SF basket from the ITS to the DTS.

The mobile crane placed a shielded gate on top of the ITS. The ITS-IS lid was then removed, and the gate was temporarily closed to provide radiation shielding. An adapter ring for the dry transfer cask (DTS) was installed on the shielding gate. The mobile crane placed the empty DTS on top of the ITS + gate (Fig. 7). This gate and the bottom gate of the DTS were opened to provide a hoisting path for the SF transport basket. Pneumatic lines were connected to the DTS grapple actuator and hoist, and the grapple was lowered into the ITS to engage the SF basket. The basket was raised into the DTS and its bottom shield gate was closed. The pneumatic tubing was disconnected and the loaded DT cask was lifted from the ITS.

Fig.7: DTS placed on top of ITS

6) Transference of the SF basket from the DTS to the LWT transport cask.

The DTS was lowered onto a shield gate that had been previously mounted on top of the upright LWT cask (Fig. 8). NAC personnel used manlifts to access and open the top shield gate and the DTS bottom gate. After the pneumatic lines were reconnected to actuate the DTS grapple and hoist, the SF basket was lowered into the LWT cask until seated. The grapple was disengaged and raised, the shielded gate on top closed and the empty DTS was removed.

7) Loose plates canning

Three items consisted of loose fuel plates with very low irradiation. These plates were inserted in transport cans provided by NAC that fitted the size of the transport basket slots.

Fig. 8: DTS placed on top of LWT

8) Check-out and testing of loaded LWT

After the LWT was fully loaded, the cask lid was placed on top and bolted.

The five loaded LWT casks were subjected to a radionuclide sampling test, consisting of the measurement of the Cs-137 activity increase in samples from the water that occupied the free volume of the loaded cask. The casks were filled with deionized water and water samples were taken initially, at 4 hours and at 12 hours after the commencement of the test. In three casks, the activity values detected in the 12-hour samples were below 1% of the acceptable increase limit (1325 dpm/ml) and the other two only reached 7% and 15% of that limit.

After this test, a controlled water removal and vacuum were performed in each cask. The next step was to ensure confinement by filling the casks with helium and monitor gas releases through the cask seals. Then the casks were placed inside their respective ISO containers.

To verify proper transport conditions, superficial contamination (α and β/γ emitters) and the dose rate in contact and at 1 m were exhaustively measured on each cask. The ISO containers were also subjected to an equivalent radiological control.

RADIOLOGICAL PROTECTION MEASURES

From the radiological protection point of view, the most sensitive stage was the SF in-air transfer from its storage position to the operation basin and, to a lesser degree, the transference of the loaded ITS inner shield from the basin to the point where the ITS outer shield was placed. In order to minimize the dose cost on the workers, these operations were carried out remotely.

After the selected assembly was engaged to be removed from the storage tube, all the personnel evacuated the CSF and stayed in the shielded monitoring station (adjoining building) during subsequent SF removal and transfer, except for the crane operator and radiological protection officer. These workers sheltered behind the lead wall with shielded view-ports.

The in-air movements were monitored via video displays from the monitoring station and two-way radios were used to communicate with the crane operator. Personnel left the station and the crane operator left the shield wall only after the assembly was safely in the operation basin.

None of the staff involved (NAC personnel, CNEA personnel, mobile crane operators, safeguards inspectors, etc) worked in the outdoor loading area while in-air transfers took place. Light and sound signals alerted the staff not to enter the waste management area during in-air transfers.
Contingency procedures had been foreseen for incidental cases (assembly disengaged in transfer, sudden crane detention).
Seventeen people participated in the campaign and the typical daily staff was about thirteen people. The collective dose was approximately 10 mSv.man and represented 50% of the estimated dose.

CONCLUSION

The RA-3 high-enrichment SF inventory (207 items, 166 standard assemblies and 41 control assemblies) was conditioned for its transport to the United States and loaded in five NAC-LWT casks. All the assemblies were cropped to shorten their length and thereby reduce the required number of casks. Previous SF full inspection and the final check-out of loaded LWT casks concluded that the whole SF inventory met the acceptance criteria for its shipment and storage in the SRS basins.
The casks were licensed by the US-NRC and by the Nuclear Regulatory Authority of Argentina (ARN). The SF conditioning and loading activities, which at that time corresponded to the largest shipment dispatched from one country in one stage, were carried out within a tight schedule in 23 days, working 12 hours per day and 6 days per week, with an average rate of 1.3 loaded baskets per day.
The total shipment campaign demanded five weeks of intense technical work and administrative preparations. The transport convoy departed from CAE on Dec 13, 2000 at 3:30 AM to the selected harbour that was about 750 km away. On the same day, the ISO containers were loaded in an exclusive-use transport vessel that departed for Charleston at 19:02 PM. The transport was carried out following national and international rules.

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