INSPECTION EXPERIENCE WITH RA-3 SPENT NUCLEAR FUEL ASSEMBLIES AT CNEA's CENTRAL STORAGE FACILITY

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ABSTRACT

Aluminum-based spent nuclear fuel from Argentina's RA-3 research reactor is to be shipped to the Savannah River Site near Aiken, South Carolina, USA. The spent nuclear fuel contains highly enriched uranium of U.S. origin and is being returned under the US Department of Energy's Foreign Research Reactor/Domestic Research Reactor (FRR/DRR) Receipt Program. An intensive inspection of 207 stored fuel assemblies was conducted to assess shipping cask containment limitations and assembly handling considerations. The inspection was performed with video equipment designed for remote operation, high portability, easy setup and usage. Fuel assemblies were raised from their vertical storage tubes, inspected by remote video, and then returned to their original storage tube or transferred to an alternate location. The inspections were made with three simultaneous video systems, each with dedicated viewing, digital recording, and tele-operated control from a shielded location. All 207 fuel assemblies were safely and successfully inspected in fifteen working days. Total dose to personnel was about one-half of anticipated dose.

1. INTRODUCTION

Argentina's Comision Nacional de Energia Atomica (CNEA) operates the RA-3 research reactor and a spent fuel storage facility at the Centro Atomico Ezeiza (Ezeiza Atomic Center) site near Buenos Aires, Argentina. The RA-3 reactor is a 5 MW (thermal) light water pool reactor that began operation in 1967. Highly enriched uranium (HEU) fuel assemblies were utilized from initial startup until 1987. The reactor now operates with low enrichment uranium assemblies.

Two hundred and seven (207) HEU spent nuclear fuel assemblies from the RA-3 reactor are currently stored underwater at the Central Storage Facility (residence times range from 11 to 27 years). These assemblies contain 90% U-235 enriched uranium of United States origin. The assemblies are tentatively scheduled for transfer to the Savannah River Site in the United States for long-term storage and disposition.

In October 1999, an inspection team from Westinghouse Savannah River Company (WSRC), with support from the Department of Energy – Savannah River Operations Office, joined with CNEA operations and technical personnel to perform a detailed inspection of the spent nuclear fuel stored at Ezeiza. The purpose of this inspection was to characterize the fuel condition in order to meet acceptance criteria for transportation compliance (i.e., containment), structural integrity, and deformation. The configuration of the storage facility required that the inspections be performed remotely via a video viewing and control system.

2. STORAGE FACILITY DESCRIPTION

The CNEA Radioactive Waste Management Activity Unit operates the Central Storage Facility (CSF) for research reactor spent fuel. The CSF is located within a controlled area for waste management about four kilometers from the RA-3 reactor. The reactor and waste management area are about 45 kilometers from downtown Buenos Aires. Public access to these areas is prohibited.

The CSF building is 35.2 meters long, 11.5 meters wide and 4 meters 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 spent nuclear fuel (SNF). The front sector has six (6) rows with sixteen (16) storage tubes per row. The back sector has six rows with seventeen (17) tubes per row. The storage rows have raised curbs at grade level with a lead filled plug in the top of each storage tube. Total capacity is 198 storage tubes holding a maximum of two (2) standard assemblies per tube.

Each 316 series stainless steel storage tube is 2.1 meters deep with an inside diameter of 13.7 centimeters. Each tube can hold two (2) standard assemblies or one (1) control assembly. There is a minimum of fifteen (15) centimeters of water shielding above two stacked standard assemblies or thirty (30) centimeters of water shielding above the top end of the control assembly (about 100 centimeters above the fuel plates).

The storage tubes and rows are interconnected via a filtration/deionization system with recirculation capability.

An overhead crane in the CSF handles the storage tube shield plugs and the SNF. The main hoist is rated at 1000 kg with a floor to hook span of 2.5 meters. A small auxiliary hoist for handling individual fuel assemblies is mounted on the crane bridge. The crane and auxiliary hoist can be operated remotely via a tethered pendant controller or wireless controller.

A shielded station for the crane operator is located at one end of the CSF. The three-sided station is constructed of 10-centimeter thick lead brick inside a steel frame. The front wall is approximately 2 meters wide by 2.75 meters high with two viewports.

3. FUEL DESCRIPTION

RA-3 assemblies are of the typical material test reactor (MTR) design with nineteen (19) curved fuel plates in each standard assembly (Figures 1 and 2). The fuel plates are aluminum clad uranium-aluminum alloy. The standard assembly has a lifting bail at the top and a flow nozzle at the bottom. Control assemblies have only fifteen (15) fuel plates, two vacant slots for insertion of neutron absorber plates, and longer side plates to accommodate controls for the manipulation of absorber plates. The stored assemblies are uncropped and range in length from 88 centimeters for standard assemblies to 161.1 centimeters for control assemblies. There are four (4) assembly variations (based on fuel loading) described in Table 1.

Table 1: Assembly Configurations

Assembly Type	*Standard*	*Control*	*Standard*	*Control*
Number of Fuel Plates	19	15	19	15
Plate Thickness (cm)	0.14	0.14	0.13	0.13
Fuel Meat Thickness (cm)	0.056	0.056	0.052	0.052
Uranium Content (weight %)	18.5	18.5	15	15
U-235 Enrichment	90%	90%	90%	90%
Initial U-235 Content (g)	200	158	150	117
Number of Assemblies	80	24	86	17

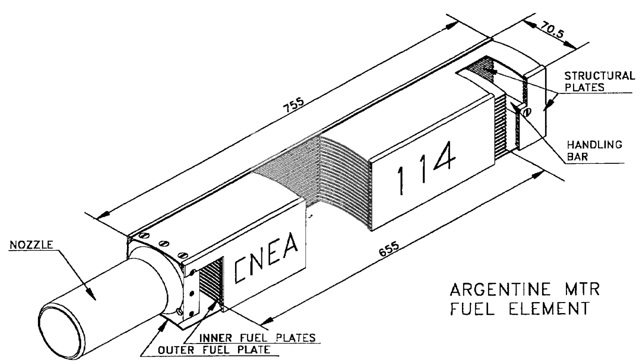

Figure 1: RA-3 Fuel Assembly

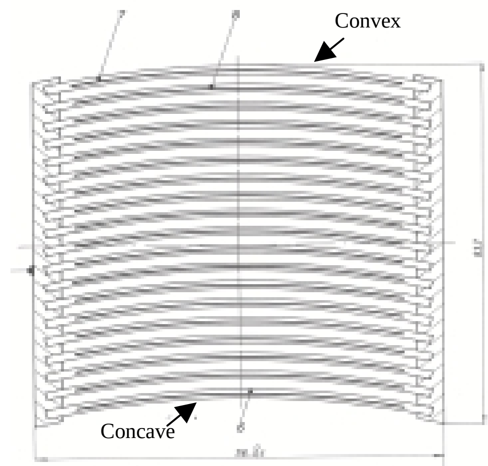

Figure 2: Cross-Sectional View of Fuel Assembly

Assembly cross sectional area is about 8.4 centimeters by 7.6 centimeters, and the fuel plates are roll-swaged to the aluminum side plates.

4. PLANNING FOR COMPREHENSIVE FUEL INSPECTION

A preliminary inspection in June 1999 led to a decision to inspect all 207 HEU assemblies prior to shipment back to the U.S. The physical condition of each assembly was to be characterized during a comprehensive visual inspection and documented. The inspections would assist shippers in preparing cask certifications and provide assurance that the SNF can be safely handled and stored in Savannah River Site basins.

Extensive preparations were undertaken at the Savannah River Site to provide suitable remote inspection equipment and minimize personnel radiation exposure. The Savannah River Technology Center Remote and Specialty Equipment Systems Section developed multiple specialized video systems, monitoring/recording equipment, and fuel handling tools for detailed SNF inspections. Viewing systems included three above ground cameras, a borescope, an underwater video probe, and underwater cameras. Each system was tested at the Savannah River Site to assess relative performance and gain operating experience. A mock storage tube was constructed and filled with water for testing video equipment, and a dummy MTR assembly was utilized.

The best images were obtained with the above ground cameras located approximately 120 degrees apart and four to five feet from the dummy assembly (Figure 3). Pan, tilt, and zoom controls were provided for each above ground camera along with a display screen and a digital video recorder for each camera. These cameras were selected as the primary inspection tool with the intent of inspecting as many assemblies as possible by remotely raising each assembly out of the storage tube.

The video probe allowed full depth viewing inside the water filled storage tubes for assemblies that could not be raised out of the tubes. The video probe consisted of a microminiature color camera sealed in waterproof tubing and fiber-optic lighting. An operator wearing video goggles manually manipulated the probe. The video image was displayed and recorded on the equipment used with the above ground cameras. The videoprobe provided a good quality color picture within a limited field of view.

A small diameter, waterproof camera was installed on a grappling tool to aid in viewing and manually grasping lower assemblies in the storage tubes (Figure 4). The camera signal again was fed to video goggles worn by the fuel-handling operator. The camera-equipped grappling tool was used to manually raise the bottom assembly about 1 meter until the assembly could be secured with another lifting tool described below.

An additional camera was installed on a tripod to facilitate remote in-air transfer of assemblies to other storage tubes. The camera was positioned adjacent to the intended tube at an elevation that gave the hoist operator certainty that the assembly was directly over the tube before lowering. This video image was also displayed and recorded on one of the video screens for the above ground cameras.

Common tong tools were used for grappling and removing assemblies with bails from the storage tubes. For control assemblies that have no bail, a tool with retractable pins was provided to engage openings in the top of the side plates. Multiple tool lengths were supplied to accommodate two-tier storage within the tubes. Each handling tool had a large bail at the top that was manually secured to the auxiliary hoist hook. Each tool also had a manual locking pin securing the operating mechanism after engagement and preventing inadvertent release of a fuel assembly.

Figure 3: Remote Cameras

Figure 4: Camera-equipped Grappling Tool and Video Goggles

5. CNEA EQUIPMENT PREPARATIONS FOR COMPREHENSIVE INSPECTION

Some modifications were required to CSF equipment and facilities to support in-air inspections of fuel assemblies. A block shield wall was erected inside the Equipment Building to reduce radiation exposure at the camera control station. This building is approximately 10 meters from the CSF, and coaxial camera cables were suspended between the two buildings.

The auxiliary hoist on the CSF overhead crane was upgraded with a new speed reducer. A hook with a keeper was installed on this hoist to ensure the fuel handling tools could not be released inadvertently.

The pendant control for the overhead crane was supplemented with a new wireless remote control. The new controller operated the crane bridge, trolley, and the main and auxiliary hoists. The wireless remote control enhanced radiation protection for the crane operator by allowing him to remain fully behind the shield wall in the CSF during all in-air fuel handling.

6. INSPECTION SEQUENCE

Comision Nacional de Energia Atomica and Westinghouse Savannah River Company personnel performed the comprehensive SNF inspection during a three-week period beginning in late October 1999. The inspection program was divided into four phases. The program progressed from easy hands-on inspections of unirradiated assemblies to the more difficult remote inspection and consolidation of HEU assemblies. The general inspection sequence was as follows:

1. Hands-on inspection and digital photography of six unirradiated assemblies.
2. Remote above grade video camera inspection of irradiated assemblies from storage tubes containing single assemblies. Each assembly was simply raised for inspection and lowered back into the tube afterward (Figure 5).
3. Remote above grade video camera inspection of irradiated assemblies from storage tubes containing two stacked assemblies. The top assembly was relocated to another storage tube after inspection to allow the lower assembly to be raised for viewing.
4. Video probe inspections of fuel assemblies that either could not be raised or required downward looking views.

The remote above grade video camera inspection required between four and nine minutes per assembly. One hundred ninety eight assemblies were inspected with this process. The cameras were manually repositioned after inspecting assemblies in two or three adjoining storage tubes. The remaining nine assemblies were inspected hands-on or with the videoprobe.

Figure 5: In-Air Inspection

The three above grade video cameras were typically positioned to provide clear views of both outer fuel plates and at least one side plate on each assembly after removal from the storage tube. Operators zoomed and focused each camera on the plate in view and panned up and down the full length of the assembly while recording the inspection on digital videotape. The inspection record for each assembly consisted of 4 to 6 minutes (7 to 9 minutes for the control assemblies) of videotape from the three cameras. Special emphasis was placed on recording the assembly identification numbers and any abnormal characteristics such as damage or excessive corrosion.

Facility personnel sheltered behind the monitoring and control station shield wall inside the Equipment Building or withdrew to a safe distance from the CSF while assemblies were in air (Figure 6).

The crane operator and a radiological control technician sheltered behind the shielded wall inside the CSF. Personnel behind the shield wall utilized two-way radios to communicate with the crane operator. Radios were also utilized to communicate with the control station while repositioning the cameras between assembly inspections.

Entrance into the area around the CSF was controlled and barricades set-up. A rotating and flashing warning light was utilized to signify when the in-air inspections were in progress.

Figure 6: Equipment Building Monitoring Station

7. CORROSION ASSESSMENT

The 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. Corrosion nodules less than 1/8 inch in diameter were assumed not to penetrate the fuel plate cladding. This 1/8 inch criteria is based upon corrosion surveillance testing at the Savannah River Site and field inspections at other research reactors. About 45% of the fuel assemblies exhibited minimal or no corrosion damage, and only 10% of the inventory showed any significant corrosion indications. The reviews concluded that the SNF condition is generally satisfactory for handling, shipment, and storage in the Savannah River Site Basins. It was noted that three assemblies were missing bails and that one assembly contained a stainless steel thermocouple. There were no observations of corrosion damage different to that encountered from on fuel inspection trips at other research reactors.

A database documenting inspection results and a photo album of still images were created during the review. This information was provided to the Department of Energy and the SNF shipping contractor to aid loading and transportation preparations. Placement of corroded assemblies into sealed secondary confinement cans will not be required.

8. SUMMARY

Extensive preplanning by CNEA and WSRC personnel facilitated the SNF inspections and no major delays were encountered. Visual inspections of all 207 HEU assemblies were completed in 15 working days versus the 21 days originally allocated. Personnel worked 12-hour days, six days per week to set up and perform the inspections. Typically 14 to 18 assemblies were inspected per day.

No transferable contamination was detected inside the CSF despite extensive in-air handling of SNF. Routine use of consumable gloves, shoe covers, and absorbent paper minimized the risk of spreading contamination.

The remote in-air inspection methodology effectively limited personnel radiation exposure. The total cumulative dose received by all personnel (19 total persons participated in the effort and the typical daily staff was about 10 persons) was about 1,000 millirem. Each worker wore electronic dosimeters with alarm setpoints and carefully tracked accumulated exposure.

The video cameras provided excellent resolution and clarity during in-air inspections of the SNF. The digital videotapes maintained this resolution.