USE OF A DEEP AND NARROW POOL TO STORE SPENT FUEL

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ABSTRACT

Storage Facility for Irradiated Fuel from Research Reactors (FACIRI, from its acronym in Spanish) is an away-from-reactor wet interim storage facility for spent fuel that has been definitively discharged from CNEA's research reactors.
FACIRI comprises a group of basins and associated systems which had originally been designed to transfer the PHWR spent fuel from the Atucha I nuclear power plant to the first cell in the reprocessing-cell line. The reprocessing project was closed before start-up and the basins remained unused.
Therefore, the storage concept was determined by the existing storage pool pit, with a 5 m^2 surface and a depth of 16 m, and which is linked to an 8-metre-deep auxiliary pool where the fuel is unloaded from the transport container prior to transferring to its storage position.
In line with the shape of the pit, the storage concept is based on baskets, each holding up to 32 MTR-type fuel assemblies, which can be piled to form columns. The pit hosts two columns, one with nine baskets and another one with ten. There are three different types of baskets: for standard fuel assemblies, for control fuel assemblies and for encapsulated fuel. Baskets are mainly built in aluminium, particularly those parts that are in contact with the spent fuel, which stands in full contact with the water bulk. Pool water is demineralised and the facility has a water purification system that includes filtering and deionisation to ensure the water quality needed to preserve fuel integrity.
Baskets have a cylindrical shape, with the cross section representing the major (5/6) sector of a circle. The spaces representing the minor (1/6) sectors of the circles, when the baskets in the column are conveniently aligned, generate an access canal to lower levels. This access is used to guide the fuel with the appropriate grappling tool to the selected storage position.
Another important feature of the baskets is that each of them may swivel round 360° independently from the rest of the column, thus allowing proper alignment to create access to any storage position. Swivelling requires little torque thanks to the use of a set of bearings conveniently distributed in the baskets and in the column supporting structure. The baskets are manually turned with a special tool that slides into the central shaft of the basket column up to the position required to engage the selected basket.

1. INTRODUCTION

The National Atomic Energy Commission (CNEA) owns and operates all research reactors in Argentina and is responsible for spent fuel management. The only research reactor that currently generates spent fuel the country is the RA-3 reactor (10 MW) located at Ezeiza Atomic Centre (CAE, from its acronym in Spanish). RA-3 core is composed by aluminium based MTR-type fuel assemblies.

In order to improve and expand its spent fuel storage capacity, CNEA initiated a project to implement a new away-from-reactor wet interim storage facility using an existing group of basins and associated systems which had originally been designed to transfer the PHWR spent fuel from the Atucha I nuclear power plant to the first cell in the reprocessing-cell line. The reprocessing project was closed before start-up and the basins remained unused.

As a result of this initiative, the Storage Facility for Irradiated Fuel from Research Reactors (FACIRI, from its acronym in Spanish) started up. This facility provides the necessary capacity to not only hold the RA-3 fuel assemblies stored in the former storage facility, but also the spent fuel output of that reactor for approximately the next 20 years, as well as the irradiated fuel from RA-0, RA-1 and RA-6 reactors. The cladding and structural parts of all these fuels are made of aluminium alloys, and the nuclear material is low-enrichment uranium.

● 2. STORAGE CONCEPT

The main storage basin of the facility was originally designed for the short-term storage of spent fuel from Atucha I (which is approximately 5m long) before entering in the reprocessing line. This fact determined the size of the pit: It is 16 m deep and has a small horizontal section (approximately 5 m^2). Since research reactor fuel is only approximately 1m long, a new storage concept was developed to make use of the volume given by the large depth. The selected storage concept consists of baskets that stack one over the other, forming columns inside the pit (Figure 1). The storage pool houses two columns of baskets, one with ten baskets and the other with nine. The geometry of the baskets is cylindrical and each can store up to 32 fuels. Considering the two columns of baskets, the total number of storage positions ascends to 608. The fuels are stored in vertical position and in full contact with the water bulk.

The storage pool is connected with a smaller auxiliary pool, only 8 m in depth, which is used for the reception of the spent fuel discharged from the shielded transfer container. This auxiliary pool is also used to perform various complementary underwater operations on the spent fuel (encapsulation, visual inspection, gamma spectrometry, etc.).

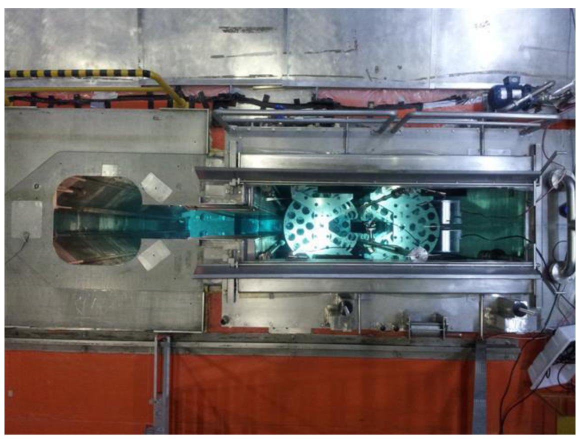

Fig. 1: Top view of FACIRI pools. To the left, the auxiliary pool. To the right, the storage pool with the two columns of cylindrical baskets underwater.

Baskets have a cylindrical shape, with the cross section representing the major (5/6) sector of a circle. The spaces representing the minor (1/6) sectors of the circles, when the baskets in the column are conveniently aligned, generate an access canal to lower levels, in particular, to the selected basket. Then, the fuel is guided along this access with the appropriate grappling tool to the selected storage position (Figure 2 and 3).

Each basket's shaft consists of a hollow tube of stainless steel that allows them to be fitted to one another, thus generating a central hollow axis in the respective column. Except for the mentioned shaft, baskets are built in aluminium, particularly those parts that are in contact with the spent fuel.

Another fundamental design feature is that each basket can swivel round 360° independently of the rest of the baskets in the column. Swivelling of the baskets requires little torque thanks to the use of a set of bearings conveniently distributed in the baskets and in the column supporting structure. The baskets are manually rotated with a special tool that can slide through the central axis of the column and engage at the position required to swivel the desired basket.

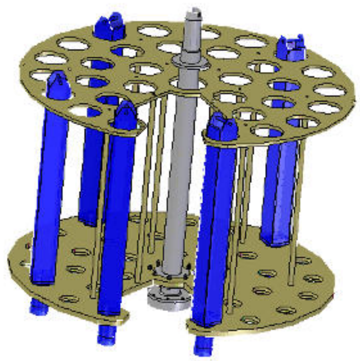

Fig. 2: Basket for storage of standard MTR fuel.

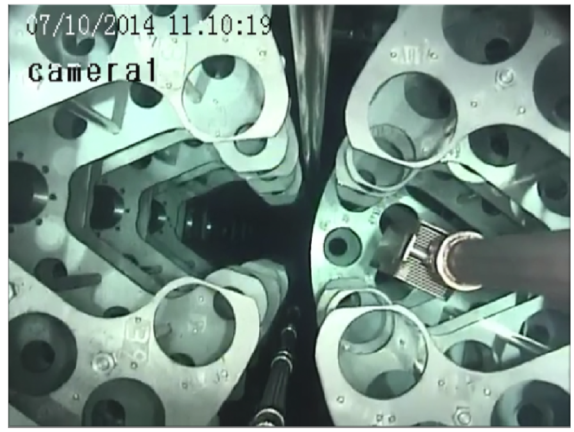

Fig. 3: Fuel descent through the canal formed by the alignment of the baskets.

Three different types of baskets exist depending on the type of fuel to be stored:

- Baskets for standard MTR fuel,
- Baskets for control MTR fuel and,
- Baskets for fuel isolation cans, which are used to store various kinds of fuel (e.g. failed MTR-type fuel or fuel pins such as those used in RA-1 reactor).

Columns rest on a supporting structure which hangs fixed to the exterior of the pit at ground level. This structure also functions as a mean of alignment of the columns maintaining the geometry of the system. As the structure hangs from the exterior of the pit, there is no structure in contact with the pool floor, and contacts with the lining of the pool are minimized.

Underwater operations are monitored through two underwater cameras with zoom, pan / tilt and illumination features. Video output of the underwater operations is recorded, thus enabling video fuel inspection (Figure 4).

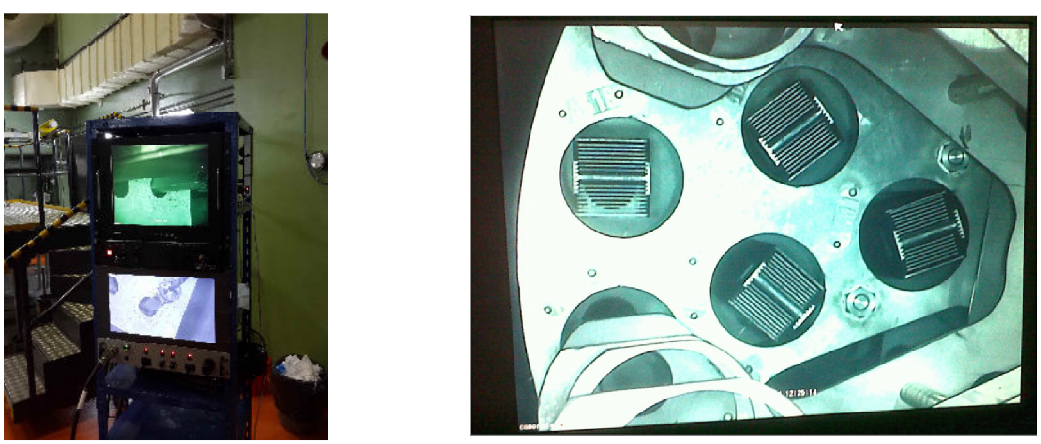

Fig. 4: Underwater camera systems used in FACIRI. To the right, view of fuels stored in a basket.

3. FACILITY OPERATION

The facility operates in two marked stages. The first, the reception stage, starts with the reception of the fuel transfer system and ends with the discharge of the fuel in the auxiliary pool. Usually, this stage is repeated until 4 fuels have been discharged in this pool. The second stage is the inspection, canning (if necessary) and the storage of the fuels in the storage pool.

The RA-3 reactor, the former storage facility and FACIRI are located on the same atomic centre. Therefore, simple fuel transfer systems are available to move one spent fuel at a time from the former two to the latter. These systems basically consist of a shielded container mounted on a cart. The fuel is transported vertically inside and it is either introduced or removed through the lower end of the container with the aid of an ad-hoc hoist.

Once the transfer system enters the facility inlet bay, it is subjected to a reception control that includes dose rate measurements. Then, the shielded container is conveniently attached with a set of slings to the main hoist of the facility bridge crane, slightly lifted and moved across the facility main room up to the auxiliary pool (Figure 5). The bridge crane with its 40 ton main hoist is a key component of the storage facility; it is also equipped with a 2-ton hoist for general purposes, and a 0.75-ton hoist for handling the underwater tools.

The container is centred and positioned on top of the auxiliary pool, where an auxiliary shielding assembly has been installed. This assembly consists of a metallic plate attached to a cylindrical shielding lined in stainless steel. When necessary, a shielded adapter is added. Its lower part stays submerged in the water bulk when the device is mounted on the pit mouth. Therefore, with the fuel container positioned on top of the auxiliary shielding, a shielded canal is formed for the fuel discharge. The container lid is opened and the fuel lowered along the safe path by the ad-hoc hoist until the fuel is inserted in a rack; then the fuel is disengaged from the hoist hook.

Fig. 5: View of the manoeuvres with the shielded container during the fuel discharge operations in order to position it on top of the auxiliary pool.

After reception operations are finished, the fuel is transferred from the auxiliary pool to the storage position at the storage pool. Grappling tools are long enough to allow the operator on a mobile platform to access to any of the baskets underwater (Figure 6). These tools consist of a stainless steel tube of approximately 5 cm in diameter and 15 m long, with a manual control for opening and closing the clamp mechanism at the tip (Figure 7). Due to their weight, the tools must be operated with the aid of the bridge crane.

Fig. 6: View of the operator on the mobile platform handling a grappling tool.

Fig. 7: Testing of the grappling tool for standard type MTR fuel and fuel isolation cans.

When the fuel reaches the access canal, a visual inspection is performed using underwater cameras. Video records of the outer surfaces of each fuel are stored to assess its evolution in time. Then the fuel is transferred to the storage pool, where it is softly lowered and inserted in the selected basket storage position.

● 4. WATER QUALITY

An ion exchange system maintains the quality of the demineralised water at the appropriate levels of conductivity (about 1 µS/cm) to preserve the integrity of spent fuel during storage.

Water purification operations mainly consist in the circulation of approximately 240 m^3 of pool water per month (representing approximately 4 renovations of the water contained in the pool) through a mechanical filtering device and a deionization system (mixed ion-exchange resin bed). In accordance with international recommendations, periodical measurements of pH, conductivity and temperature are carried out at three sampling points at different depths. Besides, water chemical and radiological content are periodically measured. The results of the conductivity measurements are shown in Figure 8. It is interesting to note a slight tendency to the water stratification along the pool depth that can be noted in the conductivity and temperature measurements, as well as in the corrosion and microbiological evaluations. To prevent this phenomenon, the facility has an internal recirculation system to keep homogenised the water bulk, which is used in conjunction with the main water treatment system.

High resolution gamma spectrometry measurements of water pool showed evidence of sporadic presence of Co-60 and Cs-137 (less than 7 Bq/l and 13 Bq/l respectively) just after fuel storage operations. Radionuclides activity falls below the detection threshold (1.1 Bq/l and 1.6 Bq/l, respectively) after the subsequent water purification treatment.

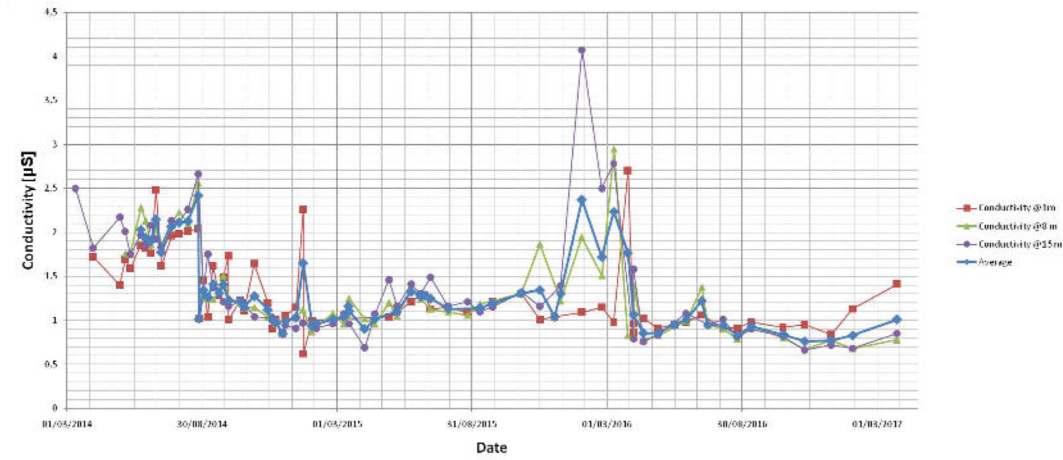

Fig. 8: Evolution of conductivity of the storage pool.

5. CONCLUSIONS

The need to expand the research reactor spent fuel storage capacity in CNEA required the implementation of a new facility which led to the adaptation of a deep and narrow storage pool. FACIRI implementation demanded an exhaustive process that included the refurbishment of the pools, storage concept selection and detail engineering of its complex column structures, the fine-tuning of systems and devices and operation practices, cold tests, the preparation of mandatory documentation, training and qualification of the operating personnel and finally a hot start up process prior to the facility licensing. All these stages proved that the facility is able of receive and store spent fuel safely. The staff proved to be well trained to operate the facility. FACIRI's operating license was granted in November 2016. At the time of writing, 88 MTR type fuel assemblies from the RA-3 reactor and from the former storage facility have been stored in this new facility.

When underwater operation must be performed at larger depths, operator plain view is not enough to track the precise manoeuvres required. Thus, the aid of closer views and additional illumination provided by the camera is essential for the task accomplishment.

Storage operations with the long grappling tools require operator expertise, but their utilisation did not present insuperable difficulties, even when the manoeuvres were at deeper levels.

Procedures to maintain fuel integrity (water quality control, corrosion surveillance by coupon racks, microbiological studies, underwater visual inspection, etc.) have been implemented. Studies to assess the evolution of the stored fuel will be implemented in the near future.

Collective gamma dose Hp(10) for the reception of the first 60 fuels was 493 μSv, giving an average of 1,07 μSv per fuel per operator. Dose received due to the underwater operations was negligible so far.