

Experience in unattended monitoring systems applied to PHWR reactors in Argentina–
Progress Achieved

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Summary

The progress achieved with the unattended monitoring safeguards systems (UMS) applied for verification of spent fuel transfers in PHWR nuclear power plants in Argentina is described. The safeguards verification activities to cover the spent fuel transfers between two nuclear reactors in Atucha complex have been done using a mobile system based on neutron detectors and surveillance applied to the various stages of the transfer process. These systems are verified during the routine inspections at these facilities. For this verification a specific joint procedure IAEA/ABACC has been successfully applied over the last year.

Another UMS project has been tested for a long period at Embalse nuclear power reactor. This system covers the spent fuel transfers from the pond to the dry storage site. This UMS is a more complex system based on different types of detectors, containment and surveillance means and its application is combined with unannounced inspections (UIs).

The main components of these systems and the results achieved are presented. The expectations for the future in terms of safeguards efficiency and effectiveness are discussed.

The field trials and the continuous cooperation with the Argentinean Nuclear Regulatory Authority (ARN) and the Facility Operators have been fundamental for the successful development and implementation of the UMS concept under the framework of the ABACC-IAEA joint use of equipment and technologies.

1. Introduction

The Embalse Nuclear Power Plant (CNE) started commercial operation in 1984. It is a CANDU 600-type on-load re-fuelling reactor for electrical generation. The net electrical output of the unit is 600 MW(e). The reactor uses heavy water as moderator and as coolant and its fuel is natural uranium in form of bundles. The reactor containment building is separate from the spent fuel building. Besides electrical power, CNE is also used to produce Cobalt-60, a radioisotope used in medical and industrial applications.

In this type of reactor a large inspection effort is spent verifying SF transfers from the pond to dry storages.¹ In order to reduce this inspection effort, ABACC and the IAEA created a Working Group (WG) to analyze the safeguards practices and activities, as well as a possible application of Unattended Monitoring Systems (UMS).² As result, ABACC and the IAEA developed an UMS Joint Use Procedure in 2014.³

The Nuclear Power Plant President Juan Domingo Perón (CNA1) is an on-load 363 MW(e) pressurized heavy water reactor (PHWR) of Siemens design that commenced operation in 1974. The reactor core is composed of 252 fuel elements installed in cooling channels. Taking into consideration the operational needs, the current SF inventory and the maximum capacity of the SF ponds, the SF storage has reached its maximum capacity. As the construction of a dry storage is not yet completed, the facility operator provisory started transferring SF to the pond of the Nuclear Power Plant President Néstor Kirchner (CNA2). The CNA2, located next to CNA1, is also an on-load PHWR with similar design as CNA1, but it has 745 MW(e) of power

and started operating in 2015. ABACC and the IAEA developed a Joint Procedure for the verification of these transfers using UMS.⁴

This paper describes the main components of the unattended monitoring systems used in Embalse and Atucha and the results achieved up to now. The impact on safeguards efficiency and effectiveness is discussed.

2. Unattended Monitoring System Applied for SF Transfers in Embalse

The dry storage in Embalse was constructed in 1993 to cope with the SF storage demand during the reactor lifetime. The SF bundles must remain at least 5 years in the wet storage for thermal cooling and radioactive decay before being transferred to the dry storage.⁵ The SF is stored in above ground, reinforced concrete storage canisters (silos), as presented in the Figure 1 and silo details scheme in the Figure 2. There are a total of 216 silos constructed to date. The dry storage consists of concrete shielded canisters, each canister capable of containing up to 9 baskets. The basket design is such that up to 60 spent fuel bundles can be loaded and, therefore, each canister can safely store up to 540 spent fuel bundles. The loaded spent fuel silos are kept under dual C/S with both E-type and cobra seals.



Figure 1: The modular array of concrete silos (dry storage) at Embalse.

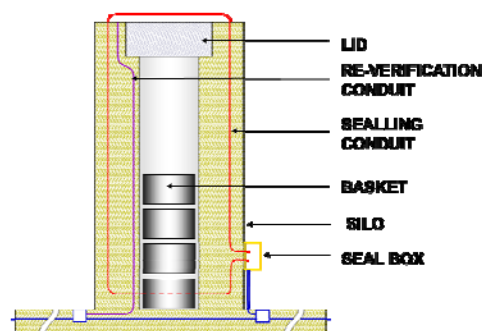


Figure 2: Scheme of a silo (dry storage) at Embalse.

An UMS was developed to increase the efficiency and and the effectiveness of the transfer verification. The proposed methodology meets the safeguards requirements to maintain continuity knowledge during all phases of the SF transfer, as all diversion scenarios are covered through application of NDA measures, and surveillance and containment means.

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In order to achieve 100% coverage of the nuclear material involved in transfers over the material balance period, UIs are performed on a random basis for verification at selected access points of the SF transfers. The main objectives of unannounced inspections are 1) to confirm the declared activities submitted by the operator in the mailbox, 2) to check the UMS performance and deter for any tampering with the system and 3) to perform inspection activities, depending on the current operational process status.

The core fuel discharge is monitored by the VXI Integrated Fuel Monitor (VIFM) & Core Discharge Monitor (CDM) and the spent fuel transfer to the bay is counted using the CANDU spent fuel bundle counter (VIFB). The main, reception and defective bays are monitored by a digital surveillance system consisting of overhead cameras monitoring the spent fuel and underwater cameras monitoring the cobalt source transfers.

The SF transfers to the Dry Storage Area (DSA) are monitored by a UMS, which includes:

- i) Under water cameras monitoring the loading of SF bundles into a basket in the main pond;
- ii) Additionally connected to the VIFB system, gamma detectors in collimators in the main pond;
- iii) Y/N monitors installed on the welding station to monitor any basket transfers from the spent fuel bay to the welding station;
- iv) Gamma detectors per Silo are installed at the start of each SF transfer campaign in empty silos monitored by SEGM designated to operate in turn as long the silos are filled and connected to the VIFB system.

This facility has two SF flasks for transferring SF baskets from the bay area to the DSA. Both SF flasks are normally parked in the main bay, adjacent to the drying/welding station area. The main components of the UMS system are schematically presented in the Figure 3.

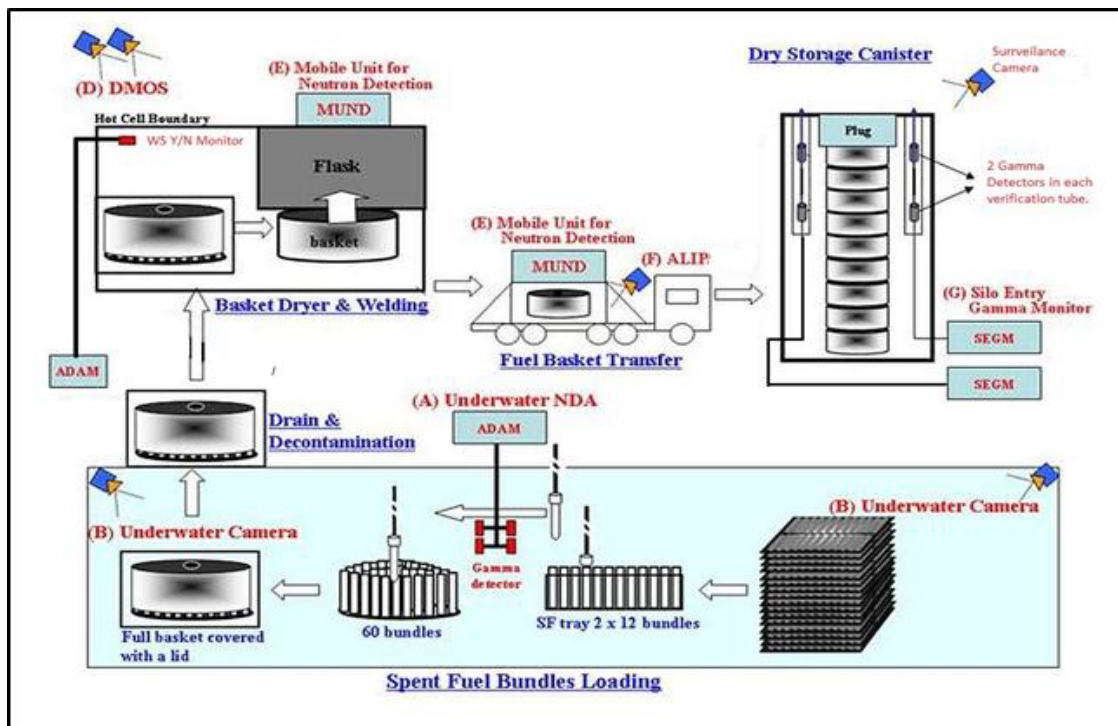


Figure 3: Installation of UMS for CANDU Spent Fuel Transfer at Embalse NPP

3. Results for Unattended Monitoring System Applied for SF Transfer in Embalse

The experience acquired during the last four years has demonstrated the reliability of the UMS system. There were no discontinuities occurred in the measurements due to data loss or detector failure. The gamma detectors in the pool and welding station are connected directly to the VIFM and the cameras in this area are also connected to the Digital Multi-camera Optical Surveillance System (DMOS).

The collection of data using neutron detector is achieved through data logger with storage capacity for up to two years. The detectors system in the silos operates with two cabinets and NGAM data acquisition modules.

The surveillance system consists of two types of cameras and the components of the UMS have been tested under adverse environmental conditions.

The cameras installed on the trailers work in standalone mode and have the capability to operate for 45 days. The MUNDS also operate in standalone mode with the same capacity.

The system now is under field trial with the presence of inspectorate on site to evaluate the equipment performance. Once the system has operated successfully (without failure) for a full inspection period, it will be ready for routinely application.

4. Safeguards Equipment Used for Unattended Monitoring System Applied for SF Transfer in Atucha

The SF transport flasks are specially designed for transfer in Atucha and they are manufactured to accommodate one SF per flask. Atucha fuel element is about 6 meters long and 10 centimeter diameter. A total of four SF flasks and two transport trailers have been used during the transfer campaign. Each trailer has capacity for carrying two flasks per transfer.

The measures to meet the Safeguards Criteria for On Load Reactors⁶ are described in the Safeguards Procedure for the verification of spent fuel transfers from Atucha 1 (CNA1) to Atucha 2 (CNA2) nuclear power plants⁴. In order to maintain the continuity of knowledge (CoK) on the SF, the safeguards approach considers a combination of surveillance and neutron detection.

The Figure 4 shows the trailer with two surveillance cameras installed and one flask with a MUND neutron detector (Mobile Unit for Neutron Detection).



Figure 4: The trailer for flask transfer with surveillance and MUND detector

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A surveillance system covering the ponds and removal route of spent fuels has been implemented using existing cameras at the CNA1 and CNA2 SF ponds. In addition, temporary cameras were installed on the transport trailers. Each transport trailer was fitted with ALIP + NGSS cameras. An additional temporary NGSS camera was installed at the CNA2 fuel receiving area.

A 100% surveillance coverage of the nuclear material inventory contained in SF during the transfer campaign was achieved as follows:

- At CNA1
 - a. Monitoring through surveillance the unloading process of the empty flask moving from the trailer into the SF pond. The MUND count rate confirms that flask is empty. Loading of SF into the flask was verified using the routine surveillance at SF pond building 1. In addition, the MUND count rate confirms that SF is inside the flask. Loading of the flask onto the transport trailer is monitored using the temporary NGSS+ALIP cameras installed on each of the transport trailers and camera at SF pond building 1.
- Between CNA1 and CNA2
 - b. Monitoring the transfers of the loaded/empty flasks through NGSS+ALIP surveillance installed on each transport trailer.
 - c. Monitoring the presence of SF in flasks during the transfer through a redundant MUND installed on each flask.
- At CNA2
 - a. Monitoring the unloading process of the flask from the transport trailer containing a SF to the pond through surveillance at the fuel receiving area. The movement of the transport trailer inside the containment area has been achieved using a temporary NGSS camera installed at the CNA2 fuel receiving area.
 - b. Monitoring the arrival of the full flask to the SF unloading area through surveillance over the SF ponds. At this position the MUND detector system confirms that the SF was moved from the flask to the pond, and the flask is then empty. The routine NGSS camera at the pond building monitors the whole flask movements. Finally when both flasks are empty and stored on the trailer, the MUND's on each flask confirm that they are empty. The camera monitors the exit of the pond fuel receiving area.

The MUND detector systems are generally designed to provide CoK during SF transfer from the reactor building to a dry storage location. In this application, the SF transfer is carried out between two spent fuel ponds, and a typical MUND neutron detector signature is presented in the Figure 5.

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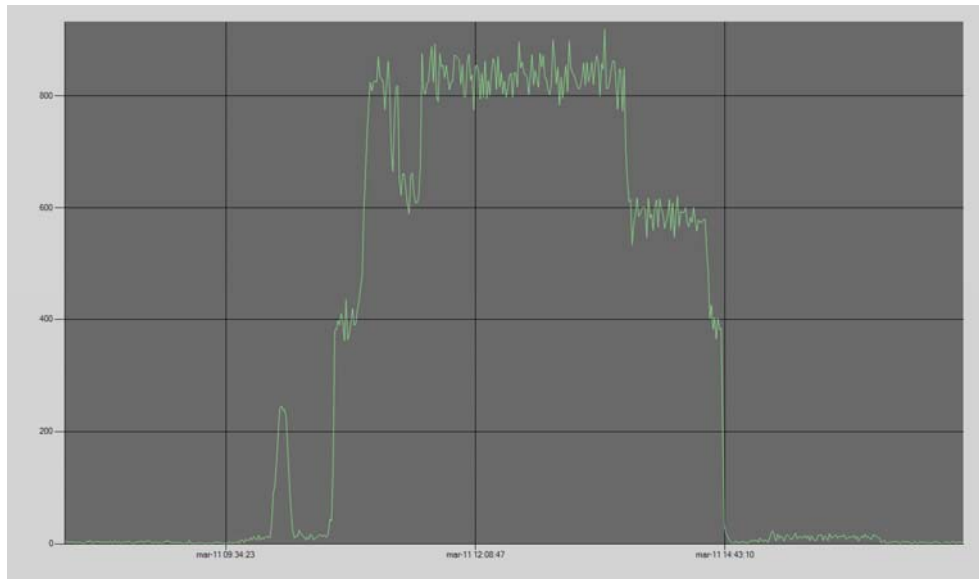


Figure 5: MUND neutron count rate signature during SF transfer from CNA1 to CNA2

The general concept for MUND installation was to place one MUND box on each of the transfer shipping flasks (four MUND boxes in total). For MUND battery charging and data collection, a docking station consisting of one or two cabinets, pending on the vehicle's/shipping flasks' parking location.

The docking station infrastructure allows unattended data download to the collect computer, and battery recharging.

For the maintenance of the MUND detector systems, two options were analysed:

- Stand Alone MUND: Inspectors exchange MUNDs, during an inspection scheduled for this purpose, download data and connect the MUND removed from the shipping flask to the docking station for charging;
- Unattended data download: Connection of the MUND box to the docking station by the operator and/or state authority every week while the MUND remain mounted on the shipping flask.

The preferred option was the second one, but the first one could be implemented as a temporary solution.

5. Conclusions

The cooperation between ABACC, the IAEA, the Argentinean National Authority and the Operator led to a rationalization of the safeguard's activities at Embalse Nuclear Power Plant, in particular for the spent fuel bundles transfer to the dry storage. ABACC/IAEA safeguards measures and activities have been approved to be implemented during partial UMS test for spent fuel transfers to dry storage in Embalse.

As consequence, the inspection effort applied for transfer verification is expected to be significantly reduced.

Based on the experience in Embalse, the application of unattended monitoring systems for verification of SF transfers in Atucha over the last two year has been successful. A significant reduction of 150 inspector-days per year could be achieved.

6. Acknowledgements

The continuous cooperation of the Argentinean Nuclear Regulatory Authority (ARN) and the Operators has been fundamental for ABACC successful developing and implementing UMS to verify spent fuel transfers in Argentinean nuclear power plants.

The continuous coordination between ABACC technical officers and the technical staff of IAEA Safeguards Operation B has allowed the optimal development of procedures and approaches for nuclear power plants in Argentina.

7. References

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