EARLY CONCEPTION OF AN UNATTENDED MONITORING SYSTEM FOR SPENT FUEL TRANSFERS TO DRY STORAGE AT ATUCHA 1 NUCLEAR POWER PLANT

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Abstract

Atucha I Nuclear Power Plant (NPP) is a pressurized heavy-water reactor (PHWR) located 100 km from the city of Buenos Aires, Argentina. It employs slightly enriched uranium (0.85 ^{235}Uw%) as fuel and heavy water for cooling and neutron moderation. It is the first nuclear power plant in Latin America and it has been in operation since 1974. Its current gross electrical power is 362 MW.

The Nuclear Regulatory Authority (ARN) of Argentina is the State organization responsible for issuing the reactor operation license, including nuclear safeguards requirements. Atucha I NPP is under safeguards control by the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC) and the International Atomic Energy Agency (IAEA).

Taking into account the Atucha I NPP lifespan project, the operator has constructed a new dry storage building next to the spent fuel building. This new building has the capacity to allocate 2754 spent fuel assemblies. The fuel assemblies are defined as difficult-to-access (DTA) upon to their insertion into the silo of the storage. Therefore, specific safeguards measures should be implemented to maintain the continuity of knowledge of the nuclear material during the whole storage period.

The commissioning of the dry storage will be carried out during 2022. During November and December 2021 all the necessary safeguards equipment for unattended monitoring of the SF transfers were installed by ABACC and the IAEA. This paper describes the process applied during the construction to define the safeguards technologies and methods to monitor this activity, which involves early interactions with the project designers, operator, ARN, ABACC, and the IAEA. Additionally, it details the equipment installed to maintain the Continuity of Knowledge (CoK) during the transfers of the nuclear material for dry storage based on a dual containment and surveillance (C/S) concept.

1. BACKGROUND

Atucha I NPP is a Siemens-KWU on-load refueling power reactor with a gross electrical power output of 363 MWe. It uses slightly enriched uranium (0.85% concentration of the isotope U-235) for fuel and heavy water as the coolant and moderator. Each fuel assembly has 37 active bars with a length of 5.3 m. It has been in operation since 1974 and is the first nuclear power plant commissioned in Latin America.

A new dry storage (named ASECQ) has been constructed as an extension of the spent fuel ponds building. The new dry storage system for spent fuel assemblies is composed by 306 silos. Each silo containing a canister for nine fuel assemblies. Therefore, more than 200 SQ will be stored.

The safeguards aspects were considered since the beginnings of project. The discussions included the operator company Nucleoeléctrica Argentina S.A. (NA-SA), the designer National Commission of Atomic Energy (CNEA), the national regulator ARN, and the safeguards agencies ABACC and IAEA.

In September 2016 ARN and the Department of Energy of the United States of America (DOE) and the National Nuclear Security Administration (NNSA) organized the workshop “Containment and Surveillance for Spent Nuclear Fuel at Atucha 1”. This workshop was held at ARN Headquarters in Buenos Aires, Argentina. The participants included experts from NA-SA, CNEA, ARN, ABACC, IAEA, and DOE/NNSA. The objective of the workshop was to discuss the different technologies that could be used to maintain the CoK during the transfers of the nuclear material from spent fuel ponds to the dry storage. For the workshop’s table top exercises, the participants were divided in groups. Each group had designers, operators, regulators, and safeguards experts. As a result of the workshop the designers were aware of the importance of safeguards and they were open to made design modifications to include safeguards equipment.

Since the beginning of the project, the operator and the ARN agreed that the CoK should be maintained by an unattended monitoring system (UMS) in order to reduce the presence of inspectors during the transfers and to minimize the collective dose. The relatively high temperature and dose rates expected on top of the full silos were the reason to explore an alternative containment technology instead of the application of metal seals. To tackle this challenge, the Laser Curtain for Containment (LCCT) was developed by the IAEA with the technical assistance of the European Commission’s Joint Research Center and with support of ABACC and Argentina. Before the system could be authorized for safeguards use, a series of extensive field tests under real conditions were conducted at one Argentinian facility under the Argentine Member State Support Program.

ARN established as a requirement that the operator include within its official project schedule the installation of safeguards equipment. In this way, the installation of the safeguards´ equipment was an integral part of the project.

One of the most important challenges was to define the organizational structure and the chain of responsibilities that were necessary to carry out the project. The joint planning made it possible to identify the necessary delivery times for the supplies and services provided by the contractors, the necessary technical requirements for the facility, as well as the technical details of the C/S system, LCCT technology and the others UMS equipment.

During the dry storage construction, the operator proposed to perform four Design Information Verification per year, one in each inspection (three Interim Inspections and one Physical Inventory Verification). These visits allowed ABACC and IAEA to interact directly with the designers and operators to find the best solution to the issues that arose about the location and installation of the equipment. The verification measures and activities finally agreed by NA-SA, ARN, ABACC, and IAEA, maintain the CoK during the transfers using solid and reliable technology, adequate backup systems and concise procedures.

2. DESCRIPTION OF THE DRY STORAGE

The ASECQ building is a massive reinforced concrete structure with external walls 0.75m thick, where the SFs, previously verified and kept in the SF ponds, are stored. The storage capacity is of 2,754 SFs. The only SF transfer route to the ASECQ is through a gate between the ASECQ and the SF pond building. The components of the system are:

The Storage Unit (UA, Spanish acronym) is a stainless-steel container (basket) with a capacity to store 9 spent fuel assemblies. It consists of 9 tubes which house one SF assembly per tube and has penetrations to allow for air circulation/cooling when placed inside the Silo Unit.

The Silo Unit (US, Spanish acronym) is a 5 mm thick stainless-steel watertight box with an airtight seal cap. Equipment for drawing and monitoring the vacuum inside the US is installed on top of it. Each US houses one UA containing 9 spent fuel assemblies.

The Transport Container (CT, Spanish acronym) is a shielded container to house a UA during transfer from the SF pond to the dry storage, where the UA will be unloaded inside the corresponding US. The CT weights 48 metric tons.

3. SAFEGUARDS MEASURES FOR THE TRANSFER AND THE STORAGE

The UMS was developed to increase the efficiency and the effectiveness of the transfers verification and to reduce the doses of the personnel involved. The proposed methodology meets the safeguards requirements to maintain CoK during all phases of the SF transfer and to contain the SFs stored at the silos. The UMS in Atucha 1 is based on a combination of surveillance cameras (NGSS), LCCT system and NDA equipment to cover the entire SF transfers and their storage in the ASECQ.

The transfers start with the loading of nine SF assemblies into a UA in the maneuvering pond. Underwater SF counters detectors verify the selected spent fuel assemblies by attribute test (gamma radiation detection) with simultaneous 100% item counting, while they are being loaded into a UA. The detectors can distinguish the direction of the SF assembly to determine if the SF is being loaded or unloaded.

In addition, in the maneuvering pond there are underwater cameras (UWCs) to perform l00% item counting and all related operations thereby confirming that nine SF assemblies are loaded into a UA and the UA is properly lifted into the CT. The UWCs also can ensure the absence of shielding of the underwater SF counters detectors.

Once the UA is full, the UA is loaded into the CT. The transfer of the CT from the maneuvering pond to ASECQ and the unloading of the UA into a selected US is monitored by a MUND (Mobile Unit Neutron Detector). The MUND confirms that the UA was properly underwater loaded into the CT, transferred to the ASECQ building and unloaded to a selected US. As a safeguards requirement, the MUND (Mobile Unit Neutron Detector) should be installed before the start of the commissioning. Due to some delay in its manufacturing, some especial arrangement would to be done. The close collaboration among all parties allowed the ABACC and IAEA technicians to install the MUND in the transport container at the manufacturer company.

The UMS surveillance system also considers NGSS cameras already installed in the SF building to monitor the transfers, and new NGSS cameras installed in the dry storage area.

In addition, the LCCT system detects the designated US position where the UA is loaded in the SF storage vault and monitors the CT in the SF storage vault. It also detects the presence of any large items in the storage area. The LCCT system creates a containment curtail which detects intrusion into predefined regions-of-interests (ROIs), allowing to detect if a UA is removed from the dry storage. The LCCT and the surveillance cameras compose the dual C/S system in the ASECQ.

All components have redundancy and backup power supply provided by UPS systems and transmit its State-of-Health (SoH) data remotely to ABACC and the IAEA-HQs. In case of any problem related to the SoH, ABACC contacts ARN to notify about the situation and plan the necessary activities in order to check the systems and bring them back to full operations (remotely or through on-site technical visits).

Is important to remark that all the components of UMS were tested at the facility and the necessary adjustments were done before the start of the transfers. In addition, the first transfer was also monitored by inspectors in order to verify that all UMS components were working properly.

4. CONCLUSIONS

The early interaction among the designer, the operator, the national regulator, IAEA, and ABACC to identify safeguards concepts and technologies was highly advantageous for the project.

The national regulatory requirements to include the installation of safeguards equipment in the official schedule of the project brought extremely beneficial results. The awareness of the designers about the safeguards issues made possible to include all the considerations and requirements inherent to international safeguards.

The design modifications to include the safeguards equipment helps to avoid the extra costs of installing safeguards equipment at the facility and optimize all those factors related to operation, safety and security.

It is important to test all the components of UMS at the facility before the start of the transfers. This allow the technicians to made all the necessary adjustments without the risk of losing the CoK.

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