The Verification of Spent Fuel Elements in Atucha I.

A Well Succeeded Experience.

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The Argentine nuclear reactor Atucha I, designed in the sixties and operating since 1974, is of the type Pressure Heavy Water Reactor – PHWR and its reload of fuel elements is accomplished during its normal operation, not being necessary to shut it down for reload (it is known as an On Load Reactor).

At the time when it was designed and started operating, the criteria of safeguards applied to this type of reactor did not require the total verification of the spent fuel elements which would be stored in the pools after being used-up in the reactor. The safeguards approaches evolved with the purpose of dealing with the various scenarios of diversion and, from 1991 onwards, the total verification of the spent fuel elements has been required before they can be stored in the storage pools.

On account of its design, from which there are very few similar exemplars in the world, Atucha I utilizes fuel of peculiar format and dimensions. Their movements in the pools and between the pool and the reactor are complex activities. Besides, the spent fuel elements are stored compactedly in two layers of difficult access. The movements for the retrieval or transfer of these fuel elements from their storage location require a great deal of effort from the operator. Since it was not built in compliance with the requirements of the new criteria of safeguards, for many years the facility had been failing to conform to these criteria, which began to affect the results of the verification process of all nuclear materials of the country, due to the amount of spent fuel elements that were considered as non-verified. Consequently, it became a priority to develop a methodology and install the equipments which would allow to meet these criteria.

In the recent past, several solutions were tested in order to satisfy the safeguards requirements, but all the attempts were frustrated due to the complexity of the storage as well as to the need to install equipments in a reactor that was already built and operating. The impossibility to install the measuring instruments in channels which were already fully concluded arouse from the very necessity of having to make perforations of great dimensions for the installation and from the lack of access to locations protected by great construction works.

In order to reach a solution, the problem was divided in two phases:

- Create a methodology able to verify the movement of any new spent fuel element which is placed into the storage pool or of any of the old ones that for any reason should return to the ractor.
- Verification of the spent fuel elements already stored, in order to establish a control on the initial inventory.

NB: Scenarios of retrieval of spent fuel elements from the storage pool in flasks are covered through the permanent surveillance of the pools.

A nuclear detection system, which is installed in the fuel storage pool contiguous to the entrance of the channel that leads to the reactor, was conceived in order to verify the flux of the spent fuel elements (introduced / retrieved) in the pools, and yet avoid the necessity of great construction works and of shutting down the reactor. The system consists of four solid state detectors capable of distinguishing a spent fuel element from a fresh one or from irradiated tools. The system also allows to determine in which direction the spent fuel element is moving (in or out of the reactor). The signals are transmitted to a central pannel where they are processed electronically (by means of a VIFM System), their corrections are determined and computational tools are made available in order to obtain a complete analysis of the movements. The computational tools facilitate the retrieval and the analysis, by the inspectors, of the information obtained during routine inspections performed at the facility.

In so far as it would be impossible to execute any construction work in the facility, the detectors were installed on the sides of the manoeuver pool for fuel elements. It is necessary that these detectors be constantly surveilled, so as to ensure that they are not shielded or altered, nor suffer any other type of interference. After being installed and tested, the system proved to be reliable and suited to its use, besides offering adequate tools with which the inspectors can draw their conclusions.

Besides the wanted knowledge, it was necessary to employ a great deal of creativity in order to execute the verification of the spent fuel elements already in storage.

The traditional method used for the verification of spent fuel elements consists in counting the total of emissions by means of a detector of cadmium (zinc) telluride, with the confirmation of the peak of cesium in order to characterize the plutonium contained by the fuel. However, this methodolgy proved to be of extreme complex application from the physical-nuclear point of view, due to the high level of radiations (counting) in the proximity of each spent fuel element because of the agglomeration of fuel elements. Attempts were made to perform this measurement through the top of the fuel elements, but they were invalidated because of the non-active portion that exists on the upper part of these elements, which leads to a non-differentiation between the background values and the measurement signal. (Extensions are set on the elements for their manipulation, with the result that the active part of the fuel is located approximately 70 cm lower than the top.) Efforts were made to accomplish the task through the bottom part, facing the difficulties which are inherent to moving remotely a detector in a space not higher than 40 cm. Experiments were also made between the fuel elements, but the amount of shielding required by the detector in order to be able to discriminate the background signal from the measurement made the access impossible, since the available space is of approximately 15 cm.

Thus, the method of counting the total of emissions had to be put aside since it was not adequate to the local conditions, and measurements through the emission of neutrons were tried: first with the evaluation of fast neutrons, which did not work out because the difference of the signals was too small for the discrimination, and then with thermal neutrons. In order to do so, the concept of a set of four fuel elements stored in the shape of a square with one element on each vertex was developed, in which the detector is introduced inside the square (at the crossing of the diagonals) in order to measure the total emission of neutrons for the four elements. Thus, it was possible to obtain a counting discriminating quite precisely the difference between sets containing 4, 3 (with 1 empty, not spent or dummy vertex), 2 or only 1 fuel element. Several tests were accomplished to establish the new methodology and to determine its limits of acceptancy and errors. This new method and the associated equipment are known by SFNC (Spent Fuel Neutron Counter).

The right positioning of the detector and its manipulation inside the sets of stored fuel elements were still to be solved. A new testing phase followed, with the purpose of developing a device that would allow to move the detector and setting it in the right position without causing damage to nor interfere with the spent fuel elements. The high level of compactedness with which the fuel elements are stored, as well as the local working conditions (through a rolling bridge over the pool) turned this task into a difficult one, for whose accomplishment the IAEA and ABACC had to develop several systems as wella as mechanical and optical devices.

All these activities, including the measurement tests, the acquirement of the equipments and devices, the installation of the system and the final testing in the field, were carried out within a year and a half.

A considerable effort was made by all the parties involved, the operator of the nuclear power plant of Atucha, the National Argentine Authority – ARN, the IAEA and ABACC, in order to turn this system operational in a period of time which can be considered as a record-time. Finally, in January 2004, the inspection for the Verification of the Physical Inventory (PIV) was performed, during which the inventory of the spent fuel elements stored in the pool was verified and the system for the control of the flux of fuel elements was put into operation. Soon, the inspections for the periodic verification of the facility will be carried out and, hopefully, they will bring forth more experience with and performance data of the Fuel Counter, as well as practice in subaqueous surveillance.
Having been implanted successfully, the new system shall make it possible to meet the new safeguards criteria and avoid an impact in the evaluation of all the nuclear material in the country.