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ALTERNATIVES TO REACH SAFEGUARDS GOALS AT ATUCHA I NUCLEAR POWER PLANT

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ABSTRACT

This paper describes the main features of Atucha I Nuclear Power Plant (NPP) and the traditional safeguards approach applied to the plant up to now by the IAEA and ABACC. This facility was built in the 70´s and has been in operation since 1974. Due to the application of Safeguards Criteria 1991-1995, this reactor has partially attained the quantity component of the inspection goal, as with the current safeguard scheme the scenario of unrecorded Pu production is not fully covered. To reach this goal it seems necessary to acquire a system to qualitatively measure irradiated fuels moved between the reactor and the pond and vice versa.

In this regard, a study has been carried out by the Nuclear Regulatory Authority of Argentina (ARN) jointly with ABACC to determine the feasibility of monitoring the flow of spent fuels by detecting the radiation emitted by them. This proposal tends not only to fulfil safeguards requirements but also to minimize the facility constructive modifications. This last is a very important aspect considering the NPP has been working for twenty seven years. This study shows a positive balance as permits reaching safeguards goals according to safeguards criteria in use nowadays requiring very little modifications to the plant. A detailed description of the unattended system proposed will be given.

In this paper it was also considered a potential alternative to the implementation of an unattended system based on an scheme of unannounced inspections. Finally, to conclude this paper, we offer a comparison between those two alternatives aiming at arriving at the best conclusion to comply with the IAEA and ABACC requirements without falling in undesirable constructive modifications to this plant.

1. DESCRIPTION OF ATUCHA I NUCLEAR POWER PLANT (NPP)

Atucha I is an on load pressured heavy water reactor (PHWR). The Net Power of this NPP is 335 MW. The reactor started operation with natural uranium fuels but now it works with low enriched uranium fuel assemblies (0,85%). The core grid has a capacity of 252 fuels. Each fuel is formed by 37 rods placed in three concentric circles and with an active length of 5,300 mm. One of this rods is structural. The reactor is refrigerated and moderated by D2O. There are two parallel circuits for the refrigerator and two parallel circuits for the moderator. In this Plant there are two pools for storing the spent fuels. The re-fuelling frequency, for low enriched fuels, is of 0,72 fuels per day when the reactor is working at high power. There is only one channel between the reactor and the pool and the flow of fuels (fresh, burnt up and semi burnt up) is through it.
Currently, there are approximately 8,100 spent fuels in the pool what stands for 550 SQ.

2. CURRENT SAFEGUARDS APPROACH AT ATUCHA I NPP

The current safeguard approach is based on the combination of inspection activities, complemented with the application of containment and surveillance measures. The auditing activities require the preparation of a set of operational and accounting records and reports. All of them are handled by the operator during the inspections.

All the above mentioned measures were designed to cope with the following diversion scenarios:

- Diversion of spent fuels from the reactor core through the big component gates in the containment sphere of the reactor.
- Diversion of the spent fuels from the pond area..
- Unrecorded Production of Plutonium, partially covered.

As the timeliness verification goal for irradiated fuel is three month, routine inspections are performed with a frequency of 4 inspections per year. During a routine inspection the following activities are carried out:

- Auditing of the operator records to look for consistency with the reports.
- Verification of the operating records.
- The spent fuels at the higher level of the ponds and the accessible fuels in the lower levels are counted .
- Re-change of the seals (standards, equipment)
- Surveillance System Service.
- The change of the TLD´s installed in the containment.

During a Physical Inventory Verification, the following activities are performed by the inspectors:

- Auditing of operating and accounting records.
- Counting, identification and NDA of fresh fuels.
- Counting of fuels in the pond. Cerenkov effect would be sight for spent fuels.
- The spent fuels at the lower level are counted using an underwater camera.
- Service of the surveillance system (MIV cameras, there are five installed at the pond area).
- Occasionally, a first quick review of the films in the field with a handling monitor.
- The change of the TLD´s installed in the containment.

The inventory in the core of the reactor is not static as the fuels are continuously exchanged at an average rate of 0.72 fuels per day and the activities performed do not permit to know the flow of fuels going in and out of the reactor core.

3. POSSIBLE MISUSE SCENARIO NOT COVERED BY THE CURRENT APPROACH

Atucha I was built in 70´s and revising the possible misuse scenarios that might be applied to this NPP, it was found that the unrecorded production of Pu had not been fully covered since Criteria 91-95 has been applied.

In any on load reactor the exchange rate of fuels, using declared or undeclared fresh fuels, might be increased by lowering the average burn-up of the fuels. The hypothesis to be considered is the increase in the exchange rate, falsifying all the applicable records. Under this consideration the number of spent fuels transferred to the pond might be higher than declared by the operator. This, obviously reflects the inventory in the pond is bigger than declared and therefore the Pu production is not fully covered by the Agencies. Finally, by inducing a surveillance failure at the pond area the extras spent fuels assemblies could be removed. As clearly could be understood a re-verification of the pond inventory would not detect this diversion scenario.

Some alternatives to resolve the problem were already developed . It seems that one possible way to maintain the continuity of knowledge in the core is monitoring all core fuel charges and discharges. This control could be carried out by the installation of an unattended system. Another alternative is the implementation of unannounced inspections complemented by surveillance measures.

4. UNATTENDED SYSTEM DEVELOPPED JOINTLY BY ABACC AND THE NUCLEAR REGULATORY AUTHORITY (ARN) OF ARGENTINA

4.1 Introduction:

The irradiated fuel assemblies might be conducted out of the reactor through three possible ways. The first one refers to two openings in the containment of 12 m and 4 m diameters, those constitute large equipment transfer gates, through which the irradiated fuels might be taken out. These gates are welded and bolted and might be visually verified by the inspectors at any time. The second one is through a channel from the core to the pond by means of a trolley which drives the fuels in or out of the pond.

The loading/unloading fuels process is as follows. When at the core, the removal of the spent fuels are carried out by a large shielded fuelling machine that is holding from a crane. This fuelling machine, operated from the control room, might change the spent fuels by fresh or semi burnt up ones or might change the position of the fuels in the core. This fuelling machine charges up to five fuels. Once the fuelling machine takes the spent fuel element, it is placed on top of a shielded titling flask which contains Heavy Water and the spent fuel is discharged. Then the D_2O is changed by H_2O. Then the titling flask, floaded by H_2O, moves from vertical to horizontal position and it is transported to the pond by the trolley. At the pond the spent fuel is horizontally loaded into a second unshielded tilting device. Then, the spent fuel is placed in vertical position to be loaded and stored in the bay storage racks. In case fresh and semi burnt up fuels are charged to the core the reverse steps described above are followed. See figure 1.

The unattended system jointly proposed by ARN and ABACC is based on a detailed study of the fuel transfer steps above described. The unattended system is formed by gross gamma detectors and a surveillance system dived at the pond focused to the transfer channel. The detectors would be positioned in such a way as to register the direction of each transfer. The underwater cameras would record all the movements through the transfer channel into and out of the bay. Among the functions of these under water cameras might be mentioned that serve as a redundancy of the detectors and as the only possible way to sight the presence of a shielded flask, what might cover the detectors avoiding their readings, or the transfer of irradiated tools. The two sets of shielded and collimated gamma detectors would be located adjacent to the tilting mechanism while it is in the horizontal position. One set of detectors would be located as close as possible to the transfer exit tube. The second set of detectors would be placed downstream, at about a distance of three quarters of the length of a fuel , still in horizontal position. The advantage of using collimated gamma detectors are to improve the ratio signal-background distinguishing between high irradiated fuels and the low burn up ones and to limit the solid angle of vision of the detectors, necessary condition for fuel direction determination.

The detectors shall be placed as close as possible to the tilting mechanism for limiting the space for the introduction of undeclared detector shielding. This closest position would be defined by not disturbing the operator procedures and keeping the detectors in a safe location. The two sets of underwater cameras would be directed to the discharge port and to the tilting mechanism, confirming not only the discharge of the spent fuel but also gamma detectors remain in the right position and that not special shielding is entered to the pond.
To increase the reliability of the whole system, two independent detectors in each position and two independent cameras would be installed. See figure 2.

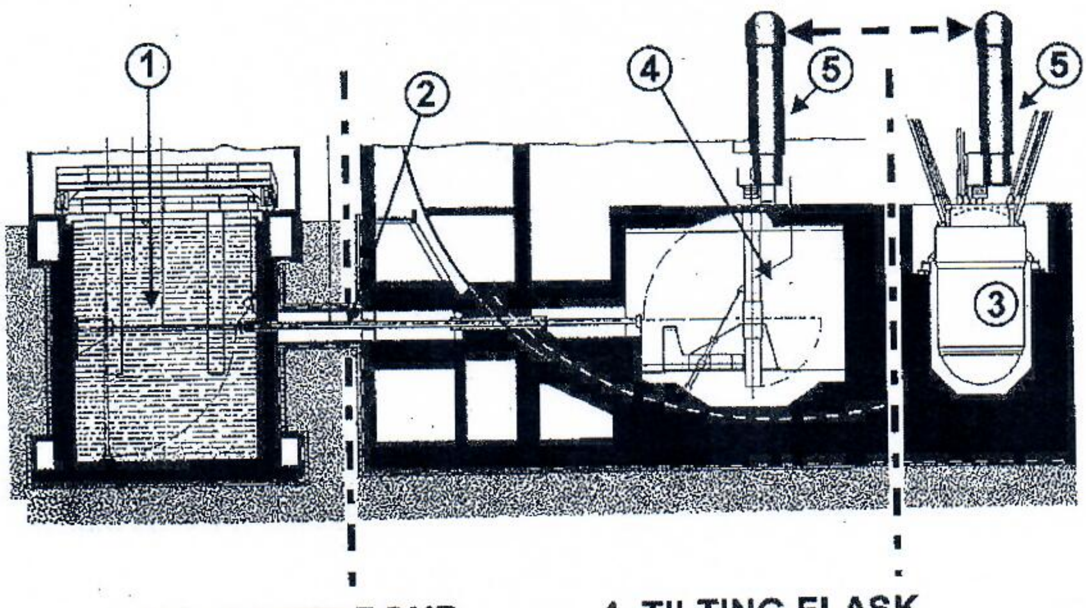
The digital signals from the gamma detectors and the images from the surveillance cameras are sent to a server that would process the data and generate reports and images for a set safeguard period. This server would also have redundant functions for power supply and data storage.

4.2 Basic Parameters involved in the Project:

Time involved: The transfer process is carried out manually and the minimum fuel transfer time from the core to the bay or vice versa is of at least one hour. The constructive characteristic of the detectors

used in the system would define the maximum an the minimum time limits associated to the system. When arriving to the pond the fuel elements would be considered as lineal gamma sources.
Considering the case of a fuel with a maximum burn up, *The Lowest Measurement Time* would be given by the time required by the detector to make the measurement without feeding up. *The Highest Measurement Time* would be defined by the minimum activity detectable by the detectors of the system.

Spent Fuels as Gamma Sources: The gamma activity of a fuel depends on the power at which the reactor had been working and the history of the fuel element. That is to say the period the fuel remained in the core, its position in there and if the fuel was reused (the case of a semi burnt up fuel entering to the core). When a fuel element is taken out of the core, it contains very short half life gamma emitters, that abruptly decay in few minutes, and long half life gamma emitters as Cs 137. As the minimum transfer time from the core to the pond is of about an hour, we would only consider the case of long half life gamma rays emitters. For the specific case of spent fuels with very low burn up an so very low quantity of long half life fission products, specific considerations would be made taking into consideration the detectors specifications.



1 TRANSFER POND
2 TRANSFER CHANNEL
3 REACTOR VESSEL
4 TILTING FLASK
5 FUELLING

Figure 1

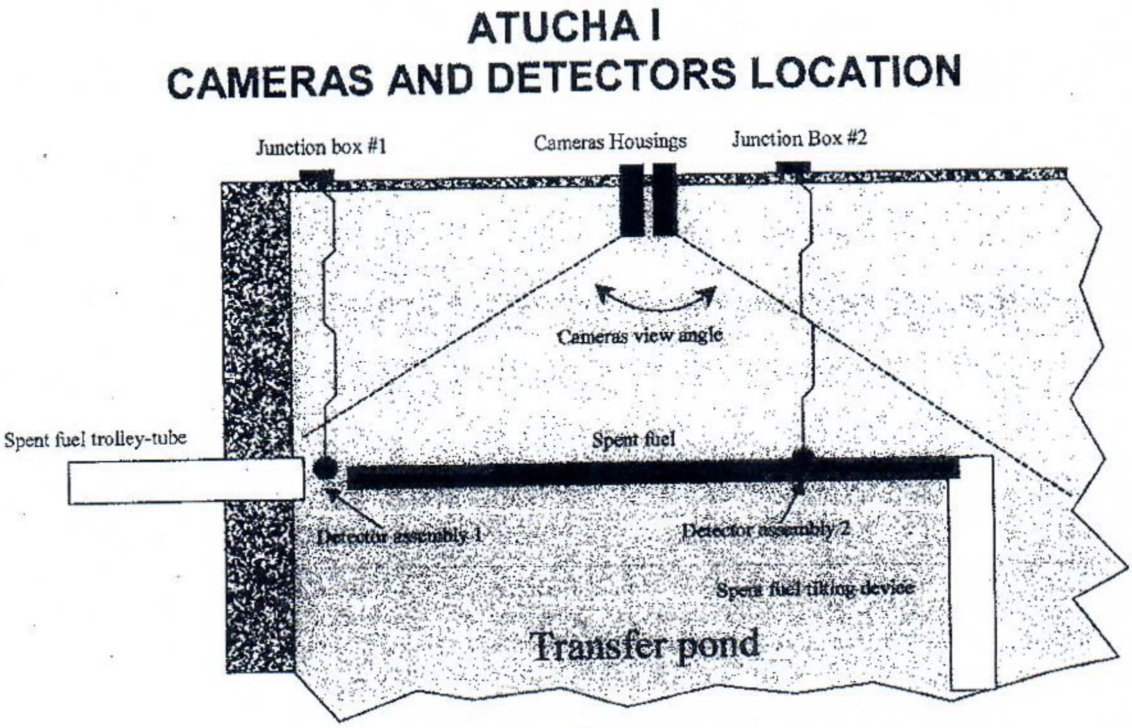


Figure 2

5. POSSIBLE SCHEME OF UNANNOUNCED INSPECTIONS

A potential alternative to cover the scenario described as not completely covered, as it is stated in the SIR, is implementing an unannounced inspection regime strengthened by a surveillance system. Under the current legal framework, the probable detection of undeclared Pu production is associated with the possibility of finding undeclared spent fuels ready to be shipped, for instance inside flasks. Another possibility is given by finding discrepancies between operational records presented by the operator and the effective quantity of fuels verified in the spent fuel storage pools during the inspections.

Activities to be carried out during unannounced inspections:

- The absence of undeclared transfer flask in the pond area shall be verified.
- The number of spent fuels counted in the ponds shall be compared with the spent fuel quantity declared on the updated operator records.

Under the assumption that both activities could be performed successfully, it may be concluded that the unannounced inspection approach covers all the relevant concealment strategies timely. The first concealment strategy considered is a hide away of the transfer flask simultaneously to the inspection arrival. In this regard, we consider the fact of inadvertent shipping of the spent fuel transfer casks almost impossible due to Atucha I fuels length which is about six meters. It must also be considered that the shielding of the shipping cask required to transport those fuels should be very huge. Then the loading and transfer operation require special arrangements, enough time and a carefully planned operation with a simultaneously induced surveillance failure.

The second concealment strategy is to return the undeclared fuels to the reactor building through the transfer channel. This operation requires more than thirty minutes per fuel.

To assure an effective detection probability, the unannounced inspections should be implemented under certain general conditions to obtain an appropriate performance. In our point of view the most important ones are:

a) The unannounced inspections should be carried out at any time and without any restriction.

b) Immediate access to the pool area and specifically to the transfer pond should be possible.

c) The advance notification to the state officers and to the operator should not allow the fulfilling of any of the concealment strategies.

To meet these general conditions we propose an unannounced inspection regime complemented with surveillance measures.

Two cameras focusing to the transfer pool area form the additional surveillance system. One of the cameras should be an underwater camera located in the transfer pond. It should be set to record images from the port of the transfer channel and the external camera should be set to record the activities in the dry transfer pool. The system should have an adequate redundancy to avoid tampering and single failure (at least a back up camera for each one will be installed). Due to memory capacity restrictions, the server will save in memory the images taken along three or four consecutive days. After the fourth day, the server will reset its memory records and will begin a new record cycle. To fulfil the first condition the surveillance system should be designed to send the information encrypted to IAEA and ABACC review station, that could, for instance, be located in B A.

By the surveillance system the inspector will have unrestricted and immediate access to the images from the transfer pool area without sending any notification to the state or to the operator. Then, conditions b) and c) are automatically met. In addition the four day record cycle setting gives the access to the activities in the transfer pool area during national holidays and weekends and so condition a) is also complied.

In addition to the images recorded by the surveillance system, the quantity of spent fuels discharged from the core and the quantity of semi burnt fuels charged to the core should be declared to meet safeguards criteria.

The main activity to be carried out during an unannounced inspection is the verification of the operator declaration. In this regard, some arrangements should be discussed with the State as some current procedures should be modified to fulfil the inspection goals. For instance, the information about the core fuelling and reshuffling are currently updated monthly and the implementation of an unannounced inspection regime should require daily or weekly availability of this information.

6. GENERAL REMARKS ON IMPLEMENTATION OF AN UNATTENDED SYSTEM AND THE UNANNOUNCED INSPECTION REGIME

1) For the implementation of both systems, the experience already gained with remote monitoring system at Embalse NPP is useful. On one hand, unannounced inspections should require the installation of underwater cameras and the remote transmission of images and on the other hand, the unattended system should require the installation of detectors, underwater cameras and the availability of server capacity,
2) For both systems the state of health should be checked.
3) The failure of the unattended system would require the spent fuel inventory re-verification
4) The unattended system should be designed to detect all the movement of any spent fuel. That is to say the system should detect the long time decay fuels, the short time decay fuels and the fuels that have been in the core for a very short period of time. It also should detect any irradiated tool or refrigerating channels to be changed.

5) The implementation of unannounced inspections regime implies negotiations between the State and the Agencies about the procedures to be applied, the information to be transmitted outside the facility, the cameras setting period for the recording cycle, etc.
6) The implementation of unannounced inspections will require the modification of the current procedure to declare Nuclear Production. The monthly calculate of Nuclear Production will be made daily or weekly depending on the cameras time setting.
7) Unannounced inspection regime requires less initial investment.
8) From the operator point view the unattended system is less intrusive.
9) Both system do not imply any relevant modification to the facility.
10) The unattended system could be implemented with authorised devices from the IAEA, nevertheless some tests should be performed beforehand.
11) In case the IAEA authorised devices are not suitable for the system, some development should be carried out but the final components should be approved by the IAEA.
12) For the current legal framework it seems better to implement the unattended system.