EXPERIENCE IN DEVELOPING SAFEGUARDS' PERFORMANCE REQUIREMENTS FOR A REMOTE MONITORING SYSTEM

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Abstract

Most of the inspection effort at a typical CANDU 600 Nuclear Power Station located at Embalse, Cordoba Province, Argentine Republic, is associated with the activities for safeguarding the transfers of spent fuel bundles from the ponds to a dry storage. The foregoing receives the attention of a special working group during its deliberations and the consideration of the application of new technologies such as a remote monitoring system (RMS). A RMS started to be developed in 1995 and the intention of the designers is to offer the system to the safeguards organizations, being the IAEA and ABACC the main potential "users" of such system.

One of the main task of the working group was to prepare a set of safeguards performance requirements that should fulfill a RMS to be accepted for safeguards use, a situation that seems to be new in safeguards. Performance requirements were widely use in the past for development or acceptance of safeguards equipment. However, in this case the requirements must be formulated in such a way as to provide freedom to the designers and the underlying safeguards concepts were part of the task.

The paper describe the problems faced, the process followed for developing the performance requirements and presents the main requirements. It should be noted that the requirements are intended as a guide to the designers of the RMS and an useful tool for the evaluation of a proposed design by the potential users (i.e. the safeguards organizations). Finally, it is indicated that although the requirements presented were developed for an specific case they can be an useful reference when dealing with similar cases.

Introduction

The Embalse Nuclear Power Station (EMBALSE NPS) is a typical CANDU 600 Reactor that started to operate in 1983. It is located in the Cordoba Province, about 800-km from Buenos Aires, Argentina. In 1993, a dry storage was built to extend the storage capacity of spent fuel bundles (SFB) at the facility. For dry storage, the spent fuel bundles are loaded into steel baskets. A steel cover is welded to the basket to form a leak-tight containment. The dry storage consists of concrete shielded canisters, each canister capable of containing up to 9 baskets. Each basket can accommodate up to 60 bundles and, therefore, every canister can safely store up to 540 spent fuel bundles with a cooling time usually of more than five years (one significant quantity, i.e., 8 kg of plutonium, is contained in about 120 SFB or 2 full loaded baskets).

Since the start of the operation of the dry storage most of the inspection effort at this facility is associated with the activities for safeguarding the transfers of SFB from the ponds to the dry storage where they are placed under a dual C/S system.

The transfers of SFB from the ponds to the canisters is made manually and basically consist of the following steps:

a) Lowering of the internal transfer flask (flask 1), loaded with an empty basket, into the spent fuel pond;
b) Collection of the SFB and transfer to the cask loading position (underwater);
c) Loading of 60 SFB into the basket (underwater);
d) Lifting of flask 1 out of the water and transfer into the welding cell.
e) Unloading of the basket, drying, and welding;
f) Loading of the welded basket into the external transfer flask (flask 2);
g) Transfer of flask 2 from the welding cell to the designated canister (by truck), flask 1 returning to the pond (step a);
h) Removing the canister lid, positioning flask 2 on top of the canister, and unloading the basket;
i) Removing of flask 2 and closing the canister with the lid;
j) Once the canister is fully loaded, the lid is welded to the canister liner.

The current safeguards activities can be summarized as follows: After loading of the SFB into the basket (step c) the inspectors count and randomly identify and verify by NDA the loaded SFB (two out of sixty SFB are usually verified) and maintain the continuity of knowledge until cask loading has been completed with step j) and a dual C/S system is applied. A gamma profile of the loaded canister is taken using special tubes located inside the concrete shield.

Transfers of SFB to dry storage do not take place all around the year but are organized in campaigns. Usually one campaign per year is performed which will last about three months. The transfer operations need to follow a sequential order into which the safeguard activities are integrated. Therefore, although the actual safeguards activities does not usually exceed 4 hours per working day, the process may requires inspectors to be available at the facility for 10 to 12 hours per day.

The Problem

By the end of 1995, the IAEA and ABACC agreed to establish a working group to analyze the safeguards activities at EMBALSE and to make recommendations aimed at increasing the efficiency and effectiveness. The Argentinean National Authority was invited to participate, and the WG met twice a year in 1996, 1997, and 1998 when it concluded its activities and produced a final report.

Also in 1995, the Argentinean National Authority and the Department of Energy (USA) initiated a study aimed at developing a remote monitoring system (RMS) for safeguarding the transfers of SFB from the pond to the canisters (meanwhile the Agency and ABACC have joined this effort). The system is at present under development and the first full test is scheduled to take place during the 1999 transfer campaign. The challenge for the designer of the remote monitoring system is notable, considering that the Operator will not change his procedures, i.e., the human control and operation of the spent fuel transfers to dry storage.

The WG reviewed the safeguards activities implemented at Embalse and made several recommendations for improving the current safeguards practice embracing inspections for interim and physical inventory verifications and for safeguarding the transfers of SFB to the canisters.

One of the main tasks of the WG was to propose requirements that would need to be fulfilled by the RMS under development. This generates what seems to be an unique situation in safeguards: to prepare requirements for an unattended remote monitoring system for which the underlying safeguards approach was not yet defined. In other words, the challenge was to prepare requirements in a way that no special technique or device would be implicitly or explicitly recommended and, at the same time, provide assurance that any RMS that fulfill these requirements would be in principle acceptable for safeguards purposes.

This situation seems to be new in safeguards, where Performance requirements are widely used as guidelines for the development and as criteria for the acceptance of safeguard equipment. However, in these cases the system under development had to fulfill a well-defined function with known applications in safeguards schemes. In addition, usually safeguards approaches were not developed to fulfill a priori fixed requirements but in an iterative process by identifying diversion possibilities, selecting safeguards measures for their detection, investigating concealment possibilities and conceiving safeguards counter measures. In the case of the requirements for a RMS for the spent fuel transfers to dry storage at Embalse, the development of the underlying safeguards concepts were also part of the task.

Although this situation seems to be new in dealing with safeguards, the use of general performance requirements (PR) is a usual practice in other nuclear areas, like radiation protection and nuclear safety. Typical examples are the International Basic Safety Standards/1/ and the Regulations for the Safe Transport of Radioactive Materials/2/. The use of the experience gained in other areas helped the WG in preparing the requirements.

The advantages and difficulties associated to the use of performance requirements are briefly described in the Final Report of the Embalse Working Group/3/. In summary, this approach gives freedom to the designers and has proved to be appropriate in other areas, like nuclear safety, provided that frequent discussions take place between “designers” and “users” during the development (in this case the users are the safeguards organizations).
Although the formulation of the PR was such that freedom was given to the designers, the case of the transfers of SFB to the dry storage at EMBALSE was specifically addressed. Therefore, it is stressed that any extrapolation of such requirements to another case of transfers of SFB to a dry storage may require proper adaptations.

The Process

The process for developing the PR started after the second meeting of the WG that took place at the EMBALSE NPS in occasion of a transfer campaign allowing all participants to observe and analyze the transfers “in situ”. Then a first attempt was made drafting PR covering one part of the transfer operation (from the welding station to the canister). In the following meetings PR where prepared for covering the first part of the transfer operation (from the pond to the welding station) and later on these PR where revised and consolidated.

In developing the performance requirements, the WG followed the iterative process traditionally used for developing safeguards approaches and started with a list of diversion possibilities, which is considered complete. The diversion scenarios considered are briefly described below:

In the Storage Bay:
-the basket load is overstated and the missing SFB remain in the bay until surveillance fail.
-the basket load is understated (e.g. by using a larger basket) and the excess bundles are later removed in other stage (surveillance will record the movement of a declared flask transfer).
Note: basket load operation is carried out underwater and the standard surveillance system is unable to cover these scenarios.

Upon transfer to the welding cell
-the flask used for the transfer from the pond to the welding station can be removed and discharged elsewhere (completely or partly), refilled with dummies and brought back to the

welding cell (exchange of two similar flask is also considered).

In the welding cell:
-SFB are removed from a loaded basket before welding and left into the welding cell. Later these missed SFB may be transferred to another location via either the sliding shielding door or the port for transfer flask 2 (eventually they can return to the Storage Bay using the same flask as before).

Upon transfers to the Canisters
-the flask used for the transfer from the welding station to the canister deviates from the designed route and the basket is discharged elsewhere.

In the Canister
-baskets already loaded are removed and possibly replaced by empty baskets or baskets loaded with dummies.

A more detailed description of the diversion scenarios was included as an Annex to the Final Report/3/ as a guide for improving the understanding of the PR.

The WG, instead of selecting particular safeguards measures, concentrated its efforts to define general requirements which, if fulfilled, will provide adequate safeguards coverage of all identified diversion scenarios without predetermining the applicable safeguards measures. Thus, the functional requirements for the RMS were prepared.

In a second step, the WG investigated the safeguards consequences of a failure to meet a particular requirement and derived technical performance requirements such that the associated risks are limited to a tolerable level, i.e., the events with severest consequences must have the lowest probability of occurrence. The WG further considered requirements regarding data processing, storage, transmission, and evaluation. It was realized, however, that these requirements need to be further specified, once the RM system and the set of generated data are fixed.

The Performance Requirements

The full set of PR prepared by the WG is included in the Final Report. The requirements are divided in two parts; the first deals with functional requirements aimed at fulfilling basic safeguards demands while the second is intended to assure that the system will operate in a reliable manner. The first part of the requirements is presented below:

. -The system shall assure that only successfully verified fuel bundles are loaded into the designated basket.

. - The system shall confirm the number of fuel bundles loaded into the basket.

. - The system shall assure that no fuel bundle is removed/replaced undetected from the basket while the basket remains in the pond.

. - The system shall assure that the loaded basket is transferred from the pond to the welding station and that no fuel bundle is removed undetectedly during this transfer.

. - The system shall assure that no fuel bundle is removed undetected while in the welding station.

. - The system shall confirm that after welding the basket is loaded into the transfer cask and that no bundle remains undetected in the welding station.

. - The system shall assure that the contents of the basket loaded into the transfer cask at the welding station remains unchanged while it is transferred to and loaded into the selected canister.

. - The system shall assure that only the specified basket is loaded into the selected canister.

. - The system shall assure that no basket is removed without detection from a partially or fully loaded canister not yet under dual containment system.

Using this part of the PR and the information available to the WG on the design of the RMS (as of April 1998) it was carried out a preliminary evaluation of the basic conceptual design that indicated that the RMS, as then conceived, did not fulfill all the requirements. The result of such evaluation was transmitted to the designers and all problems identified have been addressed.

Regarding the second part, called “Design Requirements” use was made of safety basic principles aimed at assuring enough reliability, such as redundancy and diversity as well as the criterion of higher the consequence lower the probability. The worst cases of loss of continuity of knowledge were particularly discussed bearing in mind the difficulties for recovering the knowledge for instance of a partially loaded canister or a welded basket. In this regard, special attention was paid to the interaction between the system and the operator, bearing in mind that if the operator proceed with the transfer and the system fail the consequences will be paid by all parties, but particularly by the operator. A detailed exposition of this part of the PR is beyond the scope of this paper but as examples three out of seventeen requirements are included below:

- The probability of a failure of the system that would imply the need to re-verify fuel bundles from a welded basket shall be as low as possible and shall not exceed 10-4 per basket.

- Redundancy and diversity of instruments/equipment shall be used as appropriate to fulfill these requirements, in particular to loaded canisters not yet under dual C/S system.

.- All relevant data information must be stored on site. This will be the primary data storage. Data transmission off site, necessary to provide confirmation to the safeguards' organizations that the system is working properly shall be implemented. On-site review capabilities should be incorporated to the system for inspectorates' use

Conclusion

In cases where safeguards is already based in standard practices for maintaining the continuity of knowledge, like PWR reactors, the main problem for a RMS seems to be the transfer of the safeguards data to the Organizations concerned. In cases like the one described here, where it is intended to move from a human control to a RMS there is a need to establish general safeguards requirements. These requirements will constitute a guide for the designers of an unattended RMS and will be a useful tool for the evaluation of proposed designs by the intended users (i.e., the safeguards organizations). Although the PR presented in this paper were developed for a specific case they could constitute a useful guide for preparing PR for similar cases. Finally, it is noted that other requirements than those described here should be considered by the designers, such us those related with local safety rules, the need to consider external events (e.g. whether conditions) or limitations imposed by safety requirements on the operations. Other requirements needs also be addressed in the safeguards area such as those related with data to be transmitted off site, frequency and timing of such data transmission and data sharing.

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