MISUSE STRATEGIES IN SMALL CENTRIFUGE ENRICHMENT PLANTS

Marco A. Marzo, Alfredo L. Biaggio
ABACC - Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials
Av. Rio Branco 123 Gr. 515, 20040-005 Rio de Janeiro, Brazil

ABSTRACT

Since ABACC started its operation one of the main problems faced was the application of safeguards to a small centrifuge enrichment plant for testing centrifuges in cascade mode. This plant consist of a few fully independent cascades, does not operate in a routine basis and panels prevent visual access to the centrifuges and their surroundings for preserving sensitive information.

The safeguards' objectives for enrichment facilities encompass the detection of the diversion of declared nuclear material as well as the detection of facility misuse. For small centrifuge plants misuse scenarios seems to dominate, particularly those associated with feeding the plant with undeclared LEU. The safeguard's approach for commercial facilities, based on the Hexapartite Project and the evolution thereof, seems not to be directly applicable to these cases.

This paper presents a concise analysis of eventual misuse strategies in a small R&D centrifuge facility and a possible safeguard's approach, suggesting the main control elements to be applied. The particularities arising from the existence of panels or boxes covering the centrifuges are specifically addressed.

INTRODUCTION

ABACC safeguards are intended to fulfill their obligations under the Bilateral[1] and Quadripartite[2] safeguards' agreements in an effective and efficient manner. Since ABACC started its operation one of the main problems faced was the application of safeguards to a small centrifuge enrichment plant for testing centrifuges in cascade mode. The plant consist of a few fully independent cascades, does not operate in a routine basis and panels prevent visual access to the centrifuges and their surroundings for preserving sensitive information. The characteristics of the facility together with the restrictions arising from the operator's right to protect technologically, industrially or commercially sensitive information make complex the design of an appropriate safeguards approach.

Although the facility has a small capacity, its presents many features of a research and development facility and is intended to be very flexible in terms of operation schedule, feeding material and level of uranium enrichment.
Preliminary analysis, looking for ideas and guidelines in use in other parts of the world, showed that for large centrifuge plants there was a significant amount of information on safeguard's approach, safeguards activities and diversion scenarios. In the case of large centrifuge plants the "Hexapartite" approach[3] has been applied, while the information on small centrifuge enrichment plants was scarce. The "Hexapartite" safeguards approach is based on the verification that the facility is operating as declared through a combination of safeguards measures that includes unannounced inspections where the inspectors access to the cascade area can be eventually delayed up to a maximum of two hours.
The IAEA Safeguards Criteria[4} for enrichment facilities using gas centrifuge and other gas dynamic processes are based on the "Hexapartite" safeguards approach and, therefore, are intended for large facilities. For small facilities, when the inventory of any material type is less than one Significant Quantity (SQ), the IAEA Safeguards Criteria seems to consider only an annual physical inventory verification and environmental swipe sampling. The IAEA's Criteria for small facilities were probably developed considering a small plant that operates in a routine basis, which is not the case addressed in this paper.
In the last years environmental swipe sampling has been introduced as a routine safeguard's activity for enrichment facilities being a notorious improvement for safeguarding these plants. This tool may constitute and effective way of confirming that the plant does not produce enrichments larger than declared and is quite appropriate for small plants, where the times involved allow to practically fulfill the timeless component in spite of the delay in getting swipe sampling results.

The safeguard's approaches described above seems not to be directly applicable to a small centrifuge R&D enrichment plant which does not operate in a routine basis an has screens covering the cascades. The non-routine operation, the panels and other constrains intended to preserve sensitive information make it necessary to consider misuse scenarios such as the possibility of feeding the plant with undeclared LEU, either from behind the panels that cover the cascades or through the F/W-stations.

SAFEGUARDS OBJECTIVES

The basic safeguards' objectives are to detect the diversion of significant quantities of nuclear material and to verify that the facility is operating as stated. In general, for enrichment facilities, the safeguards' objectives are:

a) To verify that the plant does not produce highly enriched uranium (HEU);
b) To verify that the plant does not produce significant quantities of undeclared LEU;
c) To verify that declared nuclear material is not diverted from the plant.

Considering these general objectives, specific safeguards' goals are established, according to the type and size of the facility.

MISUSE STRATEGIES

From the safeguard's point of view, the main features of an R&D small centrifuge enrichment plant are the following:

(a) Small equilibrium time and small in process inventory;
(b) Non-routine operation;
(c) Relative short time for HEU production using LEU as feed, even being recycling necessary because of the small capacity;
(d) Small nuclear material inventory;

The item (d) implies that the scenario of diversion of declared material is not relevant. The other points difficult the confirmation of non-misuse of the facility. The verification activities are also complex because the Operator considers the separative work capacity of each cascade and of each centrifuge as sensitive information and the use of feed of different enrichment is foreseen. Considering the flexibility of the facility, the undeclared production of LEU or HEU is the most important scenario to be considered. Being small the capacity of the facility, the only possibility of producing HEU is feeding with LEU (recycle would be necessary to produce a significant quantity). Table 1 presents a summary of the main misuse scenarios and suggested safeguards measures.

Table 1
Analysis of Misuse Scenarios and Proposed Safeguards Measures

Misuse Scenario Safeguards Measures
Undeclared feeding and withdrawing at F/W-station Prompt access
existence of clandestine lines penetrating the F/W-station in unannounced inspections; Environmental Sampling
Undeclared feeding and withdrawing at cascade hall Prompt access
unannounced inspections; Verification that the cascades are not connected in series in unannounced inspections; Verification of existence of clandestine lines penetrating the cascade areas in unannounced inspections; Environmental Sampling

SAFEGUARDS APPROACH

The safeguards approach presented is based on measures aimed at detecting the undeclared production of HEU and LEU; nuclear material accountancy; verification of the flow of nuclear material into and out of the process area; and verification of inventory and inventory changes. The following assumptions are made:

(i) Swipe sampling can effectively detect the undeclared production of HEU and possibly of LEU with enrichment higher than 5%;
(ii) Advance notification will be provided by the Operator to allow the opportune verification of UF6 cylinders (feed cylinders before connection and product and tail cylinders before shipment out of the facility);
(iii) A special NDA method developed for detecting hidden UF6 cylinders can be used; and
(iv) Conditions that would make effective unannounced inspections should be agreed.

In the context described above the safeguards objectives will be fulfilled as follows:

A. - Periodic swipe sampling for covering the objective (a) (undeclared production of HEU and, probably, of LEU with enrichment higher than 5%).
B. - Routine verifications of feed, product and tail flow, auditing of records and other activities aimed at confirming that no declared material has been diverted from the plant and that the plant is operated as declared. Thus covering objective (c) (diversion of declared material), and to some extent objective (b) (undeclared production of LEU up to 5%).
C. - Unannounced verification of the cylinders connected to the F/W station together with NDA for the detecting hidden cylinders behind the panels and other activities as described below for additional confirmation that objective (b) is appropriately covered.

The first alternative approach considered by ABACC was the concept of perimeter control. In this approach all penetrations to/from the perimeter area that includes the cascade hall (doors, windows, pipes, etc), that could be used to introduce/removal nuclear material are covered by containment and/or surveillance. In the case that would be necessary to transfer to the cascade area any container, a NDA method shall be applied to assure that the container has no nuclear material. Container transfers from/to the cascade area shall be notified in advance. This concept has therefore a strong negative impact on the operator's work condition. In addition, due to the possible necessary presence of inspector at the facility, the safeguards cost is high.

In case that the C/S System fails, it should be verified that there is no nuclear material accumulated behind the panels. With this objective, ABACC, in co-operation with the IAEA, and with the support from the Brazilian Nuclear Energy Commission (CNEN) and the Technology Center of the Navy in São Paulo (CTMSP), developed a method using passive gamma and passive and active neutron measurements.

A second alternative safeguard's approach considered is the use of the perimeter control to increase the effectiveness of unannounced inspections. In this approach the perimeter integrity is assured for the time from the arrival of the inspector at the facility until their access to the perimeter. All penetrations to/from the perimeter area that could be used to removal nuclear material in that time interval are covered by containment and/or surveillance. The advantage of this "simplified" perimeter control is that it reduces the impact on the plant operation and the need of the presence of inspectors. At the other hand, as the detection goal in terms of amount of nuclear material is strongly reduced, more NDA measurements are need.

A procedure for announced and unannounced inspection to the F/W-station should allow verifying that the cylinders connected are those previously verified. A particular system for the verification of such cylinders is being used during announced and unannounced inspections. The introduction of the perimeter control will not change this situation.

The unannounced inspections to the cascade hall are able to confirm the independence among cascades as well as the continuity of the main piping between each cascade and their respective F/W-station. This scope is not changed when the perimeter control is applied.

CONCLUSIONS

For a small centrifuge enrichment plant, the lack of transparency due to the panels originates an uncovered misuse scenario, i.e. the F/W behind the panels. As a counteraction ABACC proposed initially to introduce a perimeter control aimed at assuring that the only nuclear material that reach the process area (F/W-station and cascades' hall) is that previously verified. This concept has a negative impact on the facility's operation and its application is expensive. The resolution of potential anomalies required the application of NDA methods at the cascade hall. A simplified perimeter control aimed at assuring the effectiveness of unannounced inspections seems to be the best solution. Swipe sampling is used for confirmation that no HEU was produced, although in this case the conclusion of the activity would have a remarkable delay. Unannounced inspection remains a fundamental tool to cover several other misuse scenarios.

Finally, it is noted that in the context of the new technologies, if an unattended system is installed, unannounced inspections could play a role for confirming that such a system is working properly.

REFERENCES

[1] “Agreement between the Republic of Argentina and the Federative Republic of Brazil for the Exclusively Peaceful Use of Nuclear Energy”. INFCIRC/395. IAEA, Vienna, November 1991

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[3] LOVETT, J. M., “Safeguarding Uranium Enrichment Facilities”. STR-86. IAEA, Vienna, 1979.