INNOVATIVE TOOLS APPLIED TO ENHANCED SAFEGUARDS APPROACHES AT CENTRIFUGE ENRICHMENT FACILITIES

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I – ABSTRACT

ABACC has been involved in the application of safeguards to indigenous sensitive enrichment facilities since the start of its activities in 1994. The implementation of safeguards approaches for these centrifuge enrichment facilities were always guided by the necessity of reducing intrusiveness and by the protection of sensitive information which always were of great concerns to the Agencies and the Operator.

Nevertheless, the approaches approved to be used shall be safeguards efficient and effective. In order to achieve these goals and considering that at the beginning the plants had small enrichment capacity, the approaches had a tendency to rely on significant inspection resources being man-power or facility equipment dedicated. The experience initially gained was very important and useful, and the approaches were implemented with priority on safeguards effectiveness.

As far as the plant enrichment capacity increases the safeguards approach and measures must be updated in order to have an efficient and sound able scheme. Innovative safeguards tools were developed or the old ones were adapted, in order to cover the diversion scenarios on this new situation. New technology measures are also taking into consideration to improve the safeguards approach.

This paper presents the tools used in the ABACC system enrichment facilities to maximize safeguards effectiveness taking into account the non-disclosure of sensitive information and the optimization of the inspection resources whenever the enrichment capacity is increased. Those elements include, among others, the random closing of the SWU and mass balance combined with operational declarations through mailbox; the unannounced access to the cascade hall strengthened by the use of surveillance on some strategic points; managed visual or surveillance access during DIVs and unannounced inspections; use of complementary conventional surveillance and containment on connected cylinders at the feed and withdraw stations and on potential feed points; and, swipe sampling.

The paper addresses the benefits and difficulties of these tools when applied as verification measures to cover main diversion-misuse scenarios contemplated in the safeguards approach.

II - INTRODUCTION

Due to the characteristic of the facilities controlled by ABACC – R&D laboratories and cascade operation testing facilities, which do not have a industrial routine operation and the need to protect sensitive information – alternative safeguards approaches have been developed by

ABACC, in cooperation with the IAEA and Brazil [1]. At present, the challenge is to apply safeguards to the initial steps of construction of one commercial facility that for safeguards purpose can be considered a small commercial centrifuge enrichment facility. Also, in this case, the standard enrichment safeguards approach, usually based on the Hexapartite Project [2], may not be directly applied because the cascades are enclosed in panels due to the operator's requirement to protect sensitive information. However, despite the presence of panels restricting the view of the centrifuges, the managed visual access agreed in this facility assures that the inspectors have access to all the relevant information for safeguards purpose.

The objective of this paper is to present some alternatives and new safeguards tools to be used at this small commercial centrifuge enrichment facility, which is presented as an example case. The facility will produce regularly uranium enriched up to 5% from natural uranium. Cascades are connected in parallel and housed in independent buildings with a common vacuum system and F/W stations. The design capacity less than 150,000 kg SWU/year has been taken as reference facility. The flow of nuclear material and the rate of connection/disconnection of cylinders from the process are low compared with other commercial enrichment facilities and consequently, we can qualify the plant, concerning to safeguards, as a semi-commercial enrichment plant.

Marzo et al. [3] have shown a comparison among the different approaches and scenarios to centrifuge enrichment plants based on the size of the plant. The safeguards tools proposed for the above size of plant makes use of perimeter control, special measurement instruments and operational special procedures to attend the safeguards requirements. These tools are usually very intrusive, requires high inspection effort and operators agreement on plant operational changes.

The innovative tools used on the present safeguards approach have introduced an optimization on the way that the scenarios are covered, reducing or even eliminating the burn of some safeguards tools previously mentioned. A concise analysis of the main elements used as control tools and its coverage of the relevant misuse/diversion scenarios on the safeguards approach are presented in order to assess their applications to example case.

III - SAFEGUARDS TOOLS APPLIED TO SMALL CENTRIFUGE ENRICHMENT FACILITIES

From the safeguards point of view, misuse scenarios are the dominant concerns when developing safeguards approaches for testing or R&D enrichment plants with small SWU capacity installed. The safeguards approach implemented by ABACC in these small R&D ultracentrifuge plants have been aimed to deter the possible misuse scenarios, particularly those associated with feeding the plant with undeclared LEU. Based on this assumption the safeguards approach applies the following safeguards measures, in order to achieve the objectives to cover misuses scenarios:

- Nuclear material accountancy in order to evaluate the correctness and consistency of the accounting and operative information;
- Verification of the physical inventory taking;
- Environmental sampling for detection of HEU or LEU higher than the upper limit declared;
- NDA and DA verification measurements of the nuclear material flow on announced basis. Since the flow and associate process parameters data in R&D plants are considered

confidential, the flow is verified in batches sequences, which requires a large inspection effort even with low throughput;
- Unannounced access to the cascade hall in order to detect any change in the visible configuration of the cascades;
- NDA measurements (gamma plus active and passive neutrons) through the protecting panels during unannounced access to the cascade hall, in order to discard the presence of undeclared nuclear material behind the panels; and,
- C&S measures to increase the effectiveness of the unannounced access to the cascade hall (temporary perimeter).

It is important to mention that in this case we are dealing with small plants, very flexible and with inspection access constraints, such as visual observation, determination of SWU per machine or cascade, usually treated as a technological property secret. This will increase the inspection effort allocated mainly to the NDA verifications, to establish temporary perimeter and the use of associated surveillance.

As long as the plant increases in side, if the access constraints remains the same, the effort necessary to apply the safeguards with the same tools or procedures becomes very large, expensive and sometimes unfeasible due the characteristics of construction.

IV - DIVERSION SCENARIOS FOR SEMI COMMERCIAL CENTRIFUGE ENRICHMENT FACILITIES

The safeguards' objectives for these types of enrichment facilities also consider the detection of the diversion of declared nuclear material and facility misuse.

Diversion scenarios on declared nuclear material include:
- Reporting false flow data; or,
- Reporting a false (inflating) MUF/SRD.

Concealment of these scenarios requires introducing gross, partial or bias defect into uranium or isotopic content in some items, complemented with data falsification.

Relevant scenarios of facility misuse include:
- The production of high enriched uranium (HEU) or low enriched uranium with enrichment higher than 5%; or,
- Undeclared production of low enriched uranium with enrichment lower than 5%.

In this range of the capacity installed (SWU), the facility misuse scenario continues to be the more important concern from the safeguards point of view. The timely detection of unrecorded production of HEU remains the dominant concern. Taking into account this fact, the safeguard approach should evolve towards more standardize models, strengthened any weak point before reaching the capacity for producing HEU in short time.

Based on that, a safeguards approach was developed for this semi-commercial plant covering the credible diversion paths. Due to the characteristics of the plant, flexible in points of connection and dispersed among different buildings, a special attention was given to the possible points for feeding and withdraws. To avoid the application of a very complex system of containment and surveillance, the approach strength the strategic points where an undeclared feeding is feasible, by containment and surveillance, and also strength the control of the declared

feed and withdraw, by flow control. This will cover all relevant scenarios that make use of undeclared material.

V - SAFEGUARDS REQUIREMENTS

For facilities with inventory or throughput higher than one significant quantity (SQ), a set of safeguards activities are required, that include [4]:

- Periodic accounting and operating records auditing;
- Annual physical inventory verification with annual material balance evaluation;
- Internal flow verification (feed, product and tails cylinders) and inventory changes verification (domestic and international transfers, category changes, measure discards, retained wastes, blending, etc.);
- Periodic verification of operator's measurement system;
- Simultaneous verification of similar strata, at different facilities, in order to prevent the presence of borrowed nuclear material during the PIV; and,
- Design information verification.

Additional measures, such as the listed below, shall also be applied may in order to confirm the absence of unrecorded production of direct use material, or any other misuse of the facility.

- Environmental swipe sampling, taking to detect production of uranium enriched higher than declared;
- C&S at the F/W station to maintain the knowledge of connected feed and withdraw cylinders;
- Perimeter control, if the approach so requires;
- Unannounced inspections in strategic points of the plant, including unannounced access to the cascade hall to detect any change in the configuration or undeclared feed and/or withdraw.
- Enhanced DIV to verify relevant information for safeguards purpose with managed access;
- C&S at the strategic points;

All inspection activities aim to verify that declared nuclear material is not diverted, to confirm that the plant operates as declared and to detect any signature of facility misuse can be implemented under the framework of INFCIRC/153 or similar agreements. Inspection activities to detect undeclared nuclear material should be agreed upon between the parties or implemented under other framework.

VI - INNOVATIVE TOOLS APPLIED IN THE SAFEGUARDS APPROACH

The innovative tools applied in this semi-commercial enrichment plant are designed and implemented taking into consideration the following parameters:

- The process design and configuration;
- The Operator constraints on plant information and accessibility based on technical property confidentiality;
- The installed SWU capacity – above R&D and below commercial;
- The storage capacity of the cylinders connected to feed and withdraw stations;
- The rate of connection of cylinders at the feed and withdraw stations;
- The plant layout distribution and points of access during unannounced inspections;
- The information provided by the Operator on process data, related to the process flow;

- The possibility of applying containment and surveillance along strategic points of the process;

The following set of innovative tools has been applied as safeguards measures on this Plant:

- VISUAL, RECORDED AND SURVEILLANCE DIV TOOLS (DIV verification devices)

The objective of this activity is to confirm the validity of the information provided in the DIQ and to verify that no changes have been introduced in the configuration of the cascades, main headers, UF6 F&W stations, general vacuum station, strategic points and building (general containment). In addition, in any opportunity in which the inspectors have access to the cascade hall and other restricted areas, the verification of the absence of clandestine piping or unidentified support equipment introduced in the facility has to be confirmed.

During the unannounced inspections and during the announced DIVs, all the relevant information for DIV purposes is accessible. The National Authority has requested some provisions to protect the disclosure of sensitive information (managed visual access is used as a tool in this case). While the access of the inspectors to all the relevant information for safeguards purposes is assured, this activity is carried out following agreed procedures.

Reference files of the main headers and related piping have been recorded at the baseline DIV and are maintained under seal at the facility (recorded DIV tools). Due to information protection, managed visual access to those parts of the piping near the centrifuge is provided during unannounced access to the cascade hall. To guarantee that no undeclared feed or withdraw is done at these locations, authenticated digital photographs files of these sections are taken during inspections, on a random basis, and compared with baselines or used confirm the configuration remain as declared and to discard the presence of hidden equipment or cylinders in those spaces. Any changes in configuration shall be notified in advance to update the reference files.

The advantage of this visual and recorded enhanced DIV is to replace the NDA measurements used to guarantee that no nuclear material is hidden at points with visual limited access. This process is faster both in preparations for the inspection as when performing the activity.

As long as the plant is increasing the capacity and new cascades are being added to the installation, even the recorded photographs will be a time consuming activity. To handle this problem a moveable surveillance tool, called bird’s eye view system, is under development in order to compare the configuration of the cascades and to verify that undeclared items are not behind the panels. This tool will be used at the moment the access to the cascade hall takes place. A baseline configuration is recorded to be used as reference files during inspections.

Another tool that is being investigated and will help to speed up this verification is Laser Scanning technology that easily allows the comparison between lay out configurations (piping, equipment, etc.) and reference configurations files.

These tools, moveable surveillance - bird’s eye view - and laser technology will allow an enhanced DIV (complete and correct) without disclosing any sensitive information, applicable to plants of relatively large size. The moveable surveillance and laser device developed for this

purpose have to be approved by the IAEA for safeguards application. In this regards, laser technology is being successfully applied in industrial reprocessing plants.

- SWIPE SAMPLING

This activity is carried out on random basis during the year. Swipe samples are collected following agreed procedures on those strategic points referenced in the baseline DIV of the facility. Strategic points located inside the cascade hall are sampled during unannounced inspections and points located outside the cascade hall are sampled during interim inspections.

In addition, during the PIV, samples can be collected at any point of the baseline. Swipe samples are an effective tool for HEU production or enrichment above the declared.

- SWU BALANCE, MAIL BOX and FULL ACCESS TO FEED AND WITHDRAW MATERIAL

The SWU balance, connected with the mail box requirements, is an alternative tool to control material flow on the enrichment plant. The combination of SWU balance, Uranium and U235 closing balance (mass balance), the verifications of all cylinders to be connected or disconnected form the process during interim and PIV inspections, the confirmation of the cylinder movement at unannounced inspections, the rate of cylinders to be connected and access to the feed and withdraws balances allows the Agencies to calculate almost exactly the process flow. Besides, all these information strength the control in many points of the plant.

This activity is performed three times a year on random basis and during the PIV. This activity demands the taking of DA samples from the F, P, and T lines simultaneously during any inspection (interim or unannounced) randomly selected. In order to confirm the mass and SWU balance, access to the load cells data at the UF6 F&W station and the provision of supporting information in advance must be provided to the inspectorates (mail box). The samples can be taken on the sampling points at the F& W station or within the cascade hall as appropriate.

The following information is required for this purpose:

- Amounts of F, P, and T intended to be processed for each of the next three months.
- The weights of the feed, product and tails cylinders connected to the process expressed as unified uranium (element and isotope).
- Projected SWU for the forthcoming three months period projected per month.

This information is provided on monthly basis and should fulfill additional requirements from ABACC and IAEA.

- The declaration must be unalterable.
- Only one declaration is allowed for each period.
- It should be secure for IAEA and ABACC data bases.
- The declaration cannot be falsely denied by the National Authority/Operator.
- Just an authorized party can provide the declaration.

For the time being, the methodology adopted for these monthly declarations is that the operator provides his declaration to the National Authority following internal procedures and internal encryption codes. The National Authority assumes the responsibility to provide this information to ABACC and the IAEA in parallel.

Once received by ABACC/IAEA, acknowledge is automatically generated and provided to the NA. Provisions to avoid false declaration in name of the Operator/NA are under discussion and will be adopted once agreed between the parties. Commercial available software is being used for encryption and secure transmission through internet.

In addition to the information requested to support the Mass and SWU balance, the following complementary information (operational information and/or program) is requested in advance:

- Projected UF6 receipts from outside facilities.
- Projected Shipments from the facility
- Projected increment of the installed capacity
- Operational and maintenance activities in the cascade area, UF6 F&W station, and vacuum station that might have impact on the safeguards approach.
- PIV date.

As long as the plant increases its size to industrial values (over a 1000000SWU/Year) the use of flow monitor becomes more practical. To remain with the same innovative tool, the number of times, when the SWU and mass balance will be closed, shall be increased in order to keep the same level control. This innovative measure is less intrusive and cheaper than flow monitor.

- SURVEILLANCE AT STRATEGIC MEASUREMENT POINTS

To make the safeguards approach more robust, application of special surveillance, containment or verification may be used. For instance in the present approach the Agencies apply:

- C&S at the UF6 F&W station in order to maintain the knowledge on all connected feed and withdraw cylinders.
- C&S on the sampling points inside the cascade hall.
- Containment measures in the vacuum station.
- Coverage by C& S measures of any potential feed point in the feed line.
- Continuity of knowledge on the disconnected cylinders using VACOSS seals linked with the surveillance system.

VII - CONCLUSIONS

The safeguard approach applied to a semi-commercial plant, with special requirements on sensitive information and flexibility must take advantage of some safeguards tools to avoid increasing the cost of safeguards equipment and inspection effort.

The combined tools, such as photo recorded, moveable surveillance and new technology devices for scanning save a lot of time during DIV verification of complex and detailed plant processes. Environmental swipe sample may replace the enrichment monitors taking into consideration the time for the detection of undeclared production of HEU and the capacity of the plant.

The randomization introduced in the safeguards approach for the mass and SWU balance closing and the balance of U235 through simultaneous DA samples from the F, P and T lines, is effective not only to detect diversion of declared flows but also to detect misuse of the facility.

This technique substitutes the flow measurement instrument and gives an initial alert for the HEU production scenario.

The application of special surveillance and containment will help to strength the safeguards at specific strategic points without interfering with the plant requirements.

However, some of the innovative tools highlighted in this paper are still under testing or implementation phase and the Agencies shall be alert to introduce new technological instruments or measurements that may help to optimize the current approach.

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