Applying Enhanced Safeguards Approaches at Centrifuge Enrichment Facilities

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Abstract:

ABACC has been involved in the application of safeguards to small sensitive enrichment facilities since the start of its activities in 1994. The negotiation and implementation of safeguards approaches for small centrifuge enrichment facilities were important achievements that effectively showed the advantages of having a close cooperation between the international and the ABACC regional safeguards system.
Even though the experience gained initially was very important and useful, the approaches implemented were focused with priority on safeguards effectiveness and on the special provisions to protect sensitive information. As a consequence the approaches required large inspection resources, which limited their application to facilities with small installed enrichment capacities.
This paper deals with the new challenges to maximize safeguards effectiveness, the non-disclosure of sensitive information and the optimization of the inspection resources whenever the enrichment capacity is increased.
A safeguards approach that includes innovative elements was developed. Those elements include the random closing of the SWU and mass balance complemented by operational declarations through mailbox; the unannounced access to the cascade hall strengthened by the use of surveillance on some strategic points; managed visual access and comparison with reference files during DIVs and unannounced access; use of complementary conventional surveillance on connected cylinders at the feed and withdraw stations and on potential feed points; and, swipe sampling.
The potential application of new technologies is also foreseen in this approach. In the near future good progress is expected in the remote transmission of safeguards data (e.g. the mailbox declarations), the state of health of the surveillance system and the use of VACOSS seals in conjunction with the conventional surveillance on the feed and withdraw station.
The main safeguards measures involved in this approach are described. The main diversion-misuse scenarios and the correspondent safeguards measures are analyzed.

1- Introduction

The objective of this paper is to present the main elements used as control tools included in the safeguard approach applied to a commercial enrichment facility.

Even though the Hexapartite Project was taken as reference safeguards approach, new safeguards measures have been introduced in the light of the new technologies available and the need to maximize the safeguards effectiveness optimizing the inspection resources. Those safeguards measures are described in this paper and the coverage of the relevant diversion scenarios is discussed.

This safeguards approach has been developed by ABACC and the IAEA in the framework of the Quadripartite Agreement.

2- Description of the reference facility

In this paper a centrifuge commercial enrichment facility with a design capacity less than 200,000 kg SWU/y, has been taken as reference facility. The flow of nuclear material is low compared with other commercial enrichment facilities and consequently, the rate of connection /disconnection of cylinders from the process is not so high.

As usual in Centrifuge facilities with a large number of centrifuges ordered in cascades, they are grouped in modules housed in independent buildings. All the cascades are connected in parallel and the capacity of each cascade is declared in the design information. The facility will be operated to produce enriched uranium less than 5 % U235 handled in 30 B cylinders. The natural uranium used as feed material and the tails of depleted uranium will be handled in 48 Y cylinders.

In the reference facility all the junctions in the main headers between the cascade hall and the Feed and Withdrawal (F&W) station are welded. However, from a safeguards point of view consideration is given to non declared feed and withdrawal and for that reason the declared sampling points relevant for the safeguard approach are under containment and surveillance (C&S).

All the cascades have a common vacuum system and as usual in this type of facility, there is a common F&W station, where access to process weighing system is allowed for inspection purposes. The 48Y feed cylinders are connected to standard commercial autoclaves and the product and tails material are removed directly from the process in 30B and 48Y cylinders respectively.

3-Acquisition paths considered.

Scenarios like the existence of a clandestine facility or the misuse of other declared facilities are not excluded. The diverted or undeclared produced uranium could be shipped to one of these facilities for further enrichment.

Consequently, the following acquisition paths were considered:

a) Diversion of declared uranium;
b) The undeclared production of low enriched uranium (LEU) to a level less or equal to the declared maximum;
c) The undeclared production of high enriched uranium (HEU) or low enriched uranium to levels higher than the declared maximum.

The acquisition path applicable to **declared nuclear material** can be implemented

- Reporting false flow data or
- Reporting a false MUF/SRD.

In both cases, the detection of the concealment demands the introduction of gross, partial or bias defect verification of uranium and/or isotope content of selected items present during the PIV or subject to domestic transfers, complemented with the detection of the falsification of data.

The acquisition paths identified in hyphens b), and c) requires the misuse of the facility using the flexibility introduced in the design or introducing clandestine piping to modify the original configuration.

While the capacity installed is small, the misuse scenarios are an important concern from the safeguards point of view, particularly those associated with feeding the plant with undeclared feed material. The timely detection of unrecorded production of HEU remains the dominant concern.

4- Safeguards criteria requirement

In the case of facilities with an inventory/throughput higher than 1 SQ, the following activities are foreseen in the safeguards criteria:

- Periodic auditing of accounting and operating records, annual material balance evaluation and confirmation of nuclear material transfers.
- Annual PIV.
- Verification of domestic and international transfers.
- Verification of Internal flow (feed, product and tails cylinders) and inventory changes (category changes, measure discards, retained wastes, blending, etc.).
- Periodic verification of the operator's measurement system.
- Simultaneous verification of similar stratums, at different facilities, in order to prevent the presence of borrowed nuclear material during the PIV when the inventories in the other facilities, for similar stratums are greater than 1 SQ.
- Design information verification.
- Swipe sampling

Additional measures are to be implemented in order to confirm the absence of unrecorded production of direct use material, or any other misuse of the facility and to confirm the enrichment level is not higher than declared.

Under the framework of INFCIRC/153 or similar agreements like INFCIRC/435, the inspection activities addressed aim to verify that the declared nuclear material is not diverted, to confirm that the plant operates as declared and to detect any signatures of facility misuse can be implemented. The inspection activities will therefore assure that the operator's declarations about the facility are correct and complete.

5- Safeguard Approach

The following safeguards measures are included in the safeguard approach:

Design information verification.

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 station, general vacuum station, strategic points and building (general containment). In addition, the absence of clandestine piping or unidentified support equipment introduced in the facility is confirmed.

This activity is carried during the PIV and in any opportunity the inspectors have access to the cascade hall (Unannounced inspections).

Swipe Sampling

This activity is carried out on random basis during the year. Swipe samples are collected following agreed procedures on those strategic areas referenced in the baseline of the facility Strategic areas located inside the cascade hall are sampled during unannounced inspections and areas located outside the cascade hall are sampled during interim inspections. In the PIV, samples can be collected at any area of the baseline.

Nuclear Material Accountancy

In order to evaluate the correctness and consistency of the accounting and operational information.

Managed visual access to the cascade hall

During the unannounced inspections and during the DIVs, all the relevant information for DIV purposes is accessible. Provisions to protect the disclosure of sensitive information are being arranged while the access of the inspectors to all the relevant information for safeguards purposes is assured. This activity is carried out following agreed procedures.

Extra Verification of U/U235 mass balance and SWU capacity usage

This activity is carried out during the PIV and on random basis during the year . This activity requires take DA samples from the feed, product and tail lines simultaneously during any inspection randomly selected, to obtain the data from the load cells at the UF6 F&W station and the provision of supporting information in advance.

The advance information given by the operator is the following:

- 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 to ABACC and IAEA simultaneously on monthly bases.

Operational programmes

In addition to the information requested to support the mass and SWU balance, the following operational information 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.

Complementary measures

- C&S at the UF6 F&W station in order to maintain the knowledge on all connected feed and withdrawal cylinders.
- C&S measures on strategic points inside the cascade hall and vacuum system.
- Special 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.

Inspection effort

The inspection effort foreseen in this reference facility is one PIV plus the interim inspections to meet 100% coverage of the nuclear material flow.
Unannounced access is aimed at detection/deterrence of any misuse of the facility. The activities carried out during the unannounced inspections seek for confirmation that the configuration of the cascades has not been changed, that undeclared UF6 feed/withdrawal points have not been introduced and that the facility operates as declared. The installed capacity of the reference facility will increase gradually, for this reason the inspection effort established in the safeguards approach follows the provisions of the Hexapartite Project and takes into consideration the following:

- A maximum inspection effort compatible with the maximum capacity expected in the facility and,
- A minimum inspection effort compatible with the capacity of the first module.

Unannounced inspections can be triggered by IAEA or ABACC at any time in this facility.

6- Improvements introduced in this Safeguards Approach

The safeguards approach adopted for this facility does not apply any perimeter concept (neither permanent nor transitory), consequently containment and surveillance measures covers the continuity of knowledge on strategic points like cylinders connected to process and strategic points on feed, product and tail lines.

The surveillance system has adequate redundancies to ensure maximal reliability of the system; however, a common failure still could arise. As an additional improvement, the system selected is prepared for remote transmission of state of health (SOH) of the server and cameras. The SOH initial testing is being programmed for the first half of 2007 and this provision would be implemented as soon as agreed procedures can be arranged with the national authority.

According this safeguards approach, the closing of the U/U235 mass balance and the SWU balance on random basis is complemented with monthly mailbox declarations.

The combination of the information requested on processed and produced nuclear materials during the last month and the advance information requested for the next three months period, allow ABACC and the IAEA to closely follow up on the production schedule, and to implement adequate planning of the verification activities in such a way that 100% of the internal flow can be verified and the timely detection of any change in the throughput or usage capacity.

Commercial available software is used for encryption and secure transmission through internet. This declaration must fulfil the following requirements agreed between the agencies.

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

To achieve an adequate accuracy in the weighing system complete access and validation of the operator weighing system is required. The possibility to have an independent file where daily operational data can be recorded in parallel to the Operator data, are being considered as a methodology to validate such data.

Even though the remote transmission of the weights data is not yet foreseen in the approach, the monthly declaration complemented with the on-site independent files of daily data and surveillance provides an adequate material balance verification capability at any time during the material balance period. The verification of the calibration of load cells will be performed in any opportunity the inspectors have access to the load cells or cylinders have been disconnected from the process.

Finally, the use of Vacoss seals linked with the surveillance system at the F/W station is foreseen in this approach. This feature will be implemented once the frequency of connection-disconnection of the cylinders to the process becomes higher than the frequency of announced inspection. This tool would allow the confirmation of the operator's declaration regarding the movements of cylinders connected to the process and allowing the operator to move cylinders out from the surveillance field of view without requiring the presence of the inspectors for such activity.

7- Acquisition paths coverage

A summary information is provided in Annex 1.

8- Conclusions.

This safeguard approach uses an ad-hoc procedure to replace the enrichment/flow monitors not yet available for commercial use for this facility. This ad-hoc procedure requires, from the facility, an operation very close to the operational program as declared in advance on monthly bases and, the continuous follow up from the IAEA and ABACC.

The randomization introduced in the safeguard 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 that implies the production of enriched uranium above the maximum declared or the use of undeclared feed to produced undeclared LEU.

Through the analysis presented in this paper we can observe that an adequate coverage for the most credible diversion/misuse scenarios applicable are met in this safeguards approach. However, some of the improvements highlighted in this paper are still under testing or implementation phase.

New technologies are continuously under development to increase the efficiency of the safeguards measures applied in general and, in particular, to centrifuge enrichment facilities. Taking into account this fact, the approved safeguard approach includes the provisions to be revised in order to incorporate new technologies and/or experiences gained in applying safeguards which could enhance the effectiveness and the efficiency of this approach. In particular, it allows the application of any further development able to improve the timely detection of any misuse of the facility or to strengthen any weak point before reaching the capacity for producing HEU in short time.

Annex 1

Coverage of the Acquisition paths

Acquisition Path	Concealed Method	Safeguards Measures
Diversion of declared uranium	- Removal/replacement with dummy, depleted ,natural or less enriched uranium - Diversion into the MUF/SRD	Closing the U and U235 mass balance through the verification of inventory and internal and external flow.
Undeclared production of LEU (≤ 5%U235) through declared UF6 F&W station	- SWU diversion. - Undeclared UF6 cylinders connected to the process at the F/W station.	- Closing the SWU balance at random (3 times a year). - Mailbox information on monthly bases. - Verification of Feed cylinders before connection to the process. - C&S at the UF6 F&W station and strategic sampling points. - Verification of connected cylinders to the process
Undeclared production of LEU (≤ 5%U235) through undeclared UF6 F&W station	- SWU diversion. - Clandestine F&W station. - Undeclared UF6 cylinders. - Undeclared empty cylinders - Clandestine piping -	- Closing the SWU balance at random (3 times a year). - Mailbox information on monthly bases. - Unannounced access to verify the absence of clandestine piping and UF6/empty cylinders. - DIV (reference pictures) inside and outside cascade hall.
Production of HEU or LEU higher than 5% U235	- SWU diversion. - Cascades reconfiguration	- Swipe sampling. - Closing the SWU balance at random (3 times a year). - DIV of cascade configuration during unannounced inspections.