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TRIPARTITE ENRICHMENT PROJECT: SAFEGUARDS AT ENRICHMENT PLANTS EQUIPPED WITH RUSSIAN CENTRIFUGES

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I. INTRODUCTION

This Paper describes major results of the work undertaken in the Tripartite Enrichment Project carried out under an Agreement between the IAEA the Ministry of the Russian Federation on Atomic Energy (Minatom), and under a Contract between the IAEA and the China Atomic Energy Authority (CAEA). The complete results of the work are published by the Agency in Tripartite Enrichment Project Summary and Task Reports.

In 1993, the Government of the People's Republic of China informed the Agency that China had decided on a voluntary basis to add the Shaanxi Uranium Enrichment Plant to the list of eligible facilities under the Voluntary Offer Safeguards Agreement (INFCIRC/369). The Plant was under construction at the time. After consultations, the Agency selected the Shaanxi Plant in September of 1997 for the implementation of safeguards.

The Agency realized that the safeguards approach used at gas centrifuge uranium enrichment facilities in other States would not be fully applicable. Chief among the reasons for this conclusion were the observations that enrichment plants incorporating Russian gas centrifuges are designed for a much greater degree of operational flexibility than other plants, and that travel conditions to the Shaanxi Plant at least at present are not compatible with requirements for unannounced access at the facility for the performance of unannounced inspections in the cascade area.

The Tripartite Enrichment Project was conceived as a means to develop a safeguards approach for any plant equipped with Russian centrifuge technology. The Project was created through a cooperative arrangement involving specialists from Minatom, CAEA and the IAEA. It comprised seven tasks, the salient products of which are summarized in the following paragraphs.

As the work proceeded, progress meetings were held in Vienna, Beijing and Moscow, and critical discussions were held at the Angarsk Enrichment Plant in the Russian Federation and at the Shaanxi Enrichment Plant in the People's Republic of China.

II. SUMMARY OF RESULTS OF INDIVIDUAL TASKS

Task 1. Design Information Questionnaire

A Design Information Questionnaire was prepared for a Model Plant incorporating Russian centrifuges designed to produce low enrichment uranium, and capable of providing 200,000 separative work units per year. Russian experts concentrated on the cascade hall portion of the Model Plant, all internal equipment and all interconnections with other buildings. Chinese experts provided input on the UF_6 handling areas, the analytical laboratory and the waste handling areas.

Task 2. Nuclear Materials Accountancy System

Under Task 2, a Nuclear Materials Accountancy System was described for the Model Plant. It presents a description of the two material balance areas, the five flow key measurement points and the seven inventory key measurement points foreseen. It describes the provisions for maintaining knowledge over the location and amounts of nuclear material on a continuous basis, the procedures for physical inventory taking and for estimating the process inventory and hold-up within the process and related equipment. It includes descriptions of the operating and accounting reports and the provisions for reporting, as required for the implementation of IAEA safeguards. Further, it includes a description of the methods, instrumentation, calibration and error estimation methods employed for all measurements of weight, uranium concentration and isotopic composition, and concludes with provisions for the use of computers to facilitate the accuracy and timeliness of nuclear materials accountancy information.

Task 3. Analysis of HEU Production Capability

The Russian and Chinese Project staff examined the Model Plant to identify possibilities for the production of uranium enriched to 20% or more, through process, piping or equipment modifications or through changes in operational practices, as might be applicable. The analysis was divided into two categories of possibilities. The first category comprised scenarios for "quick diversions" in which three specific scenarios were identified and analyzed:

- Use of the entire cascade with the plant's UF_6 feed and withdrawal stations;
- Use of a portion of entire cascade with the plant's UF_6 feed and withdrawal stations; and
- Use of the whole cascade with non-standard sublimer/desublimer arrangements (e.g., cold traps of the emergency dump system).

The second category comprised "slow diversions" in which four scenarios were identified and analyzed:

- Use of a part of the cascade with a stationary sublimer/desublimer in the cascade hall;
- Use of a part of the cascade with a portable sublimer/desublimer in the cascade hall;
- Use of a part of the cascade with modified process piping; and
- Use of a part of the cascade with new external piping to hidden sublimer/desublimer units installed outside of the plant areas accessible to Agency inspectors.

Each of these scenarios was considered to be plausible, and corresponding detection arrangements were identified and assessed. The detection arrangements include both design information verification activities and inspection activities, including environmental sampling. The Task report illustrates the relationship between the verification activities proposed and the diversion scenarios identified.

Task 4. Evaluation of Selected IAEA Enrichment Verification Methods & Equipment

Three investigations were carried out under this Project as summarized in the Task 4 Report.

- First, the feasibility of applying two NDA instruments (CHEM and CEMO) used as "yes/no" monitors in other centrifuge enrichment plants subject to IAEA safeguards was considered, but they were found to be not well suited for plants equipped with Russian centrifuge technology. Those instruments serve to detect whether the uranium enrichment of the process gas in a cascade header pipe is above or below 20%. CHEM is applied during inspections, while CEMO is applied continuously. For plants using Russian centrifuges, steel piping is used which significantly reduces the signal that would be detected by the CHEM or CEMO enrichment monitors. In addition, flexible piping arrangements make it possible to by-pass any installed instrument. It was agreed as part of the safeguards approach (Task 6) that continuous enrichment monitors that measure and record the actual enrichment could be used by the Agency. The development of such a monitor will be explored outside the provisions of this Project.

- Second, locations for environmental samples were investigated and optimal locations specified. Testing was carried out in a Russian plant to confirm the selections. In addition, a new technique was developed to provide a means to collect particles from within the plant vacuum system piping, that should provide a means to detect any use of the plant to produce highly enriched uranium. The new technique is being pursued under arrangements outside the provisions of this Project.
- Third, a novel combination of VACOSS electronic seals and surveillance was introduced for testing at the Chinese enrichment plant, providing a means to track and verify all declared feed, product and tails cylinders. The tests are successful; however, some improvements in the seals and in the software used to establish and maintain a seals application data-base are suggested.

Task 5. Review of IAEA Safeguards Criteria

The findings indicate that some modifications/interpretations of the existing IAEA Safeguards Criteria are necessary for the Safeguards Approach set forth in Task 6 to be implemented. The proposed modifications are in the nature of alternatives to some of the existing Criteria, as necessary and appropriate for gas centrifuge enrichment plants equipped with Russian centrifuges.

Task 6. Safeguards Approach

Taking into account the work carried out in all of the tasks above, a safeguards approach has been developed for the Model Plant. The Task Report describes the three objectives for safeguards at such facilities: detection of the production of highly enriched uranium; detection of the production of low enrichment uranium in excess of declared amounts or the declared enrichments; and detection of diversion of declared low enrichment uranium, natural uranium or depleted uranium. The Report identifies the possible diversion scenarios and the corresponding detection mechanisms. It describes the purposes of design information verification, the activities to be carried out inside the cascade hall (and the access to be afforded to Agency inspectors for that purpose), and the activities to be carried out in the UF_6 handling areas and the building perimeter, including the roof.

The Task Report goes on to describe the inspection activities outside the cascade hall, comprising:

- examination of records and reports;
- accountancy and control of UF_6 in feed, product and tails cylinders;
- verification of receipts and shipments;
- verification of declared transfers to and from the sublimation/desublimation stations; and
- swipe sampling outside the cascade hall.

Inside the cascade hall, the safeguards approach lays out the inspection activities required to meet the three objectives:

- visual examination of equipment and area;
- swipe sampling in the cascade hall;
- special particulate sampling using installed sample filters (so-called "Koshelev Filters");
- product flow monitoring;
- continuous enrichment monitoring;
- separative work monitoring; and
- application of containment and surveillance at sublimation/desublimation stations and cascade hall entry and exit points.

Provisions are presented for unannounced inspections into the cascade hall during routine inspections, noting that access to the cascade hall is foreseen for every routine inspection for the purpose of servicing the flow meters, continuous enrichment monitors and Koshelev Filters.

The safeguards approach envisions the introduction of SWU (separative work) monitoring as a means to confirm the actual production of the plant, and thereby provide a means to assure that the entire production capacity is used to produce declared product. Three possibilities for SWU monitoring are under consideration:

- annually, in conjunction with closing the material balance;
- monthly, on the basis of verified transfers of inputs and outputs through cylinder verification; and
- monthly, on the basis of the flow monitors and continuous enrichment monitors installed in the plant.

The safeguards approach describes the provisions foreseen for physical inventory verification, and for material balance evaluations, including shipper/receiver analyses, determination of material-unaccounted-for, and the difference statistic, D.

The equipment foreseen for implementing the safeguards approach is described in the last section of the Task Report. While some of the equipment exists and can be implemented directly, other equipment must be developed and tested before it can be authorized for routine inspection use. UF_6 flow monitors, continuous enrichment monitors and Koshelev Filters are three areas where further developments are planned or are already underway.

Task 7. <u>Design Verification Training Exercise</u>

Given the differences existing between enrichment plants equipped with Russian centrifuges and other gas centrifuge plants, and the lack of Agency experience in applying safeguards at plants equipped with Russian centrifuge technology, Task 7 was undertaken to provide training to a group of inspectors in preparation for the actual DIV activities if IAEA safeguards are to be implemented at such plants. The training exercise was carried out at the Shaanxi Enrichment Plant in July, 1998. Russian experts were responsible for the parts of the exercise addressing all activities within the cascade hall, while Chinese experts were responsible for activities outside the cascade hall.

III. CONCLUSIONS

The objectives for establishing this Project have been met. The Safeguards Approach developed in the course of this Project provides a basis for effective safeguards to be applied and integrates various technologies to provide an efficient scheme through which the three applicable safeguards objectives can be satisfied in a cost-effective manner. The actual proof of the effectiveness of the proposed Safeguards Approach will take some time to confirm. Some of its elements are yet to be developed, however, in concept, all are considered practicably attainable.

This Project was undertaken to develop concepts, procedures and techniques to facilitate implementing IAEA safeguards at enrichment plants equipped with Russian centrifuge technology, where the Agency had no previous experience and where obvious and fundamental differences made the application of the standard safeguards approaches difficult to implement. Also, the provisions that would affect inspector access into the cascade hall and the possibilities for monitoring relevant plant operating parameters were unknown. In the course of the Project, the three parties came together with constructive suggestions at every point where complications might have limited the Agency's ability to provide effective safeguards. The result, as described in the Summary Report and expanded in the Task Reports, is very positive.

The methods and procedures foreseen are in some cases valid for other enrichment plants employing gas centrifuge or other enrichment technologies. As experience is gained in the application of these methods and procedures, it will be appropriate to reconsider the implementation of safeguards at other plants to improve their effectiveness and/or efficiency.

In June 1999 a final version of the Tripartite Enrichment Project Report and Task Reports were issued.

In August 2001 in the framework of the Russian Support Program a Training Course « Nuclear Material Safeguards for Gas Centrifuge Uranium Enrichment Plants » for IAEA Inspectors was held at Angarsk Electrolysis Complex (AECC).

Experts from Russia, China and IAEA plan to continue joint efforts to facilitate the implementation of effective and efficient IAEA Safeguards at Enrichment Plants equipped with Russian Centrifuge Technology.

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