Safeguards Research and Development at ABACC. Accomplishments and future strategy

Odilon A. M. do Canto, Orpet J.M. Peixoto, Erwin G. Galdoz
ABACC- Brazilian Argentine Agency for Accounting and Control of Nuclear Materials
Av. Rio Branco 123 Gr 515, 20040-005-Rio de Janeiro- Brazil
E-mail: odilon@abacc.org.br; orpet@abacc.org.br; galdoz@abacc.org.br

I – ABSTRACT

Since the inception of the implementation of the Quadripartite Agreement (INFCIRC/435), ABACC took note of the need to develop a technical capacity to face the challenges to be a safeguards agency as well as gain credibility in the nuclear safeguards world. This capacity means to develop and implement systems in the technical area, in the inspection framework, in the conceptual analysis of processes and approaches and in the political scenario. These tasks will certainly generate needs in missing fields in which research and development (R&D) projects would be necessary.

Beyond this responsibility, ABACC has been involved in the application of safeguards to sensitive and complex installations, as enrichment facilities, which require special equipment, safeguards procedures and technical expertise. It is not uncommon that the application of a safeguards approach needs new developments and searching for unique solutions in which R&D plays a significant role. Although ABACC looks for direct application, the R&D as a strategic quality for the organization has never been neglected.

This paper summarizes the R&D projects that ABACC has participated in or accomplished. It also presents the policy applied by ABACC for R&D in new safeguards system technology, and personnel qualification to fulfill the needs on the present and future safeguards and non proliferation applications. It also addresses the R&D collaboration with other non proliferation and safeguards organizations.

II – Introduction

To apply safeguards as an inspectorate, ABACC had to build a system which must have competence to fully develop, implement and evaluate safeguards measures. That means, this system must have human resources capacity, a set of well developed and useful equipment, a trained and knowledgeable inspectorate body and a good headquarters support system to integrate all data obtained from safeguards activities and to generate its evaluation.

The system must function efficiently since the planning of a safeguards measure, which will rely on the right safeguards approach, the preparation for the inspection, the instruments and equipment to be used and the way that ABACC will treat and evaluate the data obtained.

If the safeguards measure to be applied is well known the task is facilitated by the proper handling and operation of equipment and information available. However, not always the implementation has of the shelf methodology, equipment or instrument to be used. This situation becomes even more challenging when we are dealing with sensitive installations, where for different reasons it is not possible to apply directly a known approach or available equipment.

This is the point where a safeguards agency like ABACC has to be involved with safeguards research and development. The R&D to be done or supported by a safeguards agency has always to aim a direct application of the safeguards methodology or technology.

III - Policy in R&D projects

ABACC is in charge to implement The Common System of Accounting and Control of Nuclear Material (SCCC) which is the basic system to support the Bilateral Agreement between Brazil and Argentina. The SCCC together with the IAEA safeguards criteria are the fundamental rules for the Quadripartite Agreement.

The SCCC was conceived as a full scope safeguards system to be implemented by a central executive body (the permanent staff of ABACC), which is technically and financially supported by the Parties to carry out its duties. This system requires the concurrence of efforts of the countries to support ABACC's activities (for instance, they need to expand their inspection capabilities to be able to provide ABACC with the necessary support to carry out inspection in the other country). This double role of the National Authorities is not new in the safeguard's field, and contributes for the effectiveness of the safeguard tool. The technical support available from the two parties embraces inspectors; consultants; equipment maintenance and calibration; preparation of standards, laboratory services and any other safeguards related study or service.

That means that ABACC has to look for and manage~~d~~ the necessary support from the states in order to build its system. This support shall not compromise the confidentiality of the safeguards system neither the credibility of the whole system.

ABACC has the responsibility to manage and support the necessary R&D safeguards projects in the countries or any other institution. Even ~~though~~ when the ABACC's staff is composed with highly qualified and experienced technical elements, ABACC does not have its own laboratories or enough technical personnel to conduct new R&D techniques for a particular application or to adapt and get acquainted with new methods and technologies to be used at the inspections.

It is also ABACC's responsibility to foster the development of the countries laboratories and expertise necessary for applying the safeguards. For instance, in order to check the status of the laboratories that analyze the samples collected by the inspectors, the ABACC technical support area keeps a permanent inter comparison program running. These comparison programs are carried out with the cooperation of other international laboratories - NBL and IAEA (Seibersdorf).

Groups of experts of Brazil and Argentina are also called by ABACC as consultants in order to discuss a particular technology whenever it is necessary. Cooperation with other institutions as DOE/USA, CEA, EURATON, JRC, IAEA and some countries are very successful and profitable to overcome this point.

~~.~~IV – Methodology applied by ABACC on the decision making on R&D Projects

The application of safeguards in the jurisdiction where ABACC operates has offered different challenges in a range of different technical aspects. The technical activities are mainly oriented to the verification of operator declarations of material inventories or facilities usage, as stated in the Quadripartite Agreement signed by the parties involved.

As ABACC has no own R&D laboratories, it's main role is to analyse and identify the technical problems arising from the application of safeguards, to understand the possible solutions, select the best approach taking into account operational aspects, technical feasibility, and economic boundaries, and finally direct and coordinate the R&D activities performed in one or more R&D institutions related to ABACC. Final evaluation of the results is also ABACC responsibility, prior to normal and routine implementation.

The technical activities derived from the safeguards verification procedures can be categorized in four different areas:

- Non Destructive Assay (NDA)
- Destructive Assay (DA)
- Containment and Surveillance (C&S)

- Data management

Non Destructive Assay (NDA)

When the verification must be performed with a low or medium probability of detection, the results coming from non destructive assay techniques is enough to obtain a conclusion. These techniques include material weighing (mass determination), gamma spectroscopy to verify the presence of nuclear material, the enrichment of uranium compounds or the indication of a determined element. Neutrons detection to verify the presence of nuclear material or to verify enrichment of nuclear fuel elements, Cerenkov Viewing Devices to verify the presence of irradiated nuclear materials, etc. Normally, the results are immediately available to the inspector in the field, and conclusion can be obtained prior to leave the facility under inspection.

Destructive Assay (DA)

If a higher probability of detection is needed, more precise measurement techniques are required. In that case Destructive Analysis offers a range of possibilities to determine concentration and enrichment of nuclear compounds, with adequate levels of precision and uncertainties. Different procedures, depending on the physical or chemical condition must be employed to take samples for further analysis in proper analytical laboratories. The results are not available immediately, and conclusion must be deferred until the analysis is performed by the selected laboratory, and results sent back to ABACC for final inspection closing.

Containment and Surveillance (C&S)

Once a given inventory of material, equipment or facility has been verified, future measurement efforts can be significantly reduced if adequate containment and surveillance are applied, to verify that no material diversion or equipment tampering occurred during a determined time interval.

A wide range of scenarios can be found, depending on the nature of the facility to be subject to surveillance. Careful analysis of all possible deviation paths are analysed and proper surveillance equipments must be selected and deployed. In some situations, special requirements can be found, and special equipment systems must be designed or existing devices must be adapted to fulfil particular requirements.

Data Management

Data management is also a permanent challenge, to guarantee the availability and security of all information produced during the process of safeguards application. The sensitiveness of the information handled imposes carefully designed methods to store and process all the information. Technological evolution of digital processing and communication equipments offer a number of opportunities to improve data management, but the use and implementation of innovation in the field requires careful analysis of benefits and risks, prior to its routine application.

V – Research and Developments Projects

1) Safeguards Studies

ABACC has been involved in the development of unique safeguards approaches that required from the staff significant research efforts on the technologies available and on the

testing of new equipment as well to develop some of them. This was mainly oriented to enrichment facilities with special requirements.

2) Non Destructive Analysis

2.1 – NDA for gamma and neutron detection for visual restricted access points at enrichment cascades

In sensitive enrichment plants the DIV verification to guarantee that diversion activities are not carried out in the cascade, visual observation is necessary. Due to operator requirement to restrict visual access to sensitive areas, ABACC and IAEA have developed a methodology, through gamma and neutron measurements in the cascade area, to guarantee that no undeclared nuclear material is present in the areas where the visual restriction applies. This was a R&D performed with the joint participation of IAEA, ABACC, DOE and National Authority.

2.2 – New configuration and calibration for using neutron collar for unique type of fuel element with slight enrichment

The need to make partial measurement in unique type fuel assemblies for HWPR with slight enrichment (0,95%) and limited by the use of a steel protection tube, conducted ABACC and IAEA to develop a special configuration and cross calibration on the coincidence collar equipment that should be used. The procedure to be established has to deal with the narrow gap to differentiate the natural uranium from the slightly enriched material, taking into account the standard errors from the system.

2.3 – NDA System to verify a difficult to access spent fuel assemblies stored in a Spent Fuel Pond

The on load reactor stored its fuels on a highly closed packed two layers configuration and the movement of the fuels for verification results in an inspection effort extremely high beyond it would be a very large task for the operator. ABACC and IAEA have developed a NDA underwater neutron counter system known as SFNC (Spent Fuel Neutron Counter) specially dedicated for verification of fuel assemblies at the heavy water reactor storage pool, analyzing the neutron signals in the gap between assemblies without moving the fuel assemblies

2.4 – Environmental Sample Analysis

- Measure U and Pu using bulk analysis

The project aim to develop the capability to measure, through bulk analysis, both U and Pu at levels expected in environmental. Using procedures based on discussions among the DOE experts and participants from Brazilian and Argentinean laboratories, ABACC-support laboratories participated with DOE laboratories in a round-robin exercise to determine the amount and isotopic composition of plutonium, at levels as low as 0.2 ng of Pu, in samples prepared from dried solutions of reference materials

After successful demonstration of the capability to make accurate low-level measurements of Pu, ABACC support laboratories will develop and demonstrate the capability to perform the necessary chemistry to separate and purify U and Pu in samples that contain both elements. This is an on going project and it has obtained very good results with Brazilian and Argentinean laboratories.

- Development of TIMS (Thermal Ionization Mass Spectroscopy) and SIMS (Secondary Ion Mass Spectrometry) analysis.

ABACC is initiating a R&D project to develop a laboratory in the region that could perform either SIMS or TIMS analysis of environmental samples. This project will contemplate the development of human resources and also the laboratory structure to fully support this technology.

2.5 - Gamma Evaluation Codes for Plutonium and Uranium Isotope Abundance Measurements by High-Resolution Gamma Spectrometry

Since 1994, the Institute for Reference Materials and Measurements (IRMM) of the Joint Research Centre (JRC) of the European Commission, IAEA and ABACC work on the development of tools for plutonium isotope abundance measurements by high-resolution gamma spectrometry (HRGS). The trend to use increasingly higher burn up plutonium materials, measurements on freshly separated nuclear material in reprocessing plants or the presence of actinides other than uranium and plutonium in materials designed for future fuel cycles have resulted in the need to develop new tools for software analysis.

One of the main issues of this development is to address the concerns of the inspectorate authorities (International Atomic Energy Agency (IAEA), European Atomic Energy Community (EURATOM) and ABACC) about the standardization and sustainability of gamma evaluation codes. Clear guidelines were identified and a roadmap for future developments of gamma codes. ABACC is working in this R&D project together with IAEA and Member State Support Program's (MSSPs) to the IAEA.

2.6 - Development of Software for Enrichment Measures

Currently, ABACC is using various versions of software and hardware to determine the isotopic abundances for uranium. Inconsistencies between the versions of the software have resulted in data discrepancies that often have to be manually corrected. The goal of this research activity is to evaluate the variety of isotopic software analysis packages that are currently used by ABACC to verify operator declarations for enriched uranium and provide guidance for standardizing and upgrading the software to broaden the applicability, improve the data quality, ensure that software quality assurance procedures are being met, and control the final product's distribution. This R&D project is being developed in the framework of ABACC and DOE collaboration agreement

2.7 - Development of Differential Peak Absorption (DPA) technique

The use of MMCG (Mini Multi-Channel analyzer and hyper-pure Germanium detector) with the software MGAU in enrichment meter mode for the determination of enrichment of UF_6 cylinders must meet the condition of the infinite- thickness of UF_6 in the position where the detector is located during measurement. This is called the Infinite-Thickness Condition (ITC). If this condition is not met, the results obtained by the inspector in the field will be incorrect. With the goal of helping the inspector in this procedure, ABACC make the R&D on a software tool to analyze the spectra achieved, and to determine if the ITC is met. The method under development is based on the Differential Peak Absorption (DPA) technique, in which the relation of count rates measured for different gamma rays photo peaks coming from the same isotope depends on the thickness of the materials present between the isotope and the detector. Applying this technique, the relation between count rates at the photo peaks of ^{235}U in a spectrum obtained from an UF_6 cylinder can be compared with the expected value for the ITC.

3) Destructive Analysis

3.1 - UF_6 sampling methodology with alumina pellets

Due to the disadvantages of the actual UF_6 sampling method, ABACC has developed a method (named ABACC-Cristallini Method) of sampling UF_6 for enrichment determination. The new method uses a fluorothene P-10 tube type containing alumina pellets that absorb and hydrolyze UF_6 directly during the sampling. The alumina pellet retains up to few hundreds milligrams of U (in a solid compound – UO_2F_2) without the need of using liquid nitrogen during sampling. With this new method the UF_6 samples leaving and left at the installation (archive sample) will be lower and less reactive as the actual methodology.

The laboratory procedures for manipulating the sample will be much easier (no need for hood, gas sampling, vacuum system, nitrogen cleaning, etc), the residual uranium retained at the laboratory will be much lower, the sampling device is less expensive, and there will be saves in transport cost and on cleaning. It is also relatively safer concerning radiological protection aspects during transportation. Figure 1 shows the two types of UF_6 sampling device and the alumina pellets.

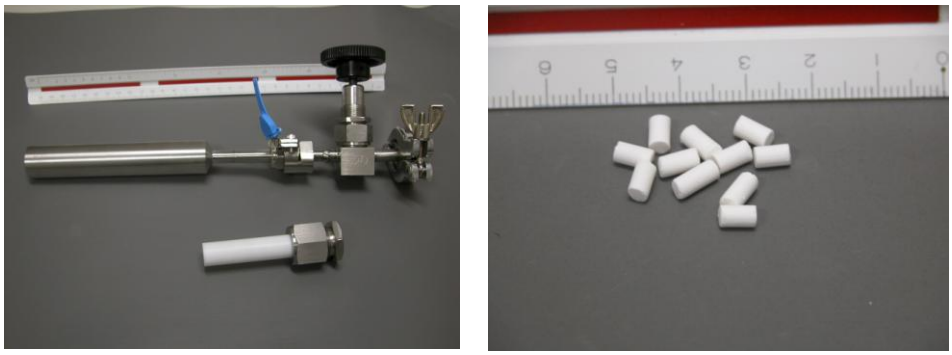

Figure 1: *UF_6 sampling devices – Hoke tube / fluorothene P-10 tube and alumina pellets*

4) Information systems

4.1 – Secure data transmission

In the field of information management, major efforts has been done to develop software tools to help the inspectorate during the coordination and execution of inspection tasks, and also special software to manage and handle material accounting information has been developed by ABACC.

Data security, encryption and authentication are also permanent concerns, with different purposes:

- to protect the confidentiality of the information, specially when the information is transmitted by using public communication systems like Internet, and
- to assure that legitimate information is being used to obtain safeguards conclusions, and no tampering occurred to mask or hide any diversion activity.

4.2 - Load cell authentication

To confirm the mass and separative work in enrichment process the verification of the balances and load cells is a new safeguards tool in consideration. Due the limitations to install its own equipment, the use of operator instruments is almost the only solution. The proposed solution is based on the sharing of the load cells data, installed for normal plant monitoring, but using an independent data processing and storage device. In order to authenticate the obtained data, ABACC had to develop a new system to guarantee this authentication.

5) Surveillance systems

5.1 Secure Video Surveillance System (SVSS)

The Secure Video Surveillance System (SVSS) is a R&D equipment development based on the collaboration between the U.S. Department of Energy (DOE), Sandia National Laboratories (SNL), and the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC). The joint project addresses specific requirements of having a surveillance system with a short picture interval taking (PTI) to be used in supporting unannounced inspections conducted by ABACC and the International Atomic Energy Agency (IAEA) in sensitive installations to cover special periods of time. SVSS integrates commercial off-the shelf (COTS) technologies for all individual components, with the addition of updated tamper indication and data authentication features. The SVSS is able to retain historical surveillance data for hours, with picture intervals as short as 1sec

5.2 Moveable Surveillance System for restricted access points

In sensitive enrichment plants the DIV verification is made through the comparison of images taken during the baseline and images at the verification inspection. As long as the plant is increasing the size, new cascades are being added, and this activity becomes a time consuming one. 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 the restricted access points at the cascade hall.

6) Human Resources

R&D projects are conducted by qualified specialist. On this field the ABACC supports the qualification of the Brazilian and ~~Argentina~~ Argentinean specialists in basic formation, such as the graduate degrees and in training on the new developments.

ABACC also provide training courses and seminars for ABACC Officers and inspectors with the participation of external organizations. Training in specific equipment or activity to be developed is also performed in laboratories from other countries always in the framework of technical cooperation agreements.

7) Support Systems at Headquarters

7.1 - Operation database

The need to have a system that could manage all data collected during the inspections and integrate with the different technical areas of ABACC made ABACC to develop a program called "Sistema de Dados de Operações – SDO". This system allows the management of technical and administrative data and the production of detailed reports related to safeguards implementation.

The SDO integrates all data from safeguards inspection in a fast, reliable and secure network. It's based on a SQL platform and has multiple interfaces to provide information to external and internal channels of ABACC.

7.2 - Accountancy database

When the ABACC began effective operations, it started to establish its own inspection procedures, including the auditing of records and the comparison thereof with reports. These procedures consist of three electronic working papers named VR-A (summary form), VR-B

(comparison form) and VR-C (updating form). One special characteristic of the procedure is that it must be completely performed during the inspection in order to provide a preliminary summary of the results of books auditing to the Operator/National Authority. With the main purpose of making easier the completion of the form by the inspectors and having the results in electronic media in order to facilitate the evaluation of the results and the follow-up of discrepancies, special software was developed to be utilized in field during the inspections running on a portable computer.

The software was completed in 1999 and started to be used in routine basis in the beginning of 2000. The software allows completing the VR-A, VR-B and VR-C forms with the following advantages: a) organizes the activities to be performed; b) checks all the information entered, for example, MBA codes, algebraic sign of element/isotope weight, etc.; c) cross-checks the relationship between different fields to assure that the numeric information entered by the inspector is correct; d) No calculations need to be performed by the inspector manually; and e) have a mechanism for error detection that do not allow to finalize the auditing if there is a discrepancy between the inspection data and the book data.

The data collected during the inspections feeds the ABACC database, internal checkings are executed and automatic reports are generated for feedback the legal flow of information. The system is receiving the normal maintenance and updates since it was implemented and a Joint Use System for this software was established with the IAEA. Special files and reports are generated for feeding the IAEA database.

VI - Collaboration with other organizations

The R&D projects are conduct together with other organizations. In fact, ABACC have the policy to develop new technological systems in cooperation with IAEA, which is an end user as ABACC, and with other organizations which have human resources or laboratories.

R&D Projects	Application	Hardware development	Collaboration Organizations
Safeguards Studies	Enrichment - centrifuge and gas diffusion	No	IAEA
	On load safeguards approach	No	IAEA
NDA	Gamma and neutron detection for visual restricted access points at enrichment cascades	Yes	IAEA/CNEN/DoE
	Gamma evaluation on hold up at diffusion plants	No	IAEA/CNEA/DoE
	Neutron collar for unique type of fuel element with slight enrichment	Yes	IAEA
	System to verify a difficult to access spent fuel assemblies stored in a Spent Fuel Pond	Yes	IAEA
	U and Pu using bulk analysis	No	CNEN/ARN/DoE
	TMIS and SMIS analysis	Yes	CNEN/ARN
	Gamma Evaluation Codes for Plutonium and Uranium Isotope Abundance Measurements by High-Resolution Gamma Spectrometry	No	EURATOM/IAEA/DoE
	Software for Enrichment Measures	No	DoE
	Differential Peak Absorption (DPA) technique	No	DoE
DA	UF_6 sampling methodology with alumina pellets	Yes	CNEN/ARN
Information System	Load cell authentication	Yes	CNEN/Operator/IAEA
Surveillance systems	Secure Video Surveillance System	Yes	DoE
	Moveable Surveillance System	Yes	CNEN/IAE
Support Systems	Operation database	No	
	Accountancy database	No	IAEA

VII – Final remarks

R&D is an important activity at ABACC´s duties in the context of applying safeguards in the framework of the Quadripartite Agreement. Since the starting of ABACC system, the organization has put a lot of effort in fulfilling this requirement.

The successful projects developed by ABACC and its partners in this field have contributed for the use of recent technologies in safeguards and also to apply safeguards more efficiently. ~~Te~~ The products and knowledge that came form the R&D projects are being helpful ~~for~~ also to other safeguards and non-proliferation organizations.

REFERENCES:

[1] IAEA: " The Agreement between the Republic of Argentina, the Federative Republic of Brazil, the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials and the International Atomic Energy Agency for the Application of Safeguards", INFCIRC/435, IAEA, Vienna, March 1994.