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The European Commission Cooperative Support Programme: Activities and Achievements

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Abstract. The IAEA bases its technical and scientific Programme on contributions from the Member State Support Programmes (MSSP). The European Commission Cooperative Support Programme (EC-SP) started in 1981 to support IAEA's activities in the field of nuclear safeguards. Since its beginning, the EC-SP has been operated by the European Commission's Joint Research Centre (JRC) and its institutes at Ispra-Italy, Geel-Belgium and Karlsruhe-Germany. The EC-SP tasks provide technology and expertise in many technical areas related to the effective implementation of safeguards verification measures including the detection of undeclared materials, activities, and facilities. The paper will detail the main activities of the EC-SP in recent years, namely (a) the specific work as part of tasks with well-defined milestones and deadlines, (b) training activities and (c) the technical consultancy support to the many IAEA meetings and expert groups.

1. Introduction

The European Commission Collaborative Support Programme – EC-SP, to the IAEA was officially created in 1981 with an exchange of letters between Directors of the European Commission and the IAEA. Since then the EC-SP has been involved in more than 110 tasks in different Safeguards areas.

This paper details the main EC-SP activities. It starts with some historical background and description of the current modes of operation, including the close collaboration with the European Commission's Directorate General on Energy, in charge of the implementation of the EURATOM treaty. It then highlights some recent contributions of the EC-SP and ends with some discussion on current practices and future.

2. Historical Background

The IAEA was created in 1957, the same year the Treaty of Rome – instituting the European Economic Community, and the EURATOM Treaty – instituting the European Atomic Energy Community, were signed. As a consequence of the EURATOM Treaty, an executive Commission of EURATOM (later merged into the Commission of the European Communities which later became the current European Commission) was mandated to implement the EURATOM Treaty, including all Nuclear Safeguards and verification measures.

In 1970 the Nuclear Non-Proliferation Treaty – NPT – entered into force and the IAEA received the mandate to create and implement an International Nuclear Safeguards regime.

Considering the technical character of Nuclear Verification methodologies, there was much technical collaboration between the IAEA and the European Commission's Joint Research Centre – which had been created in 1959 with the specific role of fostering joint European research in nuclear energy related matters.

After the creation in 1977 of the Member State Support Programme – MSSP, the European Commission joined the MSSP in May 1981 with an exchange of Letters establishing a "formal Cooperative Support Programme between the IAEA and EURATOM in the field of Safeguards Research and Development". The signatories were Mr Sigvard Eklund, Director General of the IAEA and Mr Wilhelm Haferkamp, the German Commissioner for External Relations including Nuclear Affairs of the Commission of the European Communities (President: Gaston Thorn).

The exchanged letters indicated that "the programme will cover the following areas of R&D activity":

a) Surveillance and Containment

b) Measurement technology

c) Training Course

d) Information data, treatment and evaluations

As it can be seen these areas are still very much updated in terms of the current activities between the EC-SP and the IAEA. Table 2 illustrates the first five EC-SP tasks.

Task No.	Title	Accepted
EC-B-00071	Inspector Training Course in NDA and DA	1986
EC-E-00177	Modular Laser Surveillance System (LASSY)	06-1987
EC-E-00178	Image Processing System for Film and Videotape Review	06-1987
EC-X-00179	Feasibility Study of a PWR Fuel Assembly Sealing System	1989
EC-E-00182	Identification of Items by Means of Surface Topography	1989

Table 1: First EC-SP Tasks (Source: IAEA SPRICS)

3. EC-SP Modes of Operation

From an operational point of view the European Commission’s Joint Research Centre (JRC) operates the EC-SP. Indeed, three JRC institutes with an active work programme in the field of Nuclear Safeguards are actively collaborating with the IAEA within the framework of EC-SP. These are:

- Institute for the Protection and Security of the Citizen (IPSC), Ispra, Italy
- Institute for Reference Measurements and Materials (IRMM), Geel, Belgium
- Institute for Transuranium Elements (ITU), Karlsruhe, Germany

The European Commission Directorate General on Energy – ENER, in charge of the implementation of the EURATOM Treaty, is kept informed about all IAEA requests and progress and implementation of current tasks. On a case by case basis and whenever appropriate, ENER proposes trilateral collaboration schemes for the execution of specific tasks.

As any other MSSP, IAEA’s Support Programme Coordination Group meets twice a year with the coordinator of the EC-SP and specific task officers for overall task review meetings.

3.1 Research and Development Tasks

The different meetings between JRC and IAEA staff contribute to a widespread dissemination of knowledge:

- JRC staff is aware about IAEA needs and orientations.
- IAEA staff learns about recent research activities, including results, investments, etc.
- The regular MSSP coordinator meetings and IAEA R&D reports also contribute to this exchange of knowledge

These bilateral exchanges are beneficial as they contribute to bring together end-users and developers. Further, the good understanding of IAEA needs often influence future JRC multi-annual work programmes. On an annual basis, the definition of objectives and deliverables for the different groups also reflect the current IAEA tasks.

3.2 Expert Meetings and Workshops

JRC staff regularly participates to meetings, expert networks, workshops, etc. organised by the IAEA. These, again, contribute to a better understanding of IAEA needs in specific areas and are beneficial in looking ahead for future research avenues, eventually to be implemented in forthcoming years.

3.3 Collaboration with other Support Programmes

Given the organisation of the European Union and the existence of the ESARDA association – focusing on R&D for Safeguards, it is considered positive to disseminate JRC current R&D activities for the IAEA to other EU Member States – MS – with an active MSSP.

Ten EU MS participate at IAEA's MSSP: Belgium, Czech Rep, Finland, France, Germany, Hungary, Netherlands, Spain, Sweden and UK. These Member States are invited to participating at the EC-SP's Annual Review Meeting. In some cases, when discussing specific tasks or IAEA requests, it is beneficial to extend the discussion to other Support Programmes. This practice has been found useful both from the IAEA's perspective and from the participating MSSPs. Not only the discussions are richer, but also it is possible to better coordinate and focus on future efforts and initiatives.

4. EC-SP Today

In Summer 2010, the situation of the European Commission's Support Programme was as follows:

NDA: Equipment, Modelling and Measurements	7
Sealing, Containment and Surveillance	6
Analytical and Reference Techniques	6
Support To Safeguards in Japan: JNFL And JMOX Projects	7
Information Technologies for Non-Proliferation	3
Training	6
Other	3
Total	38

Table 2: Number of tasks in different technical areas, situation of the EC-SP in Summer 2010

Further to the execution of the tasks, the EC-SP also regularly participates at Technical Meetings, Expert Groups, Networks and Consultants Group Meetings organised by the IAEA.

5. Recent Highlights of the EC-SP

5.1 Reference Materials

The IAEA continued to receive reference materials and particles as requested. In particular, the use of the new uranium IRMM-3100a: 233U/235U/236U/238U=1/1/1/1 "quad" isotopic reference material was demonstrated [EC A 00318 – Special Reference and Source Materials for DA]. This new isotope reference material is ideal for verifying the inter-calibration of multi-detector systems in isotope mass spectrometry. As a result JRC-IRMM certified reference materials are now regularly applied in IAEA SGAS measurements strengthening the effectiveness and efficiency of IAEA Analytical Services.

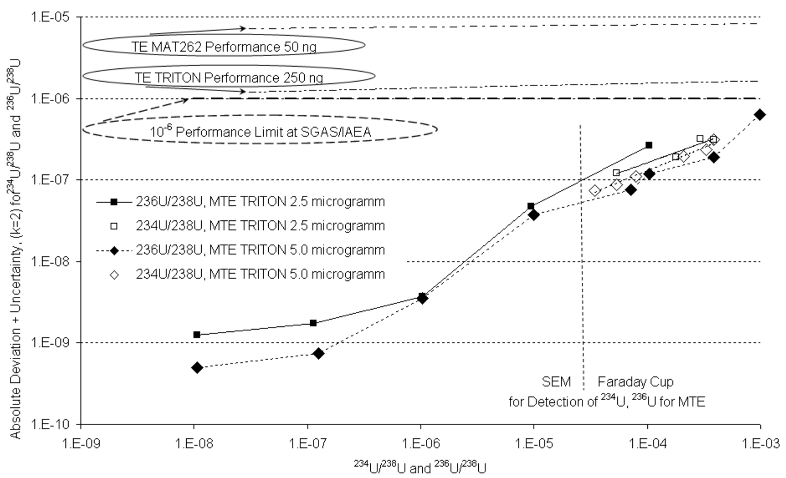


Figure 1: Performance of the Modified Total Evaporation method for minor uranium ratios $n(^{234}U)/n(^{238}U)$ and $n(^{236}U)/n(^{238}U)$

Associated to the work in reference materials, advanced training techniques in Mass Spectroscopy were developed and experience transferred to the IAEA [EC B 01752 – Mass Spectrometry Training]. In particular, there were courses in thermal ionization mass spectrometry (TIMS). The capabilities and sample throughput for measurements of the minor uranium isotope ratios have been improved by implementing the so-called "modified total evaporation technique" at the IAEA Safeguards Analytical Services (SGAS-Seibersdorf). The performance of the MTE method for the minor uranium ratios $n(^{234}U)/n(^{238}U)$ and $n(^{236}U)/n(^{238}U)$ is seen in Figure 1. It is well below the performance limit for the entire range of ratios as required by the IAEA [1]. The excellent performance of this technique was demonstrated and is considered to be officially accepted for safeguards measurements at the IAEA SGAS.

In 2010 JRC-IRMM provided results to the IAEA on verification measurements of the recently domestic produced and certified JAEA LSD spikes and of batches of IAEA LSD spikes used for measurement of uranium and plutonium in fissile material control at the onsite laboratory in Rokkasho [EC A 1806 – Verification of mixed U-Pu Spikes] [2]. The reference materials used to accomplished this task were subject to a an inter-calibration campaign using state-of-the art measurement procedures carried out linking IRMM plutonium spike reference materials to underpin the confidence in the use of these IRMM reference materials for safeguards verification and environmental measurements. The compatibility of selected IRMM plutonium reference materials was demonstrated and the traceability of the certified values of the plutonium isotopic contents to the SI was confirmed. In addition this study was also linked to IRMM's successful participation in the external plutonium interlaboratory comparison programme EQRAIN-11, demonstrating IRMM's measurement capabilities for plutonium analysis.

5.2 Large Geometry Secondary Ion Mass Spectroscopy – LG-SIMS

The analysis of environmental particle samples is one of the means to detect the occurrence of undeclared activities dealing with enrichment and processing of nuclear materials. The techniques used today have proven to be effective for Safeguards measures and is a corner stone in the implementation of IAEA's additional protocol. For many years JRC-ITU has been involved with the development of novel analysis techniques aimed at the accurate identification of the constituents of fine particulate material. The ultimate goal is to perform accurate and precise measurements, determining the isotopic composition of the particles selected. This is of utmost relevance for safeguards as these particles are representative of the original material and their composition provides specific information about the source and, often, about the chemical/industrial processes used [3]. The results of this R&D effort are regularly communicated to the IAEA which, eventually, incorporates them as part of their standard analysis methodology and procedures.

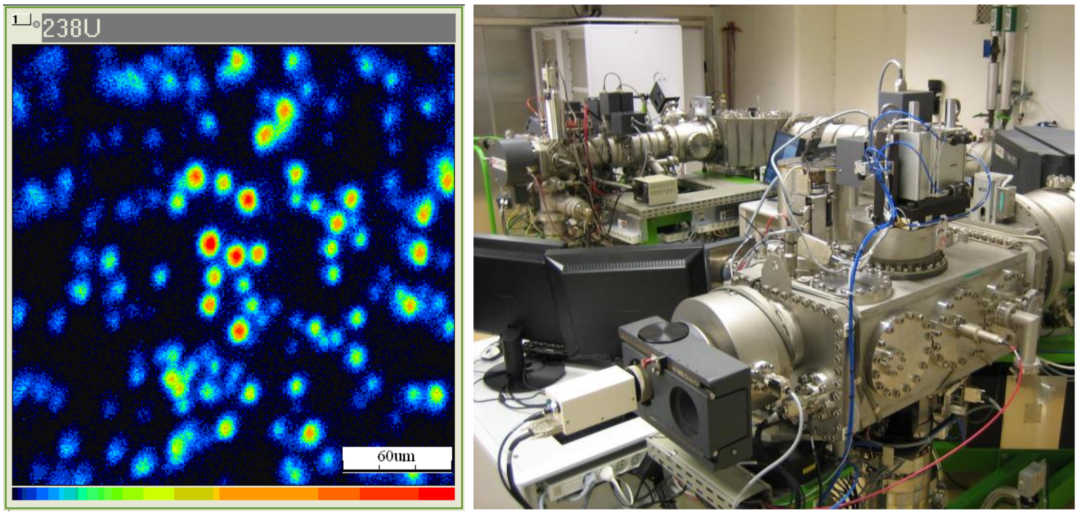


Figure 2: Example of JRC-ITU Automated Particle Measurement (APM) screening software that was recently developed by the company Cameca in cooperation with JRC-ITU, and a photo of an LG-SIMS from NORDSIM laboratory, Stockholm (equal to the one to be soon installed at JRC-ITU).

JRC-ITU is currently in the process of acquiring a Large Geometry Secondary Ion Mass Spectroscopy instrument – LG-SIMS. This instrument is the very same as the one that the IAEA will have in a near future as part of the new SAL laboratories. LG-SIMS improves the performance in uranium particle analysis, namely, high sensitivity at high mass resolution. Common molecular interferences are removed effortless, thus improving the minor isotope measurements. The results of uranium isotopic measurements are comparable to the best available TIMS measurements. The implementation of LG-SIMS will strengthen the Safeguards capabilities as it combines highest performance with a timeliness that does not exist today with the current use of small geometry SIMS and the fission track – TIMS method. This instrument also improves the detection capabilities of particles in a large matrix of other material.

5.3 COMPUCEA: Combined Procedure for Uranium Concentration and Enrichment Assay

COMPUCEA [Task EC A 01507] (Combined Procedure for Uranium Concentration and Enrichment Assay) is used for on-site analytical measurements in support of joint Euratom-IAEA inspections during physical inventory verification (PIV) campaigns in European Low-Enriched Uranium (LEU) fuel fabrication plants. The analytical technique involves the accurate determination of the uranium element content by energy-dispersive X-ray absorption edge spectrometry (L-edge densitometry) and of the 235U enrichment by gamma spectrometry with a LaBr3(Ce) detector. For evaluation of the LaBr3 spectra a modified version of the NaIGEM code is used, which has recently been adapted to handle the presence of reprocessed uranium.

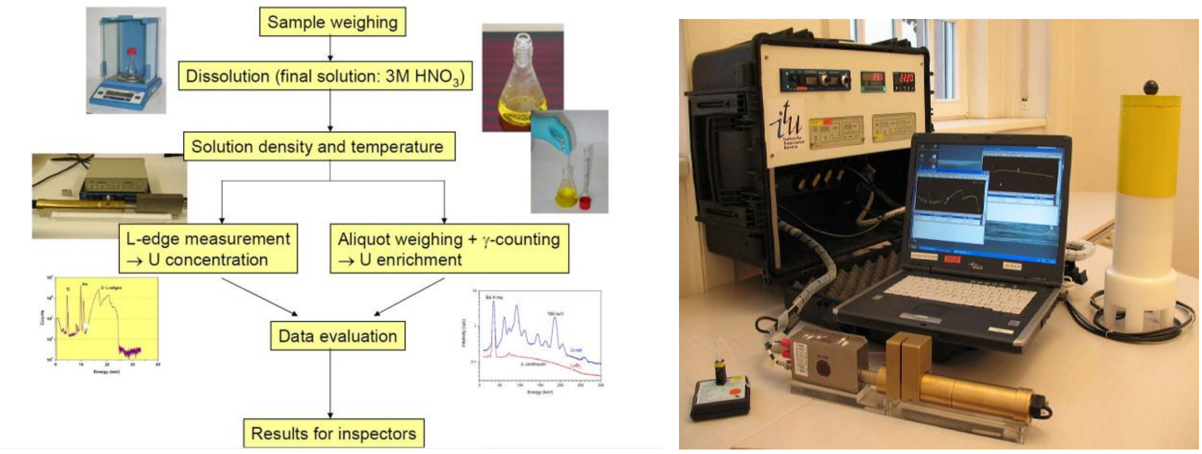


Figure 3: Procedure for the COMPUCEA technique and equipment

Following the successive and extensive evaluation of COMPUCEA's performance [4], both in the laboratory and in field, the technique is now proposed to be used by the IAEA outside the European Union. First tests have already occurred and training actions are being prepared.

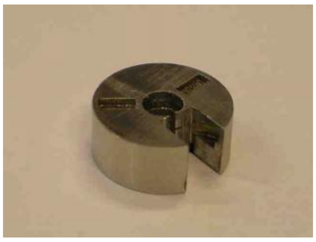
5.4 Ultrasonic Seals

JRC developed an ultrasonic seal [Task EC-E-01559] that is used in its different versions by EURATOM and IAEA Safeguards systems. The internal structure of the ultrasonic seal comprises a unique non-reproducible identity and a frangible element (integrity) which breaks when an attempt is made to remove the seal from the sealed item. The reading device consists of a transducer which generates an ultrasonic signal and senses the reflected signal. The transducer rotates above the sealing bolt recording the ultrasonic echoes reflected over a complete revolution.

The core of the ultrasonic seal (photo to the very right, below) is a cylindrical assembly containing its unique identity and an integrity feature which breaks when opened. This assembly is radiation resistant and particularly reliable even under very harsh environmental conditions.

The identification feature is an assembly of several discs randomly stamped which are stacked in a random disposition and brazed together to form a univocal identity (second from left photo). Brazing paste is put in several parts of the stack in a quantity that will adequately braze the disks, but not fill all the holes. This is done by heating them up to 1000°C for several minutes in the furnace. As the diffusion of the brazing follows a random process, it is not possible to predict the identities that will be produced. The parts providing identity and integrity are then brazed together to form the core of the ultrasonic seals. This core is then welded into the top of the seal. The bodies of the seals are designed according to each application.

DISCS WITH RANDOM ANGULAR INCISIONS



STACK OF DISCS (UNIQUE IDENTITY)

INTEGRITY FEATURE

ULTRASONIC CORE: IDENTITY AND INTEGRITY FEATURES BRAZED TOGETHER

Figure 4: Core of ultrasonic seals.

Following the validation by an independent vulnerability assessment study, JRC ultrasonic seals are now classified as category A equipment and are used in nuclear installations in Romania, Canada and Pakistan.

5.5 3D Laser range Finder for Design Information Verification

Design Information Verification – DIV – is becoming increasingly important in International Safeguards as a way to verify that the plant set-up is consistent with the declared intent of its activities. Because of the complexity of nuclear installations, design verification can be extremely challenging and time consuming. Within the framework of Task EC-E-01425, JRC-IPSC developed a 3D laser based tool for Design Information Verification (DIV) purposes [5]. The DIV system is divided in two main components: (i) a commercial off-the-shelf laser range scanner for data acquisition, i.e., capture the 3D coordinates, of a given environment with millimetre accuracy and (ii) a suite of JRC developed software applications needed to create an accurate 3D reference model, automatically analyse a verification model and detect changes, as well as manage all acquired and processed datasets, including secure storage and data authentication. This JRC developed system – 3DLR – is currently being used by the IAEA and Euratom.

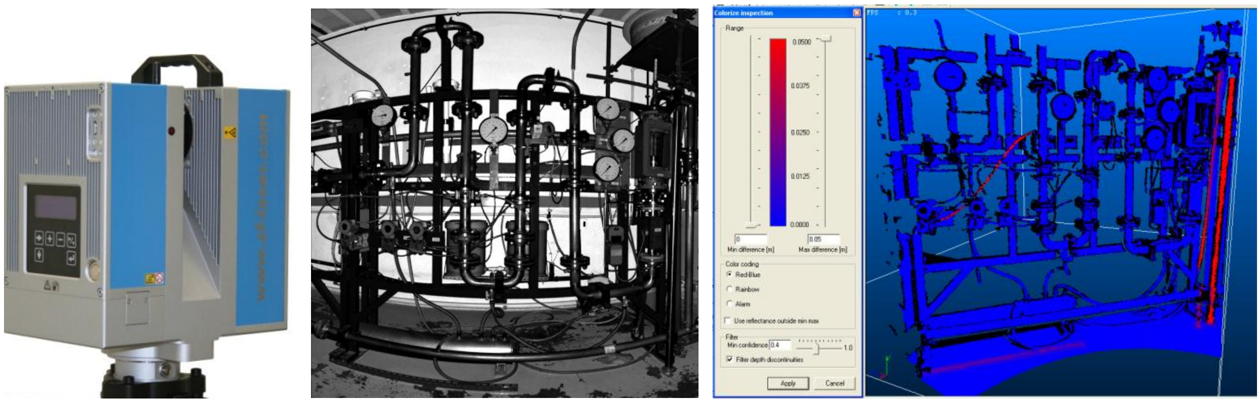


Figure 5: 3D Laser Range Finder used in the 3DLR, and examples of 3D capturing of a complex scene including automated 3D scene change detection – for verification purposes.

5.6 Development of an integrated approach to GCEP safeguards

The current IAEA strategy on safeguarding enrichment plants is still based on the results of the Hexapartite Working Group dating back to the early eighties. This working group tried to develop a system of mutually (IAEA and operators) acceptable assurances allowing the inspection of GCEP without disclosing sensitive technological information. Since then a lot of technological improvements have occurred, more countries had access to gas centrifuge technology and undeclared enrichment programmes have been discovered. All these factors call for an upgrade of the safeguards approach and the IAEA has started a process of modernisation of the inspection concept at GCEP's.

The current system relies on regular inspections for nuclear material accountancy based on NDA verifications (mostly on product cylinders) complemented by containment and surveillance measures. In addition LFUA (Limited Frequency Unannounced Access) to the cascade hall are allowed.

JRC is working in the frame of the EC-SP to develop an innovative integrated approach to GCEP safeguards that could improve effectiveness in the verifications of theis kind of plants. The approach is based on three pillars:

- Continuous monitoring of load cells at feed/withdrawal stations, complemented with cascade modelling, aiming to a nearly real time accountancy (NRTA) of material in the plant
- Tracking/identification/authentication of cylinder flow in the plant
- Improved NDA techniques for verification of cylinders

The first goal is currently not fully addressed in an ongoing SP task, even though it is partly included in the proposal 10/TAU-005 “Evaluation of data collected from operator systems at enrichment plants” aiming to the analysis and evaluation of operator provided data at the GB-II plant. The general principle is to acquire continuously cylinder weight data from the load cells at the feed/product/tail stations (mostly provided by operator equipment) and to analyse them in order to confirm the plant operation according to the expected behaviour and to exclude the presence of undeclared operations and/or the diversion of material. Since the monitoring is done only at the endpoints of the plant and no physical parameters are measured in the cascade hall, there is the need to develop theoretical models simulating the functionality and operation of the centrifuges and cascades in order to be able to analyse and correlate the signals measured at the entry and exit points and to conclude on the compliance of the operations with declarations.

The second part is done under task EC-E-1696 “L2IS: Laser Item Identification System” [] and aims to have a real-time tracking of flow of cylinders in the plant, complemented with identification and authentication features. The L2IS is capable of monitoring all transfers of UF6 cylinders between process areas by uniquely identifiying each cylinder through exploring the unique 3D microstructure of each cylinder’s surface. It has been demonstrated that every cylinder has a unique ‘fingerprint’ which remains stable even under extreme environmental conditions. The L2IS system is composed of a portable unit, operated in attended mode, and a fixed installed unit, operated without inspector presence. An inspector, using the portable unit, acquires the fingerprints of a given set of feed cylinders intended to be used over the forthcoming months. The fixed system monitors the flow of previously identified cylinders in a transfer corridor. This system is coupled with standard video surveillance that can remotely transmit state of health information to IAEA Headquarters. The video surveillance can be interfaced with electronic seals applied to the cylinders to record and display seals data (e.g. status, time/date of application). The integration of data from the L2IS with data from weighing and NDA stations is foreseen to monitor and verify all transfers. This will provide a high deterrence of diversion or substitution, and an increased probability of detection thereof. After one year of field testing, successful results of the L2IS have been reported [6].

Figure 6: L2IS Portable and Fixed reading Stations

Finally the improved NDA on cylinders is executed under task EC-A-1687 “State of the Art of NDA Techniques Applicable to UF6 Cylinders”. The current verification system on cylinders relies on accurate weight measurements at the accountancy scales and on gamma spectrometry for enrichment measurements. Current technology on gamma spectrometry does not allow to reach the wished accuracy in the cylinders used at GCEP plants: the large cylinder wall attenuates too much the soft X-rays needed to perform spectral analysis with intrinsic calibration methods and the measurements done based on the enrichment-meter principle require an accurate knowledge of the wall thickness in order to correct accurately for the attenuation [7]. JRC has analysed the potentiality to improve the measurements of cylinders using passive neutron measurements. This alternative technique is based on the measurement in a well controlled geometrical configuration of the total neutron source generated by (alpha,n) reactions within UF6. This is not a direct indicator of enrichment since the main contribution to the neutron source comes from 234U. Nevertheless 234U/235U ratio is constant within a plant and known when the enriched UF6 is directly produced from natural feed, which is the most common operational case. The application of the technique could be problematic to cases such as blending of products, reprocessed uranium, re-enrichment of tails, products from enriched feed.

6. Discussion and Conclusions

JRC's experience in operating the European Commission Support Programme, in line with the collaboration of DG-ENERGY, has been very positive. The franc dialogue with the IAEA led to a programme of applied research targeted to Nuclear Safeguards applications. This programme has produced several pieces of work with relevance to international Safeguards stakeholders.

Discussing about the IAEA Member State Support Programme, one can highlight the role of an MSSP as a facilitator between National, Regional and International Safeguards. The organisations implementing the MSSP must have a deep understanding of IAEA needs and translate these needs into technical research and development work.

Further, the participation in an MSSP makes people, and specially technical people, aware of IAEA Safeguards and the continuous challenge in "raising the bar".

The existence of an MSSP creates, somehow, a sense of partial ownership in what concerns the implementation of International Safeguards. This makes politicians and decision makers more informed about IAEA Safeguards, its rules, modes of operation and technical requirements.

7. Acknowledgments

The authors express their gratitude to all colleagues in ENER and JRC for their collaboration in implementing the European Commission Support Programme. In particular, a special word for all JRC task officers, action leaders and unit heads who provided material for this paper. We also thank IAEA's Support Programme Coordination team for the excellent relations and good discussions aimed at the continuous improvement of the efficiency of the EC-SP.

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