Hungarian Experience in the Role of a Technical Support Organization – Expert Support and R&D Activities in Nuclear Safeguards and Forensics, Participation in International Cooperation

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Abstract. The Institute of Isotopes (IoI) of the Hungarian Academy of Sciences has been – since the mid-fifties – engaged not only in basic and applied research related to the use of radioisotopes in Hungary but also in the production, trade and safety of radioisotopes supported by the central accountancy at national level. Based on its experience and capabilities the technical tasks of nuclear safeguards and forensics have been delegated to the Institute by governmental decrees. Thus the Institute is one of the Technical Support Organizations of the Hungarian Atomic Energy Authority (HAEA) providing expert support in the areas mentioned above and maintaining the central isotope registry. An Agreement between HAEA and IoI specifies both routine and R&D activities supporting authority functions. These include the development and application of both non-destructive (i.e. gamma spectrometry, neutron-coincidence counting and laser ablation inductively coupled plasma mass spectrometry) and destructive (i.e. inductively coupled plasma mass spectrometry) analytical methods to satisfy domestic needs as well as to explore novel methods both for safeguards and nuclear forensics purposes. Methods have been developed to identify and quantify nuclear material in fresh and spent fuel assemblies and to characterize seized or found nuclear material of unknown origin and also environmental samples. The validation of these measurement methods have been performed in inter-laboratory comparisons organized by the Joint Research Centers of the European Union and by other international organizations such as IAEA and the International Technical Working Group on Nuclear Smuggling (ITWG). The presentation describes TSO activities both at domestic level and in potential international cooperation initiatives. The need of regional cooperation is emphasized discussing advantages and difficulties.

1. Introduction

Technical support organizations have got basic role in assuring safe, secure and peaceful application of nuclear energy worldwide. Their role and experience, however, depends very much on the level of research, development and application of nuclear energy in the given country as well as on the financial support available. The Institute of Isotopes (IoI) of the Hungarian Academy of Sciences has been – since the mid-fifties – engaged not only in basic and applied research related to the use of radioisotopes in Hungary but also in the production, trade and safety of radioisotopes supported by the central accountancy at national level. The Institute has gained extensive experience with the measurement and handling of radioactive and nuclear material and based on this experience and capabilities the technical tasks of nuclear safeguards and forensics have been delegated to the Institute by governmental decrees. Thus the Institute has become one of the technical support organizations of the Hungarian Atomic Energy Authority with key role in the development and application of nuclear measurement techniques and methods for nuclear safegurds and forensics providing expert support in the areas mentioned above and maintaining the central isotope registry. The tasks and responsibilities of the Institute have been involved in an agreement between the two establishments with the aim of assuring suitable frame to keep and develop further the achieved scientific and technical basis for the implementation of the long term goals of the Institute of Isotopes. This agreement contains the development and application of safeguards control methods using both non-destructive and destructive analytical methods. Non-destructive analytical methods at the Institute include gamma spectrometry, neutron-coincidence counting and laser ablation inductively coupled plasma mass spectrometry, while inductively coupled plasma mass spectrometry (ICP-MS) is used as destructive analytical

method to satisfy domestic needs as well as to explore novel methods both for safeguards and nuclear forensics.

2. The role of TSO at national level

One of the main roles of a technical support organization at national level is the continuous involvement in R&D programmes in order to comply with the requests from the nuclear sector. The successful fulfilment of these tasks is important not only to keep the contact with real life, but also it is the secret to keep the talented young staff at the Institute, since the overwhelming routine tasks do not mean a challenge for the new generation. To keep up with the introduction and application of novel nuclear measurement methods and techniques is the key element of the compliance with the expectations. These research and development activities are fully supported by the HAEA thus helping the introduction of new nuclear measurement methods for the support of authority functions. To improve the quality of the work carried out at the Institute the accreditation of the ICP-MS laboratory is in progress as well as the involvement of the laboratory in the IAEA's NWAL laboratory network.

Technical assistance, based on well established R&D programmes is provided at national level upon request to nuclear research reactors and power reactors, as well as other organizations and institutions. A few examples of methods developed in the past two decades are given below including application fields and tasks performed in the Institute:

2.1. R&D activities in safeguards

- Methods, based on high- and medium-resolution gamma spectrometry for verifying the ^{235}U enrichment of fresh WWER-440 fuel assemblies and for detecting the presence of reprocessed uranium in the assemblies were developed and tested.
- Gamma-spectrometry was also used for the verification of the burn-up and of the U and Pu content of spent fuel assemblies, supplemented by neutron measurements.
- A spent fuel attribute tester (SFAT) for IAEA inspectors was developed and installed for WWER-440 type spent fuel assemblies [1].
- The U and Pu content of damaged spent fuel, stored in sealed containers at the Paks NPP were measured by the Institute of Isotopes, using the techniques, discussed above.

The success of these exercises has been based on the previous experiences originating from the long term research and development work of the co-workers of the Institute and it underlines the necessity of the support and planning of such work.

These techniques and methods supported national authorities and international organizations in the following areas e.g.:

- Verification of WWER-440, as well as WWER-SM (research reactor) spent fuel assemblies.
- Verification of Pu samples and Pu-Be neutron sources.
- Analysis of environmental (e.g. swipe) samples.

2.2. R&D activities in "nuclear forensics"

In the last decade of the previous century the task of identification, characterization and securing illicit nuclear material seized in Hungary was delegated to the Institute by governmental decree. The Institute possesses the necessary experience and capabilities to

characterize nuclear materials of unknown origin and the instrumentation available include gamma-spectrometry (including a low-background setup), mass spectrometry (ICP-SFMS equipped with a laser ablation sample introduction system), a clean laboratory, neutron coincidence counting and electron microscopy. Recent R&D activities involve:

- Characterization of seized uranium samples by gamma spectrometry [2]
- Assay of Pu in Pu-Be sources [3].
- Assay of nuclear material by PGAA [4].
- Analysis of nuclear material of unknown origin by mass spectrometry.

These techniques and methods supported national authorities in the identification and first assessment of seized nuclear material on spot.

2.3. Analysis of environmental and swipe samples

The mass spectrometer and the clean laboratory are used, among others, to quantify trace amounts of transuranic elements (in particular Th, U, Pu, ^{241}Am) in the environment. In addition, methods were developed for the bulk analysis of uranium and plutonium in swipe samples.

3. The importance of cooperation and its possibilities

Cooperation betwen TSO-s and national and/or international institutions has got key role in both helping countries with less experience and shorter scientific history on this field. According to our experiences more intensive connection among TSO-s in various countries would be needed. So far mainly coordination exists in this field and the lack of cooperation is due mainly to the lack of financial background, although the need for stronger cooperation exists. These activities should be initiated also by national technical support organizations thus exchanging knowledge as well as helping countries with less experience. Regional cooperation could also be initiated to help futher exchange of experience by forming international consortia.

Examples for existing cooperations include the Hungarian support programme to IAEA safeguards with realized technical achievements like the SFAT for IAEA inspectors to verify low burnup and long cooled fuel assemblies.

Another example originates from the incident in Paks Nuclear Power Plant, where a few fuel assemblies were seriously damaged creating a technical safeguards problem. The verification of the damaged fuel assemblies was performed with an instrument – an underwater verifier - developed specifically for this purpose used by the scientists of the Institute of Isotopes in cooperation with the IAEA safeguards inspectors.

The quantitative measurement of the Pu content in Pu-Be neutron sources leading to the establishment of a real inventory - due to the lack of declaration of the Pu content in the original certificates - was also part of the Hungarian support programme.

Important part and goal of the such cooperation programmes is the validation of nuclear measurement methods developed in the Institute. These activities have been carried out partly in bilateral exercises, as well as in inter-laboratory comparisons organized by the Joint Research Centers of the European Union and by other international organizations such as IAEA and the International Technical Working Group on Nuclear Smuggling (ITWG).partly in cooperation with JRC Institutes and partly in the frame of international tests like the „Round Robin” exercises to characterize highly enriched uranium samples in 2002 and in 2010.

Inter-laboratory exercises with IPSC, Ispra helped the Institute in the validation of the method developed for the determination of the Pu content of Pu-Be sources by providing us with a calorimeter to perform gamma and neutron measurements.
Joint exercises have been organized with the ITU to analyse seized nuclear material and the age determination of uranium containing samples.

The involvement in the research programmes of the European Union is another possibility to strengthen cooperation between countries already belonging to and/or waiting to join the Union. The technical level with respect to experience varies very much in European states showing a broad range in nuclear forensic capabilities with no complete picture available in literature to assess and compare capabilities of European nuclear forensic laboratories. Leading institutions are the JRC ITU and the IAEA, while many states are lacking up-to-date techniques mainly because of shortage of funding. To some extent ITWG annual meetings and Round Robin exercises, IAEA and ESARDA symposia provide information to the community. The author's impression is that the various labs have very different capabilities. Known international or regional cooperation is probably limited, however, IAEA is organizing and supporting Coordinated Research Programmes (CRPs) also in nuclear forensics.

In order to improve nuclear forensics capabilities the establishment of an international consortium in the frame of the EU FP7 programme was initiated with the participation of seven European states to carry out coordinated research in nuclear forensics. More than 7 laboratories responded positively and provided us with detailed information on their capabilities and running R&D projects. The issue looked very promising, also JRC-ITU was ready to join the consortium, but at this point it was understood that the scope of FP7, as finally declared, did not incorporate "generic" research.

4. Conclusions

Taking into account the present technical and administrative activities of the Institute of Isotopes it is clear that the present cooperation with the Hungarian Atomic Energy Authority is very fruitful, helps a lot to maintain the necessary R&D technical level. It is the intention of the Institute, however, to develop further the safeguards and nuclear forensics capabilities in order to avoid the 'ad hoc' cases, since the efficient activity of TSO needs the continuity with respect to perform suitable R&D.

Further efforts at least to maintain, but rather to improve the present level of bilateral and multilateral international cooperation will be made using all available potential routes.

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