

Position Statement

“Synthetic Particles for Micro-Particle Analysis – Paving the Way to Safeguards Applications”

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Starting point Forschungszentrum Jülich is currently engaged in R&D efforts on a method to synthesize micro-particles for application in international safeguards. These particles are to be used by the IAEA for quality assurance purposes in particle analysis on trace amounts of nuclear material extracted from environmental swipe samples taken as part of IAEA inspections. Per definition, analytical measurements provide quantitative measurement results which are obtained under controlled conditions. Common requirements on quality assurance exist, with internationally recognized standards and procedures. The use of measurement standards and reference material, ideally certified by dedicated institutions, is in fact mandatory in analytical measurements. Quality assurance measures are indispensable in analytical measurements which create data to derive Safeguards conclusions. It is planned to use the synthesized particles for quality assurance purposes for techniques, instruments and procedures used for particle analysis by the IAEA in-house Safeguards Analytical Services and the member laboratories of the Network of Analytical Laboratories determining isotope ratios of uranium and plutonium atoms found in environmental swipe samples. Our method is capable of delivering particles with parameters according to specifications by the IAEA. Current efforts are focused on controlling the particle parameters with even higher precision and accuracy to foster the quality of measurement data.

Quality of Safeguards The specifications for the synthetic particles are deduced from quality goals that the IAEA safeguards community has determined for micro-particle analysis methods. For measurement data, guidance on what quality actually means, how to ensure quality and how it is assessed is established in metrological terms (metrology = science of measurement and its application). Here the term ‘uncertainty’ plays a central role, which is quite clearly defined and is assessed quantitatively, usually using well characterized reference standards. In the context of IAEA safeguards, the notion of quality and confidence is more complex. Considering nuclear material accountancy in facilities, the safeguards verification measures are designed to fulfill certain quantitative verification goals. However,

verification of the peaceful use of nuclear energy involves a wide variety of data and information sources to derive conclusions on the completeness of declarations or the absence of undeclared activities.

Particle analysis, for example, represents a verification measure that yields information on the absence of undeclared nuclear activities. The quality of micro-particle analysis is of particular importance in analyzing the information from environmental swipe samples, and the availability of synthetic particles as reference standard may contribute in augmenting the reliability of results thus contributing to sound safeguards conclusions.

Breaking new ground A further topic to be addressed is the extension safeguards particle analysis beyond isotope ratio determination. The synthetically produced particles may be very helpful in extending the currently used particle analysis for extraction of additional information. After all, methods for ultra-trace analysis and micro-analytical tools are continuously improving and expanding. An emerging technique is the micro-analysis of oxygen O^{18}/O^{16} isotope ratios in solid particles, bearing the potential of additional geo-location of particles. However, the safeguards boundary conditions impose several challenges in extracting useful safeguards information from obtained analytical data. Open questions arise with respect to mechanisms of the uptake of oxygen in particles, the relation between oxygen isotopes and the source location of particles, sample stability, background contributions, etc. Therefore significant scientific knowledge and R&D is required in order to establish the utility of the method for safeguards information. Here, specifically designed particles with designated oxygen isotope ratios could bring potential benefits in establishing the validity of analytical results, an essential step towards application in safeguards.

Scientific knowledge as resource for safeguards The extraction of valuable information from analytical measurements also depends on available scientific knowledge from various fields. Staying with the example of studying oxygen ratios in particles, one can resort to a rich body of data and knowledge on oxygen isotope ratios in the atmosphere, which have been extensively studied in environmental sciences. However, the details of the openly available data, sometimes complemented by modelling and interpolation, need to be considered. For example, oxygen isotope ratios in the atmosphere exhibit a temporal variation at a given location. Furthermore uncertainties in the body of data provided by a scientific community used to supplement safeguards measurements may be difficult to quantify or might render analytical measurement results useless for safeguards purposes.

The discussion can be evolved or expanded to more general terms. As emerging technologies and techniques may depend on scientific knowledge from a wide range of disciplines, the question arises, how this knowledge can be effectively applied for IAEA safeguards. For example, Kr-85 atmospheric air sampling has been studied for its potential application to detect undeclared reprocessing in Safeguards which relies on atmospheric transport modeling to draw information from Kr-85 sample datasets. When the utility of the method is to be assessed, one should also consider the degree of confidence one can have in models used for interpretation of data. Vice versa, the requirements on analytical measurements and the extent of the scientific basis depend on the safeguards questions that are to be answered in verification. For example, how exact does geo-location have to be? Would detection of anomalies be sufficient? Does the gain justify the cost, when it comes to implementation? Such questions will have to be faced when dealing with the problem of integrating emerging technologies for measurements in safeguards.