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Abstract
In the European Union, nuclear material is reprocessed from irradiated power reactor fuel at two sites - La Hague in France and Sellafield in the United Kingdom. These are the largest nuclear sites within the EU, processing many hundreds of tons of nuclear material in a year. Under the Euratom Treaty, the European Commission has the duty to assure that the nuclear material is only used for declared purposes. The Directorate General for Energy (DG ENER), acting for the Commission, assures itself that the terms of Article 77 of Chapter VII of the Treaty have been complied with. In contrast to the Non Proliferation Treaty, the Euratom Treaty requires to safeguard all civil nuclear material in all EU member states - including the nuclear weapons states.
The considerable amount of fissile material separated per year (several tonnes) calls for a stringent system of safeguards measures. The aim of safeguards is to deter diversion of nuclear material from peaceful use by maximizing the chance of early detection. At a broader level, it provides assurance to the public that the European nuclear industry, the EU member states and the European Union honour their legal duties under the Euratom Treaty and their commitments to the Non-Proliferation Treaty. Efficient and effective safeguards measures are essential for the public acceptance of nuclear activities. A thorough analysis of the options to perform nuclear material accountancy at reprocessing plants concluded - in the early 1990s - that sampling of material from the process streams would be required. However, transport of the samples to a central Euratom laboratory should be avoided for reasons of cost effectiveness and timeliness. It was therefore decided to establish laboratories on the sites of Sellafield and La Hague. These laboratories were opened ten years ago and have been working continuously since then. They are operated by inspector analysts of the JRC Institute for Transuranium Elements (ITU) at Karlsruhe, Germany, on behalf of the Safeguards Directorate at the Directorate General for Energy, Luxembourg.
The sample measurement methods were selected using the criteria of a highest possible measurement accuracy (better than 0.10/0) and a minimum of resource consumption. The methods developed and deployed are based on the following approach: from previous experience it was decided to analyse most of the samples by radiometric methods: KX-ray absorption for the uranium concentration, X-ray fluorescence for the uranium/plutonium ratio, and gamma spectrometry for the analysis of individual uranium and plutonium isotopes. The radiometric X-ray techniques must be calibrated against an absolute standard. To this end, isotope dilution mass spectrometry was chosen as the primary technique which also serves for quality control of the radiometric methods due to its superior accuracy. It is more labour intensive and is therefore carried out only on a subset of about 10% of the samples and allows one to measure both the uranium and plutonium concentrations and the respective isotopic compositions. Quality assurance measures - both internal and external quality control - are of particular importance for accountancy measurements at facilities with a large throughput of nuclear material. The work at the on-site laboratories is performed according to quality management principles and follows the requirements of an ISO 17025 accredited laboratory. Analytical methods and procedures are continuously being improved and the laboratories are benchmarked through regular participation to inter-comparison exercises. The objective for the on-site laboratories is to conform to the latest international standards, which is in fact achieved at daily operation. An important pillar of nuclear material accountancy at reprocessing plants is the measurement of samples from the process streams in order to accurately determine the quantities of uranium and plutonium present. The verification measures must be capable of detecting nuclear material with a high probability and in a timely fashion. Analysts of ITU are present on-site for more than 40 weeks per year, ensuring a continuous flow of samples and of results. The laboratories receive samples from all the plants on the respective sites, with dissolved spent fuel, plutonium products – including mixed oxide fuel - and inventory samples as the most important types of material from an accountancy viewpoint. The obtained analytical data are used by DG ENER for direct comparison with the operator's results and allow for an evaluation of the material flows and the material balance in a timely manner.
During operation of the on-site laboratories, particular emphasis was put on the achievement of highest, state-of-the-art measurement accuracies. Values were improved from about 1 % at the start of the project down to the present values of below 0.1 %. In view of the several tonnes of fissile material separated per year, this important achievement puts robust limits on the uncertainties for the material inventory. The major advantages of on-site laboratories are: timeliness, sample authentication, efficiency and cost-effectiveness, waste reduction, re-verification possibilities, and significantly reduced transport needs.
Civil operations with nuclear material must be carried out such that the material is only used for declared purposes. Euratom Safeguards provides an independent verification of this obligation to the general public, the EU Member States, and the international community. Direct physical verification of the nuclear material is fundamental to the ability for diversion detection. In facilities handling large amounts of nuclear material the verification measures employed must be capable of detecting a diversion of nuclear material with a high probability and in a timely fashion. The analytical results of the on-site laboratories provide DG ENER with independent information on the nuclear material inventory. With ten years of operation, the high-quality and independent measurements performed by the on-site laboratories playa crucial role in safeguarding reprocessing plants.

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