Sustainable Nuclear Power Initiative

Pacific Northwest NATIONAL LABORATORY

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Safeguards and Proliferation Detection

Focus Area Fact Sheet

Focus Area Description

The Safeguards and Proliferation Detection (SPD) Focus Area delivers technological advancements to improve the "safeguardability" of the expanding global nuclear fuel cycle. Preventing fissile material diversion and misuse of facilities that produce and handle nuclear fuels is fundamental to gaining public acceptance of the expanded use of nuclear power.

Heading off latent proliferation risk

Uranium enrichment and spent nuclear fuel reprocessing are the two core elements of the expanding nuclear fuel cycle that represent the greatest vulnerability for misuse or diversion. The commercial enrichment process for making low-enriched uranium (LEU) fuel for nuclear power reactors can be quickly adapted to produce highly-enriched uranium (HEU) for nuclear weapons. There also is a potential diversion pathway for LEU product using undeclared feed in a declared enrichment plant. LEU diverted from a large declared enrichment plant could supply feed to a small undeclared enrichment plant, since comparatively little additional separative work is required to produce significant quantities of HEU from diverted LEU. Similarly, spent nuclear fuel reprocessing separates weapons usable plutonium. Increasing capacities of enrichment and reprocessing are required to fuel a nuclear power renaissance, but further spread of these sensitive technologies to additional nations represents a significant increase in latent proliferation risk.

One approach to heading off this growing risk is the concept of a voluntary trade regime known as reliable fuel services and supply (RFS&S). Under this proposed regime, an assured supply of legitimate nuclear fuel and spent fuel services would be provided to nations which agree to a moratorium on development or acquisition of their own fuel cycle capabilities. The implementation of RFS&S regimes could help reduce the spread of enrichment and reprocessing technologies.

Improvements in the ability to detect noncompliance with IAEA safeguards agreements include: 1) enhancements in the technical safeguards approach for enrichment and reprocessing facilities to more accurately account for nuclear material, 2) the ability to safely manage and safeguard an increasing amount of spent nuclear fuel in interim dry storage and within RFS&S related spent fuel shipments, and 3) improvements in the ability to detect and verify noncompliance with IAEA monitored nonproliferation agreements.

Urenco centrifuge machines.

Science and Technology Capabilities

The Pacific Northwest National Laboratory's (PNNL) 40-year history of radiological R&D is built on the 60-year nuclear heritage of the nearby DOE Hanford Site, the location of the world's first large scale nuclear reactors and reprocessing plants. Hanford has played a significant role since the birth of the nuclear age in the development of both defense and nuclear technologies. The Hanford heritage has made PNNL well suited to support the development of safeguards and proliferation detection technology. Specific areas of Laboratory expertise include:

- *Radiation detector modeling and design*
- *Trace actinide chemistry, separations and measurement*
- *Tamper indicating device engineering*
- *Integrated system design and prototyping*
- *Domestic and international nuclear material safeguards policy, regulations, and associated analysis.*

PNNL capabilities support a variety of national security programs for federal clients including radiological monitoring programs for the Department of Homeland Security, Customs and Border Protection, and the National Nuclear Security Administration.

SPD Focus Area Investments

PNNL has directed much of its R&D investments in Safeguards and Proliferation Detection in proof-of-principle projects related to enhancing commercial nuclear fuel cycle safeguards. Investments include technologies for safeguards at enrichment and reprocessing plants, spent fuel management facilities, proliferation detection technologies including nuclear forensics, novel containment and surveillance technologies, as well as nonproliferation policy and analysis. SPD research in this area is published in technical journals and presented at leading proliferation prevention venues, such as annual meetings of the Institute of Nuclear Materials Management.

Enrichment Safeguards

- *Integrated Container Verification System (ICVS)* – Features a demonstrated NDA technique for whole UF6 cylinder assay with measurement accuracy of 5%. Potential exists for an unattended monitoring device that tracks uranium flows in enrichment plants while integrating unique cylinder ID, cylinder weight, and whole cylinder assays of items moving in and out of feed and withdrawal areas.
- *Laser Ablation Absorbance Ratio Spectroscopy (LAARS)* – Applies a demonstrated laser spectroscopy technique for detection of HEU particles at ultralow concentrations. When combined with an automated aerosol collection system, the technique provides the potential for timely and unattended monitoring of collected samples that can undergo more detailed laboratory analyses.

Reprocessing Safeguards

- *Electrochemical separations cell for enhanced safeguards analysis* – Develops a new technique for separating purified microscopic samples of uranium, plutonium, and possibly other transuranics in-situ from process solutions for accurate safeguards accountancy through drastically simplified laboratory measurements of microscopic grab samples and unattended in-line process monitoring.

Spent fuel from nuclear reactor operations is accumulating worldwide and is safely stored for extended periods in dry storage facilities such as this one. Spent fuel contains significant amounts of plutonium, and is verified under IAEA safeguards.

Verifying Japan's Rokkasho reprocessing plant's declaration represents the largest and most complex IAEA safeguards undertaking at a single facility.

Spent Fuel Safeguards

- *New NDA Methods for direct measurement of Pu and U in spent fuel* – Preliminary viability simulations and analysis performed for the assay of single fuel pins indicates the High Energy Delayed Gamma Spectroscopy (HEDGS) method is capable of direct Pu isotope assays with uncertainties less than the 10 percent typical of today's confirmatory method, and without the need for operator-declared information about the fuel. New in FY10, the Advanced NDA for Safeguards (ANDAS) project will provide for the design, development, and deployment of a safeguards dedicated lead slowing down spectrometer (LSDS), capable of accurate, nondestructive measurements of Pu in spent fuel assemblies. When completed, the LSDS will be one of only three such devices in the United States.

Proliferation Detection and Nuclear Forensics

- *Isotopic ratio fluence monitors* – Leverages prior demonstration of the use of trace metal isotope ratio methods to verify Pu production declarations through evaluation of in-reactor materials. This research is being expanded for safeguards use through the design and development of small, retrievable, tamper-resistant indicators to measure reactor fluence exposure in CANDU reactors, with possible expansion to future reactor designs, such as the PBMR.
- *Advanced sorptive and signature indicating materials* – Designing novel materials for the collection of nuclear proliferation signatures with vastly improved selectivity and sensitivity performance. Research includes materials development for noble gas sorption, development of functionalized magnetic monopoles, and development of a novel trimeric protein which fluoresces only in the presence of U bearing materials (uranyl).

Nonproliferation Policy and Analysis

- *Analytical Framework for Assessing the Performance of Reliable Fuel Services and Supply* – Development of a method for economic and policy analysis of RFS&S to provide insight into the nonproliferation value added by various trade regime reform policy proposals.

Containment and Surveillance Technology

- *Tamper indicating container coatings* – Demonstrates quick detection for revealing breeches in IAEA tamper indicating enclosures with an optically stimulated luminescent (OSL) material, even in the absence of visible tamper indications.

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