LA-UR-97-1141

C.54

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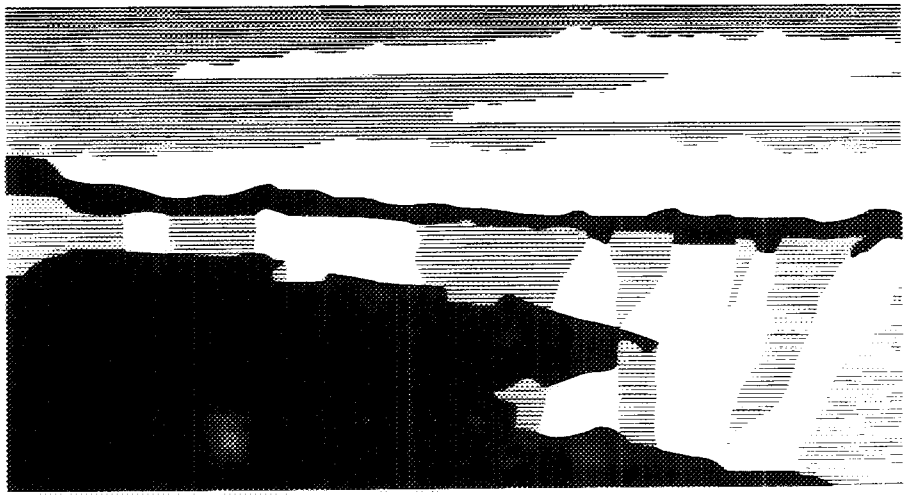
Submitted to: Proceedings of the Workshop on International Inspection of Excess Fissile Materials
Washington, DC
February 19-20, 1997



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Form No. 836 R5
ST 2629 10/91

ARIES NDA SUITE: Fully-integrated and Automated Nuclear Material Assay System for Measurement of Special Nuclear Materials

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INMM Workshop on International Inspections of Excess Fissile Materials
February 19 and 20, 1997, Washington, DC

Executive Summary

The Advanced Retirement and Integrated Extraction System (ARIES) mission involves the demonstration of advanced technologies for the integrated dismantlement of surplus nuclear weapon components (pits) and the packaging of the recovered plutonium into long-term storage containers. The unclassified plutonium product is suitable for traditional international safeguards, as well as other potential inspection regimes. As indicated in the recent Secretary of Energy's Record of Decision (ROD), this unclassified excess material is anticipated to be offered for international safeguards under the US Voluntary Offer (INFCIRC/288) performed by the International Atomic Energy Agency (IAEA).

The ARIES nondestructive assay (NDA) suite offers state-of-the-art capabilities that provide highly accurate, precise material assay meeting IAEA bias defect measurement levels. Because of these levels of performance, the requirement of destructive analysis is largely removed. The unique combination of automation and high accuracy suggests the possibility of dual-use operator-owned IAEA authenticated instrumentation. Finally, the concept of continuous unattended monitoring for international safeguards applications with the ARIES NDA suite is intriguing and may encourage additional deployments of similar NDA systems internationally or elsewhere within the DOE complex.

ARIES Process and Disposition

ARIES supported by the DOE Office of Fissile Material Disposition is designed to integrate disassembly and conversion of surplus pits (those excess to defense needs) into a stable unclassified form. The ARIES system consists of a number of subsystems as follows: pit bisection, plutonium removal via a hydride-dehydride process resulting in a metal ingot, casting of the plutonium into a nominal mass, and possible conversion to oxide. At this point the material is effectively unclassified with a nominal mass and form. The final product is then packaged and placed into a long-term storage container. This container meets the 3013 storage standard, and is decontaminated prior to NDA assay. Following the ARIES NDA suite assay, the container is ready for interim storage and ultimate disposition (both of which are anticipated to be under international safeguards). The disposition options announced by the Secretary of Energy's ROD (1/97) include reactor burning and immobilization with final placement into an underground repository.

Under various Presidential announcements and Directives, the US policy is to place excess fissile materials under international safeguards subject to classification limitations and national security needs. Hence, the plutonium output from the ARIES process is anticipated to be offered for international safeguards.

ARIES NDA Suite

The ARIES NDA consists of four computer-based NDA instruments integrated with a host computer and a robotic handling system. The integrated ARIES NDA suite is designed to measure all ARIES products and wastes that are contained in the specialized 3013 contamination-free stainless-steel containers. The NDA assay instrumentation consists of: a gamma-spectrometer for determining the plutonium isotopic distribution, a segmented gamma scanner for waste assay, a neutron counter for waste and product assay, and a calorimeter for high precision assay. A key component of the system is the extensive use of automation and robotics for sample handling. These features are anticipated to increase throughput and reduce radiation exposure, while maintaining the highest standards of material accounting and control. The system capabilities and design are indicated in the Table 1.

Table 1. Materials Measurement Methods

Item Measured	Amount of SNM	Measurement Method				
		SGS	Cal	Pu Iso	Neutron	
					Passive	Active
Pu Metal Product	> 100 g Pu		X	X	X	
Pu Contaminated with Be	< 10g Pu	X		X	X	
Pu Contaminated High Density Waste	< 50 g Pu			X	X	
Pu Contaminated Low Density Waste	< 50 g Pu	X		X	X	
Uranium	> 0.5 kg U				X	X
U Contaminated Low Density Waste	< 50 g U	X				

The gamma-isotopic measurement combined with calorimetry or neutron counting data provides the total plutonium mass of a container. Together, calorimetry and neutron counting are complementary assay techniques that provide high assurance of correct and valid measurements. The ARIES neutron counter is able to measure both products and wastes. The primary assay method will be passive coincidence counting, but multiplicity analysis can be used to correct for certain matrix effects. Active interrogation can be used for measurements of uranium. Calorimetry measures the heat produced by alpha decay and is a function of the mass and the plutonium isotopic distribution. Calorimetric assay is the most precise and accurate for the plutonium product (>100 grams).

The ARIES NDA suite is strongly leveraged on existing technology and based on this extensive measurement experience. All instruments are of proven NDA designs largely developed at Los Alamos and in use throughout the world, internationally (IAEA) and the US DOE complex.

Inventory Differences

Experience with many processes at the Los Alamos Plutonium Facility indicates that inventory differences (IDs) are largely driven by NDA measurement biases. For comparison purposes, the Los Alamos plutonium casting process is similar to ARIES (that is, a high throughput process with low wastes). The IDs for casting are small, on the order of a few tenths of a percent. The anticipated IDs for the ARIES process should be comparable to those observed for the casting process. Any biases will become apparent as measurements are compared to external audits (e.g., IAEA) or other facilities (i.e., shipper/receiver differences). A standards-based measurement program also serves to minimize ID's and allow continuous assessment of process ID's. Table 2. summarizes the expected measurement uncertainties for the ARIES NDA suite.

Table 2. ARIES NDA Suite: Precision and Bias

	Calorimetry — Pu Iso		Neutron — Pu Iso	
Instrument	Precision	Bias	Precision	Bias
Calorimeter	0.25%	0.08%		
Gamma Spec P_{eff}	0.25%	0.11%		
Neutron Counts			0.25%	0.1%
Gamma Spec - $^{240}Pu_{eff}$			2.0%	0.14%
Overall Precision & Bias	0.35%	0.2%	2.0%	0.25%

Conclusion

The ARIES process converts classified nuclear weapon components (pits) to unclassified plutonium forms in standard containers. The forms and containers potentially could be offered to the IAEA for international safeguards in alignment with current US policy. The ARIES instrumentation suite offers true standardized state-of-the-art NDA assay capabilities to minimize inventory differences for the ARIES process. The ARIES NDA suite enables high quality materials accountancy where high accuracy significantly reduces needs for destructive analysis. Importantly, the material assay precision is such that it meets the IAEA bias defect measurement criterion.