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Measurements at Los Alamos National Laboratory Plutonium Facility in Support of Global Security Mission Space

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Abstract

The Los Alamos National Laboratory Plutonium Facility at Technical Area (TA) 55 is one of a few nuclear facilities in the United States where Research & Development measurements can be performed on Safeguards Category-I (CAT-I) quantities of nuclear material. This capability allows us to incorporate measurements of CAT-IV through CAT-I materials as a component of detector characterization campaigns and training courses conducted at Los Alamos. A wider range of measurements can be supported. We will present an overview of recent measurements conducted in support of nuclear emergency response, nuclear counterterrorism, and international and domestic safeguards. This work was supported by the NNSA Office of Counterterrorism.

1 Introduction

Many projects require access to and use of radioactive materials in various forms and configurations. Hazard Category 2 facilities are designed to contain material and processes that have the potential for significant on-site consequences, including nuclear criticality events. They are required when the amount of a radionuclide is higher than a threshold value, which is based on the effective dose delivered. However, for ^{233}U, ^{235}U, and ^{239}Pu a lower threshold, the criticality limit, also applies. For these three isotopes, the Hazard Category 2 limit applies only when segmentation or the nature of the process precludes criticality - otherwise, all amounts greater than the criticality limit must be contained in a Hazard Category 2 facility or Type B container. The Hazard Category 2 thresholds and criticality limits for a number of isotopes of interest are given in Table 1. Note that the criticality limits are significantly smaller than the Hazard Category 2 thresholds based on dose, particularly for ^{235}U, where the criticality

Nuclide	Hazard Category 2 Threshold	Criticality Limit
^{233}U	23 kg	500 g
^{235}U	110 mt	700 g
^{238}U	710 mt	
^{237}Np	83 kg	
^{239}Pu	900 g	450 g
^{241}Pu	28 g	

Table 1: Threshold amounts of nuclear materials requiring a Hazard Category 2 facility

Contained ^{235}U [kg]		Categories			
		I	II	III	IV
Attractiveness	A – Weapons	All	N/A	N/A	N/A
	B – Pure Products	≥5	≥1 and <5	≥0.4 and <1	<0.4
	C – High-Grade	≥20	≥6 and <20	≥2 and <6	<2
	D – Low-Grade	N/A	≥50	≥8 and <50	<8
	E – Other	N/A	N/A	N/A	Reportable Quantities

Table 2: Safeguards categories for ^{235}U as a function of mass and attractiveness

limit reduces the minimum amount of material that requires a Hazard Category 2 facility from 110 metric tons to 700 grams.

The hazard categorization is not the only factor determining where and how nuclear materials can be stored and used. Nuclear materials in the DOE complex are also divided into safeguards categories based on the mass of material present and its attractiveness to diversion. These categories determine the materials, protection, control, and accountancy (MPC&A) required to handle and store them. There are four safeguards categories, ranging from CAT-IV through CAT-I, with CAT-I materials requiring the highest level of protection. For example, CAT-I materials must reside within several layers of restricted-access areas and require a Vulnerability Assessment. Table 2 provides the category mass ranges for different types of ^{235}U items. Note that, since the criticality limit for ^{235}U is 700 g, even many CAT-IV items may require a Hazard Category 2 facility. Therefore, performing many measurements of interest to global security missions requires a facility that not only fulfills the MPC&A requirements needed to safeguard material of a given safeguards category, but also one that is build to Hazard Category 2 specifications. Currently, there are only two Hazard Category 2 nuclear facilities in the Department of Energy (DOE) complex that routinely support these types of measurements: the Device Assembly Facility (DAF) at the Nevada National Security Site (NNSS) and Plutonium Facility (PF) 4 at Technical Area (TA) 55 Los Alamos National Laboratory (LANL).

The Nuclear Engineering & Nonproliferation (NEN) Division at LANL has a long history of applying nondestructive analysis techniques to support safeguards, materials control and accountancy, and other tasks at the TA-55 Plutonium Facility. NEN division designed, produced, and/or technology transferred most of the nondestructive assay (NDA) equipment and software currently in use at PF-4, and collaborated with personnel at TA-55 to design systems

Figure 1: Multiple gamma-ray and neutron detectors in position, prior to a measurement. The source will be placed in the center of the configuration.

for specific processes, including in-process monitoring of aqueous solutions and fast neutron coincidence counters. These long-standing collaborations have resulted in the development of a strong relationship between NEN division and our colleagues at TA-55, which allows us access to unique materials and capabilities.

2 Measurement Capabilities at PF-4

Of the two Hazard Category 2 facilities, TA-55 possesses a wider range of forms and materials. TA-55 has more than 500,000 items, including metal or oxide objects of Th, ^{233}U, ^{235}U, ^{238}U, Pu, Np, Am, and Cm. In addition, TA-55 has NELAs (Nuclear Explosive-Like Assemblies) and product oxides created by ARIES and has an inventory of pits for measurement. We have performed measurements at PF-4 in support of various global security missions, including detector characterization and testing, benchmark measurements, training, and concept of operations work. These complement the measurements that can be performed at the National Critical Experiments Research Center (NCERC) at DAF.

The ability to access quantities as large as CAT-I of nuclear material enables us to test gamma-ray and neutron detectors against various combinations and configurations of nuclear material and assess their performance in realistic scenarios. Figure 1 shows a typical experimental setup for characterization of multiple detectors. Access to casting and machining facilities on-site means that objects and shielding materials can be tailored to a specific scenario. We can also take benchmark measurements of objects to verify calculations. These types of tasks are key to the development of instruments and data analysis techniques.

NEN division conducts training in nuclear safeguards, nondestructive assay (NDA), and

Figure 2: Practicing gamma-ray spectrometry

emergency response operations. The quantities and range of nuclear materials available at TA-55, available infrastructure, and existing capabilities make it an excellent location for this work. Participants can be given access to items similar to those they might encounter in the field, including threat objects. Figure 2 shows participants in a training course practicing gamma-ray spectrometry techniques.

3 Opportunities for Global Security Measurements

While access to PF-4 allows us to perform many measurements that cannot be made elsewhere, there are still limits to its capabilities. Since PF-4 is a working nuclear facility, background radiation levels can be too high to perform some sensitive measurements. In addition, the space is extremely limited, so some large items and pieces of equipment, such as portal monitors or large cargo containers, cannot be accommodated at all. Large objects and equipment also cannot be used in measurements at DAF, so there is currently no location in the DOE complex that can simulate measurements and scenarios involving CAT-I material in a cargo or vehicle environment.

Adjacent to PF-4 are a number of locations, including a paved and covered area of ∼5,000 sq.f. that was previously used as a staging area for the shipment of material from LANL to the DAF. This area, the SST pad, is not currently in use and is inside the security perimeter that determines in which areas CAT-I material may be used. A design for an upgraded SST pad, which would both make it easier to conduct CAT-I measurements for current programs and expand the range of applications that can be addressed, has been developed.

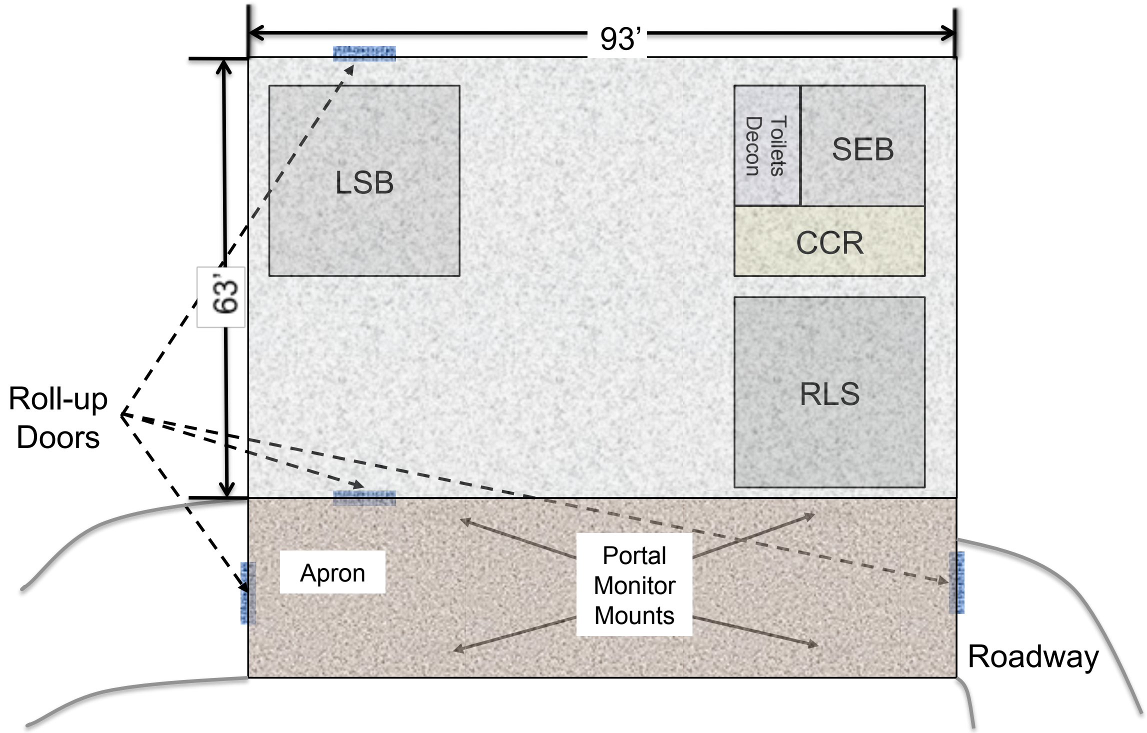

Figure 3: Conceptual design of SST pad expansion, showing enclosure of covered area and roadway and placement of permanent facilities

The conceptual design of the SST pad expansion involves enclosing at least the covered area, and possibly the paved roadway adjacent to it, with a steel shell. A combination of permanent facilities and temporary or reconfigurable buildings would be installed to serve a variety of purposes. Figure 3 shows one of the conceptual layouts for the SST pad interior with the proposed permanent facilities: a low-scatter bay (LSB) for neutron measurements, reconfigurable laboratory space (RLS), a reconfigurable class- and control room (CCR), a shielded experimental bay (SEB), and decontamination and toilets. The SST pad would be fitted with roll-up doors to both the roadway and the main experimental area, to facilitate bringing large equipment and objects into both parts of the facility.

The enhanced SST pad would significantly expand the types of CAT-I measurements that can be performed in the DOE complex. The roadway, with its multiple sets of portal monitor mounts, could be used for port, cargo container, and vehicle scenarios. Furthermore, since the roadway would be covered and enclosed by a wall, it could test portal monitors and other exterior equipment year-round, regardless of weather. The enclosed roadway would also allow measurements and training to occur without being observed.

This facility would expand the range of training scenarios for emergency response. The combination of outdoor and indoor space would enable the conducting of drills or exercises simulating all steps of the process, beginning with the detection of a potential threat object in a vehicle passing through a portal monitor, progressing to reporting to triage or reachback, adjudication, and disposition.

4 Conclusion

TA-55 has capabilities that complement ongoing work at the DAF and can be utilized to support missions that were not moved to the DAF/NCERC. TA-55 can be used to provide an advanced Intrinsic Radiation (INRAD) facility for stockpile stewardship support, active and passive NDA experiments and techniques, testing and evaluation, and areas where low- and high-dose radiography can be performed on the same materials. Many of these capabilities are currently underutilized and can be further taken advantage of to support national and homeland security efforts, emergency response, nuclear counterterrorism, nuclear forensics, and stockpile stewardship.