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Title: A Continuous Measurement Safeguards Approach

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A Continuous Measurement Safeguards Approach

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Abstract

The material control and accountability measurement program at Los Alamos National Laboratory has remained essentially the same for multiple decades. Criteria for the acceptance of verification and confirmation measurement results, the exact timing of measurement performance, and the measurement techniques have slowly evolved, but the safeguards program continues to perform measurements at the time of regularly scheduled inventories and material movements. Little safeguards inventory credit is given to the multitude of nondestructive assay measurements made by operations personnel during the normal course of operations. By taking safeguards credit for these measurements and instituting a random sampling procedure for determining the timing of additional measurements, LANL can both enhance safeguards and reduce the impact of these activities on programmatic work. This more efficient approach will provide increased assurance of the inventory and contribute to increased detection and assessment when implemented as part of an integrated material control and detection and assessment program. The authors propose one option for this continuous measurement approach. Demonstration of successful implementation at one NNSA facility could then be used to asses the viability of implementation of similar programs throughout the NNSA complex.

Introduction

Measurements play a vital role in any safeguards program. The goals of the safeguards program are (1) To provide assurance to NNSA, the public, and other stake holders that LANL's inventory of nuclear material (NM) is present in its stated quantities and in the stated locations, (2) To deter, detect, and respond to the unauthorized possession, use, or sabotage of NM, and (3) To complete these safeguards goals in a safe manner using a graded approach that also minimizes the impact to programmatic activity.

Measurements are used to establish and maintain defensible inventory values for all reportable quantities of NM on inventory in support of the safeguards program goals. Measurements allow the establishment of defensible inventory values, the verification of inventory values during inventory activities or following material transfers, and assist in the resolution of anamolies.

For the measurements to be meaningful, the data must meet precision and accuracy requirements. These requirements must be established with consideration for the (1) Material type to be quantified, (2) Chemical and physical form of the material, (3) Contribution of the measurement uncertainty to the ability to deter and detect diversion using the inventory difference, (4) End-use of the inventory value, and (5) Graded safeguards. The goals in Table 1 were established by LANL with these considerations in mind. Measurement method selection, operator training, and instrument control provide assurance that the precision and accuracy goals are being met at LANL.

Table 1 - Safeguards Accountability Accuracy Goals

Pu Items
(m is the mass of plutonium.)

Material Form	Attractiveness Level	m < 250g +/- g	250g ≤ m < 500g %	500g ≤ m < 2000g %	2000g ≤ m %
Pure Products	B	25	3.5	2.0	1.6
High-grade Materials	C	25	3.5	2.0	1.6
Low-grade Materials	D	50	15	10	10
All Other Materials	E	50	NA	NA	NA

Enriched Uranium (EU), Neptunium (Np), and Americium (Am) Items
(m is the mass of the element of concern.)

Material Form	Attractiveness Level	m < 500g +/- g	500g ≤ m < 2000g %	2000g ≤ m %
Pure Products	B	100	10	6
High-grade Materials	C	100	10	6
Low-grade Materials	D	150	20	10
All Other Materials	E	150	30	30

To meet the safeguards program goals, precise and accurate measurements must also be completed and documented in a timely fashion. Items are selected for measurement using a statistical sampling procedure as part of the process of validating LANL's inventory of NM. These measurements provide a snapshot in time of an item's NM content. Items are also measured at regular points in each material process at LANL and under certain conditions following the transfer of material across MBA boundaries. It is the integration of data from all three measurement times that allow LANL to meet the safeguards goals.

Current Measurement Approach

As stated above, measurement situations are currently encountered for MC&A purposes. First, material is measured when it crosses a MBA boundary under certain conditions as required by DOE Order M 474.1-1. LANL currently has XX category I MBAs, YY category II MBAs, and ZZ category III and IV MBAs. Material movements are recorded via a near real-time accounting system and the operating organizations are responsible for ensuring that these measurements are completed within the specified time requirements and meet the acceptance criteria for verification or confirmation measurements, as appropriate. Verification and confirmation measurements are typically not required for items that are attractiveness level D or E material, or items that are composed of less than 50 grams of NM.

Second, material is measured at specified points in the processing sequence. These measurements typically serve multiple purposes. They provide data for tracking and monitoring inventory adjustments associated with batch material processing, as well as validating that material is present in the proper location and quantities. This measurement data may also assist in the monitoring of material status for quality control or process management. The responsibility for completion of these measurements again resides with the operating organizations. These measurements may be used for the establishment of book values depending on the measurement type and process stage at which the measurement occurs.

Finally, at the time of physical inventory (PI), a sample consisting of randomly selected items are subjected to confirmation or verification measurements. The population from which the sample is drawn is based on a facility's inventory, which may span multiple MBAs. The sample is designed so that if the inventory contained a 3% defect rate , there would be at least a 95% probability that one or more defects would be included in the sample The selection process uses a graded approach that weights items according to category, attractiveness, and the tamper indicating status of the item. For category I processing MBAs, the PI measurement sampling is conducted every two months. For the LANL plutonium facility, this sampling typically results in approximately 110 items being selected from a population of approximately 2500 items in the processing MBAs. Semi-annually the same sampling process is followed for the items in category I storage MBAs. The statistical sampling is conducted by the MC&A oversight organization, which is independent of the operations organization. It is typically this third measurement situation, consisting of randomly selected items for measurement, that receives the most oversight attention and is given the most safeguards credit in the MC&A program.

Proposed Measurement Approach

The first two measurement situations described above in the current approach provide a more timely representation of the status of the NM inventory than the third measurement situation associated with the random sample for PI. It has previously been suggested[1-2] that the measurements be divorced from the PI process and be conducted on a more frequent random basis. The authors propose randomly selecting a small number of items, on a weekly basis, to be measured in lieu of being conducted as part of the PI process. Selecting items for measurements on a more frequent basis than weekly introduces logistical hassles with little to no improvement in detecting diversion of material.[1]

For the plutonium facility at LANL, each weekly selection will consist of 13 items randomly selected items from the population on the process floor and four items from storage. This will result in the selection of 104 items during each bimonthly inventory period from the processing areas as well as 104 items from storage. If one assumes that the sampling may be represented by a binomial density function, a sample size of 99 items is sufficient to detect a 3% or greater defect rate with a 95% confidence for the populations in these areas at LANL.

A statistical weighting algorithm will be applied such that the probability of selecting any given item will be a function of the following item characteristics: time since last transaction, material category, material attractiveness level, and the status of tamper indicating devices. By considering the "time since the last transaction," material that is in constant use, and therefore under frequent observation, is less likely to be selected for measurement. Selections are to be made for each calendar week with the exception of the first and last two weeks of the calendar year, to accommodate the annual LANL holiday closure, for a total of 49 weeks with measurements in a given year.

Once an item is selected, the operating organization must have the item measured within two calendar weeks unless it has been measured within the previous two calendar weeks and had not undergone any processing since the last measurement. Allowing this measurement window, ± two weeks from the date of selection, enables the operators to take credit for measurements previously performed for material in process or for material transfers. All measurement data will be required to be supplied to the MC&A oversight organization for review by the end of this time window. To reduce the possible falsification of measurement data, all measurements will be completed under a two-person rule. The acceptance criteria for measurements to be considered as successfully verifying or confirming a particular item will be the same as currently used at LANL. Verification measurements must be completed on instruments under measurement control that meet or exceed LANL's precision and accuracy goals to the extent possible.

The PIs which occur at annual, semi-annual, and bimonthly frequency at LANL would not include any measurements except for those required to help resolve anomalies detected as part of the inventory process. For example, investigating a missing tamper indicating device. Maintaining up-to-date accountability values would not be impacted since PIs at LANL do not currently involve measurements that would result in adjustments to inventory book values except in unusual circumstances. Typical problems identified during inventories have included labeling discrepancies, TID misapplications, and TID record errors. By removing the measurement requirements from periodic PIs, the MC&A oversight organization will be able to better concentrate on these problem areas during PIs.

Measurement Approach Comparison

The implementation of the proposed ("continuous") measurement approach would require more coordination between oversight and operations personnel at LANL. It also complicates the interpretation of measurement and PI data for the purpose of determining whether or not the DOE requirement that a 3% or greater defect rate would be detected with a confidence level of at least 95%. However, there are several advantages to the proposed continuous approach.

1. The measurement related resource demands will be leveled over most of the calendar year rather than requiring approximately 110 measurements in a single two-week window. These resources include: nondestructive assay and balance instruments, personnel, and space for material staging.

2. Impact on programmatic activity will be decreased due to the simplified PI process. The time to conduct a PI should be greatly reduced and require the participation of fewer personnel.

3. The total number of measurements required to meet MC&A goals will be reduced by crediting those measurements performed in support of processing and for the movement of NMs.

4. Deterrence against theft, diversion, or misuse of NM will increase. Although the total number of measurements will be reduced, the frequency of measurements will increase, which reduces the predictability of when an item may be selected for measurement.

5. Safeguards assurance will more consistently be high throughout the calendar year rather than spike during bimonthly, semi-annual, or annual PIs. The continuous measurement approach will result in a reduction in the average time to detecting diversion of material.[1-2]

6. The possibility of time-based diversion scenarios will be minimized and/or eliminated. Currently, the "best" time for an abrupt diversion attempt is immediately following one of the periodic PIs. In such an attempt, the time to detection can be 2-12 months depending on the exact scenario and the type of MBA in which it occurs. Schanfein and Ticknor demonstrated that the average time to detection of an abrupt diversion attempt under such conditions can be improved by as much as a factor or two by the implementation of a continuous measurement approach.[1] Under the continuous measurement approach there is no "best" time to divert NM. Schanfein and Ticknor also demonstrated modest improvements for protracted diversion scenarios, where material is removed in smaller amounts over several weeks.[1]

References

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