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Enhancement of Material Control and Accounting Programs through the Conduct of a Gap Analysis and the Development and Implementation of a Comprehensive MC&A Program Plan

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Introduction

An effective safeguards program for nuclear materials is dependent on the integration of activities in the traditional safeguards elements: physical protection, protective force, and material control and accounting (MC&A). The design and integration of these traditional safeguards elements must be based on a technical analysis performed in characterizing the vulnerabilities and related risks of the facility against a designed-basis threat. Each of these elements requires a near seamless integration with each other, as well as within a site's operations organization.

One of the key objectives of an effective nuclear Material Control and Accountability (MC&A) program is to address the threat posed by an active or passive "insider" who, acting alone or in collusion, could attempt protracted or abrupt diversion or theft of special nuclear material (SNM). The function of material accountancy is to detect the loss or unauthorized removal of special nuclear material from the plant or facility in a timely manner. Detection is accomplished by means of measurements and transfer records of material movements and periodic inventories to verify that all material is accounted for. The function of material control is to assure the integrity of the nuclear material and the accountancy data.

This paper focuses on the development and implementation of a detailed material control and accounting program plan that considers both regulatory compliance demands and performance standards. Consideration of both of these demands is necessary to reduce exposure to theft and diversion, to reduce regulatory jeopardy, and to minimize to the extent possible adverse impacts with site operations.

Systematic Approach for Implementation of an MC&A System in an Operating Facility

A comprehensive MC&A plan should be developed that provides the design for the MC&A System, the basis for procurement of equipment and the development of operating procedures. The MC&A plan serves as a planning document for material control and accounting for review and evaluation of all elements of the existing program. The evaluation should consider the content and status of implementation for existing MC&A activities (either stand alone or integrated), the safeguards value of the existing plan implementation, and the levels of compliance with regulatory mandates. Assessment activities should focus on the three elements that are required to ensure implementation an integrated and comprehensive plan:

- Plant Configuration (facility layout, equipment and configuration),
- People and Resource Application (baseline and required personnel resources and organizations), and
- Procedural Implementation (documented instructions, operator aids, and procedures that are supported by a job task analysis based training program).

Completion of this review, or gap analysis, considering the existing status of the MC&A program and the requirements of a fully compliant program will lead to the development of a plan that, when implemented, will meet all site and regulatory needs.

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Following completion of this gap analysis, a path forward to close any deficiencies should be developed and reviewed by site management for acceptance and funding, or non-acceptance and a knowledgeable assumption of any risks resulting from continuation of the gaps or deficiencies. From this point, a revision or fresh development of an integrated material control and accounting program plan can be pursued.

Plant Organization

Plant management should establish a central MC&A organization that defines the requirements to meet the regulatory mandates applicable to the site. The organization should have sufficient independence from the line/implementing organizations so that it can provide oversight of the implementation of MC&A program.

The MC&A organization should include a dedicated staff, or minimally, matrixed personnel with well defined MC&A program responsibilities, that are supported by a cadre of other site personnel with defined MC&A responsibilities, to include:

- Program Management/Administration
- Accounting
- Inventory
- Containment and Surveillance
- Data Analysis
- Analytical support personnel (laboratory and statistical)
- Measurement support personnel (Destructive Assay (DA) and Non Destructive (NDA)).
- Engineering and other technical support personnel interfaces
- Oversight of Facility Material Balance Area (MBA) Programs
- Performance Testing of system effectiveness

The site organization provides a centralized material control and accounting function by, but not limited to, developing and maintaining a site-wide MC&A Plan, site-level procedures and policies, and providing guidance to site organizations in the implementation of MC&A requirements.

The site custodian is the material manager responsible for ensuring full compliance with site and MBA procedures pertaining, but not limited to, nuclear material accounting, access control, measurements, inventories, transfers into and out of the MBA, and data reporting. The site custodian serves as the central point for authorization of shipments to and from the site and for reporting nuclear material inventory and other data submissions to the governmental or national organization.

At the facility level, local MBA custodians must not be responsible for multiple MBA's for which transfers between occur to ensure no comprise of accounting data. Nor should they have responsibilities for performing measurements or handling nuclear material. There should be a clear boundary in the separation of duties between those responsible for accountability and control of the SNM versus those who are responsible for the handling of the material. Local MBA custodians and alternate custodians shall be appointed by management of the facility responsible for the MBA where material is located.

Local MBA custodians collect nuclear material measurement data, nuclear material transfer data and physical inventory data for the site's nuclear material accounting system and are responsible for daily administrative checks for areas with material movements. The site and local custodians jointly prepare reports required to support physical inventory taking.

An effective MC&A system requires the support of many organizations. Specialists in the areas of NDA and DA are required to perform accountability measurements and support performance of confirmatory measurements during nuclear material transfers and during inventory. Engineering/technical specialists are

required to define and provide operational support to MC&A systems such as scales, access control equipment and measurement systems. Maintenance organization(s) are an integral component of ensuring reliable operations of MC&A equipment. In addition, statistical support is needed in preparation for physical inventories, analyzing measurement data, and development of quality control charts for measurement equipment.

MBA Structure

To facilitate implementation of an effective MC&A system, facility management should consider dividing the facility into MBAs. The structure of MBAs should be based on unit operations and processes to establish Key Measurement Points (KMPs) and to identify the location and quantity of SNM in the MBA. MC&A procedures are then implemented in each MBA that enables a more manageable system of material control and accounting. Considerations in MBA designations include bulk material or discrete item processing, change in nuclear material form or operation, nuclear material transfer methods and frequency, method and ease of performing accounting measurements, physical layout, and personnel access. A primary consideration is establishing MBAs when the type of nuclear material changes. For example, a reactor fuel storage area and the reactor should be considered as separate MBAs, considering that reactor operations change the isotopic composition of nuclear material in the fuel. Similarly, when nuclear material changes in attractiveness, as a result of processing operations, MBA boundaries should be defined such that the lower and higher attractive material are processed in different MBAs. Likewise, if the nuclear material changes form, i.e., bulk liquid material to solid, the MBA boundary may be defined as both a bulk MBA and a solid MBA.

An effective MC&A system relies on accurate accountability data prior to transfer of nuclear material to another MBA. Factors that could affect this include methods of transfer into and out of an MBA, ease of measurement, type and accuracy of the measurement method(s), and frequency of transfers.

Material Accounting Functions

Another key component of an effective MC&A program is the material accounting functions necessary to ensure the inventory of nuclear material is documented and validated to ensure no material has been diverted or removed without authorization.

MBA custodians should identify source documents of accounting data and participate in the development of transfer records unique to the MBA and type of material. These could include completed operating procedures, log books and measurement data.

The accounting system structure should address the following elements:

Accounting Structure (Automatic date and record of transactions)

- MBA reporting defined/authorized locations addressed
- Multiple material types accounted for (material code/name/weight of reportable element & isotopes)
- Mixed material type items
- Attractiveness levels determined for MBAs
- Material description codes/material form
- Internal Adjustments reviewed by technical and accounting personnel

Shipment Receipts

- Measurement/accounting interface
- Limits of Error calculated
- Timely recording and receipt of shipment/receipt data

MBA Custodian Records

- Inventory differences reviews by technical and accounting personnel
- Inventory reconciliations fully supported and transparent
- TID records maintained for seal numbers and types

Accounting/Measurements Interface

- Data from measurement system is accurate and timely and entered into the system by analytical lab/MBA custodian/material accounting
- Bias corrections coordinated

The accounting system should have the capability to generate reports required for national, site and facility needs. These could include transaction reports, inventory reports, physical inventory reports, and site material management reports and documents.

An essential cornerstone in ensuring nuclear material is not stolen or diverted is the performance and documentation of the inventory for nuclear material in processing or storage areas. Facilities should develop inventory procedures that define the inventory frequency for MBAs consistent with national and agency regulations as well as the performance mechanics of physical inventory taking. The procedure should require multiple-person teams, sampling plans, item count, TID seal and material ID verification and confirmation of specific storage locations where discreet items are stored.

MC&A inventory procedures should distinguish between bulk MBAs where nuclear material processing occur and item MBAs where nuclear material is stored in containers. For bulk MBA inventories, a semi-static period of operation is needed where only limited transactions are allowed under controlled conditions during the inventory taking. The bulk inventory procedure defines the protocol for release of process tanks or groups of tanks for transfer and/or processing once the location and integrity of items verified and all required bulk material measurements are validated. The procedure should include steps to ensure that measurement equipment is approved for the application, is calibrated and is within the calibration frequency.

The item inventory procedure establishes the timeframe prior to inventory after which there is no item movement in to or out of the MBA or sub-MBAs. The procedure verifies that the measurement equipment used is approved for the application and is calibrated within the calibration frequency. It provides for a systematic “walk-through” of the MBA, including all processing and storage areas to include the location and identification of items such as waste that are co-located with SNM. All items/material are recorded and verified and waste items containing accountable quantities of nuclear material are inventoried. It identifies items that are accounted for through serial number identification, where TID serial numbers are checked containerized materials are verified for container integrity to the extent possible, and verification measurements are to be performed, as required, e.g., mass measurement and NDA.

Procedures for reconciliation of the physical inventory involve the comparison of the inventory on record (or book inventory) with the results of the physical inventory. It involves the closing of the material balance around each MBA and includes the calculation of Limits-of-Error for Inventory Difference (LEID). The LEIDs provide a method for assessing the significance of the inventory difference between the book inventory and physical inventory results.

Material Control Functions

An element of an effective material control program is the implementation of a robust Tamper Indicating Device (TID) program. The function of a TID is to preserve the integrity of the accountancy data, reduce the inventory effort and provide for detection of possible diversion. The primary portions of the TID

program are control and application/destruction. In addition, response procedures should be in place in the event anomalies are encountered.

The first step in implementation of a TID program is determination of the type of TID. Active TID's (e.g., radio-frequency emitting TIDs that provide a signal if the TID is broken) and passive (mylar, multi-lok, e-cup, lead seal) should be evaluated for the cost and benefit to the program and the integrity, sustainability and maintenance of the seal under operating conditions. All TIDs should have a unique identification number dedicated to the site/facility involved and be approved for the specific application.

Appointment of a TID Seal Custodian is a critical aspect of effective control of TIDs. The TID Seal Custodian is responsible for storage and issuance of TIDs that are stored in a secured repository with access only by those who are authorized to issue them to users who are documented on the TID users list. The Custodian also ensures TID logs are maintained in a secured repository with access only by authorized personnel. As part of separation of duties, TID issuers should not be authorized to apply/destroy TIDs. The TID Seal Custodian ensures that records are maintained that document the receipt, issuance, return, transfer, application, and destruction of TIDs assigned to the MBA.

Establishment of a Daily Administrative Check (DAC) program should be considered to provide an additional level of assurance that the accountancy records are complete and no nuclear material has been stolen or diverted within the facility. The DAC program looks for abnormalities or obviously missing or mislaid items in areas where material is handled or moved.

Implementation of a two-person rule program helps to prevent a single insider from having the opportunity to steal or divert nuclear material. Facility Management must first ensure controls are established to ensure members of a two-person rule team have authorization for the category and amount of nuclear material to be under their control, are properly trained in the activities they are to perform, are capable of detecting incorrect or unauthorized action, and have completed two-person rule training. In addition, controls must also be established to ensure that one individual cannot gain access to a secured storage area, and that unauthorized or unaccompanied authorized personnel cannot access a storage area undetected.

Procedures should be in place to ensure all waste leaving a Material Access Area (MAA) is monitored. Approved methods are to be utilized to monitor waste and/or radioactive material being removed from an MAA approved control limits for monitoring methods used to establish and document detection limits for all waste and/or radioactive material leaving an MAA. Procedures must also define response actions when an out-of-limit condition is encountered, and for investigating all out of limit conditions. Effective monitoring for the removal of waste material containers from an MAA uses a combination of two-person rule, TIDs, and NDA scanning as the material exits the MAA.

MC&A Equipment

Equipment used for accountability or verification measurements should be certified for application to the nuclear material being measured. This equipment could be scales for mass measurement, destructive analysis equipment and/or non-destructive analysis equipment. All equipment should be part of the maintenance system and have defined calibrations, calibration frequencies, and preventative maintenance items as appropriate. In addition, the equipment should be under a measurement control program to ensure the accuracy and precision of measurements.

Analytical equipment used for non-destructive assay and destructive assay measurements should also be part of a measurement control program. This program should consist of the following elements:

- Standards used should be representative of the material being measured
- Uncertainty of standards if less than that of the measurement equipment

- Standard measurements should be performed every day the equipment is used for accountability measurements
- Use of a method to determine if the measurement equipment is in-control or out-of-control
- Determination and reporting of random and systematic errors
- Correction of measurement results are documented and used to account for long term bias of the measurement equipment.

Procedures

The effectiveness of an MC&A program is dependent on the development of supporting documentation to implement the provisions of the plan. The documentation, in the form of formal procedures, detailed operator instructions, and supporting operator aids serve to ensure that the workers in the field have correct and accurate information immediately available to them to ensure compliance with any regulatory and operational demands.

The development of implementation procedures is a formalized process that should involve a detailed review of the provisions of the plan, and a logical flow down of referenced activities to implementation procedures that can be followed by the field personnel. The procedures may differ significantly in scope, and could include site-level procedures, procedures that address cross-cutting activities involving multiple activities or operational elements, and detailed operating procedures that directly implement MC&A requirements on an activity by activity basis.

In all cases, the formalized procedures should be included in a procedure control or administration program, to ensure that procedures are verified in the field for both accuracy and operability, that the procedures are subject to both periodic reviews and reviewed when revised, and that an effective procedure distribution process is in place to ensure that only the most recently approved procedures are disseminated for use.

Essential to the implementation of the MC&A procedures is the conduct of appropriate knowledge and skill based training for the personnel tasked to implement the procedures in the field. The training, developed with the input from a detailed job-task analysis, will consider all provisions of the approved procedures. Just as procedures require a walk down in the field, the training should also be reviewed to ensure that all tasks are adequately addressed through the training module and can be properly demonstrated in periodic performance tests.

Considering the importance of the accurate implementation of the MC&A program, the personnel provided training should be subject to both knowledge and skill based evaluations, with well established metrics identified to confirm that the trained personnel can in fact implement the plan, consistent with procedures. The development and maintenance of procedures, and the training of MC&A staff should be an on-going activity under the joint direction of the Site nuclear material manager, the facility MBA custodian and facility process operations.

As a site prepares to implement a MC&A program many factors as described above need to be taken into consideration. Based on a technical vulnerability analysis, a thorough understanding of the type, form and quantity of nuclear material is foremost in establishing and effective program. A review of the regulatory requirements (site, industry and national) can then be completed which establishes requirements for the MC&A program implementation. Completion of these activities will allow for MBAs and key measurement points to be determined, accounting measurement equipment to be obtained, and procedure development and personnel training to occur. Documenting the program's control and accounting elements related to plant (equipment), people (staffing and training) and procedures in an MC&A plan is an effective means of defining the structure of the program and describing upgrades and enhancements that may be

required. The MC&A Plan provides a single source document that can be used to build assessment criteria for evaluating performance as part of routine internal and external assessments.