United States Nuclear Regulatory Commission

Protecting People and the Environment

NUREG-1065
Revision 3

Acceptable Standard Format and Content for the Material Control and Accounting Plan Required for Special Nuclear Material of Low Strategic Significance

Draft Report for Comment

Office of Nuclear Material Safety and Safeguards

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ABSTRACT

This document provides a revised structure for NUREG-1065, Revision 2, dated 1995, which contains information that the licensee or applicant should provide in its material control and accounting (MC&A) plan, formerly the fundamental nuclear material control (FNMC) plan. It applies to U.S. Nuclear Regulatory Commission (NRC) licensees (other than production or utilization facilities licensed in accordance with 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," or 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants," and waste disposal facilities) authorized to possess and use more than 350 grams of unencapsulated special nuclear material (SNM) of low strategic significance. The revision has been structured to serve as a direct outline for licensees to use in preparing their MC&A plans.

This document provides a revised structure and information to facilitate compliance with 10 CFR 74.3, "General performance objectives," and 10 CFR 74.31, "Nuclear Material Control and Accounting for Special Nuclear Material of Low Strategic Significance," regarding the licensee or applicant preparation and implementation of MC&A plans and corresponding NRC review and inspection. Presented herein is the acceptable format and content for those MC&A plans, addressing (1) the performance objectives that must be met, (2) the MC&A program capabilities that must be achieved to meet those objectives, (3) the incorporation of checks and balances to detect falsification of data and reports that could conceal the theft or diversion of SNM, and (4) basic commitments that should be made.

This document includes guidance for implementing new requirements pertaining to tamper-safing, and the designation of material balance areas and item control areas. All other modifications involve format and editorial changes designed to clarify and facilitate preparation or revision of the required MC&A plan.

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ABBREVIATIONS

CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
DQ	detection quantity
DT	detection threshold
HEU	high-enriched uranium
IAEA	International Atomic Energy Agency
ICA	item control area
ID	inventory difference
LEU	low-enriched uranium
MBA	material balance area
MC&A	material control and accounting
NDA	nondestructive assay
NMMSS	nuclear materials management and safeguards system
NRC	U.S. Nuclear Regulatory Commission
SEID	standard error of the inventory difference
SNM	special nuclear material
SRD	shipper-receiver difference
TID	tamper-indicating device
U	uranium
^{233}U	uranium-233
^{234}U	uranium-234
^{235}U	uranium-235
^{238}U	uranium-238
U_3O_8	Urano-uranic oxide
UF_6	Uranium hexafluoride
wt %	weight percent

1. INTRODUCTION

The Atomic Energy Act of 1954, as amended, directed the U.S. Atomic Energy Commission (AEC) to regulate the receipt, manufacture, production, transfer, possession, use, import, and export of special nuclear material (SNM) to protect the public health and safety, and to provide for the common defense and security. The Energy Reorganization Act of 1974 transferred all the licensing and related functions of the AEC to the U.S. Nuclear Regulatory Commission (NRC).

The principal requirements for SNM licensing are found in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 70, "Domestic Licensing of Special Nuclear Material," and 10 CFR Part 74, "Material Control and Accounting [MC&A] of Special Nuclear Material." Regulations in 10 CFR 70.22 (b) specify that a license application must contain a complete description of the applicant's program for the control and accounting of such SNM to show how compliance with the graded MC&A requirements of 10 CFR Part 74, subparts B-E, will be accomplished. This document describes the standard format and content suggested by the NRC for use in preparing MC&A plans for facilities authorized to hold SNM of low strategic significance.

This introduction describes the basis for the five general performance objectives of 10 CFR 74.3 and the MC&A program features and capabilities needed to meet the objectives. Chapters 1-10 address the program capabilities needed to maintain accurate, current, and reliable information on the licensee's SNM and to confirm its quantities and locations. Chapters 11 and 12 address the program capabilities needed to promptly investigate and resolve anomalies indicating a possible loss of SNM, and provide information to aid in the investigation and recovery of missing SNM. Chapter 13 addresses recordkeeping requirements. These 13 chapters provide an outline for an acceptable MC&A plan for facilities authorized to hold SNM of low strategic significance.

The acceptance criteria are for the use of applicants (or licensees) and NRC licensing reviewers. An application or proposed revisions that meet these criteria should be acceptable to the NRC staff. However, comprehensive criteria are included as examples, and each applicant or licensee should develop an MC&A program and plan that considers the unique features of its particular operation. Where additional guidance is available on particular topics, an appropriate reference is included in the acceptance criteria section. Recommendations in this document provide guidance to applicants and licensees. Licensees may use this guidance when making changes to their existing approved MC&A plans.

In preparing MC&A plans, applicants should consider the capabilities specified in 10 CFR 74.31, "Nuclear Material Control and Accounting for Special Nuclear Material of Low Strategic Significance," and the general performance objectives specified in 10 CFR 74.3. After accepting an MC&A plan and imposing it as a condition of license, the NRC will evaluate the adequacy of a licensee's MC&A performance by inspecting for performance with commitments and practices described in the plan.

Because 10 CFR 74.3 and 10 CFR 74.31 are performance-oriented regulations, they do not contain a detailed set of technical specifications. With this flexibility, applicants and licensees have many alternatives on how their overall MC&A program is designed, managed, and operated, which would permit a risk-informed performance-based approach that focuses on and, in turn, concentrates licensee resources on MC&A activities most important to safeguards.

Accordingly, this document does not attempt to cover all possible methodologies that a licensee might use to meet the MC&A requirements. Instead, it provides examples of acceptable MC&A approaches. The document is intended for use by applicants, licensees, and the NRC safeguards licensing reviewers. Acceptance criteria are not to be regarded as rigid, fixed standards. That is, a lower effectiveness of one capability relative to a particular aspect can be tolerated if there is a compensating system feature, or combination of features, that provides an overall effective safeguards system. In the final analysis, an NRC reviewer must make a judgment on whether the applicant's or licensee's MC&A plan provides adequate assurance that regulatory requirements will be met.

The contents of an MC&A plan are discussed in Chapters 3–15. The body of an approved MC&A plan will be made a condition of license in accordance with 10 CFR 70.32(c), and compliance with the MC&A plan commitments and pertinent procedures will be inspectable. Explanations and discussions in the plan should be sufficiently detailed and precise so that NRC licensing reviewers, NRC inspectors, and licensee personnel responsible for developing and implementing the plan have a clear and common understanding of what the MC&A plan requires.

The annex (or appendix) of an MC&A plan should provide supplementary and general information about the facility and the MC&A program (e.g., copies of blank record forms, site map, process diagrams, an example standard error of the inventory difference (SEID) calculation). The annex will not be incorporated as a condition of license and will not be the basis for inspection. Therefore, descriptions that the applicant or licensee present to satisfy regulatory intent must be in the plan itself, rather than the annex, and must provide adequate detail so that it is not largely dependent on examples or supplementary information in the annex for proper understanding. As a result, procedures detailed in the annex may be changed without NRC approval or notification, provided that plan commitments and capabilities are not degraded.

By using this standard format for preparing an MC&A plan, a licensee or applicant will minimize administrative problems associated with the submittal, review, and approval of the plan. Preparation of an MC&A plan with this standard format will assist the NRC in evaluating the plan and in standardizing the licensing and review process. However, the NRC does not require conformance with the standard format. An applicant may use a different format if it provides an equal level of completeness and detail.

2. GENERAL PERFORMANCE OBJECTIVES, RELATED REQUIREMENTS,COMMITMENTS, AND ACCEPTANCE CRITERIA

General Performance Objectives

The five general material control and accounting (MC&A) performance objectives applicable to all U.S. Nuclear Regulatory Commission (NRC) Title 10 of the *Code of Federal Regulations* (10 CFR) Part 70, "Domestic Licensing of Special Nuclear Material," licensees are set forth in subpart A of 10 CFR Part 74, "Material Control and Accounting of Special Nuclear Material" (10 CFR 74.3). The basis of these general performance objectives, and the related requirements in subpart C of 10 CFR Part 74 (applicable to NRC licensees authorized to hold special nuclear material (SNM) of low strategic significance) are discussed below.

1. Maintain accurate, current, and reliable information on, and confirm the quantities and locations of SNM in the licensee's possession.

The purpose of this performance objective (10 CFR 74.3(a)) is to verify the presence of all SNM held by the licensee, and to detect the occurrence of any significant loss, including possible theft or diversion. To maintain current information on all such SNM, licensees should have in place a program that provides timely, accurate, and reliable information about the quantity and location of SNM in their possession. Accurate information means that item quantities for both the element uranium (U) and the isotope ^{235}U are based on measured values or on reliable information. Reliable information means that the quantity of SNM in an item and the location of all items are known (except for items in solutions with a concentration of less than 5 grams of ^{235}U per liter, and items of waste destined for burial or incineration). The location designations must be specific enough to provide for the retrieval of the items in a prompt manner. Reliable information also means that the quantities and locations of all nonexempt SNM material, and items listed in the accounting records, are correct and verifiable.

The licensee or applicant should accurately account for all SNM that is received and shipped by maintaining reliable records based on accurate measurements. When a shipment is received, the licensee should begin monitoring movement and location of the material within the facility using item control procedures (1) to monitor the location and integrity of items until they are processed and (2) to ensure all SNM quantities of record associated with receipts, shipments, discards, and ending inventory are based on measurements. Monitoring the material in process may involve the use of process or material control data. A detailed and accurate recordkeeping system for the generated data that provides knowledge of the material's location on a timely basis should be maintained to support this function.

The licensee must conduct total plant physical inventories at intervals not to exceed 370 calendar days in accordance with 10 CFR 74.31(c)(5). Each physical inventory must be conducted in a way that provides at least a 90 percent power of detecting any actual loss or theft of a detection quantity (DQ) that may have occurred since the last yearly inventory. A DQ is a site-specific quantity of ^{235}U, the magnitude of which is discussed in Chapter 6.

The licensee should verify the presence of all SNM that the facility currently possesses, as stated in its accounting records. This verification is normally accomplished through a shutdown and cleanout of processing equipment, measurement of cleanout materials and measurement of any materials not previously measured in their existing form, visual verification (on a

100 percent basis) of the presence of all possessed SNM items (through unique item identities), and confirming the SNM quantities associated with unencapsulated and unsealed items on ending inventory. However, a dynamic (i.e., non-shutdown) inventory of some or all processing equipment may be used if the measurement uncertainty associated with the total material balance (for the inventory period) is within the 0.25 percent of active inventory constraint specified in 10 CFR 74.31(c)(4).

Recommendations pertaining to physical inventories are detailed in Chapter 7. In summary, a total plant physical inventory involves:

- verifying the presence, on a 100 percent basis, of all uniquely identified SNM items listed in the accounting records
- measuring (by direct measurement or, if direct measurement is not feasible, by indirect measurement) all bulk SNM quantities on hand (i.e., all SNM not in item form)
- measuring any items not previously measured
- verifying the identity and integrity of all encapsulated items and items affixed with tamper-indicating devices
- measuring an SNM-related parameter for a sample of randomly selected unencapsulated and unsealed items, based on a statistical sampling plan, to verify the previously measured quantities of SNM contained in such items

The physical inventory program should be managed and maintained independent of the production or operations organization, but it should not be excluded from using process monitoring and production control data.

2. Detect, respond to, and resolve any anomaly indicating a possible loss, theft, diversion, or misuse of SNM.

3. Permit rapid determination of whether an actual loss, theft, diversion, or misuse of SNM has occurred.

The purpose of these performance objectives in 10 CFR 74.3(b)-(c) is to ensure that licensees can adequately detect and respond to indications of possible loss, theft, diversion, or misuse of SNM and rapidly determine whether or not a loss, theft, diversion, or misuse of SNM occurred.

As further discussed in Chapter 13, the licensee or applicant should have a formalized program to detect, respond to, and resolve any anomaly that may indicate a possible loss of SNM. Resolution of such anomalies means that the licensee has made a rapid determination whether an actual loss of a significant quantity of SNM has occurred, including possible theft or diversion. An anomaly detected during a material balance closure needs to be investigated and resolved in accordance with 10 CFR 74.31(c)(5).

Resolution of an anomaly depends on the type of indicator. Various types of anomalies at plants could occur from a wide range of possible underlying scenarios (e.g., from unidentified or inadequately monitored loss mechanisms, simple theft, complex diversions). The investigation and resolution process should begin with a thorough review of the MC&A records to locate blatant errors. These errors might include omissions of entire items, incorrect entries to

computer programs or records, transcription errors, incorrect estimates of the amount of holdup in equipment, or calculation errors. A detailed examination of the MC&A records for each material type should identify gross errors. The next stage in the resolution process would be to isolate the process or storage area that appears to be causing the anomaly. Once this is accomplished, all of the information that contributed to the SNM quantities for that location should be verified. If resolution still is not accomplished, the licensee should remeasure and sample material in the process or storage areas to verify quantities. If the investigation of an indicator results in a determination that an actual loss or theft has occurred, the loss or theft must be reported to the U.S. Nuclear Regulatory Commission (NRC) in accordance with 10 CFR 74.11, "Reports of Loss or Theft or Attempted Theft or Unauthorized Production of Special Nuclear Material."

4. Provide information to aid in the investigation and recovery of missing SNM in the event of an actual loss, theft, diversion, or misuse.

The purpose of this performance objective in 10 CFR 74.3(d) is to ensure that licensees provide adequate assistance in any investigations that a government agency conducts of an actual loss, theft, diversion, or misuse of SNM. If the NRC or other Government agencies deem it necessary to conduct an investigation relating to actual (or highly suspected) events pertaining to missing material, the licensee is to provide any information it considers relevant to the recovery of material involved in a loss, theft, or diversion . The burden shall be on the licensee to provide all information that it recognizes as relevant, as opposed to providing only information that the investigators request. Additional information and recommendations pertaining to providing information to aid in investigations are provided in Chapter 14.

5. Control access to MC&A information that might assist adversaries to carry out acts of theft, diversion, misuse, or radiological sabotage involving SNM.

The purpose of this performance objective in 10 CFR 74.3(e) is to implement the practices and procedures needed to provide effective material control and material accounting for deterrence and detection of theft, diversion, misuse, or radiological sabotage involving SNM. Components of control access to MC&A information may include access control, material containment, material surveillance, etc. Effective control systems should be multi-layered, and redundant systems should be used to eliminate the consequence of a single-point failure.

The licensee should implement an effective quality assurance program that minimizes the possibility of potential failures for the MC&A program. These control measures can provide necessary checks and balances that contribute to deterrence of material loss, theft, diversion, or misuse. Access control involving all movements of people and materials into and out of the material access areas should be carefully monitored and controlled. Adequate containment and surveillance measures should provide assurance that the integrity of nuclear material values is maintained.

Primary attention should be paid to preventing errors or mistakes by MC&A personnel, and to prevent violations of procedures or compromises of MC&A information and data. A system of checks and balances should be established to ensure data accuracy; this system should detect any instances of unauthorized access to data. Mistakes because of inadequate training, accidents, improper equipment operation or maintenance, or any other unintentional actions, can cause the MC&A program to lose its effectiveness.

Commitments and Acceptance Criteria Pertaining to General Performance Objectives

The applicant or licensee MC&A plan should provide definitive commitments that adhere to the regulatory requirements and meet the acceptance criteria for these general performance objectives and corresponding program capabilities. These commitments should be stated in the MC&A plan.

The commitments and acceptance criteria are listed in Chapters 3–5, and 7–15.

The following chapters of this document incorporate and expand on the performance objectives and the MC&A program and plan capabilities specified in 10 CFR 74.3 and 74.31. The chapters are arranged in a format and sequence to provide applicants and licensees an outline for their required MC&A plans.

3. MANAGEMENT STRUCTURE

3.0 Regulatory Intent

The purpose of 10 CFR 74.31(c)(1) is to require licensees to implement a management structure that permits effective functioning of the material control and accounting (MC&A) program. The regulations ensure that the plant management structure will not adversely affect MC&A program performance. Documentation, review and approval of critical procedures, and the assignment of key functions to specific positions eliminates ambiguities. The management structure is meant to separate key MC&A functions and provide overchecks that increase MC&A program reliability and make deceit and falsification less likely. It is also meant to free MC&A management personnel from conflicts of interest with other major functions, such as production.

3.1 Corporate Organization

The corporate structure should be described and all corporate organization positions that have responsibilities related to MC&A at the licensee's site should be identified. A description of the corporate-level functions, responsibilities, and authorities for MC&A program oversight and assessments should be provided. At least one corporate official should be responsible for the control and accounting of all special nuclear material (SNM) that the licensee possesses.

3.2 Plant or Site Organization

A description of the site's management structure emphasizing MC&A should be provided. The site management structure should be described to the extent that it can be clearly shown that the MC&A organization is independent of potentially conflicting responsibilities. This description also should state how responsibilities are assigned for the following functions:

- overall MC&A program
- SNM custodianship
- receiving and shipping of SNM
- analytical laboratories
- bulk and nondestructive assay (NDA) measurements
- sampling operations
- measurement control system
- physical inventories
- onsite SNM handling operations

A brief description should be provided for each site-level position, outside of the MC&A organization, which has responsibilities relating to MC&A activities (e.g., sampling, mass measurements, analytical measurements, and measurement control). For each position, the functions, responsibilities, and authorities should be clearly described.

3.3 MC&A Organization

An organizational chart and position-by-position description of the entire MC&A organization should be provided. An individual should be designated as the overall manager of the MC&A program and the MC&A plan must demonstrate the assurance of independence of action and objectivity of decision for the MC&A manager. Two options for meeting the organizational

independence are (1) report directly to the plant or site manager or (2) report to an individual who reports directly to the plant or site manager and who has no production responsibilities.

3.3.1 Responsibilities and Authority

A description that clearly indicates the responsibilities and authority of each supervisor and manager should be provided for the various functions within the MC&A organization. The description should indicate how the activities of one functional unit or individual serve as a control over, or checks on, the activities of other units or individuals. The MC&A plan should explain how coordination is achieved and maintained between the MC&A organization and other plant organizational groups that perform MC&A-related activities. A definitive statement should be made specifying on how the MC&A manager ensures appropriate review and approval for all written procedures pertaining to MC&A-related activities, and to any future revisions that are issued both within and outside of the MC&A organization. In addition to the MC&A manager function, at a minimum, the functions listed below should be addressed:

- nuclear material accounting
- measurement control system
- item control system
- statistical applications

Whenever more than one key MC&A function is assigned to the same person, the MC&A plan should clearly describe the checks and balances that preclude the following:

- performance of accounting or record control functions by individuals who also generate source data

- assignment of sole authority to any individual to overcheck, evaluate, or audit information for which he or she is responsible

Examples of appropriate checks and balances are:

- Review measurement data and calculations by another individual.

- Maintain a duplicate copy of all source data and transfer forms under controls separate from the accounting function.

- Perform independent audits.

- Separate computer program maintenance from the program user function.

The management structure should assign responsibility for SNM undergoing processing and in storage to a single individual or group. The duties of the individual(s) should include but are not limited to:

- Maintaining appropriate inventory control over SNM in their assigned area

- Authorizing and recording all movements of SNM into and out of their assigned area

- Maintaining appropriate local MC&A records or ensuring that other records, such as production records, contain necessary MC&A information
- Participating in physical inventories as required
- Assisting in internal or external alarm resolution activities as required
- Ensuring that, when SNM is processed in bulk form, only authorized persons have hands-on access to the material
- Notifying proper authorities of irregularities in material and MC&A data handling.

For some individuals in management or supervisory positions, some modifications to procedures, such as restricted access without escort to some areas, may be necessary to provide sufficient assurance that the system cannot be compromised.

3.3.2 MC&A Procedures

Critical MC&A procedures are those written procedures which, if not performed correctly, could result in a failure to achieve one or more of the performance objectives of 10 CFR 74.3 and the program capabilities of 10 CFR 74.31(c). The body of the MC&A plan should identify all critical MC&A procedures. A licensee's development of its critical MC&A procedures, and any changes later made to them, should involve technical review by cognizant licensee personnel, be approved by line management directly affected, and also be approved by a level of management above the level responsible for executing the procedures. The MC&A plan should contain a definitive statement that the procedures will be followed. The set of critical MC&A procedures should, at a minimum, adequately address the following topics, regardless of which facility organizational group is responsible for the particular topic:

- accountability record system
- sampling and measurements
- measurement control system
- item control system
- physical inventories
- investigation and resolution of shipper-receiver differences and loss indicators
- determination of standard error of the inventory difference (SEID), active inventory, and inventory difference (ID)
- providing information to aid in investigations
- MC&A recordkeeping
- independent assessment of the effectiveness of the MC&A program

- tamper-safing

- designation of material balance areas (MBAs), item control areas (ICAs), and custodial responsibilities

3.4 Training and Qualification Requirements

This section of the MC&A plan should describe the training programs that will be established and maintained to provide qualified personnel and the continuing level of qualification for the personnel assigned to MC&A responsibilities. Training procedures and qualification criteria should be discussed in definitive statements. Minimum qualification requirements should be stated for each key MC&A position.

3.5 MC&A Program Description

The length of this section and its level of detail will depend on the information provided in the previous sections of this chapter. The overall MC&A organization should be described in a way that explains how the general performance objectives of 10 CFR 74.3 and the capabilities of 10 CFR 74.31(c) will be effectively achieved.

The individual who has responsibility for each of the following MC&A-related functions should be specified by title:

- overall MC&A program management (Note: This individual should have no major non-MC&A-related responsibilities)

- measurements (Note: Responsibility may be divided on the basis of type of measurements, e.g., analytical laboratory measurements, NDA measurements, bulk measurements, and sampling)

- measurement control

- statistics

- accountability records

- item control

- physical inventories

- custodial responsibilities (e.g., SNM storage and movement controls)

- investigation and resolution of indicators that suggest possible loss of SNM

- receiving and shipping of SNM

- analytical laboratories

- MC&A recordkeeping system and controls

The MC&A program description should include the policies, instructions, procedures, duties, responsibilities, and delegation of authority in sufficient detail to demonstrate the separation of duties or overchecks built into the MC&A program.

3.6 Material Control Boundaries

This section of the MC&A plan should describe how the facility establishes various material control boundaries to minimize the occurrence of, and facilitate resolution of, MC&A anomalies, such as IDs, missing SNM items, and potential SNM theft or diversion.

The MC&A plan should describe the establishment of MBAs and ICAs because they are the basis for the control and accounting for all nuclear material in the facility. An MBA or ICA should correlate to physical or administrative boundaries and monitored locations. The MBA or ICA should be designed to limit losses to a specific area (i.e., the MBA should not be so large that it cannot localize inventory or process differences to a manageable level). Materials transferred into and out of an MBA or ICA must have quantitative measurements as specified in the MBA and ICA definitions in 10 CFR 74.4, "Definitions."

The MC&A plan should describe roles and responsibilities of nuclear material custodians for MBAs and ICAs. The material custodian should have direct interaction with the MC&A organization and should be located within the physical operations area. Custodians who are responsible for more than one MBA or ICA should not be able to make material transfers between MBAs or ICAs under their direct control.

3.7 Commitments and Acceptance Criteria

In its MC&A plan, the applicant or licensee should provide definitive commitments that adhere to the regulatory requirements and meet acceptance criteria applicable to management structure. A finding that the licensee's MC&A plan for management structure is acceptable and in accordance with the internal control requirements of 74.31(c)(1), will be based on, but not limited to, the following acceptance criteria:

- The authorship, approval authorizations, and effective dates of MC&A policies and procedures will be documented, and will involve appropriate management and technical staff.

- The responsibilities and authorities for each position assigned a function having a significant impact on SNM control and accounting (including all positions authorized to control SNM movement, generate source data, define or implement measurement control requirements, and conduct data analysis) are defined clearly in a written position description that defines the responsibilities for that position.

- The qualifications and experience required for each position assigned an SNM control and accounting function will be sufficient to permit adequate performance of the duties required of that position.

- The descriptions of the management structure and assignment of duties and authorities show that those responsible for each MC&A function will have sufficient authority to perform the function in the intended manner.

- The MC&A organization is separate from the production organization and is also separate from organizations that generate source data, if practical; otherwise, independence of the functions is attained through suitable controls and overchecks.

- The MC&A program management responsibility is designated to an individual at an organizational level sufficient to ensure independence of action and objectiveness of decisions.

- No two key MC&A functions are assigned to the same person unless sufficient checks and balances are provided. As a consequence of this criterion:

    - Individuals who generate source data, such as performing measurements, or perform shipping and receiving activities, do not perform any accounting or record control functions unless suitable overchecks are provided to prevent falsification of both source data and accounting records

    - No individual has the sole authority to overcheck, evaluate performance, or audit information for which he or she is responsible

- The responsibility for each MC&A function is assigned to a specific position in the organization, and the organization is structured so that key functions are separated or overcheck one another. The position descriptions are available in writing to the personnel affected.

- All current critical MC&A procedures are made easily accessible to all affected individuals, and are maintained to show for each procedure (1) the revision number, (2) date issued, (3) who prepared the procedure, and (4) who approved the procedure (as indicated by signature and date signed).

- Management policies are established, documented, and maintained to ensure that all critical MC&A procedures are adhered to, including measurement procedures used for accountability purposes.

4. MEASUREMENTS

4.0 Regulatory Intent

The intent of 10 CFR 74.31(c)(2) is for licensees to maintain a system of measurements to ensure that all quantities of special nuclear material (SNM) (both element and fissile isotope) in the accounting records are based on reliable measurements. The measurement uncertainty associated with the values entered into the accounting records must be sufficiently small to ensure that the limit specified in 10 CFR 74.31(c)(4), for the total material control and accounting (MC&A) measurement uncertainty (associated with a physical inventory material balance), is not exceeded. Except for sealed sources, all SNM receipts are to be measured for the purpose of performing shipper-receiver evaluations. In the absence of any significant shipper-receiver differences (SRDs), a licensee may book either its measured values or the shipper's measured values. When recording shipper's values (for SNM receipts), the measurement uncertainty associated with the shipper's values needs to be known and used in the determination of standard error of the inventory difference (SEID). It is also intended that a licensee's measurement program provide bias estimates to be used in correcting inventory difference (ID) values and SRDs for significant measurement biases. Estimation of, and correction for, measurement bias is discussed further in Chapters 5 and 6.

4.1 Measurement Points

The MC&A plan should identify and describe each measurement used for accounting purposes. Measurements (1) establish the quantities in each custodial area, material balance area (MBA), or item control area (ICA), and in the facility as a whole, and (2) contribute to the desired capability to localize losses and to generate and to assess alarms. Measurement points or sampling stations should be selected to provide quantitative information about material flows and inventories that will permit detection and localization of any loss or diversion, or to confirm that no diversion has occurred. Typically, three functional types of MBAs and ICAs are present: (1) processing, (2) storage, and (3) receiving and shipping. The identification and definition of measurement points for processing MBAs are necessary because of the physical or chemical changes of the nuclear materials that occur in these MBAs. The storage and the receiving and shipping areas are typically ICAs. Typical processing MBAs include (1) processing areas, (2) decontamination and recovery areas, (3) laboratory areas, and (4) feed and product sampling and transfer areas. The identification and definition of measurement points for processing MBAs are necessary because of the physical or chemical changes of the nuclear materials that occur in these MBAs. The storage and the receiving and shipping areas are typically ICAs.

4.2 Measurement Systems

The MC&A plan should describe in detail each measurement system used for nuclear material accounting purposes. The principal elements and operations involved in the measurement systems for MC&A encompass mass (or weight) or volume determination; sampling; chemical analyses for element and isotope; and nondestructive assay (NDA). Each measurement system should also be defined or identified by its unique set of the following parameters: (1) measurement device or equipment used, (2) standards used for calibration, and (3) standards used for control. Additionally, for analytical laboratory measurements, the following should also be identified: (1) sampling technique and equipment used, (2) sample aliquoting technique, and (3) sample pretreatment methodology. Elements of the measurement control program (e.g., standards traceable to a national system) used for validating and

determining control limits, precision, and accuracy levels for each measurement system used for accountability are described in Chapter 5.

The MC&A plan should provide descriptions for each measurement system associated with bulk, analytical, and NDA measurements, and should identify, where applicable, any other measurement systems used for accounting purposes that do not fall within these categories. These descriptions should provide sufficient information to demonstrate how the systems are implemented to ensure the capability to meet the precision and accuracy limits. The following sections provide examples of the types of information necessary for selected measurement systems.

4.2.1 Bulk Measurement Systems

For each weighing system, the applicant or licensee should specify the type of weighing device, the type of container(s) weighed, material within the containers being weighed, capacity of the weighing device (e.g., capacity not to exceed X kilograms), range to be used, sensitivity of the device (e.g., sensitivity is +/- Y grams), and the calibration frequency.

For each volume measurement system, the MC&A plan should identify the vessel (e.g., tank, column), capacity of the vessel to which the measurement applies (e.g., capacity not to exceed X liters), the material being measured, the volume measuring device and instrumentation, the sensitivity of each device and system (e.g., sensitivity is +/- Y milliliters), the range of operation or calibration, and the calibration frequency.

4.2.2 Analytical Measurement Systems

For each analytical measurement system, the MC&A plan should specify the following:

- type of material or chemical compound (e.g., UF_6, uranium alloy, UO_2, uranyl nitrate solution) being sampled and measured
- sampling technique(s)
- sample handling (i.e., pre-analysis sample storage and treatment)
- analytical method used
- characteristics measured (e.g., grams of uranium per gram sample, ^{235}U isotopic concentration)
- measurement interferences
- expected measurement uncertainty
- types of calibration standard(s) and calibration frequency

4.2.3 NDA Measurement Systems

For each NDA measurement system, the MC&A plan should identify the following:

- the NDA equipment package (i.e., type and size of detector, and type of associated electronics and computer interface, as appropriate)
- the type of container measured
- SNM material type within container
- attribute measured
- measurement configuration (including source to detector distance)
- calculational method
- expected measurement uncertainties

4.2.4 Other Measurement Systems

If applicable, the MC&A plan also should identify any other measurement systems used for accounting purposes that do not fall within the three categories covered by Subsections 4.2.1, 4.2.2, and 4.2.3.

4.3 Measurement Uncertainties

The expected measurement uncertainties of the described measurement systems should be provided. Variance components for calibration, sampling, random, and systematic error for each measurement system should be stated. The units in which the errors are expressed should be clearly identified.

4.4 Measurement Procedures

The licensee or applicant should define how assurance is demonstrated that measurement procedures (i.e., methods) are established, approved, and maintained. This can be accomplished by (1) making a definitive statement that an approved measurement procedures (i.e., methods) manual, or set of approved manuals, are established and maintained, (2) stating which organizational units are responsible for the preparation, revision, and approval of measurement procedures, and (3) defining the requirements for periodic review of the procedures.

A clear statement should be made defining how the facility ensures that a measurement procedure cannot be used for accountability purposes without documented approval. Each procedure should be approved by the overall MC&A manager and the manager of the organizational unit responsible for performing the measurement. The measurement control program manager should also approve measurement procedures.

The MC&A plan should provide a definitive statement that all SNM quantities in the material accounting records are based on measured values, and that measurement systems are maintained for the measurement of SNM associated with the following:

- additions to inventory (e.g., receipts)
- removals from inventory (e.g., shipments and measured discards)
- material on ending inventory

For receipt of material, the licensee may use shipper's measured values rather than its own measurements, provided that (1) a shipper-receiver comparison, based on attributes or confirmatory measurements, shows no significant SRD (as defined by 10 CFR 74.31(c)(7)); (2) in the case of a significant difference between shipper and receiver, no significant difference exists between shipper's value and the umpire value used to resolve the difference; or (3) the material in question is exempted from shipper-receiver comparison requirements (e.g., sealed sources and samples). However, when booking shipper's values, the shipper's measurement uncertainty should be used when determining SEID.

4.5 Commitments and Acceptance Criteria

In its MC&A plan, the applicant or licensee should provide definitive commitments that adhere to the regulatory requirements and meet the acceptance criteria applicable to measurements. A finding that the licensee's MC&A plan for assuring that all quantities of SNM are based on reliable measurements is acceptable and in accordance with 10 CFR 74.31(c)(2), will be based on, but not limited to, the following acceptance criteria:

- A program of measurement procedures and methods is maintained for all SNM receipts, removals and inventory items, and all quantities of SNM in the material accounting records are based on measured values.

- Measurement systems that are the key contributors to the total measurement standard error will be identified. The list will be reviewed annually and updated as necessary. The measurement control program will monitor and control key measurement systems and their standard deviations.

- A basic description or summary of each key measurement system that is used to generate SNM quantities for accountability purposes is provided. A measurement system being defined as any instrument or device, or combination of devices, used to derive (1) an element concentration, (2) an isotope quantity, (3) a ^{235}U enrichment or isotopic distribution, (4) a bulk material mass (weight), or (5) a bulk material volume, and which can be characterized by its random and systematic error components.

- The set of key measurement systems, based on recent (or anticipated) measurement control data and modes of process operations, is expected to account for at least 90 percent of the total measurement uncertainty contribution to the SEID.

- The recalibration frequency for each measurement system is compatible with its expected stability. Recalibrations for all measurement systems should be performed at frequencies compatible with widely established, or licensee demonstrated, stability for each particular system.

- All calibrations are made with the use of primary standards or primary reference materials (certified and issued by the National Institute of Standards and Technology or NBL, or equivalent organization) or with reference standards traceable to primary standards. The standards used for calibrations need not be representative of the unknowns to be measured by the system unless it is to be regarded as a bias-free system calibrated during each time of use, in which case the calibrations standards must be representative.

When determining an SNM quantity by weighing, sampling, and analyses, the net weight of material in each item within a uniform material batch (or lot), such as blended UO_2 powder or sintered UO_2 pellets, should be determined by direct mass measurement. However, the element or isotope concentrations for the batch do not have to be determined for each container; instead, they may be derived by sampling procedures, including:

- Analysis of composite samples or measurements of representative items, objects, or samples selected by statistical sampling

- Use of concentration or enrichment factors determined from historical averages, controlled input specifications values, or empirical relationships in which such values or relationships are tested periodically, their uncertainties or bounds have been determined to be within 2.00 percent of the factor value, and where diversions with material substitution are improbable. However, heterogeneous materials, such as ammonium diuranate, may not be assigned common factors unless the quantities are small, such as less than 500 grams of contained ^{235}U (per material type, per inventory period). Justification for any materials assigned common factors without batch-by-batch verification analyses should be presented in the MC&A plan.

5. MEASUREMENT CONTROL SYSTEM

5.0 Regulatory Intent

The intent of the measurement control requirements in 10 CFR 74.31(c)(3) and (4) is that measurement systems (described in Chapter 4) used to establish special nuclear material (SNM) accountability quantities be controlled by a formal measurement control system that results in a ^{235}U total measurement standard error that is within 4,500 grams ^{235}U or 0.125 percent of the ^{235}U active inventory quantity (whichever is greater). That is, in terms of a 95 percent confidence level, twice the standard error associated with a material balance total material control and accounting (MC&A) measurement uncertainty (for ^{235}U) must be less than the greater of 9,000 grams ^{235}U or 0.25 percent of the ^{235}U active inventory. It is also intended that the measurement control program also provides bias estimates for adjusting inventory difference (ID) results and correcting shipper-receiver measurements for significant measurement biases.

5.1 Organization and Management

The organization and management of the measurement control system should be described in sufficient detail to show how the measurement quality assurance function is assigned and how independence from the analytical laboratory and other units performing either sample taking or measurements is maintained. The measurement control system manager should be at a management level that is sufficiently high to ensure objectivity and independence of action. Thus, the measurement control system manager could either report directly to the overall MC&A manager or, if in a different organizational unit, be on the same level as the MC&A manager.

The licensee's measurement control system should be properly managed to ensure adequate calibration frequencies, sufficient control of biases, and sufficient measurement precision to achieve the capabilities required by 10 CFR 74.31(c)(3) and (4).

5.1.1 Functional Relationships

The relationship and coordination between the measurement control system manager, the analytical laboratory, and other measurement performing groups needs to be clearly defined. Adequate assurance should be provided so that the measurement control system manager has the authority to enforce all applicable measurement control requirements.

5.1.2 Procedures

The measurement control system procedures should be established and maintained in a manual that is kept current and readily available. This manual should contain all the currently applicable written procedures pertaining to measurement control and measurement quality assurance. Responsibility for preparation, revision, and approval of manual procedures should be specified. Individual measurement control procedures should have documented approval by the measurement control system manager. The procedures should address the following:

- calibration frequencies and methods
- standards used for calibration (i.e., description and storage controls)

- standards used for control (i.e., method of obtaining or preparation, and traceability)
- control standard measurements
- replicate sampling and replicate measurements
- verification of process control instrumentation through comparison with other process instruments
- control limits and control responses
- generation and collection of control data
- recordkeeping controls and requirements

5.1.3 Contractor Program Audits and Reviews

If an outside contractor or offsite laboratory provides measurement services, the review program used to monitor the offsite measurements should be described. Such reviews are to ensure that the contractor or offsite laboratory has an acceptable measurement control program to the extent that use of the contractor's measurements will not compromise the licensee's ability to meet any measurement or measurement control requirement contained in either 10 CFR 74.31(c) or in its MC&A plan. An initial review of the contractor's measurement control program should be conducted before licensee use of measurements performed by the contractor or offsite laboratory.

All contractor or offsite laboratory assessment findings and recommendations should be documented and submitted to both the measurement control system manager and the overall MC&A manager within 30 calendar days of review completion. The two managers should arrive at an agreement on corrective actions that should be taken, based on their evaluation of the report, and should transmit these findings to the contractor or offsite laboratory in writing. The licensee should not use measurements performed by such contractors or offsite laboratories until they have verified that the corrective actions have been instituted.

The persons who conduct a contractor review need not be employed by the licensee; but they should not be employed by, or in any way associated with, the contractor or offsite laboratory so that the independence of the conclusions may be maintained.

5.2 Calibrations

The MC&A plan should summarize the licensee's calibration program and confirm that the licensee has written procedures covering the following topics:

- calibration frequency for each measurement device or system
- identification of the standards used for calibration of each measurement device or system
- protection and control of standards used to calibrate measurement systems to maintain the validity of their certified or assigned values

- the range of calibration for each measurement device or system and the minimum number of calibration runs (observations) needed to establish a calibration

Unlike control standards, standards used for calibrating measurement systems need not be representative of the process material or items to be measured by the calibrated device or system. If practical, the standard used during the calibration process should be subjected to all the steps involved in the measurement process that the process unknowns are subjected to (e.g., sample pretreatment), but this need not always be the case.

It is the primary measurement device, not necessarily the entire measurement system that needs to be calibrated, especially when the primary measurement device is common to two or more measurement systems. For example, the Davies & Gray titrimetric method often is used to analyze samples for uranium concentration of two or more different material types (e.g., UF_6, UO_2, UNH solutions). In this case, more than one measurement system is involved because different sampling and sample pretreatment methods and different control standards are used. The potassium dichromate ($K_2Cr_2O_7$) titrant, however, is common to the systems; thus, the titrant is what is calibrated (or standardized) with a primary reference material such as certified $K_2Cr_2O_7$ certified U_3O_8 or certified uranium metal.

In the case of nonconsumable standards used to calibrate measurement systems (e.g., weight standards), the frequency of recertification of assigned values should be specified. The recertification frequency should depend on how often the standards are handled, the standard's stability, and the adequacy of the controls used to maintain the integrity of the standards. Biennial recertification of such standards is usually acceptable.

The MC&A plan should contain a definitive statement that no SNM accountability value is based on a measurement that falls outside the range of calibration. The MC&A plan also should identify those measurement systems that are point-calibrated. A point-calibrated measurement system is one in which the following are true:

- The entire measurement system is calibrated with a standard or set of standards that is representative of the process unknowns that the system measures. That is, the representative calibration standard(s) undergoes all the measurement steps, and in the same manner, that the unknowns do.

- One or more calibration standards are processed and measured along with each unknown or set of unknowns measured. That is, both the standard(s) and unknown(s) are measured during the same general time interval, with the same individual measuring both the standard(s) and unknown(s).

- The measurement values assigned to the process unknowns are derived from the measurement response observed for the standard(s) that was measured along with the unknown(s).

- The measurement response for each unknown should fall within plus or minus 10 percent of the response for a standard measured at the same time as the unknown, or as in the case of a low concentration unknown, the difference between the unknown's response and the standard's response should be less than four times the standard deviation associated with the standard's response.

5.3 Control Standards

For measurement systems that are not point-calibrated, a defined method for the periodic measurement of control standards should be established and followed. Control standard measurements serve the dual purpose of (1) monitoring the stability of a previously determined calibration factor, and (2) estimating the average system bias over a period of time (e.g., an inventory period). The minimum total number of control standard measurements during the time period, as well as the typical frequency, needs to be specified for each measurement system. Generally speaking, for each key measurement system, a minimum of two control standard measurements should be made during each week that the system is in use. For those key systems that are used less than 8 weeks during a given material balance period, more than two control standard measurements per week of system use may be necessary to provide:

(1) A minimum of 12 control standard measurements for those systems used during the material balance period to measure material totaling less than 100 kilograms of ^{235}U

(2) A minimum of 24 control standard measurements for those systems used to measure a total of 100 or more kilograms of ^{235}U

Key measurement systems for the current inventory period are any set of designated measurement systems (of the licensee's choosing) which, based on the most recent previous period, account for at least 90 percent of the total measurement variance contribution to the standard error of the inventory difference (SEID). Included within the set of key measurement systems should be any system used to measure an SNM quantity (during an inventory period) greater than 25 percent of the active inventory, regardless of its contribution to SEID. The minimum number of control standard measurements for situations (1) and (2), above, can be reduced to 8 and 16, respectively, for non-key measurement systems that measure from 10 to 25 percent of the active inventory, and the minimum number of control standard measurements for situations (1) and (2) can be further reduced to 4 and 8, respectively, for those non-key systems used to measure less than 10 percent of the active inventory quantity.

Control standards should be representative of the process material or items being measured. To be representative, the standards need not always be identical to the process unknowns; but any constituent of the process material or any factor associated with a process item, that produces a bias effect on the measurement should be present to the same degree in the control standards. For scales used to weigh very large items, such as UF_6 cylinders, the control standard weights should be artifact standards (e.g., both empty and full UF_6 cylinders) of certified mass to avoid a bias effect caused by buoyancy or point loading.

For each measurement system that is not point-calibrated, the control standards to be used for control standard measurements should be identified or described. Along with material composition and matrix factors, biases also can be induced by changes in (among other things) temperature, humidity, line voltage, and background radiation. Biases also can be operator or analyst induced. Therefore, the scheduling of control standard measurements should be based on the following considerations:

- Does the variation between analysts or operators need to be considered and therefore monitored?
- Can environmental variables contribute to measurement bias?

- Is bias likely to vary with respect to the time of day?

- Is a particular bias likely to be long term, short term, or cyclic in nature?

- Is bias a function of the process measurement values over the range of calibration (i.e., is the relative percent bias nonuniform over the range of calibration)?

- What controls or procedures are needed to ensure that sampling or aliquoting of the control standard is representative of the sampling or aliquoting of the process material?

- To estimate the bias for each measurement system, how alike—in terms of chemical composition, uranium concentration, density, homogeneity, and impurity content—should the control standards be relative to the process unknowns?

5.4 Replicate Sampling

For systems involving sampling, duplicate measurements performed on single samples or measurements of replicate samples are necessary to estimate the combined analytical plus sampling random error. For nonsampling measurement systems such as nondestructive assay (NDA) and weight measurement systems, the random measurement variance component can be derived either from (1) replicate measurements performed on process items, or (2) the data generated from the measurement of control standards.

The licensee should ensure that replicate samples are independent of one another. The number of replicate samples measured for each analytical measurement system that is designated as a key measurement system, during an inventory period should be equal to one of the following:

(1) 100 percent of the accountability batches sampled (when less than 15 batches)

(2) the greater of 15 samples or 15 percent of the accountability batches sampled

(3) 50 samples (when 15 percent of the batches is greater than 50)

For non-key analytical measurement systems, the minimum number of replicate samples to be measured during an inventory period should be equal to one of the following:

(4) percent of the accountability batches sampled (when less than eight batches)

(5) the greater of eight samples or 10 percent of the accountability batches sampled

(6) 25 samples (when 10 percent of the batches is greater than 25)

For each measurement system involving sampling and analysis, the MC&A plan should indicate (1) how many samples are taken and measured for each accountability batch measurement, and (2) how many analyses are performed on each accountability sample. If two or more samples are used and one or more analyses per sample are performed for each accountability batch measurement, replicate requirements are automatically met. If, however, one sample per batch is normally used for accountability purposes, the replicate program should include a periodic taking of a second (i.e., replicate) sample. For NDA and mass (weight) measurement

systems, replicate data can be obtained either from the repeat measurements on production items or by using the data generated from the control standard program. That is, each consecutive pair of control standard measurements (for a given NDA or mass system) can be considered a replicate pair. The minimum number of replicate measurements performed during an inventory period for a given key NDA or mass system should be as given in items (1), (2), or (3), above, except that the numbers or percentages are in terms of items measured, rather than batches sampled. Likewise, for non-key NDA and mass measurement systems, the minimum number of replicate measurements should be as given in items (4), (5), or (6) above. The scatter in the repeat measurements is used to estimate the random error variance using a statistical technique known as the one-way analysis of variance. (The U.S. Nuclear Regulatory Commission (NRC) recommends the statistical methods described in NUREG/CR-4604, "Statistical Methods for Nuclear Material Management," issued December 1988, for satisfying the statistical requirements of 10 CFR 74.31; see also Chapter 6 of this document.) Replication not only improves the precision of results obtained from the statistical analysis of the measurement data, it also can detect gross errors in the data.

5.5 Control Limits

Both warning and out-of-control limits are to be established and used for control standard measurements for those measurement systems used for nuclear material accountability. Out-of-control limits are also to be used for replicate measurements and measurement of replicate samples. However, warning limits are optional for the replicate program. For point-calibrated systems, the assigned value of the standard(s) measured along with the unknown(s) is assumed to be valid. If the standard's true value could change because of factors such as evaporation, moisture pickup, or oxidation, the value of the standard should be checked periodically. Therefore, control limits for the verification measurements associated with such standards should be established. This is especially true for those point-calibrated systems that use a single standard, or aliquots from a single standard, over any extended period of time.

The licensee normally sets the warning and out-of-control limits based on a tradeoff between (1) the cost of investigating and resolving incidents in which limits are exceeded and (2) the cost of accepting measurements of poor quality. Warning limits set at the 0.05 level of significance and out-of-control limits set at the 0.001 level of significance are usually sufficient. When a system generates a control measurement that falls beyond an out-of-control limit, the system should not be used for accounting purposes until it has been brought back into control (i.e., within the upper and lower warning limit).

Control limits should be recalculated at a predetermined frequency and modified if required. The MC&A plan should clearly explain how control limits are established and the frequency for redetermining them.

5.5.1 Measurement Control Data Analysis

Measurement control data such as control standard measurement results and the differences between measurement values of replicate pairs should be plotted for generation of control charts. All control charts should be reviewed at least once every 2 weeks unless a measurement system was not used during that period. The review should assess the frequency of control data exceeding either the warning or the out-of-control limits and also provide an evaluation for any significant trends.

5.5.2 Response Actions

Either the analyst or the operator performing a control measurement or their supervisor should be responsible for promptly reporting any control measurement that exceeds an out-of-control limit. Such reporting should be made to the measurement control system manager (or his or her designee), who should have the responsibility and authority to carry out or direct the necessary response and corrective actions.

Minimum response and minimum corrective action requirements should be clearly defined. In addition, the measurement control manager (or his or her designee) should be responsible for, and have the authority for, determining and executing additional response and corrective actions as deemed appropriate.

The minimum response to a reported incident of a control measurement exceeding an out-of-control limit should consist of the following:

- verifying that the measurement system in question has been taken out of service for accountability measurements
- documenting the occurrence of the event
- performing at least two additional control measurements
- performing additional control measurements, if results of item (3) do not show the system to be back in control, using a different control standard or different replicate sample (as appropriate) or recalibrating the measurement system, or making any necessary system repairs
- reviewing measurements performed on the system in question since the last in-control run to determine if there is a need to remeasure any items

For those measurement systems that make a significant contribution to the SEID, the response to an out-of-control condition also should include the remeasurement of any samples (or items) that were measured before the out-of-control condition but after the last within-control measurement. The validity of the previous measurements can be established without a complete remeasurement of all the samples (or items) involved if remeasurement on a last in, first out" basis is used. That is, the last sample (or item) measured before the out-of-control measurement, should be the first to be remeasured, and continuing in reverse order until two consecutive remeasurements are found to be in agreement with their initial measurement at the 95 percent confidence level.

5.6 Commitments and Acceptance Criteria

In its MC&A plan, the applicant or licensee should provide definitive commitments that adhere to the regulatory requirements and meet the acceptance criteria applicable to the measurement control system. A finding that the licensee's MC&A plan for maintaining measurement quality and estimating measurement uncertainty values is acceptable and in accordance with 10 CFR 74.31(c)(3) and (4), will be based on, but not limited to, the following acceptance criteria:

- The description of the measurement control system shows that the measurement systems that are the key contributors to the total measurement standard error will be routinely and adequately monitored for both bias and random error. The standard deviations of measurement systems are estimated from replicate data from measurements made in the same manner as made routinely on typical process samples and items. If standard deviations are based on replicated measurements of standards (for NDA or mass measurement systems), data are collected demonstrating that the standard deviation estimates do not differ significantly from those based on replicated process item measurements. (Note: For analytical chemistry measurements, the combined analytical plus sampling random error must be derived from the measurement of replicate process samples rather than based on multiple measurements of a standard.)

- All reasonable and probable sources of measurement error, such as the effects of sampling, instruments, environmental factors, and variability between operator and analysts are included in the estimates for standard deviations, either directly as experimental variables in an analysis of variance or by being included in the sample of measurement control data from which the standard deviations are determined. It must be shown that it is reasonable to expect that the measurement systems that could significantly affect the ID will be in control (when used for accounting purposes) so that twice the total measurement standard error will be within the limits stated in 10 CFR 74.31(c)(4) when calculated at the time of a physical inventory.

- Bias tests are made by measurements of representative control standards whose assigned values are traceable to national measurement systems. As reasonably achievable, the control standards should closely resemble the unknowns to which the measurement is applied, and the measurement procedures and conditions of measurement must closely resemble those of typical measurements made on process unknowns.

- A record of bias estimates for each key measurement system (not defined as a bias-free, point-in-time calibrated system), as derived from control standard measurements, is maintained. The basis for determining the time frame associated with each significant bias needs to be provided (so that the quantity of measured SNM to which that bias applies can be determined). Bias corrections (expressed as both grams element and grams isotope) are derived for each significant bias (based on the quantity of measured SNM to which the bias applies). The MC&A plan must confirm that each significant bias is either applied as corrections to items listed in the accounting records (if the correction for an individual item is greater than the rounding error for that item), or included in the net bias correction to ID (on line 7 of NRC Form 327).

- Schedules and frequencies of replicate and control standard measurements are designed so that the estimates of standard deviations and measurement biases will be based on measurement control data collected under the same measurement circumstances and over the same time span corresponding to that of the SNM accounting measurements to which the standard deviations and bias estimates will be applied. The standard deviation and bias of each key measurement system should be evaluated periodically. The frequency of such evaluations should typically be at least every 4 months. When determining the average bias and standard deviation of a particular measurement system for an inventory period, pooling of data from previous determinations may be used only if statistical tests show that the standard deviations and biases from prior determinations do not differ significantly from that of the current period, and further provided the pooled data do not include any data generated more than 24 months before the current determination of such bias or standard deviation.

- The effort that the licensee expended in monitoring and controlling the bias and standard deviations of each measurement system is shown to be consistent with its impact on ID and the total measurement standard error. The number of degrees of freedom for estimating the measurement standard deviation may be graded according to its contribution to the total measurement standard error.

- Warning limits for a change in bias (for those systems that are not point-in-time calibrated, bias free) will be set at the 0.05 level of significance (or tighter), unless adequate justification for less stringent limits is provided. Warning limits are optional, however, for the monitoring of replicate data (for standard deviations). If a control datum exceeds this limit, the individual responsible for the measurement control program will be notified (this normally should occur within 72 hours) and a data review will be initiated to find the cause, and corrective action will be taken when appropriate. Such reviews and corrective actions are completed and documented within 2 weeks.

- Unless adequate justification for less stringent limits is provided, out-of-control limits for both standard deviation and bias are set at the 0.001 level of significance for all key measurement systems, except that no bias control limits are needed for bias-free, point-in-time calibrated systems. If a control datum exceeds this limit, the system in question shall not be used for MC&A purposes until corrective action and resolution is completed, and the system is back in control within the upper and lower boundaries of the warning limit. Likewise, any measurement values generated between the last within control datum and the out-of-control datum shall not be used for MC&A purposes until their validity has been confirmed. Such confirmation can be accomplished by remeasurement of the involved items or samples on a last in, first out" basis until two consecutive remeasurements are found to be in agreement with their initial measurement at the 95 percent confidence level. It should be noted that other criteria for initiating corrective action relative to potentially out-of-control measurement systems may be accepted where it can be demonstrated that the licensee's capability to meet the 0.25 percent of active inventory limit for total MC&A measurement uncertainty (as specified in 10 CFR 74.31(c)(4)) will not be jeopardized.

- The approach used for bounding the total measurement standard error for a typical material balance period meets the following criteria:

  – All reasonable and probable sources of measurement error affecting ID are included.

- Any assumed measurement standard deviations are shown to be reasonable. They may be shown to be reasonable by comparison to either records of the licensee's past performance data or to published measurement performance in similar applications.

- The calculation of the total measurement standard error is performed in accordance with a recognized error propagation method. Such methods have been published in the recommended NUREG/CR-4604 (1988), as well as in TID-26298 (1973), and the International Atomic Energy Agency (IAEA) statistics handbook (1989).

- The licensee will confirm that the accountability measurements that a contractor provides are controlled by a measurement control program, and that the licensee will confirm that the contractor's measurement control program is adequate by conducting audit and assessment reviews of the contractor's program at intervals not to exceed 24 months.

- The measurement systems have adequate calibration frequencies, sufficient control of biases, and sufficiently small standard deviations to achieve the requirements of 10 CFR 74.31(c). A measurement control system is used—by both in-house activities and any contractor that performs MC&A measurement services for the licensee—to ensure that the quality of the measurements is maintained on a level consistent with the NRC requirements.

6. STATISTICS

6.0 Regulatory Intent

Proper use of statistics is important to ensuring that the regulatory requirements in 10 CFR 74.31, "Nuclear Material Control and Accounting for Special Nuclear Material of Low Strategic Significance," are met. An effective statistical program will ensure measurement systems perform within control limits, measurement uncertainties are calculated and propagated, the inventory difference (ID) and standard error of the inventory difference (SEID) are properly determined, and significant shipper-receiver differences (SRDs) are identified. For example, 10 CFR 74.31(c)(5) requires licensees to calculate the ID and SEID for the material balance period terminated by each physical inventory. Proper use of statistics is important to correctly propagate the uncertainties from all measurements into an accurate SEID value.

6.1 Determination of Measurement Uncertainties

To achieve the general performance objectives of 10 CFR 74.3, and meet the 10 CFR 74.31 requirements, each licensee or applicant should institute a statistical program that evaluates the material control and accounting (MC&A) data to ensure that (1) the measurement data are analyzed in a rigorous manner and (2) statistical tests and inferences concerning the status of the nuclear material possessed are appropriately tested. The U.S. Nuclear Regulatory Commission (NRC) sponsored the development of a comprehensive reference that specifically addresses the statistical treatment of measurement control and accounting data. The NRC recommends the statistical methods described in NUREG/CR-4604, "Statistical Methods for Nuclear Material Management" (1988), as well as in TID-26298 (1973) and the International Atomic Energy Agency (IAEA) statistics handbook (1989), for satisfying the statistical requirements of 10 CFR 74.31.

The MC&A plan should:

- contain a detailed discussion of the procedures and methodologies for estimating measurement variance components
- discuss how biases are determined and how bias corrections are applied, including:
    - how often biases are estimated
    - how the bias' effect on the measured quantity of material in an item is determined
    - when and how bias corrections to items are made
    - how their effect on ID is determined
    - when and how bias corrections are applied to the ID
- describe the procedure and means for determining active inventory
- provide all relevant information regarding the determination of the SEID

- specify the nominal (typical) detection quantity (DQ), and the method for determining the actual DQ for a given material balance period. Also confirm that DQ will not exceed 1.30 percent of the larger of annual additions to or removals from process, except when 1.30 percent of additions to or removals from process is less that 25 kilograms of ^{235}U, in which case the DQ need not be less than 25 kilograms of ^{235}U. (Note: For those facilities that do not use any chemical processing, DQ should be limited to 0.90 percent of annual additions to or removals from process, but need not be less than 25 kilograms of ^{235}U.)

- specify the methodology for determining ID threshold values to be used to provide a 90 percent power of detecting a loss of a DQ, as required by 10 CFR 74.31 (c)(5). (See Chapter 5 for additional information on ID limits and response actions.)

6.2 Determination of Standard Error of the Inventory Difference

As defined in 10 CFR 74.4, the SEID means the standard deviation of an ID that takes into account all measurement error contributions to the ID components. For strategic SNM facilities, nonmeasurement contributors to the ID are not to be included in the SEID calculation. However, for facilities possessing only SNM of low strategic significance, the NRC allows licensees to take limited credit for nonmeasurement contributors. It is not really possible to quantify the nonmeasurement contribution to the uncertainty associated with a given ID, but 10 CFR 74.31 licensees are permitted to assume that the total nonmeasurement contribution to SEID equals the total measurement error contribution. When including only measurement uncertainty, SEID (for either U or ^{235}U, as applicable) can be expressed as follows:

SEID =

where

k = number of measurement systems
G_i = total grams uranium (or ^{235}U) measured during inventory-period by measurement system i
$(\sigma_i)_s$ = systematic-error standard deviation for measurement system i
$(\sigma_i)_r$ = random error standard deviation for measurement system i
n = number of batches (items) measured by measurement system i

When taking the maximum allowable credit for nonmeasurement contribution (which assumes a 1:1 ratio of measurement to nonmeasurement contributions),

SEID =

In theory, SEID provides the uncertainty, at the 67 percent confidence level, of the ID estimate.

The MC&A plan should provide all relevant information regarding the determination of SEID. There should also be a commitment that at least two individuals independently verify the correctness of the SEID calculation for each total plant material balance. If the SEID value is calculated by a computer, the verification by two or more persons involves a checking for correctness of the input data that the computer used to calculate SEID.

The method to be used for estimating the SEID for the typical material balance, as shown in the Annex, should be consistent with the following criteria:

- All reasonable and probable sources of measurement error for the key measurement systems affecting IDs are included.

- The selection of the key measurements whose variances are to be included in calculating the standard error is justified by an analysis of the relative magnitudes of the variance components of a typical ID and their comparative effect on the SEID.

- Any measurement error standard deviations not actually determined by the measurement control program are shown to be reasonable either by comparison with published state-of-the-art measurement performance in similar applications (see such sources as Rogers (1983), and Reilly and Evans (1977)) or with records of past performance data from the licensee's facility. Records showing these data should be available to the NRC.

- The calculation of the SEID is performed in accordance with a recognized error propagation method. Such methods have been published by Jaech (1973) and the IAEA (1977).

6.3 Bias Corrections

From a statistical perspective, biases that are not statistically significant (at the 95 percent confidence level) should never be applied as adjustments (corrections) to the accounting records. If one wishes to obtain the best estimate of the true ID value, it can be argued that such insignificant biases should be applied as a non-accounting adjustments to the initially calculated ID (as obtained from the ID equation: ID = BI + A – R - EI). Such practice is not deemed necessary, however, for material balances pertaining to SNM of low strategic significance, and thus is optional.

For statistically significant biases (at the 95 percent confidence level), it is common practice to adjust the accounting values for individual items if the bias effect (as grams element and grams isotope) on the item is more than the rounding error for that item, and if less than the rounding error, to apply the bias as a non-accounting adjustment to the ID. Under a well-designed and well managed measurement control program, bias corrections to the accounting records should seldom, if ever, be necessary under the above mentioned approach. Although the effect on an individual item from a statistically significant bias should be negligible, the effect of that bias across hundreds or thousands of items (whose SNM values were derived from the biased measurement system) could have a very significant impact on the ID value.

Nevertheless, in view of the very large quantity of SNM (of low strategic significance) that is of a safeguards significance, NRC acceptance criteria does not normally call for applying bias corrections to either the accounting records or as an adjustment to ID unless the effect of a single significant bias or the net sum of all significant biases is unusually large.

As a minimum, to meet NRC acceptance criteria, a bias correction for a single key measurement system should be considered "significant," and thus applied either as corrections

to the accounting records or as an adjustment to the ID, if (1) such bias is statistically significant at the 95 percent confidence level, and (2) either or both of the following are also true:

(1) Applying the correction would cause the ID to exceed its detection threshold (DT) value

(2) The bias is greater than 0.0100 percent relative and also affects the ID value by more than 1,000 grams ^{235}U.

Additionally, the net algebraic sum (expressed as grams ^{235}U) of all statistically significant (95 percent confidence level) biases, from key measurement systems not defined as bias-free, that have not been applied as a correction or adjustment under Condition I and/or II, above, is considered to be significant and is to be applied as a net adjustment to the ID if either or both of the following are true:

- Applying such correction would cause the ID to exceed its DT value
- The net correction impacts the ID value by more than 5.00 percent of the licensee's DQ, or 10,000 grams ^{235}U, whichever is larger

All measurement systems affecting an ID estimate or shipper-receiver comparison should be monitored for bias except as noted below. The intensity of the monitoring program is proportional to the significance of the measurement system for the test involved. The key measurement systems (i.e., those that contribute at least 10 percent of the estimated measurement standard deviation of an SRD or an ID estimator) should be tested for bias at least monthly except where:

- the measurement system has been demonstrated to be quite stable and the results predictable
- the system is defined as bias-free

Where the above conditions exist, the bias tests can be extended to 3 months or exempted altogether if the system qualifies as bias-free.

The bias tests should be made using the mean of at least eight control standard measurements. Bias corrections should be made to individual items if the bias exceeds twice the standard deviation of its estimator and also exceeds the rounding error of affected items.

Measurement systems are statistically "bias-free" if a representative standard is run for each unknown or set of unknowns measured at the same time, or representative standards are measured before or after a group of process samples and the standard(s) measurement response and assigned value, rather than any previous calibration information, are used in determining the value of the unknown(s).

7. PHYSICAL INVENTORIES

7.0 Regulatory Intent

The intent of the physical inventory requirements in 10 CFR 74.31(c)(5) is to require licensees to perform annual physical inventories to confirm that a loss or diversion of a safeguards significant quantity (i.e., a detection quantity (DQ)) of low strategic special nuclear material (SNM) has not occurred. Licensees are required by 10 CFR 74.31(c)(5) to conduct physical inventories at intervals not to exceed 370 calendar days. The principal method of confirming the presence of SNM is to perform a physical inventory and compare it to the book (record) inventory. If all SNM is included, the expected difference between the book inventory and the physical inventory is zero plus or minus the measurement uncertainty associated with both the physical and book inventories. In any actual case, the size of the estimated inventory difference (ID) depends on measurement errors, as well as various nonmeasurement contributors, such as recording errors, unmeasured losses, and unmeasured residual holdup as discussed further in Section 7.5 (see Glossary for the definition of "residual holdup").

7.1 General Description

The applicant or licensee should provide a general description of how physical inventories of the plant will be planned, conducted, assessed, and reported.

The material control and accounting (MC&A) plan should contain a definitive statement that physical inventory functions and responsibilities are reviewed comprehensively with the involved individuals before the start of each physical inventory.

A book inventory listing, derived from the MC&A record system, should be generated just before the actual start of each physical inventory; such listing shall include all SNM that the records indicate the licensee should possess at the inventory cutoff time.

The ID and related information associated with each physical inventory of low-enriched uranium (LEU) (i.e., U.S. Department of Energy/U.S. Nuclear Regulatory Commission (DOE/NRC) material code 20-E1 and 20-E2) are to be reported to the NRC, pursuant to 10 CFR 74.17(a), on an NRC Form 327 as the results of a physical inventory. In addition, if the licensee possesses any material associated with material codes 20-E3 and 20-E4 (i.e., high-enriched uranium (HEU)), 70 (^{233}U), 50 (Plutonium), or, 83 (Plutonium-238), such material also must be subject to the physical inventory, and each material code ID and associated information must be reported on separate NRC 327 Forms.

7.2 Organization, Procedures, and Schedules

The MC&A plan should explain the makeup and duties of the typical physical inventory organization. The individual that has responsibility for the coordination of the physical inventory effort should be identified by position title. The MC&A plan also should indicate how the preparation and modification of inventory procedures is controlled.

The MC&A plan should contain a definitive statement that specific inventory instructions are prepared and issued for each physical inventory.

7.3 Typical Inventory Composition

The typical expected in-process inventory within the equipment for both uranium and ^{235}U at the time of the physical inventory should be specified. A typical composition of SNM as stored items at the time of a physical inventory also should be presented. Plants may be (but are not required to be) divided into a number of material balance areas (MBAs) and item control areas (ICAs) to reflect the functional activities as follows:

> Processing—an MBA in which occurs (1) routine transfers of nuclear material from one container to another, (2) changes in chemical assay, or (3) changes in chemical or physical form. Various measurements are required to define materials flows through the process and to perform physical inventories so that periodic material balances can be completed for the MBA. Because these measurements have associated uncertainties, a processing MBA will normally have a nonzero ID for each inventory. Of the total plant MBAs and ICAs, a relatively small number might be processing MBAs. Examples are the decontamination and recovery operations; analytical laboratory; and material rebatching, blending, and sampling operations. Physical inventories for the decontamination and recovery operations are the most complex and involve the most coordination and careful timing.
>
> Storage—ICAs in which all materials are within containers with measured values and are being stored for future processing or shipment. Some minor sampling of containers can occur in a storage ICA. Because nuclear materials in a storage ICA primarily are accounted for on an item basis, a true storage ICA typically will have a zero ID for each inventory period when all items are accounted for and their integrity and previously documented measured values are confirmed.
>
> Receiving and shipping—an ICA from which materials are shipped or into which materials are received from off site. This ICA type normally will serve as an interim storage area and will see more activity (i.e., changes in current inventory) than the typical storage ICA. At some facilities, sampling and rebatching of items may occur in this type of ICA.

7.4 Description of Typical Item Strata

The MC&A plan should describe the expected item population in terms of the following:

- type of item (i.e., stratum)
- expected range of the number of items within each stratum
- the average uranium and ^{235}U content of the items within each stratum
- the expected rate of item generation and consumption for each stratum

7.5 Conducting Physical Inventories

The MC&A plan should contain a description of the inventory methodology, including cutoff and inventory minimization procedures, and should identify all measurements (including sampling) sufficient to meet the requirements of 10 CFR 74.31(c)(5). The MC&A plan also should contain

sufficient information to show how the total in-process inventory for both uranium and ^{235}U is obtained.

The means for measuring or estimating residual holdup should be addressed in detail, and the change or variation in such holdup from one physical inventory to the next also should be discussed. This information is important to ensure no SNM held under license (except for waste materials assigned to holding accounts in accordance with the exceptions provided in 10 CFR 74.31(c)(6) and DOE/NRC Form-741 instructions) will be omitted, and no quantity will be counted more than once.

The MC&A plan also should contain adequate commitments to ensure that each physical inventory will be organized and coordinated so that all involved persons are instructed in the use of uniform procedures of checking SNM quantity and recording observations. The means for conducting the inventory must ensure that any SNM held under license (except for waste materials as noted above) is properly inventoried.

A detailed inventory notice should be prepared for each physical inventory. The notice should be issued to all involved parties and should contain instructions that define the timing and performance of various inventory steps and conditions under which the inventory will be taken. Specific sampling points throughout the process and instructions on data submission to the accountability organization should be identified. The instructions should highlight any required deviation from normal inventory procedures contained in the plant's operating procedures.

A description of the procedures and methodologies associated with performing physical inventories should be provided in sufficient detail to demonstrate that valid physical inventories are conducted. Such description should include a general outline of the following:

- organization and separation of functions
- assignment of inventory teams and their training in the use of uniform practices
- obtaining, verifying, and recording of source data
- control of inventory forms
- assurance that item counts verify the presence of each item while preventing any item from being counted more than once
- implementation of cutoff and material handling procedures

Decontamination and recovery is a complex operation involving the disassembly and decontamination of failed pieces of process equipment, and recovery of uranium from various types of scrap materials. The basic inventory procedure should involve establishing a cutoff of movement of materials into the area and processing all materials to a measurable form, such as containers of solution or oxide. Except for the decontamination enclosure in which in-process solutions are mixed, sampled, and measured volumetrically, the inventory process should involve emptying and flushing of process systems and piping, which then could be measured using nondestructive assay (NDA) techniques to establish levels of residual holdup, if such holdup is significant.

Special item storage and handling or tamper-indicating methods, which are used to ensure that the previously measured and recorded SNM content values can be used for inventory purposes without remeasurements, also should be described. In addition, the MC&A plan should provide a description of how item identities are verified and how tampering with the contents of items will be detected or prevented.

Items that are not encapsulated, affixed with tamper-indicating device (TIDs), or otherwise protected to ensure the validity of prior measurements need special attention. The basis for determining which items are to be measured at physical inventory time and the justification of any proposed alternatives to measurement of any SNM included in the inventory should be presented. If statistical sampling is proposed as an alternative method to 100 percent verification, the MC&A plan should describe the sampling plan. Such description should include:

- the method of segregating the types of items to be sampled (i.e., selected for remeasurement)
- the procedure for calculating the sample size (i.e., the number of items) for each stratum
- the parameter to be measured (e.g., gross weight or total ^{235}U content)
- the quality of the measurement methods used to verify original measurement values (for the parameter being measured)
- the procedure for reconciling discrepancies between original and remeasurement values, and for scheduling additional tests and remeasurements
- the basis for discarding an original SNM value and replacing it with a remeasurement value

One acceptable way for establishing the number of items (to be randomly selected for remeasurement) from a given stratum to give the required 90 percent power of detecting a loss of a DQ is given by the following equation:

$$n = N\,[1 - (0.10)^{x/g}]$$

where

n = number of items to be remeasured
N = total number of items in the stratum
x = maximum ^{235}U content per item (kilograms)
g = DQ = detection quantity (kilograms ^{235}U)

When using such a statistical sampling plan to confirm the validity of prior measurements, the remeasurement value obtained for each item (among the n items remeasured) must be compared to its original value. If the difference for a given item exceeds some pre-determined limit (usually three times the standard deviation of the measurement, or, 3 sigma), that item is designated as a “defect.” To achieve the 90 percent power of detection capability for detecting a loss of a DQ, there must be at least a 90 percent probability that one or more “defects” will be encountered among the items remeasured across all involved stata if an actual loss of a DQ has occurred. If, across all strata, one or more defects are encountered, a second set of n randomly selected items (or all remaining items if $n \geq 0.5\,N$) from each stratum should be remeasured. If

one or more defects are encountered (across all item stata) while performing any second round of remeasurements, all unsealed and unencapsulated items not yet remeasured are to be remeasured. Any item, regardless of whether there are any defects, whose remeasured value differs from its original measurement by more than two sigma (2σ) should have its accounting value revised to reflect its remeasured quantity.

The MC&A plan also should contain a definitive statement that all items on ending inventory that have not been previously measured are measured for inventory purposes.

The rationale for determining when the element and isotope factors for items, objects, or containers are measured directly for inventory and when they may be based on other measurements should be presented in the MC&A plan. For example, if the ^{235}U contained in liquid waste batches is derived by applying an average enrichment factor to the measured uranium element content, the rationale for such practice (as opposed to measuring each batch for both uranium and ^{235}U content) should be discussed, and the method for establishing the average enrichment factor should be described.

If the content of items is established through prior measurements and those items are sealed with TIDs or access to them is controlled, the SNM quantity in those items may be based on those measured values. Otherwise, verification of SNM content can be achieved by reweighing either (1) all items within a given stratum or (2) randomly selected items from the stratum based on a statistical sampling plan. A statistical sampling plan will not be acceptable if there is any likelihood of any significant change in the uranium concentration (or weight fraction) or in the uranium isotopic distribution because of such factors as oxidation, change in moisture content, commingling with materials of different enrichments, or different compositions.

7.6 Inventory Difference Limits and Response Actions

Each licensee should have a well-defined system for evaluating total plant IDs and taking actions when IDs exceed certain predetermined thresholds. As a minimum, there should be two response levels, and three levels are recommended, for excessive IDs. The following would be an acceptable approach for three increasing levels of response actions with respect to physical inventories:

Warning-level ID

^{235}U ID ≥ 1.7(standard error of the inventory difference (SEID)) + 500 grams, or

U ID ≥ 1.7(SEID) + 10 kg U

Significant ID problem

U or ^{235}U ID ≥ 3(SEID)

Major ID problem

^{235}U ID ≥ DQ - 1.3(SEID)

All of the above limits are expressed in terms of absolute values of ID without regard for algebraic sign. The minimum response for a warning-level ID should be a documented licensee

investigation conducted by the MC&A organization. Such an investigation should provide a conclusion for the probable cause of the excessive ID and give recommendations for avoiding recurrences. When a warning-level ID is positive, it should be regarded as being equivalent to an indicator of a possible loss that requires investigation and resolution.

For a significant ID problem, an extensive investigation by the licensee should be conducted. If a significant ID problem cannot be satisfactorily explained, a reinventory may be needed.

For any unresolved ID determination that remains a major ID problem (without regard to algebraic sign), the licensee should conduct a plant-wide reinventory and investigation. The NRC considers a positive ID large enough to be a major ID problem as a very serious condition.

The MC&A plan should fully describe in definitive statements the minimum response actions for each ID action level.

7.7 Commitments and Acceptance Criteria

In its MC&A plan, the applicant or licensee should provide definitive commitments that adhere to the regulatory requirements and meet the acceptance criteria applicable to the physical inventories. A finding that the licensee's MC&A plan for conducting physical inventories is acceptable and in accordance with 10 CFR 74.31(c)(5), will be based on, but not limited to, the following acceptance criteria:

- An MC&A program will be maintained that is capable of confirming, at intervals not to exceed 370 calendar days, the presence of all SNM expected to be present (at a given time) based on accurate, current, and reliable information. The inventory must ensure that no SNM held under license will be omitted, and no quantity will be counted more than once.

- Unless otherwise required by Facility Attachments that satisfy 10 CFR Part 75, "Safeguards on Nuclear Material—Implementation of US/IAEA [International Atomic Energy Agency] Agreement," physical inventories will be performed at least every 370 calendar days and will be used as the basis for reconciling and adjusting the book inventory that is done within 60 calendar days after the start of each physical inventory.

- For each physical inventory, inventory procedures are clearly written and are reviewed and approved by the individual responsible for conducting the physical inventory.

- The individual responsible for conducting the physical inventory is either free from potential conflicts of interest or is overchecked sufficiently to prevent compromising the validity of the physical inventory.

- Each physical inventory listing will include all SNM possessed on the inventory date, except for waste materials assigned to holding accounts (in accordance with the exception provided in 10 CFR 74.31(c)(6) and DOE/NRC Form-741 instructions). All such listed SNM quantities are to be based on measurements, and no quantity will be counted more than once.

- Within 60 calendar days after the start of each physical inventory, the inventory difference (ID) will be determined. Any ID, which is rejected by a statistical test that has a 90 percent power of detecting a discrepancy of a quantity of ^{235}U that the NRC

established on a site-specific basis, will be reported to the appropriate NRC safeguards organizational units.

- Discrepancies in the identity, quantity or location of items, objects or containers of SNM that are detected during a physical inventory will be corrected.

- ID values will be corrected for (1) accounting adjustments resulting from prior period activity, and (2) significant biases that have not been previously taken into account. (Note: See the definition of significant bias in Chapter 4.)

- Adjustments made to reconcile the book inventory to the physical inventory are in accordance with standard accounting practices and are traceable and auditable in the MC&A records.

- Whenever a finalized ^{235}U ID (after applying any appropriate bias corrections and prior period adjustments) is greater than the ^{235}U detection threshold (DT) and is not resolved within the 60 calendar day reconciliation period, all SNM processing should be halted and a reinventory conducted. (Note: This applies to both positive and negative ID values.)

- The results of all physical inventories and of investigations and resolution actions following any excessive ^{235}U ID are recorded and auditable. An excessive ID is one (regardless of the algebraic sign) that exceeds both 3.00 times SEID and 9,000 grams ^{235}U.

- The MC&A plan contains adequate commitments to ensure that each physical inventory will be organized and coordinated so that all involved persons are instructed in the use of uniform procedures of checking SNM quantity and recording observations.

- The inventory procedures provide for confirming the presence of all items by direct observation and the presence of all quantities of SNM, that are neither encapsulated nor tamper-safed, by direct measurement or an acceptable alternative. The proposed alternatives to remeasurement should satisfy one of the following criteria:

  - The SNM content is verified by statistical sampling and measurement of representative items, objects, or samples of the material. The total overall sampling plan should support the capability for detecting any loss in excess of the current DQ with 90 percent (or better) probability.

  - The previous measurement results are accepted because the items are stored in a controlled access enclosure that provides protection equivalent to tamper-safing.

  - Residual holdup in significant amounts which remains after cleanout or draindown may be estimated if the estimate is based on previously measured values, and it is periodically verified or validated.

  - For material whose SNM content has been previously measured, and there is no likelihood of any significant change in the uranium concentration (or weight fraction) or in the uranium enrichment because of such factors as oxidation, change in moisture content, commingling with materials of different enrichment or different composition, etc., the previously determined uranium and ^{235}U content may be accepted without verification of SNM content, provided the gross weight or net weight of all items within

the population is confirmed by (1) a 100 percent reweighing of all such items, or (2) reweighing an adequate number of randomly selected items (based on a statistical sampling plan) to provide a 90 percent (or better) probability of detecting a loss equal to or greater than the current DQ

- As an additional alternative to remeasurement (of unsealed SNM) at physical inventory time, a program of routine process monitoring will be acceptable when the combination of the process monitoring program and the inventory procedures will achieve the same level of loss detection capability as that provided by a physical inventory in which all unencapsulated items are either tamper-safed or remeasured.

- Any previously measured, but unsealed (or unencapsulated) SNM that is on hand at the time of the physical inventory, and which is to be introduced into subsequent processing steps before inventory reconciliation should be remeasured or have its prior measurement value confirmed (by an acceptable alternative) before the subsequent processing is initiated.

- The DQ (in kilograms ^{235}U) for any given inventory period will be no greater than 1.30 percent of that period's throughput for facilities involved in chemical processing (such as UF_6 conversion, scrap recovery, oxidation or reduction processes, etc.), and no greater than 0.90 percent of throughput for facilities where material only undergoes physical changes (such as pressing UO2 powder into pellets or loading pellets into fuel rods), unless the 0.90 or 1.30 percent of throughput (as appropriate) is less than 25 kilograms ^{235}U, in which case the DQ need not be less than 25 kilograms. The ^{235}U throughput is defined as the greater of "additions to process" or "removals from process" during a 12-month inventory period.

- The MC&A plan should state that the DT for an excessive ID will result in a 90 percent (or better) probability of detecting a discrepancy (i.e., an apparent gain or loss) equal to or larger than the ^{235}U DQ for the inventory period in question. In general, a licensee may assume the ID distribution approximates a normal distribution, and therefore:

$$DT = DQ - 1.3(SEID)$$

- In general, a licensee may assume the ID distribution approximates a normal distribution. Acceptable methodology for calculating the measurement error contribution to the SEID by error propagation is found in NUREG-4604 (1988), TID-26298 (1973), and the IAEA statistics handbook (1989). Special attention is given to inclusion of all measurable sources of error to avoid underestimating the SEID.

- In addition to the DT ID alarm limit, there is at least one excessive ID warning level limit that when exceeded will require an investigative response action. The resources and level of effort to be committed to the investigation of an excessive ID will be proportional to the magnitude of the ID, but will be sufficient to reassess the results of the physical inventory, the accounting records, and the measurement control program data; to confirm the relevant calculations and data analysis; and when necessary, to carry out searches for unmeasured inventory such as residual holdup and measured discards. Investigations are to be completed within 60 days after initiating the inventory (except when the NRC grants additional time for extenuating circumstances).

8. ITEM CONTROL

8.0 Regulatory Intent

The intent of 10 CFR 74.31(c)(6) is to require licensees to establish, document, and maintain an item control system to protect against unauthorized and unrecorded removal of items, or of material from items, and to enable timely location of items. Items, as defined in 10 CFR 74.4, "Definitions," mean any discrete quantity or container of special nuclear material (SNM) or source material, not undergoing processing, having a unique identity and also having an assigned element and isotope quantity. Examples of items are known quantities of SNM in well-defined and uniquely identified containment such as cans, drums, and canisters, or fixed units such as fuel assemblies. Un-containerized solid SNM, such as uranium metal ingots or buttons, are also items if they are uniquely identified. To promptly locate a given item, sufficient current information must be recorded.

8.1 Organization

The material control and accounting (MC&A) plan should identify the individual responsible for overseeing the item control system by position title. Positions of those individuals who have significant item control system responsibilities also should be identified.

8.2 General Description

The applicant or licensee should state that the overall MC&A program maintains a record of all SNM items, regardless of quantity or duration of existence. In addition, the item control system should provide current knowledge of the location, identity, and quantity of all SNM contained in all items that are not excepted from the item control requirements. As stated in 10 CFR 74.31(c)(6), the following items are excepted from its requirements:

- containers of waste (designated for burial or incineration)
- containers of solution in which the ^{235}U concentration is less than 5.00 grams per liter.

All other items should be stored and handled in a manner that enables detection of, and provides protection against, unauthorized or unrecorded removals of SNM. All items, whether or not they are subject to item control system coverage, should have a unique identity. For items subject to the item control system, the following are acceptable ways to provide unique identity:

- a unique alpha-numeric identification on a tamper-indicating device (TID) applied to an SNM container

- a unique alpha-numeric identification permanently inscribed, embossed, or stamped on the container or item itself

- a uniquely prenumbered (or bar-coded) label applied to each item that has good adhesive qualities such that its removal from an item would preclude reuse of the label

Location designations that the MC&A records show need not be unique, but location designations should be specific enough so that any item may be located within 1 hour. Longer times may be acceptable but should be further justified in the MC&A plan. The MC&A record

system should be controlled in such a way that the record of an item's existence cannot be destroyed or falsified without a high probability of detection. Each nonexempt item should be stored and handled in a manner that enables detection of, and provides protection against, unauthorized or unrecorded removals of SNM.

8.3 Item Identity Controls

Descriptions should be provided of the item records showing how items are identified for each material type and each type of container. If the unique number on a TID is the basis for providing the unique item identity, the MC&A plan should:

- describe the type of TID used
- describe how the TIDs are obtained and what measures are carried out to ensure that duplicate (counterfeit) TIDs are not manufactured
- describe how the TIDs are stored, controlled, issued, and accounted for
- describe how TID usage and disposal records are maintained and controlled

Similar information should be provided for other methods of unique item identity (e.g., labels).

8.4 Storage Controls

Item storage areas and controls should be fully described in the MC&A plan. In particular, controls that are used as the basis for ensuring the values of prior measurements, as opposed to remeasuring the item at inventory time, should be discussed in detail and the rationale for accepting prior measurements explained. Any controls used to ensure the validity of prior measurements should be equivalent to the protection provided by tamper-safing, which is defined by 10 CFR 74.4 as the use of devices on containers or vaults in a manner and at a time that ensures a clear indication of any violation of the integrity of previously made measurements of the SNM in the container or vault.

Both administrative controls (e.g., custodian assignments and limiting authorized access to storage areas) and physical controls (e.g., locked or alarmed doors) should be identified.

8.5 Item Monitoring Methodology and Procedures

As part of the item control system, a licensee should maintain a system of item monitoring that:

- verifies that items shown in the MC&A records are actually stored and identified in the manner indicated in the records
- verifies that generated items and changes in item locations are properly recorded in the MC&A record system in a timely manner
- can detect, with high probability, any real loss of items, or uranium from items

The item monitoring system should conduct the following activities at least monthly:

- for each item inventory stratum, compare the actual storage status to the recorded status of a sufficient sample of randomly selected items from the item control system records

- for each item inventory stratum, check the accuracy of the MC&A records for a sufficient sample of randomly selected items from each storage area

- check the accuracy of a sufficient sample of randomly selected production records of created and consumed items

The actual frequency of the above activities, and the size of the random sample, should be a function of the expected discrepancy rate based on prior observations. The MC&A plan should specify (1) minimum monitoring frequencies associated with each storage area, (2) discrepancy rates that trigger more frequent monitoring frequencies, and (3) commitments for resolving discrepancies.

8.6 Investigation and Resolution of Item Discrepancies

The applicant or licensee should provide definitive statements of the procedures and controls that will ensure that all incidents involving missing or compromised items or falsified item records will be investigated. A compromised item is (1) one displaying evidence of tampering or (2) an unencapsulated and unsealed item assigned to a controlled, limited-access storage area that is found elsewhere.

If any unencapsulated and unsealed item is located after having been determined to be missing, or if an item is found to be compromised, its contents should be reestablished by measurement (e.g., by NDA or by weighing, sampling, and analysis). Recommendations on resolution of indicators (Chapter 11) of this document should be used to resolve item discrepancies.

8.7 Commitments and Acceptance Criteria

In its MC&A plan, the licensee should provide definitive commitments that adhere to the regulatory requirements and meet the acceptance criteria applicable to maintaining current knowledge of items and detecting unauthorized removals. A finding that the licensee's MC&A plan for the item control system is acceptable and in accordance with 10 CFR 74.31(c)(6), will be based on, but not limited to, the following acceptance criteria:

- The licensee's item record system uniquely identifies items. The records include information on the chemical form, quantity of material (element and isotope), physical description, identification label or number, and location. The system provides reasonable assurance of detecting falsification or destruction of records of an item's existence. Groups of items that are produced, stored, processed, or otherwise handled together as a unit, such as a batch or sublot of material, may be uniquely identified and stored as a separate group under conditions such that group identity, composition, and quantity will be maintained constant.

- The record of the status of an item can be completed or updated in sufficient time to allow the licensee to meet the requirements for promptly locating an item.

- For items that will not be remeasured at inventory time, the item control procedures provide reasonable assurance that the SNM contents stated in the records are valid and that unauthorized removal of SNM from the item has not occurred. Remeasurement is not necessary if the SNM content of the item was measured previously and reasonable assurance is provided that the SNM content has not subsequently changed.

- Items that are excepted from the 10 CFR 74.31(c)(6) item control requirements fall into one of the following categories:

  – Waste destined for burial or incineration;

  – Solutions having less than a 5.00 grams ^{235}U per liter concentration;

- A current accounting is maintained of the total quantity of SNM contained in items that are exempted from item control. The accounts identify the quantities by material type category for both controlled and exempted items.

- For items that are subject to the 10 CFR 74.31(c)(6) item control requirements, a record system will be maintained to provide knowledge of the current status of such items' identity, uranium and ^{235}U content, and stored location. For items subject to this commitment, the item control and records system provides the capability to promptly locate and confirm the existence of any specific item or group of items upon demand. The item record system is secured so that the record of an item's existence cannot be destroyed or falsified by a single individual without a very high probability of detection.

- Each item subject to the 10 CFR 74.31(c)(6) item control requirements will be stored and handled in a manner that enables detection of or provides protection against unauthorized or unrecorded removals of SNM; knowledge of the SNM content is otherwise ensured by tamper-safing or maintaining the item as a sealed source (i.e., as encapsulated material).

- All incidents involving missing or compromised items or falsified item records will be investigated. A compromised item is one for which there is evidence of tampering or one that is found outside its assigned controlled access area.

- The contents of a compromised item or an unsealed, unencapsulated item located after it has been missing will be predetermined by measurements (e.g., by nondestructive assay (NDA) or by weighing, sampling, and analysis).

9. SHIPPER-RECEIVER COMPARISONS

9.0 Regulatory Intent

The intent of 10 CFR 74.31 (c)(7) is to require the licensee to conduct and document shipper-receiver comparisons for all special nuclear material (SNM) receipts, on a total shipment basis, and on an individual batch basis when required by 10 CFR Part 75, and ensure that any shipper-receiver difference (SRD) that is statistically significant and exceeds twice the estimated standard deviation of the difference estimator and 500 grams of ^{235}U, is investigated and resolved.

9.1 Receiving Procedures

On receipt of SNM, the first action should be to verify the number of items, the item identities, and the integrity of individual items and of tamper-indicating devices (TIDs). All SNM shipments received from an external supplier are to be subject to shipper-receiver comparisons. Such comparisons involve measurement of received material by the receiver, or by the receiver's contractor (who is independent of the shipper), and comparing receiver's total receipt measurement for element and isotope to that of the shipper's.

Previously, in approving material control and accounting (MC&A) plans, the U.S. Nuclear Regulatory Commission (NRC) staff has recognized situations in which the cost of conducting and documenting shipper-receiver comparisons outweighs the safety benefit of doing so, and has accordingly granted relief in the form of exemptions notwithstanding the 10 CFR 74.31(c)(7) provision that the requirement applies to "all SNM receipts." Examples of situations in which such relief has been granted are:

- shipments containing less than 500 grams of ^{235}U
- individual items containing less than 50 grams ^{235}U
- encapsulated items, whose encapsulation integrity has not been compromised, and which the licensee is to retain as encapsulated items
- fuel assemblies and fuel rods that the licensee previously shipped and that are being returned, provided that the original encapsulation has not been compromised
- UF_6 cylinders that are empty except for a heel quantity of UF_6
- Heterogeneous scrap that must be subject to dissolution before a meaningful accountability measurement can be obtained. Both shipper and receiver should agree to accept the "after dissolution plus residue" measurements for accounting purposes.

In the future, should licensees seek similar relief from the 10 CFR 74.31(c)(7) requirements, specific exemption requests will need to be submitted in accordance with 10 CFR 74.7, "Specific Exemptions." Whether granting such exemption requests are authorized by law and will not endanger life or property or the common defense and security, and are otherwise in the public interest, will be determined on a case-by-case basis.

For any SNM received, the licensee must provide all appropriate information on the U.S. Department of Energy (DOE)/NRC Form 741 that accompanies the shipment, in

accordance with 10 CFR 74.15, "Nuclear Material Transaction Reports." (Note: See NUREG/BR-0006, "Instructions for Completing Nuclear Material Transfer Reports (DOE/NRC Forms 741 and 740M)," for instructions and requirements for completing DOE/NRC Form 741.)

9.2 Determination of Receiver's Values

For UF_6, the licensee may establish receiver's values by (1) measuring the ^{235}U isotopic concentration by nondestructive assay (NDA), (2) weighing each cylinder to determine net weight UF_6 (gross weight minus certified cylinder tare weight), and (3) applying an historical established percent uranium factor (that is periodically confirmed or updated by measurement). This practice avoids the need to sample UF_6 cylinders and analyze the samples (except when obtaining data to establish or update the historical percent U factor). However, it is more desirable and common practice to derive UF_6 receipt values based on the measurement of UF_6 samples. Arrangements usually can be made with the UF_6 supplier to provide samples of the shipped UF_6. The receiving facility should have an agent (who is independent of the shipper) witness the sampling (that represents the UF_6 contained in the cylinder(s) to be shipped), apply a tamper-indicating seal to the sample, and verify the unique identity of the filled cylinder.

SNM receipts not in the form of UF_6 should be measured for total quantity (mass), element concentration, and isotope abundance, as opposed to using a historical factor for deriving element content.

The validity of the shipper's data should be substantiated with appropriate and timely receiver checks and measurements, including gross weight, adequate sampling techniques, NDA measurements (if appropriate), and destructive measurements (scrap excepted). (See Chapter 4 on measurements.) Shipper's values may be accepted and booked without receiver element or isotope measurements for encapsulated items, such as fuel elements or rods, if NDA measurement is not feasible.

9.3 Evaluation of Shipper-Receiver Differences

When shipper's measurement uncertainty (or standard error) information is available, the following should define the estimated standard deviation of the difference estimator or combined standard error:

combined standard error =

where

= shipper's measurement standard error

= receiver's measurement standard error

If the shipper's measurement uncertainty values are not available, the receiver can assume that the shipper's measurement uncertainty is equal to (but no greater than) its own uncertainty. In this situation (i.e., both shipper and receiver have the same measurement uncertainty), the following becomes the combined measurement standard error:

combined standard error =

= 1.414

The difference between the shipper's value and the receiver's value (i.e., the SRD), in terms of the total shipment, must be considered significant whenever the SRD exceeds both 500 grams of ^{235}U and twice the combined standard error. If subject to 10 CFR Part 75 (international safeguards), a SRD in excess of both 500 grams ^{235}U and twice the combined standard error in a single batch within the shipment also must be regarded as significant.

9.4 Resolution of Significant Shipper-Receiver Differences

The MC&A plan should describe the steps involved in investigating a significant SRD and discuss how such difference is resolved. The criteria for defining a resolved SRD also should be presented. Generally, resolution of a significant SRD involves a referee (or umpire) measurement of a retainer sample(s) but not of the material weight. The resolution process should specify whose weight value is used in the resolution process if the shipper's and receiver's weights differ by more than one-half of the total combined standard error.

9.5 Commitments and Acceptance Criteria

In its MC&A plan, the licensee should provide definitive commitments that adhere to the regulatory requirements and meet the acceptance criteria applicable to shipper-receiver comparisons. A finding that the licensee's MC&A plan for conducting SRD evaluations and resolving significant SRDs is acceptable and in accordance with 10 CFR 74.31(c)(7), will be based on, but not limited to, the following acceptance criteria:

- Each shipping container is inspected within 5 working days after receipt for loss or damage to the container or TIDs to determine if SNM could have been removed. If the integrity of a container is questionable, the presence of all items that were packaged in the shipping container will be confirmed within 24 hours of discovering the questionable integrity. Only acceptable tamper-safing methods will be used as described in Section 11.1 of this document and as agreed to with the receiver.

- The receiver performs confirmatory measurements of scrap shipments to determine the amount of element and isotope within a time period consistent with the accountability needs of the shipper.

- The test for significance of an SRD is based on statistical tests.

- The investigation procedure for significant SRDs is sufficiently comprehensive to ensure that the difference will be resolved. Comprehensiveness is sufficient if the licensee shows the capability to verify records, resample, perform remeasurements, establish liaison with the shipper, provide samples to a referee laboratory, and perform the

statistical analysis needed to evaluate the measurements. Investigation and resolution should be completed within 90 days of material receipt.

- Measurements of the quantity of SNM received in each shipment will be performed and the SRF will be tested for statistical significance. The element and isotope content of SNM shipped or received by the licensee are based on measurement systems subject to measurement control. Occurrences of significant SRDs in excess of 500 grams ^{235}U and missing items will be reported promptly to the shipper.

- Measurement results for shipments and receipts will be corrected for biases that are significant at the 0.05 level (i.e., for any bias that exceeds two times the standard error associated with a mean), and which affect individual items by more than their rounding error in terms of ^{235}U or uranium content.

- For SNM received, SRDs that are statistically significant and also greater than 500 grams ^{235}U, on a total shipment basis (and also on a batch basis when subject to 10 CFR Part 75), will be detected within 30 calendar days of receipt.

- The documentation of shipments and receipts should be completed and transmitted within the timeframe specified in NUREG/BR-0006.

10. ASSESSMENT AND REVIEW OF THE MATERIAL CONTROL AND ACCOUNTING PROGRAM

10.0 Regulatory Intent

The intent of 10 CFR 74.31(c)(8) is to require independent assessments of the MC&A program. Licensee management must periodically (at least every 24 months) review and assess the performance of the material control and accounting (MC&A) program, evaluate its effectiveness, and document management's action on prior assessment recommendations and any identified deficiencies. It is intended that the review will be performed by knowledgeable, technically competent individuals free from conflicts of interest. Further, the deficiencies will be brought to the attention of plant management so that the deficiencies will be corrected. It should be emphasized that this review process is intended to be much more than a routine audit for compliance with existing procedures and commitments. Conclusions and recommendations relative to overall program effectiveness and to the adequacy of the program—including that of any contractor that performs MC&A measurements on the licensee's behalf—must be made.

10.1 General Description

The capabilities, performance, and overall effectiveness of the licensee's MC&A program should be independently reviewed and assessed at least every 24 months. The MC&A plan should describe the assessment and review program in terms of:

- maximum interval between assessments
- selection procedures for the assessment team
- number of team members to be selected
- qualification and expertise of team members
- independence of individual team members from the MC&A responsibilities and activities they are reviewing and assessing
- maximum elapsed time and minimum actual effort to be used for completion of the assessment and issuance of a final team report

The entire MC&A program generally should be reviewed and evaluated during each assessment. When this occurs, intervals between assessments can be as much as 24 calendar months. However, if individual assessments only cover part of the MC&A program, individual subsystems should be assessed at intervals no greater than 12 calendar months. The schedule should ensure the entire program is reviewed over the course of 24 calendar months. Thus, the type of assessment (partial or total) and the maximum interval between assessments should be specified in the MC&A plan. "Interval" means the elapsed time between either the start of or termination of successive assessments.

The responsibility and authority for the assessment program should lie at least one level higher in the licensee's organizational structure than that of the MC&A manager. Such responsibility should include selecting the assessment team leader and initiating corrective actions. Team

members may be selected from the facility staff or from outside, but an individual member should not participate in the assessment of the parts of the MC&A program for which that person has direct responsibility. Hence, the MC&A manager may not be a team member. Also, a given individual should not assess the parts of the program that are the responsibility of another team member if the other team member is assessing the given individual's area. The leader of the assessment team should have no responsibilities for managing any of the MC&A elements being assessed.

The minimum number of individuals on any given assessment should depend on the knowledge and expertise of the team relative to MC&A activities and their experience in conducting assessments. Personnel assigned to the assessment team should have a demonstrated understanding of the regulatory objectives and requirements of the MC&A program and should have sufficient knowledge and experience to be able to judge the adequacy of the parts of the program they review. The team should have authority to investigate all aspects of the MC&A program and should be given access to all necessary information.

To provide a meaningful and timely assessment, the review and evaluation process should not be protracted. The actual review and investigation activities should be completed in 30 calendar days, with an additional 15 calendar days allowed for completing and issuing a final team report.

10.2 Report of Findings and Recommendations

The areas to be reviewed should encompass the entire MC&A program, and the level of detail of the reviews should be sufficient to ensure that the assessment team has adequate information to make reasoned judgments of the program's effectiveness. The team report, as a minimum, should state findings pertaining to:

- organizational effectiveness to manage and execute MC&A activities
- management responsiveness to indications of possible losses of uranium
- staff training and competency to carry out MC&A functions
- reliability and accuracy of accountability measurements made on special nuclear material (SNM)
- effectiveness of the measurement control system in monitoring measurement systems and its sufficiency to meet the requirements for controlling and estimating both bias and the standard error of the inventory difference (SEID)
- soundness of the material accounting records
- effectiveness of the item control system to track and provide current knowledge of items
- capability to promptly locate items and effectiveness in doing so
- timeliness and effectiveness of SRD evaluations and resolution of excessive SRDs
- soundness and effectiveness of the inventory-taking procedures

- capability to confirm the presence of SNM
- capability to detect and resolve indications of missing uranium

On completion of each assessment, the findings and recommendations for corrective action, if any, should be documented. The written report should be distributed to the plant manager, the MC&A manager, and other managers that the assessment affects.

10.3 Management Review and Response to Report Findings and Recommendations

Management should review the assessment report and take the necessary actions to correct MC&A program deficiencies. The management review should be documented within 30 calendar days following the submittal of the assessment team's report, and it should include a schedule for the correction of deficiencies. Corrective actions, if any, that pertain to daily or weekly activities should be initiated promptly after the submittal of the final assessment report.

The MC&A plan should address resolution and followup actions associated with concerns identified in the assessment report. The individuals responsible for resolving identified concerns, and the timeliness of such resolution, should be specified.

10.4 Commitments and Acceptance Criteria

In its MC&A plan, the licensee should provide definitive commitments that adhere to the regulatory requirements and meet the acceptance criteria applicable to independent assessments of the MC&A program. A finding that the licensee's MC&A plan for such assessments is acceptable and in accordance with 10 CFR 74.31(c)(8), will be based on, but not limited to, the following acceptance criteria:

- The capabilities and performance of the MC&A program will be reviewed and its effectiveness will be independently assessed at least every 24 months. That is, the nominal elapsed time from the completion of one review or assessment to the completion of the next will not exceed 24 calendar months.
- The periodic assessments will be comprehensive and sufficiently detailed to enable the assessment team to rate the MC&A program effectiveness, capability, and performance by comparison with the expected and required performance. The overall assessment objectives are to determine that the MC&A program, as designed and implemented, is continuing to meet the overall safeguards goals, and to identify weaknesses or deficiencies in the program design or performance that may need correcting.
- The areas to be reviewed encompass the entire MC&A program and the level of detail of the reviews is sufficient to ensure that the assessment team has adequate information to make reasoned judgments of the MC&A program effectiveness, which includes:
    - Organizational effectiveness and management responsiveness to indicators of possible SNM losses
    - Staff training and competency to carry out MC&A functions
    - Soundness of the material accounting records

- Capability to promptly locate items
- Timeliness and effectiveness of SRD evaluations and resolution of significant SRDs
- Soundness of physical inventory procedures and practices
- Effectiveness of the measurement control system to monitor key measurement systems, establish bias estimates and measurement uncertainties, and meet the requirements for controlling the total MC&A measurement uncertainty associated with ID
- Capability to confirm the presence of SNM
- Capability to resolve indications of missing SNM and aid in any government-led investigation pertaining to missing SNM, and provide information that would aid in the recovery of missing SNM

- Generally accepted auditing principles are used to check each type of record in which a representative sample (of a sufficient number) of randomly selected records is examined

- Qualified individuals from outside or qualified individuals from inside the facility organization whose work assignments and positions within the organization will not impair their ability to make objective judgments of the MC&A program capabilities and performance perform the reviews and assessments. Personnel assigned to the assessment team will have an adequate understanding of the regulatory objectives and requirements of the MC&A program and will have sufficient knowledge and experience to be able to judge the adequacy of the parts of the program they are asked to review. The team will have authority to investigate any aspect of the MC&A program and will have access to all relevant information.

- An individual team member will not participate in the assessment of any part of the MC&A program for which he or she has direct responsibility. Also, an individual “A” will not assess any part of the program that is the responsibility of person “B” if “B” is assessing an area under the responsibility of “A.”

- The entire MC&A program will be reviewed and evaluated during each single assessment (to be completed within an elapsed time that is short relative to the time between changes in the MC&A program and is demonstrated to be able to include any such changes made during the review or assessment). Conducting two or more assessments during a 24-month interval, in which only part of the MC&A program is covered in each, is not deemed acceptable. That is, reviewing a single component of the MC&A program at 24-month intervals is not very meaningful unless knowledge is obtained of how well the other components currently interact. Piecemeal review and evaluation is permissible, however, if each subsystem is covered at 12-month (or less) intervals.

- The leader of the assessment team will have no responsibilities for performing or managing the functions being assessed. The assessment team leader will have no responsibility for managing or performing any of the MC&A functions.

- The responsibility and authority for the assessment program and for initiating corrective

actions will lie: (1) at least one level higher in the organization than the MC&A Manager, or (2) at a level equal to that of the onsite plant manager.

- Each overall review and assessment will be conducted and completed in a time frame that is short (e.g., a week) with respect to the time for changes that have occurred in the MC&A program, and will include any such changes made during the time the review or assessment is being conducted.

- The completion date for any review or assessment is defined as the date when the team submits its final written report (of findings and recommendations) to plant management. The start date is the first day in which one or more team members actually inspect records or interview MC&A personnel, and such start date will be documented.

- The results of the assessment and recommendations for corrective action, if any, will be documented and reported to the plant manager and other managers that the assessment affects. Management will review the assessment report and take the necessary actions to correct MC&A program deficiencies. Such corrective actions (if any) that pertain to daily or weekly activities will be initiated within 40 calendar days after the submittal of the review or assessment final report.

- Management's response to recommendations from the review and assessment, including any corrective actions that management ordered, and the expected time frame for completing such actions, will be documented within 30 calendar days following the submittal of the team's report.

11. TAMPER-SAFING

11.0 Regulatory Intent

The intent of 10 CFR 74.31(c)(9) is to require licensees to maintain and follow tamper-safing procedures for special nuclear material (SNM) containers and vaults, including controlling access to, and distribution of, unused seals and records. The purpose of such procedures is to document the distribution, application, and destruction of tamper-safing devices, as well as routine inventory of unused tamper-safing devices. Records are to be retained for at least 3 years (or longer if specifically required by regulations external to 10 CFR 74.31) thereby providing a way to assess the performance of the tamper-safing program and inspect for compliance with regulatory requirements.

11.1 Characteristics of Tamper-safing Devices

Tamper-safing devices on containers or vaults are used to secure the integrity of SNM either when it is in transit or stored on site. The objective of tamper-indicating devices (TIDs) is to ensure that no tampering or entry has occurred while the TID is on the container. Therefore, for MC&A purposes, the degree of confidence in the selection of a TID sealing system will vary depending on its unique characteristics and intended use.

When selecting tamper-safing devices, licensees should consider the following:

- Intended use–the determination that the TID is appropriate for tamper-safing the container and withstanding the working environment, (i.e., temperature, moisture, repeated handling).
- Application–the relative ease or difficulty of physically applying the TID.
- Substitution–the ability of a TID to be destructively removed and replaced by a new TID without detection.
- Removal and reapplication–the ability of a TID to be removed and reapplied without detection.
- Alteration of label data–the ability to alter recorded data on the TID without the alteration being apparent.
- Integrity verification–the degree of effort required to verify the TID is intact or indicates tampering.

The licensee should confirm manufacturer claims that the removal of a TID is not possible without detection by testing potential TIDs to see if they can be removed from the containers on which they are to be used. The licensee should confirm the results using the manufacturer's documented procedures and the samples used. The experiments should be documented, both with regard to what techniques were used to attempt to defeat the TID and observations as to the degree of success in defeating the TID. In lieu of licensee testing, similar tests that an independent third party conducted may be considered acceptable.

11.2 Use of Tamper-safing Devices

The MC&A plan may allow the use of tamper-safing devices to:

- Ensure the long-term validity of measurement data—the application of a TID to an item containing measured quantities of nuclear materials may allow the licensee to maintain the validity of the original measured value, thus eliminating or decreasing the frequency of the need to remeasure the items to verify its nuclear material content.

- Reduce the effort to conduct physical inventories or item control activities—the application of a TID to a container housing multiple items may allow the licensee to maintain the validity of container's contents, thus minimizing the number of items required to be verified during a physical inventory or item control activity.

- Provide assurance of integrity of in-transit material—the application of a TID to a shipping container may allow the licensee to maintain the validity of a shipping container's contents and ensure that the integrity of the shipment has not been violated. To achieve this goal, the shipper should apply the TID(s) to the shipping container, verify the integrity of the TID(s) shortly before departure of the shipment, and provide the appropriate information (i.e., shipping container serial numbers, TID(s) type(s), and serial number(s)) to the receiver. Upon receipt of the shipment, the receiver should verify the shipping container serial numbers, TID(s) type(s), serial number(s), and the TID(s) integrity. Any discrepancies should be considered an MC&A anomaly and be addressed by the facility's MC&A resolution program.

11.3 Description of Tamper-safing Records

The tamper-safing system should identify all records, forms, reports, and standard operating procedures used throughout the system. Such records should include, but are not limited to, the following:

- receipt of purchased TIDs

- issuance of TIDs

- identification of the person applying the TIDs

- identification of the person who verified the application of the TID

- identification of the container to which the TID was applied, including the TIDs serial identification (if applicable)

- removal and destruction of TIDs

- routine inventory of unused and unissued TIDs

- identification of roles and responsibilities, including:

- designation of the TID control officer(s)

- personnel approved to apply, verify, and destroy TIDs

- training of personnel in the application, verification and destruction of TIDs

11.4 Commitments and Acceptance Criteria

The acceptability of a TID is based on an evaluation of the attributes of the device in relation to time to defeat the tamper-indicating features. TIDs that the U.S. Nuclear Regulatory Commission (NRC) already deems acceptable include: Type E, pressure-sensitive, tamper-evident wire seals, fiber optic seals and steel padlocks. Other tamper-safing devices may be equally acceptable. Licensees proposing to use TIDs not currently approved by the NRC must provide the appropriate information, including references, to enable licensing reviewers to assess the adequacy of the proposed TID type.

In its MC&A plan, the licensee should provide definitive commitments that adhere to the regulatory requirements and meet the acceptance criteria applicable to the use of tamper-safing devices. A finding that the licensee's MC&A plan for tamper-safing is acceptable and in accordance with 10 CFR 74.31(c)(9), will be based on, but not limited to, the following acceptance criteria:

- Only TIDs that are controlled and accounted for will be used to maintain the validity of previously established SNM quantities associated with items.

- Written procedures will be maintained to ensure that individuals authorized to handle TIDs are properly trained.

- Preferably a single individual, but no more than three individuals, none of whom have any responsibility for seal application or destruction, is (are) designated as the TID control officer(s).

- Only individuals authorized for that purpose will apply and remove TIDs.

- Unused TIDs will be controlled and inventoried. Unissued TIDs are stored in a locked container within a room that is locked when unoccupied or in an approved repository. Blocks of TIDs issued to designated individuals are stored in a locked container within a room that is locked when unoccupied or in an approved repository.

- When TIDs are not in storage they are in the possession of authorized individuals (i.e., the TID control officer or person responsible for applying the TID). As a rule, the number of available TIDs issued to these individuals should be limited to a single day's use.

- The licensee has in his possession a commitment from the seal manufacturer that plates and/or dies and production residuals are controlled and protected, and

- Upon removal, TIDs are destroyed (i.e., crimped, flattened, or otherwise rendered unusable) and properly disposed.

- Records of TID application, verification, removal, and destruction will be documented, and control measures will be implemented to prevent alteration of records for containers protected by TIDs.

12. DESIGNATION OF MATERIAL BALANCE AREAS, ITEM CONTROL AREAS, AND CUSTODIANS

12.0 Regulatory Intent

The intent of 10 CFR 74.31(c)(10) is to ensure that the material balance areas (MBAs) and item control areas (ICAs) that licensees designate will enable them to identify inventory differences (IDs) and item locations on a scale smaller than that of the entire plant. Regulations in 10 CFR 74.31(c)(10) require licensees to designate MBAs and ICAs and assign custodial responsibilities for these areas, and to provide internal controls to deter or detect any diversion or misuse of special nuclear material (SNM) at the licensee's facility.

12.1 Material Control Boundaries

The MC&A plan should describe how the licensee establishes various material control boundaries to minimize the occurrence of, and facilitate resolution of, MC&A anomalies. Examples of such anomalies are inventory differences (IDs), missing SNM items, and potential theft or diversion of SNM.

Because MBAs and ICAs are important foundations for controlling and accounting for all SNM in a facility, the MC&A plan should describe the process for how their locations are chosen. An MBA or ICA should correlate to physical or administrative boundaries and monitored locations. The MBA or ICA should be designed to limit losses to a specific area (i.e., the MBA should not be so large that the licensee cannot localize inventory or process differences to a manageable level). Materials transferred into and out of an MBA or ICA must be subject to quantitative measurements, as specified in the definitions of MBAs and ICAs in 10 CFR 74.4, "Definitions."

12.2 Custodians

The MC&A plan should describe the roles and responsibilities of the custodians for MBAs and ICAs. Each custodian should have direct interaction with the MC&A organization, and such individuals should be located within the physical operations area. Custodians who are responsible for more than one MBA or ICA should not have the authority to make material transfers between MBAs or ICAs that are both under their direct control.

12.3 Commitments and Acceptance Criteria

In its MC&A plan, the licensee should provide definitive commitments that adhere to the regulatory requirements and meet the acceptance criteria applicable to the designation of MBAs, ICAs, and custodians. A finding that the licensee's MC&A plan for designating MBAs, ICAs, and custodians is acceptable and in accordance with 10 CFR 74.31(c)(10), will be based on, but not limited to the following acceptance criteria:

- MBAs and ICAs should have defined physical and administratively controlled areas that allow for the physical and administrative control of nuclear materials such that the quantity of nuclear materials being moved into or out of the MBA is a measurement-based assigned value for element and isotope contents.

- MBAs and ICAs are established in such a way as to minimize the occurrence of, and facilitate the resolution of, MC&A anomalies.

- MBA and ICA structures are properly documented and clearly described, including physical boundaries and categories of material in the individual MBA or ICA.
- Custodial responsibilities are assigned for each designated MBA and ICA.
- Custodians responsible for more than one MBA or ICA are not authorized to transfer material between MBAs and ICAs under their control.

13. RESOLVING INDICATIONS OF LOSS, THEFT, DIVERSION, OR MISUSE OF SPECIAL NUCLEAR MATERIAL

13.0 Regulatory Intent

The intent of the 10 CFR 74.3(b) and (c) general performance objectives is for licensees to be able to promptly investigate and resolve any indications of a possible loss, theft, diversion or misuse of special nuclear material (SNM), whether arising from errors or deliberate actions.

13.1 Methods and Procedures for Identifying Indicators

The material control and accounting (MC&A) plan should discuss the way that the licensee will resolve indicators of a possible loss, theft, diversion or misuse of SNM. The licensee's resolution program should address the possible indicators of missing uranium. The MC&A plan should enumerate all the potential indicators that can be postulated and develop resolution procedures for each. Any anomaly could potentially be an indicator of loss, theft, diversion, or misuse of SNM. An anomaly is an unusual observable condition (such as excessive discrepancies, missing items, broken tamper-indicating devices (TIDs), or other possible indicators) that might result from theft, diversion, or other misuse of SNM. The terms "indicator" and "anomaly" may be used interchangeably to describe a condition that may require further investigation to determine if an actual loss, theft, diversion, or misuse of SNM occurred.

The following are examples of possible indicators of missing SNM:

- lack of agreement between a physical inventory and its associated book inventory in which the ^{235}U inventory difference (ID) is positive and exceeds 1.7 times the standard error of the inventory difference (SEID) by more than 500 grams
- determination through the item control system that one or more items are not in their designated locations and the actual locations are not immediately known
- discovery that an item's integrity or its TID was compromised
- information from the process control system indicating potential loss of material from the process system
- an allegation of theft or diversion

13.2 System and Procedures for Investigating and Resolving Loss Indicators

One or more MC&A procedures should address the system and practices for investigating and resolving loss indicators. The licensee should have well-defined procedures for promptly investigating and resolving indications of possible missing SNM, and procedures for rapidly determining whether an actual loss of SNM has occurred. These procedures should include criteria for determining when an investigation of loss indicators can be concluded.

Resolving a loss indicator means that the licensee has made a determination that loss, including possible diversion or theft, has not occurred and is not occurring. For each type of indicator, the licensee should develop detailed resolution procedures and should describe or outline them in the MC&A plan.

Any investigation of an indication of a loss or theft should provide, whenever possible, (1) an estimate of the quantity of SNM involved, (2) the material type or physical form of the material, (3) the type of unauthorized activity or event detected, (4) the time frame within which the loss or activity could have occurred, (5) the most probable cause(s), and (6) recommendations for precluding reoccurrence.

For indications that a loss or theft may have occurred, the resolution process should include (1) thoroughly checking the accountability records and source information, (2) locating the source of the problem, (3) isolating the exact reason for the problem within the area or processing unit, (4) determining the amounts of SNM involved, and (5) making a determination that the indication is or is not resolved. The resolution procedures should be prepared in such a way that no individual that could have been responsible for the potential loss also would be responsible for its resolution. If an investigation of an indicator results in a conclusion that the indication is true, such conclusion must be reported to the U.S. Nuclear Regulatory Commission (NRC) within 1 hour of its determination in accordance with 10 CFR 74.11, "Reports of Loss or Theft or Attempted Theft or Unauthorized Production of Special Nuclear Material." The MC&A plan should specify the time allowed for resolution. In general, a time not exceeding 72 hours should be adequate.

13.3 Response Actions for Unresolved Indicators

Response actions to unresolved indicators should be clearly defined and on a graded scale appropriate to the level of potential safeguards significance. The responsibility and authority for initiating and executing such escalating levels of response actions also should be defined.

For indicators of missing SNM, the level of safeguards concern is related to such factors as:

- the potential quantity of ^{235}U involved
- the material attractiveness of the potential missing uranium (in terms of fabricating a nuclear explosive device) relative to its enrichment and composition or form (e.g., U metal, U_3O_8, uranyl nitrate solution, UF_6, scrap, or waste)

13.4 Documentation Requirements

The MC&A plan should identify all documentation requirements associated with the licensee's program for the reporting, investigation, and resolution of missing SNM indicators. Review and approval requirements and document custodial responsibility also should be defined. As a minimum, documentation of the following should be included:

- investigation procedures
- resolution procedures
- reporting of the indicator to MC&A management, including date and time the indicator was reported, name of individual who discovered the indicator, and description of indication

- investigation findings and conclusion, including resolution status, date issued, name and signature of principal investigator, and approval signature of MC&A manager

- reports made to the NRC for unresolved indicators and for indicators determined to be real, including date and time the report was made, method of communication, and name of the NRC individual contacted.

Additional types of information that may be necessary are described in Section 14.3 of this document.

13.5 Commitments and Acceptance Criteria

In its MC&A plan, the licensee should provide definitive commitments that adhere to regulatory requirements and meet the acceptance criteria applicable to investigating and resolving anomalies indicating possible SNM misuse. A finding that the licensee's MC&A plan for resolving indications of loss, theft, diversion, or misuse of SNM is acceptable and in accordance with 10 CFR 74.3(b) and (c), will be based on, but not limited to the following acceptance criteria:

- Adequate commitments are provided to ensure a high probability that any indicator of missing SNM will be (1) recognized as an indicator, (2) investigated, and (3) resolved.

- The licensee will conduct a prompt investigation for all indications of possible loss, theft, diversion, or misuse of SNM.

- A cause or probable cause that is based on objective evidence will be assigned to each indication of possible loss that the licensee investigates.

- Investigation and resolution procedures will provide for adequate overchecks to ensure that no individual who could have been responsible for a possible loss or theft of SNM would be the sole or primary individual responsible for resolving the indicator.

- No investigation relative to an indication of an SNM loss or theft exceeding the current detection quantity (DQ) should be declared as completed but unresolved without first conducting a shutdown, cleanout inventory in which all unsealed SNM is remeasured for element and isotope.

- The licensee will report the results of all investigations of alleged thefts, and any indications of a loss of SNM that remains unresolved after 30 calendar days, to the appropriate NRC MC&A licensing authority.

14. INFORMATIONAL AID FOR ASSISTING IN THE INVESTIGATION AND RECOVERY OF MISSING SPECIAL NUCLEAR MATERIAL

14.0 Regulatory Intent

The intent of 10 CFR 74.3(d) general performance objective is for licensees to have ready and provide to investigators any information deemed relevant to the recovery of special nuclear (SNM) involved in a loss or theft. The burden is on the licensee to provide (without being asked) all information that it recognizes as being relevant, as opposed to only providing information that the investigators are knowledgeable enough to request. This objective pertains to investigations and recovery operations, relating to actual (or highly suspected) events pertaining to missing SNM, which would be conducted by the U.S. Nuclear Regulatory Commission (NRC) or other government agencies, such as the Federal Bureau of Investigations.

The 10 CFR 74.3(d) performance objective states that the licensee must be able to provide, in a timely manner, information to aid in the investigation and recovery of missing SNM in the event of an actual loss, theft, diversion or misuse.

14.1 Types of Information

The kinds of information that may aid the investigation and recovery effort are:

- data or observations that led the licensee to determine that a loss or theft of uranium may have occurred
- data, observations, and assessments associated with attempts to resolve the indication of missing material
- the time period during which the material may have left the facility
- the path and means by which the material may have left the facility

14.2 Information Indicating Possible Losses of SNM

Information indicating that a loss of uranium may have occurred can come from process or production yield data, physical inventory results, item control activities, or shipper-receiver comparisons. This information could include:

- material accountability data records and reports
- inventory records
- inventory difference (ID) and propagation of error calculations
- inventory reconciliation reports

- indications of unrecorded or unauthorized removals of SNM from storage or process locations
- reports of apparent destruction or falsification of records pertaining to SNM
- records of broken tamper-indicating devices (TIDs) or compromised item integrity
- indications of unauthorized entry into SNM storage areas
- reports from monthly item status inspections
- material receipt and log records
- results from shipper-receiver difference (SRD) evaluations
- process quality assurance or production control records
- documentation relating to an alleged or confirmed theft

14.3 Information on Resolving Indications of Missing SNM

Information associated with resolving indications of missing SNM is provided in Chapter 13. This information and information that may aid in the recovery of missing material would include:

- the type of unauthorized activity detected
- the interval during which the loss may have occurred
- the amount of material and form of the material involved in the loss
- results of measures to validate indicators
- results of extended measures to resolve indicators
- results from special inventories (or re-inventories) and tests performed
- audit results of the SNM accountability source data
- assessments of measurement data and measurement controls
- results from reviews of the material control and accounting (MC&A) program and status of corrective actions
- history of indicator investigation and resolution activities
- anomaly investigation and resolution procedures and conclusions
- probable cause of the loss

- any abnormal events that may have contributed to or caused the loss

- the names of individuals who could have been responsible for the loss

Much of the backup information necessary to assist in an investigation would be records maintained in the facility records system described in Chapter 15.

14.4 Commitments and Acceptance Criteria

In its MC&A plan, the licensee should provide definitive commitments that adhere to regulatory requirements and meet the acceptance criteria applicable to providing information to assist in the investigations and recovery of missing uranium or unauthorized production. A finding that the licensee's MC&A plan for providing informational aid is acceptable and in accordance with 10 CFR 74.3(d), will be based on, but not limited to the following acceptance criteria:

- Procedures are in place for the efficient and timely gathering of relevant information to be provided to government investigators to aid them in the investigation and recovery activities associated with missing SNM.

- Information will be provided to appropriate government authorities to aid them in their investigation of indications or allegations of missing material and in the recovery of SNM in the event of a loss that could include theft or diversion.

15. RECORDKEEPING

15.0 Regulatory Intent

The intent of 10 CFR 74.31(d) is to require the licensee to establish and maintain records that demonstrate that the general performance objectives of 10 CFR 74.3 and the 10 CFR 74.31(a)-(c) requirements have been met. Records should include those documenting the:

- receipt, shipment, disposal, and current inventory of special nuclear material (SNM) held under license
- quantities of SNM added to and removed from process
- shipper-receiver evaluations associated with SNM receipts

Records must be retained for at least 3 years (or longer if specifically required by regulations external to 10 CFR 74.31), thereby providing a way for assessing the MC&A program performance and inspecting for compliance with regulatory requirements. However, in accordance with 10 CFR 74.19(b), material control and accounting (MC&A) procedures (as documented in licensee records) must be retained until the Commission terminates the license.

15.1 Description of Records

The MC&A plan should identify all records, forms, reports, and standard operating procedures that show compliance with the requirements of 10 CFR Part 74. Such records should include, but are not limited to, the following:

- documents that define changes in the MC&A management structure or changes in responsibilities relating to MC&A positions
- procedures pertaining to any accountability-related measurement or sampling operation
- forms used to record or to report measurement data and measurement results, including source data
- forms and notebooks used to record calibration data associated with any accountability measurement system
- forms and notebooks used to record quantities, volumes, and other data associated with the preparation of standards, both calibration and control, used in connection with accountability measurement systems
- forms and official memos used to record or report measurement control system data, control limit calculations, and out-of-control investigations
- forms listing and providing instructions associated with physical inventories
- forms and formal worksheets used in the calculation of standard error of the inventory difference (SEID), inventory difference (ID), and active inventory values

- ledgers, journals, and computer printout sheets associated with the accountability system
- ledgers, journals, and computer printout sheets associated with the item control system, including seal usage and “attesting to” records
- U.S. Department of Energy/U.S. Nuclear Regulatory Commission (DOE/NRC) Forms 741 and 742 and NRC Form 327
- forms, memos, and reports associated with identification of, investigation of, and resolution of significant shipper-receiver differences (SRDs)
- loss indication and alleged theft investigation reports
- investigation reports pertaining to excessive IDs
- official reports containing the findings and recommendations of MC&A program assessments and any letters or memos pertaining to response actions to assessment team recommendations
- forms used for recording data associated with the item monitoring program
- monitoring program status or summary reports
- records of training sessions, including date given, topics covered, name of instruction(s), and names and signatures of those attending
- training, qualification, and requalification reports and records

Examples of the more important MC&A forms should be provided in the MC&A plan annex or appendix. The retained records and reports should contain sufficient detail to enable NRC inspectors to determine that the licensee has met the requirements of 10 CFR 74.31(a)-(c), and has met the general performance objectives of 10 CFR 74.3.

15.2 Program and Controls for Ensuring an Accurate and Reliable Record System

The MC&A plan should describe the controls used to ensure that records are highly accurate and reliable.

The record system also should provide a capability for easy traceability of all SNM transactions from source data to final accounting records.

The following topics should be addressed:

- the auditing system or program to verify the correctness and completeness of records
- the overchecks for preventing or detecting missing or falsified data and records
- the plan for reconstructing lost or destroyed SNM records
- the access controls used to ensure that only authorized persons can update and correct records

- the protection and redundancy of the record system such that any act of record alteration or destruction will not eliminate the ability to provide a complete and correct set of SNM control and accounting information needed to achieve the performance objectives of 10 CFR 74.3.

15.3 Commitments and Acceptance Criteria

In its MC&A plan, the licensee should provide definitive commitments that adhere to the regulatory requirements and meet the acceptance criteria applicable to recordkeeping. A finding that the licensee's MC&A plan for the recordkeeping system is acceptable and in accordance with 10 CFR 74.31(d) will be based on, but not limited to, the following acceptance criteria:

- Access to MC&A information will be controlled to provide deterrence and detection of theft, diversion, misuse, or radiological sabotage involving SNM.

- A record retention system is maintained for those records necessary to show that the MC&A system requirements of 10 CFR 74.31(c) have been met. Such records are retained for at least 3 years, unless a longer retention time is specified by 10 CFR 74.15(b), 10 CFR Part 75, "Safeguards on Nuclear Material—Implementation of US/IAEA Agreement," or by a specific license condition. The records referred to in 10 CFR 75.22, "Accounting Records," and 10 CFR 75.23, "Operating Records," and generated during any period that the facility is under International Atomic Energy Agency (IAEA) safeguards will be retained for at least 5 years. Records of the following will be maintained current and will be retained for at least 3 years:

    - Management structure, MC&A job descriptions, and MC&A policies and procedures

    - Accounting source data records (accounting source data normally consist of shipping and receiving forms, physical inventory forms, and the forms used for initially recording measurement and measurement control data)

    - Records of shipments and receipts and investigations of significant SRDs plus the information used to resolve them

    - Measurement data for receipts, shipments, discards, and inventory

    - Calibration of measurement systems, measurement control data, bias estimates, and the statistical analyses of the measurement control data

    - Data used to demonstrate that the measurement system performance achieves the SEID limits that 10 CFR 74.31(c)(4) requires

    - Physical inventory listings and inventory work sheets

    - Calculations of detection thresholds for excessive IDs of a safeguards significance (i.e., ID alarm point for detecting a loss equal to or greater than the detection quantity (DQ))

- Calculations of the SEID and information used to reconcile an excessive ID (i.e., an ID that is greater than or equal to 3.00 times the SEID)
- Reports of investigations and resolution of indications of loss of SNM
- The results of independent assessments and management action taken to correct any deficiencies identified

- Sufficient protection and redundancy of the record system is provided so that an act of record alteration or destruction will not eliminate the capability to provide a complete and correct set of SNM control and accounting information that could be used to confirm the presence of SNM, resolve indications of missing material, or aid in the investigation and recovery of missing material.

- All SNM transactions from source data to final accounting records will be readily traceable.

- The source data will be retained in its original form until the physical inventory and any subsequent ID investigations have been completed. After this time, any readable facsimile is acceptable for the remainder of the required retention period. All other records may be retained as hard copy, microfiche, permanent computer readable forms, or other permanently readable forms.

- The records will be retrievable, sufficiently complete and detailed to permit auditing all parts of the MC&A system, and traceable back to original source data.

- The records of the data that are the basis of the calculated SEID will permit traceability to the sources of the variances because of calibrations, bias adjustments, and random effects in the measurements. These records may be summaries of calibrations, bias tests, and variance monitoring data or control charts.

- The record system will have sufficient redundancy to enable reconstruction of lost or missing records so that knowledge of the SNM inventory is always available. The primary records, as contrasted with duplicate or backup records, will be provided security against computer failure, fire or water damage, vandalism, and access by unauthorized persons.

- All retained MC&A records are to be readily accessible to meet time restraints relative to their use. In general, the record retention system should possess the capability to retrieve records used for measurement control or accountability within 24 hours if the record was generated within the past 12 months, and within 7 calendar days if generated more than 12 months ago. Physical inventory listings are to be available within 24 hours for the latest two physical inventories. Item control records are to be retrievable in time to satisfy the criteria in Section 8.7.

- Overchecks or other controls, including access controls for updating and correcting records, are provided to prevent or detect errors in the records that would affect ID and item location.

16. GLOSSARY

The following terms are defined in the context of (1) their usage in this document or (2) how they should be used if contained in the material control and accounting (MC&A) plans submitted in accordance with 10 CFR 74.31, "Nuclear Material Control and Accounting for Special Nuclear Material of Low Strategic Significance."

ACTIVE INVENTORY (AI)–The sum of beginning inventory (BI), additions to inventory (A), removals from inventory (R), and ending inventory (EI), after all common terms have been totally excluded. A common term is any special nuclear material (SNM) value (or item) that appears in both BI and EI, or both BI and R, or both A and R, or both A and EI, with both values derived from the same measurement (and thus does not contribute to the uncertainty associated with the current-period inventory difference (ID)). The active inventory is used as an indicator of processing throughput or measurement activity.

ADDITIONS TO INVENTORY–Quantities of SNM, of a given material type code, added to a plant inventory and which, before such addition, were not part of the plant's total possessed quantity for the material type code in question.

ARTIFACT STANDARD–A container or item of certified mass, having a size, shape; and mass that is representative of a particular type of process related item or container (e.g., a UF_6 cylinder). Weighing error that buoyancy causes is eliminated through the use of artifact standards for scale calibrations.

ASSIGNED VALUE–A value for mass, volume, SNM concentration, SNM quantity, etc., assigned to a standard weight, standard material, etc.; used for calibrating or controlling a measurement device or system. An assigned value may not necessarily be a certified value, but if not, it should be traceable to a certified standard. In any event, it is the best estimate of the standard's true value.

BEGINNING INVENTORY (BI)–The total itemized quantity of SNM of a given material type code possessed by a "plant" at the start of a material balance period (inventory period). The BI quantity for any given material balance period is (by definition) exactly equal to the ending inventory quantity for the immediately previous period.

BIAS (MEASUREMENT BIAS)–A unidirectional component of error that affects (to the same degree) all members of a measurement data set. A bias can thus be estimated from the deviation of the mean of several measurements of a representative standard from the reference value (or assigned value) of such standard. If a bias is large enough to have an effect on the recorded value of SNM items, the accountability values of such items should be appropriately adjusted. If a bias is too small to affect individual items, its effect across all measured items (or material quantities) should be determined as an absolute quantity (e.g., as grams U and grams ^{235}U). The net sum of all biases (as absolute quantities) not applied as corrections to individual items is then applied as a bias correction to ID.

CALIBRATION–The process of determining the numerical relationship between the observed output of a measurement system and the actual value of the characteristic being measured, as based on primary or reference standards.

CERTIFIED STANDARD–A standard weight, material, device, or instrument having an assigned value that is guaranteed to be within specified limits by a nationally or internationally recognized organization (e.g., bureau, laboratory, etc.) that issues or certifies standards.

CHECK STANDARD (BENCH STANDARD, WORKING STANDARD)–A standard, not necessarily traceable to a primary standard, which is used routinely (e.g., daily or weekly) to check (or verify) the reliability of a measurement device, instrument, etc. (including those of accountability measurement systems). Such standards are not, however, used for the actual calibration or control of accountability measurement systems.

COMBINED STANDARD ERROR–An error band derived from the respective standard error values associated with each of two measurements (usually independent of each other) performed on a given material quantity. For both measurement values (of the pair) to be regarded as being in agreement, they must not differ from each other by more than the calculated combined standard error, which is normally calculated by taking the square root of the sum of squared individual standard errors. That is:

$$\text{combined S.E.} = [(\sigma_1)^2 + (\sigma_2)^2]^{1/2}$$

CONFIRMATORY MEASUREMENT–A measurement that confirms (within measurement uncertainty at the 95 percent confidence level) a previously established parameter, such as net weight, enrichment, etc., associated with an SNM item (or SNM quantity), but which does not thoroughly verify the previously established element or isotope quantity assigned to such item. Confirmatory measurements are sometimes used as the basis for concluding that previous measurement values for uranium and ^{235}U (or element and isotope) quantities are still valid.

CONTROL STANDARD–A standard that (1) is representative of the process material being measured and (2) is itself measured periodically to monitor for and to estimate any bias associated with the measurements of the process material in question. A control standard must be traceable to a primary standard or to a primary reference material.

DEPLETED URANIUM–Any uranium-bearing material whose combined ^{233}U plus ^{235}U isotopic content is less than 0.70 weight percent (wt %) (relative to total uranium elemental content).

DETECTION QUANTITY (DQ)–A site-specific ^{235}U quantity for licensees subject to 10 CFR 74.31, “Nuclear Material Control and Accounting for Special Nuclear Material of Low Strategic Significance,” or 10 CFR 74.33, “Nuclear Material Control and Accounting for Uranium Enrichment Facilities Authorized to Produce Special Nuclear Material of Low Strategic Significance.” The DQ is normally a function of annual throughput, but for low throughput low-enriched uranium (LEU) facilities, the DQ need not be less than 25 kilograms of ^{235}U. The DQ also can be described as a goal quantity, the loss or theft of which must be detected with a 90 percent (or better) power of detection whenever a physical inventory is taken.

DETECTION THRESHOLD (DT)–An ID limit that will be exceeded (with 90 percent or higher probability) by an ID resulting from the taking of a physical inventory whenever there has been an actual loss of a DQ. The DT is a function of both the DQ and the standard error of the inventory difference (SEID), as shown by the following equation:

$$DT = DQ - 1.3(SEID)$$

ENDING INVENTORY (EI)–The total-itemized quantity of SNM of a given material type code possessed by a "plant" at the end of a material balance period, as determined by a physical inventory. The EI quantity for any given material balance period is (by definition) exactly equal to the BI quantity for the next period.

ENRICHED URANIUM–Any uranium-bearing material that does not qualify as natural or normal uranium, and whose combined ^{233}U plus ^{235}U isotopic content is 0.725 percent or higher by weight, relative to total uranium element content.

INVENTORY RECONCILIATION–The adjustment of the book record quantity of both element and fissile isotopes to reflect the results of a physical inventory. In the broad sense, inventory reconciliation also includes the activities of calculating (1) the ID for the material balance period in question, (2) the uncertainty (i.e., SEID) value associated with the ID, (3) the active inventory for the period, and (4) any bias adjustment or prior period adjustment associated with the ID value.

MATERIAL BALANCE PERIOD–The time span to which a material balance or physical inventory pertains.

MATERIAL TYPE CODES–Number codes for identifying basic material types with respect to SM, SNM, and byproduct materials. These codes are used by the nuclear materials management and safeguards system (NMMSS) for tracking U.S.-owned and U.S.-possessed materials worldwide. For SNM, seven material type codes have been assigned as follows:

CODE	MATERIAL TYPE
10	depleted uranium
20	enriched uranium (*)
50	plutonium
70	uranium-233 (**)
83	plutonium-238 (***)
88	thorium
89	uranium in cascades

(*) For U.S. Department of Energy/U.S. Nuclear Regulatory Commission (DOE/NRC) Form 742 purposes, material code 20 has four subcodes (E1, E2, E3, and E4) to denote enrichment range. For NRC Form 327 purposes, code 20 has two subcodes, namely LEU and high-enriched uranium (HEU).

(**) Uranium materials should be regarded as material code 70 if the ^{233}U isotopic distribution is greater than (1) 10.00 wt % relative to total uranium element content, or (2) both the ^{235}U isotopic concentration and 5.00 percent by weight of the total uranium; otherwise report as material code 10, 20, or 81, as appropriate.

(***) Plutonium materials should be regarded as material code 83 if the ^{238}Pu isotopic distribution is greater than 10.00 wt % relative to total plutonium element content. Otherwise, report as material code 50.

MEASURED DISCARD (MD)–A measured quantity of gaseous, liquid, or solid waste that a facility no longer possesses, or which has been transferred (accounting-wise) to a waste

holding-account through a DOE/NRC Form 741 transaction. (Reference 10 CFR 74.13(a) for reporting of waste holding account.)

MEASUREMENT CONTROL SYSTEM–A managed system for monitoring and controlling both accuracy and precision of SNM accountability measurements.

NATURAL URANIUM–Any uranium-bearing material whose uranium isotopic distribution has not been altered from its naturally occurring state. Natural uranium is nominally 99.283 wt % ^{238}U, 0.711 wt % ^{235}U, and 0.006 wt % ^{234}U.

NORMAL URANIUM–Any uranium-bearing material having a uranium isotopic distribution that can be characterized as being (1) 0.700 wt % to 0.724 wt % in combined ^{233}U plus ^{235}U and (2) at least 99.200 wt % in ^{238}U. (Note: All natural uranium having a ^{235}U isotopic abundance in the range of 0.700 wt % to 0.724 wt % is normal uranium, but not all normal uranium is natural uranium.)

POINT-CALIBRATED MEASUREMENT SYSTEM–A measurement system in which the measurement value assigned to an unknown measured by the system is derived from the response obtained from the measurement of a representative calibration standard(s) that was measured along with (i.e., at the same time as) the unknown. The standard(s) must undergo all the measurement steps (e.g., aliquoting, sample pretreatment), and in the same manner, as the unknown. Point-calibrated measurement systems can be regarded as bias free, provided that adequate controls are in place to ensure the validity of the standard's assigned value.

PRIMARY STANDARD–Any device or material having a characteristic or parameter (such as mass, uranium concentration, uranium isotopic distribution, etc.) whose value is certified (within a specified uncertainty) by a nationally or internationally recognized bureau, laboratory, etc., that issues or certifies standards.

PRIOR PERIOD ADJUSTMENT–Any correction (i.e., adjustment) to an ID value because of a correction applied to a component of BI after the inventory period started. Such corrections may be because of the resolution of an SRD on material received during a prior inventory period, correction of a recording error, etc. Because these types of corrections have nothing to do with current period losses or errors, and because the official BI value is not adjusted, an adjustment to the ID value (derived from the ID equation) is necessary to obtain an ID that reflects only current period activity.

PROCESS MONITORING–A system of monitoring production data (e.g., flow rates, yields, densities) and of production control or quality control measurements (as opposed to accountability measurements) that could provide early (i.e., timely) detection of an anomaly that may indicate a significant loss or theft of SNM or indicate unauthorized enrichment activities.

RESIDUAL HOLDUP–Any SNM that remains within processing equipment (including ventilation filters and ductwork) after system draindown or cleanout. If, at the time of physical inventory, the total quantity of residual holdup is significant, such holdup must be measured (or estimated on the basis of partial measurements and engineering calculations) and included in the physical inventory listing. The uncertainty associated with a total measured or estimated residual holdup quantity must be included in the calculation of the SEID.

RESOLUTION OF AN INDICATOR–A definitive determination (with auditable evidence) by the licensee that an indicated possible theft or loss of uranium was a false indicator.

SHIPPER-RECEIVER DIFFERENCE (SRD)–The difference between what a sending facility (i.e., shipper) claims was contained in a shipment (of SNM) and what the receiving facility claims was received, where both shipper and receiver values are based on measurement.

STANDARD–See definitions for CERTIFIED STANDARD, CHECK STANDARD, CONTROL STANDARD, PRIMARY STANDARD, and STANDARD REFERENCE MATERIAL.

STANDARD DEVIATION–The random error (at the 67 percent confidence level) associated with a single value of a data set, which in turn is also a measure (or indication) of the precision relating to a set of measurements (or set of data) pertaining to the same item or sample of material. Standard deviation is calculated as follows:

$$\text{standard deviation} = S = \sqrt{\frac{\quad}{\quad}}$$

where
n = number of measurements performed
x_i = the value obtained for the ith measurement for i = 1, 2, 3 ..... n
$\bar{x}$ = the average value for all n measurements

STANDARD ERROR–The random error (at the 67 percent confidence level) associated with the average, or mean, value of a data set derived from repetitive determinations on the same item or sample. Mathematically, standard error is the standard deviation divided by the square root of the number of individual measurements used to derive the mean value.

STANDARD REFERENCE MATERIAL–A material or substance that qualifies as a primary standard and whose concentration with respect to a nuclide or isotope, a chemical element, or chemical compound is certified within a specified uncertainty.

SYSTEMATIC ERROR–A unidirectional error that affects all members of a data set. The terms “bias” and “systematic error” are often interchanged. However, any determined bias (i.e., a bias estimated from control standard measurements) has an uncertainty value associated with it. Thus, after correcting for any estimated bias, the uncertainty of that bias can be regarded as a systematic error. If an estimated bias is not applied as a correction, the combination of the bias plus its uncertainty should be regarded as the systematic error.

VERIFICATION MEASUREMENT–(1) A nondestructive assay (NDA) measurement of an item conducted to verify that a previous NDA measurement value for isotope content of that item is still valid. (2) The re-weighing and re-sampling of an item, batch, lot, or sublot and performing chemical assays of the re-sample for element and isotope concentrations so as to verify a previously measured value for element and isotope content of the item (batch, lot, or sublot). Verification is achieved if the original and verification measurement values (for element and isotope quantities) agree within the range of measurement uncertainty (at the 95 percent confidence level).

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This document supersedes NUREG-1065, Revision 2 (Published December 1995)

11. ABSTRACT (200 words or less)

This document provides a revised structure for NUREG-1065, Revision 2, dated 1995, which contains information that the licensee or applicant should provide in its material control and accounting (MC&A) plan, formerly the fundamental nuclear material control plan. It applies to U.S. Nuclear Regulatory Commission (NRC) licensees (other than production or utilization facilities licensed in accordance with Title 10 of the Code of Federal Regulations (CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," or 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants," and waste disposal facilities) authorized to possess and use more than 350 grams of unencapsulated special nuclear material (SNM) of low strategic significance. The revision has been structured to serve as a direct outline for licensees to use in preparing their MC&A plans.

This document provides a revised structure and information to facilitate compliance with 10 CFR Part 74 Subpart A, "General Provisions," and Subpart C, "Special Nuclear Material of Low Strategic Significance," regarding the licensee or applicant preparation and implementation of MC&A plans and corresponding NRC review and inspection.

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