NUREG–1065
Rev. 2

Acceptable Standard Format and Content for the Fundamental Nuclear Material Control (FNMC) Plan Required for Low-Enriched Uranium Facilities

U.S. Nuclear Regulatory Commission

Office of Nuclear Material Safety and Safeguards

O. R. Joy

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Abstract

This document provides a revised structure for NUREG-1065, Revision 1, dated 1985, which contains information that the licensee or applicant should provide in its fundamental nuclear material control (FNMC) plan. The revised structure has been patterned after the acceptable standard format and content for the FNMC plan required for low enriched uranium enrichment facilities, NUREG/CR-5734, K/ITP-415, dated 1991. That document was structured in a manner to serve as a direct outline for licensees preparation of their FNMC plan while NUREG-1065 was structured to more closely follow and elaborate on the contents of 10 CFR 74.31.

This revised structure for NUREG-1065 continues to implement the requirements of 10 CFR 74.31. It applies to NRC licensees (other than production or utilization facilities licensed pursuant to 10 CFR Part 50 or Part 70 and waste disposal facilities) that are authorized to possess and use more than one effective kilogram of unencapsulated SNM of low strategic significance. Unlike the structure of the enrichment guide, however, this revision for NUREG-1065 includes a complete set of affirmations required from licensees. These are the same affirmations that appeared in Revision 1 of NUREG-1065 but in some instances the language has been modified to clarify intent.

All other modifications involve format and editorial changes designed to provide clarifications and facilitate preparation or revision of the required FNMC plan.

Contents

Acronyms

CFR	Code of Federal Regulations
DQ	Detection quantity
DT	Detection threshold
FKG	Formula kilogram
FNMC	Fundamental nuclear material control
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
U	Uranium
U-233	Uranium-233
U-234	Uranium-234
U-235	Uranium-235
U-238	Uranium-238
UO_2	Uranium dioxide
U_3O_8	Urano-uranic oxide
UF_6	Uranium hexafluoride
wt %	Weight percent

Introduction

An applicant's fundamental nuclear material control (FNMC) plan must demonstrate how the basic capabilities specified in 10 CFR 74.31(c) are achieved and maintained and how such capabilities are used to achieve the performance objectives listed in 10 CFR 74.31(a). After accepting an FNMC plan and imposing it as a condition of license, the U.S. Nuclear Regulatory Commission (NRC) will judge the adequacy of a licensee's materials control and accountability (MC&A) performance by inspecting for compliance with commitments and practices described in the plan.

Because 10 CFR 74.31 is, for the most part, a performance-oriented regulation, the emphasis is on defining objectives rather than the means for achieving them. Thus, applicants and licensees have many alternatives with regard to how their MC&A system and program are designed, managed, and operated. Hence, this document cannot begin to cover all possible methodologies that a licensee might use to achieve the desired objectives. Instead, this document provides examples of acceptable MC&A approaches commonly or typically used by low enriched uranium fuel fabricators. This document is intended for use by applicants, licensees, and NRC safeguards licensing reviewers. For the most part, recommended criteria are not to be regarded as rigid, fixed standards. That is, a lower effectiveness of one feature relative to a particular aspect can be tolerated if there is a compensating feature, or combination of features, that provides an overall effective safeguards system. Although not likely, a licensee could fail to meet most of the criteria recommended in this document and still achieve the regulatory objectives. In the final analysis, an NRC reviewer must make a judgment as to whether the applicant or licensee can achieve with high probability, without going beyond its FNMC plan commitments, the objectives stated in 10 CFR 74.31(a). The recommendations provided herein pertain to both applicant submitted FNMC plans and any revisions made to existing approved plans.

Pages 3 through 10 of this introduction section describe the basis of the three general performance objectives of 10 CFR 74.31 and the MC&A system features and capabilities needed to meet the objectives. The chapters that follow incorporate and expand on (1) the general performance objectives, and (2) the system features and capabilities. The first eight chapters are arranged in a sequence corresponding to the system capabilities required by 10 CFR 74.31(c)(1) through (8), of which (c)(5), and hence chapter 5, deals with the first performance objective of confirming the presence of SNM. Chapters 9 and 10 address the second and third performance objectives --- "resolving indications of missing uranium" and "aid in the investigation and recovery of missing material". Chapter 11 deals with the record keeping requirements of 10 CFR 74.31(d). Together these 11 chapters provide applicants or licensees an outline for an FNMC plan.

The body of an FNMC plan, corresponding to Chapters 1 through 11, shall be a condition of license, and compliance with the FNMC plan commitments, the required affirmations, and related procedures will be inspectable. Explanations and discussions appearing in the body of the plan should be detailed and precise, as opposed to general and vague, so that all parties concerned (i.e., NRC licensing reviewers, NRC inspectors, and licensee personnel responsible for plan execution) have a clear and nonconflicting understanding of the what, how, and when aspects of each plan commitment.

The annex (or appendix) of an FNMC plan should provide supplementary and general information about the facility and the MC&A system [e.g., copies of blank record forms, site map, process diagrams, an example standard error of the inventory difference (SEID) calculation, etc.]. The annex will not be incorporated as a condition of license and will not be the basis for inspection. Thus, descriptions presented by the applicant or licensee to satisfy regulatory intent must be in the plan itself, rather than the annex, and must provide adequate detail so as not to be largely dependent on examples or supplementary information in the annex for proper understanding.

Performance Objectives, System Features and Capabilities, and Affirmations

Performance Objectives

The general performance objectives and the system capabilities to be addressed by the FNMC plan are set forth in 10 CFR 74.31. The basis on which each of the three general performance objectives and eight system capabilities were formed is described in the following paragraphs of this section together with identification of the related required licensee affirmations.

General Performance Objectives

1. **Confirm the presence of special nuclear material**

   The purpose of this objective is to verify the presence of or to detect the occurrence of any significant loss or theft of special nuclear material (SNM). To maintain current information of the SNM in their possession, licensees should have in place a program that provides timely, accurate, reliable information about the quantity and location of materials in their possession. Accurate information means that item quantities for both the element uranium and the isotope U-235 are based on measured values or on reliable factors. Reliable information means that the quantity of material in an item and the location of all items is known (with the possible exception of items that have been created, transferred, or consumed within the past 8 hours) and that the location designations are 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 classes of material and items listed in the accounting records are correct and verifiable (with the possible exception of items that have been created, transferred, or consumed within the past 8 hours).

   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 introduced to the process and (2) to ensure all SNM quantities of record associated with receipts, shipments, discards, and ending inventory are based on measurements. Recommendations for meeting the performance objectives for the item control program are provided in Chapter 6 of this document, and for measurements and measurement control programs are provided in Chapters 2 and 3, respectively. 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 should conduct total plant physical inventories at an average interval of no more than 12 months, with no single interval (between any two consecutive physical inventories) being greater than 13 calendar months. Each physical inventory must be conducted in a manner 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 U-235, the magnitude of which is discussed in Chapter 4 of this document.

   The licensee should verify the presence of all SNM currently possessed by the facility, as stated in its accounting records. This verification is normally accomplished by 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 (by means of unique item identities), and confirming the SNM quantities associated with unencapsulated and unsealed items on ending inventory. However, a dynamic (i.e., nonshutdown) inventory of some or all processing equipment may be utilized 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 5 of this document. In summary, a total plant physical inventory involves:

(1) verifying the presence, on a 100 percent basis, of all uniquely identified SNM items listed in the accounting records

(2) 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)

(3) measuring any items not previously measured

(4) verifying the identity and integrity of all encapsulated items and items affixed with tamper-indicating seals

(5) measuring a 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 should not be excluded from using process monitoring and production control data.

2. Resolve Indications of Missing Uranium

The licensee or applicant should have a formalized program to resolve any indication that SNM is missing. Resolution of such indicators means that the licensee has made a determination that a theft or loss of SNM has not occurred. Only indications that suggest a possible loss of items or material from items equal to or greater than 500 grams of U-235 need be investigated; a possible loss of a detection quantity detected during a material balance closure needs to be investigated and resolved in accordance with 74.31(c)(5). Multiple loss indications from items and/or process equipment within a material balance period must be resolved even though the loss from each event is less than 500 grams of U-235. This resolution need not occur until the total potential loss equals or exceeds 500 grams of U-235.

Resolution of an indicator depends on the type of indicator. Anomalies at plants can indicate a number of scenarios from simple theft to complex diversions. The resolution process in some cases 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 calculational 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 NRC pursuant to 10 CFR 74.11.

3. Aid in the Investigation and Recovery of Missing Material

If the NRC and/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, without specifically being asked, any information deemed relevant to the recovery of material involved in a loss, theft, or diversion . The burden shall be on the licensee to provide (without being asked) all information that it recognizes as being 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 10 of this document.

The licensee is required to make affirmations with respect to these three performance objectives and the eight system capabilities, and these must be stated (without any modification) in the FNMC plan. The affirmations are listed below:

Affirmations Pertaining to Performance Objectives

- An MC&A system will be maintained that is capable of confirming, at least annually, the presence of all SNM expected to be present (at a given time) based on the accounting ledgers, with the possible exception of waste materials transferred to (via DOE/NRC Form 741 transactions) and stored in holding accounts.
- An expeditious investigation will be promptly initiated for all indications of significant losses (≥500 grams of U-235) of SNM and each allegation or indication of SNM theft.
- Information will be provided to appropriate Federal Authorities to aid in their investigation of indications of missing material and in the recovery of SNM in the event of a loss, theft, or unauthorized diversion.
- A cause or probable cause that is based on objective evidence will be assigned to each indication of possible loss that is investigated.
- The results of all investigations of alleged thefts, and any indications of a significant loss (≥500 grams U-235) which remain unresolved after 30 calendar days shall be reported to the appropriate NRC MC&A licensing authority.

Affirmations Pertaining to System Capabilities

To meet the three general objectives, the MC&A system depends on features and capabilities as required by 10 CFR 74.31(c)(1) through (c)(8) and 74.31(d). These system capabilities and their related affirmation statements are identified below, and are discussed in Chapters 1 through 8 and 11 of this document.

(1) Establish, document and maintain a management structure which assures clear overall responsibility for material control and accounting functions, independence of MC&A management from production responsibilities, separation of key responsibilities and adequate review and use of critical material control and accounting procedures.

In its FNMC plan, the licensee must make the following affirmations with respect to management structure:

- Responsibility for the overall MC&A system management is assigned to a position that is separate from production responsibilities or any other responsibilities that may give rise to conflict of interest.
- The responsibility for each MC&A function is assigned to a specific position in the organization, and the organization is structured in a way that the key functions are separated or overcheck one another. The position descriptions are available in writing to the personnel affected.
- The facility organization and the MC&A policies and procedures are documented.
- All critical MC&A procedures, and any revisions thereto, are reviewed and approved prior to their implementation.
- 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.

(2) Establish and maintain a measurement system which ensures all quantities in the material accounting records are based on measured values.

The licensee must make the following affirmations with respect to the accountability measurement system:

- 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. These are considered as key measurement systems and their standard deviations are monitored and controlled by the measurement control program.

(3) Follow a measurement control program which assures that measurement bias is estimated and significant biases are eliminated from inventory difference values of record.

The licensee must make the following affirmations with respect to measurement quality:

- A measurement control program is followed by which all measurement biases associated with key measurement systems, are estimated and any significant biases are eliminated from inventory difference (ID) values and shipper/receiver differences.
- The calculation of the measurement contributions to SEID are traceable to the appropriate measurement error data and to the calibration standards used.
- The total measurement uncertainty is controlled so that twice its standard error for each material balance period will be less than the greater of 9,000 grams of U-235 or 0.25 percent of the active U-235 inventory for the inventory period. (NOTE: "Twice the standard error associated with total measurement uncertainty" can also be denoted as "LEID", i.e., "the limit of error of the inventory difference").
- The measurement systems have adequate calibration frequencies, sufficient control of biases, and sufficiently small standard deviations to achieve the requirements of 74.31(c)(4). A measurement control program is used by both in-house and by any utilized contractor to assure that the quality of the measurements is maintained on a level consistent with the regulatory requirements.

(4) In each inventory period, control total material control and accounting measurement uncertainty so that twice its standard error is less than the greater of 9,000 grams of U-235 or 0.25% of the U-235 active inventory, and assure that any measurement performed under contract are controlled so that the licensee can satisfy the requirements.

(5) Unless otherwise required to satisfy 10 CFR Part 75, perform physical inventories at least every 12 months (with no more than 13 calendar months between any two consecutive physical inventories); and, within 60 days after the start of the inventory, reconcile and adjust the book inventory to the results of the physical inventory, and resolve, or report an inability to resolve, any inventory difference which is rejected by a statistical test which has a 90% power of detecting a discrepancy of a quantity of U-235 established by NRC on a site specific basis

The licensee must make the following affirmations with respect to physical inventories:

- An MC&A system will be maintained that is capable of confirming, at least annually, the presence of all SNM expected to be present (at a given time) based on the accounting ledgers, with the possible exception of waste materials transferred to (via DOE/NRC Form 741 transactions) and stored in holding accounts.
- Unless otherwise required by Facility Attachments that satisfy 10 CFR Part 75, physical inventories will, on the average, be performed at least every 12 months (with no more than a 13 calendar month interval between consecutive physical inventory dates) and will be used as the basis for reconciling and adjusting the book inventory which is done within 60 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 the conduct of the physical inventory.

- The individual responsible for the conduct of 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), with the possible exception of waste materials assigned to holding accounts (in accordance with DOE/NRC Form-741 instructions) and residual holdup that can be regarded as zero by definition, and that all such listed SNM quantities shall be based on measurements (for SNM quantity).

- Within 60 days after the start of each physical inventory, the inventory difference will be determined. Any inventory difference, which is rejected by a statistical test that has a 90% power of detecting a discrepancy of a quantity of U-235 established by the NRC on a site-specific basis, will be reported to the appropriate MC&A licensing and MC&A inspection organizational units at NRC Headquarters.

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

- Inventory difference 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 of this Plan).

- 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 U-235 ID (after applying any appropriate bias corrections and prior period adjustments) is greater than the U-235 detection threshold (DT) and is not resolved within the 60-day reconciliation period, all SNM processing will be halted unless otherwise authorized by the NRC. [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 U-235 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 U-235.

(6) Maintain current knowledge of items when the sum of the time of existence of an item, the time to make a record of the item, and the time necessary to locate the item exceeds 14 days. Store and handle, or subsequently measure, items in a manner so that unauthorized removals of substantial quantities of material from items will be detected. Exempted are items individually containing less than 500 grams of U-235 up to a total of 50 kilograms of U-235, solutions with a concentration of less than 5 grams of U-235 per liter, and items of waste destined for burial or incineration.

The licensee must make the following affirmations with respect to maintaining current knowledge of items and detecting unauthorized removals:

- For items not exempted from item control program coverage, a record system is maintained to provide a knowledge of the current status of such items for which the sum of the elapsed time from initial generation of the item plus the time required to locate the item, including any time required to complete or update item records, would exceed 14 calendar days. 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 in such a manner 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 (unless it is an exempted item) is stored and handled in a manner that enables detection of or provides protection against unauthorized or unrecorded removals of SNM; otherwise knowledge of the SNM content is assured by seals or maintaining the item as a sealed source (i.e., as encapsulated material).

- All incidents involving missing or compromised items or falsified item records are investigated. (A compromised item is one for which there is evidence of tampering or which 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 redetermined by measurements (i.e., by NDA or by weighing, sampling and analysis).

(7) Resolve on a shipment basis and, when required to satisfy Part 75 of this chapter, also on a batch basis, shipper/receiver differences that exceed both twice the combined measurement standard error for that shipment (and/or batch) and 500 grams of U-235.

The licensee must make the following affirmations with respect to resolving shipper/receiver differences:

- Each shipment received is inspected for loss or damage to the container or seals to determine if SNM could have been removed. If the integrity of the shipping container is questionable, the presence of all items that were packaged in the container will be verified.

- Except for those materials specifically identified as exempted in Chapter 7 of this FNMC plan, measurements of the quantity of SNM received in each shipment are performed and the shipper/receiver difference is tested for statistical significance. Occurrences of significant shipper/receiver differences in excess of 500 grams U-235 and missing items are reported to the shipper promptly.

- For SNM received, shipper/receiver differences that are statistically significant and also greater than 500 grams U-235, on a total shipment basis (and also on a batch basis when subject to 10 CFR Part 75), are detected within 30 days of receipt except for those materials specifically identified in Chapter 7 of this FNMC plan as being exempted from shipper/receiver evaluations.

- Measurement results for shipments and receipts are 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 impact individual items by more than their rounding error in terms of U-235 and/or uranium content.

- A significant shipper/receiver difference, e.g., one that exceeds both twice the combined measurement standard deviation for that shipment (and also any batch when subject to Part 75) and 500 grams of U-235, is promptly investigated and resolved on a shipment basis and also on a batch basis when required to satisfy 10 CFR 75.4(d).

- Significant shipper/receiver differences, as defined above, are reported to the appropriate NRC safeguards licensing organizational unit by telephone or facsimile within 5 calendar days of determining such significant difference.

(8) Independently assess the effectiveness of the material control and accounting system at least every 24 months, and document management's action on prior assessment recommendations.

The licensee must make the following affirmations with respect to independent assessment and evaluation of the MC&A system effectiveness:

- The capabilities and performance of the MC&A system 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/assessment to the completion of the next will not exceed 24 calendar months.

- Reviews and assessments are performed either by 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 judgements of the MC&A system capabilities and performance.

- Each overall review and assessment will be conducted and completed in a time frame that is short with respect to the time for changes to have occurred in the MC&A system and will include any such changes made during the time the review/assessment is being conducted.

- The completion date for any review/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 and/or interview MC&A personnel, and such start date will be documented.

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

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

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

The MC&A recordkeeping requirements of 10 CFR 74.31(d) are as follows:

(1) Each licensee shall establish records that will demonstrate that the system capabilities requirements have been met and maintain these records for at least three years, unless a longer retention time is required by Part 75 of this chapter.

(2) Records which must be maintained pursuant to 10 CFR Part 74 may be the original or a reproduced copy or a microform, if such reproduced copy or microform is duly authenticated by authorized personnel and the microform is capable of producing a clear and legible copy after storage for the period specified by Commission regulations. The record also may be stored in electronic media with the capability for producing legible, accurate, and complete records during the required retention period. Records such as letters, drawings, and specifications must include all pertinent information such as stamps, initials, and signatures.

(3) The licensee shall maintain adequate safeguards against tampering with and loss of records.

The licensee must make the following affirmations with respect to recordkeeping:

- 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 three years. The records referred to in 10 CFR 75.22 and 75.23 and generated during any period that the facility is under International Atomic Energy Agency (IAEA) safeguards will be retained for at least five years. Records of the following will be maintained current and will be retained for at least three 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. After an item is destroyed, the item location record needs to be retained for an additional 14 days but then may be destroyed);

- Records of shipments and receipts and investigations of significant shipper/receiver differences 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 standard deviation limits required by 10 CFR 74.31(c)(4);
- 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 DQ);
- Calculations of the standard error of the estimated ID and information used to reconcile an excessive ID (i.e., an ID that is > 3.00 times SEID);
- Reports of investigations and resolution of indications of loss of SNM; and
- 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.
- Ready traceability will be provided for all SNM transactions from source data to final accounting records.

The following chapters of this document incorporate and expand on the performance objectives and on the system features and capabilities of 10 CFR 74.31. The chapters are arranged in a format and sequence to provide applicants and licensees an outline for the FNMC plan.

1 Organization

1.0 Regulatory Intent

The intent of 10 CFR 74.31(c)(1) is to require licensees to implement a management structure that permits effective functioning of the MC&A system, and assures that the MC&A program performance will not be adversely affected by the plant management structure. Documentation, review and approval of the procedures, and the assignment of the key functions to specific positions eliminates ambiguities about what is to be done by whom. The management structure is meant to separate key MC&A functions from each other in order to provide overchecks that increase MC&A system reliability and counter defeat of the system through deceit and falsification. It is also meant to free MC&A management from conflicts of interest with other major functions such as production.

1.1 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 have responsibilities pertaining to the control and accounting of all SNM possessed by the licensee.

1.2 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 should also indicate how responsibilities are assigned for the following functions:

(1) overall MC&A program or system

(2) SNM custodianship

(3) receiving and shipping of SNM

(4) analytical laboratories

(5) bulk and NDA measurements

(6) sampling operations

(7) measurement control program

(8) physical inventories

(9) on-site SNM handling operations

A brief description should be provided for each site-level position, outside of the MC&A organization, that 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.

1.3 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 FNMC 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.

1.3.1 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 FNMC 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 how the MC&A manager assures appropriate review and approval for all written procedures pertaining to MC&A-related activities, and to any future revisions thereto, that are issued both within and outside of the MC&A organization. In

addition to the MC&A manager function, the functions to be addressed should include, as a minimum, the following:

(1) nuclear material accounting

(2) measurement control program

(3) item control program

(4) statistical applications

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

(1) performance of accounting or record control functions by individuals who also generate source data

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

1.3.2 MC&A Procedures

Critical MC&A procedures to be described 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 74.31(a) and the system capabilities of 10 CFR 74.31(c). All critical MC&A procedures should be identified in the body of the FNMC plan. The FNMC plan also should contain a definitive statement that the procedures will be followed. This set of critical MC&A procedures should, as a minimum, adequately address the following topics, regardless of which facility organizational group is responsible for the particular topic:

(1) accountability record system

(2) sampling and measurements

(3) measurement control program

(4) item control program

(5) physical inventories

(6) investigation and resolution of loss indicators

(7) determination of SEID, active inventory, and inventory difference

(8) providing information to aid in investigations

(9) MC&A recordkeeping system

(10) independent assessment of the effectiveness of the MC&A program

1.4 Training and Qualification Requirements

This section of the FNMC plan should describe the training programs to be established and maintained to provide qualified personnel and to provide for the continuing level of qualification with respect to 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.

1.5 MC&A System Description

The length of this section and its level of detail will be dependent on the information provided in the previous sections of this chapter. The overall MC&A organization should be described in a manner that explains how the general performance objectives of 10 CFR 74.31(a) 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:

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

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

(3) measurement control and statistics

(4) accountability records

(5) item control

(6) physical inventories

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

(8) investigation and resolution of indicators that suggest possible loss of SNM

(9) receiving and shipping of SNM

(10) analytical laboratories

(11) MC&A recordkeeping system and controls

The information in this chapter should include a description of 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 system.

This section should also include a discussion relating to critical MC&A procedures including a summary of the review, approval, and implementation control and requirements. Critical MC&A procedures and all changes to them should undergo technical review by cognizant members of the staff and be approved by line management directly affected and by a level of management above the level responsible for executing the procedures (but not beyond on site plant management).

1.6 Acceptance Criteria

A judgment that the applicant's or licensee's approach for establishing and documenting an effective MC&A program that will be maintained by an acceptable organizational (management) structure, as described in the FNMC plan, will be based on (but not limited to) the following 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 and/or implement measurement control requirements, and conduct data analysis) are clearly defined 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 (in the FNMC plan) 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 by suitable controls and overchecks.

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

- No two key MC&A functions are assigned to the same person unless adequate 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, and

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

- Critical MC&A procedures and all changes to them which directly affect the licensee's ability to detect the loss of SNM or to

resolve indications of missing SNM, as per 10 CFR 74.31(a), undergo technical review by cognizant members of the staff and will be approved by line management directly affected and by a level of management above the level responsible for executing the critical procedures (but not beyond on-site management).

- 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).

1.7 Affirmations

The five affirmation statements related to MC&A management structure, given on page 5 under section (1), must be stated (without modifcation) in the FNMC plan.

2 Measurements

2.0 Regulatory Intent

The intent of 10 CFR 74.31(c)(2) is that licensees must maintain a system of measurements to assure that all quantities of 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 so as to assure that the limit specified in 10 CFR 74.31(c)(4), for the total MC&A measurement uncertainty (associated with a physical inventory material balance), is not exceeded. Except for sealed sources, samples, and other certain materials, all SNM receipts are to be measured for the purpose of performing shipper-receiver evaluations. In the absence of any significant shipper-receiver difference, 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 SEID. It is also intended that a licensee's measurement program provide bias estimates to be used in correcting inventory difference values and shipper-receiver differences for significant measurement biases. The estimation of measurement bias is discussed in Chapter 3 (Measurement Control Program).

2.1 Measurement Points

The FNMC plan should identify and describe each measurement that is 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 and/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.

2.2 Measurement Systems

The FNMC 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 also should be identified: (1) sampling technique and equipment used, (2) sample aliquoting tech-nique, 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 measure-ment system used for accountability are described in Chapter 3.

The FNMC 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.

2.2.1 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, range to be used, sensitivity of the device, and the calibration frequency. The description should include the capacity and the sensitivity of the scale (e.g., capacity not to exceed X kilograms, and sensitivity to be at least as good as Y grams).

For each volume measurement system, the FNMC plan should identify the vessel (e.g., tank, column, etc.), capacity of the vessel to which the measurement applies, the material being measured, the volume measuring device and instrumentation, the sensitivity of each device and system, the range

of operation and/or calibration, and the calibration frequency.

2.2.2 Analytical Measurement Systems

For each analytical measurement system, the FNMC plan should specify the following:

(1) type of material or chemical compound (e.g., UF_6, uranium alloy, UO_2, uranyl nitrate solution) being sampled and measured

(2) sampling technique

(3) sample handling (i.e., pre-analysis sample storage and treatment)

(4) analytical method used

(5) characteristics measured (e.g., grams of uranium per gram sample, U-235 isotopic concentration)

(6) measurement interferences

(7) expected measurement uncertainty

(8) types of calibration standard(s) and calibration frequency

2.2.3 NDA Measurement Systems

For each NDA measurement system, the FNMC plan should identify the following:

(1) the NDA equipment package (i.e., type and size of detector, and type of associated electronics and computer interface, as appropriate)

(2) the type of container measured

(3) SNM material type within container

(4) attribute measured

(5) measurement configuration (including source to detector distance)

(6) calculational method

(7) expected measurement uncertainties

2.2.4 Other Measurement Systems

If applicable, the FNMC plan also should identify any other measurement systems used for accounting purposes that do not fall within the three categories covered by subsections 2.2.1, 2.2.2, and 2.2.3.

2.3 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.

2.4 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 assures 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 by the manager of the organizational unit responsible for performing the measurement. Measurement procedures also should be approved by the measurement control program manager.

The FNMC 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:

(1) additions to inventory (e.g., receipts)

(2) removals from inventory (e.g., shipments and measured discards)

(3) 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 shipper-receiver difference (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.

2.5 Acceptance Criteria

A judgment as to the acceptability of the applicant's or licensee's system for accountability measurements, as described in the FNMC plan, will be based on (but not limited to) the following criteria:

- A basic description or summary of each key measurement system which is utilized 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 U-235 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 standard error of inventory difference.

- 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 NIST 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 that is 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 an uniform material batch (or lot), such as blended UO_2 powder or sintered UO_2 pellets, must be determined by direct mass measurement. However, the element and/or isotope concentrations for the batch need not be determined for each container, but instead may be derived by sampling procedures, including:

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

- Use of concentration and/or enrichment factors determined from historical averages, controlled input specifications values, or empirical relationships where such values or relationships are periodically tested, 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 U-235 (per material type, per inventory period). Justification for any materials assigned common factors without batch-by-batch verification analyses must be presented in the FNMC plan.

2.6 Affirmations

The two affirmation statements, given on page 6 under section (2), relating to the measurement system capability required by 10 CFR 74.31(c)(2) must be stated (without modification) in the FNMC plan.

3 Measurement Control Program

3.0 Regulatory Intent

The intent of 10 CFR 74.31(c)(4) is that measurement systems used to establish SNM accountability quantities be controlled by a formal measurement control program that results in a U-235 total measurement standard error that is within 4500 grams U-235 or 0.125 percent of the U-235 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 MC&A measurement uncertainty (for U-235) must be less than the greater of 9,000 grams U-235 or 0.25 percent of the U-235 active inventory. It is also intended that the program provide bias estimates to be used for adjusting inventory difference results and correcting shipper-receiver measurements for significant measurement biases.

3.1 Organization and Management

The organization and management of the measurement control program 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 program manager should be at a management level that is sufficiently high to ensure objectivity and independence of action. Thus, the measurement control program 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 program 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).

3.1.1 Functional Relationships

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

3.1.2 Procedures

The measurement control program 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 program manager. The procedures should address the following:

(1) calibration frequencies and methods

(2) standards used for calibration (i.e., description and storage controls)

(3) standards used for control (i.e., method of obtaining or preparation, and traceability)

(4) control standard measurements

(5) replicate sampling and replicate measurements

(6) verification of process control instrumentation through comparison with other process instruments

(7) control limits and control responses

(8) generation and collection of control data

(9) recordkeeping controls and requirements

3.1.3 Contractor Program Audits and Reviews

If measurement services are provided by an outside contractor or off-site laboratory, the review program used to monitor the off-site measurements should be described. Such reviews are to ensure that the contractor or off-site 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 FNMC plan. An initial review of the contractor's measurement control program should be conducted before licensee use of measurements performed by the contractor or off-site laboratory.

All contractor or off-site laboratory assessment findings and recommendations should be documented and submitted to both the measurement control program manager and the overall MC&A manager within 30 days of completion of the review. 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 off-site laboratory in writing. The licensee should not use measurements performed by such contractors or off-site 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 off-site laboratory so that the independence of the conclusions may be maintained.

3.2 Calibrations

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

(1) calibration frequency for each measurement device or system

(2) identification of the standards used for calibration of each measurement device or system

(3) protection and control of standards used to calibrate measurement systems to maintain the validity of their certified or assigned values

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

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

(2) 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).

(3) 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).

(4) 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.

3.3 Control Standard Program

For those measurement systems that are not point-calibrated, a defined program 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 eight weeks during a given material balance period, more than two control standard measurements per week of system use may be necessary in order 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 U-235

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

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 SEID. Included within the set of key measurement systems, should be any system utilized 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 and/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:

(1) Does the variation between analysts or operators need to be considered and hence monitored?

(2) Can environmental variables contribute to measurement bias?

(3) Is bias likely to vary with respect to the time of day?

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

(5) 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)?

(6) 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?

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

3.4 Replicate Program

For systems involving sampling, duplicate measurements performed on single samples and/or measurements of replicate samples are necessary to estimate the combined analytical plus sampling random error. For nonsampling measurement systems such as 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) 100 percent of the accountability batches sampled (when less than 8 batches)

(5) the greater of 8 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 FNMC 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 regarded as 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 statistical methods described in Statistical Methods for Nuclear Material Management, NUREG/CR-4604, are recommended by NRC for satisfying the statistical requirements of 10 CFR 74.31; see also Chapter 4 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.

3.5 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 utilized 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 warning and out-of-control limits are normally set by the licensee based on a tradeoff between (1) the cost of investigating and resolving incidents where 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 FNMC plan should clearly explain how control limits are established and the frequency for redetermining them.

3.5.1 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 manually on graphs or entered into a computer data base for generation of control charts. All control charts should be reviewed at least once every two 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.

3.5.2 Response Actions

Either the analyst or the operator performing a control measurement or their supervisor should have the responsibility for promptly reporting any control measurement that exceeds an out-of-control limit. Such reporting should be made to the measurement control program 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:

(1) verifying that the measurement system in question has been taken out of service with respect to accountability measurements

(2) documenting the occurrence of the event

(3) performing at least two additional control measurements

(4) 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

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.

3.6 Acceptance Criteria

A judgment as to whether the applicant's or licensee's measurement control program, as described and committed to in the FNMC plan, is acceptable will be based on (but not limited to) the following criteria:

- The description of the measurement control program 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 is collected that demonstrates 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/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 impact the inventory difference 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 FNMC 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 inventory difference (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 four 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 prior to the current determination of such bias or standard deviation.

- The effort expended by the licensee in monitoring and controlling the bias and standard deviations of each measurement system is shown to be consistent with its impact on inventory difference 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 two 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 inventory difference 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 by Jaech (1973), Lumb and Tingey (1981), and the IAEA (1977).

- The licensee will confirm that the accountability measurements provided by a contractor 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.

3.7 Affirmations

The four affirmation statements, given on page 6 under section (3), relating to the measurement control system capabilities required by 10 CFR 74.31(c)(3) and (4), must be stated (without modification) in the FNMC plan.

4 Statistics

4.1 Determination of Measurement Uncertainties

To achieve the objectives and capabilities of 10 CFR 74.31, each licensee or applicant should institute a statistical program that evaluates the MC&A data to ensure that (1) the measurement data are analyzed in a rigorous manner and (2) hypotheses concerning the status of the nuclear material possessed are appropriately tested. NRC sponsored the development of a comprehensive reference that specifically addresses the statistical treatment of measurement control and accounting data. The statistical methods described in this reference, "Statistical Methods for Nuclear Material Management," NUREG/CR-4604, are recommended by NRC for satisfying the statistical requirements of 10 CFR 74.31.

The FNMC plan should

(1) contain a detailed discussion of the procedures and methodologies for estimating measurement variance components

(2) discuss how biases are determined and how bias corrections are applied, including:

  (a) how often biases are estimated
  (b) how the bias' effect on the measured quantity of material in an item is determined
  (c) when and how bias corrections to items are made
  (d) how their effect on inventory difference is determined
  (e) when and how bias corrections are applied to the ID

(3) describe the procedure and means for determining active inventory

(4) provide all relevant information regarding the determination of the SEID

(5) specify the nominal (typical) 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 U-235, in which case the DQ need not be less than 25 kilograms of U-235 [NOTE: For those facilities that do not utilize 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 U-235]

(6) 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 inventory difference limits and response actions.)

4.2 Determination of SEID

As defined in 10 CFR 74.4, the "standard error of inventory difference" means the standard deviation of an inventory difference that takes into account all measurement error contributions to the components of the ID. 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 U-235, as applicable) can be expressed as follows:

$$SEID = \left[\sum_{i=1}^{k} (G_i)^2 \{(\sigma_i)_s^2 + (\sigma_i)_r^2/n\}\right]^{1/2}$$

where

k = number of measurement systems
G_i = total grams uranium (or U-235) 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),

$$SEID = \left[2\sum_{i=1}^{k} (G_i)^2 \{(\sigma_i)_s^2 + (\sigma_i)_r^2/n\}\right]^{1/2}$$

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

The FNMC plan must 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 used by the computer to calculate SEID.

4.3 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 inventory difference value, it can be argued that such insignificant biases should be applied as a non-accounting adjustments to the initially calculated inventory difference (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 purely optional.

For biases that are statistically significant (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 inventory difference, if (1) such bias is statistically significant at the 95 percent confidence level, and (2) either or both of the following are also true:

I. Applying the correction would cause the ID to exceed its DT value, or

II. The bias is greater than 0.0100 percent relative and also impacts the ID value by more than 1,000 grams U-235.

Additionally, the net algebraic sum (expressed as grams U-235) 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/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:

III. Applying such correction would cause the ID to exceed its DT value, or

IV. The net correction impacts the ID value by more than 5.00 percent of the licensee's DQ, or 10,000 grams U-235, whichever is larger.

5 Physical Inventories

5.0 Regulatory Intent

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 ID depends on measurement errors, as well as various nonmeasurement contributors such as recording errors, unmeasured losses, unmeasured holdup, etc. The intent of 10 CFR 74.31(c)(5) is to require licensees to perform annual physical inventories so to confirm that a loss or diversion of a safeguards significant quantity (i.e., a DQ) of low strategic SNM has not occurred.

5.1 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 FNMC 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 should be possessed by the licensee at the inventory cutoff time.

The inventory difference and related information associated with each physical inventory of low-enriched uranium (LEU) (i.e., DOE/NRC material code 20-E1 and 20-E2) are to be reported to the NRC, pursuant to 74.17(a), on an NRC Form 327 as the results of a physical inventory. In addition, if any material associated with material codes 20-E3 and 20-E4 (i.e., high-enriched uranium), 70 (U-233), 50 (Plutonium), or 83 (Plutonium-238) is possessed by the licensee, such material must also be subject to the physical inventory, and each material code inventory difference and associated information must be reported on separate NRC 327 Forms.

5.2 Organization, Procedures, and Schedules

The FNMC plan should explain the makeup and duties of the typical physical inventory organization. The individual having responsibility for the coordination of the physical inventory effort should be identified by position title. The FNMC plan also should indicate how the preparation and modification of inventory procedures are controlled.

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

5.3 Typical Inventory Composition

The typical expected in-process inventory within the equipment for both uranium and U-235 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 MBAs and 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 are primarily 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 will normally 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.

5.4 Description of Typical Item Strata

The FNMC plan should describe the expected item population in terms of the following:

(1) type of item (i.e., stratum)

(2) expected range of the number of items within each stratum

(3) the average uranium and U-235 content of the items within each stratum

(4) the expected rate of item generation and consumption for each stratum

5.5 Conducting Physical Inventories

A description of the methodology, including cutoff and inventory minimization procedures, should be presented; and all measurements (including sampling) should be identified. The FNMC plan should contain sufficient information to show how the total in-process inventory for both uranium and U-235 is obtained.

The means for measuring or estimating residual process material (i.e., holdup) should be addressed in detail. The change or variation in such deposited holdup from one physical inventory to the next should also be discussed.

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 is to 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:

(1) organization and separation of functions

(2) assignment of inventory teams and their training in the use of uniform practices

(3) obtaining, verifying, and recording of source data

(4) control of inventory forms

(5) assurance that item counts verify the presence of each item while preventing any item from being counted more than once

(6) 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 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, should also be described. In addition, the FNMC 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 seals, 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 FNMC plan should describe the sampling plan. Such description should include:

(1) the method of segregating the types of items to be sampled (i.e., selected for remeasurement)

(2) the procedure for calculating the sample size (i.e., the number of items) for each stratum

(3) the parameter to be measured (e.g., gross weight or total U-235 content)

(4) the quality of the measurement methods used to verify original measurement values (for the parameter being measured)

(5) the procedure for reconciling discrepancies between original and remeasurement values, and for scheduling additional tests and remeasurements

(6) the basis for discarding an original SNM value and replacing it with a remeasurement value

One acceptable means 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 detection quantity 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 U-235 content per item (kilograms)
- g = DQ = detection quantity (kilograms U-235)

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 FNMC 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 decision 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 FNMC plan. For example, if the U-235 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 U-235 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 tamper-indicating devices 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.

5.6 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
U-235 ID $\geq$ 1.7(SEID) + 500 grams, and
U ID $\geq$ 1.7 (SEID) + 10 kg U

Significant ID problem
U or U-235 ID $\geq$ 3 (SEID)

Major ID problem
U-235 ID $\geq$ 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 FNMC plan should fully describe in definitive statements the minimum response actions for each ID action level.

5.7 Acceptance Criteria

A judgment that the applicant's or licensee's plan for physical inventories is acceptable will be based on (but not limited to) the following criteria:

- The FNMC plan contains adequate commitments to assure 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 insure that no SNM currently on hand (with the possible exception of holding account waste materials and residual holdup following cleanout that can be regarded as zero by definition) will be omitted and no quantity will be counted more than once.

- 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 must 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 shall 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 (that is too large to be regarded as zero by definition) remaining 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 due to such factors as oxidation, change in moisture content, commingling with materials of different enrichment or different composition, etc., the previously determined uranium and U-235 content may be accepted without verification of SNM content provided the gross weight and/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 prior to 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 U-235) 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 UO_2 powder into pellets and/or loading pellets into fuel rods), unless the 0.90 or 1.30 percent of throughput (as appropriate) is less than 25 kilograms U-235, in which case the DQ need not be less than 25 kilograms. The U-235 throughput is defined as the greater of "additional to process" or "removals from process" during a 12-month inventory period.

- The information in the FNMC plan shows 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 U-235 DQ for the inventory period in question. In general, a licensee may assume the ID distribution approximates a normal distribution, and therefore:

$$DT = DQ - 1.30(SEID)$$

Acceptable methodology for calculating the measurement error contribution to the SEID by error propagation is found in Jaech (1973), IAEA (1977), and Lumb and Tingey (1981). Special attention is given to inclusion of all applicable and measurable sources of error to avoid underestimating the SEID.

- In addition to the DT ID alarm limit [required by 10 CFR 74.31(c)(5)], 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 holdup and discards. Investigations are to be completed within 60 days after initiating the inventory (except when additional time is granted by the NRC for extenuating circumstances).

5.8 Affirmations

The 11 affirmation statements, given on pages 6 and 7 under section (5), and the first performance objective affirmation statement listed on page 5, related to physical inventories must be stated (without any modification) in the FNMC plan.

6 Item Control

6.0 Regulatory Intent

The intent of 10 CFR 74.31(c)(6) is to require licensees to implement item control procedures that protect against unauthorized and unrecorded removal of items, or of material from items, and that enable timely location of items. 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. In order to promptly locate a given item, sufficient current information must be recorded. These item control requirements apply only to items for which the total length of time that the item exists plus the length of time it takes to locate it (after having been recorded) exceeds 14 days. For example, if an item has been in existence for 10 days, the licensee must be capable of making a record of the item and locating the item within 4 days in order for the item to be exempt from the current knowledge requirement. Conversely, if the time to make a record of an item plus the time it takes to locate the item equals 4 days, then if the item exists for less than 10 days it need not be formally entered into the current knowledge system. Also in order to eliminate the need to keep records for insignificant quantities of SNM, waste containers and most solutions are exempt. Licensees are given some flexibility in controlling items by permitting an additional exemption of up to a total of 50 kilograms U-235 in items each containing less than 500 grams of U-235.

6.1 Organization

The FNMC plan should identify the individual responsible for overseeing the item control program by position title. Positions of those individuals who have significant item control program responsibilities should also be identified.

6.2 General Description

The applicant or licensee should state that the overall MC&A system maintains a record of all SNM items, regardless of quantity or duration of existence. In addition, the item control program should provide current knowledge of the location, identity, and quantity of all SNM contained in all items that are not exempt from item control. Items that can be exempt from item control program coverage are:

(1) items whose time of existence plus the time to record the item (since its generation) plus the time to locate the item is less than 14 calendar days

(2) any licensee-identified items listed by material type containing less than 500 grams of U-235 each but not to exceed a plant total of 50 kilograms of U-235

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

Each item that is not exempt from the item control program 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 program coverage, should have a unique identity. For items subject to the item control program, the following are acceptable means for providing unique identity:

(1) a unique alpha-numeric identification on a tamper-indicating seal applied to a container of SNM

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

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

Location designations shown by the MC&A records 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 FNMC plan. The MC&A record system should be controlled in such a manner 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.

6.3 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 tamper-indicating seal is the basis for providing unique item identity, the FNMC plan should:

(1) describe the type of seal used

(2) describe how the seals are obtained and what measures are implemented to ensure that duplicate (counterfeit) seals are not manufactured

(3) describe how the seals are stored, controlled, issued, and accounted for

(4) describe how seal usage and disposal records are maintained and controlled

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

6.4 Storage Controls

Item storage areas and controls should be fully described in the FNMC 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-indicating seals.

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

6.5 Item Monitoring Methodology and Procedures

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

(1) verifies that items shown in the MC&A records are actually stored and identified in the manner indicated in the records

(2) verifies that generated items and changes in item locations are properly recorded in the MC&A record system in a timely manner

(3) can detect, with high probability, any real loss of items, or uranium from items amounting to 500 grams or more of U-235

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

(1) 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 program records

(2) 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

(3) 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 FNMC 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.

6.6 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 9) of this document should be used to resolve item discrepancies.

6.7 Acceptance Criteria

A judgment that the licensee's FNMC plan for the control of items subject to the requirements of 10 CFR 74.31(c)(6) is acceptable will be based on (but not limited to) the following 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 exempt from the requirements for identification of each item if the group is 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 exempted from item control procedures must fall into at least one of the following categories:

  - Items that are in existence for only a relatively short period of time, as defined in 10 CFR 74.31(c)(6);

  - Waste destined for burial or incineration;

  - Solutions having less than a 5.00 grams U-235 per liter concentration; or

  - Items individually containing less than 500 grams U-235 each, not to exceed a total of 50 kilograms of U-235.

- The FNMC plan makes commitments for determining the total quantity of U-235 in items exempted from control on the basis that they contain less than 500 grams U-235 each, so as to assure that the total 50 kilogram U-235 limit is not exceeded.

- 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.

6.8 Affirmations

The four affirmation statements, given on pages 7 and 8 under section (6), relating to the current knowledge requirements of 10 CFR 74.31(c)(6) must be stated (without modification) in the FNMC plan.

7 Shipper-Receiver Comparisons

7.0 Regulatory Intent

The intent of 10 CFR 74.31 (c)(7) is to require the material control and accounting system to promptly detect and resolve all significant shipper-receiver (S/R) differences. S/R comparisons are important for confirming that either shippers' and receivers' values are acceptable for establishing the book accounting quantities associated with received material, or detecting unacceptable shippers' or receivers' values.

7.1 Receiving Procedures

Regardless of whether or not formal S/R evaluations are to be performed, the first action to be taken on receipt of SNM should be the verification of the number of items, the item identities, and the integrity of individual items and of tamper-indicating seals. Except for certain specified types of material, all SNM shipments received from an external supplier are to be subject to S/R comparisons. Such S/R 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. The FNMC plan should identify what material types, if any, are exempted from S/R evaluations. Receipt materials which may be exempted from S/R comparisons include:

(1) shipments containing less than 500 grams U-235;

(2) individual items containing less than 25 grams U-235 when the total shipment is less than 2000 grams U-235;

(3) encapsulated items, whose encapsulation integrity has not been compromised, and which are to be retained by the licensee as encapsulated items;

(4) fuel assemblies and fuel rods previously shipped by the licensee that are being returned, provided that the original encapsulation has not been compromised;

(5) UF_6 cylinders that are empty except for a heel quantity of UF_6 ; and

(6) Heterogeneous scrap that must be subject to dissolution before a meaningful accountability measurement can be obtained, and both shipper and receiver agree to accept the after dissolution plus residue" measurements for accounting purposes.

For any SNM received, the licensee must provide all appropriate information on the DOE/NRC Form 741 that accompanies the shipment. (NOTE: See NUREG/BR-0006 for instructions and requirements for completing DOE/NRC Form 741.)

7.2 Determination of Receiver's Values

For UF_6, the licensee may establish receiver's values by (1) measuring the U-235 isotopic concentration by NDA, (2) weighing each cylinder to determine net weight UF_6 (gross weight minus certified cylinder tare weight), and (3) applying a historical established percent uranium factor (that is periodically confirmed or updated by measurement). Such a 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 can usually 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 identify 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.

7.3 Evaluation of Shipper-Receiver Differences

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

$$\text{combined standard error} = [(\sigma_S)^2 + (\sigma_R)^2]^{1/2}$$

where

σ_S = shipper's measurement standard error
σ_R = 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:

$$\text{combined standard error} = [\, 2\, (\sigma_R)^2]^{1/2} = 1.414\, \sigma_R$$

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

7.4 Resolution of Significant Shipper-Receiver Differences

The FNMC plan should describe the steps involved with the investigation of 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 shipper's and receiver's weights differ by more than one-half of the total combined standard error.

7.5 Acceptance Criteria

A judgment that the applicant's licensee's FNMC plan for conducting S/R evaluations and resolving significant SRDs is acceptable will be based on (but not limited to) the following criteria:

- Each shipping container is inspected within 3 working days after receipt. If the integrity of a container is questionable, the presence of all items that were packaged in the shipping container are confirmed within 24 hours of discovering the questionable integrity.
- Confirmatory measurements of scrap shipments are performed by the receiver 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 a SRD is based on hypothesis 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.

7.6 Affirmations

The six affirmation statements, given on page 8 under section (7), relating to the resolution of significant shipper-receiver differences, as required by 10 CFR 74.31(c)(7), must be stated (without modification) in the FNMC plan.

8 Assessment and Review of the Material Control and Accounting Program

8.0 Regulatory Intent

The intent of 10 CFR 74.31(c)(8) is to require management to periodically review and assess the performance of the MC&A system and evaluate its overall effectiveness. It is intended that the review will be performed by knowledgeable, technically competent individuals free from conflicts of interest and that 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 to meet and satisfy regulatory intent are to be made.

8.1 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 FNMC plan should describe the assessment and review program in terms of:

(1) maximum interval between assessments

(2) selection procedures for the assessment team

(3) number of team members to be selected

(4) qualification and expertise of team members

(5) independence of individual team members from the MC&A responsibilities and activities they are reviewing and assessing

(6) 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 system, individual subsystems should be assessed at intervals no greater than 12 calendar months. Thus, the type of assessment (partial or total) and the maximum interval between assessments should be specified. "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 system 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 system 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 be dependent 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 system they review. The team should have authority to investigate all aspects of the MC&A system 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.

8.2 Report of Findings and Recommendations

The areas to be reviewed should encompass the entire MC&A system, 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 MC&A system effectiveness. The team report, as a minimum, should state findings pertaining to:

(1) organizational effectiveness to manage and execute MC&A activities

(2) management responsiveness to indications of possible losses of uranium

(3) staff training and competency to carry out MC&A functions

(4) reliability and accuracy of accountability measurements made on SNM

(5) effectiveness of the measurement control program in monitoring measurement systems and its sufficiency to meet the requirements for controlling and estimating both bias and SEID

(6) soundness of the material accounting records

(7) effectiveness of the item control program to track and to provide current knowledge of items

(8) capability to promptly locate items and effectiveness in doing so

(9) timeliness and effectiveness of SRD evaluations and resolution of excessive SRDs

(10) soundness and effectiveness of the inventory-taking procedures

(11) capability to confirm the presence of SNM

(12) 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 affected by the assessment.

8.3 Management Review and Response to Report Findings and Recommendations

Management should review the assessment report and take the necessary actions to correct MC&A system deficiencies. The management review should be documented within 30 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 FNMC plan should address resolution and follow-up 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.

8.4 Acceptance Criteria

A judgment that the applicant's or licensee's program for independent assessment of the MC&A program is acceptable will be based on (but not limited to) the following criteria:

- The periodic assessments will be comprehensive and sufficiently detailed to enable the assessment team to rate the MC&A system effectiveness, capability, and performance by comparison with the expected and required performance. The overall assessment objectives are to determine that the MC&A system, as designed and implemented, is continuing to meet the overall safeguards goals, and to identify weaknesses or deficiencies in the system 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 system 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 S/R difference evaluations and resolution of significant SRDs;
- Soundness of physical inventory procedures and practices;
- Effectiveness of the measurement control program 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; and
- 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.
- Personnel assigned to the assessment team will have an adequate understanding of the regulatory objectives and requirements of the MC&A system and will have sufficient knowledge and experience to be able to judge the adequacy of the parts of the system 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 system for which he or she has direct responsibility. Also, an individual "A" will not assess any part of the system that is the responsibility of person "B" if "B" is assessing an area under the responsibility of "A".
- The entire MC&A system 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 system and is demonstrated to be able to include any such changes made during the review/assessment). Conducting two or more assessments during a 24-month interval, in which only part of the MC&A system 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 a 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 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 on-site plant manager.

8.5 Affirmations

The seven affirmation statements, given on pages 8 and 9 under section (8), relating to the independent assessment and evaluation of the MC&A system effectiveness requirements of 10 CFR 74.31(c)(8) must be stated (without modification) in the FNMC plan.

9 Resolving Indications of Missing Uranium

9.0 Regulatory Intent

The intent of 10 CFR 74.31(a)(2) is for licensees to react to (i.e., investigate and resolve) any off-normal or abnormal conditions or situations that suggest a likelihood that 500 grams or more of U-235 may be missing (whether the cause is accidental or deliberate).

9.1 Methods and Procedures for Identifying Indicators

The FNMC plan should discuss the means by which the licensee will resolve indicators of missing uranium involving 500 grams or more of U-235. The licensee's resolution program should address the possible indicators of missing uranium. The FNMC plan should enumerate all the potential indicators that can be postulated and develop resolution procedures for each.

The following are examples of possible indicators of missing uranium:

(1) lack of agreement between a physical inventory and its associated book inventory in which the U-235 ID is positive and exceeds 1.7 times the SEID by more than 500 grams

(2) determination through the item control program that one or more items are not in their designated locations and the actual locations are not immediately known

(3) discovery that an item's integrity or its tamper-indicating seal was compromised

(4) information from the process control system indicating potential loss of material from the process system.

(5) an allegation of theft or diversion

9.2 System and Procedures for Investigating and Resolving Indicators

At least one major MC&A procedure should address the system and practices for investigating and resolving loss indicators because this topic pertains to one of the three performance objectives of 10 CFR 74.31(a). Thus, the licensee should have well-defined procedures for investigating indicators of possible missing uranium (involving 500 grams or more of U-235). Likewise, there should be established criteria for defining what constitutes resolution of an investigated indicator.

Resolution of an indicator means that the licensee has made a determination that loss 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 FNMC 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 of more than 500 grams of U-235 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 manner 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 NRC within 1 hour of its determination pursuant to 10 CFR 74.11. The FNMC plan should show the reasonable time allowed for resolution. In general, a time not exceeding 72 hours should be adequate.

9.3 Response Actions for Unresolved Indicators

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

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

(1) the potential quantity of U-235 involved

(2) 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)

9.4 Documentation Requirements

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

(1) investigation procedures

(2) resolution procedures

(3) reporting of indicator to MC&A management including date and time the indicator was reported, name of individual who discovered the indicator, and description of indication

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

(5) reports made to 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 NRC individual contacted

9.5 Acceptance Criteria

A judgment that the applicant's or the licensee's plan for resolving indications of missing SNM is acceptable will be based on (but not limited to) the following criteria:

Adequate commitments are provided to assure a high probability that any indicator of missing SNM that could involve 500 grams or more of U-235 will be (1) recognized as an indicator, (2) investigated, and (3) resolved.

- Investigation and resolution procedures will provide for adequate overchecks to assure 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 a loss or theft of SNM exceeding the current DQ shall be declared as completed but unresolved without first conducting a shutdown, cleanout inventory in which all unsealed SNM is remeasured for element and isotope.

9.6 Affirmations

The three affirmation statements pertaining to the 10 CFR 74.31(a)(2) performance objective, listed as bullets two, four, and five in the section at the top of page 5 ("Affirmations Pertaining to Performance Objectives"), must be stated (without modification) in the FNMC plan.

10 Informational Aid for Assisting in the Investigation and Recovery of Missing Uranium

10.0 Regulatory Intent

The 10 CFR 74.31(a)(3) performance objective pertains to investigations, relating to actual (or highly suspected) events pertaining to missing uranium, conducted by the NRC and/or other government agencies. The intent is for licensees to have ready for and to provide to the investigators any information deemed relevant to the recovery of material involved in a loss, or theft. The burden shall be on the licensee to provide (without being asked to) all information that it recognizes as being relevant, as opposed to only providing information that the investigators are knowledgeable enough to request.

10.1 Information Aid

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

(1) data or observations that led the licensee to determine that a loss or theft of uranium may have occurred

(2) data, observations, and assessments associated with attempts to resolve the indication of missing material

(3) the time period during which the material may have left the facility

(4) the path and means by which the material may have left the facility

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

(1) material accountability data records and reports

(2) inventory records

(3) inventory difference and propagation of error calculations

(4) inventory reconciliation reports

(5) indications of unrecorded or unauthorized removals of SNM from storage or process locations

(6) reports of apparent destruction or falsification of records pertaining to SNM

(7) records of broken tamper-indicating devices or compromised item integrity

(8) indications of unauthorized entry into SNM storage areas

(9) Reports from monthly item status inspections

(10) material receipt and log-in records

(11) results from shipper-receiver difference evaluations

(12) process quality assurance or production control records

(13) documentation relating to an alleged or confirmed theft

Information associated with resolving indications of missing uranium are provided in Chapter 9. This information and information that may be of aid in the recovery of missing material would include:

(1) the type of unauthorized activity detected

(2) the interval during which the loss may have occurred

(3) the amount of material and form of the material involved in the loss

(4) results of measures to validate indicators

(5) results of extended measures to resolve indicators

(6) results from special inventories (or reinventories) and tests performed

(7) audit results of the SNM accountability source data

(8) assessments of measurement data and measurement controls

(9) results from reviews of the material control and accounting program and status of corrective actions

(10) history of indicator investigation and resolution activities

(11) indicator investigation and resolution procedures and conclusions

(12) probable cause of the loss

(13) any abnormal events that may have contributed to or caused the loss

(14) 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 11.

10.2 Acceptance Criteria

A judgment that the applicant's or the licensee's plan for informational aid for assisting in the investigation and recovery of missing uranium is acceptable will be based on (but not limited to) the following criterion:

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

10.3 Affirmations

The affirmation statement pertaining to the 10 CFR 74.31(a)(3) performance objective listed as the third bullet in the "Affirmations Pertaining to Performance Objectives" section on page 5, must be stated (without modification) in the FNMC plan.

11 Recordkeeping

11.0 Regulatory Intent

The intent of 10 CFR 74.31(d) is to require the establishment, maintenance, and protection of a recordkeeping system that will demonstrate that the system capability requirements of 10 CFR 74.31(c)(1) through (8) have been met. Records are to be retained for at least three years (or longer if specifically required by regulations external to 10 CFR 74.31) thereby providing a means for assessing the performance of the MC&A system and inspecting for compliance with regulatory requirements.

11.1 Description of Records

The FNMC plan should identify all records, forms, reports, and standard operating procedures that must be retained for a minimum of 3 years, as required by 10 CFR 74.31(d). Such records should include, but are not limited to, the following:

(1) documents that define changes in the MC&A management structure or changes in responsibilities relating to MC&A positions;

(2) procedures pertaining to any accountability related measurement or sampling operation

(3) forms used to record or to report measurement data and measurement results, including source data

(4) forms and notebooks used to record calibration data associated with any accountability measurement system

(5) 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

(6) forms and official memos used to record or report measurement control program data, control limit calculations, and out-of-control investigations

(7) forms listing and providing instructions associated with physical inventories

(8) forms and formal worksheets used in the calculation of SEID, ID, and active inventory values

(9) ledgers, journals, and computer printout sheets associated with the accountability system

(10) ledgers, journals, and computer printout sheets associated with the item control program, including seal usage and "attesting to" records

(11) DOE/NRC forms 741 and 742

(12) forms, memos, and reports associated with identification of, investigation of, and resolution of significant SRDs

(13) loss indication and alleged theft investigation reports

(14) investigation reports pertaining to excessive IDs

(15) official reports containing the findings and recommendations of MC&A system assessments and any letters or memos pertaining to response actions to assessment team recommendations

(16) forms used for recording data associated with the item monitoring program

(17) monitoring program status or summary reports

(18) records of training sessions including date given, topics covered, name of instructor(s), names and signatures of those attending

(19) training, qualification, and requalification reports and records

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

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

The FNMC 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:

(1) the auditing system or program to verify the correctness and completeness of records

(2) the overchecks for preventing or detecting missing or falsified data and records

(3) the plan for reconstructing lost or destroyed SNM records

(4) the access controls used to ensure that only authorized persons can update and correct records

(5) the protection and redundance 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 74.31.

11.3 Acceptance Criteria

A judgment that the licensee's commitments for recordkeeping are acceptable will be based on (but not limited to) the following criteria:

- The FNMC plan shows that key material accounting and original source data documents and relevant reports and documents will be retained for three years or as long as needed to show continuing compliance with 10 CFR Part 74. (For example, records of the organization structure cannot be destroyed if the current structure is still the same.)

- 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 retained records and reports contain sufficient detail to enable NRC inspectors to determine that the control and accounting of the SNM has complied with the requirements of 10 CFR 74.31(c) and has met the general performance objectives of 10 CFR 74.31(a).

- 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 due to 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, in order to meet time restraints relative to their use. In general, the record retention system is to 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 6.7.

- Overchecks or other controls including access controls for updating and correcting

records are provided so as to prevent or detect errors in the records that would affect inventory difference and item location.

11.4 Affirmations

The affirmation statements relating to the recordkeeping requirements of 10 CFR 74.31(d) as listed on pages 9 and 10, must be stated (without modification) in the FNMC plan.

Glossary

The following terms are defined in the context of (1) their usage in this document and/or (2) how they should be used if contained in the fundamental nuclear material control (FNMC) plans submitted pursuant to 10 CFR 74.31.

ACCOUNTABILITY — The determination of, and current record maintenance of, special nuclear material (SNM) quantities associated with (1) receipts, (2) shipments, (3) measured discards, (4) transfers into or between material balance areas (MBAs) and/or item control areas (ICAs), and (5) total material on current inventory.

ACCOUNTANCY (ACCOUNTING) — The records (e.g., ledgers, journals, source documents, etc.) associated with accountability.

ACTIVE INVENTORY — 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 SNM material 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). The active inventory is used as an indicator of processing throughput and/or processing activity.

ADDITIONS TO INVENTORY — Quantities of SNM, of a given material type code, added to a "plant" inventory and which, prior to 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 caused by buoyancy is eliminated by 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 and/or controlling a measurement device or system. An assigned value may not necessarily be a certified value, but if not, should be traceable to a certified standard. In any event, it is the best estimate of the standard's true value.

BEGINNING INVENTORY — For each material type code, the total itemized quantity of SNM possessed by a facility at the start of a material balance period (i.e., inventory period). The beginning inventory 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 constant, unidirectional component of error that affects all members of a measurement data set. Thus, a bias can 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.

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 and/or certifies standards.

CHECK STANDARD (BENCH STANDARD, WORKING STANDARD) — A standard, not necessarily traceable to a primary standard, that 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 and/or isotope quantity assigned to such item. Confirmatory measurements are sometimes used as the basis for concluding that previous measurement values for uranium and U-235 (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.

CUSTODIAN — A designated individual who is responsible for (1) the control and movement of all SNM within a specified control area, and (2) maintaining records relative to all SNM that is transferred into or out of the area and that is currently located within the control area. Control areas are usually designated as MBAs or ICAs. From the standpoint of good safeguards practice, a single individual should not be a custodian of more than one control area.

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

DETECTION QUANTITY (DQ) — A site-specific U-235 quantity of SNM for licensees whose processing activities are limited to SNM 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 U-235. 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) probability at the time of a physical inventory.

DETECTION THRESHOLD (DT) — An inventory difference (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 detection quantity. The DT is a function of both the DQ and the standard error of the inventory difference (SEID), as shown by the following equation:

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

EFFECTIVE KILOGRAM — An effective kilogram of SNM means (1) for plutonium and U-233, their weight in kilograms; (2) for uranium with an enrichment in the isotope U-235 of 1.00 wt % (i.e., 0.01 g U-235/g U) and above, its element weight in kilograms multiplied by the square of its enrichment expressed as a decimal weight fraction; and (3) for uranium with an enrichment in U-235 below 1.00 wt %, but above 0.71 wt %, its element weight in kilograms multiplied by 0.0001.

ENDING INVENTORY — For each material type code, the total itemized quantity of SNM possessed by a facility at the end of a material balance period, as determined by a physical inventory. The ending inventory quantity for any given material balance period is (by definition) exactly equal to the beginning inventory quantity for the next period.

ENRICHED URANIUM — Any uranium-bearing material that does not qualify as natural uranium and whose combined U-233 plus U-235 isotopic content is 0.72 wt % or higher relative to total uranium elemental content.

FORMULA KILOGRAM (FKG)— The number of formula kilograms is computed by the following equation:

FKG =
[(grams U-235 contained in high-enriched uranium) + 2.5 (grams U-233 + plutonium)]
divided by 1000

FORMULA QUANTITY — Strategic SNM in any combination in a quantity of 5.00 FKGs or more.

HIGH-ENRICHED URANIUM (HEU) — Any uranium-bearing material whose U-235 isotopic content is 20.00 wt % or more relative to total uranium elemental content.

INVENTORY DIFFERENCE (ID) — The arithmetic difference between a book inventory and the corresponding physical inventory, calculated by subtracting ending inventory (EI) plus removals from inventory (R) from beginning inventory (BI) plus additions to inventory (A). Mathematically, this can be expressed as:

$$ID = (BI + A) - (EI + R)$$

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 and/or prior period adjustment associated with the ID value.

ITEM — Any discrete quantity or container of SNM, not undergoing processing, having a unique identity and also having assigned uranium and U-235 quantities.

ITEM CONTROL AREA (ICA) — An identifiable physical area for the storage and control of SNM items. Control of items moving into or out of an ICA is by item identity and SNM quantity as determined from previous measurement.

ITEM CONTROL PROGRAM — A system that tracks (i.e., records) the creation, identity, location, and disposition of all SNM items of certain predetermined item categories. In addition, item control programs usually provide a periodic verification of item existence and location for static items.

LOW-ENRICHED URANIUM (LEU) — Any uranium-bearing material whose U-235 isotopic content is greater than 0.72 wt % but less than 20.00 wt % relative to total uranium elemental content.

MATERIAL BALANCE — A comparison on a measured basis of beginning inventory plus additions to inventory to ending inventory plus removals from inventory for a given control area (or combination of control areas) over a specified period of time.

MATERIAL BALANCE AREA (MBA) — An identifiable physical area for the physical and administrative control of nuclear material such that the quantity of nuclear material being moved into or out of the MBA is represented by a measured value (for both element and isotope).

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 by-product 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 DOE/NRC Form 742, material code 20 has 4 subcodes to denote enrichment range: E1, E2, E3, and E4. For NRC Form 327, material code 20 has 2 subcodes: LEU and HEU.

**Uranium materials should be regarded as material code 70 if the U-233 isotopic abundance is greater than (1) 10.00 wt % relative to total uranium elemental content or (2) both (a) the U-233 isotopic abundance is greater than the U-235 isotopic abundance and (b) the U-233 isotopic abundance exceeds 5.00 wt % relative to total elemental uranium content; otherwise report as material code 10, 20, or 81, as appropriate.

***Plutonium materials should be regarded as material code 83 if the plutonium-238 isotopic abundance is greater than 10.00 wt % relative to total plutonium elemental content; otherwise, report as material code 50.

MEASURED DISCARD — A batch or quantity of waste, whose SNM content has been determined by measurement, that (1) has been shipped to a disposal site, released to the environment, or stored on site, and (2) has been taken off the accounting ledgers as part of the current inventory of possessed SNM.

MEASUREMENT — The process of determining a (1) uranium elemental concentration, (2) specific uranium isotopic content, (3) U-235 enrichment (i.e., isotopic abundance), (4) bulk material mass or item mass, or (5) bulk material volume. Measurement values are derived through a calibration process that establishes the relationship between instrument (i.e., device) response and the parameter being determined.

MEASUREMENT CONTROL PROGRAM — A managed program 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 % U-238, 0.711 wt % U-235, and 0.006 wt % U-234.

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 U-233 plus U-235 and (2) at least 99.200 wt % in U-238. (NOTE: All natural uranium having a U-235 isotopic abundance in the range of 0.700 wt % to 0.724 wt % is normal uranium, but not all normal uranium is natural uranium.)

PHYSICAL INVENTORY — A determination by physical means (visual and measurement) of the quantity of SNM on hand for a given material type code at a specified point in time. The primary purpose for a physical inventory is to confirm the absence of (or to detect) a loss, theft, or diversion of SNM. For the conclusion drawn from a physical inventory to be meaningful, not only does the physical presence of all material (or at least the vast majority of the material) need to be confirmed, but the quantities of material in the inventory also need to be remeasured, or other assurance provided, to verify that prior measurements are still valid. Physical inventories are to be conducted on a "plant" as well as on a "material type code" basis.

PLANT — For SNM control and accounting purposes, a plant is defined as a set of processes or operations (on the same site, but not necessarily all in the same building) coordinated into a single manufacturing, research and development, or testing effort. Most licensees have only one plant in this context. Independent on-site manufacturing efforts, such as a scrap recovery operation serving both on-site and off-site customers, should be treated as separate plants.

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, etc.), 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 and/or certifies standards.

PRIOR PERIOD ADJUSTMENT — Any correction (i.e., adjustment) to an ID value because of a correction applied to a component of beginning inventory after the inventory period started. Such corrections may be due to resolution of a shipper-receiver difference (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 beginning inventory 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, etc.) 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.

RANDOM ERROR — The variation encountered in all measurement work, characterized by the random occurrence of both positive and negative deviations from a mean value.

RECEIPT — A quantity of SNM in a shipment received by a facility from another facility.

REFERENCE STANDARD — A material, device, or instrument whose assigned value is traceable to a national standard (i.e., primary standard) or nationally accepted measurement system.

REMOVALS FROM INVENTORY — All measured quantities of SNM falling within the categories of (1) shipments, (2) measured discards released to the environment, (3) measured discards transported off-site, and (4) measured discards stored on-site and formally transferred in the accounting records to a holding account via a DOE/NRC Form 741 transaction.

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's and receiver's values are based on measurement.

SPECIAL NUCLEAR MATERIAL (SNM) — (1) Plutonium, U-233, uranium enriched in U-235, and any other material that the NRC, pursuant to the provisions of Section 51 of the Atomic Energy Act of 1954 (as amended), determines to be SNM; or (2) any material artificially enriched in any of the foregoing. There are three levels of strategic significance applied to SNM, depending on the type and quantity, defined as follows:

SNM OF HIGH STRATEGIC SIGNIFICANCE — Same as FORMULA QUANTITY (see definition).

SNM OF MODERATE STRATEGIC SIGNIFICANCE — (1) Less than a formula quantity, but more than 1,000 grams of U-235 contained in HEU, or more than 500 grams of U-233 or plutonium, or more than a combined quantity of 1,000 formula grams when formula grams are computed by the following equation:

formula grams = (grams U-235 in HEU) + 2 (grams U-233 + grams Pu)

or (2) 10,000 grams or more of U-235 contained in LEU enriched to 10.00 wt % or more, but less than 20.00 wt %, U-235.

SNM OF LOW STRATEGIC SIGNIFICANCE — (1) Less than an amount of SNM of moderate strategic significance, but more than 15 grams of (a) U-235 contained in HEU, (b) U-233, (c) plutonium, or (d) any combination thereof; (2) less than 10,000 grams but more than 1,000 grams of U-235 contained in LEU enriched to 10.00 wt % or more (but less than 20.00 wt %) U-235; or (3) 10,000 grams or more of U-235 contained in LEU enriched above natural but less than 10.00 wt % U-235.

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

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:

$$\text{std. dev.} = \left[\frac{\sum_{i=1}^{n} (x_i - x)^2}{n - 1} \right]^{1/2}$$

where

n = number of measurements performed
x_i = the value obtained for the i th measurement for i = 1, 2, 3 .....n
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 ERROR OF THE INVENTORY DIFFERENCE (SEID) — For licensees subject to 10 CFR 74.31 or 74.33, non-measurement contributions to the uncertainty of ID can be assumed or estimated, but can not exceed the measurement contribution. Thus for 74.31 and 74.33 licensees, SEID is equal to the square root of the sum of both measurement and non-measurement variances associated with the ID.

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.

TRACEABILITY — The ability to relate individual measurement results to national standards (i.e., primary standards) or nationally accepted measurement systems through an unbroken chain of comparisons.

VERIFICATION MEASUREMENT — (1) An 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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11. ABSTRACT (200 words or less)

This report documents a standard format suggested by the NRC for use in preparing fundamental nuclear material control (FNMC) plans as required by the Low Enriched Uranium Reform Amendments (10CFR 74.31). This report also describes the necessary contents of a comprehensive plan and provides example acceptance criteria which are intended to commjnicate acceptable means of achieving tbe performance capabilities of the Reform Amendments. By using the suggested format, the licensee or applicant will minimize administrative problems associated with the submittal, review and approval of the FNMC plan. Preparation of the plan in accordance with this format will assist the NRC in evaluating the plan and in standardizing the review and licensing process. However, conformance with this guidance is not required by the NRC. A license applicant who employs a format that provides a equal level of completeness and detail may use their own format. This document is also intended for providing guidance to licensees when making revisions to their FNMC plan.

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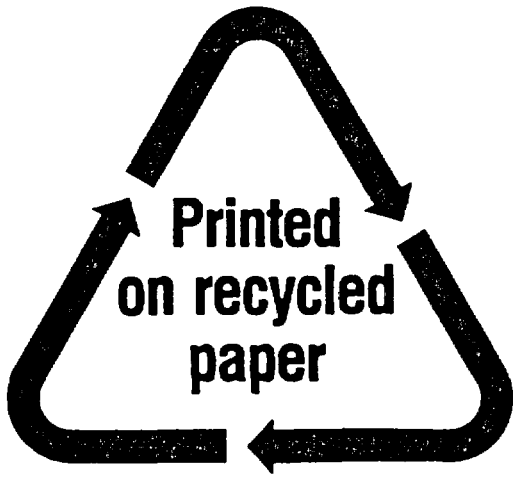

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