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(Proposed New Regulatory Guide)

PHYSICAL INVENTORIES AND MATERIAL BALANCES AT FUEL CYCLE FACILITIES

A. INTRODUCTION

Purpose

This regulatory guide (RG) describes approaches and methods that the U.S Nuclear Regulatory Commission (NRC) staff considers acceptable for licensees and applicants to use when developing material control and accounting (MC&A) system capabilities required by Title 10 of the *Code of Federal Regulations* (10 CFR), Part 74, "Material Control and Accounting of Special Nuclear Material" (Ref. 1). This RG pertains to the performance, evaluation, and reporting of physical inventories and material balances at fuel cycle facilities.

Applicability

This RG applies to fuel cycle licensees that are licensed under 10 CFR Part 70, "Domestic Licensing of Special Nuclear Material," and to Part 70 licensees that are further subject to 10 CFR Part 74 because they possess and use: special nuclear material of low strategic significance; special nuclear material of moderate strategic significance; formula quantities of strategic special nuclear material; or uranium source material and equipment capable of producing enriched uranium. This RG does not apply to licensees of power reactors, research and test reactors, or independent spent fuel storage installations.

Applicable Rules and Regulations

- 10 CFR 74 Subpart C, "Special Nuclear Material of Low Strategic Significance" (Ref. 2), requires licensees of fuel fabrication facilities and uranium enrichment facilities to implement and maintain an NRC-approved MC&A system that achieves the general performance objectives delineated in subparagraphs 74.31(a) (applicable to fuel cycle facilities other than uranium enrichment facilities) and 74.33(a) (applicable to uranium enrichment facilities). Subparagraphs

74.31(c) and 74.33(c) require that these licensees' MC&A systems provide capabilities related to physical inventories and material balances of special nuclear material (SNM) of low strategic significance, to achieve the performance objectives. Note that as stated under 74.33(b), the performance objectives applicable to uranium enrichment facilities also cover source material (SM) and depleted uranium (DU).

- 10 CFR 74 Subpart D, "Special Nuclear Material of Moderate Strategic Significance" (Ref. 3), requires that a licensee authorized to hold this type of SNM implement and maintain an NRC-approved MC&A system that achieves the general performance objectives delineated in subparagraph 74.41(a). Subparagraph 74.41(c) requires that a licensee's MC&A system provide capabilities related to physical inventories and material balances of SNM of moderate strategic significance, to achieve the performance objectives.

- 10 CFR 74 Subpart E, "Formula Quantities of Strategic Special Nuclear Material" (Ref. 4), requires that a licensee authorized to hold this type of SNM establish, implement, and maintain an NRC-approved MC&A system that achieves the general performance objectives delineated in subparagraph 74.51(a). Subparagraph 74.51(b) requires that a licensee's MC&A system provide capabilities related to physical inventories and material balances of formula quantities of strategic SNM to achieve the performance objectives.

- 10 CFR 74 Subpart B, "General Reporting and Recordkeeping Requirements" (Ref. 5), includes requirements for the fuel cycle facility licensees authorized to hold the above types of SNM, on (1) notifying the NRC of any loss or theft or other unlawful diversion of SNM or any incident in which an attempt has been made to commit a theft or unlawful diversion of SNM, pursuant to 10 CFR 74.11; (2) the periodic transmittal of material balance reports to the Nuclear Materials Management and Safeguards System (NMMSS) data base, pursuant to 10 CFR 74.13; (3) the periodic transmittal of material transaction reports to NMMSS, pursuant to 10 CFR 74.15; and (4) submitting periodic SNM physical inventory summary reports to the NRC pursuant to 10 CFR 74.17. These and related reporting topics are discussed in Section C below under "Reports."

Related Guidance

- NUREG-1280, "Standard Format and Content Acceptance Criteria for the Material Control and Accounting (MC&A) Reform Amendment" (Ref. 6), provides additional guidance on physical inventories and material balances for licensees authorized to hold formula quantities of strategic special nuclear material (SSNM).

- NUREG-1065, "Acceptable Standard Format and Content for the Fundamental Nuclear Material Control (FNMC) Plan Required for Low-Enriched Uranium Facilities" (Ref. 7), provides additional guidance on physical inventories and material balances for licensees authorized to hold SNM of low strategic significance.

- NUREG/CR-5734, "Recommendations to the NRC on Acceptable Standard Format and Content for the Fundamental Nuclear Material Control (FNMC) Plan Required for Low-Enriched Uranium Enrichment Facilities" (Ref. 8), provides additional guidance on physical inventories and material balances for enrichment facility licensees authorized to hold SNM of low strategic significance.

- NUREG/CR-4604 (PNL-5849), "Statistical Methods for Nuclear Material Management" (Ref. 9), provides additional guidance on physical inventories and material balances.

Purpose of Regulatory Guides

The NRC issues RGs to describe to the public methods that the staff considers acceptable for use in implementing specific parts of the agency's regulations, to explain techniques that the staff uses in evaluating specific problems or postulated accidents, and to provide guidance to applicants. Regulatory guides are not substitutes for regulations and compliance with them is not required. Methods and solutions that differ from those set forth in RGs will be deemed acceptable if they provide a basis for the findings required for the issuance or continuance of a permit or license by the Commission.

Paperwork Reduction Act

This RG contains and references information collections covered by 10 CFR Part 74 that are subject to the Paperwork Reduction Act of 1995 (44 U.S.C. 3501 et. seq.). As reflected in 10 CFR 74.8, the MC&A information collections were approved by the Office of Management and Budget (OMB), under control number **3150-0123**

Public Protection Notification

The NRC may not conduct or sponsor, and a person is not required to respond to, a request for information or an information collection requirement unless the requesting document displays a currently valid OMB control number.

B. DISCUSSION

Reason for Issuance

This new RG is being issued to provide implementing guidance for the applicable NRC requirements in the 10 CFR Part 74 regulations (as referenced above) that are related to physical inventories and material balances at fuel cycle facilities. Guidance on these requirements was previously provided in RG 5.13, "Conduct of Nuclear Material Physical Inventories" (Ref. 10), and RG 5.33, "Statistical Evaluation of Material Unaccounted For" (Ref. 11), but these RGs became outdated after 10 CFR Part 74 was revised. Accordingly, RG 5.13 and RG 5.33 are being withdrawn. In addition, this new RG provides updated guidance for uranium enrichment facilities by incorporating relevant guidance from NUREG-1280, NUREG-1065, and NUREG/CR-5734, without making substantive changes to that guidance.

Background

Guidance was provided by the U.S. Atomic Energy Commission (AEC) and the NRC for satisfying the MC&A regulations issued in 1973-1975 under 10 CFR 70.51-70.58. As discussed below, these regulations were later revised or deleted in consolidating MC&A requirements in 10 CFR Part 74. The associated RGs 5.13 and 5.57 thus became outdated. The current MC&A regulations reflect significant advances that have been made in using modern computer systems for controlling, tracking, and documenting the internal movements and locations of nuclear material. As a result, manually recorded documentation system capabilities are typically augmented with secured mainframes and terminals for electronic transfer entries and digital signatures.

Although the NRC until now had not updated RGs 5.13 and 5.33, it had developed key guidance as part of the rulemaking process from 1985 to 2002. Such guidance was provided in NUREG-1280 for facilities with formula quantities of strategic special nuclear material, NUREG-1065 for low enriched fuel fabrication facilities, and in NUREG/CR-5734 for uranium enrichment plants. As a result, those NUREGs are typically referenced by NRC licensing standard review plans, including criteria closely applied by the NRC staff for reviewing the adequacy of Fundamental Nuclear Material Control (FNMC) plans submitted by licensees and applicants describing how their MC&A systems meet required performance objectives. This, among other things, pertains to each plan's coverage of physical inventories and material balances. NUREG-1280, NUREG-1065, and NUREG/CR-5734 also include guidance on various MC&A aspects relevant to physical inventories and material balances, namely, management organization, measurements, measurement control, statistics, recordkeeping, and resolving indications of missing SNM. This new RG updates and consolidates guidance from RGs 5.13 and 5.33, and incorporates relevant guidance from the four NUREGs referenced in Section A above.

1. Current Risk-Informed and Performance-Based Regulations

From 1985 to 2002, the NRC conducted four major rulemakings revising the MC&A regulations and consolidating them in 10 CFR Part 74. These risk-informed and performance-based regulations are applicable to major fuel cycle facilities authorized to possess more than 1 effective kilogram of SNM in unsealed form. These rulemakings revised the requirements for taking physical inventories and evaluating inventory results. Required time intervals between facility physical inventories were lengthened. This change increased material flow and active inventory amounts, making external and internal transfers larger factors (e.g., both in resolving inventory differences (IDs) and in reconciling book inventories to the results of physical inventories). The revised MC&A requirements were also graded and made commensurate with the strategic significance of the SNM being held. This graded nature of the MC&A

requirements is shown in the following discussion regarding the MC&A regulations in 10 CFR Part 74 subparts C, D, and E, and the different categories of SNM that each of these subparts cover.

"*Strategic special nuclear material*" (SSNM) is a defined term in 10 CFR 74.4 meaning "uranium-235 (contained in uranium enriched to 20 percent or more in the U^{235} isotope), uranium-233, or plutonium." Linked to this definition is the 10 CFR 74.4 term *Formula quantity*, meaning SSNM "in any combination in a quantity of 5,000 grams or more computed by the formula, grams = (grams contained U-235 + 2.5 (grams U-233 + grams plutonium)" that is often referred to as a "Category I quantity of material." Similarly, fuel cycle facilities authorized to hold a formula quantity of SSNM are often referred to as Category I facilities. Commensurate with the high strategic significance of SSNM in quantities of 5,000 grams or more, Category I facilities are subject to the rigorous set of MC&A regulations in Part 74 subpart E.

The Part 74 subpart D regulations are applicable to SNM of "moderate strategic significance." The 10 CFR 74.4 definition of this term refers to both quantity and the uranium's enrichment level, and covers the following two sets of NRC-licensed material: (1) 10,000 grams or more of any uranium enriched in the U-235 isotope in levels ranging from 10% to 20%; and (2) 1,000 to 5,000 grams of any uranium enriched in the U-235 isotope in levels above 20%. These two sets of enriched uranium are often referred to as Category II quantities of material, and fuel cycle facilities authorized to hold such SNM are referred to as Category II facilities.

The Part 74 subpart C regulations are applicable to SNM of "low strategic significance." Similar to the above, such SNM is defined with respect to quantity and the uranium's enrichment level, and its 10 CFR 74.4 definition covers the following three sets of NRC-licensed material: (1) 10,000 grams or more of uranium-235 contained in uranium enriched above natural, but less than 10 percent in the U235 isotope; (2) 1,000 to 10,000 grams of any uranium enriched in the U-235 isotope in levels ranging from 10% to 20%; and (3) 15 to 1000 grams of any uranium enriched in the U-235 isotope in levels above 20%. These three sets of enriched uranium are often referred to as Category III quantities of material, and fuel cycle facilities that are authorized to hold any of these defined categories of SNM are accordingly referred to as Category III facilities.

As indicated above, the subpart C, D and E regulations in Part 74 move from a less to a more rigorous set of MC&A requirements, and each contains graded general performance objectives that the MC&A system must be capable of achieving. Each licensee, certificate holder, or applicant subject to the subpart C, D or E regulations must submit to the NRC an FNMC plan (in accordance with 74.31(b), 74.33(b), 74.41(b), or 74.51(c), as applicable) showing that its MC&A system meets the general performance objectives. An FNMC plan describes the licensee's MC&A system capabilities, including those capabilities related to shipping, receiving, and making internal transfers of SNM (or of SSNM in the case of Category I facilities). An FNMC plan also includes procedures for investigating and resolving significant indicators of SNM (or SSNM) theft, diversion, or other unidentified loss mechanisms.

For threat considerations, the subpart D MC&A regulations under 10 CFR 74.41 contain system capability requirements applicable to Category II facilities. In accordance with 10 CFR 74.41(c), such facilities must incorporate checks and balances that are sufficient to detect falsification of data and reports that could conceal the diversion of SNM by a single individual, including an employee in any position, or collusion between two individuals, one or both of whom have authorized access to SNM. The subpart E MC&A regulations in 10 CFR 74.51(b) contain similar system capability requirements applicable to Category I facilities to prevent the diversion of SSNM. These requirements generally underscore the importance of tamper-safing and cross-checking controls to ensure the integrity of transfers and the continued validity of their assigned SNM (or SSNM) contents.

2. Physical Inventories, Material Balances, and Inventory Differences

Done properly, material balance accounting maintains a record of the SNM possessed by a facility based on the results of the last inventory and ensuing input and output data, and then comparing and reconciling that recorded (book) inventory quantity with the results of another physical inventory. The periodic performance of physical inventories and the evaluation of resulting IDs confirms the actual physical presence of SNM holdings (in various forms and assigned locations) at specified times. This entails determining on a measurement basis the SNM content of all receipts and disbursements, maintaining records of those transactions, and counting and measuring the quantity of material on hand.

Comparisons verify the accuracy and reliability of accounting records while ferreting out anomalies to trigger corrective action. Such comparisons involve detecting, investigating, and resolving discrepancies (e.g., book-physical IDs or, for short, IDs). A positive ID indicates a possible loss, which could be due to theft, diversion, or an unidentified loss mechanism. A negative ID denotes a potential gain that, for example, might be due to a measurement bias or recording errors. An ID estimator is expected to be zero plus or minus measurement error, although various non-measurement errors can also be contributors to IDs.

Regulations in 10 CFR 74.4 define an ID as the arithmetic difference obtained by subtracting the quantity of SNM tabulated from a physical inventory from the book inventory. The book inventory is defined as being equivalent to the beginning inventory (BI) plus additions to inventory (A) minus removals from inventory (R) while the physical inventory quantity is the ending inventory (EI) for the material balance period in question (as physically determined). Mathematically, ID = (BI + A - R) – EI, or BI + A - R - EI.

As noted, the ID estimator is subject to measurement uncertainty, which is statistically estimated in terms of multiples of the standard error of the ID (SEID). Section 74.4 defines an SEID as meaning the standard deviation of an ID that takes into account all measurement error contributions to the components of the ID. While the size and sign direction of an ID may be caused by theft, diversion, or measurement errors, other contributors could be non-measurement errors, for example, recording mistakes or omissions and unmeasured process holdup or discards. For facilities possessing only SNM of low strategic significance, licensees can take limited credit for non-measurement contributors to the ID. While it is very difficult to rigorously quantify and propagate non-measurement contributors in the uncertainty associated with an ID, Category III facilities (i.e., those subject to the requirements in 10 CFR Part 74, subpart C) are permitted to assume that the total non-measurement contribution to ID equals the total measurement error contribution.

The statistical power to detect anomalies (i.e., the probability of detecting excessive IDs in the face of such uncertainties) is particularly important in testing the significance of IDs, where the power to uncover a significant loss generally increases as SEID decreases. Conversely, assurance that the SNM on record has not been lost, stolen, or diverted is provided if there are no significant unresolved discrepancies. After the causes of excessive IDs have been investigated and resolved, the plant and subsidiary book inventories should be reconciled; that is, adjusted to the results of the physical inventory.

Various inventorying and reporting requirements may also apply to source material used in processing SNM (e.g., at uranium enrichment facilities) as well as for high-enriched uranium (HEU) down-blending operations and mixed-oxide (MOX) facilities.

3. Typical Item Strata

In 10 CFR 74.4, *item* is defined as any discrete quantity or container of SNM or SM, not undergoing processing, having a unique identity and also having an assigned element and isotope quantity. The facility's MC&A procedures should describe the expected items for inventorying typically in terms of the following:

- type of item (stratum),
- expected range of the number of items,
- average elemental and isotopic content of the items within each type, and
- expected rate of item generation and consumption for each stratum.

The SNM content of groups of like items can be determined by averaging the typical measured contents of representative samples from that material at the time of the inventory, if the licensee demonstrates that any additional uncertainty resulting from the averaging method is included in the SEID estimator.

4. Static and Dynamic Physical Inventories

4.1 Static (Shutdown) Conditions

The Part 74 subpart C regulations require an annual physical inventory of all SNM held by the licensee. Such an inventory is typically referred to as a static (shutdown) inventory.

The set of Part 74 subpart C regulations applicable to uranium enrichment plants include requirements in 10 CFR 74.33(c)(4) for the bimonthly dynamic (non-shutdown) inventorying of in-process uranium and Uranium (U)-235, as discussed in Section 4.2 below. Regarding the required annual static inventory conducted at enrichment plants, 10 CFR 74.33(c)(4)(i) specifies that the inventory must cover all uranium and uranium U-235 that is contained in natural, depleted, and enriched uranium located outside of the enrichment processing equipment. As further stated in 10 CFR 74.33(c)(4)(i), when conducted in conjunction with a dynamic inventory, the static inventory provides "a total plant material balance."

The Part 74 subpart D regulations applicable to Category II facilities specify a more rigorous set of MC&A requirements for physical inventory than the requirements of subpart C that are applicable to Category III facilities. For example, 10 CFR 74.43(c)(7) requires inventories every 9 months instead of annually. In addition, 10 CFR 74.43(c) requires: (1) various cutoff procedures for transfers, records and reports; (2) instructions for process shutdown and cleanout; (3) the listing of measured values by element and isotope: and (4) the basis for accepting previously made measurements and their limits of error.

The Part 74 subpart E regulations applicable to Category I facilities specify a more rigorous set of requirements for physical inventory than the requirements of subparts C and D. For example, 10 CFR 74.59(f)(1) requires inventories every 6 months. In addition, 10 CFR 74.59(f) requires procedures for tamper-safing containers or vaults containing SSNM not in process, and the re-measurement of material previously measured but whose validity has not been ensured by tamper-safing or equivalent protection.

4.2 Dynamic (Non-Shutdown) Conditions

Enrichment levels authorized for uranium enrichment facilities are at LEU levels; however, enrichment facilities differ from LEU fuel fabrication facilities in that they possess equipment that could be covertly used to produce, under complex operating conditions, SNM of moderate and high strategic significance. That calls for additional controls at uranium enrichment facilities, for example, dynamic

inventories every 2 months and the inventorying of both SNM (which hypothetically might be covertly recycled by a potential adversary to attain higher enrichment levels) and SM (which might be clandestinely used as process feed material).

Inventory differences resulting from dynamic inventories may be calculated with a book inventory quantity based on a "running book inventory in-process inventory" (RBIPI) determination. First, the cumulative amount of SNM and SM introduced into the enrichment process since the last physical inventory (cumulative inputs or CI) is added to the quantity that was in the process beginning at that time (beginning inventory or BI). Next, the cumulative amount of nuclear material removed during that same time span (cumulative outputs or CO) is subtracted, resulting in an RBIPI, which serves as the book inventory for comparison with the successive ending dynamic inventory (EI) to determine the in-process ID. Mathematically –

$$RBIPI = BI + CI - CO$$

$$ID = RBIPI - EI \text{ or } (BI + CI) - (CO + BI).$$

Harmonization with International Standards

The International Atomic Energy Agency (IAEA) has established a nuclear services series of guides and standards that constitute nuclear materials controls and accounting. IAEA services series guides present the international expectation to assist member States when striving to achieve the appropriate levels of safeguards. Pertinent to this regulatory guide, chapters 2, 4 and 5 of IAEA Nuclear Services Series No. 15, "Nuclear Material Accounting Handbook" (Ref. 12), issued May 2008, provides recommendations for best practices and methods used to account for nuclear material. While 10 CFR Part 74 pertains to material control and accounting of special nuclear material, this regulatory guide incorporates similar guidelines and is consistent with the principles provided in the IAEA Nuclear Services Series No. 15.

C. STAFF REGULATORY GUIDANCE

Graded general performance objectives are stipulated category-by-category in subparts C (10 CFR 74.31 and 10 CFR 74.33), D (10 CFR 74.41) and E (10 CFR 74.51) of 10 CFR Part 74. Facilities should describe in procedures the system capabilities satisfying those performance objectives pertaining to physical inventories and material balances. For example, the procedures for confirming the presence and locations of SNM while detecting, investigating and resolving excessive IDs that may have resulted from either theft, diversion or other unidentified loss mechanisms. The factors presented below should be considered in performing physical inventories and determining material balances.

1. General Guidance

a. Licensees and applicants should subdivide their facility into a sufficient number of areas to enhance the effectiveness and efficiency of required system capabilities for meeting performance objectives, for example, to facilitate the taking or physical inventories and, in turn, localizing the causes of potential SNM losses in the investigation and resolution of excessive IDs.

b. Individuals should be designated for each area, with the responsibility for having knowledge of the placement and movement of all SNM within each specified area and for various MC&A controls (e.g., counter-signing). Different areas should have different responsible individuals.

2. Postulated Insider Threat

a. Category I & II facilities should have checks and balances that are sufficient to detect falsification of data that conceal diversion of SNM by (1) a single individual, including an employee in any position; or (2) collusion between two individuals, one or both of whom have access to SNM. Category I facility plans and procedures should go further by stipulating the coverage of collusion between an individual with MC&A responsibilities and another individual who has responsibility or control within both the physical protection and the MC&A systems.

b. Category I & II facilities should describe in FNMC plans and procedures how, through the overall management structure, separation of functions, over-checks, and other checks and balances, the facility separates inventory-related functions from each other to provide cross-checks to counter deceit and falsification while increasing system reliability.

3. General Descriptions and Organization, Procedures, and Schedules

a. Licensees and applicants should provide in their FNMC plans and MC&A procedures a general description on how static and dynamic physical inventories will be planned, conducted, evaluated, recorded, and reported. This should include a definitive statement that physical inventory functions and responsibilities will be reviewed comprehensively with the assigned individuals before starting such inventories.

b. FNMC plans and MC&A procedures should explain the makeup and duties of the typical physical inventory organization and scheduling. The individual having responsibility for the coordination of the inventory effort should be identified by position title. The licensee should also indicate how the preparation and modification of inventory procedures are to be controlled.

c. For static inventories, a book inventory derived from the MC&A record system should be generated immediately prior to the actual start of the EI. Such listings should include all SNM

that the records indicate should be on hand at the inventory cutoff time (except for in-process SNM to be covered with a dynamic inventory conducted in conjunction with the static inventory). An in-process book inventory listing (RBIPI) for comparison with dynamic EI results should also be prepared.

d. The facility management structure should ensure that the overall planning, coordination and administration of physical inventorying responsibilities is vested in a single individual, who should also be responsible for the completeness, reliability and integrity of records and reports of inventory and ID results.

e. The assignment of physical inventory functions in the licensee organization should provide a separation of functions so that the activities of one individual or organizational unit serve as independent controls over and checks of others.

4. General Implementation Stages

Three implementing stages should be developed for physical inventories:

(1) organization and preparation of the inventory;

(2) performance of the inventory; and

(3) evaluation of IDs, that is, identifying excessive IDs and their investigation, resolution and reconciliation.

4.1 Organization and Preparation Stage

a. The general functions and dynamics of the planning stage should emphasize facility management structure and personnel, and personnel training and qualification.

b. Special attention should be given to the acquisition and use of supporting computing systems and area terminals and data bases, e.g., implications for pre-listings, the stoppage of material movement, tamper-safing status, and later startup.

c. The licensee should consider the following in the organization and preparation phase:

(1) preparing the facility for a physical inventory (e.g., whether it is static or dynamic and what process shutdown, drain-down and cleanout are to be carried out),

(2) determining how inventory pre-listings are to be utilized and verified,

(3) identifying applicable means for controlling and using inventory listing forms and tags,

(4) applying cutoff procedures for SNM processing, transfers and record adjustments to ensure an accurate recording of material transactions and inventory listings,

(5) organizing the inventory teams, including crosschecks to minimize mistakes and counter attempts to falsify data to conceal theft or diversion,

(6) identifying controls and procedures for accepting prior SNM values without confirmatory measurements,

(7) describing the measurement methods and measurements that are needed for confirming previously established measured values not tamper-safed,

(8) identifying techniques that are to be used to ensure that all SNM is inventoried and that none is counted more than once,

(9) planning the degree that scrap or inventory is to be reduced, process holdup is to be cleaned out, and residual holdup is to be measured,

(10) specifically identifying all areas to be inventoried and the individuals responsible for all inventory activities within each area,

(11) specifically naming the personnel who will function as inventory team leaders and team members for each designated area, and

(12) specifically identifying measurement or process cleanout activities unique for the particular inventory (e.g., for dynamic inventories or for re-inventorying as part of a response to an excessive ID).

4.2 Performance Stage

a. The conduct of physical inventories should include cross-checking the accuracy and integrity of inventory line items and computerized data entry and generation. This should include describing checks and balances, for example, possible two-person inventory teams (typically consisting of an item locator or handler and a recorder) to provide assurance against potential falsification and human error, e.g., in countersigning and other over-checks.

b. The following multiple activities, common to all categories and typically needed to be carried out in this second stage, should be considered:

(1) how and when processing operations are shut down or curtailed;
(2) precluding any further material transfers;
(3) ensuring all material is inventoried and that none is counted more than once;
(4) identifying measurements that are made for inventorying;
(5) usage of prior measurements, factors, and composite data for inventory listings;
(6) extent that process holdup has been cleaned out and residual holdup is measured;
(7) designating inventory team members and team leaders for each control area and facility-wide; and
(8) use of post-inventory activities, including restart.

4.3 Reconciliation Stage

a. Licensee plans and procedures should describe how IDs are determined and evaluated, including the triggering corrective actions for IDs which exceed preset escalating thresholds (excessive IDs). This includes the calculation of IDs and SEIDs and significance testing using acceptable statistical methods and terminology. The plans and procedures should also describe types of investigative actions, the handling of prior period adjustments, and the adjustment of book records to physical inventory results.

b. At SSNM facilities subject to the 10 CFR Part 74, subpart E requirements, non-measurement contributors to ID should not be included in the calculation of SEID. But at facilities possessing

only SNM of low strategic significance, licensees should consider taking limited credit for such non-measurement contributors.

c. For Category III licensees subject to the 10 CFR Part 74, subpart C requirements, warning and/or alarm thresholds for IDs should be established in addition to the requirement to detect a site specific quantity with a 90 percent power of detection (major ID problem). For example, a licensee could have warning and alarm thresholds at twice and three times the SEID.

d. For Category II licensees subject to the 10 CFR Part 74, subpart D requirements, warning thresholds for IDs should be established in addition to the requirement to investigate an ID exceeding three times the SEID. For example, a licensee could have a warning threshold at twice the SEID.

5. Responses to IDs which Exceed Thresholds (Excessive IDs)

a. Escalating follow-up actions should be taken on excessive IDs ranging from investigations up to re-inventorying. For example, if an SSNM ID exceeds both 3 times SEID and 10 formula kilograms (FKG), the facility in response should conduct an immediate re-inventory in addition to a range of investigative and review steps for searching out probable causes of excessive IDs and taking remedial action. Such a re-inventory should also be conducted for a significant Category II problem or a major ID problem at a Category III facility.

b. When responding to an excessive ID, licensees should consider common contributors to IDs other than measurement uncertainty (resulting from the measurement and measurement control systems) such as: (1) nuclear material overlooked in conducting the inventory, (2) misplaced material, (3) holdup (e.g., in-process material held up in process equipment, piping, tanks and filters) that is inaccurately measured because of inherent limitations on measurement control, (4) holdup not accounted for (i.e., inaccessible for measurement or held up in locations unknown), and (5) recording mistakes.

5.1 Investigations

Investigations of excessive IDs should include but not be limited to:

(1) review of the inventory listing to be sure all items and SNM quantities were listed and none were listed more than once,

(2) review of measurement results for previously unidentified biases,

(3) review of inventory records for identifying and correcting other human errors,

(4) review of records for other anomalies (e.g., a possible need for re-measurements), and

(5) for Category I facilities, the statistical analysis of an appropriate sequence of historical IDs as required by 10 CFR 74.59(f)(1)(ii).

5.2 Unresolvable ID Losses and Persistent ID Losses

a. To address an unresolvable ID loss, the licensee should consider a complete plant shutdown, cleanout and considerable re-measurements.

b. For a persistent series of excessive positive IDs (losses) that may occur but cannot be resolved for root-cause and corrected, the licensee should also consider taking inventories on a more frequent basis until 3 successive IDs return to acceptable levels.

6. Physical Inventories and Measurements

a. All SNM on the physical inventory listing should be based on measurements. Prior measured values may be accepted for inventory provided they were determined by a measurement system subject to the facility's measurement control plan, and the items were either tamper-safed or stored in an area that provided access controls equivalent to tamper-safing, or the SNM was encapsulated.

b. If items on ending inventory were not tamper-safed or stored in an area that provided access controls equivalent to tamper-safing, or the SNM in the item containers was not encapsulated, the previously measured SNM content of the items should be verified by re-measurement. This should be achieved by reweighing either (1) all items or (2) randomly selected items based on a statistical sampling plan. However, a statistical sampling plan should not be acceptable if there is any likelihood of any significant change in the elemental concentration (or weight fraction) or in the isotopic distribution, because of such factors as oxidation, change in moisture content, comingling with materials or different enrichments, or different compositions.

c. Procedures should describe the decision rationale for determining when the element and isotope factors for SNM are measured directly for the inventory or may be based on other measurements.

7. Tamper-Safing to Ensure Integrity of Previous Measurements

a. Inventory planning especially should address what SNM does not have assigned elemental and isotopic values based on measurement and what items need to be re-measured since they are not tamper-safed.

b. To effectively and efficiently ensure the integrity of previous measurements, the application of tamper-safing should follow the RG 5.80, "Pressure-Sensitive and Tamper-Indicating Device Seals for Material Control and Accounting of Special Nuclear Material" (Ref. 13), and should identify as acceptable those seals and application methods identified in that guide.

c. Other advances made in tamper-indicating devices should also be considered, for example, those developed and tested by DOE's MC&A modernization program and those developed and applied by the IAEA.

8. Technological Advances in MC&A Equipment and Techniques

a. Besides advances in tamper-safing, potentially more effective and efficient inventorying tools and techniques (e.g., those developed by DOE in its modernization initiative and relevant research and development programs) should be considered for usage in operating procedures, for example, any feasible and practicable radiation-tested seals, radio frequency identification (RFID), motion

sensors, nondestructive assay (NDA) instrumentation, destructive measurement standards and round-robins, automated vaults and computer systems.

b. Licensees should use, where practicable and advantageous to do so, methods and technologies to automate MC&A functions and features that contribute to minimizing human errors in MC&A data, including inventory data. While such errors may still occur when using automated methods, there should be a smaller probability of error than when manual MC&A methods are used.

9. Statistical Sampling Plans for Re-Measurement of Inventory Items

a. Licensees should consider applying random sampling plans for verifying the SNM content of various inventory strata in lieu of 100 percent re-measurement. Procedures should particularly describe the types of items to be sampled and the number of items to be measured (sample size), as well as the parameter to be measured (e.g., gross weight or SNM content).

b. For Category I facilities, an acceptable means for establishing the number of items to be randomly selected for re-measurement would be the method of using as an acceptable goal quantity 5 formula kilograms of SSNM and 0.99 probability of detecting the loss of a goal quantity:

$$n = N\,[1 - (1 - (0.01)^{x/g}]$$

where:

n = number of items to be measured
N = total number of items in the stratum
x = maximum SSNM content per item
g = detection/goal quantity

c. The same statistical sampling plan method for Category I facilities should also be sufficient for Category II facilities; however, a goal quantity of 1 formula kilogram should be applied.

d. For Category III facilities, licensees should apply the same kind of sample size equation, but use a site-specific detection quantity (DQ) and a 0.90 probability of detecting a loss of a DQ.

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

where:

n = number of items to be measured
N = total number of items in the stratum
x = maximum SNM content per item
g = detection/goal quantity (DQ)

10. NRC Form 327 Reports

The SNM physical inventory summary reports required by 10 CFR 74.17 should be prepared and submitted following the comprehensive instructions and guidance in NUREG/BR-0096, "Instructions and Guidance for Completing Physical Inventory Summary Reports: NRC Form 327" (Ref. 14). This includes the reporting of both SNM and SM using NRC Form 327.

11. DOE/NRC NMMSS Reports

a. Periodic Nuclear Materials Management and Safeguards System material status reports, including both a material balance report and a physical inventory listing, should be prepared and submitted as required by 10 CFR 74.13.

b. The material status reports should cover all SNM holdings, as well as the possession of 1 kilogram or more of uranium or source material pursuant to the operation of enrichment services, down-blending of uranium that has an initial enrichment in the U-235 isotope of 10 percent or more, or the fabrication of MOX fuels.

12. Recordkeeping

a. Licensees should keep records showing the receipt, inventory (including location and unique identity), acquisition, transfer, and disposal of all SNM in their possession.

b. Inventory records should include:

(1) procedures pertaining to accountability-related measurement or sampling operations;
(2) forms used to record or report measurement data, including source information;
(3) forms listing and providing instructions associated with physical inventories;
(4) forms and formal worksheets used in the calculation of ID, SEID and active inventory values;
(5) ledgers, journals, and computer printout associated with the accounting system or seal usage;
(6) excessive ID reports; and
(7) loss indication and alleged theft investigation reports.

c. Licensees should ensure that their records are accurate and reliable by using (1) over-checks for preventing or detecting missing or falsified data and records, (2) access controls to ensure only authorized persons can update and correct records, and (3) the protection and redundancy of the record system such that any act of record alteration or destruction would not eliminate the licensee's ability to provide a complete set of SNM control and accounting information needed to achieve the performance objectives.

d. For Category I and Category II facilities, record and computer system integrity programs should consider:

(1) physical protection program accessibility restrictions, for example, personnel access controls, containment and surveillance;
(2) assignment of overall responsibility in the management structure;
(3) computer access controls which permit only authorized updating and correcting of records;
(4) cross-checks for preventing or detecting missing or falsified data or records;
(5) ensuring completeness of the records;
(6) locating data discrepancies and errors; and
(7) capability for reconstructing lost or destroyed records.

e. For Category I and Category II facilities, the cross-checks or controls should include:

(1) minimizing the number of people authorized to make data entries;

(2) use of card readers and passwords (or equivalent controls) to preclude unauthorized data entries;
(3) using verification methods for inventory and other material balance component records, for example, checking by random sampling;
(4) cross-checking calculations, at least by random sampling; and
(5) using two-person inventory teams, for example, in taking inventories and in entering data.

D. IMPLEMENTATION

The purpose of this section is to provide information on how applicants and licensees[1] may use this guide and information regarding the NRC's plans for using this RG. In addition, it describes how the NRC staff complies with the Backfit Rules in 10 CFR 70.76.

Use by Applicants and Licensees

Applicants and licensees may voluntarily[2] use the guidance in this document to demonstrate compliance with the underlying NRC regulations. Methods or solutions that differ from those described in this regulatory guide may be deemed acceptable if they provide sufficient basis and information for the NRC staff to verify that the proposed alternative demonstrates compliance with the appropriate NRC regulations. Current licensees may continue to use guidance the NRC found acceptable for complying with the identified regulations as long as their current licensing basis remains unchanged**.** The acceptable guidance may be a previous version of this regulatory guide.

Licensees may use the information in this regulatory guide for actions that do not require NRC review and approval, such as changes to a facility design under 10 CFR 70.72, "Facility Changes and Change Processes." Licensees may use the information in this regulatory guide or applicable parts to resolve regulatory or inspection issues.

Use by NRC Staff

The NRC staff does not intend or approve any imposition or backfitting of the guidance in this regulatory guide. The NRC staff does not expect any existing licensee to use or commit to using the guidance in this regulatory guide, unless the licensee makes a change to its licensing basis. The NRC staff does not expect or plan to request licensees to voluntarily adopt this regulatory guide to resolve a generic regulatory issue. The NRC staff does not expect or plan to initiate NRC regulatory action that would require the use of this regulatory guide. Examples of such unplanned NRC regulatory actions include issuance of an order requiring the use of the regulatory guide, generic communication, or issuance of a rule requiring the use of this regulatory guide without further backfit consideration.

During regulatory discussions on plant specific operational issues, the staff may discuss with licensees various actions consistent with staff positions in this regulatory guide, as one acceptable means of meeting the underlying NRC regulatory requirement. Such discussions would not ordinarily be considered backfitting even if prior versions of this regulatory guide are part of the licensing basis of the facility. However, unless this regulatory guide is part of the licensing basis for a facility, the staff may not represent to the licensee that the licensee's failure to comply with the positions in this regulatory guide constitutes a violation.

If an existing licensee voluntarily seeks a license amendment or change and (1) the NRC staff's consideration of the request involves a regulatory issue directly relevant to this new or revised regulatory guide and (2) the specific subject matter of this regulatory guide is an essential consideration in the staff's determination of the acceptability of the licensee's request, then the staff may request that the licensee either follow the guidance in this regulatory guide or provide an equivalent alternative process that

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1 In this section, "licensees" refers to holders of, and the term "applicants" refers to applicants for special nuclear material licenses under 10 CFR Part 70.

2 In this section, "voluntary" and "voluntarily" mean that the licensee is seeking the action of its own accord, without the force of a legally binding requirement or an NRC representation of further licensing or enforcement action.

demonstrates compliance with the underlying NRC regulatory requirements. This is not considered backfitting as defined in 10 CFR 70.76(a)(1).

Additionally, an existing applicant may be required to comply with new rules, orders, or guidance if 10 CFR 70.76(a)(3) applies.

If a licensee believes that the NRC is either using this regulatory guide or requesting or requiring the licensee to implement the methods or processes in this regulatory guide in a manner inconsistent with the discussion in this Implementation section, then the licensee may file a backfit appeal with the NRC in accordance with the guidance in NUREG-1409, "Backfitting Guidelines," (Ref. 15) and the NRC Management Directive 8.4, "Management of Facility-Specific Backfitting and Information Collection" (Ref. 16).

REFERENCES[3]

1. *U.S. Code of Federal Regulations* (CFR), "Material Control and Accounting of Special Nuclear Material," Part 74, Chapter I, Title 10, "Energy."

2. CFR, "Special Nuclear Material of Low Strategic Significance," Part 74, Subpart C, Chapter 1, Title 10, "Energy."

3. CFR, "Special Nuclear Material of Moderate Strategic Significance," Part 74, Subpart D, Chapter 1, Title 10, "Energy."

4. CFR, "Formula Quantities of Strategic Special Nuclear Material," Part 74, Subpart E, Chapter 1, Title 10, "Energy."

5. CFR, "General Reporting and Recordkeeping Requirements," Part 74, Subpart B, Chapter I, Title 10, "Energy."

6. U.S. Nuclear Regulatory Commission (NRC), NUREG-1280, "Standard Format and Content Acceptance Criteria for Material Control and Accounting (MC&A) Reform Amendment: 10 CFR Part 74, Subpart E," Washington, DC.

7. NRC, NUREG-1065, "Acceptable Standard Format and Content for the Fundamental Nuclear Material Control (FNMC) Plan Required for Low-Enriched Uranium Facilities," Washington, DC.

8. NRC, NUREG/CR-5734 (K/ITP-415), "Recommendations to the NRC on Acceptable Standard Format and Content for the Fundamental Nuclear Material Control (FNMC) Plan Required for Low-Enriched Uranium Enrichment Facilities," Washington, DC.

9. NRC, NUREG/CR-4604 (PNL-5849), "Statistical Methods for Nuclear Material Management," Washington, DC.

10. NRC, Regulatory Guide (RG) 5.13, "Conduct of Nuclear Material Physical Inventories," Washington, DC.

11. NRC, RG 5.33, "Statistical Evaluation of Material Unaccounted For," Washington, DC.

12. IAEA Nuclear Services Series No. 15, "Nuclear Material Accounting Handbook," Vienna, Austria, May 2008.

13. NRC, RG 5.80, "Pressure-Sensitive and Tamper-Indicating Device Seals for Material Control and Accounting of Special Nuclear Material," Washington, DC.

[3] Publicly available NRC published documents are available electronically through the NRC Library on the NRC's public Web site at: http://www.nrc.gov/reading-rm/doc-collections/. The documents can also be viewed on-line or printed for a fee in the NRC's Public Document Room (PDR) at 11555 Rockville Pike, Rockville, MD; the mailing address is USNRC PDR, Washington, DC 20555; telephone 301-415-4737 or 800-397-4209; fax 301-415-3548; and e-mail pdr.resource@nrc.gov.

14. NRC, NUREG/BR-0096, "Instructions and Guidance for Completing Physical Inventory Summary Reports: NRC Form 327," Washington, DC.

15. NRC, NUREG-1409, "Backfitting Guidelines," Washington, DC.

16. NRC, "Management of Facility-Specific Backfitting and Information Collection," Management Directive 8.4, October 2013. (Agencywide Documents Access and Management System (ADAMS) Accession No. ML12059A460).