SESSION 16: THE U.S. NATIONAL MATERIAL CONTROL AND ACCOUNTING SYSTEM (STATE SYSTEM OF ACCOUNTING AND CONTROL – SSAC)

OBJECTIVES

This session describes the state system of accounting and control (SSAC) for reactors and fuel cycle facilities in the licensed, commercial sector of the US nuclear community. Details of the material control and accounting (MC&A) measures dealing with the national safeguards program are discussed. The relationship between the national and the international safeguards programs of the US SSAC is discussed.

Biographical Information

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Michael Kelly has worked in the nuclear industry for over 20 years. He received a Bachelor's Degree in Mathematics from Clarkson College of Technology in 1976, and a Master's Degree in Statistics from the State University of New York at Buffalo in 1978. Before joining the Nuclear Regulatory Commission in April 1992, he worked as a Nuclear Material Control Statistician at UNC Naval Products, Uncasville CT, which was a highly enriched uranium fuel manufacturing facility. While performing duties at NRC as a material control and accounting (MC&A) inspector, he became involved in NRC activities associated with providing safeguards assistance to countries of the former Soviet Union under the U.S. Cooperative Threat Reduction Program. He is currently the project manager for NRC's MC&A cooperative activities with Russia, Ukraine, and Kazakhstan. He also participates in the Trilateral Initiative program with Russia and the International Atomic Energy Agency (IAEA), and he is a member of the U. S. Support program to the IAEA.

SESSION 16: THE U.S. NATIONAL MATERIAL CONTROL AND ACCOUNTING SYSTEM (STATE SYSTEM OF ACCOUNTING AND CONTROL – SSAC)

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I. U.S. NATIONAL MC&A REGULATIONS

In order to deter, detect, prevent, and respond to subnational attempts at theft of nuclear material or sabotage of facilities, an organized national program of material accounting and control and physical protection is needed. While these are terms that are generally used to describe the basic components of the U.S. national safeguards program, many aspects are similar and complementary to the international safeguards program.

In the U.S. national MC&A system, we generally define material control as the part of the safeguards program encompassing management and process controls to (1) assign and exercise responsibility for nuclear material; (2) maintain vigilance over the material; (3) govern its internal movement, location, and utilization; and (4) monitor the inventory and process status of all nuclear material. Material accounting is defined as that part of the safeguards program encompassing the procedures and systems to (1) perform nuclear material measurements, (2) maintain records, (3) provide reports, and (4) perform data analyses to account for nuclear material.

The material control system contributes to deterrence by providing a means of detecting unauthorized removals of SNM and tracing and identifying causes. By maintaining continuous vigilance over material, monitoring process operations, and establishing cross-checks over material movements, material transactions, and administrative controls, the material control system can provide early warning of attempts at theft or diversion. full use of process monitoring information can provide additional safeguards alarms and can improve data analysis capabilities. Thus, the material control system should contribute to the prevention function by providing timely information to improve material-loss-alarm responsiveness, leading to the interruption of attempts to steal or divert material. The material control system, by continuous monitoring and vigilance, plays a major response role in the rapid discovery of a loss of material. Material control also plays an important short-term assurance role by providing continuous indication of effective system operations and by confirming material status between physical inventories.

The material accounting system contributes to deterrence by providing an after-the-fact detection capability for significant material loss. In the case of a hoax, the material accounting system plays an important role in resolving the alleged theft by providing records of material quantities and locations to assist in the verification of plant holdings. With respect to the response function, the material accounting system, especially the records, can contribute to the after-the-fact loss detection. However, it is in the area of assurance that material accounting makes its greatest contribution to safeguards. The primary role of material accounting is to provide long-term assurance, through records of holdings verified by physical inventories, that material is present in assigned locations and in correct amounts. Of significance in this regard is the fact that as the length of the inventory period increases, and thus the uncertainty associated with the material balance, the sensitivity of the material accounting system for significant loss detection decreases as well as the capability to identify assignable causes for discrepancies. Another important function of the material accounting system is periodic adjusting of the book inventory through the physical inventories. Also related to the material accounting system is the performance of shipper-receiver receipts are not being used to disguise a material loss As noted above, the basic national MC&A regulations were

documented in 10 CFR Part 70. Since 10 CFR Part 70 deals with all aspects of SNM, it also contains regulations for applications, licensing, Inspections, violations, and health and safety matters, in addition to the MC&A requirements that constituted the basic U.S. system. Until the 1980s, these regulations applied to SNM in all licensed facilities authorized to possess and use SNM in a quantity exceeding one effective kilogram. In the 1980s, the regulatory requirements for bulk handling facilities involved with conversion, fabrication and scrap recovery operations were transferred to a new 10 CFR Part 74. The requirements applicable to item facilities remained in 10 CFR Part 70. The regulations in 10 CFR Part 70 include requirements for the following MC&A elements:

1. Records
2. Reports
3. Written Procedures
4. Facility Organizational Structure
5. Material Control Areas
6. Measurement System
7. Measurement Control Program
8. Limit of Error Calculation
9. Physical Inventory
10. Accounting System
11. Internal Controls
12. Management Activities
13. Submission of Fundamental Nuclear Material Control (FNMC) Plan.

The records regulations documented in 10 CFR 70.51(b) and (e) and 70.57(b) address the need for records of SNM receipts and shipments, beginning and ending SNM inventories, amounts of material added to or removed from process, material balance components, data and information from the measurement system and its measurement control program, etc. Also, records must be maintained for training and measurement qualifications. The regulations also address the period of time which the various records must be retained by the facility. The records requirements in 10 CFR Part 74 are essentially the same.

The regulations dealing with national level reports are in 10 CFR 70.52, 70.53, and 70.54. These reports concern the loss or theft of SNM, material unaccounted for (MUF)1 exceeding its measurement uncertainty (LEMUF), LEMUF exceeding specified limits, the semiannual Material Status Reports (Form NRC-742), and the Nuclear Material Transaction Reports (Form NRC-741) for transfers of SNM. The same national level reports are required in 10 CFR Part 74, with Inventory Difference (ID) used in place of MUF, and standard error of the inventory difference (SEID) used in place of LEMUF.

Written procedures, 10 CFR 70.51(c), are required to be established, maintained, and followed for all material control and accounting activities at bulk-handling facilities. Code 10 CFR Part 74 requires procedures for activities critical to the MC&A system.

Code 10 CFR Parts 70.58(b) and 70.57(b)(1) contain facility organizational requirements, which address the roles of the safeguards manager and the measurement control manager, the need for separation of functions within the organization, and the need for written delegation of MC&A responsibilities and authority. The material control area regulations in 10 CFR 70.58(d) address the need for physical and administrative controls for SNM by establishing material balance areas (MBAs) and item control areas (ICAs) within each plant. The custody of the SNM within each MBA or ICA is the responsibility of a single individual. In 10 CFR Part 74, the MBA/ICA concept is eliminated for LEU facilities and modified for SSNM facilities.

Code 10 CFR Part 70.58(e) contains the MC&A regulations concerning the measurement system which each facility must establish, maintain, and follow so that the SNM present at the facility can be measured. The measurement system must have the capability to determine the element and fissile isotope content of SNM received, produced, transferred between MBAs, shipped, on inventory, etc. One objective is to assure that all inputs to the material balance calculations are based on measurements and that the MUF value resulting from the material balance is a meaningful value.

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[1] MUF = Beginning Inventory + Additions - Ending Inventory - Removals

Code 10 CFR Part 70.57 reflects requirements for a measurement control program for the MC&A measurement system. The requirements In 10 CFR 70.57(b) (3-11) address the need to obtain representative samples, the calibration of each measurement technique with representative standards, the monitoring and control of each technique during its use throughout the material balance period, the generation of bias correction data, the generation of information for random and systematic errors for use in determining the measurement system uncertainty (LEMUF), etc.

LEMUF represents the uncertainty in a facility's measurement system as applied to the SNM involved in the facility's operations during a material balance period. The requirements concerning LEMUF are found in 10 CFR 70.51(e). It should be noted that the U.S. only required LEMUF calculations associated with the entire plant. LEMUF is expressed in the same units as MUF; e.g., in kilograms of uranium, U-235, or plutonium, as appropriate. The concept of LEMUF has been extensively modified in 10 CFR Part 74.

A LEMUF calculation is complex compared to the calculation of a MUF value. Since many of the inputs to the material balance expression (from which the MUF value is determined) are related, there are covariance effects which have to be dealt with properly in the LEMUF calculation in order to obtain a meaningful LEMUF value.

The regulations in 10 CFR Part 70.51(e)(3) and 70.51(f) address the subject of physical inventory. Prior to the 1980s modifications, the licensed bulk handling facilities usually performed a physical inventory every two months for plutonium and high-enriched uranium, $20% enriched, and every six (6) months for LEU (<20% enriched). The inventory requirements include procedures to assure that the quantity of SNM in each item on inventory is a measured value, each item is only listed once on the inventory, and all material containing SNM is inventoried. Also, the requirements specify that the book inventory record must be reconciled and adjusted to the results of the physical inventory; if this requirement is not carried out, there is no way of obtaining a MUF value. Requirements for physical inventories have been extensively modified in 10 CFR Part 74. for LEU facilities, the frequency has been changed to one inventory per year. for SSNM facilities, the frequency can be reduced to twice per year if these facilities have an approved extensive process monitoring system that generates timely and very localized data on material status.

The basic accounting system required in the U.S. during the 1970s provided records and reports necessary to locate SNM and to close a measured material balance around each material control area and the total plant. The accounting system included centralized records using double-entry bookkeeping practices, subsidiary accounts for each MBA and each ICA, and procedures for reconciling subsidiary accounts to control accounts as well as reconciling the accounts to the results of the physical inventory. Accounting records were maintained for quantities of SNM on Inventory and for quantities added to or removed from the facility's processing operations. The MUF value, resulting from reconciling the book inventory to the results of the physical inventory, had to be calculated within 30 calendar days after the start of the physical inventory. The regulations concerning the accounting system are found in 10 CFR 70.51(e) and 70.58(k). A basic accounting system is also required in 10 CFR Part 74. However, the deletion of MBAs and ICAs and the addition of new requirements have resulted in some modifications. A centralized record system is still required.

The requirements concerning internal controls for SNM are contained in 10 CFR Parts 70.51(e)(1), and 70.58(9)(h) and (i). These requirements address procedures for SNM received by the facility operator and shipped from the facility. Each facility must maintain a system to provide knowledge of the identity, quantity, and location of all items containing SNM. Requirements for limiting the accumulation of scrap materials, controlling and using tamper-safing seals, and the documentation of all transfers between material control areas are included. 10 CFR Part 74 regulations also include requirements for internal controls. However, internal controls have been modified for maintaining knowledge of the identity, quantity, and location of items containing SNM; limiting the accumulation of scrap; using tamper-seals; and documenting transfers between material control areas.

Management activities are concerned with development, revision, implementation and enforcement of control and accounting procedures at each facility. The safeguards manager and other facility management must approve in writing the MC&A procedures and subsequent revisions. The regulations in 10 CFR Parts 70.57(b)(2) and 70.58(c) also require a review and audit of the entire MC&A program at the facility every 12 months by knowledgeable, independent persons. The results of the review and audit must be documented and reported to the corporate and facility management. The NRC also reviews the reported findings as part of its inspection program. Except for an extension to 24 months for the review and audit at LEU facilities, equivalent requirements are reflected in 10 CFR Part 74.

The final element of the U.S. national MC&A regulations that is generic for all facilities is the requirement for submittal of an FNMC plan. This element will be discussed later in this paper.

II. MODIFICATIONS TO THE BASIC SSAC

Prior to the mid-1980s, MC&A of LEU and SSNM was governed by requirements which differed very little. Effective March 27, 1985, NRC restructured its MC&A regulations to be consistent with the strategic value of SNM. This resulted in significant differences for certain elements of MC&A programs, especially in the areas of measurement control, item control, and physical inventory. Additionally, requirements for process monitoring and human error monitoring were introduced in facilities handling SSNM. Other requirements for LEU facilities were eliminated, e.g. the requirement for multiple MBAs and ICAs and the requirement to periodically process hard-to-measure scrap. The end result of these changes was to equate the regulatory burden imposed on licensees to a level consistent with the safeguards risks posed to the public health and safety by varying strategic values of SNM. The following paragraphs describe the details of the facility-specific requirements for facilities handling SNM of low strategic significance (Section 74.31(c)(2) and (3)), the measurement control program must provide assurance that measurement biases can be estimated; significant biases can be eliminated from the ID values of record; estimated, significant biases can be eliminated from the ID values of record; and the total MC&A measurement uncertainty is controlled such that twice its standard error is less than the greater of 9 kilograms of U-235 or 0.25 percent of the active inventory. To comply with these requirements, the measurement control program must include 1) measurement of a sufficient number of representative standards to permit the calculation of reliable bias estimates, 2) identification of the key measurement systems that significantly impact on ID performance, and 3) calibration and recalibration of measurement systems with representative standards with small uncertainties in their assigned values. The objective of the latter effort is to ensure that the systematic errors, which are the key contributors to the overall measurement uncertainty, are sufficiently small to ensure that the regulatory limits of 9 kilograms or 0.25 percent of active inventory are not exceeded. Active inventory is defined as the sum of additions to inventory, beginning inventory, ending Inventory, and removals from inventory after all common terms have been excluded.

Measurement control programs for facilities processing SSNM are significantly more extensive and include tighter limits for the overall measurement uncertainty associated with the material balance. The requirements in 10 CFR Part 74.59(e) address the need for:

- Engineering analyses and evaluations of the design, installation, pre-operational tests, calibration, and operation of all MC&A measurement systems;
- Mixing and sampling studies with requirements to repeat tests at three-year intervals or when significant changes are made that potentially impact representative sampling;
- Current data on the performance of measurement systems including data for bias correction, uncertainties on calibration factors and random error deviations;
- Utilization of current program data for the estimation of the standard error of the ID (SEID) and the standard error of process differences (NOTE: Prior period data may be combined provided the measurement systems are in statistical control and the combined data are used to characterize the unknowns);
- Control of measurement performance so that the SEID estimator does not exceed 0.1 percent of active inventory;
- Application of bias correction;
- Investigation and corrective action for bias when a cumulative shipper/receiver difference for a six-month period exceeds the larger of one formula kilogram or 0.1 percent of the total quantity received; and
- Establishment and maintenance of a statistical control system designed to monitor the quality of each program measurement.

Because of the extensive scope of requirements for a measurement control program, licensees typically assign one individual whose sole responsibility is oversight of the program.

A second major element of the U.S. national MC&A program, in which regulatory requirements are significantly different, depending upon the SNM involved, is physical inventory (Section 74.31(c)(5) and 74.59(f)). There are certain basic requirements that apply to all physical inventories irrespective of the type of material. All material must be inventoried, none can be inventoried more than once, all inventory values must be based on measurements, the book inventory must be reconciled and adjusted to the results of the physical inventory, and statistically significant differences must be investigated. Beyond these basic requirements, material-dependent requirements address the frequency of physical inventories, the length of the reconciliation period, the null hypothesis to be tested, and the level of significance against which the ID result is to be evaluated. With regard to inventory frequency and reconciliation time, facilities processing SNM of low strategic significance must perform a physical inventory at least every 12 months and reconcile and adjust the book inventory within 60 days. Facilities processing SSNM must perform a physical inventory every six months and accomplish the reconciliation within 45 days.

For facilities processing SNM of low strategic significance, the licensee is obligated to resolve or report an inability to resolve any ID that is rejected by a statistical test that has 90% power of detecting a discrepancy of a quantity of U-235 established by-the NRC on a site-specific basis. In the case of a conversion facility, the site-specific quantity is calculated as 1.3% of throughput. For a fabrication facility, the quantity is 0.9% throughput. For example, the so-called goal quantity for a conversion facility with a throughput of 30,000 kilograms U-235 (1000 metric tons at three percent enrichment) per year would be 390 kilograms U-235. Note that the SEID may include a contribution from process variation equal to the measurement uncertainty. Therefore, to compute the total uncertainty it is acceptable to multiply the measurement uncertainty by 1.4. For facilities processing SSNM, ID significance evaluation is a two-stage process. The initial criterion is that an Investigation is required for any ID that exceeds three times the associated standard error and 200 grams of plutonium or U-233 or 300 grams of U-235. If such an investigation is required, it must include an evaluation of the significance of the ID relative to expected performance. "Expected performance" is determined from an analysis of an appropriate sequence of historical IDs. If the ID exceeds three times the standard deviation determined from the sequential analysis, a more intensive investigation, including possibly a reinventory, is required and the NRC must be notified. Any decision to reinventory would take into account the magnitude of the ID relative to the five-formula-kilogram goal quantity, the performance of the process monitoring system during the material balance period, and a review of the physical security records for the period.

A third element of the U.S. national MC&A program that reflects different levels of requirements based on the SNM involved is item monitoring (Sections 74.31(c)(b) and 74.55). For SNM of low strategic significance, a licensee must 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. To accomplish this objective, a licensee must establish a records system that is used as the source data for periodic checks to ensure that items are in assigned locations and unauthorized removals of substantial quantities of SNM have not occurred. Requirements for item monitoring in SSNM facilities are significantly more intense. Based on a statistical sampling plan, the licensee must be able to determine with at least a 99% probability that item losses that total five formula kilograms or more have not occurred within prescribed time periods. The time intervals for the tests are based on material attractiveness and location. Tests must be performed more frequently on attractive materials, such as metal and pure oxide, and on SSNM located outside of a vault or permanently-controlled access area.

The requirements described above for SNM of low strategic significance compose the complete MC&A program for such material. However, for SSNM, there are additional requirements that are intended to achieve more timely detection of anomalies that could be potentially indicative of diversion. In achieving more timely detection, increased sensitivity is also achieved since the quantities of material subjected to material control tests are smaller. The additional requirements documented in Section 74.53 are based on a concept referred to as "process monitoring." Process monitoring is the use of data normally extraneous to the MC&A program for safeguards purposes. The three principal sources of such data are production, production control, and quality assurance records. Other data sources such as health/safety and criticality may also be useful in certain cases. The application of process monitoring is achieved through the subdivision of the process into smaller subdivisions referred to as unit processes. For each unit process, tests are established that are designed to detect an abrupt loss of five formula kilograms or more of SSNM with at least 95% power of detection within three or seven days depending on material

attractiveness. Protracted diversion detection is accomplished through a trend analysis applied to the abrupt-loss test results.

Specific requirements for alarm resolution are documented in Section 74.57.

III. LICENSING AND THE FNMC PLAN

The basic components of the U.S. SSAC described in the previous sections are integral to the licensing process for nuclear fuel cycle facilities. The United States has a centralized licensing program based at NRC headquarters offices. The NRC licenses the construction and operation of all civilian nuclear fuel facilities involved in the processing and fabrication of uranium ore into reactor fuel.

An integral part of a facility's license is its FNMC plan. A facility's FNMC plan plays an important role in the U.S. SSAC program. Essentially this plan describes "what is done and how it is done" in the facility in order to satisfy the intent of the MC&A regulations in 10 CFR Part 70 or 74. When all of the commitments in the FNMC plan have been determined to be acceptable by the NRC licensing staff, the plan is incorporated as part of the facility's license. This means that the licensee is obligated to implement all of the commitments described in the plan for all MC&A activities. The NRC inspection staff inspects the licensed facility against its approved FNMC plan. The NRC inspection program will be discussed in detail in the following section of this paper.

Facilities are required to submit an FNMC plan if they are authorized to possess and use more than one effective kilogram of SNM or, in the case of strategic facilities, five or more formula kilograms of SSNM. The basic guidance documents that these facilities use in preparing their plans are Regulatory Guide 5.45, NUREG 1065, or NUREG 1280. These documents reflect a suggested format and, in the case of NUREGs 1065 and 1280, acceptance criteria for each MC&A element.

The acceptance criteria are characterized as a means of satisfying the regulatory objectives that would be acceptable to the NRC licensing staff but are not the only means through which a requirement could be met. The intent in providing acceptance criteria is to communicate the underlying objective of the regulatory requirement. As one might expect, there can be considerable activity associated with keeping an approved FNMC plan up-to-date. Changes made by the licensee that do not decrease the effectiveness of the MC&A program can be reported to the NRC after-the-fact in revised sections of the plan (10 CFR Part 70.32(c)). Changes that have the potential to decrease the effectiveness of the MC&A program must be submitted for approval prior to implementation (10 CFR Part 70.34). Obviously new operations would have to be reviewed prior to initiation. Periodic submittals are also required as decommissioning activities progress.

IV. TYPICAL NRC SAFEGUARDS INSPECTIONS FOR LEU FACILITIES

Complementary to the licensing process is an inspection program aimed at assessing the licensee's maintenance of the program committed to in its FNMC Plan, measuring the effectiveness of the implementation of the commitments, and monitoring compliance with the commitments regulations, and any license conditions imposed by the NRC. License conditions may be imposed either to exempt a licensee from certain requirements or place additional requirements on him. General guidance for the inspection program is provided in written procedures. The procedures directing the inspection program are listed below:

85403	MC&A System Management and Assessment
85405	Internal Controls
85407	Measurement Systems
85409	Measurement Controls
85411	Physical Inventory
85415	Records and Reports
30703	Management Meetings - Entrance and Exit Interviews
85301	MC&A for Imports and Exports
85425	Implementation of the US/IAEA Safeguards Agreement
92701	Inspector Follow-up
92702	Inspector Follow-up on Items of Noncompliance/Deviations

The first six of the procedures listed, 85403 through 85415, apply specifically to LEU fuel manufacturing facilities. They provide details of the various MC&A safeguards areas to be inspected. All program areas covered in each of these procedures should be inspected biennially, that is, over a two-year period. Comprehensive coverage of these areas of a licensee's safeguards program is required; nevertheless, the depth of inspection in a particular area varies based on the licensee's past performance in that area.

The remaining five procedures in the list apply to other facilities as well as to LEU fuel manufacturing facilities. Procedure 30703 contains the protocol for inspection visits, so it is addressed during each visit. Procedure 85301 is applied on a percentage basis, with approximately 20% of imports and exports made by LEU fuel manufacturing facilities inspected. Procedure 85425 is utilized with those facilities currently subject to IAEA safeguards oversight. Procedures 92701 and 92702 dealing with follow-up activities are applied as needed.

Scheduling and planning for the inspection program are controlled by the inspectors and their management in the Division of Safeguards and Transportation, Office of Nuclear Material Safety and Safeguards, at NRC headquarters in Washington, D.C. Prior to 1990, MC&A safeguards inspections of LEU fuel manufacturing facilities were based in the regional offices. The inspection schedule for 1991 calls for from two to four week-long visits to each LEU fuel manufacturing facility with the exact number of visits dependent the relative size and complexity of the facility.

The inspector is charged with responsibility for reviewing and assessing the licensee's implementation of and adherence to the FNMC Plan commitments and the license conditions. This is accomplished primarily by examination of procedures and other MC&A records. Inspectors also spend as much time as possible on inspection activities that test the effectiveness of the licensee's safeguards program. Because the emphasis of the Reform Amendment is on performance and not merely compliance, the inspector performs a comprehensive review that can determine the effectiveness of the overall MC&A safeguards program.

V. INSPECTION PROCEDURES

The inspection procedures provide general guidance related to areas that the inspector should examine. They also describe specific areas for the inspector to examine. Effort in the inspection program is generally focused on those areas of the licensee's system where either data or experience indicate that potential problems might exist. The purpose of the inspection procedures is to make the inspection process uniform and to assure that inspections are comprehensive. The inspection objectives stated in the various procedures are presented in the following paragraphs.

A. MC&A System Management and Assessment (Procedure 85403)

The inspection objective stated in this procedure is to confirm that the licensee's programs for managing and assessing the performance of the MC&A system provide assurance that this system is operating effectively in accordance with established regulatory requirements. The inspector must determine whether:

- A management structure has been established, documented and maintained that provides for proper assignment of clear overall responsibility for the MC&A functions, Independence of MC&A functions from production responsibilities, separation of key MC&A responsibilities, and adequate review and use of those critical MC&A procedures listed in the licensee's approved FNMC Plan.

- An acceptable independent assessment of the effectiveness of the MC&A system is being performed at least every 24 months and management action on prior assessment recommendations is properly documented.

- Past performance of the MC&A system supports the conclusion that the licensee's management and assessment programs are effective.

B. Internal Controls (Procedure 85405)

The inspection objective of this procedure is to verify that the licensee's internal controls for items and shipments/receipts of SNM provide for timely detection of unauthorized removals of SNM in item form and for prompt detection and resolution of all significant shipper/receiver differences. The inspector must determine whether:

- Special item storage and handling or tamper-indicating control methods used to exempt material from remeasurement requirements at inventory time provide adequate protection against unauthorized removals of SNM from items.
- Current knowledge of items is being maintained as required for nonexempt items and all remaining items are exempted on a valid basis.
- Shipper/receiver differences that exceed both twice their combined measurement standard error and 500 grams of U-235 are promptly resolved on a shipment basis and, when required, on a batch basis.
- Critical procedures associated with the internal controls for items and shipments/receipts of SNM are established, maintained and followed.

C. Measurement Systems (Procedure 85407)

The inspection objective of this procedure is to assure that the licensee's systems for measuring special nuclear material are sufficient to substantiate the quantities of element and isotope assigned to all materials listed in the material accounting records. The inspector must determine whether:

- Measurement systems have been established and are being maintained for the measurement of all types of SNM listed in the licensee's material accounting records.
- Calibration and control of measurement systems is based on reference standards. The representativeness of standards is maintained as required in the licensee's FNMC Plan. All measurement systems are properly calibrated and recalibrated when a need for recalibration is indicated.
- All SNM quantities recorded in the material accounting records are traceable to a measured value.
- Critical MC&A procedures involving the measurement of SNM are established, maintained and followed.
- Measurements of SNM performed for the licensee by contractor laboratories conform with all of the aforementioned requirements
- An evaluation of data collected as the result of independent sampling and analysis of materials measured by the key measurement systems confirms that the performance and results of such systems are acceptable.

D. Measurement Controls (Procedure 85409)

The inspection objective of this procedure is to confirm that an adequate measurement control program is being followed by the licensee for monitoring and controlling the errors associated with its key measurement systems. The inspector must determine whether:

- A measurement control program is being followed which assures that measurement bias is estimated and that significant biases (as defined in the licensee's FNMC Plan) are eliminated from inventory difference values of record.

- Total MC&A measurement uncertainty for each inventory period is controlled such that twice its standard error (SEID) Is less than the greater of 9 kilograms of U-235 or 0.25% of the active inventory.

- Assurance is provided that measurements performed under contract are controlled so that the aforementioned limits on SEID are not exceeded.

- Critical measurement control program procedures for the key measurement systems are established, maintained and followed.

E. Physical Inventory (Procedure 85411)

The inspection objective of this procedure is to verify that the program for inventorying special nuclear material adequately confirms the presence of SNM possessed by the licensee. The inspector must determine whether:

- A physical inventory of SNM is being performed as required at least every 12 months. All SNM currently possessed by the licensee is inventoried except for those materials specifically exempted from this requirement in the licensee's approved FNMC Plan.

- Within 60 days (30 days for licensees subject to 10 CFR 75) after the start of an inventory, the book inventory is reconciled and adjusted to the results of the physical inventory.

- The resolution of or inability to resolve an inventory difference which is rejected by an appropriate statistical test with a 90% power of detecting the loss of a site-specific goal quantity is reported within 60 days after the physical inventory begins.

- Critical procedures involving the inventorying of SNM are established, maintained and followed. Independent testing of the physical inventory listing and an evaluation of the inventory reconciliation indicate that acceptable physical inventories are being conducted by the licensee.

F. Records and Reports (Procedure 85415)

The inspection objective of this procedure is to assure that the licensee's system of records and reports provides accurate information which is sufficient to substantiate that the MC&A subsystems are complying with all applicable regulatory requirements.
The inspector must determine whether:

- Records are established and maintained for at least 3 years (5 years for licensees subject to 10 CFR 75) that adequately demonstrate that the requirements of 10 CFR 74.31(c) are being met.

- Material status reports (DOE/NRC forms 742 and 742C) and nuclear material transfer reports (DOE/NRC form 741) are prepared and distributed as required.

- Critical accounting procedures are established, maintained and followed.

- An independent audit of the systems of records and reports verifies that the accuracy of accounting information is acceptable.

G. MC&A for Imports and Exports (Procedure 85301)

The inspection objective of this procedure is to verify that material control and accounting procedures associated with the receipt and shipment of imports and exports of SNM are carried out in accordance with applicable NRC regulations and conditions specified in the export license.

The inspector must determine whether:

- Nuclear material transfer reports (DOE/NRC form 741) are prepared and distributed as required.
- Containers of SNM are protected with tamper-indicating seals. The integrity of all containers and seals is checked upon receipt for imports and prior to shipment for exports. The identity and quantity of contained SNM is reverified if tamper-safing is found to have been compromised.
- Shipper/receiver differences are reviewed and evaluated as required, and appropriate, timely investigative and corrective actions are taken to reconcile differences which are statistically significant.

H. Implementation of the US/IAEA Safeguards Agreement (Procedure 85425)

The inspection objective of this procedure is to determine whether the licensee has established, maintained and followed a system of nuclear material accounting and control in accordance with the Agreement Between the United States and the International Atomic Energy Agency (IAEA) for the Application of Safeguards in the United States, and which meets the applicable requirements specified in 10 CFR 75 and its facility Attachment (FA) or Transitional facility Attachment (TFA).

For those fuel facilities under full IAEA safeguards oversight, the NRC increases its inspection scope to include emphasis on compliance with Part 75. The intent is to identify discrepancies and resolve problems in order to facilitate on-site IAEA inspections.

I. Management Meetings -Entrance and Exit Interviews (Procedure 30703)

Upon arrival at the site, the inspector briefs licensee management on the scope and estimated duration of the inspection visit; records, procedures or documents to be reviewed; personnel to be interviewed; and special tasks or activities which require coordination between the inspector and the licensee, such as observation of sampling and analysis. At the conclusion of the inspection, the inspector briefs the licensee management on preliminary inspection findings.

J. Follow-up (Procedures 92701 and 92702)

During an inspection, problems are typically identified which require some sort of follow-up in subsequent inspection visits. Matters of this sort are referred to as follow-up items. A follow-up item may be an issue which requires more information in order to determine whether or not it is a violation of a requirement or a deviation from approved practice. A follow-up item may also be simply a matter that requires further review or evaluation by the inspector.

In order to document and track problems, and to ensure that appropriate corrective actions are taken by the licensee to resolve the problems, follow-up items are tracked numerically. Effort is made to minimize the time needed to close out these items, although it is recognized that follow-up time may reflect such circumstances as the cooperation of the licensee or the time needed to obtain analytical results from an outside laboratory.

VI. U.S. INTERNATIONAL MC&A REGULATIONS

International safeguards in the U.S. are administered by the International Atomic Energy Agency (IAEA). 10 CFR Part 75, Safeguards on Nuclear Material -Implementation of U.S./IAEA Agreement, contains the international safeguards requirements for the private sector nuclear facilities In the U.S. Essentially, the regulations in 10 CFR Part 75 correspond to the articles in the IAEA document, INFCIRC/153. The eight basic elements for implementing international safeguards are:

- A measurement system for the determination of quantities of nuclear material received, produced, shipped, lost or otherwise removed from inventory, and the quantities on inventory;

- The evaluation of precision and accuracy of measurement and the estimation of measurement uncertainty;

- Procedures for identifying, reviewing, and evaluating differences in shipper/receiver measurements;

- Procedures for taking a physical inventory;

- Procedures for the evaluation of accumulations of unmeasured losses;

- A system of records and reports showing, for each material balance area, the inventory of nuclear material and the changes in that inventory, including receipts into and transfers out of the material balance area;

- Provisions to ensure that the accounting procedures and arrangements are being operated correctly; and

- Procedures for the provision of reports to the Agency.

A comparison of these international MC&A elements with the U.S. national MC&A elements shows a strong relationship between the two sets. In the U.S., many of the MC&A procedures that have been implemented for national MC&A purposes (to satisfy the requirements in 10 CFR Parts 70 or 74) are also used for purposes of international safeguards (to satisfy the requirements in 10 CFR Part 75).
It should be pointed out that the IAEA-approved facility Attachment for a licensed facility is incorporated as a condition of license, just like the FNMC Plan. Therefore, licensees in the U.S. that have been selected for safeguards under the U.S./IAEA Agreement must follow the Facility Attachment for international safeguards, as well as the FNMC Plan for national safeguards.

VII. TECHNICAL SUPPORT

The NRC continually strives to improve the technical effectiveness of both domestic and international safeguards through various technical support activities. Domestically, the NRC has engaged in the following contractual efforts with U.S. national laboratories:

- Diversion Path Analysis

- Technical Assistance for Licensing of Uranium Enrichment facilities

- Technical Assistance on Assessing the Effectiveness of the MC&A Reform Rule

- Technical Assistance on Assessing the Effectiveness of the LEU Reform Rule

- In-line Monitoring for Uranium Enrichment Levels at Enrichment Facilities

- Verifying Measurement Capabilities through Analysis of SNM samples in support of the inspection program (ongoing contract).

Regarding international safeguards effectiveness, the NRC interacts directly with the IAEA and participates in U.S. Government interagency efforts. The NRC is improving the efficiency of IAEA verification of nuclear material transfers by working on the development of the short notice random inspection technique. The NRC

contributes to the design of safeguards systems by participating in the consultants group on the development of methods for the evaluation of effectiveness of safeguards systems. The NRC supports improved safeguards at reprocessing plants by participation in the international forum LASCAR (LArge SCAle Reprocessing plant safeguards). LASCAR assures that information of all technical safeguards measures is available to those designing reprocessing plant safeguards systems. The NRC is also contributing to the improvement of IAEA safeguards for reprocessing plants through application of the Adjusted Running Book Inventory Technique. A significant interagency effort is participation in oversight of the U.S. Government Program of Technical Assistance to IAEA Safeguards (POTAS), which was set up by Congress to meet the short-term needs of IAEA safeguards and to transfer safeguards technology to the IAEA.

VIII. NMMSS

The Nuclear Materials Management and Safeguards System (NMMSS) is co-sponsored by two agencies of the United States Government, the Department of Energy which provides the major financial contribution and the Nuclear Regulatory Commission which contributes the remaining funding. NMMSS serves national security and program management interests in the utilization of nuclear resources and also serves international interests in the programs for the peaceful application of nuclear energy and in the non-proliferation of nuclear weapons. The purpose of NMMSS is to provide quality nuclear data in a timely manner to support both domestic and foreign nuclear programs. Within the scope of the NMMSS are found all nuclear materials supplied and controlled under U.S. law and related international agreements, including U.S. nuclear materials production programs and U.S. private nuclear industrial activities. The NMMSS is responsible for maintaining and providing Information regarding production and materials management, nuclear materials safeguards, physical accountability, financial and cost accounting, and other information involving the utilization of nuclear materials for the DOE, and for providing the NRC with information regarding nuclear materials control and accountability. The NMMSS serves both agencies in support of U.S. reporting commitments based on international treaties and agreements and special information requests from other government agencies like the Arms Control and Disarmament Agency, the Department of State, and the U.S. Congress.

The automated NMMSS, which began its evolution in 1964, was an outgrowth of a manual recordkeeping system designed in 1948 primarily for material accountability. The system continues to grow and expand due to its very nature. A staff of approximately 35 people is continually called upon to create additional software to manage the database and to change the configuration of the system to enhance the capability to respond to the increasing number of requests for information involving nuclear materials activity in the U.S. and throughout the world.

IX. SUMMARY

The national material control and accounting (MC&A) system for fuel cycle facilities in the licensed commercial sector of the U.S. nuclear community is designed to deter, detect, and respond to subnational attempts at theft of nuclear material or sabotage of facilities. This system was modified in the mid-1980s to make it more consistent with the strategic value of special nuclear material (SNM). The material control system contributes to deterrence by providing a means of detecting unauthorized removals of SNM and tracing and identifying causes. The material accounting system contributes to deterrence by providing an after-the-fact detection capability for significant material loss.

A basic element of the U.S. national MC&A regulations is the requirement for submittal of a fundamental Nuclear Material Control (FNMC) plan, which is incorporated as part of the facility's license and which provides the criteria against which the NRC staff inspects the facility. The MC&A inspection program is a dynamic program which is under constant review to ensure that effective safeguards are in place and implemented at NRC licensed facilities.

International safeguards in the U.S. are administered by the IAEA and there is a strong relationship between national and international safeguards programs within the U.S. SSAC. Many of the MC&A procedures that have been implemented for national MC&A purposes are also used to fulfill international safeguards obligations. The technical effectiveness of both domestic and international safeguards continues to be improved through various technical support activities. The United States' NMMSS system provides quality nuclear data in a timely manner to support both domestic and foreign nuclear programs.

EXPERIENCE OF THE US SSAC

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U. S. Nuclear Regulatory Commission

May 2001

SAFEGUARDS:

Combination of all measures, including:

- **Material Control and Accounting**
- **Physical Protection**
- **Legal Penalties**
- **Personnel Reliability Standards**

used to protect nuclear materials and facilities against malevolent acts such as theft and sabotage.

SAFEGUARDS PROGRAMS

INTERNATIONAL SAFEGUARDS:

- Deter nuclear weapon production by non-nuclear weapons states (NNWS)
- Prevent diversion of weapons material to clandestine uses in an NNWS

NATIONAL (DOMESTIC) SAFEGUARDS: ????

Different Objectives!

NEED FOR A NATIONAL SAFEGUARDS PROGRAM

- Unauthorized Use of Nuclear Materials
  - Threat to Public Health and Safety
- Proliferation of Nuclear Weapons
  - Threat to National and International Security

OBJECTIVES OF A NATIONAL SAFEGUARDS PROGRAM

PREVENTION ====>

DETERRENCE ====>

DETECTION ====>

RESPONSE ====>

UNAUTHORIZED POSSESSION OR USE OF NUCLEAR MATERIALS

DEFINITIONS

- SPECIAL NUCLEAR MATERIAL (SNM)
  - Plutonium (any isotopic distribution)
  - U-233
  - Uranium enriched in U-233 or U-235
  - Not source material (natural uranium)
- STRATEGIC SPECIAL NUCLEAR MATERIAL (SSNM)
  - U-235 contained in uranium enriched to > 20%
  - Plutonium
  - U-233

CATEGORIES OF SPECIAL NUCLEAR MATERIAL

- For Uranium, based on enrichment level and quantity
- For Plutonium, based on quantity of Pu element
- Three Categories:
  - SNM of low strategic significance (Category III)
  - SNM of moderate strategic significance (Category II)
  - Formula quantity of SSNM (Category I)

MATERIAL CONTROL AND ACCOUNTING (MC&A)

- State System of Accounting and Control (SSAC)
- Different terms for the "A" word:

  NRC: "Accounting"

  DOE: "Accountability" (Accounting +): More than just ledgers for nuclear material quantities.

  IAEA: "Accountancy"

SSAC COMPONENTS NEEDED TO SUPPORT NATIONAL SAFEGUARDS

- SYSTEM OF NATIONAL REGULATIONS
- SYSTEM OF LICENSING
- PROGRAM OF MAINTAINING COMPLIANCE
- NATIONAL INFORMATION SYSTEM
- PROGRAM OF TECHNICAL SUPPORT

MATERIAL CONTROL

Material control can be defined as the use of control and monitoring measures in the vicinity of where nuclear material is

- processed
- stored
- transferred

to (1) prevent loss of material, or (2) detect loss of material when it occurs, in particular, through theft by one or more insiders.

MATERIAL CONTROL

- Use of control & monitoring measures to prevent or detect loss when it occurs or soon afterwards
- Elements of material control:
  - access control
  - containment
  - surveillance
  - item monitoring
  - process monitoring

MATERIAL ACCOUNTABILITY

Material accountability can be defined as:

1) The use of measurements, analyses, records, and reports to maintain knowledge of the quantities of nuclear materials present in each area of a facility, and

2) The use of physical inventories and material balances to verify the presence of material, or to detect the loss of material after it occurs, in particular, through theft by one or more insiders.

MATERIAL ACCOUNTING

- Use of measures to confirm the presence of SNM or to detect loss/theft after it occurs
- Elements of material accounting:
  - measurements
  - measurement control
  - shipper-receiver comparisons
  - records
  - item accountability
  - physical inventory

Fundamental Nuclear Material Control (FNMC) Plan

- Required for all licensees authorized to possess > 1 effective kg of SNM
- Describes "what is done and how it is done"
- Guidance provided by NRC (Acceptance Criteria)
  - Regulatory Guide 5.45
  - NUREG 1065 (Category III)
  - NUREG 1280 (Category I)
  - NUREG 5734 (Enrichment facilities)
- Changes to FNMC Plan
  - new approaches or changes that reduce effectiveness of the MC&A program (prior NRC approval needed)
  - changes that do not reduce effectiveness of program (notification after the fact)

MC&A REGULATORY OVERVIEW

- 10 CFR 70 (mid-70s)
  - same for all facilities (i.e., no grading)
  - prescriptive: tells licensees how to do things
  - still used for Category II facilities and reactors
- 10 CFR 74 (mid 80's; 90's)
  - graded approach to regulation (Category I vs. Category III)
  - performance oriented: provides objectives
  - regulations supplemented by guidance
  - FNMC plan is site specific implementation of regulations

PRESCRIPTIVE vs. PERFORMANCE ORIENTED REGULATIONS

PRESCRIPTIVE	PERFORMANCE
explicit requirements	objectives
standard approaches	innovation possible
guidance, FNMC plan less important	guidance, FNMC plan significant
inspection, licensing straightforward	inspection, licensing challenging

ELEMENTS OF THE US MC&A SYSTEM

- Records
- Reports
- Written procedures
- Facility organizational structure
- Material control areas
- Measurement system
- Measurement control (quality assurance program)
- Physical inventory
- Standard Error of Inventory Difference (SEID) calculation
- Item Monitoring
- Process Monitoring
- Independent assessments
  Submission and execution of FNMC plan

RECORDS

- SNM Receipts and Shipments
- Internal Transfers
- Inventory Data (Beginning and Ending Inventory)
- Amount and location of SNM
- Measurement Data
- Measurement Control Data
- Process Monitoring & Item monitoring results
- SEID calculations
- Training and Qualifications

REPORTS

- Loss or Theft of SNM
- ID exceeding specified limits
- SEID exceeding specified limits (Category I and II)
- Notification of MC&A Alarms (Category I)
- Material Status Reports (Form NRC-742)
- Nuclear Material Transaction Reports (Form NRC-741)
- SNM Physical Inventory Summary Report (Form NRC-327)

WRITTEN PROCEDURES

- Must be established, reviewed, maintained, and followed
- Critical procedures must be identified
- Critical procedures are subject to inspection

FACILITY ORGANIZATION (MANAGEMENT STRUCTURE

- Clear overall responsibility for MC&A
- Independence from production management
- Separation of functions (checks on activities)
- Delegation of MC&A responsibilities & authorities

MATERIAL CONTROL AREAS

- Establish material balance areas
- Establish item control areas
- Material in each area responsibility of single individual
- For LEU facilities - one MBA is permitted

MEASUREMENTS

- All SNM quantity inputs to material balance equation must be based on measured values:
  - SNM received, shipped, produced, transferred, discarded, and on inventory
- FNMC Plan must describe the methods used to measure SNM
- The measurement methods used must be able to determine element and fissile isotope content of SNM
- Tamper-safing devices can be used to protect integrity of measurement results

MEASUREMENT CONTROL

- Calibrate each measurement technique using reference standards
- Monitor & control each measurement technique (standards)
  - .05 level of significance : investigate
  - .001 level of significance: out of control
- Generate current data to determine:
  - bias estimates
  - systematic error uncertainties
  - random error uncertainties
- Ensure representative samples are taken

PHYSICAL INVENTORY

- Frequency: Category III - annual; every 2 months enrichment
  Category II - semi-annual
  Category I - every 2 months; or semi-annual
- Quantity of material in all items based on measured values
- Books must be reconciled to Physical Inventory Results
  - Category I : within 45 days
  - Category II : within 30 days (may be changed)
  - Category III: within 60 days
- All items listed, and no items listed more than once
- All material containing SNM is inventoried
- Results of Physical Inventory must be reported to NRC

STANDARD ERROR OF INVENTORY DIFFERENCE (SEID) CALCULATION

- SEID is the uncertainty in the ID at the 67% confidence level
  - For Category III facilities: non-measurement error may be included
  - For Category I and II: only measurement error included
- SEID is calculated using random and systematic uncertainties established by the measurement control program
- SEID is based on propagation of measurement errors for current material balance period
- SEID must satisfy certain limits:
  Category III: < 0.177% x Active Inventory (AI)
  Category II : < 0.25% x Throughput ≈ 0.125% x AI
  Category I : < 0.1% x AI

INVENTORY DIFFERENCE TESTS

- Category III facilities (LEU):
  - D > Detection Threshold (site specific quantity of U-235) (≈ 1% throughput)
  - Results in major NRC investigation; probably shutdown
- Category II facilities:
  - ID > ≈ 0.75% throughput: Reinventory
  - ID > ≈ 1% throughput: Shutdown, cleanout, reinventory
- Category I facilities (HEU):
  - ID > 3 x SEID (and 200 g Pu or 300 g U-235)
  - Compare with historical performance
  - If > 3 x SEID (historical), investigation/report required

ITEM MONITORING

- Category III:
  - Maintain current knowledge of items (those in existence for 14 days)
  - Periodic, random monitoring of items to confirm presence of SNM and confirm accuracy of records
- Category II:
  - Maintain current knowledge of all items
  - Items not undergoing processing must be stored in ICAs
  - All items in ICAs: tamper-safe sealed or encapsulated
- Category I:
  - Must show (with 99% probability) that loss of 5 formula kg of SSNM has not occurred
  - Time period for detection is dependent on material attractiveness and location

PROCESS MONITORING

- Just required for Category I facilities
- Objective is for timely detection of large, abrupt losses
- Division of process into "unit processes"
- Tests established to detect (with 95% power of detection) a loss of 5 formula kg of SSNM
- Time frame: 3 or 7 days depending on attractiveness of material
- Protracted diversion accomplished through trend analysis
- Tests are more timely than physical inventory

SHIPPER/RECEIVER DIFFERENCES

- Resolve significant shipper/receiver differences, where significant is defined as:
- Category III: > 2 x standard error and 500g U-235
- Category II: > 2 x standard error and 50g U-235
- Category I: > 2 x standard error and 50g U-235

INDEPENDENT ASSESSMENT OF MC&A PROGRAM

- Category I : Every Twelve Months
- Category II : Every Twelve Months
- Category III: Every Two Years

INTERNATIONAL OBLIGATIONS

- International safeguards administered by IAEA
- U.S Government designates eligible facilities
  - Excludes facilities with national security activities
- IAEA selects facilities from eligibility list
- Facility Attachment is agreed upon and incorporated into the facility's license (like FNMC plan)
- 10 CFR Part 75 contains international safeguards requirements
  - Corresponds to INFCIRC/153 requirements
  - Similar to domestic safeguards requirements

NATIONAL INFORMATION SYSTEM

- CENTRALIZED AND AUTOMATED MATERIAL TRACKING SYSTEM
  - Nuclear Materials Management and Safeguards System (NMMSS): U.S. State System
  - System processes and stores U.S. data by Facility
  - System provides comprehensive safeguards and material management information in fulfillment of national and international needs

TECHNICAL SUPPORT PROGRAM

- Research and special studies to improve the technology and methods for MC&A
- The R&D activities are conducted at the National Laboratories
- Results are the basis for new regulatory requirements and are used to resolve technical issues
- The National Laboratories also provide technical support for training of personnel

SUMMARY OF US PROGRAM

- Has evolved over time
- Comprehensive - addresses most classical elements of MC&A
- Graded Approach - depends on strategic significance of material
- Satisfies both domestic and international requirements