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REGULATORY GUIDE

OFFICE OF NUCLEAR REGULATORY RESEARCH

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MATERIAL CONTROL AND ACCOUNTING FOR URANIUM ENRICHMENT FACILITIES AUTHORIZED TO PRODUCE SPECIAL NUCLEAR MATERIAL OF LOW STRATEGIC SIGNIFICANCE

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CONTENTS

A. INTRODUCTION

Section 74.33, "Material Control and Accounting for Uranium Enrichment Facilities Authorized To Produce Special Nuclear Material of Low Strategic Significance," of 10 CFR Part 74, "Material Control and Accounting for Special Nuclear Material," contains the material control and accounting (MC&A) requirements applicable to enrichment facilities authorized to produce and possess more than 1 effective kilogram of special nuclear material (SNM) of low strategic significance.

Section 74.33 establishes MC&A performance objectives to protect against, detect, and respond to the use of uranium enrichment equipment for the unauthorized production of SNM of moderate or high strategic significance or the introduction of undeclared source material (SM) into the process equipment for the unauthorized production of uranium of low strategic significance. In addition, 10 CFR 74.33 requires licensees to provide information that will aid in the investigation of missing uranium or unauthorized enrichment of uranium. Section 74.33 also specifies performance objectives and required system features and capabilities that are consistent with MC&A requirements applicable to other NRC-licensed activities involving the possession and use of more than 1 effective kilogram of SNM of low strategic significance. Licensees and applicants are required by 10 CFR 74.33(b)(1) to submit a fundamental nuclear material control plan describing how the performance objectives, system features and capabilities, and recordkeeping requirements will be met. The general performance objectives, set forth in 10 CFR 74.33(a), that must be met by the licensee's MC&A program are:

1. Maintain accurate, current, and reliable information of and periodically confirm the quantities and locations of source material and special nuclear material in the licensee's possession;

2. Protect against and detect production of uranium enriched to 10 percent* or more in the isotope U–235;

3. Protect against and detect unauthorized production of uranium of low strategic significance;

4. Resolve indications of missing uranium;

5. Resolve indications of production of uranium enriched to 10 percent or more in the isotope U–235 (for centrifuge enrichment facilities, this requirement does not apply to each cascade during its start-up process, not to exceed the first 24 hours);

6. Resolve indications of unauthorized production of uranium of low strategic significance;

7. Provide information to aid in the investigation of missing uranium;

8. Provide information to aid in the investigation of the production of uranium enriched to 10 percent or more in the isotope U–235; and

9. Provide information to aid in the investigation of unauthorized production of uranium of low strategic significance.

This regulatory guide describes methods acceptable to the NRC staff for achieving the general performance objectives in 10 CFR 74.33. This regulatory guide discusses each important component of a licensee's MC&A program and describes methods that may be used to satisfy the rule.

Any information collection activities mentioned in this regulatory guide are contained as requirements in 10 CFR Part 74, which provides the regulatory basis for this guide. The information collection requirements in 10 CFR Part 74 have been approved by the Office of Management and Budget, Approval No. 3150–0123.

B. DISCUSSION

The MC&A requirements for uranium enrichment facilities specified in 10 CFR 74.33 have been established to provide adequate safeguards for NRC-licensed materials at such plants. The basis for such requirements is that the safeguards must be at least equivalent to those required for plants possessing material of equivalent safeguards significance. Since the requirements set forth in 10 CFR 74.33 are performance-based, this regulatory guide has been developed to describe one approach to meeting those requirements. The rationale for the approach is that the enrichment levels that are authorized for NRC-licensed enrichment plants will be the same general level as for licensees authorized to fabricate low enriched uranium fuel. However, enrichment facilities differ from fabrication facilities in that they possess equipment that could be used to produce SNM of moderate or high strategic significance. For this reason, the MC&A system for enrichment facilities must contain additional safeguards features to protect against and detect such activities.

Since 10 CFR 74.33 is a performance-based regulation, it is the objectives rather than the means for achieving them that are defined in 10 CFR 74.33(a). Thus, applicants or licensees are free to decide how to design, manage, and operate their MC&A systems. This regulatory guide is not intended to be an exhaustive description of all possible methods a licensee might use to achieve the desired objectives. Instead, this regulatory guide provides guidance on an acceptable approach for achieving the objectives in 10 CFR 74.33(a). Other alternatives are acceptable provided they satisfy the requirements of 10 CFR 74.33.

*All enrichment levels specified in this guide should be treated as weight percent and not atom percent.

C. REGULATORY POSITION

1. PERFORMANCE OBJECTIVES

Each licensee subject to 10 CFR 74.33 is required to implement and maintain an MC&A system that is capable of achieving the performance objectives of 10 CFR 74.33(a).

1.1 Maintain Accurate, Current, and Reliable Information of and Periodically Confirm the Quantities and Locations of Source Material and Special Nuclear Material in the Licensee's Possession

As used in this guide, accurate information means that the amounts and locations of the material in question are based on records and measurements; current information means that the licensee knows, through MC&A records, how much of this material is possessed at any given time and its location (i.e., in process or in storage); and reliable information means that the quantities and locations of all classes of material and items listed in the accounting records are, in fact, correct and verifiable.

1.1.1 Shipments and Receipts

The licensee must account for all SNM and SM received or shipped. This should be accomplished by maintaining reliable records that are based on measured values (10 CFR 74.33(c)(2)). Guidance on shipper-receiver procedures and the analysis of shipper-receiver data is provided in Regulatory Position 9 of this regulatory guide.

1.1.2 Monitoring Material Movements

The monitoring program must include the use of item control procedures to monitor the location and integrity of items and ensure that all SM and SNM quantities of record associated with receipts, shipments, discards, and ending inventory are based on measurements (10 CFR 74.33(c)(6)). The monitoring program should also include process-monitoring procedures to maintain current knowledge of the total uranium and U-235 within the enrichment process. Guidance on the item control program is provided in Regulatory Position 8 of this regulatory guide, while guidance on measurements and measurement control programs are in Regulatory Positions 4 and 5, respectively. Monitoring the quantity of material in process may involve the use of production and quality control data. A detailed and accurate recordkeeping system for MC&A and production data must be maintained to provide knowledge of the quantity of material on a timely basis (10 CFR 74.33(d)).

1.1.3 Dynamic Physical Inventories

In order to verify that the controls described in Regulatory Position 1.1.2 have been effective, the licensee must perform a dynamic physical inventory at intervals not to exceed 65 days (10 CFR 74.33(c)(4)(i)). This inventory provides a snapshot of the amount of material in process at a given time. Regulatory Position 7 provides guidance on the conduct of dynamic physical inventories.

1.1.4 Yearly Plant Physical Inventory

Once a year, at intervals not to exceed 370 days (10 CFR 74.33(c)(4)(i)), the licensee must conduct a total plant inventory and must be able to detect, with at least a 90 percent power of detection, an actual loss or theft of a detection quantity (DQ) that may have occurred since the last yearly inventory. DQ is a site-specific parameter that depends upon the amount of material processed annually at each facility. To satisfy the requirement in 10 CFR 74.33(c)(4)(i) to confirm the quantity and location of all SNM and SM currently possessed by the enrichment facility, the licensee must conduct both a dynamic (nonshutdown) physical inventory of the uranium and U-235 contained within the enrichment processing equipment and a static physical inventory of all other uranium and U-235 that is not within the processing equipment. Criteria pertaining to physical inventories are discussed in Regulatory Position 7. The performance of a total plant inventory should include:

1. Measuring (or, when direct measurement is not feasible, using indirect measurements) all SNM and SM quantities on hand that have not previously been measured in their current form,
2. Verifying the physical presence of all uniquely identified SNM and SM items that the accounting records indicate are on hand,
3. Measuring a sample of randomly selected unencapsulated and unsealed items, based on a statistical sampling plan, to confirm the previous measurements of SNM and SM contained in each of these items, which in turn will be used as the basis for accepting or rejecting the total SNM and SM contained in all such items, and
4. Verifying the integrity of all encapsulated items and all tamper-safed* items.

1.2 Protect Against and Detect Production of Uranium Enriched to 10 Percent or More in the Isotope U-235

The licensee should have a program for monitoring the isotopic composition of product and depleted uranium streams, independent of operations, that provides high assurance of timely detection of production of uranium enriched to 10 percent or more in the isotope U-235 before SNM of moderate strategic significance could be produced if such production could be achieved within 370 days. The licensee may also want

*"Tamper-safing" is defined in10 CFR 74.4 as the use of devices on containers or vaults in a manner and at a time that ensures a clear indication of any violation of the integrity of previously made measurements of SNM within the container or vault.

to consider monitoring other parameters besides enrichment levels and instituting a personnel monitoring program to observe activities in the process areas to protect against the production of uranium enriched to 10 percent or more in the isotope U-235. The enrichment technology used may determine the extent of the program. For example, a limited program for a gaseous diffusion technology plant would be appropriate because it is difficult for a few people to recon- figure the equipment to produce higher enrichments in a short time, while a more extensive program for a centrifuge technology plant would be appropriate because of the ease of reconfiguring the machines to produce higher enrichments in a short period of time. The program can use nondestructive assay with fixed detectors, portable detectors, or UF_6 samples taken and analyzed for U-235 concentration.

The program must be managed and maintained independent of the operations (production) unit organization (10 CFR 74.33(c)(1)(ii)), but it may make use of production and quality control data that are normally generated and used by production personnel. Additional guidance for this program is provided in Regulatory Position 12 of this regulatory guide.

The NRC Operations Center must be notified within 1 hour of discovery of any actual production of uranium enriched to 10 percent or more in the isotope U-235 as required by 10 CFR 74.11. For centrifuge enrichment facilities, this requirement does not apply to each cascade during its start-up process, not to exceed the first 24 hours.

1.3 Protect Against and Detect Unauthorized Production of Uranium of Low Strategic Significance

A program must be implemented that will, with high assurance, protect against and detect the unauthorized production of uranium of low strategic significance that is not included in the facility's accounting records (10 CFR 74.33(a)(3)). The program should be capable of detecting the introduction of feed material not declared or recorded in the facility MC&A records. The program must be managed and maintained independently of the production or operations organizational unit (10 CFR 74.33(c)(1)(ii)), but should not be excluded from using process monitoring or production control data and equipment. Additional guidance for this program is provided in Regulatory Position 12.

Pursuant to 10 CFR 74.11, discovery of actual unauthorized production of uranium of low strategic significance must be reported to the NRC Operations Center within 1 hour.

1.4 Resolve Indications of Missing Uranium

A formalized program to resolve any indication that uranium SM or SNM is missing must be developed (10 CFR 74.33(a)(4)). Resolution of such indicators means that the licensee has investigated all information relevant to the cause of the indicator and has concluded that a theft or loss of SNM or SM has not occurred. As stated in 10 CFR 74.33(c)(6), only indications that suggest a possible loss of items or of material from items involving 500 grams or more of U-235 need be investigated.

The procedures that the licensee should undertake to resolve an indication of missing uranium depend on the nature of the indicator. In some cases, the resolution process would begin with a thorough review of the MC&A records to locate blatant errors such as omissions of entire items, data entry errors in computer programs or on records, incorrect entries, transcription errors, errors in estimating the amount of material holdup in equipment, or calculational errors. A detailed examination of the MC&A records for the applicable material type should identify gross errors. The next stage in the resolution process could be to isolate the storage area or the portions of the process that appear to be involved. Once this is accomplished, all the information that contributed to the determination of the SM and SNM quantities for that storage location or process stream should be verified. If there is still no resolution, the licensee should consider sampling and remeasuring the applicable material in the applicable storage area or process stream to verify the quantities. If the investigation of an indication results in a determination that an actual loss or theft has occurred, the loss or theft must be reported to the NRC in accordance with 10 CFR 74.11. Additional guidance on resolution of indications of missing uranium is presented in Regulatory Position 11.

1.5 Resolve Indications of Production of Uranium Enriched to 10 Percent or More in the Isotope U-235

A formalized program designed to resolve indications of the production of uranium enriched to 10 percent or more in the isotope U-235 must be developed (10 CFR 74.33(a)(5)). Resolution of such indications means that the licensee has investigated all information relevant to the cause of the indicator and has concluded that enrichment of uranium to 10 percent or more in the isotope U-235 has not occurred. Since unauthorized enrichment might not be detected on a timely basis through the conduct of the static physical inventories or periodic dynamic physical inventories, the resolution process should include investigating all the information that contributed to the indication of unauthorized enrichment. Upon receipt of an indication that uranium may have been or is being enriched to 10 percent or more, the licensee is required by 10 CFR 74.33(a)(5) to take appropriate actions to investigate and resolve the indicator. Material contained in any suspect process equipment or piping or in a suspect container should be measured to determine its U-235 concentration. If the indication was generated by instrumentation or measurements, the instruments or measurement systems used for monitoring should be examined to determine whether they are calibrated and functioning properly. An examination of the processing equipment should be performed to ensure that unauthorized modifications have not been made. The presence of uranium enriched to 10 percent or more should be verified through remeasuring the material in question, whether in item form or in process equipment.

If the resolution process results in a determination that unauthorized enrichment of uranium to 10 percent or more in the isotope U-235 has actually occurred, this condition must be reported to the NRC according to 10 CFR 74.11. For centrifuge enrichment facilities, this requirement does not apply to each cascade during the start-up process, not to exceed the first 24 hours.

Guidance on resolution of indications of uranium enriched to 10 percent or more is presented in Regulatory Position 11.

1.6 Resolve Indications of Unauthorized Production of Uranium of Low Strategic Significance

A formalized program designed to resolve indications of the production of unauthorized uranium enriched to less than 10 percent in the isotope U-235 must be developed and followed (10 CFR 74.33 (a)(6)). Resolution of such indicators means that the licensee has investigated all information relevant to the cause of the indicator and has concluded that unauthorized (i.e., undeclared and clandestine) production of uranium enriched to less than 10 percent in the isotope U-235 has not occurred.

Indicators of unauthorized production of uranium of low strategic significance can come from many different sources, some of which are listed in Regulatory Position 11.2. Therefore, the resolution process will be dictated by the type of indicator that occurs. For example, if an employee reports that there appears to be an excess of UF_6 feed cylinders in a storage area, the resolution process might include verifying the report and making a detailed analysis of shipping and receiving records as well as production records. On the other hand, if it is discovered that the rate of enriched uranium production differs from scheduled production, it may be appropriate to sample and measure depleted UF_6 containers to determine whether the U-235 concentration of the depleted uranium is consistent with the authorized and declared production of enriched uranium.

In the event of any of these or other indications of unauthorized production of uranium enriched to less than 10 percent in the isotope U-235, the licensee should determine the cause of the indicator and conclude whether or not unauthorized production has occurred or is under way. A licensee determination that unauthorized production of uranium of low strategic significance has taken place is reportable according to 10 CFR 74.11. Additional guidance on resolution of indications of unauthorized production of uranium of low strategic significance is included in Regulatory Position 11.

1.7 Provide Information To Aid in the Investigation of Missing Uranium, the Production of Uranium Enriched to 10 Percent or More in the Isotope U-235, or the Unauthorized Production of Uranium of Low Strategic Significance

As previously noted, the detection of any actual loss or theft of SNM, or any actual unauthorized production of enriched uranium, is reportable under 10 CFR 74.11. Such reports, depending upon the seriousness of the material facts, may result in investigations by the NRC or other government agencies. The purposes of such investigations would be to recover any lost or stolen material, to secure and control any unauthorized material produced, and to identify and bring to justice the individuals involved. NRC licensees are required by 10 CFR 74.33(a)(7), (a)(8), and (a)(9) to provide any information, particularly the relevant information contained in the MC&A records, to assist the NRC or other government agencies in their investigations.

2. ORGANIZATION

2.1 Corporate Organization

At least one corporate-level official should have responsibilities pertaining to the control and accounting of all SM and SNM possessed by the licensee (10 CFR 74.33(c)(1)(i)).

2.2 Facility Organization

A comprehensive facility management structure should be developed (10 CFR 74.33(c)(1)). This structure should clearly establish where the responsibility lies for the (1) overall MC&A program, (2) SM and SNM custodianship, (3) receiving and shipping of SM and SNM, (4) analytical laboratories, (5) physical inventories, (6) monitoring programs to protect against and detect unauthorized enrichment activities, and (7) onsite nuclear material handling operations.

The interrelationships of facility positions outside the MC&A organization that have responsibilities relating to MC&A activities (such as sampling, bulk measurements, analytical measurements) should be identified within the management structure.

2.3 MC&A Organization

A single individual should be designated as the overall manager of the MC&A program. In order to ensure independence of action and objectivity of decision making, the MC&A manager should either report directly to the facility manager or report to an individual with no production responsibilities who reports directly to the facility manager (10 CFR 74.33(c)(1)(ii)).

The responsibilities and authority of each supervisor and manager should be established for the various functions within the MC&A organization (10 CFR 74.33(c)(1)(iii)). Careful consideration should be given to how the activities of one functional unit or individual serve as a control over or check the activities of other units or individuals. The MC&A manager should have the responsibility for reviewing and approving all written MC&A procedures, both within and outside his organization. MC&A managers should be appointed to oversee (1) the nuclear material accounting program, (2) the measurement control program, (3) the item control program, (4) the monitoring programs, and (5) the statistical program.

Whenever more than one key MC&A function is assigned to the same person, specific procedures should be developed to preclude such things as (1) performance of accounting or record control functions by persons who also generate the associated source data and (2) any person having sole authority to evaluate or audit information for which he or she is responsible (10 CFR 74.33(c)(1)(iii)).

2.4 MC&A System

In order to maintain clear overall responsibility for MC&A functions (10 CFR 74.33(c)(1)(i)), responsibility for the following MC&A activities should be established:

1. Overall MC&A program management,
2. Measurements,
3. Accountability records,
4. Measurement control and statistics,
5. Item control,
6. Physical inventories,
7. Custodial responsibilities (SM and SNM storage and movement controls),
8. Monitoring program for detecting unauthorized enrichment activities,
9. Investigation and resolution of indicators (suggesting possible loss or possible unauthorized enrichment activities),
10. Receiving and shipping of SM and SNM,
11. Analytical laboratories, and
12. MC&A recordkeeping system and controls.

Policies, instructions, procedures, duties, responsibilities, and delegations of authority should be developed to ensure that separation and overchecks are built into the MC&A system (10 CFR 74.33(c)(1)(iii)).

3. MC&A PROCEDURES

Approved written MC&A procedures must be developed and periodically reviewed (10 CFR 74.33(c)(1)(iv). These procedures should address the following topics:

- Accountability record system,
- Sampling and measurements,
- Measurement control program,
- Item control program,
- Static and dynamic physical inventories,
- Investigation and resolution of loss indicators,
- Investigation and resolution of indicators suggesting possible unauthorized enrichment activities,
- Monitoring program to detect unauthorized enrichment activities,
- Determination of the standard error of the inventory difference (SEID), active inventory, and inventory difference (ID),
- MC&A recordkeeping system, and
- Independent assessment of the effectiveness of the MC&A program.

4. MEASUREMENTS

4.1 Measurement Systems

Measurement systems and measurement procedures must be developed in order to meet the systems features and capabilities of 10 CFR 74.33(c)(2) and (3). A measurement system can be defined as any instrument or device, or combination of devices, used to derive a mass, volume, uranium element concentration, U-235 isotopic concentration, or U-235 content. Parameters that are important to most measurement systems include the measurement device or equipment used, standards used for calibration, and standards used for control. For analytical laboratory measurements, sampling equipment and technique used, sample aliquoting technique, and sample pretreatment methodology are often important parameters.

4.1.1 Bulk Measurement Systems

For each mass (weight) measurement system, a decision should be made as to the weighing device, the type of containers weighed, the material within the containers being weighed, the capacity of the weighing device, the range to be utilized, and the sensitivity of the device.

For each volume measurement system, the vessel (tank, column, etc.) to which the measurement applies, the capacity of the vessel, the material being measured (including uranium and U-235 concentrations), the volume-measuring devices, and the sensitivity and range of operation of the system should be considered.

4.1.2 Analytical Measurement Systems

For each analytical (laboratory) measurement system to be used, the following should be considered:

1. Type of material or chemical compound (e.g., UF_6, uranium alloy, U_3O_8, uranyl nitrate solution) being measured,
2. Characteristics to be measured (e.g., grams uranium per gram sample, U-235 isotopic concentration),
3. Analytical method used,
4. Sampling technique,
5. Sample handling (i.e., pre-analysis sample storage and treatment),
6. Measurement interferences (e.g., impurities), and
7. Expected measurement uncertainty.

4.1.3 NDA Measurement Systems

For each nondestructive assay (NDA) measurement system to be used, the following should be considered:

1. The NDA equipment package (detector and electronics),
2. The type of container being measured,
3. SM or SNM material type within the container,
4. Characteristics being measured,
5. Measurement configuration (e.g., source to detector distance, collimation, and shielding),
6. Calculational method, and
7. Expected measurement uncertainty.

4.2 Measurement Uncertainties

Special attention should be given to the expected measurement uncertainties for each measurement system, for example, the variance from calibration, the variance from sampling, and the random error components. The smaller each of these components can be made, the greater the likelihood that the performance objectives of 10 CFR 74.33 will be met. The units in which errors are expressed should be consistent with other sources of uncertainty.

4.3 Measurement Procedures

A set of approved written measurement procedures must be developed and followed (10 CFR 74.33(c)(1)(iv)). The organizational units responsible for the preparation, revision, and approval of the measurement procedures should be clearly identified. A periodic review of the measurement procedures must be conducted (10 CFR 74.33(c)(1)(iv)). Measurement procedures should be approved by the overall MC&A manager and by the manager of the organizational unit responsible for performing the measurement. Measurement procedures should also be approved by the measurement control program manager.

5. MEASUREMENT CONTROL PROGRAM

5.1 Organization and Management

The organization and management of the measurement control program should contain a measurement quality assurance function. Independence from the analytical laboratory and from other units performing either sample taking or measurements should be maintained (10 CFR 74.33(c)(1)(iii)). The measurement control program manager should be at a management level that is sufficient to ensure objectivity and independence of action. Thus, the measurement control program manager should either report directly to the overall MC&A manager or, if in a different organizational unit, be on the same level as the MC&A manager.

The measurement control program must be managed to ensure adequate calibration frequencies, sufficient control of biases, and sufficient measurement precision to achieve the capability required in 10 CFR 74.33(c)(3).

5.1.1 Functional Relationship

The relationship and coordination among the measurement control program manager, the analytical laboratory, and any other groups performing measurements should be defined clearly (10 CFR 74.33(c)(1)(i)). There should be adequate assurance that the measurement control program manager has the authority to enforce all applicable measurement control requirements.

5.1.2 Procedures

The measurement control program procedures must be established and maintained (10 CFR 74.33(c)(1)(iv)). All the currently applicable written procedures pertaining to measurement control and measurement quality assurance should be reviewed annually. Responsibility for preparation, revision, and approval of the procedures should be assigned. Individual measurement control program procedures should be documented and approved by the measurement control manager (10 CFR 74.33(c)(1)(iv)). At a minimum, the procedures should address:

1. Calibration frequencies and methods,
2. Standards used for calibration (description and storage controls),

3. Standards used for control (obtaining or preparing standards and traceability of standards),

4. Control standard measurements,

5. Replicate sampling and replicate measurements,

6. Control limits and control responses,

7. Generation and collection of control data, and

8. Recordkeeping controls and requirements.

5.1.3 Contractor Program Reviews

If measurement services are provided by an outside contractor or company offsite laboratory, a review program should be developed to monitor the offsite measurements (10 CFR 74.33(c)(3)(iii)). The purpose of such a program is to ensure that the contractor or offsite laboratory has an acceptable measurement control program to the extent that use of the contractor's measurements will not compromise the licensee's ability to meet any measurement or measurement control requirement contained in 10 CFR 74.33(c). An initial review of the contractor's measurement control program should be conducted prior to licensee use of measurements performed by the contractor or offsite laboratory.

All contractor or offsite laboratory review findings and recommendations should be documented and submitted to both the measurement control program manager and the overall MC&A manager in a timely fashion. The two managers should arrive at an agreement as to what corrective actions, if any, need to be taken, based on their evaluation of the report, and transmit these findings to the contractor or offsite laboratory in writing. Measurements performed by such contractors or offsite laboratories should not be used until the licensee has verified that the corrective actions have been instituted.

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

5.2 Calibrations

A calibration program that contains approved procedures for the following should be developed:

1. Calibration frequency for each measurement device or system,

2. Identification of the reference standards used for calibration of each measurement device or system,

3. Protection and control of calibration standards to maintain the validity of their certified or assigned values, and

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

In general, there are two types of measurement systems—those that are recalibrated periodically and those that are calibrated each time the system is used, based on one or a few measurements of representative standards. The latter type of calibration is often referred to as "point-calibration" and is regarded as being bias-free. In the former case, the calibration standards need not be representative because system bias is estimated from the periodic measurement of representative control standards. For point-calibrated measurement systems, the following calibration procedures should be followed.

1. The standard or set of standards used to calibrate the measurement system should be representative of the process unknowns that are measured by the system. That is, the representative calibration standard should undergo all the measurement steps in the same manner that the unknowns do.

2. One or more calibration standards should be processed (measured) along with each unknown or set of unknowns measured. That is, both the standard and the unknown are measured at the same time with the same person measuring both the standard and the unknown.

3. The measurement values assigned to the process unknowns are derived from the measurement response observed for the standard that was measured along with the unknowns.

4. The measurement response for each unknown should fall within plus or minus 10 percent of the response for a standard measured at the same time as the unknown. For unknowns of very low concentration, the measurement response should fall within plus or minus 4 standard deviations of the response for a standard measured at the same time as the unknown.

For systems that are range-calibrated, SM or SNM accountability values should not be based on measurements that fall outside the range of calibration. The calibration standards for range-calibrated systems need not be representative of the process material or items to be measured by the calibrated device or system. It is the primary measurement device, not necessarily the entire measurement system, that needs to be calibrated. This is particularly true when the primary measurement device is common to two or more measurement systems. For example, the Davies & Gray titration method is often used to analyze samples of different uranium materials to determine uranium concentration. In this case, two or more measurement systems involving different sampling methods, different sample pretreatment methods, and different control standards are being utilized. The potassium dichromate titrant is, however, common to all systems, and it is the titrant that is calibrated (or standardized) with a reference standard such as certified U_3O_8 or certified uranium metal.

In the case of nonconsumable calibration standards such as weight standards, the frequency of recertification should be given special consideration. The recertification frequency should depend on how often the standards are handled, the standards' stability, and the adequacy of the controls used to maintain the integrity of the standards. Biannual recertification of such standards is usually acceptable.

5.3 Control Standard Program

For those measurement systems that are not point-calibrated, a defined program for the periodic measurement of control standards should be established and followed. Control standard measurements are performed to (1) monitor the stability of a previously established calibration factor and (2) estimate the bias of the measurement system over a specified period (e.g., an inventory period). The calibration factor is the numerical relationship between the observed output of a measurement system and the actual value of the characteristic being measured, as based on a traceable standard. If there is a possibility of a change in the standard's true value from factors such as evaporation, moisture pickup, or oxidation, the value of the standard should be checked periodically.

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

In addition to material composition and matrix factors, biases can be induced by changes in temperature, humidity, line voltage, and background radiation, or they may be operator-induced. Therefore, in scheduling control standard measurements, the following questions should be addressed:

- Does operator-to-operator variation need to be considered and hence monitored?
- Can environmental or other variables contribute to measurement bias?
- Is bias likely to vary with respect to the time of day?
- Is a particular bias likely to be long term, short term, or cyclic in nature?
- Is bias a function of the process measurement values over the range of calibration? That is, does the relative percent bias vary over the range of calibration?
- What controls or procedures are needed to ensure that sampling or aliquoting of the control standard is representative of the sampling or aliquoting of the process material?
- How similar, in terms of chemical composition, uranium concentration, density, homogeneity, and impurity content, should the control standards be relative to the process unknowns?

5.4 Replicate Program

In order to estimate the combined analytical and sampling random error variance, measurements of replicate (duplicate) samples should be performed. Although it is not necessary to estimate how much of the total random error is due to sampling and how much is due to analysis, an estimate of the random analytical error variance can be obtained by performing replicate measurements on single samples. For nonsampling measurement systems such as NDA and weight-measurement systems, the random error variance can be derived from either replicate measurements performed on the process items or the replicate data generated from the measurement of control standards.

For each measurement system involving sampling and analysis, the following should be considered: (a) the number of samples to be taken and measured and (b) the number of analyses to be performed on each sample. Replicate samples should be independent of one another. The minimum number of replicate samples measured for each analytical measurement system depends upon the number of batches* processed during the inventory period. If there are very few batches processed during the inventory period, replicate sample measurements on all the batches may be needed. If the process in question produces a large number of batches during an inventory period, each batch need not be subjected to replicate sampling. If 14 or fewer batches are processed during an inventory period, replicate samples from each batch should be measured. Otherwise, the minimum number of replicate samples to be measured should be the greater of 15 or 15 percent of the batches generated, unless 15 percent exceeds 50, in which case the measurement of more than 50 replicate samples is not necessary.

*"Batch" is defined in 10 CFR 74.4 as a portion of source material or SNM handled as a unit for accounting purposes at a key measurement point and for which the composition and quantity are defined by a single set of measurements. A batch may be in bulk SM or SNM form or contained in a number of separate items.

5.5 Warning and Out-of-Control Limits

Both warning and out-of-control limits should be established and used for both control standard and replicate measurements for those measurement systems used for nuclear material accountability. For point-calibrated systems, the assigned value of the standards measured along with the unknowns is assumed to be valid. Control limits for the verification measurements associated with such standards should be established. This is particularly applicable to those point-calibrated systems that use a single standard, or aliquots from a single standard, over any extended period of time.

The warning and out-of-control limits are normally set based on a tradeoff between the cost of investigating and resolving incidents when limits are exceeded and the consequences of accepting measurements of poor quality. Warning limits should be set at the 0.05 level of significance and out-of-control limits should be set at the 0.001 level of significance. This means that 95 percent of the time the measurement response of the standard is expected to be within the warning limits and 99.9 percent of the time it is expected to be within the out-of-control limits. When a measurement system generates a control measurement response that falls beyond an out-of-control limit, the system should not be used for accounting purposes until it has been brought back into control below the warning limit. At regular intervals determined in advance by the licensee, control standard measurements should be made and the data should be analyzed to determine whether control limits should be modified.

5.5.1 Control Charts

Measurement control data, such as control standard measurement results and the differences between measurement values of replicate pairs, may be analyzed by automated techniques but should be plotted on graphs. All control charts should be reviewed at least once every 2 weeks unless the measurement system in question was not used during that period. The purpose of this review is to ensure that all occurrences of standards measurements falling outside the warning and out-of-control limits are documented and appropriate action has been taken. This review is also intended to detect situations in which the limits are not exceeded but there are problems that would indicate that recalibration or other corrective action should be taken. The review should address the frequency that control data exceed either the warning or the out-of-control limits and should evaluate for any significant trends.

5.5.2 Response Actions

The analyst or operator performing a control measurement, or the applicable supervisor, should have the responsibility for promptly reporting to the measurement control program manager or the designee any control measurement that exceeds an out-of-control limit and for taking the system out of service with respect to accountability measurements. Response and corrective action requirements should be developed and documented. As a minimum, response to a reported incident of a control measurement exceeding an out-of-control limit should consist of:

1. Verifying that the measurement system in question has been taken out of service with respect to accountability measurements,
2. Documenting the occurrence of the event,
3. Performing at least two additional control standard measurements, and
4. If results of 3, above, do not show the system to be back in control, performing additional control measurements using a different control standard or different replicate sample (as appropriate), recalibrating the measurement system, or, if necessary, making system repairs.

For those measurement systems that make a significant contribution to the magnitude of the standard error of the inventory difference (SEID), the response to an out-of-control condition should also include remeasurement of any samples (items) that were measured prior to the out-of-control condition but after the last within-control measurement. The validity of the prior measurements can be established without a complete remeasurement of all the samples (items) involved if remeasurement on a "last in, first out" basis is used. That is, the last sample (item) measured prior to the out-of-control measurement should be the first to be remeasured, and in reverse order continued until two consecutive remeasurements are found to be not statistically different from their initial measurements at the 95 percent confidence level. In other words, for two consecutive remeasurements, the statistical test of the null hypothesis that the difference between the measured and remeasured value is zero is not rejected.

6. STATISTICS

In order to achieve the objectives and capabilities of 10 CFR 74.33, a statistical program must be instituted to evaluate the measurement control data, ensure that measurements are accurate and precise, ensure that measurement data are analyzed in a rigorous manner, and ensure that hypotheses concerning the status of the nuclear material possessed are appropriately tested. The NRC has sponsored the development of a comprehensive reference that specifically addresses the statistical treatment of SM and SNM measurement data. The statistical methods described in "Statistical Methods for Nuclear Material Management," NUREG/CR-4604,* are acceptable to the

*W. M. Bowen and C. A. Bennett, NUREG/CR-4604, December 1988. Copies may be purchased from the U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20013-7082.

NRC staff for satisfying the requirements of 10 CFR 74.33.

At a minimum, the statistical program should address the following topics:

1. Procedures and methods for estimating measurement variance components,
2. Procedures and methods for determining and applying bias correction, including:
   - Frequency of bias estimates,
   - Method of determining the effect of a bias on the measured quantity of material in individual SM or SNM items,
   - Method for bias corrections to items and conditions under which they will be made,
   - Method for determining the effect of biases on inventory difference, and
   - Method for applying bias corrections to the inventory difference and the conditions under which they will be applied,
3. Procedures and methods for determining active inventory,
4. Procedures and methods for determining SEID,
5. Procedures and methods for determining the DQ,* and
6. Procedures and methods for determining the detection threshold (DT) values to be used to provide a 90 percent power of detecting a loss of a DQ amount of material, as required by 10 CFR 74.33(c)(4).

At least two individuals should independently verify the correctness of the SEID calculation for each total plant material balance. If the SEID value is calculated using a computer, verification may be accomplished during each physical inventory reconciliation process by two or more persons checking for correctness of the input data used by the computer to calculate SEID and checking the correctness of a sample calculation used to verify the computer program.

7. PHYSICAL INVENTORIES

7.1 General Description

Detailed procedures should be developed for the conduct of both dynamic physical inventories of the enrichment processing equipment and static physical inventories of the balance of the plant (10 CFR 74.33(c)(1)(iv)). The physical inventory functions and responsibilities should be clearly defined and comprehensively reviewed with all persons involved before the start of each dynamic and static physical inventory.

For inventorying the SM and SNM that does not reside in the enrichment processing equipment, a book inventory listing derived from the MC&A records should be generated just prior to the actual start of the inventory. This listing should include all SM and SNM that the records indicate should be possessed by the licensee at the cut-off time, except for material to be covered by the dynamic physical inventory that is to be conducted in conjunction with the static inventory.

For dynamic physical inventories, a book inventory quantity, to which the results of the dynamic physical inventory will be compared, is needed. One approach to estimating the in-process inventory is to calculate a quantity known as the "running book in-process inventory" (RBIPI). Essentially, this calculation is analogous to determining one's checkbook balance. First, the amount of SM and SNM introduced into the process since the last dynamic physical inventory is added to the amount that was in the process at that time. Then the amount of material removed from the process in the same time span is subtracted. The RBIPI is the quantity of uranium and U-235 calculated as follows:

$$RBIPI = BI + CI - CO$$

Where: BI = Beginning in-process inventory (at the start of the current inventory period) as determined from the previous dynamic physical inventory.

CI = Cumulative measured input to the enrichment process for the current dynamic physical inventory period.

CO = Cumulative measured output from the enrichment process for the current dynamic physical inventory period.

Hence, the inventory difference associated with the dynamic physical inventory is calculated as follows:

$$ID = RBIPI - EI = (BI+CI) - (CO+EI)$$

Where: EI = Ending in-process inventory as determined from the dynamic physical inventory.

7.2 Organization, Procedures, and Schedules

The composition and duties of the organization for the typical physical inventories, both dynamic and static, should be established in advance of the inventories. The individual having responsibility for the coordination of the physical inventory effort should be identified. Written procedures for both dynamic and static physical inventories should be developed and approved by the MC&A manager and no revisions should be made to these procedures without his or her approval (10 CFR 74.33(c)(1)(iv)). Specific inven-

*DQ should not exceed 1.3 percent of the annual U-235 quantity introduced into the enrichment process except when the 1.3 percent is less than 25 kg U-235, in which case the DQ need not be less than 25 kg U-235.

tory instructions should be prepared and issued for each dynamic and static physical inventory.

7.3 Inventory Composition

The quantity of material within the enrichment equipment for both uranium and U-235 at the time of dynamic physical inventory should be accounted for. UF_6 cylinders connected (valved in) to the enrichment process system should be included as part of the dynamic physical inventory. For static physical inventories, the item composition should be categorized as depleted uranium, natural uranium, or enriched uranium. If different size cylinders or other containers are used within one of the three UF_6 categories, they should be treated as different item strata.

7.4 Conducting Dynamic Physical Inventories

The licensee is required by 10 CFR 74.33(c)(4) to perform a dynamic physical inventory, which involves striking a material balance around the processing equipment as described in Regulatory Position 7.1. Indirect measurements and production parameters (as well as the analysis of process samples) to determine the quantity of material within the enrichment process may be used. The estimate of the amount of material within the process should be compared to that shown by the MC&A records to provide an indication as to whether or not a loss or theft has occurred. The loss detection sensitivity associated with the bimonthly dynamic inventories should be sufficient to detect a loss or theft of DQ or greater over a 12-month period with at least a 90 percent power of detection. A DQ is a site-specific quantity of U-235, the value of which is discussed in Regulatory Position 6 of this regulatory guide.

7.5 Conducting Static Physical Inventories

Detailed written procedures and methods associated with performing static physical inventories should be developed (10 CFR 74.33(c)(1)(iv)). These procedures should address the following:

- The organization and independence of inventory functions,
- Assignment of inventory teams and the instructions given to each team,
- The processes of obtaining, verifying, and recording source data,
- Control of inventory forms,
- The process for verifying the presence of each item while preventing multiple counting of any item, and
- The procedures for halting processing and material movement after the physical inventory has started for nonenrichment processes such as scrap recovery.

Procedures should be developed for item storage and handling or tamper-indicating methods that are used to ensure that prior measurements are valid and may be used for inventory purposes (10 CFR 74.33(c)(1)(iv)). Also, inventory procedures should address how item identities are verified and how tampering with the contents of items will be detected.

For items that are not encapsulated, affixed with a tamper-indicating seal, or otherwise protected to ensure the validity of prior measurements, procedures should be developed for determining which items are to be measured at physical inventory time. Criteria should be developed for the justification of any proposed alternatives to measurement of any SM and SNM included in the inventory. A statistical sampling plan for determining how many and which items are to be randomly selected for remeasurement may be an alternative method to 100 percent verification of prior measurements. Such a plan should address the following:

- The method of classifying into several strata the types of items to be sampled;
- The method for calculating the sample size for each stratum;
- The quality of the measurement methods used to verify original measurement values;
- The procedure for reconciling discrepancies between original and remeasured values, including when additional tests and remeasurements would be performed; and
- The basis for discarding the value of a previous measurement of SM or SNM value and replacing it with a remeasured value.

One acceptable means for establishing the number of items to be randomly selected for remeasurement from a given material type is given by the following equation, which calculates the number of items that would need to be remeasured to give a 90 percent probability of detecting the loss of DQ kilograms of U-235 from the given material stratum:*

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

Where: n = number of items to be remeasured

N = total number of items in the stratum

x = maximum U-235 content per item (kilograms)

g = DQ (kilograms U-235)

*G.F. Piepel and R. J. Brouns, "Statistical Sampling Plans for Prior Measurement Verification and Determination of the SNM Content of Inventories," prepared for the NRC by Pacific Northwest Laboratory, NUREG/CR-2466 (PNL-4057), March 1982.

Any items on ending inventory that have not been previously measured must be measured for inventory purposes (10 CFR 74.33(c)(2)).

Procedures should be developed for determining when the element and isotope factors for items, objects, or containers will be measured directly for inventory and when they may be based on other measurements. These procedures should clarify the conditions under which it is permissible to apply an average enrichment factor to the measured uranium element content and the method used to determine the factor.

If the content of items is established through prior measurements and those items are tamper-safed or access to them is controlled, the current SM or SNM quantity in those items may be based on those measured values. Otherwise, verification of SM or SNM content can be achieved by reweighing either (1) all the items within a given stratum or (2) randomly selected items from the stratum based on a statistical sampling plan. A statistical sampling plan will not be acceptable if there is any likelihood of a significant change in the uranium concentration (or weight fraction) or in the uranium isotopic composition. For example, oxidation or change in moisture content will alter the uranium concentration.

7.6 Inventory Difference Limits and Response Actions

A well-defined system for evaluating total plant inventory differences (IDs) and taking action when IDs exceed certain predetermined thresholds should be established and followed. As a minimum, there should be a response level if the U–235 ID is equal to or exceeds the detection threshold (DT). The DT for such an ID problem (DT = DQ – 1.3 SEID) may be interpreted in the following manner. If an actual loss or theft of a DQ amount or more occurred since the last static physical inventory, there is at least a 90 percent probability that the inventory difference will exceed the detection threshold. The above limit is expressed in terms of absolute values of ID (i.e., no regard for algebraic sign).

For any unresolved ID that remains greater than or equal to DT (even if the ID is negative), the licensee may need to take steps for scheduling a plant-wide reinventory and investigation. Intermediate-level thresholds may be useful in order to provide a timely mechanism for detection of losses that are less than a DQ so that the occurrence of an ID greater than or equal to DT may be avoided in future physical inventories.

The regulation in 10 CFR 74.33(c)(4)(i) requires static and dynamic physical inventories for both uranium element and U–235, and 10 CFR 74.33(c)(4)(ii) requires the reconciliation and adjustment of the book inventory for the results of the static physical inventory for both uranium element and U–235.

8. ITEM CONTROL

8.1 Organization

The person to be responsible for overseeing the item control program and the persons who have significant item control program responsibilities should be identified in the applicable MC&A procedures.

8.2 General Description

The MC&A system must maintain records of all SM and SNM items, regardless of quantity or duration of existence (10 CFR 74.33(c)(6)(i)). In addition, the item control program should provide current information about the location, identity, and uranium and U–235 quantity of all nonexempt SM and SNM items (10 CFR 74.33(c)(6)(i)). Items that can be exempt from item control program coverage are:

1. Items that exist for less than 14 calendar days, and
2. Any licensee-identified items containing less than 500 grams U–235 provided the cumulative total of such exempted items does not exceed 50 kilograms U–235.

All items, whether or not they are subject to the item control program, should have a unique identity. For items subject to the item control program, the following are acceptable means for providing a unique identity:

- A unique alpha-numeric identification on a tamper-safe seal that has been applied to a container of SM or SNM,
- A unique alpha-numeric identification permanently inscribed, embossed, or stamped on the container or item itself, or
- A uniquely prenumbered (or bar coded) label applied to each item; the label has adhesive qualities such that its removal from an item would preclude its reuse.

Locations of items shown by the item control program records need not be unique, but location designations should be specific enough so that any item can be located in a timely fashion. The MC&A record system must be tamper-proof and controlled in such a manner that the record of an item's existence cannot be destroyed or falsified without a high probability of detection (10 CFR 74.33(d)(3)).

Each nonexempt item should be stored and handled in a manner that enables detection of, and provides protection against, unauthorized or unrecorded removals of SM and SNM.

8.3 Item Identity Controls

Tamper-safe seals or other tamper-indicating devices may be used to provide unique item identity. Procedures should be developed for:

1. The type of seals utilized for the various types of containers stored,

2. The method of seal procurement and measures taken to ensure that duplicate (counterfeit) seals are not manufactured,

3. Seal storage, control, distribution, destruction, and accounting, and

4. Maintenance and control of seal usage and disposal records.

8.4 Storage Controls

Storage areas and controls for items are important elements in the item control program because they form the basis for accepting prior measurements of items, as opposed to remeasuring the item at inventory time. Any controls used to ensure the validity of prior measurements should be equivalent to the protection provided by tamper-safing seals. Both administrative controls (such as custodian assignments and limiting authorized access to storage areas) and physical controls (e.g., locked and alarmed doors) may be used.

8.5 Item-Monitoring Methodology and Procedures

As part of the item control program, a system of item monitoring that includes the following should be maintained:

1. Verification that items shown in the MC&A records are actually stored and identified in the manner indicated in the records,

2. Verification that generated items and changes in item locations are properly recorded in the MC&A record system in a timely manner, and

3. Detection, with high probability, of a real loss of items (or uranium from items) amounting to 500 grams or more of U-235.

The item-monitoring system should periodically include:

- Checking the actual storage status of a sufficient sample of randomly selected items from the item control program records from each stratum to confirm that the recorded information is correct,

- Checking the accuracy of the item control program records for a sufficient sample of randomly selected items from each storage area to ensure that all items are being properly entered into the records, and

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

The actual frequency of the above checks and the size of the random sample should be a function of an expected discrepancy rate based on prior observations. Items that cannot be located are not discrepancies but indications of possible loss or theft. On the contrary, discrepancies are inadvertent conditions such as items not in assigned locations and incorrect entries in item control program records.

8.6 Investigation and Resolution of Loss Indicators

Procedures and controls should be developed to ensure that all incidents involving missing or compromised items or falsified item records will be investigated. A compromised item is one with evidence of tampering or an unsealed and unencapsulated item that has been assigned to a limited access, controlled storage area, but is found elsewhere. If any unencapsulated and unsealed item is located after it has been determined that it is missing or if an item is found to be compromised, the contents should be verified by measurement. Additional guidance on resolution of item discrepancies is included in Regulatory Position 11.

9. SHIPPER-RECEIVER COMPARISONS

9.1 Receiving Procedures

The first action to be taken by the licensee upon receipt of SM or SNM should be verification of the correct number of items, the correct identity of the items, and the integrity of the tamper-indicating seals. The maximum elapsed time for determining whether or not a significant shipper-receiver difference (SRD) exists should be established by the licensee and should not exceed 30 calendar days.

9.2 Determination of Receiver's Values

For natural UF_6, the licensee may establish the receiver's values by measuring U-235 concentration (either by NDA or by sampling and analysis), weighing each cylinder, and using a nominal percent uranium factor. All SNM receipts, and any SM receipts not in the form of UF_6, should be measured for uranium and U-235 content.

9.3 Evaluation of SRDs

SRDs greater than 500 grams of U-235 are evaluated by testing the hypothesis that the SRD equals zero. NUREG/CR-4604, "Statistical Methods for Nuclear Material Management,"* in the chapter on hypothesis testing, provides methods that are acceptable to the NRC.

*W.M. Bowen and C. A. Bennett, NUREG/CR-4604, December 1988. Copies may be purchased from the U.S. Government Printing Office, P. O. Box 37082, Washington, DC 20013-7082.

9.4 Resolution of Significant SRDs

Resolution of a significant SRD usually involves an independent measurement of retainer samples. A retainer sample is one taken prior to shipment of the material and kept until shipper-receiver comparisons are resolved and it is determined that there is no dispute concerning the amount shipped. Resolution of such SRDs could involve testing three hypotheses. The first hypothesis is that the difference between the shipper's weight and the receiver's weight is zero. The second hypothesis is that the difference between the shipper's percent uranium element measurement and the receiver's percent uranium element measurement is zero. The third hypothesis is that the difference between the shipper's U-235 measurement value and the receiver's U-235 measurement value is zero.

If an SRD is statistically significant and it is 500 or more grams of U-235, it must be resolved (10 CFR 74.33(c)(7)). In the event that such an SRD occurs, the first thing to resolve is any significant difference between the shipper's and receiver's net weights of the material shipped (e.g., kilograms UF_6). Since the shipper will not be able to repeat the measurements upon which his net weights will be based, the licensee's resolution procedure should specify how the net weight value to which both the shipper and receiver agree is to be determined. When the shipper's and receiver's net weights are in statistical agreement with one another, the receiver can proceed to resolve the differences in elemental and isotopic measurements of the material in question, including, if necessary, remeasurement by the shipper using the retained samples.

10. ASSESSMENT OF THE MC&A PROGRAM

10.1 General Description

The capabilities, performance, and overall effectiveness of the licensee's MC&A program must be independently reviewed and assessed at least every 24 months as required by 10 CFR 74.33(c)(8). This independence should be established by ensuring that the individual responsible for assessing each portion of the MC&A program does not have routine responsibilities within that program element. It is preferred that the entire MC&A program be reviewed and evaluated during each assessment. If so, intervals between assessments can be as long as 24 months. If individual assessments do not cover the entire MC&A system, the intervals should be no longer than 12 months. "Interval" means the elapsed time between either the start of or termination of successive assessments.

The responsibility and authority in the licensee's organizational structure for the assessment program should be at least one level higher than that of the MC&A manager. Such responsibility should include the selection of the assessment team leader and the initiation of corrective actions. Team members may be selected from the facility staff or from outside, but an individual member should not participate in the assessment of the parts of the MC&A system for which that person has direct responsibility. Hence, the MC&A manager can not be a team member. Also, to guard against collusion, no pair of team members should perform assessments of each other's area of responsibility. The leader of the assessment team should have no responsibilities for managing any of the MC&A elements being assessed.

The minimum number of individuals on any given assessment team should depend on the knowledge and expertise of the team relative to MC&A activities and on their experience in conducting reviews.

Personnel assigned to the assessment team should have a good understanding of the objectives and the requirements of the MC&A program and should have sufficient knowledge and experience to be able to judge the adequacy of the parts of the system they review. The team should have authority to investigate all aspects of the MC&A system and should be given access to all necessary information.

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

10.2 Report of Findings and Recommendations

The areas to be reviewed must encompass the entire MC&A system, and the level of detail of the reviews should be sufficient to ensure that the assessment team has adequate information to make meaningful judgments of the MC&A program's effectiveness (10 CFR 74.33(c)(8)(i)). The report should provide findings pertaining to:

1. Organizational effectiveness to manage and execute MC&A activities,

2. Management responsiveness to indications of possible losses of uranium and of possible unauthorized enrichment activities,

3. Staff training and competency to carry out MC&A functions,

4. Reliability and accuracy of accountability measurements made on SM and SNM,

5. Effectiveness of the measurement control program in monitoring measurement systems and its sufficiency to meet the requirements for controlling and estimating both bias and SEID,

6. Accuracy of the material accounting records,

7. Effectiveness of the item control program to track and provide current knowledge of items,

8. Capability to promptly locate items and effectiveness in doing so,

9. Timeliness and effectiveness of SRD evaluations and resolution of excessive SRDs,

10. Reliability and effectiveness of the inventory-taking procedures,

11. Capability to confirm the quantities and locations of SM and SNM,

12. Capability to detect and resolve indications of unauthorized enrichment activities and the effectiveness of doing so, and

13. Capability to detect and resolve indications of missing uranium and the effectiveness of doing so.

On completion of each assessment, the findings and recommendations for corrective action, if any, must be documented (10 CFR 74.33(c)(8)(ii)). The written report should be distributed to the plant manager, the MC&A manager, and other managers affected by the assessment.

10.3 Management Review and Response to Report Findings and Recommendations

Management should review the assessment report and take the necessary actions to correct any MC&A system deficiencies. The management review must be documented (10 CFR 74.33(c)(8)(iii)), and it should include a schedule for the correction of deficiencies. Corrective actions, if any, that pertain to daily or weekly activities should be initiated promptly after the submittal of the final assessment report.

11. RESOLVING INDICATIONS OF UNAUTHORIZED PRODUCTION OF ENRICHED URANIUM AND MISSING URANIUM

Procedures must be developed for resolving indicators of either missing uranium involving 500 or more grams U-235 or of indicators of unauthorized enrichment (10 CFR 74.33(a)(4), (5), (6), and 10 CFR 74.33(c)(1)(iv) and (c)(5)). The three generic types of indications are:

1. Indications that either uranium source material or enriched uranium is missing,

2. Indications that unauthorized production of uranium of low strategic significance has been or is occurring, and

3. Indications that the enrichment equipment has been or is being used to produce enriched uranium with an enrichment of 10 percent or more in the isotope U-235.

The resolution program should address the possible indicators of missing uranium. A determination of potential indicators that can be postulated for the three types of indications above should be made, and appropriate resolution procedures for each postulated indicator should be identified. In addition, the time limits within which resolution of indicators must be accomplished and the actions to be taken if resolution has not occurred within that time should be specified.

11.1 Indicators of Missing Uranium

Possible indicators of missing uranium include:

- Determination through the item control program that a specific item is not in its authorized location and its actual location is not known,
- Discovery of tampering with the MC&A records,
- Discovery that an item's integrity or its tamper-indicating seal has been compromised,
- A significantly lower remeasured value on any item, batch, or lot of measured material in which the difference between the original and remeasured values exceeds twice the standard error plus 500 grams or more U-235,
- Discovery of unauthorized feed or withdrawal equipment in the processing area,
- Information from the process control system indicating a potential loss of material from the process system.

Resolution of an indication means that the licensee has concluded that a loss or theft of more than 500 grams of U-235 has not occurred. For each anticipated type of loss indicator, a detailed resolution procedure should be developed.

When appropriate, the resolution process may include (1) a thorough check of the accountability records and source information, (2) locating and isolating the source of the problem, (3) isolating the exact reason for the problem within the area or processing unit, (4) determining the amounts of uranium and U-235 involved, and (5) making a determination that the indication is or is not resolved. The resolution procedures should be implemented in such a manner that no individual who could have been responsible for the potential loss could also be responsible for resolution.

11.2 Indications of Unauthorized Production of Uranium Enriched to Less Than 10 Percent in the Isotope U-235

Possible indicators of unauthorized production of uranium enriched to less than 10 percent in the isotope U-235 include:

- Presence of unauthorized product, feed, or depleted uranium cylinders in the processing area,

- Presence of UF_6 cylinders that have not been entered into the MC&A record system,

- Variations from planned production schedules,

- A change in the enrichment assay of UF_6 tails from that specified by production schedules,

- An excess amount of depleted uranium or an excess rate of depleted uranium production,

- Incorrectly identified cylinders, such as depleted uranium or feed identified as enriched product material,

- Discovery of tampering with the MC&A records,

- Discovery of unauthorized feed or withdrawal equipment in the processing area,

- An allegation that unauthorized enrichment of uranium to 9.9 percent or less in the isotope U-235 is or has been occurring, and

- Reconfiguration of the enrichment equipment to permit unauthorized operation.

Resolution of an indication means that the licensee has concluded that unauthorized production of uranium enriched to less than 10 percent in the isotope U-235 has not occurred and is not occurring. For each anticipated type of indicator, detailed resolution procedures should be developed.

In the event of any of these or other indicators of possible unauthorized production of uranium enriched to less than 10 percent in the isotope U-235, the licensee should determine the indicator's cause and come to a conclusion as to whether or not unauthorized production has occurred or is occurring. If an indication of unauthorized production is determined to be true, the NRC must be notified within 1 hour pursuant to 10 CFR 74.11.

11.3 Indications of Unauthorized Production of Uranium Enriched to 10 Percent or More in the Isotope U-235

Possible indicators of unauthorized production of uranium enriched to 10 percent or greater in the isotope U-235 include:

- Any measurement from a process stream monitoring program that indicates out-of-specification enrichment concentrations,

- Unauthorized withdrawal equipment in the enrichment processing area,

- Unauthorized reconfiguration of enrichment equipment,

- Discovery that enrichment-level monitoring equipment has been compromised,

- An allegation that unauthorized production of uranium enriched to 10 percent or more in the isotope U-235 has occurred or is occurring, and

- Higher than normal nuclear signal, caused by the presence of uranium enriched to 10 percent or more, from a container or process system.

Resolution of an indication means that the licensee has concluded that unauthorized production of uranium enriched to 10 percent or greater in the isotope U-235 has not occurred and is not occurring. For each anticipated type of indicator, detailed resolution procedures should be developed.

Since unauthorized enrichment might not be detected through the conduct of static physical inventories or dynamic physical inventories, the resolution process should include the investigation of all the information that contributed to the indication of unauthorized enrichment. On receipt of an indication that uranium enriched to 10 percent or more may have been or is taking place, the licensee should verify, by remeasuring, whether material enriched to greater than 9.99 percent is present in the process equipment or items. Depending on the type of indicator, immediate isolation of the process area or storage area from which the indication was received may be needed until the indication is resolved. The instruments and measurement systems used for monitoring should be examined to determine whether they are functioning properly. The processing equipment should be thoroughly examined to ensure that unauthorized modifications have not been made. The presence of uranium enriched to 10 percent or more should be verified by remeasuring the material in question, whether in item form or in the process equipment. If this investigation determines that an indication of unauthorized enrichment to 10 percent or more is true, the NRC must be notified within 1 hour of such determination pursuant to 10 CFR 74.11.

If the investigation conducted to resolve the indication is inconclusive, further measures are needed before the licensee may conclude that the indication is resolved. To protect against the relocation and concealment of the enriched uranium, a thorough investigation of the entire facility should be performed by persons independent of the processing organization.

12. PROGRAM FOR PRECLUDING OR DETECTING UNAUTHORIZED PRODUCTION OF ENRICHED URANIUM

There are several alternative approaches available to protect against and detect unauthorized production of enriched uranium. The licensee may perform an analysis to identify and evaluate all credible scenarios through which clandestine enrichment could occur and provide a monitoring program to protect against and detect each scenario. One approach for detecting unauthorized production of uranium enriched to 10 percent or more in the isotope U-235 would be a program to monitor the enrichment level of the uranium in all process streams and all possible withdrawal paths so that SNM of moderate strategic significance could not be produced within any period of 370 calendar days and any uranium enriched to 20 percent or more in the isotope U-235 would be detected. Detecting production from undeclared feed of enrichment levels that are within the limits authorized by license must rely on measures other than monitoring of enrichment levels.

12.1 Organization

The person responsible for executing the program for precluding or detecting unauthorized production of enriched uranium should be identified by title or position in the organization. This person need not be part of the MC&A organization, but must be independent of the production organization. Personnel who are assigned program responsibilities should also be independent of production supervision (10 CFR 74.33(c)(1)(ii)). This program should be well coordinated with both MC&A and production management. The program director should have the necessary authority to carry out all aspects of the program.

12.2 Monitoring Program for Clandestine Enrichment Scenarios

12.2.1 General Description of Program

The overall design of this program should be based, at least in part, on a clandestine enrichment path analysis. That is, for each credible scenario for clandestine enrichment, there should be a monitoring system for the timely detection of that scenario.

With respect to the monitoring program for detecting unauthorized production of uranium enriched to 10 percent or more, one acceptable approach would be to monitor the enrichment level in all process streams and all possible withdrawal paths, at adequate frequencies, so that (1) 10,000 grams or more of U-235 contained in uranium enriched between 10 and 20 percent (which would be SNM of moderately strategic significance) could not be produced within any period of 370 calendar days, and (2) any production of uranium enriched to 20 percent or more (i.e., HEU) would be detected before the production of HEU containing 1000 grams of U-235 could occur. That is to say, regardless of monitoring methodology, if unauthorized production of uranium enriched between 10 and 20 percent in U-235 occurs at such a slow rate that production of a quantity representing SNM of moderate strategic significance (i.e., 10,000 grams of U-235) would take more than 370 calendar days, it is not necessary that such production be detected by the monitoring program. However, if SNM of moderate strategic significance (involving uranium enriched between 10 and 20 percent) can result from unauthorized enrichment activities within 370 days or less, the monitoring is to detect such production before 10,000 grams of U-235 contained in such material is produced. For unauthorized production of uranium enriched to 20 percent or more, regardless of the production rate, detection is to occur before 1000 grams of U-235 contained in HEU is produced.

These scenarios for production of uranium enriched to 10 percent or more in the isotope U-235 should include process system adjustments, batch recycle processing, cascade interconnections, cascade isolation, and cascade reconfiguration.

To preclude unauthorized production of uranium enriched to 10 percent or more in the isotope U-235, the following types of measures should be considered:

- Process design features that preclude unauthorized enrichment to be conducted simultaneously with normal (authorized) production,
- Personnel access controls that limit the number of individuals who could gain access to the enrichment processing equipment or its control mechanisms,
- Physical security controls such as locked and alarmed doors or TV monitors that would detect unauthorized access to processing equipment or product material,
- Process control systems that could detect unauthorized use of production equipment,
- Production control and process monitoring activities that could contribute to the detection of the unauthorized production of uranium enriched to 10 percent or more in the isotope U-235, and
- Use of tamper-indicating seals on process valves and flanges.

For the program to protect against and detect unauthorized production of uranium enriched to less than 10 percent in the isotope U-235, the following topics should be considered:

- The type of monitoring and surveillance, and its frequency, to be applied to the processing areas;
- The type of monitoring and surveillance, and its frequency, to be applied to the process control room and other areas where operation of processing equipment can be controlled or modified;
- The type of monitoring and surveillance, and its frequency, to be applied to potential feed and withdrawal areas;
- Process monitoring activities (e.g., radiation and flow metering) other than process sampling that could contribute to the detection of unauthorized production;

- Use of tamper-indicating seals on process valves and flanges;

- Personnel access controls that limit the number of individuals who could gain access to the enrichment processing equipment or its control mechanisms;

- Physical security controls such as locked and alarmed doors, closed circuit television monitors, etc., that would detect unauthorized access to processing equipment or product material;

- Production control activities that could contribute to the detection of unauthorized production;

- Employee education to increase the probability of reporting of potential unauthorized activities by facility personnel; and

- Notification of appropriate MC&A personnel by operations organizations of the operating status of the cascades, especially when a cascade is isolated from the process stream.

12.2.2 Program Sensitivity

While any actual enrichment of uranium to 10 percent or more in the isotope U-235 is prohibited (except for cascade start-up in centrifuge facilities as noted in Regulatory Position 1.2), the detection sensitivity need not be absolute. Since large quantities of uranium enriched to between 10 and 20 percent in the isotope U-235 would be required for a meaningful malevolent activity, 10 CFR 74.33(c)(5) requires that production of uranium in this enrichment range be detected before SNM of a moderate strategic significance could be produced within a 370 day period. That is to say, there should be a high assurance of detecting the production of 10,000 grams or more of U-235 in the form of uranium enriched to between 10 and 20 percent in the isotope U-235. Production of uranium to greater than 20 percent in the isotope U-235 should be detected soon enough to preclude the actual production of 1 kilogram of U-235 contained in HEU.

12.2.3 Data, Information, and Activities To Be Monitored

The means for independently verifying that the actual enrichment levels in the various process streams are consistent with design enrichment parameters should be developed. In developing the monitoring program, activities such as the following should be considered:

- Independent weighing, sampling, and isotopic assay of material introduced at the feed addition stations,

- Independent weighing, sampling, and isotopic assay of material withdrawn at the product and tails withdrawal stations,

- Independent sampling and isotopic assay of in-process material at randomly selected points, and

- Verification that the quantity of U-235 independently determined to be in the product and tails is consistent with the independently determined feed input.

For gaseous diffusion and gas centrifuge facilities, the licensee or applicant should consider monitoring such process parameters as UF_6 gas pressures, flow rates, enrichments, valve positions, operating parameters, cascade configuration and connections, and tracking all potential UF_6 containers in the process area. The purpose is to ensure that the amount of enriched uranium being produced agrees with production schedules.

12.3 Program for Monitoring Output Streams

The overall design of the program should include analysis of all processing and product streams to determine where uranium isotopic measurements should be made and at what frequency to preclude clandestine enrichment activities. That is, for each identified scenario for clandestine enrichment, there should be a monitoring system for the timely detection of any implementation of that scenario. Since NDA measurement techniques can be useful for detecting the presence of uranium enriched to unauthorized levels, the use of such techniques, either by manual measurements using portable NDA instruments or instruments that are permanently affixed to the process equipment, should be considered. In the former case, administrative controls should be used to detect or preclude collusion of the measurement personnel with a potential clandestine perpetrator. In the latter case, frequent inspection and testing of the instruments should be performed to detect or preclude tampering or disabling of the NDA measurement system.

The scenario analysis should address each product stream regardless of material type or composition and should be conducted by persons that have a thorough knowledge of the processing equipment and enrichment technology. All conceptual means for production of uranium of enrichment levels equal to or greater than 10 percent in the isotope U-235 should be identified. These approaches should include process system adjustments, batch recycle processing, cascade interconnections, and cascade reconfiguration (e.g., increasing the number of stages).

The extent of the monitoring program should depend on the same types of measures as those identified in Regulatory Position 12.2.1 for monitoring clandestine enrichment scenarios.

12.4 Decision Criteria for Declaring Unauthorized Production

An MC&A procedure that defines the basis for (a) declaring that unauthorized production of uranium enriched to 10 percent or more in the isotope U-235 has taken place and (b) declaring that unauthorized production of uranium enriched to less than 10 percent in the isotope U-235 has taken place should be developed.

Whenever there is an indication that unauthorized enrichment is or may be occurring, that indication must be subject to the investigation and resolution requirements of 10 CFR 74.33(c)(5), which are discussed in Regulatory Position 11 of this regulatory guide. If actual unauthorized production of enriched uranium is discovered, that discovery must be reported to the NRC within one hour as required by 10 CFR 74.11.

13. RECORDKEEPING

13.1 Description of Records

The MC&A program must utilize and retain all records, forms, reports, and standard operating procedures pursuant to 10 CFR 74.33(d). Such records should include, but are not limited to, the following:

- Documents recording changes in the MC&A management structure or changes in responsibilities relating to MC&A positions,
- Any procedures pertaining to accountability measurements (including sampling) and measurements related to the requirements of 10 CFR 74.33(c)(5),
- Forms used to record or report measurement data and measurement results, including source data,
- Forms (notebooks, etc.) used to record calibration data associated with any accountability measurement system,
- Forms (notebooks, etc.) used to record quantities, volumes, and other data associated with the preparation of standards (both calibration and control) used in connection with accountability measurement systems,
- Forms used to record or report measurement control program data, control limit calculations, out-of-control investigations,
- Forms (listings, instructions, etc.) associated with a physical inventory (both dynamic and static),
- Forms (worksheets, etc.) used in the calculation of SEID, ID, and active inventory values,
- Ledgers (journals, computer printout sheets, etc.) associated with the accountability system,
- Ledgers (journals, computer printout sheets, etc.) associated with the item control program, including seal usage and "attesting to" records,
- Completed DOE/NRC-742 and NRC-327 Forms and incoming and outgoing DOE/NRC-741 Forms,
- Forms (memos, reports, etc.) associated with identification of, investigation of, and resolution of significant shipper-receiver differences,
- Loss indication and alleged theft investigation reports,
- Investigation reports pertaining to indications of unauthorized enrichment activities,
- Investigation reports pertaining to excessive inventory differences,
- Reports containing the findings and recommendations of MC&A system assessments as well as any letters or memos pertaining to actions in response to assessment team recommendations,
- Forms used for recording data associated with the monitoring program,
- Records and forms used to document authorized reconfiguration of enrichment equipment,
- Status reports or summary reports pertaining to the monitoring for unauthorized enrichment and item monitoring programs, and
- Training, qualification, and requalification reports or records.

All retained records and reports must contain sufficient detail to enable NRC inspectors to determine that the licensee has attained the system features and capabilities and has met the general performance objectives (10 CFR 74.33(d)(1)).

13.2 Program for Ensuring an Accurate and Reliable Record System

Controls to ensure that records are highly accurate and reliable should be developed. Specific MC&A procedures dealing with record protection should be developed and followed. The record system should also provide a capability for easy traceability of all SM and SNM transactions from the point at which the data is generated to the final accounting records.

This program should address the following topics:

- The auditing system or program to verify the correctness and completeness of records,

- The procedures designed to prevent or detect the falsification or destruction of data or records by an individual,
- The plan for reconstructing lost or destroyed SM or SNM records,
- Access controls used to ensure that only authorized persons can update and correct records, and
- The protection and redundancy of the record system so that any act of record alteration or destruction will not eliminate the ability to provide complete MC&A information.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants regarding the NRC staff's plans for using this regulatory guide.

Except in those cases in which an applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the methods described in this guide will be used in the evaluation of Fundamental Nuclear Material Control Plans submitted by applicants or licensees pursuant to 10 CFR 74.33.

REGULATORY ANALYSIS

A separate regulatory analysis was not prepared for this regulatory guide. The regulatory analysis prepared for 10 CFR 74.33, "Nuclear Material Control and Accounting for Uranium Enrichment Facilities Authorized To Produce Special Nuclear Material of Low Strategic Significance," provides the regulatory basis for this guide and examines the cost and benefits of the rule as implemented by the guide. The rule sets forth the NRC staff position on MC&A at licensed enrichment plants and provides safeguards to protect the health and safety of the public. While the costs of rulemaking in this instance are slightly higher than the costs of imposing license conditions, the advantages of promulgation by rulemaking include the opportunity for public comment, which better assures that all appropriate issues are raised prior to the imposition of these requirements.

A copy of the regulatory analysis is available for inspection and copying for a fee at the NRC Public Document Room, 2120 L Street NW., Washington, DC, as part of the file on the *Federal Register* Notice dated October 31, 1991 (56 FR 55991).

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