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# DRAFT REGULATORY GUIDE DG-5002

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

This regulatory guide is being issued in draft form to involve the public in the early stages of the development of a regulatory position in this area. It has not received complete staff review and does not represent an official NRC staff position.

Public comments are being solicited on the draft guide (including any implementation schedule) and its associated regulatory analysis or value/impact statement. Comments should be accompanied by appropriate supporting data. Written comments may be submitted to the Regulatory Publications Branch, DFIPS, Office of Administration, U.S. Nuclear Regulatory Commission, Washington, DC 20555. Copies of comments received may be examined at the NRC Public Document Room, 2120 L Street NW., Washington, DC. Comments will be most helpful if received by April 19, 1991.

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## A. INTRODUCTION

The Nuclear Regulatory Commission has proposed material control and accounting (MC&A) requirements for uranium enrichment facilities in a proposed amendment, Section 74.33, "Material Control and Accounting for Uranium Enrichment Facilities Authorized To Produce Special Nuclear Material of Low Strategic Significance," to 10 CFR Part 74, "Material Control and Accounting for Special Nuclear Material." Section 74.33 would provide the regulatory basis for licensing the material control and accounting activities at enrichment facilities that are authorized to produce and possess more than one effective kilogram of special nuclear material (SNM) of low strategic significance.

Uranium enrichment facilities, because of the nature of the operations and the types of materials that will be onsite, pose two special problems that must be addressed in the NRC's regulations. Since the equipment used to enrich uranium to authorized levels can also be used to produce SNM of moderate and high strategic significance, the NRC can not rule out the possibility of deliberate misuse of the equipment. In addition, there is the possibility that undeclared source material (SM) could be introduced into the process equipment and that unauthorized production of uranium of low strategic significance could occur for the purpose of unauthorized distribution of SNM. Section 74.33 would establish material control and accounting (MC&A) performance objectives to protect against, detect, and respond to such occurrences. In addition, § 74.33 specifies performance objectives, system features, and capabilities that are consistent with MC&A requirements for other NRC-licensed facilities that are authorized to possess and use more than one effective kilogram of special nuclear material of low strategic significance.

Section 74.33 would set forth the general performance objectives that must be met by the licensee's MC&A program. These are as follows:

1. Maintain accurate, current, and reliable knowledge of source material and special nuclear material;

2. Protect against and detect any 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 any production of uranium enriched to 10 percent or more in the isotope U-235; and
6. Resolve indications of unauthorized production of uranium of low strategic significance.

This regulatory guide is being developed to describe methods acceptable to the NRC staff for achieving the general performance objectives in the proposed § 74.33. Alternative methods will be considered acceptable provided the licensee or applicant demonstrates that all the objectives will be met.

Paragraph 74.33(b)(1) would require that the licensee prepare and submit to the NRC a Fundamental Nuclear Material Control (FNMC) Plan that will describe the MC&A program and how it will meet the objectives, system features, and capabilities of § 74.33. This regulatory guide also provides guidance pertaining to the information that should be provided in the FNMC Plan. Each regulatory position in this regulatory guide discusses an important component of a licensee's MC&A program, and each component has its own objectives. For example, the licensee's organizational structure is important to ensure that there is adequate independence between production programs and MC&A functions so that concerns over production objectives do not adversely impact MC&A. Similarly, the goal of the measurement program is to ensure that values associated with the amounts of material on hand are based on good measurements so that unauthorized removal of material may not go undetected. The information to be provided in the FNMC Plan about each MC&A program component has been requested to allow the NRC to determine whether that component will meet its objectives and whether the entire MC&A program's objectives will be met when these components are taken as an aggregate. Other information not requested by the NRC that would provide insight concerning the effectiveness of the program should also be presented in the FNMC Plan.

Any information collection activities mentioned in this draft 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 cleared under OMB Clearance No. 3150-0123.

## B. DISCUSSION

The proposed 10 CFR 74.33 on material control and accounting (MC&A) for uranium enrichment facilities authorized to produce and possess uranium of low strategic significance (up to a maximum U-235 enrichment of 9.99 percent) necessitates developing objectives, criteria, and guidance to be used during the development of FNMC Plans that applicants will be required to submit. An applicant's FNMC Plan should demonstrate how the system features and capabilities specified in § 74.33(c) will be achieved and maintained and how they will be utilized to achieve the performance objectives of § 74.33(a).

Because the proposed § 74.33 would be a performance-based regulation, it is the objectives rather than the means for achieving them that are defined in § 74.33(a). Thus, applicants or licensees are free to decide how to design, manage, and operate their MC&A system. Hence, this regulatory guide is not intended to be an exhaustive description of all possible methodologies that a licensee might use to achieve the desired objectives. Instead, this regulatory guide provides guidance on acceptable approaches for achieving the objectives in § 74.33(a). Other alternatives are acceptable provided they satisfy the regulatory intent.

In the final analysis, the NRC staff must make a judgment as to whether the applicant or licensee can, without going beyond its FNMC Plan commitments, achieve with high probability the objectives stated in § 74.33(a) and satisfy the system features and capabilities stated in § 74.33(c). The guidance provided in this regulatory guide pertains to both FNMC Plans submitted by applicants and any future revisions made to existing plans. It is very important that explanations and discussions appearing in the FNMC Plan be as detailed and precise as possible so that any potential ambiguity is minimized.

Supplementary and general information about the facility and the MC&A system (e.g., copies of blank record forms, a site map, process diagrams, an example of the standard error of inventory difference (SEID) calculation) may be provided in appendices to the FNMC Plan. The appendices to the FNMC Plan will not be incorporated as a condition of license and will not be the basis for inspection. Thus, the description of all MC&A system components and actions to be taken are to be presented in the body of the plan and should not be dependent upon supplementary information in an appendix for proper understanding.

## C. REGULATORY POSITION

### 1. PERFORMANCE OBJECTIVES

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

#### 1.1 Maintain Accurate, Current, and Reliable Knowledge of Source Material and Special Nuclear Material

In order to maintain current knowledge of source material (SM) and special nuclear material (SNM) in its possession, a licensee should have in place a program that provides information about how much material it possesses and where that material is. As used in this guide, accurate knowledge means that the amounts and locations of the material in question are based on measurements; current knowledge means that the amounts and locations of all items and material classes are known; and reliable knowledge 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 or applicant should account for all SNM and SM received or shipped. This should be accomplished by maintaining reliable records that are based on accurate measurements. Detailed guidance on shipper-receiver procedures and the treatment of shipper-receiver data is provided in Regulatory Position 9 of this regulatory guide.

##### 1.1.2 Monitoring Material Movements

The monitoring program should include the use of item control procedures to monitor the location and integrity of items until the material is introduced into the process and ensure that all SM and SNM quantities of record associated with receipts, shipments, discards, and ending inventory are based on measurements. 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 involves the use of production and quality control data. A detailed and accurate recordkeeping system for MC&A and production data should be maintained to provide knowledge of the quantity of material on a timely basis.

1.1.3 Dynamic Physical Inventories

In order to verify that the controls described in Regulatory Positions 1.1.1 and 1.1.2 have been effective, the licensee should perform a dynamic physical inventory at intervals not to exceed 65 days. This inventory provides a snapshot of the amount of material in process at a given time. The licensee would be required by § 74.33(c)(4) to strike a material balance around its processing equipment, including any on-line $UF_6$ feed, product, or tail cylinders. This material balance may rely on indirect measurements and production parameters, as well as the analysis of process samples, to estimate the material in the enrichment process. The amount of material estimated to be within the process should be compared to 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 detection quantity (DQ) or greater loss or theft 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 limits of which are discussed in Regulatory Position 6 of this regulatory guide. 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, as stated in § 74.33, the licensee is to 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 DQ that may have occurred since the last yearly inventory. According to § 74.33, confirming the presence of all SNM and SM currently possessed by the enrichment facility, as stated in its accounting records, involves both a dynamic (non-shutdown) physical inventory of the uranium and U-235 contained within the enrichment processing equipment and a static physical inventory of all other uranium material

that is not within the processing equipment. Criteria pertaining to physical inventories are discussed in Regulatory Position 7. Note that a total plant inventory involves:

1. Measuring (or, when direct measurement is not feasible, using indirect measurements) all bulk SNM and SM quantities on hand (i.e., all SNM and SM not in item form),
2. Verifying the 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 total SNM and SM contained in all items, and
4. Verifying the integrity of all encapsulated items and all tamper-safed items.

1.2 Protect Against and Detect Any 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 tail streams, independent of operations, that provides high assurance of timely detection of any production of uranium enriched to 10 percent or more in the isotope U-235. The licensee may also want 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 more than 10 percent in the isotope U-235. The enrichment technology used may determine the extent of the program. For example, a limited program for the gaseous diffusion technology would be appropriate because it is difficult for a few people to reconfigure the equipment to produce higher enrichments in a short time, while a more extensive program for the centrifuge technology 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 should be managed and maintained independent of the operations (production) unit organization, but it may make use of production and quality control data that are normally generated and used by production personnel.

Detailed 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 the first 24 hours of its startup.

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

A program should be implemented that will, with high assurance, protect against and detect the unauthorized production of any uranium of low strategic significance that is not included in the facility's accounting records or planned production schedules. The program should be capable of detecting the introduction of any feed material not declared or recorded in the facility MC&A records. The program should be managed and maintained independently of the production or operations organizational unit, but should not be excluded from using process monitoring or production control data and equipment. Detailed 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 is to be reported to the NRC Operations Center within 1 hour.

### 1.4 Resolve Indications of Missing Uranium

The licensee or applicant should have a formalized program to resolve any indication that SM or SNM is missing. Resolution of such indicators means that the licensee has investigated all the information that could cause the indicator and has concluded that the indicator was not caused by a theft or loss of SNM or SM. As stated in § 74.33(c)(6), only indications that suggest a possible loss of items of 500 grams or more of U-235 need to 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, errors in inputting values into computer programs or on records, incorrect entries, transcription

errors, errors in estimating the amount of 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 process that appears to be involved. Once this is accomplished, all the information that contributed to 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 remeasuring and sampling the applicable material in the 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. Detailed 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

Licensees or applicants are responsible for developing and following a formalized program designed to resolve indications of the production of uranium enriched to 10 percent or more in the isotope U-235. Resolution of such indications means that the licensee has investigated all the information that could cause the indicator and has concluded that the indicator was not caused by enrichment of uranium to 10 percent or more in the isotope U-235. Since unauthorized enrichment might not be detected through the conduct of physical inventories or periodic dynamic 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 should 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 and measurement systems used for monitoring should be examined to determine whether they are 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 first 24 hours of its startup.

Detailed 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

Licensees and applicants are also responsible for developing and following a formalized program designed to resolve indications of the production of unauthorized uranium enriched to less than 10 percent in the isotope U-235. Resolution of such indicators means that the licensee has investigated all the information that could cause the indicator and has concluded that the indicator was not caused by unauthorized production of uranium enriched to less than 10 percent in the isotope U-235.

Since there are a number of different activities the licensee will need to employ to protect against and detect unauthorized production of uranium enriched to less than 10 percent in the isotope U-235, 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 $UF_6$ tails to determine whether an excess exists because of the unauthorized introduction of excess feed.

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. Detailed guidance on resolution of indications of unauthorized production of uranium of low strategic significance is included in Regulatory Position 11.

## 2. ORGANIZATION

### 2.1 Corporate Organization

The corporate structure should be described in detail in the FNMC Plan, and all corporate organization positions that have responsibilities related to nuclear MC&A at the licensee's site should be identified. At least one corporate official should have responsibilities pertaining to the control and accounting of all SM and SNM possessed by the licensee.

A description of the corporate level functions, responsibilities, and authorities for MC&A program oversight and assessments should be provided.

### 2.2 Facility Organization

The FNMC Plan should contain a description of the management structure for the facility. The description should address all positions that interface with the nuclear MC&A program. The facility management structure should be shown by means of comprehensive organization charts. As a minimum, the charts should indicate where the responsibility lies for (1) the 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.

A brief description should be provided for each facility position outside of the MC&A organization that has responsibilities relating to MC&A activities (such as sampling, bulk measurements, analytical measurements). For each such position, the functions, responsibilities, and authorities should be clearly described.

### 2.3 MC&A Organization

The MC&A organization should be described in detail in the FNMC Plan, including the responsibilities of all managerial and supervisory positions. A single individual should be designated as the overall manager of the MC&A pro-

gram. 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.

### 2.3.1 Responsibilities and Authority

A description that clearly indicates the responsibility and authority of each supervisor and manager should be provided for the various functions within the MC&A organization. The FNMC Plan should describe how the activities of one functional unit or individual serves as a control over or checks the activities of other units or individuals. The FNMC Plan should explain how coordination is achieved and maintained between the MC&A organization and other plant organizational groups that perform MC&A-related activities. There should be a clear definitive statement that the MC&A manager will review and approve all written MC&A procedures, both within and outside his organization pertaining to MC&A related activities, and any future revisions. In addition to the MC&A manager function, the functions to be addressed should include, as a minimum: (1) nuclear material accounting program, (2) the measurement control program, (3) the item control program, (4) monitoring programs, and (5) statistical program.

The portion of the FNMC Plan pertaining to statistics should identify the persons responsible for such activities as calculation of the standard error of the inventory difference (SEID), determination of active inventory, evaluation of shipper-receiver differences, and determining control limits.

Whenever more than one key MC&A function is assigned to the same person, the FNMC Plan should clearly describe the checks and balances that preclude such things as (1) performance of accounting or record control functions by persons who also generate source data and (2) any person having sole authority to evaluate or audit information for which he or she is responsible.

### 2.3.2 Training and Qualification Requirements

This section of the FNMC Plan should describe the training programs to be established and maintained to provide qualified personnel and to provide for a continuing level of qualification for personnel assigned to SM and SNM control and accounting responsibilities. Training procedures and qualification criteria should be discussed in clear definitive statements. Minimum qualification

requirements should be stated for each key MC&A position. The FNMC Plan should describe how the training program addresses the human factors aspects of MC&A in enrichment plants.

## 2.4 MC&A System Description

The length of the discussion for this topic and its level of detail will be somewhat dependent on the information provided in other portions of the FNMC Plan. The overall MC&A organization should be described in a manner that explains how the six general performance objectives of § 74.33(a) and the features and capabilities of § 74.33(c) will be effectively achieved.

The persons who have responsibility for the following and other significant MC&A-related functions should be specified by title:

1. Overall MC&A program management [Note: This individual should not have any major non-MC&A-related responsibilities],
2. Measurements [Note: Responsibility may be divided on the basis of the type of measurements, such as analytical laboratory measurements, NDA measurements, bulk measurements, and sampling],
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.

This chapter of the FNMC Plan should also include a description of the policies, instructions, procedures, duties, responsibilities, and delegation of authority in sufficient detail to demonstrate the separation and overchecks built into the MC&A system.

## 3. MC&A PROCEDURES

The FNMC Plan should describe the MC&A procedures that, if not performed correctly, could result in a failure to achieve one or more of the performance objectives of § 74.33(a) or the features and capabilities of § 74.33(c). All MC&A procedures should be identified in the body of the FNMC Plan. The FNMC Plan should also contain a clear definitive statement that the procedures will be followed. The MC&A procedures as a minimum should adequately address the following topics, regardless of which facility organizational group is responsible for the particular topic:

- Accountability record system,
- Sampling and measurements,
- Measurement control program,
- Item control program,
- Both 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 SEID, active inventory, and inventory difference,
- MC&A recordkeeping system, and
- Independent assessment of the effectiveness of the MC&A program.

## 4. MEASUREMENTS

### 4.1 Measurement Points

The FNMC Plan should identify and describe each and every measurement point, used for either accounting purposes or a monitoring program to detect an unauthorized activity, in terms of (1) location, (2) material type (e.g., $UF_6$ source, product, tails material, uranium metal, scrap) being measured, and (3) characteristic being measured (e.g., gross weight, % U, U-235 concentration).

## 4.2 Measurement Systems

The FNMC Plan should describe in detail each measurement system used for nuclear material accounting purposes. A measurement system can be defined as any instrument or device, or combination of devices, used to derive mass, volume, uranium element concentration, U-235 isotopic concentration, or U-235 content. Each measurement system should also be defined or identified by the following parameters: (1) the measurement device or equipment used, (2) standards used for calibration, (3) standards used for control, (4) sampling technique and equipment used, (5) sample aliquoting technique, and (6) sample pretreatment methodology.

The FNMC Plan should include descriptions of each measurement system associated with bulk, analytical, and NDA measurements.

### 4.2.1 Bulk Measurement Systems

For each mass (weight) system, the FNMC Plan should specify the weighing device, the type of containers weighed, material within the containers being weighed, capacity of the weighing device, range to be utilized, and sensitivity of the device. The description should include the capacity and the sensitivity of the scale (e.g., capacity not to exceed x kilograms, and sensitivity to be at least as good as y grams).

For each volume-measurement system, the FNMC Plan should identify the vessel (tank, column, etc.) to which the measurement applies, the capacity of the vessel, the material being measured, the volume-measuring devices, and the sensitivity and range of operation of the system.

### 4.2.2 Analytical Measurement Systems

For each analytical (laboratory) measurement system, the FNMC Plan should specify the following:

1. Type of material or chemical compound (e.g., $UF_6$, uranium alloy, $U_3O_8$, uranyl nitrate solution) being measured,
2. Characteristics measured (e.g., grams U per gram sample, U-235 concentration),
3. Analytical method used,

4. Sampling technique,
5. Sample handling (i.e., pre-analysis sample storage and treatment), and
6. Measurement interferences (e.g., impurities).

4.2.3 NDA Measurement Systems

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

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. Collimation and shielding, and
6. Calculational method.

4.2.4 Other Measurement Systems

If applicable, the FNMC Plan should also identify any other measurement systems used for MC&A that do not fall within the three categories covered by Regulatory Positions 4.2.1, 4.2.2, and 4.2.3.

## 4.3 Measurement Uncertainties

The expected measurement uncertainties for each measurement system should be provided, for example, the variance from calibration, the variance from sampling, and the random error components. When the variance caused by sampling is insignificant, the variance caused by sampling may be combined with the variance from analysis. The units in which the errors are expressed should be clearly identified.

## 4.4 Measurement Procedures

The licensee or applicant should make a clear statement in the FNMC Plan that an approved measurement procedures (methods) manual, or a set of approved manuals, will be established and maintained. The organizational units responsible for the preparation, revision, and approval of measurement procedures should be stated. There should also be a clear definitive statement that a periodic review of the procedures will be conducted.

There should be a clear statement that any given measurement procedure cannot be used without documented approval. As a minimum, each procedure should be approved by the overall MC&A manager and by the manager of the organizational unit responsible for performing the measurement. Measurement procedures 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 be described in the FNMC Plan in sufficient detail to show how the measurement quality assurance function is assigned. The FNMC Plan should describe how independence from the analytical laboratory and from other units performing either sample taking or measurements is maintained. 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 should be managed to ensure adequate calibration frequencies, sufficient control of biases, and sufficient measurement precision.

#### 5.1.1 Functional Relationship

The relationship and coordination among the measurement control program manager and the analytical laboratory and other groups performing measurements (such as those monitoring U-235 concentrations in process piping and equipment) should be clearly defined. 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 should be established and maintained in a readily available manual. This manual should contain all the currently applicable written procedures pertaining to measurement control and

measurement quality assurance. These procedures should be reviewed annually. Responsibility for preparation, revision, and approval of the procedures should be specified. Individual measurement control program procedures should have documented approval from the measurement control manager. At a minimum, the procedures should address:

1. Calibration frequencies and methods,
2. Standards used for calibration (specifications and storage controls),
3. Standards used for control (obtaining or preparation of 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, the review program used to monitor the offsite measurements should be described in the FNMC Plan. The purpose of such reviews is to ensure that the contractor or off-site laboratory has an acceptable measurement control program to the extent that use of the contractor's measurements will not compromise the licensee's ability to meet any measurement or measurement control requirement contained in either § 74.33(c) or in its FNMC plan. 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 within 30 days of completion of the review. The two managers should arrive at an agreement as to what corrective actions need to be taken based on their evaluation of the report and transmit these findings to the contractor or offsite laboratory in writing. The licensee should not use measurements performed by such contractors or offsite laboratories until they have verified that the corrective actions have been instituted.

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

## 5.2 Calibrations

The FNMC Plan should describe the licensee's calibration program in terms of:

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.

The licensee or applicant should make a clear statement in the FNMC Plan that an approved calibration procedures manual will be established and maintained. Unlike control standards, calibration standards 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 of their assigned values should be specified. 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.

The FNMC Plan should contain a clear statement that no SM or SNM accountability value will be based on a measurement that fell outside the range of calibration. The FNMC Plan should also identify those measurement systems that are point-calibrated. A point-calibrated measurement system is one in which:

1. The measurement system is calibrated with a standard or set of standards that are representative of the process unknowns that are measured by the system. That is, the representative calibration standard undergoes all the measurement steps in the same manner that the unknowns do.
2. One or more calibration standards are 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 a range that is 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 for each unknown should fall within a range of plus or minus 4 standard deviations (associated with measuring the standard) of the response for a standard measured at the same time as the unknown.

## 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, (2) estimate the system bias over the calibration period, and (3) estimate the average system bias over the material balance period. The minimum number of control standard measurements during the calibration period, as well as the typical frequency,

should be specified in the FNMC Plan for each measurement system. In most cases, an estimate of the bias may be based on a minimum of 16 control standard measurements.

Control standards should be representative of the process material or items being measured. To be representative, the standards need not always be identical to the process unknowns, but any constituent of the process material or any factor associated with a process item that 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 cylinders (both empty and full) of certified mass, so as to avoid a bias effect caused by buoyancy or point loading.

For each measurement system that is not point-calibrated, the control standards to be used should be identified and described in the FNMC Plan. In addition to material composition and matrix factors, biases can also be induced by changes in temperature, humidity, line voltage, and background radiation, or they may be operator-induced. Therefore, the scheduling of control standard measurements should be based on the following considerations:

- Does the variation between operators 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, is the relative percent bias nonuniform over the range of calibration?
- What controls or procedures are needed to ensure that sampling or aliquoting of the control standard is representative of the sampling or aliquoting of the process material?
- To eliminate bias in each measurement system, 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

Duplicate measurements performed on single samples (or single items) and measurement of replicate samples should be performed to estimate the analytical and sampling variance components. When the variance caused by sampling is insignificant, the variance caused by sampling may be combined with the variance caused by analysis. For nonsampling measurement systems such as NDA and weight measurement systems, the analytical variance component 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 FNMC Plan should indicate (a) how many samples are to be taken and measured for each accountability batch measurement and (b) how many analyses are to be performed on each accountability sample. If two or more samples are used and two analyses per sample are performed for each accountability batch measurement, replicate requirements are automatically met. If, however, one sample per batch is normally used for accountability purposes, the replicate program should include periodically taking a second (replicate) sample. The licensee should ensure that replicate samples are independent of one another. The number of replicate samples measured for each analytical measurement system during an inventory period should equal at least one of the following:

1. 100 percent of the accountability batches sampled,
2. the greater of 15 samples or 15 percent of the accountability batches sampled, or
3. 50 samples.

## 5.5 Control Limits

Both warning and out-of-control limits should be established and utilized for both control standard and replicate sample measurements for those measurement systems used for nuclear material accountability. For point-calibrated systems, the assigned value of the standards measured along with the unknown is assumed to be valid. 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. Therefore, control limits

for the verification measurements associated with such standards should be established. This is especially true for those point-calibrated systems that use a single standard, or aliquots from a single standard, over any extended period of time.

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

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

### 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 review should address the frequency that control data exceeds 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 supervisor, should have the responsibility for promptly reporting any control measurement that exceeds an out-of-control limit. Such reporting should be made to the measurement control program manager or the designee, who should have the responsibility and authority to carry out the necessary response and corrective action.

Minimum response and minimum corrective action requirements should be clearly defined and stated in the FNMC Plan. In addition, the measurement control program manager should be responsible for, and have the authority for, determining and executing additional response and corrective actions as deemed appropriate.

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

1. Verifying that the measurement system in question has been taken out of service with respect to accountability measurements,
2. Documenting the occurrence of the event,
3. Performing at least two additional control measurements, 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) or recalibrating the measurement system.

For those measurement systems that make a significant contribution to the magnitude of the 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.

## 6. STATISTICS

In order to achieve the objectives and capabilities of § 74.33, each licensee or applicant should institute a statistical program that evaluates the MC&A data to ensure that measurements are accurate and precise, that measurement data are analyzed in a rigorous manner, and 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 accounting data. The statistical methods described

in "Statistical Methods for Nuclear Material Management," NUREG/CR-4604,* are recommended by the NRC for satisfying the requirements of § 74.33.

The FNMC Plan should:

1. Include a detailed discussion of the procedures and methodologies for estimating measurement variance components,
2. Discuss how biases are determined and how bias corrections are applied, including:
   a. How often biases are estimated,
   b. How the effect of a bias on the measured quantity of material in individual SM or SNM items is determined,
   c. When and how bias corrections to items are made,
   d. How their effect on inventory difference is determined, and
   e. When and how bias corrections are applied to the inventory difference,
3. Describe the procedure and means for determining active inventory,
4. Provide all relevant information regarding the determination of SEID,
5. Specify the detection quantity (DQ), which should not exceed 1.3 percent of the annual U-235 quantity introduced into the enrichment process except when 1.3 percent of additions to process is less than 25Kg U-235, in which case the DQ need not be less than 25Kg U-235, and
6. Specify the method for determining DQ threshold values to be used to provide a 90 percent power of detecting a loss of a DQ, as required by § 74.33(c)(4).

There should be a clear definitive statement in the FNMC Plan that at least two individuals will 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 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. Other techniques that provide an equivalent level of protection may be proposed.

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*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.

## 7. PHYSICAL INVENTORIES

### 7.1 General Description

The applicant or licensee should provide a general description in the FNMC Plan of how both dynamic (nonshutdown) inventories of the enrichment processing equipment and static inventories of the balance of the plant will be planned and conducted.

The FNMC Plan should contain a clear statement that physical inventory functions and responsibilities will be clearly defined and comprehensively reviewed with all persons involved before the start of each dynamic and static inventory.

For static inventories, a book inventory listing derived from the MC&A record system should be generated just prior to the actual start of the inventory, and such a listing should include all SM and SNM that the records indicate should be possessed by the licensee at the inventory cut off time, except for material to be covered by the dynamic inventory that is to be conducted in conjunction with the static inventory.

For dynamic 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 use a "running book in-process inventory" (RBIPI) technique. 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 inventory.

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

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

## 7.2 Organization, Procedures, and Schedules

The FNMC Plan should explain the makeup and duties of the organization for the typical physical inventory, both dynamic and static. The individual having responsibility for the coordination of the physical inventory effort should be identified by position title. The FNMC Plan should also indicate how the preparation and modification of inventory procedures are to be controlled. The FNMC Plan should contain a clear statement that specific inventory instructions will be prepared and issued for each dynamic and static inventory.

## 7.3 Typical Inventory Composition

The typical expected in-process inventory of material within the enrichment equipment for both uranium and U-235 at the time of dynamic physical inventory should be specified in the FNMC Plan. For gas centrifuge and gaseous diffusion plants, the in-process inventory should be specified by accounting for $UF_6$ gas, solid $UF_6$, and residual holdup solids deposited within the equipment.

A typical composition, by material types, of a static physical inventory should also be presented. $UF_6$ cylinders in inventory should be accounted for by material type (i.e., tails, feed, and product). If different size cylinders are used within one of the three $UF_6$ categories, they should be treated as different material types.

## 7.4 Conducting Dynamic Physical Inventories

A description of the dynamic inventory methodology, including cutoff and inventory minimization procedures, should be presented in the FNMC Plan with all measurements (including sampling) being identified. The FNMC Plan should contain sufficient information to show how the total in-process inventory for both uranium and U-235 is obtained. The means for measuring or estimating residual deposited holdup should be addressed in detail. The change or variation in such deposited holdup from one dynamic inventory to the next should also be discussed.

## 7.5 Conducting Static Physical Inventories

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

- Inventory functions are organized and how the functions are separated,
- Inventory teams are assigned and instructed on the use of uniform practices,
- Source data is obtained, verified, and recorded,
- Inventory forms are controlled,
- Item counts verify the presence of each item while preventing any item from being counted more than once, and
- Cut-off and material handling procedures for nonenrichment processes such as scrap recovery are implemented.

The FNMC Plan should describe special item storage and handling or tamper-indicating methods that are used to ensure that the prior measurements are valid and may be used for inventory purposes.

The FNMC Plan should also describe how item identities are verified and how tampering with the contents of items will be detected or prevented.

For items that are not encapsulated, affixed with tamper-indicating devices, or otherwise protected to ensure the validity of prior measurements, the basis for determining which items are to be measured at physical inventory time and a justification for any proposed alternatives to measurement of any SM and SNM included in the inventory should be presented. If a statistical sampling plan for determining how many and what items are to be randomly selected for remeasurement is proposed as an alternative method to 100 percent verification, the FNMC Plan should describe the sampling plan. Such a description should include:

- The method of classifying (stratifying) the types of items to be sampled (i.e., selected for remeasurement);
- How the sample size (i.e., the number of items) will be calculated 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 an original 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 stratum 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 from the given stratum:*

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

Where: n = number of items to be remeasured
N = total number of items in stratum
x = maximum U-235 content per item (kilograms)
g = DQ (kilograms U-235)

The FNMC Plan should contain a clear statement that any items on ending inventory that have not been previously measured will be measured for inventory purposes.

The decision rationale 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 should be presented in the FNMC Plan. For example, if the U-235 contained in liquid waste batches is derived by applying an average enrichment factor to the measured uranium element content, the rationale for such a practice (as opposed to measuring each batch for

*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.

both uranium and U-235 content) should be discussed, and the method for establishing the average enrichment factor should be described.

If the content of items is established through measurements and those items are tamper-safed or access to them is controlled, the 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 any significant change in the uranium concentration (or weight fraction) or in the uranium isotopic distribution from such factors as oxidation, change in moisture content, commingling with materials of different enrichments, or different compositions.

## 7.6 Inventory Difference Limits and Response Actions

Each licensee should have a well-defined system for evaluating total plant inventory differences (IDs) and taking action when IDs exceed certain predetermined thresholds. As a minimum, there should be three response levels for excessive IDs. The following would be an acceptable approach for three increasing levels of response actions:

Warning-Level ID: U-235 ID $\geq$ 1.7 (SEID) + 500 grams
Significant ID Problem: U-235 ID $\geq$ 3(SEID)
Major ID Problem: U-235 ID $\geq$ DT

The detection threshold (DT) for a major ID problem, DQ - 1.3 (SEID), may be interpreted in the following manner. If an actual loss or theft of a DQ amount or more occurred during the last static physical inventory period, there is at least a 90 percent probability that the inventory difference will exceed the detection threshold. All the above limits are expressed in terms of absolute values of ID (i.e., no regard for algebraic sign). The minimum response for a warning-level ID should be a documented licensee investigation, conducted by the MC&A organization. Such an investigation should provide a conclusion for the probable cause of the excessive ID, and give recommendations for avoiding recurrence. When a warning-level ID is positive, it should be regarded as being equivalent to an indicator of a possible loss that requires investigation and resolution (see Regulatory Position 11.1).

Although the thresholds for a warning-level ID, significant ID problem, and major ID problem refer to amounts of U-235 and not uranium element, the licensee should note that § 74.33(c)(4)(i) requires static and dynamic physical inventories for both uranium element and U-235, and § 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.

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

For any unresolved ID determination that remains a major ID problem (even if the ID is negative), the licensee may need to take steps for scheduling a plant-wide reinventory and investigation. The NRC considers a positive ID large enough to be a major ID problem as a very serious condition.

The FNMC Plan should fully describe the minimum response actions for each ID action level.

## 8. ITEM CONTROL

### 8.1 Organization

The FNMC Plan should identify the position title of the person responsible for overseeing the item control program. The positions of those persons who have significant item control program responsibilities should also be identified.

### 8.2 General Description

The applicant or licensee should state in the FNMC Plan that the MC&A system will maintain a record of all SM and SNM items, regardless of quantity or duration of existence. In addition, the item control program should provide current knowledge of the location, identity, and quantity of all nonexempt SM and SNM items. Items that can be exempt from item control program coverage are:

1. Items that have an existence time of less than 14 calendar days, and
2. Any items identified by the licensee by material type containing less than 500 grams U-235 each but not to exceed a site total of 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 having 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 FNMC Plan should specify the maximum time in which an item must be located. The MC&A record system should 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.

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

Examples and descriptions of the item records that show how items are identified for each material type and each type of container should be provided in the FNMC Plan.

If the unique number on a tamper-safe seal is the basis for providing unique item identity, the FNMC Plan should:

1. Describe the type of seals utilized,
2. Describe how the seals are obtained and what measures ensure that duplicate (counterfeit) seals are not manufactured,
3. Describe how the seals are stored, controlled, issued, destroyed, and accounted for, and
4. Describe how seal usage and disposal records are maintained and controlled.

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

## 8.4 Storage Controls

Storage areas and controls for items should be fully described in the FNMC Plan. In particular, controls that are used as the basis for accepting prior measurements, as opposed to remeasuring the item at inventory time, should be discussed in detail and the rationale for accepting prior measurements should be explained. 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) should be specified in the FNMC Plan.

## 8.5 Item-Monitoring Methodology and Procedures

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

1. Verifies that items shown in the MC&A records are actually stored and identified in the manner indicated in the records,
2. Verifies that generated items and changes in item locations are properly recorded in the MC&A record system in a timely manner, and
3. Can detect, with high probability, any real loss of items or uranium from items amounting to 500 grams or more of U-235.

The item-monitoring system should call for the following activities to be conducted at least on a monthly basis:

1. 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,
2. 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

3. 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. Discrepancies are not missing items, but rather conditions such as items not in assigned locations and incorrect entries in item control program records. The FNMC Plan should contain a clear statement that procedures for identifying and resolving item discrepancies will be maintained and followed.

## 8.6 Description of Typical Item Strata

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

1. Type of item (i.e., stratum),
2. Expected number of items within each stratum,
3. Expected range of the number of items within each stratum,
4. The average uranium and U-235 content of the items within each stratum, and
5. The expected rate of item generation and consumption for each stratum.

## 8.7 Investigation and Resolution of Item Discrepancies

The applicant or licensee should discuss in the FNMC Plan the procedures and controls that will ensure that all incidents involving missing or compromised items or falsified item records will be investigated. A compromised item is 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 unsealed or unencapsulated 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. Specific guidance on resolution of item discrepancies is in Regulatory Position 11.

## 9. SHIPPER-RECEIVER COMPARISONS

### 9.1 Receiving Procedures

The first action to be taken upon receipt should be verification of the correct number of items, the correct identity of the items, and the integrity of the tamper-indicating seals. The applicant or licensee should specify in the FNMC Plan what other checks and measurements are to be conducted upon receipt. The FNMC Plan should state, for each material type, the maximum elapsed time for determining whether or not a significant shipper-receiver difference (SRD) exists.

### 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.

The resolution procedures should specify which weight is used in the resolution process if the shipper's weight differs by more than one-half of the combined standard error. The FNMC Plan should specify which set of weights will be entered into the accountability records in the event that the hypothesis that the difference between the shipper's and receiver's weights is equal to zero has been tested and not rejected.

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*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

The FNMC Plan should describe the procedures to be followed in the investigation of a significant SRD and should discuss how such difference will be resolved. The criteria for determining that a significant SRD is resolved should also be presented in the FNMC Plan. Resolution of a significant SRD usually involves a referee measurement of retainer samples.

Resolution of significant SRDs could involve testing two 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 U-235 assay value and the receiver's U-235 assay value is zero. If the significant SRD is due to a difference in weights, the licensee should ensure that the balance is functioning properly. If the balance requires repair and recalibration, the material should be reweighed. If the significant SRD is due to a difference in U-235 assay, the referee sample should be sent to the referee laboratory for measurement. In addition, the licensee should ensure that the assay system is functioning properly.

## 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 § 74.33(c)(8). The FNMC Plan should describe the assessment program in terms of:

1. Maximum interval between assessments,
2. Selection procedures for the assessment team,
3. Minimum number of team members to be selected,
4. Qualification and expertise of team members,
5. Independence of individual team members from their MC&A responsibilities and the activities they review and assess, and
6. Maximum elapsed time and minimum actual effort to be utilized for completing the assessment and issuing a final team report.

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. Thus, the type of assessment (partial or total) and the maximum interval between assessments should be specified. "Interval" means the elapsed time between either the start of or termination of successive assessments.

The responsibility and authority 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 should encompass the entire MC&A system, and the level of detail of the reviews should be sufficient to ensure that the assess-

ment team has adequate information to make reasoned judgments of the MC&A program's effectiveness. 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 bias and the 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 verify the presence 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, should be documented. 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 should be documented within 30 days following the submittal of the assessment team's report, and it should include a schedule for the correction of deficiencies.

Corrective actions, if any, that pertain to daily or weekly activities should be initiated promptly after the submittal of the final assessment report.

The FNMC Plan should address resolution and follow-up actions associated with concerns identified in assessment reports. The individuals responsible for resolving identified concerns, and the timeliness of such resolution, should be specified.

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

The FNMC Plan should discuss the means by which the licensee will resolve indicators of either missing uranium involving 500 or more grams U-235 or of indicators of unauthorized enrichment. The three generic types of indications are as follows:

1. Indications that either source material or enriched uranium is missing,
2. Indications that unauthorized production of uranium of low strategic significance has been 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.

The resolution program should address the possible indicators of missing uranium. The FNMC Plan should discuss potential indicators that can be postulated for the three types of indicators above and identify appropriate resolution procedures for each. In addition, the FNMC Plan should specify 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.

### 11.1 Indicators of Missing Uranium

Possible indicators of missing uranium could include the following:

- Determination through the item control program that a specific item can not be located,
- 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 SM or SNM value on any item, batch, or lot of measured material in which the difference between the original and remeasured values exceeds the standard error and 499 grams or more U-235,
- Discovery of unauthorized feed or withdrawal equipment in the processing area,
- Discovery that a process monitoring system has been compromised,
- Discovery that the process has been reconfigured to permit unauthorized removal of SM or SNM,
- An allegation of a theft.

Resolution of an indication means that the licensee has concluded that a theft of more than 500 grams of U-235 has not occurred. For each anticipated type of loss indicator, the licensee should develop detailed resolution procedures and should document them in the FNMC.

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 SNM or SM 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 be 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 the following:

- Presence of unauthorized product, feed, or tails 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,

- An excess amount of $UF_6$ tails or an excess rate of $UF_6$ tail production,
- Incorrectly identified cylinders, such as $UF_6$ tails or SM 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 10 percent or less in the isotope U-235 is or has been occurring,
- Reconfiguration of the process to permit unauthorized operation of the enrichment equipment.

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, the licensee should develop detailed resolution procedures and should document them in the FNMC Plan.

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 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 according 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 greater than 10 percent in the isotope U-235 has occurred or is occurring,

- High radiation 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, the licensee should develop detailed resolution procedures and should document them in the FNMC Plan.

Since unauthorized enrichment might not be detected through the conduct of physical inventories or dynamic 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 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 according 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 clan-

destine enrichment could occur and provide a monitoring program to protect against and detect each scenario. Alternatively, a program could be instituted to monitor the enrichment level of the uranium in all process streams and all possible withdrawal paths so that any amount of uranium enriched to 10 percent or more in the isotope U-235 would be detected.

## 12.1 Organization

The person responsible for executing the program for detecting unauthorized production of enriched uranium should be identified in the FNMC Plan by title or position in the organization. This person need not be part of the MC&A organization, but should be independent of the production organization. Personnel who are assigned program responsibilities should also be independent of production supervision. This program should be well coordinated with both MC&A and production management.

The overall organization, including the minimum staffing requirements and functions, should be described in the FNMC Plan. There should also be a clear statement that the program director will 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. The analysis should be extensive and conducted by persons having a thorough knowledge of the processing equipment and enrichment technology. All scenarios for production of uranium enriched to 10 percent or more in the isotope U-235 should be identified. These scenarios should include process system adjustments, batch recycle processing, cascade interconnections, cascade isolation, and cascade reconfiguration to increase the number of stages.

The extent and complexity of that portion of the program aimed at protecting against and detecting enrichment of uranium to 10 percent or more should be dependent on the minimum time it could take to produce a formula quantity of high enriched uranium.

When the unauthorized production of uranium enriched to 10 percent or more in the isotope U-235 is the primary concern, 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 activities that could contribute to detection,
- Process monitoring activities,
- Use of tamper-indicating seals on process valves and flanges.

In describing the portion of the program aimed at protecting against and detecting production of uranium enriched to greater that 10 percent in the isotope U-235, the FNMC Plan should address the following:

- Sampling ports and frequency of sampling to be used for monitoring product streams,
- The means for verifying the validity of process control measurements and laboratory enrichment measurements (i.e., how would falsification of process measurements be detected?),
- The type of equipment or instrumentation, in addition to and independent from that used and controlled by production personnel, to be utilized for monitoring purposes.

The FNMC Plan should address the following aspects of the program to protect against and detect unauthorized production of uranium of low strategic significance:

- The type of surveillance and its frequency to be applied to the processing areas,
- The type of surveillance and its frequency to be applied in the process control room and other areas where operation of processing equipment can be controlled or modified,
- The type of surveillance and its frequency to be applied to withdrawal areas and feed introduction areas,
- Process monitoring activities, other than process sampling, that could contribute to the detection of unauthorized production,
- The use of tamper-indicating seals on process valves and flanges,
- Production control activities that could contribute to the detection of unauthorized production.

12.2.2 Data, Information, and Activities To Be Monitored

The specific data, information, and activities to be monitored should be identified in the FNMC Plan. The frequency of each specified monitoring activity and frequency of data evaluation should be addressed.

The means for independently verifying the authorized process enrichment parameters should be described in the FNMC Plan. The program could consider sampling for such activities as the following:

- 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
- Verifying 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 the activity of most interest is whether unauthorized high enriched uranium is being produced, NDA measurement techniques for enrichment may be useful. Either manual measurements using portable NDA instruments can be performed or the instruments can be permanently affixed to the process equipment. In the former case, administrative controls should be used to prevent collusion of the measurement personnel with a potential clandestine perpetrator. In the later case, frequent inspection and testing of the instruments should be performed to prevent 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 and complexity 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.

The specific data that will be collected and analyzed should be identified in the FNMC Plan. The frequency of the measurements and of data evaluations should be stated.

The means for independently verifying the authorized process enrichment parameters, listed in Regulatory Position 12.2.2, should also be identified in the FNMC Plan.

The FNMC Plan should address such aspects as:

1. Type and frequency of uranium isotopic measurements,
2. Type and frequency of monitoring NDA measurements,

3. Required accuracy of the isotopic measurements, and
4. Administrative controls to be applied to all monitoring measurements.

## 12.4 Documentation Requirements

The applicant or licensee should commit, in the FNMC Plan, to having an MC&A procedure that defines the basis for (a) declaring that unauthorized enrichment has taken place and (b) declaring that unauthorized production of uranium of low strategic significance has taken place.

Whenever there is an indication that unauthorized enrichment is or may be occurring, that indication should be subject to the investigation and resolution requirements of § 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 should be reported to the NRC within 1 hour as required in 10 CFR 74.11.

# 13. RECORDKEEPING

## 13.1 Description of Records

The FNMC Plan should identify all records, forms, reports, and standard operating procedures that must be retained 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 § 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 and documents used to record or report measurement control program data, control limit calculations, out-of-control investigations, etc.
- 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 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,
- Official 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,
- Monitoring program status or summary reports,
- Training, qualification, and requalification reports or records.

Examples of the more important MC&A forms should be provided in an appendix to the FNMC Plan.

The retained records and reports should contain sufficient detail to enable NRC inspectors to determine that the licensee has attained the system features and capabilities of § 74.33(c) and has met the general performance objectives of § 74.33(a).

13.2 Program for Ensuring an Accurate and Reliable Record System

The FNMC Plan should describe the controls that are utilized to ensure that records are highly accurate and reliable. The record system should also provide a capability for easy traceability of all SM and SNM transactions from source data to final accounting records.

The following topics should be addressed:

- The auditing system or program to verify the correctness and completeness of records,
- The overchecks for preventing or detecting missing or falsified data and records,
- The plan for reconstructing lost or destroyed 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.

This draft guide has been released to encourage public participation in its development. Except in those cases in which an applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method to be described in the active guide reflecting public comments will be used in the evaluation of Fundamental Nuclear Material Control Plans submitted by applicants or licensees pursuant to § 74.33.

## REGULATORY ANALYSIS

A separate regulatory analysis was not prepared for this regulatory guide. The regulatory analysis prepared for proposed amendments to 10 CFR Part 74, "Material Control and Accounting for Special Nuclear Material," provides the regulatory basis for this guide and examines the cost and benefits of the rule as implemented by the guide. 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 Enclosure 3 to Secy 90-277.

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