INSPECTION PROCEDURE 85309

MEASUREMENT SYSTEMS AND CONTROL

PROGRAM APPLICABILITY: 2681

85309-01 INSPECTION OBJECTIVE

Determine that an adequate program has been established and is implemented and maintained for measuring the quantities of SSNM received, produced, transferred, inventoried, shipped, discarded or otherwise removed from inventory. The program must be sufficient to estimate the quantities of element and isotope assigned to material in its possession. The licenses program must also provide estimates of the standard deviation of such estimated quantities. This program must assure that the quality of each SSNM measurement system is thoroughly tested and evaluated before its use and is continually controlled to a level of effectiveness sufficient to satisfy the capabilities required for detection, response and accounting.

85309-02 INSPECTION REQUIREMENTS

Measurement systems must comply with all applicable NRC regulations and safeguards license conditions. The FNMCP contains general commitments relative to the measurements systems. By inspection determine whether:

02.01 A system of measurements has been established and is maintained which is sufficient to: [74.59(d)]

a. Substantiate the plutonium element and uranium element and fissile isotope content of all SSNM received, produced, transferred between areas of custodial responsibility, or inventoried, or shipped, discarded, or otherwise removed from inventory.

b. Enable the estimation of the standard deviation associated with each measured quantity.

c. Provide the data necessary for performance of the material control tests required by 74.53(b).

02.02 The quality of SSNM measurement systems and material processing has been continually controlled to a level of effectiveness sufficient to satisfy the capabilities required for detection, response, and accounting. To achieve this objective the licensee shall: [74.59(e)]

a. Perform process and engineering analyses and evaluations of the design, installation, preoperational tests, calibration, and operations of all measurement systems to be used for MC&A purposes.

b. Perform process and engineering tests using well characterized materials to establish or to verify the applicability of existing procedures for mixing and sampling SSNM and maintaining sample integrity during transport and storage. Test must be repeated at least every three years, at any time there is a process modification that alters the physical or chemical composition of the SSNM, or whenever there is a change in the sampling technique or equipment.

c. Generate current data on the performance of measurement processes, including, as appropriate, values for bias corrections, uncertainties on calibration factors, and random error standard deviations. The program must include:

    1. The ongoing use of standards for calibration and control of all applicable measurement systems. Calibrations must be repeated whenever any change in a measurement system occurs which has the potential to affect a measurement result or when program data, generated by tests performed at pre-determined frequency, indicate a need for recalibration. Calibrations and test must be based on standards with traceability to national standards or nationally accepted measurement systems.

    2. A system of control measurements to provide current data for the estimation of the standard deviations that are significant contributors to the measurement uncertainties associated with shipper/receiver differences, inventory differences (ID), and process differences.

d. Utilize the data generated during the current material balance period for the estimation of the standard error of the inventory difference (SEID) and the standard error of the process differences. Calibration and measurement error data collected and used during immediately preceding material balance periods may be combined with current data provided that the measurement systems are in statistical control and the combined data are utilized in characterizing the unknowns.

e. Evaluate all program data and information to assure that measurement performance is so controlled that the SEID estimator is less than 0.1 percent of active inventory.

f. Apply bias corrections by an appropriate procedure whereby:

    1. Bias corrections are applied to individual items if for any measurement system the relative bias estimate exceeds twice the standard deviation of its estimator, the absolute bias estimates exceeds 50 grams of SSNM when applied across all affected items, and the absolute bias estimate on an individual item basis exceeds the rounding error of affected items.

2. All biases (regardless of significance) that are not applied as corrections to individual items are applied as corrections to the ID.

g. Investigate and take corrective action, as appropriate, to identify and reduce associated measurement biases when, for like material types (i.e. measured by the same measurement system), the net cumulative shipper/receiver differences accumulated over a six-month period exceed the larger of one formula kilogram or 0.1 percent of the total amount received.

h. Establish and maintain a statistical control system designed to monitor the quality of each type of program measurement. Control limits must be established to be equivalent to levels of significance of 0.05 and 0.001. Control data exceeding the 0.05 limits must be investigated and corrective action taken in a timely manner. Whenever a single data point exceeds the 0.001 control limit, the measurement system in question must not be used for material control and accounting purposes until it has been brought into control at the 0.05 level.

85309-03 INSPECTION GUIDANCE

03.01 Regulations. 74.59(d), 74.59(e)

03.02 Regulatory Guides and Reports. NUREG-1280, Standard Format and Content Acceptance Criteria for the Material Control and Accounting (MC&A) Reform Amendment, Section 4.3, "Measurements," and Section 4.4, "Measurement Control."

03.03 Criteria. The inspector verifies that SSNM values used for MC&A purposes are based on measurements, that the uncertainties associated with the measured values are quantified, and that the licensee continually controls the quality of measurement systems employed for MC&A to a level sufficient to satisfy the capabilities required for loss detection, response, and accounting. The goals of the quality control program for SSNM measurements are to maintain the SEID within the limits specified in 74.59(e)(5) and minimize the measurement error contribution to the standard deviations associated with the material control tests required by 74.53(b).

Pre-inspection Activities. To prepare for the inspection, the inspector should review the specific portions of the FNMCP and the safeguards license conditions for the planned inspection activities; review the previous inspection report for the site; review any unresolved or followup items to be addressed during the inspection; and review any communications (including information notices and bulletins) with the facility since the last inspection.

Post Inspection Activities. Followup is conducted as described in Manual Chapter 92701 and the Inspection Report is generated as described in Manual Chapter 0610.

a. The inspector reviews the SEID and material control tests to compare the significant contributors to the variances of the IDs and the process monitoring estimators with the

descriptions in the FNMCP. If the licensee has difficulties with an indicator, the inspector should determine whether a specific material type is the cause and whether this has been described in the FNMCP. The results of the evaluation should be discussed with the licensee.

All measurement points must be identified and must include as a minimum facility receipts, transfers between areas of custodial responsibility, points where SSNM products are generated, unit process boundaries, facility shipments, effluent discharge points, and significant sidestreams.

At each measurement point, the material types to be measured and the measurement system to be used must be described. The measurement systems should include the sampling method, mass or volume, chemical assay or nondestructive assay, and isotopic analyses as appropriate. Components of each measurement system should include the equipment required, a synopsis of technique, range of application, sensitivity, precautions, and random/fixed error estimates.

The use of factors is limited to those situations where timely measurements are impractical. Factors must be based on measurements, monitored, and updated when appropriate statistical tests indicate the need for updating.

Appropriate measurements for material control tests will depend upon availability of substitute materials, predictability of material composition, and material accessibility.

b. The adequacy of the licensee's measurement program must be independently verified by the inspector. Although most of the effort in this area should focus on measurement systems that either contribute significantly to the SEID for the plant material balance or measure a significant portion of the inventory or transfers during an inventory period, each measurement system used for accountability purposes, irrespective of whether of not it is considered to be a key system, must be evaluated in some manner. The primary measurement systems usually warrant a comprehensive review of system data as well as an evaluation using independent sampling and analysis. The remaining measurement systems may only need a simple review of data generated by the system. Nevertheless, if the throughput of the SSNM measured by such a system were to significantly increase, it should receive a greater level of evaluation. The selection of measurement systems for detailed evaluation should be based on previous inspection results.

Assessment of Measurement Proficiency. Materials measured by primary measurement systems should be independently sampled and analyzed by the inspector to determine the acceptability of these systems (UF_6 would normally be an exception). The number of samples needed should be determined using a 10 percent false alarm rate coupled with the degree of variation (i.e., the magnitude of allowable deviation) deemed

appropriate by the inspector. Using this approach, the inspector should be able to select a sample size that is large enough to support a meaningful comparative statistical analysis without placing an undue burden upon the licensee. The statistical methods used to evaluate the resultant data shall include, as appropriate, tests of individual and cumulative differences, tests of means, and tests of variance. The results of all such analyses shall be discussed with the licensee during a subsequent inspection and thoroughly documented in an inspection report. If the results obtained are inconclusive, the evaluation could be continued by either performing some additional sampling and analysis (e.g., split samples) or by having the licensee analyze independently certified standards brought in by the inspector. However, once an inspector verifies that a measurement problem exists, the licensee shall be required to perform any analyses deemed necessary by the inspector to isolate the specific source of the problem.

Examination of Measurement Standards and Storage. Measurement standards should be stored under controlled conditions that ensure the continued validity of the standards' assigned values. The assigned values of these standards should be traceable through an unbroken chain of comparisons to a national system of measurement standards. This requires that all instruments (including volumetric glassware, thermometers, etc.) used in preparing standards be properly calibrated and that documentation of traceability be available for all such standards. Recertification of the assigned values of standards should be done in accordance with commitments contained in the FNMCP. When possible, control standards used for the measurement control program should also be representative of materials being measured. That is, each control standard should have a matrix and SSNM concentration resembling that of the material being processed. However, since this is not always practical, the use of nonrepresentative standards may be permissible if it is adequately justified in the FNMCP or other appropriate documentation.

Evaluation of Calibration Procedures. The inspector should determine whether the measurement systems have been calibrated in accordance with commitments contained in the FNMCP. These commitments should clearly state the criteria to be used for performing the initial calibration of a system and for determining the need for recalibration. The calibrated range must span the anticipated range of process material values. Any results outside of the range of calibration should not be allowed for material control and accounting purposes (this range includes the uncertainty associated with the standard used for calibration).

The inspector should verify that calibration procedures conform to approved practices. Process and engineering tests must be performed using well characterized materials, to verify the applicability of mixing and sampling procedures for SSNM and assure sample validity during transport and storage.

In general, process and engineering tests to verify the applicability of mixing and sampling procedures need not be performed for 1) UF_6; 2) any material that utilizes a standard sampling technique as recommended by an ASTM guide, ANSI standard, Regulatory guide, etc, provided the sampling device is a simple manual device and historical data exists which demonstrates that the mode in which it is being used produces an unbiased sample, or 3) any material which contributes less than 10 grams of U-235, U-233 or Pu to the material balance.

Calculation of the Standard Deviation. The inspector should determine whether current data generated during the inventory period is used by the licensee for establishing bias correction values, uncertainties on calibration factors and random error variances.

The inspector should determine whether sufficient control standard measurements and replicate analyses of process materials were performed to permit a determination of the standard deviation associated with each measured quantity. The amount of effort expended to determine the magnitude of random and systematic errors should be related to the role that such errors play in the calculation of the SEID. As a general rule, the license should have analyzed a minimum of 15 replicates during each material balance period for each material type. In addition, a minimum of 16 measurement of control standards should be measured per material balance period for each measurement system on the basis of a minimum of two standards per week that a system is in operation. However, fewer than the above minimums may be acceptable if justified by an effort/benefit analysis.

No replicates are required for bulk volume measurements; reproducibility results obtained during calibration are sufficient. Random error variances for scales, balances, and NDA can be determined from individual or replicate measurements of standards or process materials. Systematic errors whose contribution to the SEID is less than 5 grams HEU, U-233 or Pu can be excluded from the calculation of the SEID, provided that their total contribution is less than 50 grams.

When a statistically significant change occurs in the estimated standard deviation of a material control test statistic, the alarm threshold of the test is adjusted as necessary to ensure that a goal quantity loss of SSNM will be detected with a probability at least as high as that required by 74.53(b)(2).

When a process modification occurs, sufficient data are generated to provide a reliable estimate of the standard deviation applicable to the material control test.

The magnitude of the uncertainties associated with process variabilities is determined and applied in the overall uncertainty (standard deviation) utilized in establishing alarm thresholds.

The estimated standard deviations of the material control test statistics are maintained at or below a level sufficient to achieve the loss detection capabilities established pursuant to 74.53(b) without incurring an excessive rate of false alarms.

Current inventory period data is used for the estimation of the SEID and the standard deviations associated with the process differences. Data generated in immediately preceding material balance periods may be combined with current data when it can be demonstrated that the data is from the same distribution, and the combined data are utilized to establish current period SSNM values.

The inspector compares the SEID to the active inventory to determine whether the measurement systems have been controlled. The inspector should review the processing and production control records to assure that scheduling practices are not significantly affecting MC&A performance, for example scrap recovery practices.

Bias corrections are applied to individual items whenever a bias estimate exceeds twice the estimated standard deviation of the estimator, 50 grams of SSNM, and the rounding error of affected items. Otherwise, the impact of uncorrected biases is applied as a correction to the ID. Uncorrected biases are not entered in the accounting records.

The emphasis of bias correction should be to obtain an unbiased value for the total plant ID quantity. Each bias correction that is greater than its uncertainty at the 95 percent confidence level should be considered to be statistically significant. All affected items and associated records should be corrected if the effect on the individual items is greater than the rounding error associated with the accounting records. With respect to the above, bias correction need not be considered if:

1. A measurement system utilizes a point calibration/standardization technique in a manner such that the quantities assigned to unknowns are determined directly from standards data and the range of uncertainty for unknowns intersects the region within plus or minus ten percent of the standard's assigned value.

2. The bias of a measurement system is less than the uncertainty in the standard reference material involved of the system's standards or the uncertainty in the system's control standard's provided the uncertainty is less than 0.05 percent.

For all SSNM, both statistically significant and insignificant bias corrections must be included in the reported plant ID value or a prior period adjustment. In addition, bias correction information from prior periods must be maintained and accurately tracked so that it can be correctly applied to SSNM listed under each term in the plant ID expression (i.e.,

beginning inventory, ending inventory, additions to inventory, removals, and prior period adjustments). The number of significant figures in each bias correction should be consistent with the number of significant figures in the originally assigned value.

Bias corrections associated with material control test are either applied prior to assessing the significance of the test results or are available for resolution.

Monitoring of Cumulative Shipper/Receiver Differences. The inspector should verify that cumulative shipper/receiver differences for each like material type are routinely monitored, and when they are determined to be statistically significant and exceed the larger of one FKG or 0.1 percent of the quantity shipped, corrective action is taken to identify and correct measurement biases.

Calculation of Standard Deviation for Each Measured Quantity. To inspect the statistical controls of measurement systems, the inspector should perform a file check to determine whether all measurement systems are monitored, should review several key measurement systems, and should observe procedural compliance.

Use of Control Charts and Establishment of Alarm Thresholds. The inspector should verify that a statistical control system is maintained to ensure that measurements employed for MC&A purposes are obtained from measurement systems that are in a state of statistical control. Control limits are established at the 0.05 and 0.001 levels of significance. Control limits must not be recalculated simply to resolve an out-of-control situation. Whenever a measurement system is operating between the 0.05 and 0.001 control limits, more data should be collected and analyzed. MC&A management should be promptly notified of this condition. Such notification should occur within 48 hours if one data point falls in this range and within 24 hours if two consecutive points fall in this range (excluding Saturdays, Sundays, and holidays if the plant is not operating). Investigations of exceeded control limits should concentrate on determining the assignable cause of such situations. These investigations and the associated corrective actions should be completed and documented within 7 calendar days. MC&A management must have the authority to suspend measurement activities for MC&A purposes when a system's data exceeds the 0.001 control limit.

The measurement control program must monitor the measurement of all standards and replicates analyzed for MC&A purposes unless specifically exempted by a license condition. The inspector should determine that control charts or their equivalent are used in conjunction with more comprehensive analyses of control data during and at the end of each material balance period. Such analyses should include but not be limited to trend analysis, analysis of out-of-control data, analysis of the appropriateness of control limits, and tests for randomness and normality. The results of these analyses

should be reported to all individuals who have direct or indirect responsibility for performing the associated measurements.

Monitoring of Contractor Measurement Systems. The inspector should verify that contractors who perform MC&A measurement services have implemented and maintained a control program for measurement errors and for human errors. The program will be of such depth and intensity as not to degrade the MC&A system. The inspector normally should review the licensee's audits of contractor measurement control programs as part of inspecting requirement 02.08 in Inspection Procedure 85XX7. If issues are identified for follow up, then the inspector should discuss the concerns with the licensee management and as appropriate, schedule follow up activities for the contractor. These follow up activities may be coordinated with routine NRC inspection activities for the contractor, but should consider the impacts on the licensee.

03.04 Inspection Activities Flowchart. Figure 1 shows a flow chart of the measurement system and control inspection activities.

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FIGURE 1

MEASUREMENT SYSTEMS AND CONTROL INSPECTION

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