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MATERIALS MANAGEMENT IN AN INTERNATIONALLY SAFEGUARDED FUELS REPROCESSING PLANT

Volume I

by

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ABSTRACT

The first volume of this report summarizes the results and conclusions for this study of conventional and advanced nuclear materials accounting systems applicable for both large (1500 MTHM/yr) and small (210 MTHM/yr) spent-fuel reprocessing facilities subject to international verification. The second volume describes the requirements and functions of materials measurement and accounting systems (MMAS) and conceptual designs for an MMAS incorporating both conventional and near-real-time (dynamic) measurement and accounting techniques. Effectiveness evaluations, based on recently developed modeling, simulation, and analysis procedures, show that conventional accountability can meet IAEA goal quantities and detection times in these reference facilities only for low-enriched uranium. Dynamic materials accounting may meet IAEA goals for detecting the abrupt (1-3 wk) diversion of 8 kg of plutonium. Current materials accounting techniques probably cannot meet the 1-yr protracted-diversion goal of 8 kg for plutonium. Supporting information, including detailed facility and process descriptions, and details of the design and analysis procedure are given in a third volume (Appendixes).

EXECUTIVE SUMMARY

INTRODUCTION

This report is the second in a series of efforts by the Los Alamos Scientific Laboratory (LASL) to identify problems and solutions involved in the international safeguarding of light-water-reactor spent-fuel reprocessing plants. Problem areas in materials accounting were identified in a previous Problem Statement (LA-7551-MS). The potential solutions are based on conceptual designs for improved materials measurement and accounting systems. These designs invoke technology that has been demonstrated or can be projected in a time frame consistent with the construction schedule of future nuclear fuel-cycle facilities. These design studies are intended to define systems concepts, to develop methods for evaluating safeguards systems and the data they produce, and to stimulate further development of the facilities, processes, systems, and instrumentation needed for improving nuclear materials accounting, thus providing more effective safeguards. Containment and surveillance techniques are the subject of a companion document to be issued by the Sandia Laboratories, Albuquerque.

These international safeguards studies are a logical extension of conceptual design efforts to improve nuclear materials accounting in domestic fuel-cycle facilities. The activity is part of an integrated safeguards systems program implemented by the LASL Safeguards Systems Group (Q-4), at the direction of the US Department of Energy's Office of Safeguards and Security (DOE/OSS). Previous studies in the safeguards conceptual design series address the materials management requirements for mixed-oxide fuel refabrication facilities (LA-6536), spent-fuel reprocessing plants (LA-6881), plutonium nitrate conversion (LA-7011) and co-conversion facilities (LA-7521 and LA-7746-MS), spent-fuel storage ponds (LA-7730-MS), thorium-uranium fuel-cycle facilities (LA-7372 and LA-7411-MS), large fast-critical reactors (LA-7315), and nuclear waste repositories (LA-8049-MS). In the present report, the reprocessing and conversion plants studied in LA-6881 and LA-7011 served as the design basis for an internationally verifiable safeguards system.

BASIS FOR THE STUDY

More than 105 nations subscribing to the Non-proliferation Treaty of 1968 (NPT) have agreed that domestic or State's safeguards systems are the foundation of international safeguards. Safeguards requirements under the NPT are described in the International Atomic Energy Agency (IAEA) document INFCIRC/153, which provides for:

- Materials accounting as a safeguards measure of fundamental importance, with containment and surveillance as important complementary measures;
- The incorporation in safeguards agreements of changes resulting from improvements in safeguards technology, operating conditions and experience; and
- Making full use of the State's materials accounting system and avoiding unnecessary duplication of that function.

The improved domestic materials accounting systems developed under the LASL-DOE/OSS program therefore form an appropriate base for improved international safeguards in fuel-cycle facilities.

The application of international safeguards is negotiated between the IAEA (Agency) and the State (operator) on a case-by-case basis. "Goal quantities" have been proposed by the IAEA for purposes of inspection planning, but have not been formally accepted. These "goals" are estimates of the quantities of nuclear material required to produce an explosive device and the time necessary to convert these materials to that purpose. The goals include the detection of the diversion of:

- 75 kg of ^{235}U contained in low-enriched uranium over a period of 1 yr.
- 8 kg of separated plutonium as the oxide or nitrate in 1-3 wk (abrupt diversion).
- 8 kg of plutonium over an entire year (protracted diversion).
- 8 kg of plutonium contained in irradiated fuel in 1-3 months.

REFERENCE FACILITIES

In this study we have adopted these goal quantities as points of reference for the diversion-detection sensitivities in two classes of reprocessing plants. The first facility processes 1500 metric tonnes of spent fuel annually and has a collocated plutonium nitrate-to-oxide conversion plant with a capacity to handle 15 metric tonnes per year of plutonium as the nitrate solution from the reprocesing plant. This facility is considered typical of large reprocessing plants that may be under IAEA safeguards in the 1990s timeframe. As reference facilities, we used the Allied-General Nuclear Services' (AGNS) Barnwell Nuclear Fuel Plant and a Savannah River Laboratory-Savannah River Plant design of a large conversion plant. The second facility processes 210 metric tonnes of spent fuel annually, without conversion, and was considered typical of plants presently under IAEA safeguards. The PNC facility at Tokai-mura, Japan, (Tokai) was used as the reference facility.

OPERATOR'S SYSTEM FOR MATERIALS MEASUREMENT AND ACCOUNTING

The operator's materials measurement and accounting system combines conventional and near-real-time (dynamic) accounting techniques. The conventional portion of the materials accounting system relies on discrete-item counting and materials balance closure following periodic shutdown and cleanout physical inventory.

The dynamic materials accounting portion of the system depends on frequent closures of materials balances about major portions of the process. The materials balance closure requires that a measurement of the in-process inventory be performed during process operation, but shutdown of the process is not required for each closure. Dynamic materials accounting relies on physical inventories to provide reference values for accounting over longer time periods.

For materials accounting, the large reference reprocessing plant is divided into six materials balance areas (MBAs):

- Fuel receiving, storage, chop and leach (MBA 1)
- Separations process (MBA 2)
- Uranium product storage (MBA 3)
- Plutonium nitrate storage (MBA 4)
- Plutonium nitrate-to-oxide conversion (MBA 5)
- Plutonium oxide storage (MBA 6).

The small reference facility includes only the first four MBAs.

MBAs 1, 3, 4, and 6 are item control areas. Materials accounting for safeguards will rely on item accounting.

MBAs 2 and 5 are process MBAs, with nuclear material continuously moving through the processes. Materials accounting in these areas combine both conventional and near-real-time accounting techniques. For conventional accounting, a materials balance is taken in each MBA following a shutdown and cleanout physical inventory. For near-real-time accounting, each MBA may be treated as a single accounting area, or, depending on process considerations, the MBA can be partitioned into additional, functionally discrete accounting envelopes referred to as unit process accounting areas

(UPAAs). The frequency of materials balance closures is dictated by process considerations such as the throughput, and the accessibility of the in-process inventory per measurement.

In this study, MBA 2 of the large reprocessing plant was treated both as a single UPAA (designated UPAA 1 2), and as two separate UPAAs: the headend process (UPAA 1) and the plutonium purification process (UPAA 2). The conversion process MBA (MBA 5) also was treated as a single UPAA (UPAA 3 4 5): as three parallel UPAAs, one for each process line (UPAAs 3, 4, and 5): and finally each process line was divided into two UPAAs, with the continuous (plutonium nitrate feed to oxide filtration) process treated as one UPAA; and the batch-operated (calcination to product loadout) process treated as a second UPAA.

For the small reprocessing plant, MBA 2 can be divided into three UPAAs. This subdivision is possible because there are buffer tanks between the decontamination and uranium-plutonium partition cycles and between the partition and plutonium purification cycles. These buffer tanks can be used as transfer measurement points to delineate UPAAs.

EFFECTIVENESS OF THE OPERATOR'S SYSTEM OF MATERIALS ACCOUNTING AND CONTROL

The design and evaluation of the accounting system are based on computer simulations of the reference facilities because these facilities have either not been built or have not been operated in a full production mode. Additionally, alternative operating, measurement, and accounting strategies can be readily compared.

The modeling and simulation approach requires (1) a detailed dynamic model of the process based on actual design data and operator experience; (2) computer simulation of the model process; (3) a dynamic model of each measurement system based on best estimates of instrument performance and behavior; (4) simulation of accounting measurements applied to nuclear materials flow and in-process inventory data generated by the model process simulation; and (5) evaluation of simulated materials balance data from various materials accounting strategies.

Analysis of materials accounting data for detection of possible nuclear materials diversion is one of the major functions of the materials measurement and accounting system. Diversion may occur in two basic patterns: abrupt diversion (the single theft of a relatively large amount of nuclear materials) and protracted diversion (repeated thefts of nuclear materials on a scale too small to be detected in a single materials balance because of measurement uncertainties).

The use of unit-process accounting and dynamic materials balances enhances the ability to detect such diversions, but it also means that the operator of the safeguards system will be inundated with materials accounting data.

Decision analysis, which combines techniques from estimation theory, decision theory, and systems analysis, has been developed as a logical framework of tools for statistical treatment of the dynamic materials accounting data that become available sequentially in time. Its primary goals are (1) detection of the event(s) that nuclear material has been diverted, (2) estimation of the amount(s) diverted, and (3) determination of the significance of the estimates.

The decision analysis algorithms include the Shewhart chart, Cusum, uniform diversion test, sequential variance test, smoothed materials balance test, and Wilcoxon rank sum test. The algorithms for the Shewhart chart, Cusum, uniform diversion test, sequential variance test, and smoothed materials balance test are structured to account for correlated data (so-called systematic errors) so that correct variances are computed for the associated decision tests.

The decision tests must examine all possible sequences of the available materials balance data because, in practice, the time at which a sequence of diversions begins is never known beforehand. Furthermore, to ensure uniform application and interpretation, each test should be performed at several levels of significance. A graphical display called the alarm-sequence chart is used to indicate those sequences that cause alarms, specifying each by its length, time of occurrence, and significance.

One essential part of designing nuclear materials accounting systems is analyzing their expected performance in detecting losses of nuclear material. Systems performance analysis, in turn, implies the definition of suitable performance measures that can be easily related to externally established criteria. Thus, there are two aspects of the analysis problem: first, defining performance measures, and second, relating those measures to established, quantitative performance criteria.

Performance measures for any nuclear materials accounting system embody the concepts of loss-detection sensitivity and loss-detection time. Because of the statistical nature of materials accounting, loss-detection sensitivity can be described in terms of the probability of detecting some amount of loss while accepting some probability of a false alarm. Loss-detection time is the time required by the accounting system to reach some specified level of loss-detection sensitivity. The loss scenario is not specified; that is, whether the loss occurs in an abrupt or in a protracted fashion, the total amount of loss is the measure of performance. Note also that loss-detection time only refers to the internal response time of the accounting system.

Intuitively, the performance of any accounting system is describable by some function

$$P[L,N,\alpha] \quad ,$$

where P is the accounting system's probability of loss detection, L is the total amount of loss over a period of N balances, and α is the false-alarm probability. Thus, a convenient way of displaying systems performance is a three-dimensional graph of the surface P versus L and N for some specified value of α. These graphical displays, called performance surfaces, portray the expected performance of an accounting system as a function of the three performance measures, loss, time, and detection probability, rather than as a single point.

The effectiveness of the operator's materials measurement and accounting system in detecting diversion was evaluated for both conventional and near-real-time materials accounting using the tools described above. In evaluating the performance of conventional accounting, the buildup of measurement correlations caused by long-term errors was simulated. Uncertainties in the small relative biases between the input and output measurements make the major contribution to the materials balance uncertainties over long accounting periods. Better control of these relative biases result in significant improvements in the sensitivity of conventional materials accounting to protracted diversion.

Small long-term biases have a much smaller effect on near-real-time materials balances taken over short accounting periods. For these short accounting periods, short-term errors, that is, errors that persist over a given calibration period, become the dominant factor in the materials balance uncertainty. In evaluating the performance of near-real-time accounting, control of short-term errors was simulated for input and output measurements. Controlling these errors involves careful design of a measurement control program for each measurement technique applied at flow key measurement points.

Table S-I lists ^{235}U materials balance standard deviations in the process MBAs of the reference facilities. The materials balance standard deviations are based on a shutdown and cleanout physical inventory and were calculated using state-of-the-art measurement techniques reviewed in the report. A range of values is given for two

TABLE S-I

URANIUM-235 MATERIALS ACCOUNTING IN THE REFERENCE FACILITIES

Accounting Period (months)	Materials Balance Standard Deviations (kg) — Large Reference Facility — Chemical Separations Area	Materials Balance Standard Deviations (kg) — Small Reference Facility — Chemical Separations Area
3	6.3-10.4	0.8-1.3
6	11.6-20.3	1.5-2.6
12	22.3-40.1	2.8-5.1

cases. In the first case, feed and product concentration measurements were recalibrated every 2 days. In the second case, instruments were not recalibrated during the accounting period. These materials accounting sensitivities will be degraded if high-quality measurements cannot be obtained. Conversely, the sensitivities could be improved if measurement errors can be controlled more effectively by identifying the dominant error sources and establishing effective measurement control procedures. Note that the diversion-detection sensitivity is $\sim$3.3 times the materials balance standard deviation for a 95% detection probability and a false-alarm probability of 5%.

Table S-II summarizes plutonium materials balance standard deviations for the process MBAs of the reference facilities. Additional accounting strategies are discussed in Sec. V of the report. Materials balance standard deviations for accounting periods $\leq$1 month are based on in-process inventory measurements while the process is operating. In each case, a range of uncertainties is given for the entire process area. The cases considered range from best-case estimates of contactor in-process inventories with 2-day recalibrations of feed and product flow and concentration measurements to worst-case estimates of in-process inventories and no recalibrations within the accounting periods. Note that the diversion-detection sensitivity is $\sim$3.3 times the materials balance standard deviation for a 95% detection probability and a false-alarm probability of 5%.

IAEA VERIFICATION

The application of international safeguards to reprocessing plants is the subject of intensive study within the IAEA and by member states.

TABLE S-II

PLUTONIUM MATERIALS ACCOUNTING IN THE REFERENCE FACILITIES[a]

	Large Reference Facility				Small Reference Facility	
	Chemical Separations Area		Conversion Area		Chemical Separations Area	
Accounting Period	Materials Balance Frequency[b]	σ (kg Pu)	Materials Balance Frequency[c]	σ (kg Pu)[d]	Materials Balance Frequency[e]	σ (kg Pu)
1 balance	1/2 days	2.1-2.4	1/2.88 h	0.40	1/day	0.25-0.38
1 day	---	---	1/2.88 h	0.43	1/day	0.25-0.38
1 wk	1/2 days	2.5-2.8	1/2.88 h	0.70-0.85	1/day	0.30-0.43
2 wk	1/2 days	3.0-3.6	1/2.88 h	1.1-1.4	1/day	0.36-0.52
1 month	1/2 days	4.0-5.7	1/2.88 h	2.0-2.4	1/day	0.48-0.77
2 months	---	---	1/2 months	4.0-4.9	---	---
3 months	1/3 months	7.5-14.0	1/3 months	5.9-7.2	1/3 months	0.94-1.9
6 months	1/6 months	13.0-26.8	---	---	1/6 months	1.7-3.7
1 yr	1/yr	23.8-52.7	---	--	1/yr	3.2-7.3

[a]Materials balance standard deviations for accounting periods ≤1 month are based on in-process inventory measurements while the process is operating. Materials balance standard deviations for accounting periods >1 month are based on a shutdown and cleanout physical inventory. Ranges are given for the cases that are considered in Sec. V. Unless otherwise noted, the accounting strategies shown here use chemical analysis techniques for the feed and product batches.

[b]Dynamic materials balances taken every 2 days include five input accountability batches and two product batches.

[c]Dynamic materials balances taken every 2.88 h include one input accountability batch and three product batches.

[d]An on-line measurement technique for the product batches is used in the accounting strategy shown here. This measurement is replaced by the result of chemical analysis of a sample 8 h after the batch is produced.

[e]Dynamic materials balances taken every day (immediately after the product evaporator is drained) include two feed accountability batches and one product batch.

The responsibility of the IAEA, as specified in INFCIRC/153, para. 30, is "that the technical conclusion of the Agency's verification activities shall be a statement, in respect of each materials balance area, of the amount of material unaccounted for over a specific period, giving the limits of accuracy of the amounts stated." That statement has three important implications. First, the objective is a "technical conclusion." Clearly, the technical safeguards measures (materials accounting, containment, and surveillance) must provide the basis for conclusions having a minimum of ambiguity and subjectivity. Second, the conclusion is a statement of material unaccounted for and its associated uncertainty for each MBA. This is not equivalent to a conclusion of possible diversion by the State. Conclusions concerning the possibility of diversion are derived from technical safeguards and other sources of information. Such conclusions may be initiated in the form of a statement by the Agency to the Board of Governors that it cannot meet its safeguards responsibilities in a particular State. Third, the conclusion is the result of the Agency's verification activities. Because international safeguards are a joint undertaking of the IAEA and its Member States, a two-step process must be implemented: the State's system of accounting and control must provide all information necessary for the Agency to meet its responsibilities, and the Agency must verify that information.

In this two-step process the IAEA plays a dual role. In partnership with Member States, the Agency promotes the development of effective and efficient State's safeguards systems. It must make full use of the State's system of accounting and control. Conversely, the Agency must determine whether the State's system is adequate for the Agency to discharge its safeguards responsibilities and must independently verify the information provided by the State.

To meet its obligations, the Agency must consider the necessity for continuous inspection in reprocessing/conversion plants. This is consistent with the maximum permitted routine inspection effort given in INFCIRC/153, para. 80, which corresponds to more than 1000 man-days of inspection per year for a 200 MTHM plant. Inspectors need not necessarily be in the plant at all times but may be available on call nearby for important verification activities.

Two sensitive issues are the protection of design information that the operator regards as proprietary and inspector access inside the plant. The Agency will require detailed plant and process design information including proprietary process details to plan the safeguards approach. The operator will need reasonable assurance that such information will be adequately protected.

The operator must provide in his production plans for critical inspector verification activities. Continuous inspection, with access to sensitive plant areas and process data, is an extension of past practice and places an additional burden on the operator, but this extension of activities will be necessary to achieve the postulated safeguards goals.

Effective safeguards in reprocessing-conversion plants cannot be based on conventional materials balance accounting alone. In particular, short detection-time goals cannot currently be met in small or large reprocessing plants. An overlay of advanced safeguards measures including containment, surveillance, and dynamic materials accounting is designed specifically to address the short-detection-time problem. In the feed and product storage and handling areas, the emphasis is on conventional item accounting complemented by enhanced containment and surveillance. In the main process areas, the emphasis is on materials accounting supplemented by containment and surveillance. In the small plants currently under safeguards, a retrofit of advanced safeguards measures appears to be both feasible and adequate with minimal plant or process modifications.

The Agency verification of the State's materials accounting system must be directed toward detection of both abrupt and protracted diversion. Methods of diversion concealment include:

- Diversion hidden by measurement uncertainties
- Falsification
  - Nuclear material tampering
  - Instrument tampering
  - Data tampering
  - Falsification of measurement error statistics.

The Agency verification activities, including inspections, materials accounting, containment, and surveillance, are designed to address these potential diversion schemes through

- Examination of information provided by the State,
- Independent information collection,
- Evaluation of the inspector's information.

The materials accounting verification activities must include Agency access to key measurement points; active participation in the materials measurement and calibration programs; and application of statistical techniques to evaluate the significance of operator and Agency measurement data.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The basis for international safeguards arrangements is described in INFCIRC/153 for nations party to the NPT and in INFCIRC/66 for non-NPT nations, and is reviewed in Sec. III for the operator's system and Sec. VI for Agency verification. The objective of international safeguards, as declared by these documents, is the "...timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities..." The emphasis is on "...the use of materials accountancy as a safeguards measure of fundamental importance, with containment and surveillance as important complementary measures... ." The manner and frequency of inspections for compliance are negotiated between the IAEA and the host nation on a case-by-case basis and are documented in the so-called "Subsidiary Arrangements" and "Facility Attachments."

By materials accounting the IAEA seeks to obtain to a satisfactory degree of confidence (now accepted as 95%) that a significant amount of nuclear material is not diverted from a materials balance area over a specified period. The Agency has not formally specified significant quantities or detection times. Goals of detecting 8 kg of plutonium as PuO_2 in 1-3 wks for abrupt diversion and 8 kg of plutonium as PuO_2 in 1 yr for protracted diversion have been proposed. A sensitivity of 75 kg of contained ^{235}U in 1 yr was considered as the goal for abrupt and protracted diversion of low enriched uranium.

From these studies (Tables S-I and S-II), we conclude that

- For ^{235}U the proposed IAEA criteria for diversion sensitivity and timeliness probably are attainable, both for large and small reprocessing plants by conventional materials accounting, if rigorous materials measurement control programs are instituted.
- For plutonium, the proposed IAEA criteria for sensitivity and timeliness cannot be met solely by conventional materials accounting for either facility.
- In the large chemical separations process area the proposed IAEA criteria for detecting abrupt diversion of plutonium probably can be met by dynamic materials accounting, if a rigorous measurement control program is undertaken.
- In the large chemical separations process area the proposed IAEA criteria for detecting protracted diversion probably cannot be met because the goal quantity is only 0.05% of the annual plant throughput.
- In the conversion process area the proposed IAEA criteria for detecting abrupt diversion probably can be met using dynamic materials accounting.

- In the conversion process area the proposed IAEA criteria for detecting protracted diversion probably cannot be met because the goal quantity is only 0.05% of the annual plant throughput.
- In the small chemical separations process area the proposed IAEA criteria for abrupt diversion probably can be met using dynamic materials accounting.
- In the small chemical separations process area the proposed IAEA criteria for protracted diversion may be achievable using materials accounting but only if materials measurements and measurement controls can be improved over those assumed in this study.

Achieving a satisfactory sensitivity to protracted diversion in the main process area may be the most difficult technical safeguards problem. The factor limiting the detection of protracted diversion may be the uncertainty in residual, long-term relative biases between the input and output accountability measurements. Although considerable effort is currently expended on input and output accountability measurements (separately), insufficient attention has been given to controlling the long-term <u>relative</u> uncertainties between these measurements. It is expected that these relative uncertainties can be controlled within the range 0.1-1% (1σ) of throughput. Thus, improved input-output flow control may yield a detection threshold (3.3σ) for protracted diversion of perhaps 0.5% of throughput. On an annual basis, that corresponds to a diversion rate of one significant quantity (8 kg Pu) per year from a 200-MTHM plant. The potential diversion rate from large plants (1500 MTHM) probably will exceed one significant quantity per year.

Consequently, there is presently some disparity between the suggested IAEA criterion for sensitivity to protracted diversion and the near-term projected capability of even advanced safeguards systems. At the same time, safeguards technology is still evolving, continuing to narrow the gap between desired and realizable performance. In recognition of this fact, alternative <u>forms</u> and <u>values</u> of criteria should be considered, from the standpoint of both technical and institutional/political ramifications.

The materials accounting system described in this report was established for existing or designed facilities. Process design and measurement methodology limit the sensitivity of both conventional and near-real-time accounting strategies through correlated systematic errors and uncertainties in in-process inventory. This study has identified the following areas where modifications in process or plant design could improve the State's materials accounting system and the Agency's verification program.

- Nondestructive assay verification of fuel burnup and/or fissile content of irradiated fuel (App. N).

- Accountability tank design to provide accurate sampling and analysis for input measurement.
- Use of centrifugal contactors where feasible to minimize in-process inventory (App. J).
- Improved codecontamination to permit improved measurements of inputs to the PPP and to minimize in-process inventory in the PPP.
- Redundant measurement instrumentation in process tanks, where feasible.
- Installation of process buffer tanks to decouple continuous process operations.
- Instrumentation on process tanks containing significant nuclear material for volume and concentration measurements.
- Accessibility of in-process inventory for measurement.
- Collocation of reprocessing and conversion facilities to eliminate the plutonium nitrate product concentration operation.
- Installation of flow and concentration measurements in some process streams to improve plant UPAA structure for near-real-time accounting.
- Design of instruments at key measurement points for easy accessibility for maintenance and recalibration. Instruments should be tamper-resistant or tamper-indicating.
- Use of computer-based data acquisition and data reduction.

The design of the materials accounting system should take into consideration the capabilities and limitations of containment and surveillance as well as of materials accounting systems. Conventional accounting, supported by improved containment and surveillance techniques, probably will be required in item control areas. Improved materials measurement and accounting systems, protected by improved surveillance systems, will be required for process areas.

The concepts and techniques described in this report should be implemented in existing facilities to demonstrate their applicability and to quantify their effectiveness and compatibility with modern nuclear fuel processes.

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