LEGIBILITY NOTICE

LA-UR--90-2486

DE90 014898

Received by OSTI

AUG 0 6 1990

Los Alamos National Laboratory is operated by the University of California for the United States Department of Energy under contract W-7405-ENG-36

TITLE: AN APPROACH TO SAFEGUARDS FOR A NUCLEAR MATERIALS PLANT

AUTHOR(S): Neil R. Zack

SUBMITTED TO: 31st Annual Meeting of the Institute of Nuclear Materials Management, Los Angeles, July 15-18, 1990

Los Alamos

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

FORM NO. 836 R4
ST. NO. 2629 5/81

AN APPROACH TO SAFEGUARDS FOR A NUCLEAR MATERIALS PLANT*

Neil R. Zack
Safeguards Systems Group
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

ABSTRACT

This paper discusses a safeguards system that could be employed for a hypothetical nuclear material processing or production facility. The approach results in an integrated system of accountability measurements and nuclear materials control measures designed to monitor the storage, processing, and transfer of nuclear materials as well as placing adequate restraints upon personnel movement. It is the goal for every safeguards system, whether planned for a new facility or to be overlaid upon an existing facility, to be transparent to the plant operators, while accomplishing the necessary safeguards and security functions. This approach fulfills this need and presents graded protection to areas of varying sensitivity and accomplishes control at the source rather than placing increased reliance upon after-the-fact detection capabilities. These considerations will help a new or existing facility meet the new directions being established for safeguarding nuclear materials.

INTRODUCTION

The design and implementation of all or part of a safeguards and security system that just meets requirements might appear to be sufficient and cost effective. However, the requirements and guidelines that are implemented for today's environment are not likely to be the ones that will be used in tomorrow's public scrutiny. A facility may save current funds by planning to just meet existing requirements and permit any new requirements to be funded by tomorrow's monies. But, overlaying a new system or technique on an existing facility will be costly as well as inefficient. Quick fixes such as using security inspectors in place of surveillance systems saves today's jiggle switches construction dollars at the expense of tomorrow's operating funds while decreasing system performance. Although it is difficult to foresee the future, a cost-effective, efficient safeguards and security system that exceeds current requirements should be designed and implemented to be a state-of-the-art system. Outdated systems that are to be overlaid or enhanced with new systems should be similarly updated.

The approach for any safeguards system for a new or existing facility must be to implement an integrated means of accountability measurements and nuclear materials control. These measures should be specifically designed to monitor the storage, processing, and transfer of nuclear materials to ensure that no material is lost or removed, and that the materials have been adequately measured. The accountability and control portions of the safeguards system should tie-in closely with the physical security system to assure that no diversion or theft of significant quantities of nuclear material has taken place. Of course, specifying criteria for a safeguards system during all design stages for the plant and process allows the overall system to be integrated as needed and to be 'glove-fit' to meet the requirements. Overlaying a new safeguards system upon an existing facility requires that the system be designed to fit with existing portions. Implementation and integration problems will result from attempting to tie new, old, automated, and manual systems together; it also will produce some resistance from personnel who are comfortable with the status quo. In other cases, process requirements and procedures may not permit adoption of any new techniques or systems but only allow modification of the existing systems.

Old and new ideas and techniques could be used to specify a practical state-of-the-art integrated safeguards system whose components can be applied totally to a new facility or could be considered individually for application into an existing operation. The remainder of this paper discusses techniques that could be employed to help a facility meet the requirements for safeguarding nuclear materials. Regardless of the facility or the methods chosen, the requirements must be met.

*This work was supported by the U.S. Department of Energy, Office of Safeguards and Security.

SPECIFYING A SYSTEM

The design (or redesign) of a safeguards system must begin with a thorough understanding of the operational processes involved and their respective measurement and monitoring points. From this information, material balance areas (MBAs) can be outlined that enclose areas of similar operational capabilities with each incorporating the required high-quality measurement point(s). However, the need to enlarge or decrease a particular MBA may depend upon the ability to measure the nuclear material being transferred into or out of that particular MBA. It may be logical to combine MBAs when the material being transferred cannot be adequately assayed to produce the quality of measurement value needed. That is, rather than decreasing detection sensitivity by employing low-quality measurements, MBAs may be combined so that high-quality measurements can be used for all significant transfers. If the process contains major recycle streams, it might be important to combine the main process and recovery areas into a single MBA to eliminate multiple measurements of recycle material. However, with any combining of MBAs, it is more difficult to identify and localize abnormal safeguards conditions. Therefore, sub-MBAs and/or material control areas (MCAs) should be identified to help identify and resolve anomalies. These could be based on less rigorous measurement points such as mass (weight), with care taken to prevent substitution of the nuclear material. For example, the sub-MBAs could be a string of glove boxes or a group of tanks. The MCA, which could be defined as a unit of a sub-MBA, could be an individual glove box or a single tank. Thus, the sub-MBA and MCA arrangement could be structured as compartments to make use of existing process measurement points for materials control purposes. Additional measurements could be added to these compartments, as appropriate, to support materials control and accounting (MC&A) needs. These structures also could use process monitoring points for tank volume, level recorders, etc., to define boundaries. This configuration concept would help make the system as transparent to the process as possible and still enhance the system's loss detection capability by localizing abnormal conditions to smaller areas. The MBA boundaries, however, would still involve the use of higher quality accountability measurements.

Accountability

The safeguards' accountability subsystem must provide adequate information to meet requirements concerning the location and amount of any accountable nuclear material in the facility at any given time and should provide the ability to detect abrupt or protracted thefts or diversions. All designs and methods should facilitate the efficiency of the accountability system in meeting the requirements and facilitate defensibility of data and information. Such a system would provide a cost-effective near-real-time accounting system that would provide appropriate safeguards but also would benefit other plant systems such as criticality safety.

To provide the necessary safeguards information, all measurements that indicate the presence of any accountable nuclear material must be reported to the Material Control & Accountability system (preferably, automatically without human data handling) even if the reasons for measurement were other than accountability. This information on concentration, isotopes, and impurities would allow the nuclear material's identity to be maintained until a physical process change has occurred in which the new measurement information to be carried forward could be linked to previous information to maintain material pedigree and traceability. Measurement bias and precision information should be provided automatically with these results. They should be bias corrected and reported with the measurement uncertainty associated with the instrumentation and the particular techniques applied, and should be as timely as practical. Therefore, a quality control program is mandatory, with measurement results reported to the safeguards system, but not limited to the minimum reportable quantity levels stated in the requirements. These results should only be constrained by the instrumentation used. These data, as applicable, should be available to an automated computer program for statistical evaluation and to determine nuclear material control limits and inventory related values.

Measurements should be made using analytical chemistry methods, in-line monitoring for holdup, process control measurements, nondestructive assay, and other related process monitoring instrumentation. Defensibility of all results should be demonstrated through the use of traceable national reference standards. If primary standards are not available, then standards must be prepared and certified to primary standards, where possible. Validation of all measurement and estimation techniques should be completed and documented prior to formal start-up of the facility.

With the MBAs and the measurement system defined, an analysis or modeling study can be completed to demonstrate acceptability of each MBA's loss detection sensitivity as required to meet the orders. These values depend upon the quality of the measurements which, in turn, are highly dependent upon the samples to be analyzed being representative of the process point sampled. To verify that the samples will be indicative of the process, sampling and sample storage studies should be completed prior to use of the system. The sample storage study will validate that the sample, once obtained for analysis, will remain as truly representative of the original material until the sample is no longer required. An archival sample, properly stored, should be maintained for each batch of product leaving the plant until shipper/receiver differences are resolved, and the material has been formally accepted by the receiver. This sample could be maintained as a reference sample for resolution of any problems or could be held for historical use.

Control

MBAs, sub-MBAs, and MCAs are designated to monitor internal movement of nuclear material and to aid in inventory control throughout the facility. In this regard, the movement of all accountable nuclear material should be tracked, and all nuclear material storage positions should be continuously monitored. Tracking the material could involve monitoring the time required to transfer material from one location to another or using radio frequency (RF) tracking devices applied to each nuclear material transfer container. The RF tracking system would monitor the passage of the material through specific locations in the process or facility. Continuous monitoring of storage locations could be accomplished through the use of movement sensors on each container (for example, jiggle switches that would alarm when the container is disturbed), area motion detectors, and/or closed-circuit television. An additional benefit would be derived from the use of a location or container motion sensor coupled with a physical attribute monitor, e.g., a thermocouple to monitor gross heat output from plutonium-bearing materials or a load cell to continuously monitor the mass of the material. When coupled with the entire safeguards and security system, this monitoring system would help reduce the need to inventory the nuclear material because its integrity would be assured from the time it was initially placed in storage.

Each nuclear material transaction request should be automatically approved before the material is moved with the information automatically recorded after the transaction has been attempted or has taken place. The transaction request information to be checked for acceptability should include:

- all identification numbers associated with the material and container(s),
- time and date of transaction,
- person(s) requesting the move,
- location of person(s) requesting the transaction,
- type and amount of material to be moved,
- material origin and destination,
- pertinent measurement information required for the move,
- material control limits at the originating location, and
- material remaining at originating location.

If any of these acceptability checks should fail, the transaction should be physically blocked; i.e., a glove box door interlock would not permit the transfer to occur, alarms would remain enabled, and/or a transport mechanism would not be enabled. Multiple transfer request failures by the same person(s) during a 24-hour period should automatically disallow the person(s) from using the system and should provide an appropriate alarm. The locked-out personnel should be reinstated only by safeguards personnel. Apparently, the most efficient way to perform these checks would be through an automated system in which the personnel at their workstation(s) would enter the required information into a computer terminal. The result would be a go or no-go situation in which these procedures and automated controls would help prevent unauthorized personnel from obtaining access to nuclear material as well as to provide an independent audit and tracking mechanism as nearly free as possible from human data handling errors. For example, this control system could be used to perform the following checks:

- the personnel requesting the transaction may have access to the room, but are they authorized to move the material and do the anticipated work?;
- is the quantity and type of material requested normally used at that destination?; and/or
- will the requested material leave an unacceptable quantity of retained material at the original location, or is the batch material balance unacceptable?

No single adversary could readily defeat this system and gain access to nuclear material without causing multiple failures and/or alarms. Furthermore, personnel that would have access to modify the automated systems would not have access to the nuclear material, thus providing another layer of protection.

In addition to nuclear material, access to related MC&A information and essential process control and monitoring equipment must be controlled. Access to information, equipment, and nuclear material should be designed using the compartmentalization concept. For example:

- any safeguards' data and information gathering capability would be automated and physically independent from other systems and, at a minimum, would maintain independent monitoring of any commonly required information;
- data and information available in the MC&A computer system would be limited to that required to meet safeguards requirements and functions;
- other measuring, monitoring, and controlling devices and instrumentation would be distributed and functionally independent so that each would contain all pertinent memory, algorithms, and processing capabilities required for its specific controlled devices; and
- automated process and control methods, data collection, and necessary monitoring would be employed to provide accurate and timely data and information collection.

In this way, access by personnel and interfacing capabilities can be controlled to specific areas of the process, the facility, and/or data and information gathering systems, thus permitting localization and monitoring of non-normal conditions to facilitate their identification and isolation. If this system is automated as are similarly structured physical security systems, anomalies can be detected and responded to during the early phase of the condition rather than after the fact.

Inventory

After each nuclear material's transaction at the facility, the MC&A system should automatically update the book inventory and determine the preliminary inventory difference, if any, for each MBA and/or sub-MBA involved in the transaction. This overall system could provide an administrative check concerning all nuclear material within the facility at any moment in time without struggling with data and information that might be weeks old or not entered into the inventory data base. These techniques would allow the facility to know that no items are obviously missing and that there is no indication of any other abnormal conditions, while providing the location of nuclear material within the protected area and without causing an interruption in operation. Interfacing this system with the physical security system would permit a rapid correlation of data between the two systems by comparing the physical security alarm(s) with any MC&A anomalies or alarms at that location.

The automated generation of a book inventory would only be used to provide immediate information and would not supersede the requirements for periodic physical inventory of all nuclear material. The process must be designed and structured to support a physical inventory by providing rigorous estimates or measured values of materials retained within process vessels, ducting, pipes, etc. and assurances that all nuclear material has been inventoried. However, the integrated safeguards and security system might permit a decreased or abbreviated inventory schedule and, therefore, reduce costs and personnel exposure.

CONCLUSION

The safeguards systems discussed above, when coupled with the appropriate physical security arrangements, produce an integrated safeguards and security system that would help satisfy the requirements and the needs for defense in depth. While it is likely that no single methodology or technique can satisfy the orders, taken as a whole, the proposed system should adequately respond to the safeguards and security functional needs.

The materials control and accountability portion of the proposed safeguards system will provide data and information to establish compliance with the materials accounting and materials control chapters of the DOE orders. The system will help meet the requirements by:

- tracking all nuclear material movement;
- documenting all transactions;
- maintaining a measurement control program;
- providing a "near-real-time" special nuclear material (SNM) book inventory and distinct inventory location;
- controlling access to SNM, related data, and system components;
- supporting decreased inventory schedules;
- automatically generating required statistical data upon request;
- correlating data and information as needed;
- performing administrative checks on demand;
- detecting anomalies for appropriate response; and
- supporting an in-depth audit trail.

An automated data collection, correlating, and analysis system would be desirable for both new and existing facilities. The cost of these systems would be readily paid back in decreased human data handling, verification, and problem solving. An automated correlation of related data would be beneficial to detecting anomalies and providing a timely response. Although the automated systems hold great promise, without full integration and design interaction from all phases of the involved process departments, the errors of the past would be repeated such that any progress would be pushed aside in favor of familiar manual systems.