RECEIVED BY OSTI JUN 07 1985

LA-UR--85-1649

DE85 012710

CONF-850556--9

TITLE: AN INTEGRATED NONDESTRUCTIVE ASSAY SYSTEM FOR A NEW PLUTONIUM SCRAP RECOVERY FACILITY

AUTHOR(S): M. Baker

SUBMITTED TO ESARDA
7th Symposium on Safeguards and
Nuclear Material Management
Liege, Belgium
May 21-23, 1985
(FULL PAPER)

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

AN INTEGRATED NONDESTRUCTIVE ASSAY SYSTEM FOR A NEW PLUTONIUM SCRAP RECOVERY FACILITY

M. P. Baker
Los Alamos National Laboratory
Los Alamos, NM 87545 USA

Abstract

A consortium of laboratories is collaborating with the Savannah River Plant to develop an integrated system of state-of-the-art nondestructive assay (NDA) instrumentation to provide nuclear materials accounting and process control information for a new plutonium scrap recovery facility. Individual microcomputer-based instruments report assay results to an Instrument Control Computer (ICC). The ICC, in turn, is part of a larger computer network that includes computers that perform process control and nuclear materials accounting functions. Integrated system design considerations, integral testing, and individual instrument measurement functions are discussed.

1. Introduction

A new plutonium scrap recovery facility is being constructed at the Savannah River Plant (SRP). The Los Alamos National Laboratory is collaborating with SRP to define and develop an integrated system of modern, automated nondestructive assay (NDA) instrumentation that will provide nuclear materials accounting and process monitoring information to the operators of this facility. The goal is to provide an accountability system that is capable of drawing frequent material balances with minimum reliance on laboratory measurements of analytical samples. The integrated system is illustrated schematically in Fig. 1.

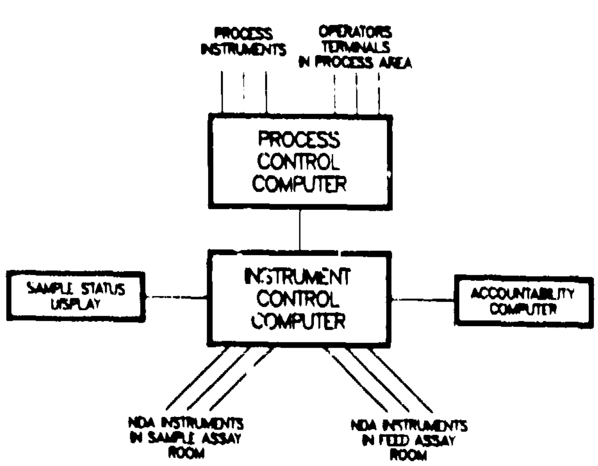

Fig. 1. Schematic diagram of integrated NDA system for new plutonium scrap recovery facility.

This state-of-the-art instrumentation is being designed and fabricated by the Los Alamos National Laboratory, Lawrence Livermore National Laboratory, Mound Laboratories, and Savannah River Laboratory. Los Alamos is also serving as system coordinator, combining the individual components into an integrated package with the ten NDA instruments reporting to a central Instrument Control Computer (ICC). The ICC, in turn, is integrated into a facility computer network that includes other computers dedicated to process control and nuclear materials accounting functions. The three computers that make up this network have dedicated functions but exchange relevant information via a DECNET communications link to optimize the simultaneous performance of all these functions. An extended integrated test of the entire system will be performed at Los Alamos prior to installation in the facility.

2. Facility Process/NDA Measurement Description

This new facility is designed to recycle and recover off-specification plutonium, excess process waste, and process scrap. The layout of the process is shown in Fig. 2. Input materials scheduled for recovery are brought from a storage vault to a dedicated Feed Assay Room (FAR) where their total plutonium contents are determined for input accountability purposes using a series of NDA measurements. Following the input accountability measurements, the materials are transferred into a feed glovebox train (Feed) for

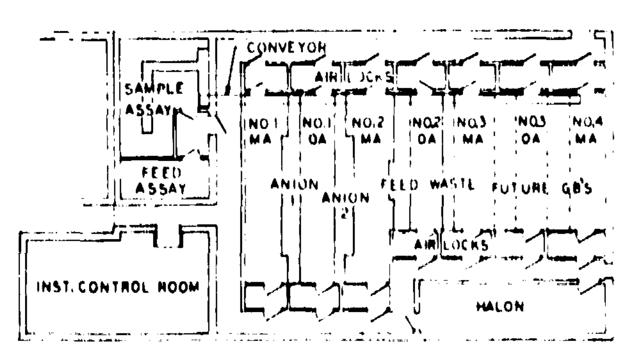

Fig. 2. Physical layout of plutonium scrap recovery facility.

preparation before their dissolution in one of two dissolver/anion-exchange glovebox trains.

After chemical processing, solutions are transferred out of the facility as product or waste. Required NDA measurements of dissolver/anion-exchange cabinet solutions are performed on samples obtained from process vessels and transferred by conveyor to a dedicated glovebox in a Sample Assay Room (SAR). Bulk and solution sample identification labels are input to the appropriate computer systems using bar-code readers connected through computer terminals.

Solid waste from the process will be transferred by conveyor to the waste-handling cabinet and assayed for plutonium content by NDA. The results of the measurement will determine whether the waste is recycled in the facility or sent to burial. Liquid waste will be sampled and assayed for plutonium content by NDA in the SAR. These solutions are recycled in or transferred out of the facility consistent with their plutonium content. In addition to the instrumentation discussed above, a sodium iodide, gamma-ray detector array will be deployed at key points in the process. Measurements from this array will be used to determine holdup in process equipment, set criticality alarm limits, and monitor the process.

3. NDA Measurement System Description

The design of the integrated NDA measurement system is shown in detail in Fig. 3. Each NDA instrument that is part of the integrated system is microcomputer-based and thus is capable of stand-alone operation if the central computer is out of service. This modular system design feature has allowed each instrument supplier more freedom in individual instrument design. It also permits the parallel development of many individual NDA instruments by several suppliers to minimize the total time required to develop the entire system. Nevertheless, certain hardware features, such as microcomputers, pulse processing modules, and multichannel analyzers, are common throughout the system. Note that in almost every case at least two NDA measurement systems are controlled by a single MICRO/PDP-11 computer.

In addition, there are many standard software features, the most important, from the point of view of facility operations is the interface between the individual NDA instruments and the operator performing the assays. All instruments are operated from dedicated microcomputer terminals and have standardized operator/instrument dialogue. This standardization reduces the complexity of operator training as well as potential confusion, since the same operator will likely perform assays on several instruments.

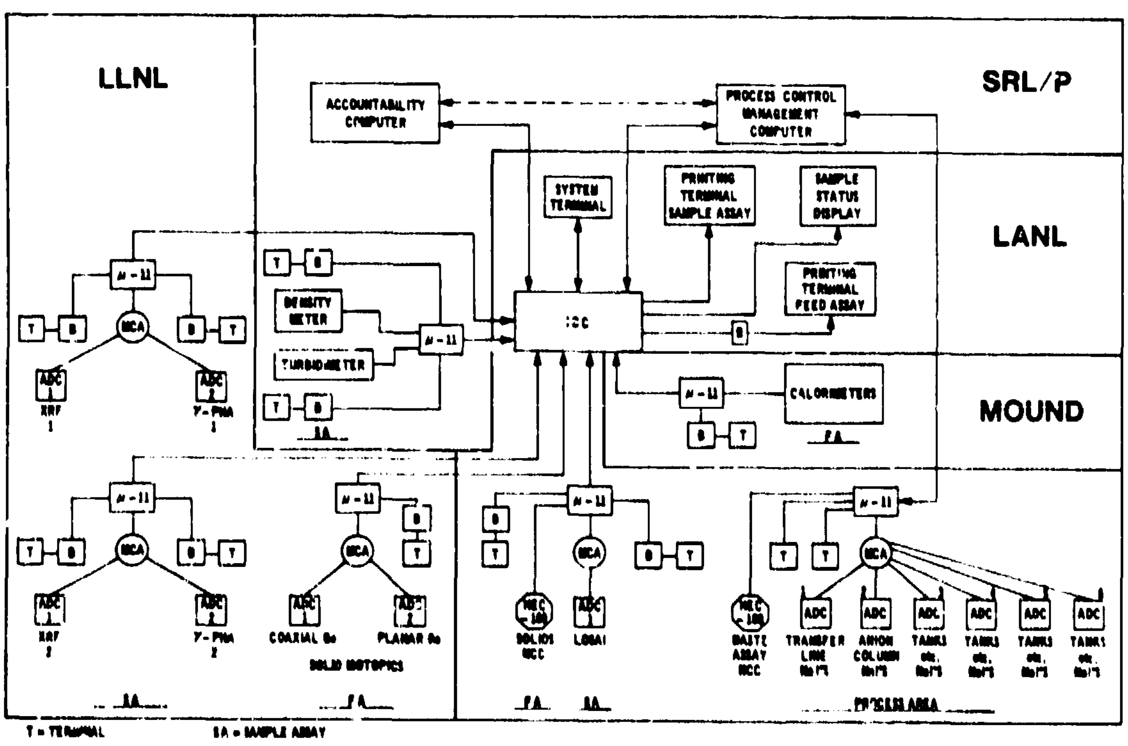

Fig. 3. Detailed design of integrated NDA system for new plutonium scrap recovery facility.

The operator/instrument interaction standard is based on our experience with installed instruments at the Los Alamos Plutonium Facility. During the last five years, each new instrument installed has featured further refinements of the operator/instrument interaction with the goal of developing a truly user-friendly system.

Another standard design feature is the communication between individual NDA instruments and the ICC. All such communications is through serial lines using a standardized communications protocol developed for the neutron interrogator that was recently installed at the Fluorinel and Storage Facility of the Idaho Chemical Processing Plant[1]. All communications are to be initiated by the NDA instruments. Except when acknowledging receipt of information or sending requested information, the central computer is ready to receive messages. Several features are incorporated into the protocol for checking the correctness of messages. Each message contains a byte count (to check the message length) and a checksum (to check the longitudinal sum of the message characters) so that the integrity of the communication message can be verified. All information is transferred in ASCII characters so that a non-intelligent terminal can be used for debugging.

A measurement control (MC) program is also common to all instruments. A well-designed MC program is crucial for assuring the validity of the NDA assay results. The MC program for the various instruments is based on that developed for the Los Alamos Plutonium Facility[2]. This MC program has been in operation at Los Alamos for the last five years and substantial operational experience has been accumulated.

The measurement controls are divided into two levels. Level 1 MC is performed at the individual NDA instruments where a few simple statistical checks are performed. These checks include a bias check, a precision check, and a background check performed at regular intervals.

Diagnostic checks[3] are also incorporated. For gamma-ray systems, the diagnostic checks consist of a detector resolution check and zero and gain stabilizer checks. For neutron coincidence systems, the diagnostic checks would include a totals-to-accidentals test, a totals test, and a coincidence test. The diagnostics checks will be performed for every assay.

Level 2 MC is performed at the ICC level. At this level, control charts will be maintained for all the NDA systems to monitor the trends of the bias-check and precision-check data. Besides performing more extensive statistical tests, all the MC data will be archived at the ICC and can be retrieved to study individual instrument performance.

4. Individual NDA Instrument Development

The individual NDA instruments are being developed and fabricated by four instrument suppliers. The instruments, their suppliers, the nature of the NDA measurement, and the location of the instrument in the facility are given in Table I. Generally, the solids isotopic analyzer measurement will be used in conjunction with either the calorimeter measurement or the feed coincidence counter measurement to determine the total plutonium mass of input materials in the FAR. In the SAR, the integrity of samples is assured by first checking for suspended solids in the turbidimeter and then comparing the sample density, measured with the densitometer, to the measured density, obtained with differential pressure transducers, of the tank from which the sample was obtained. If these tests are successful, the plutonium concentration of the sample is then measured in either the x-ray fluorescence analyzer, the gamma PHA analyzer, or the LOSAI analyzer.

TABLE I

NDA INSTRUMENTS FOR INTEGRATED MEASUREMENT SYSTEM

Instrument	Supplier	Measurement Type	Location
Feed coincidence counter	Los Alamos	Effective ^{240}Pu mass	FAR
Calorimeter (4)[a]	Mound	Heat	FAR
Solids isotopic analyzer	LLNL	Pu isotopic fractions	FAR
Turbidimeter	SRL	Suspended solids	SAR
Densitometer	SRL	Solution density	SAR
X-ray fluorescence (2)[a]	LLNL	Pu concentration	SAR
Gamma PHA (2)[a]	LLNL	Pu concentration	SAR
LOSAI	Los Alamos	Pu concentration (Low)	SAR
Waste coincidence counter	Los Alamos	Effective ^{240}Pu mass	Process area
NaI monitor array	Los Alamos	^{239}Pu mass	Process area

[a]Number of individual measurement units.

Note that there are two x-ray fluorescence and gamma PHA measurement systems. This instrument selection provides two types of redundancy. First, in normal operation the two measurement techniques are performed on duplicate samples to provide independent plutonium concentration values for comparison purposes. Second, if either instrument type is out of service, there is a backup unit to take over the measurement function while the first instrument is repaired. These redundancy features are critical since these two measurements are part of the output accountability determinations for the facility.

The instruments located in the process area report to the process control system and have important process monitoring functions. These instruments will also provide accountability information when material balances are drawn.

5. Instrument Control Computer (ICC)

As shown in Fig. 3, the ICC has three major functions. The first of these is to serve as a focal point and communications link for all the NDA measurements in the Feed Assay and Sample Assay Rooms. The second function is to communicate with the Process Control Computer and the Nuclear Materials Accounting Computer. The final major function is to gather and archive all information necessary for providing an "audit trail" and performing the facility accountability function. The ICC also schedules the assay of samples in the SAR by means of a display screen above the glovebox and validates feed material cans as they enter and leave the FAR.

The computer selected to perform these functions is a Digital Equipment Corporation VAX 11/750 with an RA81 fixed Winchester disk drive for on-line operations and an RL02 disk drive with removable disk packs for archiving data or transporting information between machines. We are using the VMS operating system and DECNET for communications with the other large computers in the network. Information is exchanged with the MICRO/PDP-11-based NDA instruments over standard serial communications lines using a standard Los Alamos-developed protocol. The ICC is installed at Los Alamos and is currently being used for software development.

We are testing the software packages that will provide the communications with the NDA instruments. The software packages for scheduling samples and communicating with the Process Control and Nuclear Materials Accounting Computers are under development. We are currently designing data bases for the ICC, which will serve the major functions of archiving all data received, establishing a record of process transactions, and providing input to the facility nuclear-material-accounting function

6. System Integration and Future Plans

Following acceptance testing of the individual instruments in June 1985, all NDA instruments will be shipped to Los Alamos and assembled for acceptance testing of the integrated system. The primary purpose of the latter test, currently scheduled for January 1986, is to assure the performance of the NDA instrument/ICC communications and the ICC software.

The 100-h acceptance test of the integrated system will be followed by an extensive training program provided by Los Alamos and the other contractors for facility personnel. The purpose of this training is to provide the instrument developers with the opportunity to instruct facility operations and maintenance personnel in the principles and use of the equipment that comprises the integrated NDA system.

At the completion of the training sessions, all equipment will remain in Los Alamos until the facility construction schedule will permit delivery of the integrated system to the construction site. At that time, Los Alamos and the other contractors will assist facility personnel in installing the integrated system. Following the installation and consistent with the facility start-up schedule, Los Alamos will assist in performing the initial calibration and check-out of all NDA instrumentation. When the facility achieves full operating capacity, an extensive evaluation of integrated system performance will be conducted. The evaluation will include careful NDA/analytical chemistry comparisons of random samples and complete statistical analyses.

Implementing this integrated system in a process environment represents a major step in realizing the full capabilities of modern NDA instrumentation. We anticipate that the successful operation of this multilaboratory, integrated NDA system will point the way to future innovations in the design of nuclear materials accounting systems.

7. References

1. G. W. Eccleston, S. S. Johnson, H. O. Menlove, T. Van Lyssel, D. Black, B. Carlson, L. Decker, M. W. Echo, "FAST Facility Spent-Fuel and Waste Assay Instrument," American Nuclear Society, Conference on Safeguards Technology: The Process-Safeguards Interface, Hilton Head Island, South Carolina, November 28-December 2, 1983. (Full paper LA-UR-83-3382).

2. W. R. Severe, C. C. Thomas, Jr., "Measurement Control Program for In-Line NDA Instruments," 20th Annual Meeting of the Institute of Nuclear Material Management, Albuquerque, New Mexico, July 16-18, 1979; Nuclear Materials Management VIII, 620-633 (1979).

3. S. -T. Hsue, T. Marks, "Measurement Control Program for NDA Instruments," American Nuclear Society, Conference on Safeguards Technology: The Process-Safeguards Interface, Hilton Head Island, South Carolina, November 28-December 2, 1983. (Full paper LA-UR-83-3253).