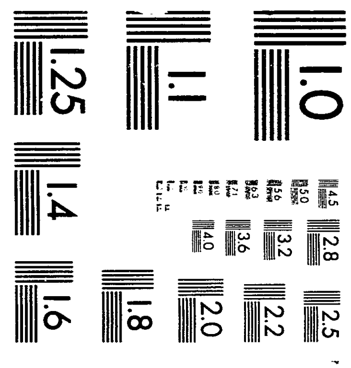

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UCRL-JC-112769
PREPRINT

The Lawrence Livermore National Laboratory Intelligent Actinide Analysis System

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This paper was prepared for submittal to the
34th Annual Meeting Institute of Nuclear Materials Management
Scottscale, Arizona
July 18-21, 1993

July 1993

Lawrence Livermore National Laboratory

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The Lawrence Livermore National Laboratory Intelligent Actinide Analysis System *

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Abstract

We have developed an Intelligent Actinide Analysis System (IAAS) for Materials Management to use in the Plutonium Facility at the Lawrence Livermore National Laboratory. The IAAS will measure isotopic ratios for plutonium and other actinides non-destructively by high-resolution gamma-ray spectrometry. This system will measure samples in a variety of matrices and containers. It will provide automated control of many aspects of the instrument that previously required manual intervention and/or control. The IAAS is a second-generation instrument, based on our experience in fielding gamma isotopic systems, that is intended to advance non-destructive actinide analysis for nuclear safeguards in performance, automation, ease of use, adaptability, systems integration and extensibility to robotics. It uses a client-server distributed monitoring and control architecture. The IAAS uses MGA3 as the isotopic analysis code. The design of the IAAS reduces the need for operator intervention, operator training, and operator exposure.

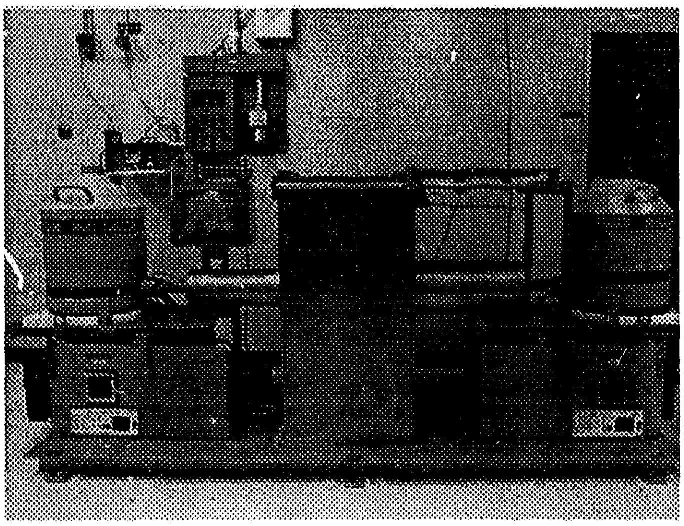

Figure 1. Intelligent Actinide Analysis System

Introduction

The IAAS, as shown in Figure 1., is a two-detector HPGe gamma-ray spectrometer system based on a network of PCs, Unix workstations, and X-terminals. The overall system is controlled by a Sun SPARCstation IPX computer system. This system provides executive control, data analysis, data management, and acts as the file server for the

* This work performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under Contract W-7405-Eng-48 and supported, in part, by the U.S. Department of Energy Office of Safeguards and Security.

other computers. The other computers are IBM-PC compatible 386 computers which are embedded in the instrument and controlled over a network.

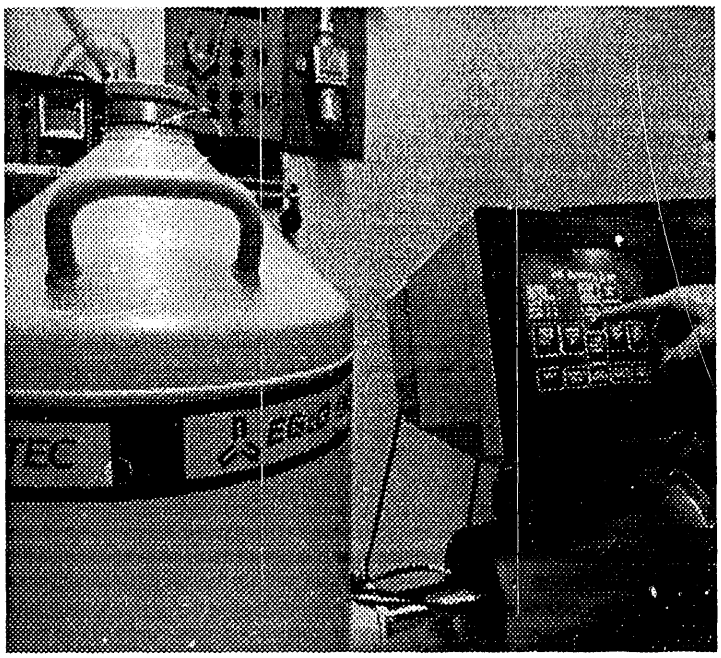

Figure 2. IAAS Local Operator Interface

One of the PCs serves as the data acquisition subsystem, controlling two Ortec 92X Spectrum Master integrated spectroscopy systems. The other serves as the instrument monitoring and control subsystem, controlling motors and a touch screen, and processing switch and other sensor inputs.

Design Goals

We had a set of several design goals for this instrument. We wanted to improve acquisition and analysis quality assurance. We wanted an instrument with high reliability. We wished to reduce the necessity of operator interactions with the instrument. We wanted to minimize sample setup, acquisition time and radiation exposure to operators so that sample turnaround and ALARA are improved. We wanted the design to be extensible to *hands-off* facilities. We wanted to allow remote monitoring and control of the instrument. This would be a requirement for *vaulted* systems and would allow for more flexible load management. We also wanted to allow for remote over-the-network software maintenance and installation.

Reduce Operator Interactions

The IAAS is designed to be self-calibrating. The first system has software assisted adjustment of amplifier gain and zero. Extensions or new instruments can have software controlled amplifier gain and zero to fully implement self-calibration. The IAAS is also designed to be self-adjusting. It currently has software assisted absorber selection. Again, this feature could be fully automated in an upgrade or future instrument. It also has automated sample-detector geometry where detector are positioned for optimum count rate under software control. The detector bias is under computer control. The IAAS performs a software pre-check to determine optimum measurement conditions and count-time. The system can also automatically determine the optimum scan to perform on the sample. The instrument is designed to be self-checking. The software performs checks of door interlocks, sample rotation and elevator motion. The analysis software checks for consistency of results from different energy regions and warns of sample inhomogeneity.

High Reliability

There are several aspects of the IAAS that enhance reliability. Monitoring and control functions are distributed, but the instrument controllers can still function autonomously. Single point failures will not disable the entire network, although they can cause time-outs and soft-failures we do not envision single-point failures that result in loss of data. Modular hardware and software design should ease repairs and reduce time to repair. The system is implemented using a dual-network design that insulates and protects the instruments from 'traffic' and other problems on a general-use LAN, while still allowing restricted access to data and status from outside the instrument network. The system is built with an uninterruptible power supply and powerfail notification software to allow for orderly shutdown or completion of measurements. A watchdog timer facility will allow recovery from transient hardware failures and PC 'hangs.' Finally redundant workstations and controllers can be installed for soft fail-over to further improve instrument availability.

Quality Assurance Improvements

Several design features are intended to improve data acquisition and analysis quality assurance. First, the IAAS is self-diagnosing and self-correcting for certain conditions and provides an 'expert' advisor capability to the operator for remedying other situations. Also, all significant events associated with data collection and analysis are logged by the system into a comprehensive audit trail that we can also use for performance analysis and problem resolution. Finally, the system recommends to the operator and performs measurement control checks and maintains a database of analysis accuracy and precision values with respect to a set of standards.

Extensible Design

The hardware and software are extensible for implementation in upgrades, future instruments, or for *hands-off* facilities, where we can not expect regular personnel contact with instruments. The top-loading design and software for the IAAS allow for simple interfacing to robotic sample handling systems. The modular hardware and software design will ease modifications to analysis and instrument control. The IAAS, because of its networked design and software, can be simply integrated with other material control and accountability systems. It also expands to additional isotopic instruments on the network at a lower incremental cost since multiple instruments can share the Unix workstation.

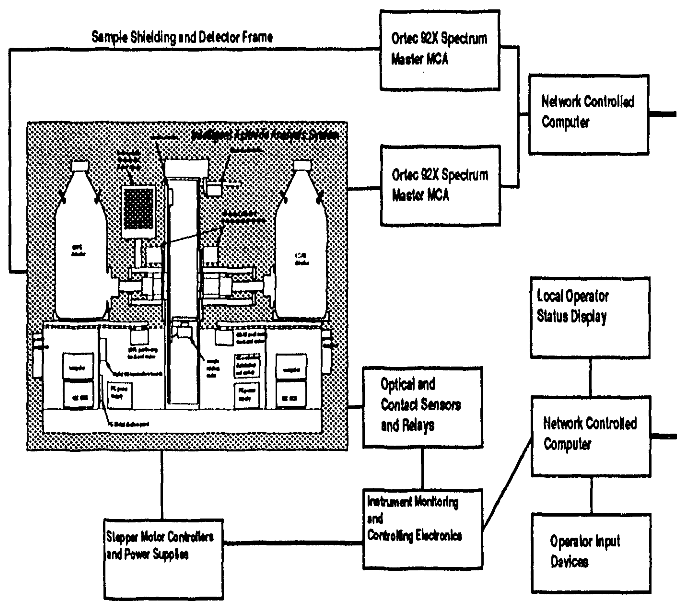

Figure 3. Instrument Network

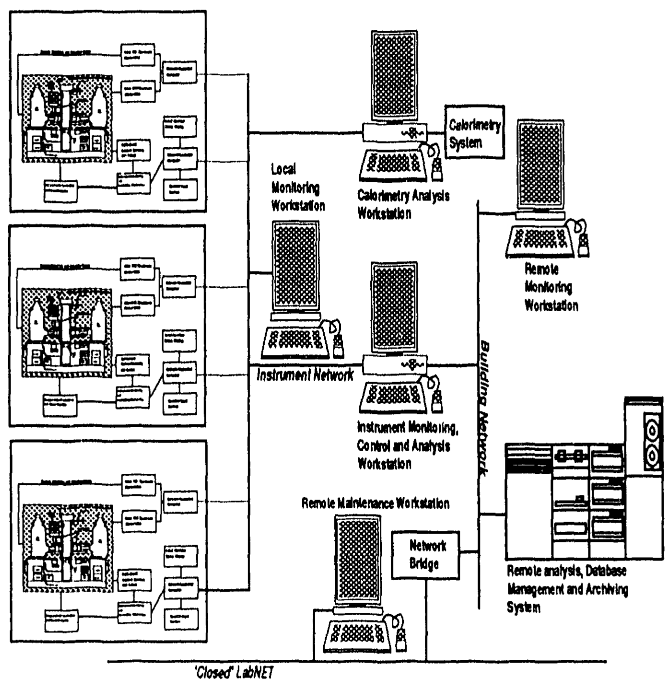

Figure 4. Network Overview

Another aspect that adds to the extensibility of the IAAS is the use of industry standards in its design and implementation. Some of the standards embraced were X for graphics, NFS for a network file system, and TCP/IP and ethernet for networking. Use of these standards simplify design, development and maintenance because of commercial support. Because standards should have a longer life than some other technologies their use enhances the scalability and flexibility of the design and provides some level of vendor independence.

Network Controlled Computer

The basis for the data acquisition and control subsystems are network controlled computers. These are essentially PC compatibles without local display, keyboard or disks, but with a network interface that allows diskless boot and redirection of keyboard and display I/O to the Unix workstation. This gives us access to the plethora of hardware adapters and software packages available to the PC. The software runs on the PCs, but the applications display on and take their input from EGA/VGA emulating windows on the Unix workstation. Interprocess and interprocessor communication is file-based on the workstation and the PCs. Very little system dependent code had to be generated for this arrangement, the shared virtual file systems provide adequate functionality and performance for this instrument. However, systems with multiple instruments may require communication through network sockets for adequate performance.

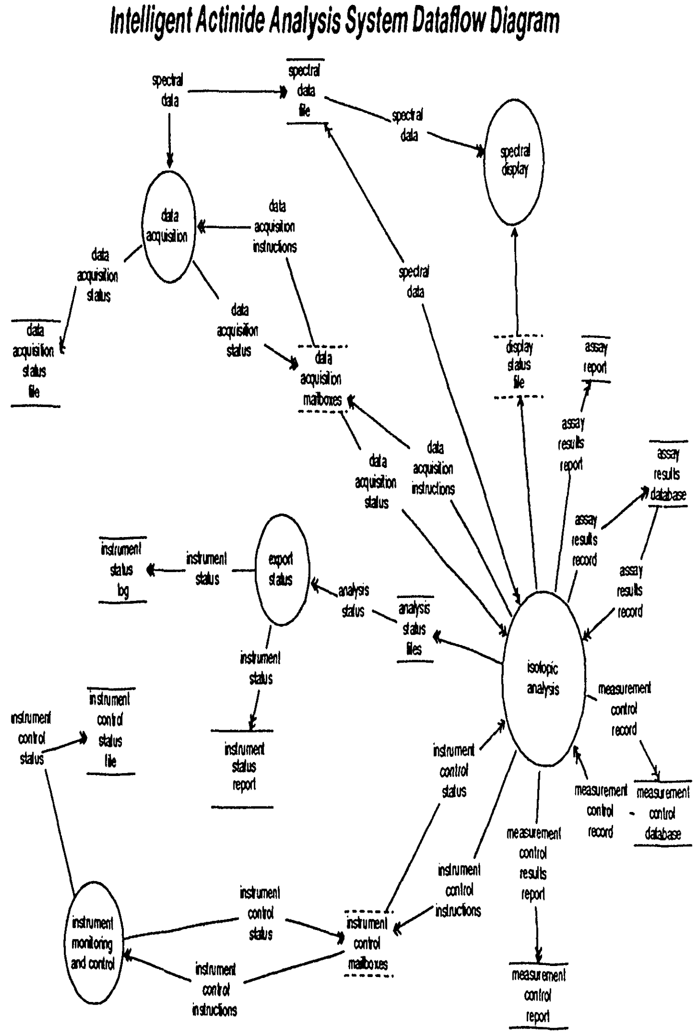

Figure 5. IAAS Dataflow Diagram

Operational Status

The IAAS is currently installed in the measurements vault of the Plutonium Facility at LLNL. We are currently concluding validation tests and training the operators so the instrument can become operational. A control chart from the testing of the IAAS is shown in Figure 6.

We hope to extend some aspects of this instrument once it becomes operational. Automating absorber selection and placement, and creating a graphical user interface (GUI) that takes full advantage of the windowing environment and is simpler for the operators to master are two examples. Fully automated calibration would also be a useful feature and one that would allow these QA tasks to be off-loaded from the operators .

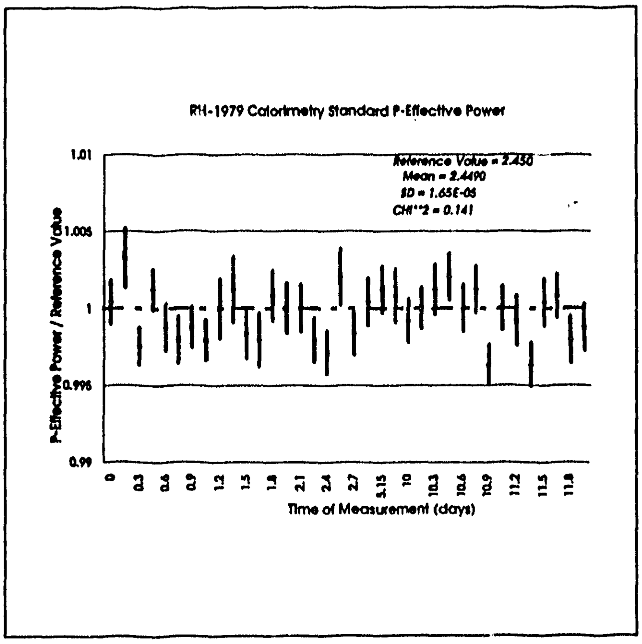

Figure 6. Control Chart from IAAS Test Runs

Summary

The design of the IAAS represents the second generation of gamma-isotopic NDA technology from the Safeguard Technology Program at LLNL. In pursuit of better meeting Complex-21 needs we are looking to further reduce operational costs and radiation exposure by using robotic sample handling, implementing further increases in automation of operator functions. We are aiming for compatibility with integrated safeguards concepts by designing systems which interface easily to other NDA and MC&A systems or can become part of a distributed MC&A database for highly automated real-time material accounting.

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