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HOLDUP MEASUREMENT SYSTEM II  
(HMSII)

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# THE HOLDUP MEASUREMENT SYSTEM II (HMSII)

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## Abstract

A project is in progress that addresses two of the problems with existing holdup measurement technology; the need for compact instrumentation and a more efficient means of reducing the massive amounts of data to quantities of Special Nuclear Materials (SNM). The approach taken by the project utilizes the Miniature Modular MultiChannel Analyzer (M<sup>3</sup>CA)[1,2], a complete and truly portable gamma-ray spectroscopy system, under development at Los Alamos National Laboratory. The hardware is then integrated and automated by the Holdup Measurement System II (HMSII) software being developed by the Oak Ridge Y-12 Plant. Together they provide the hardware components, measurement control in the field, automated data acquisition, data storage and manipulation which simplify holdup measurements.

## Introduction

In-field gamma-ray holdup measurements are generally more challenging than any measurements made in a laboratory environment. The challenge arises from the variability of environment and equipment, the measurement/data recording techniques, and knowledge of the deposit itself.

Currently, holdup measurement technology offers a choice between complex, multi-person and simple, single-user instrumentation. The complex instrumentation uses the Davidson Portable MultiChannel Analyzer (PMCA) coupled to a sodium iodide detector. The PMCA is a complete but cumbersome gamma-ray spectroscopy system, which generally requires additional personnel and/or transportation aids to hold the detector, data reduction/storage equipment, and other additional items. The single-user system uses a simplistic, single- or dual-channel unit that tends to yield a "go/no-go" or rate-meter type measurement. It suffers from temperature and gain instabilities, its detectors lack adequate shielding/collimation, and it

cannot easily measure continuum background or analyze more than one peak.

Facility operators are attracted to the simple in-field measurements that, in the long run, generate less mixed waste and minimize handling and radiation exposure. However, the growing concerns for health and safety and safeguards are dictating more precise quantitative measurements. The goal of the Los Alamos/Y-12 holdup measurement project is to provide hardware and software building blocks that a minimally trained operator can use to provide quantitative monitoring on a much more frequent basis than has been possible in the past.

## Technological Advancements

The advances in electronics are more rapid and more impressive every year. The Miniature Modular MultiChannel Analyzer (M<sup>3</sup>CA)[1,2] development at Los Alamos is benefiting from market-driven advancements and their spin-offs. Some of the specific hardware developments are smaller, faster processors and compact storage/controller units. Most of these have minimized power consumption and reduced size and weight. These readily available pieces can be interconnected with miniature, standardized interfaces. Also, the hardware availability is increasing, and unit costs are decreasing.

Bar code technology, which will play a major role in the future of holdup measurements, is being more widely used for tracking items that must be inventoried frequently. Recent developments include a hand-held bar code reader for data collection that is also a 386-based computer with full DOS 5.0 compatibility. It will allow the user to run many standard PC programs and control elaborate equipment in the field.

Software developments are also proceeding at a commensurate pace. New commercial tools, such as powerful and flexible databases, exhibit enhanced features that take advantage of the hardware improvements. Products can be used across several hardware platforms and with different operating systems. The data files of the more sophisticated software can be accessed by many different programs, thus helping to reduce transcription or translation errors.

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## Integration of User Needs and Modern Technology

The "downsizing" of the weapons complex is reducing the personnel that Facility Operators have available to perform the holdup measurements necessary to fulfill the Department of Energy's (DOE's) increasing requirements. It would be to the Operator's advantage if the previously mentioned technologies could be applied to compensate for these diminishing resources. Los Alamos and Y-12 are addressing this need by designing modules that can be interfaced to meet the measurement needs of the weapons complex. These needs range from personnel safety to criticality safety to accountability type measurements. Traditional personnel and criticality safety monitoring of holdup has been of high frequency, but low quality. Requirements for quality and quantity of accountability measurements, however, are ever-increasing, resulting in holdup measurement campaigns that are very labor intensive and time consuming. Los Alamos and Y-12 are pursuing an approach that would, after the first intensive measurement campaign, allow minimally trained operators to perform quantitative measurements during the course of their normal monitoring for safety purposes. The Holdup Measurement System II (HMSII) will play an important role in this new approach by increasing operational simplicity and by unburdening measurement personnel of the need to make most of the operating decisions. Furthermore, less equipment carried into the field reduces the potential for contamination.

As previously mentioned, software is becoming available that is independent of computer platforms and operating systems. These programs have identical user interfaces independent of the systems they run on. This philosophy should be extended to new Nondestructive Analysis (NDA) hardware as much as possible. It can be facilitated by designing simple interfaces that require compatibility with several systems. The advantages are that less training is required for new users, new modules can be used with existing equipment, and it is easier to assemble the modules into new instruments.

This modular concept is being implemented in the M<sup>3</sup>CA. A small number of hardware and software modules will form a very powerful NDA "tool kit". This kit will use simple, standardized interfaces that can couple to different controllers. The simple serial interfaces used will allow a variety of platforms to manipulate the M<sup>3</sup>CA. Each application will start with primary modules from the "tool kit", which should satisfy the applications needs of most user's. Only a small amount of simple, application-specific development will be required.

## Using the HMSII: Introduction

Holdup is residual nuclear material retained by process equipment after operation. Accumulations can be significant to criticality safety and accountability because small amounts per unit area distributed throughout large facilities generally add up to large amounts. Periodic NDA of holdup provides measured nuclear material quantities for inventory records and for criticality safety checks. Assurance of only "safe" quantities of nuclear materials in equipment avoids unnecessary and costly clean outs and minimizes radiation doses to operators.

A viable program for quantitative measurements of holdup requires thousands of gamma-ray measurements in a short time, frequently with limited access in challenging environments. The user requires equipment that is rugged, reliable, compact, lightweight and simple to use.

These holdup measurements are one potential application for the M<sup>3</sup>CA and the HMSII software. The following sections address the role of the HMSII software for holdup measurements at a typical facility.

The HMSII is built on a database management package for operating the M<sup>3</sup>CA or a Davidson/Ortec detector. The MCA is controlled via an Intermec 9440 Portable Bar Code Reader or its equivalent. The programmable 9440 controls all aspects of field data collection from the MCAs and stores the reduced spectral data transferred to it from the MCAs. Figure 1 shows the assembly of equipment (M<sup>3</sup>CA, shielded sodium iodide detector and 9440) for automated acquisition, reduction and storage of gamma-ray spectral data under the HMSII.

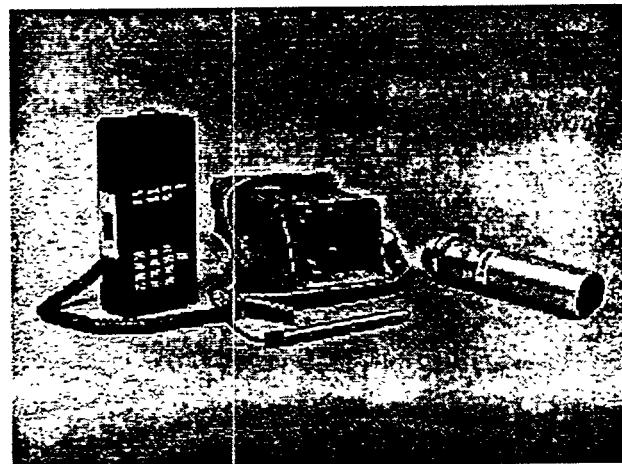


Fig. 1

The HMSII software uses formulas for measurement control, as well as physical models and analysis algorithms for quantitative gamma-ray assay of holdup. All these are based on principles presented in the U.S. Department of Energy Safeguards Technology training program, "Nondestructive Assay of Special Nuclear Materials Holdup." This NDA training program was developed at and is taught by Los Alamos National Laboratory specifically for holdup measurements.

The menu-driven software for the system is written entirely in FoxPro by Microsoft. The HMSII is designed to run on any 386 or higher PC with 640 Kb of memory. All the HMSII software is menu controlled. Each menu option executes a separate program module written for that specific task. When each option is finished, control is returned back to the Main Menu (Fig. 2).

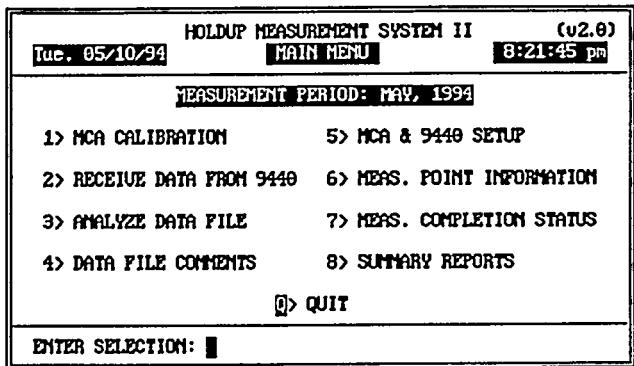


Fig. 2

#### Using the HMSII to Design A Plant-wide Holdup Measurement Plan

The design of a holdup measurement plan still requires personnel with NDA training, extensive holdup measurement experience, and knowledge of facility operations. These personnel must first determine the optimum settings and operating parameters, set up regions of interest (ROIs) and perform calibrations for assay of holdup in generalized deposit geometries, as described in the "Non-Destructive Assay of Special Nuclear Materials Holdup" course manual. These calibrations require long count times in locations with controlled or limited background radiation. Electronics set up under the HMSII use a PC that is serially interfaced to the M<sup>3</sup>CA. The operating parameters for the detector/MCA pair are entered into the HMSII using Menu Option 5 (Fig. 2). These data provide consistent setup of the gamma-ray spectroscopy equipment each time measurements are to be performed. The HMSII, with the PC, also automates the analysis of the calibration data. The calibration is carried out with the aid of MCA emulator software

that displays the gamma-ray spectrum. The calibration data, entered into the HMSII using Menu Option 1 (Fig. 2), documents the unique response of a detector/MCA pair to well characterized quantities of SNM. The horizontal arrow at the bottom of the Figure 3 block diagram illustrates the setup and calibration using the PC. A subset of the HMSII parameters for setup and calibration are transferred to the bar code reader/controller for use in the field to assure quality of the measurements. The diagonal line at the right side of the Fig. 3 block diagram illustrates the transfer of parameters to the bar-code reader/controller.

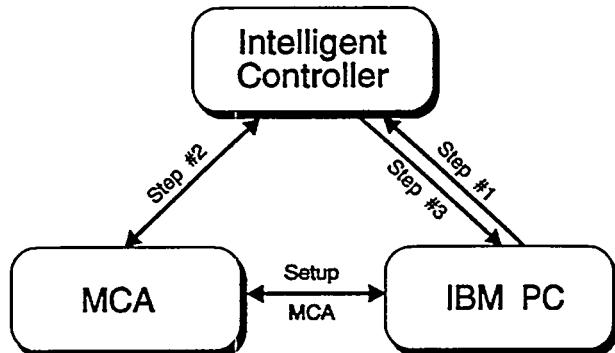


Fig. 3

Upon completion of these steps, the NDA experts would go through part of a facility to establish the quantity of SNM holdup in the system at that moment in time. A second purpose is to identify suitable locations for measurements to be performed on a regular basis. These routine measurements would determine significant changes in the distribution and quantity of holdup that would require adjustments to the SNM holdup inventory. Special care is taken to shield from and correct for background for these initial measurements. Each measurement location must be characterized as to whether the deposit is a point, line, or area source (as defined in the "Non-Destructive Assay of Special Nuclear Materials Holdup" course). The NDA experts must also determine the appropriate correction factors for each location to account for the attenuation of the intervening material(s) and the SNM itself. Information about each location is then entered into the HMSII PC data base using Menu Option 6 (Fig. 2).

The locations chosen for regular monitoring are selected with two criteria in mind, they must be characteristic of the equipment they are to represent and distinguishable from background. This can be accomplished by careful selection of the locations and/or by specifying the angle and distance at which the measurements are made.

Each measurement location will have a seven digit bar-code label affixed to it, providing a unique

identifier for each measurement. The first two digits are used to designate a building, wing or floor. The third and fourth digits signify a specific equipment system (exhaust duct, coolant system, vacuum line, etc.). The remaining three digits are used as an identifier for the specific measurement location on each system. After the completion of the first phase, the NDA experts will quantify the existing SNM holdup in the system(s), and select an essential set of measurement locations for routine assay.

Routine plantwide assay of holdup can be subsequently turned over to personnel with only rudimentary training in NDA. The measurement personnel carry only the bar-code reader/data logger, the MCA and the detector into the operating area. Any routine holdup measurements would proceed as follows:

- 1.) Under the supervision of the NDA expert, the PC is used, and first serially connected to the bar code reader to load the HMSII software (necessary for field holdup data collection and MCA control), into the bar code reader [Menu Option 5/4]. Secondly, the PC loads the operating parameters to the bar-code reader for an MCA/detector pair [Menu Option 5/1]. Finally, the PC is connected to the MCA to set the operating parameters (High Voltage, Gain, LLD, ULD, etc...) for the specific MCA/detector pair being used [Menu Option 5/2]. Following these rapid operations, the serial link between the bar code reader and MCA is made and measurement personnel are ready to obtain holdup data in the plant.
- 2.) The measurement personnel perform the holdup measurements. They need merely to wand the bar-code, press "enter" to begin spectrum acquisition, and hold the detector in proper relation to each measurement location. The quality of the spectral data obtained from these measurements is checked automatically. The HMSII provides this function through the use of repeated measurements of a check standard and by monitoring the centroid and count rate of a reference peak resulting from a source on the face of the detector. The user performs holdup measurements at bar-coded locations until time or the memory allocated for storage of data has been exhausted.
- 3.) The user returns the bar code reader/data logger to the NDA expert who serially transfers the data (typically several hundred measurements) to the PC. Following data transfer, the serial link between the M<sup>3</sup>CA and the bar code reader is reestablished, and the user resumes measurements until all locations have been measured.

A single user might perform as many as 1000 holdup measurements in an 8-hour shift. Step 3 also archives measurement data from several users. The HMSII software uses a data base that is easily customized for each facility. The data base links the reduced measurement data with physical and mechanical details associated with each individual measurement location in the process. These details are those entered in Option 6 (eg., geometry, attenuation effects, etc.). It then links with the appropriate setup and calibration data and calculates the individual holdup assay results and uncertainties. The HMSII then combines contiguous quantitative results appropriately to give the holdup quantity and its uncertainty for each piece of equipment, process line, or even an area.

#### Measurement Results

In June of 1992, preliminary testing of the HMSII was carried out at a Los Alamos training facility. Six simulated holdup deposits within equipment were configured with two dozen designated measurement locations indicated by bar code labels affixed to the equipment. Two of the authors measured all 24 locations repeatedly. Seven other participants each measured the 24 locations once. All measurements are shown in Figure 4.

In April of 1993, Enriched Uranium Operations (EUO) at Y-12 began the removal of some old process ductwork. Several NDA practitioners were called in to quantify the <sup>235</sup>U contained within the ducts, necessitated by Criticality Safety and Nuclear Material Control and Accountability (NMC&A) requirements. Criticality Safety required assurance that the ducts presented no credible criticality concerns during removal and decontamination.

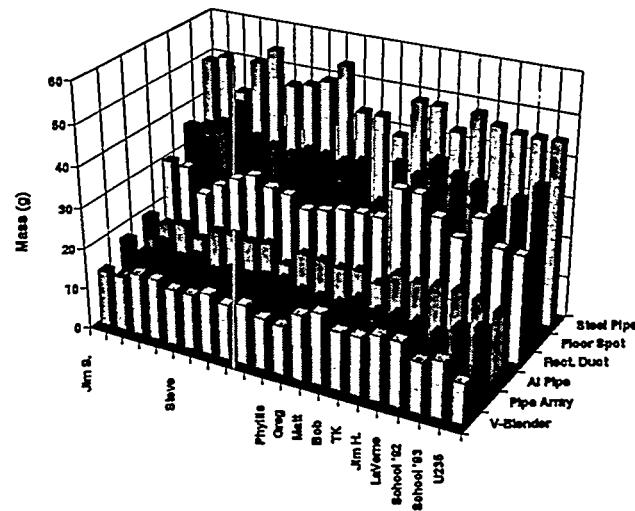


Fig. 4

Thus, the ductwork had to be measured before removal. Because some of the material could not be removed by the decontamination process, the ducts required remeasurement after cleaning to provide proper accounting of the appropriate area's inventory.

The ducts ranged from 20 inches to 42 inches in diameter and were typically 8 feet in length. The sections were constructed of either stainless steel or carbon steel with a rubberized coating. The sizes of the ducts, low quantities of SNM, spacing problems, and background concerns required some specialized algorithms for each series of measurements. These factors prevented the use of the automatic calculation function of the HMSII, although it could have been used on subsequent measurements if necessary. The HMSII provided continuous quality assurance for all of the data collected, supplied the associated setup and calibration, and automatically formatted for import to a spreadsheet for manipulation and calculation. With 25 construction personnel "in-waiting" until values were delivered, the NDA practitioners were able to provide almost-on-demand holdup measurements and calculations. Several sections of duct were selected for recovery versus holdup prediction comparison. The amount of  $^{235}\text{U}$  that was determined from the portable holdup measurements and the values actually recovered agreed to within 18 percent.

#### Summary

The goal of the holdup measurement improvement project is to provide MCA hardware and software building blocks for technical users to solve a variety of problems with the help of non-technical personnel. The HMSII software and the M<sup>3</sup>CA are the integration of all the elements of holdup measurements. From hardware setup and calibration to measurement control and data collection, the analysis and archival of an almost infinite number of holdup measurement points is easier for the user. Together they provide a complete holdup measurement data "management" system to meet changing requirements.

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