INEL-96/00188

CONF-960804--54

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AUG 2 2 1996

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PACKAGED LOW-LEVEL WASTE VERIFICATION SYSTEM

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ABSTRACT

Currently, states and low-level radioactive waste (LLW) disposal site operators have no method of independently verifying the radionuclide content of packaged LLW that arrive at disposal sites for disposal. At this time, disposal sites rely on LLW generator shipping manifests and accompanying records to insure that LLW received meets the waste acceptance criteria. An independent verification system would provide a method of checking generator LLW characterization methods and help ensure that LLW disposed of at disposal facilities meets requirements. The Mobile Low-Level Waste Verification System (MLLWVS) provides the equipment, software, and methods to enable the independent verification of LLW shipping records to insure that disposal site waste acceptance criteria are being met.

The MLLWVS system was developed under a cost share subcontract between WMG Inc., and Lockheed Martin Idaho Technologies through the Department of Energy's National Low-Level Waste Management Program at the Idaho National Engineering Laboratory (INEL).

INTRODUCTION

The Low-Level Radioactive Waste Policy Amendments Act of 1985 gives individual states the responsibility to provide for the disposal of commercial LLW generated within their boundaries. The Act also allows the states to enter into regional compact agreements, and cooperatively develop new LLW disposal facilities. New LLW disposal facilities will accept packaged wastes from a wide range of generators. These wastes will vary in physical form, package type, and radionuclide content. It has been determined that an independent verification of the packaged waste radionuclide content at LLW disposal facilities would be useful. Verification methods should be non-destructive in nature, economical in use, and reflect the methods employed by generators to characterize a container prior to shipment.

There are several methods that, when used collectively, can provide a relatively high degree of confidence in the determination of LLW container content. Methods currently in use include the direct sample method, and dose-to-curie conversion. The direct sample method is usually applied to process wastes such as bead resins and filter sludges. The method involves sampling a batch or loaded container, radionuclide analysis of the sample using gamma spectroscopy, and the application of scaling factors to the gamma spectral data to determine the hard-to-detect nuclide content for waste classification. The dose-to-curie conversion method is usually applied to dry activated wastes and cartridge filters and is also used for process wastes. The process involves the use of container-specific gamma radiation measurements, estimation of the gamma radionuclide content using a dose-to-curie conversion model, and application of scaling factors to estimate hard-to-detect radionuclide content.

Using these methods, the generator is estimating the gamma emitter content and then applying scaling factors to these estimates for key gamma emitters, such as Co-60, to estimate the hard-to-detect radionuclide content.

DISCLAIMER

The MLLWVS acknowledges current practices in its approach to verifying the contents of packaged LLW. The MLLWVS directly measures gamma emitter distribution and then employs dose-to-curie conversion methods to estimate gamma emitter content. A comprehensive scaling factor database is then used to estimate the hard-to-detect radionuclide content.

SYSTEM DESCRIPTION

The MLLWVS is capable of independently verifying the radionuclide content of packaged LLW. This system could be employed at LLW generator or disposal sites as an independent verification of container content. It could be configured as a mobile or a fixed unit. As a mobile unit, a company could contract services to waste generators and/or disposal sites to characterize LLW packages that are ready for shipment or receipt at a disposal facility. Additionally, this system could be installed by waste generators as a permanent system to aid in waste characterization. The MLLWVS can assay various types and sizes of containers such as drums, boxes, liners, and HICs, that can fit within the AP-300 cask. See Figure 1 for a sketch of the trailer-mounted system.

The system is controlled by the MLLWVS software program. The program provides for control of the gamma spectrometer positioning table and shield plug retrieval device as well as waste characterization and generation of verification reports. The program was developed in Windows™ NT and utilizes WMG's RADMAN™ waste characterization and classification modules. The RADMAN™ routines, access a radionuclide library compiled from the RSIC DLC-80 DRALIST data set which includes data for 496 radionuclides. Dose-to-curie conversion factors, used to estimate gamma emitter activity, are calculated using the MegaShield™ point kernel shielding code. WMG's MegaShield™ point kernel code incorporates point kernel shielding techniques and geometric progression buildup factors from ANSI/ANS 6.4.3 to estimate gamma emitter activity based on the measured dose rate. Hard to detect radionuclide content is estimated using Co-60-based scaling factors. The scaling factor database was compiled from 1,421 independent laboratory sample analysis results from 41 commercial nuclear power stations for 15 waste streams.

The MLLWVS consists of a trailer-mounted AP-300 lead-shielded shipping cask, liner turntable, ultrasonic sensors, GM tube radiation measurement system, gamma spectral system, and associated hardware and software. The system is mounted on a 40 foot long by 8 foot wide trailer. Five 1 ½-inch diameter holes were drilled through the cask wall to allow the gamma spectral system to make measurements on LLW packages within the cask. The holes are 10-inches apart on the same vertical axis. Removable shield plugs are provided for these holes. Additional holes have been drilled at the cask bottom to accommodate the turntable, G-M tube, and ultrasonic sensor cables.

A turntable inside the cask rotates the waste containers while measurements are taken. The turntable is approximately 6 feet in diameter and 9 inches high, and is capable of rotating waste containers weighing up to 12,000 pounds, at a speed of 1 rpm. Speed of rotation is adjusted by a variable speed controller.

Two ultrasonic sensors are mounted on the cask interior, with one at 90 degrees from the other aimed at the center of the cask. These sensors determine the distance from the radiation detectors, to the package being surveyed. Signals from the ultrasonic sensors are also used to ensure that the container is centered on the turntable relative to the measurement locations. These features allow a reproducible fixed geometry for all standard waste containers.

G-M SYSTEM

The G-M tube measurement system consists of three Eberline Model SRM-300 Smart Radiation Monitors with Eberline HP-310 Energy Compensated G-M detector probes. The SRM-300 is connected to a computer for data acquisition and analysis. The radiation measurements can be viewed on the display contained in the SRM-300, or on the computer data acquisition screen. Multiple readings are taken at each location and stored in the computer for further analysis. The HP-310 probes are capable of performing radiation measurements in the range of 10 mR/hr to 500 R/hr. The probes are located at varying axial locations within the cask and can be manually moved prior to making measurements. This allows the probes to be placed in the best locations possible for each container.

GAMMA-RAY SPECTROMETER

The gamma-spectrometer consists of a Canberra intrinsic germanium (Ge) 10% detector and an "Inspector" multi-channel analyzer. The Inspector permits the collection of 8192 channel pulse-height spectra with a maximum of 32 bits/channel. The Inspector contains a detector amplifier, an Analog-to-Digital Converter, a high voltage power supply, and an INEL-developed pulser interface. The pulser interface is used by the gamma-ray analysis software to:

1. Establish a spectrum specific energy scale

2. Correct a spectrum for pulse pile-up

3. Verification of correct spectrometer operation during the period of data collection.

The Inspector communicates with a personal computer (PC) via the serial interface port. The pulse height spectrum is collected in the Inspector and transferred to the PC where a specialized version of a general gamma-ray spectral analysis software package for personal computers (PCGAP)[1] is used to analyze the spectrum. PCGAP was developed at the INEL and is a derivative of a software package which was developed for VAX computers. A detailed description of the mathematical model and algorithms employed are given elsewhere.[2] Basically, non-linear least-squares fitting of photo-peaks to a gaussian function are employed to determine photo-peak areas. The software is designed to operate under the Windows™NT operating system and is written in two computer languages, C and FORTRAN. For the most part, spectral analysis functions are programmed in FORTRAN with the operator interface routines and spectrometer control functions programmed in C. Visual C++ is used to compile C-code and Power-FORTRAN for the FORTRAN code. Most of the spectral display and spectrometer control functions are programmed using a MOTIF X window system from Hummingbird Communications, LTD.

The Ge detector assembly has its own tungsten shield and collimator to reduce background radiation and focus the detector on the waste container within the cask. The collimator has two different apertures for making measurements. The higher the radiation field associated with the waste container, the smaller the aperture used.

The Ge detector assembly is mounted on a lifting and positioning platform and support structure attached to the cask exterior (Figure 2). The platform moves the detector vertically and horizontally along the cask surface stopping at each pre-drilled hole for a measurement. The detector positioning platform has an actuator for removing and replacing shield plugs. It positions the detector and its associated shield and collimator at a fixed distance from cask penetrations and retracts to allow the removal and replacement of shield plugs.

The trailer has a control panel mounted on the rear. This panel houses the computer, printer, and data acquisition electronics for the gamma spectral and G-M measurement systems. The computer controls system movements, system data acquisition, data analysis, data storage, system control and quality assurance functions.

MLLWVS SYSTEM OPERATION

Once the mobile system arrives at the site, the positioning system and gamma spectrometer will be calibrated. The manifested data for the package to be verified will be input by the system operator prior to loading the package in the cask to minimize personnel exposure. This data could be scanned or transferred by file. The required input parameters consist of: the physical characteristics of the package (read from a container database), manifested activities by radionuclide, waste weight and volume, and the manifest NRC and DOT classification status.

Crane support is required to remove the cask lid, which weighs approximately 8,000 lb., and to load the waste package into the cask. Feedback from the ultrasonic sensors can then be used to ensure that the waste package is centered on the turntable. The ultrasonic sensors will be particularly useful when loading relatively small diameter packages such as 55-gallon drums.

After the package has been loaded and the cask lid is replaced, load cells in the turntable are used to measure the package gross weight. The gross weight is used in conjunction with the container empty weight to determine the waste weight. At this point the liner turntable is activated and the package is rotated at a constant rate of 1 rpm. The ultrasonic sensors can then be used to determine accurate distances from the source to the G-M detectors and then the package radiation survey results are recorded for one complete revolution. This provides a 360 degree view of the package radiation levels at three axial heights, to account for a potentially non-homogeneous source distribution. The radiation survey results are integrated over the count time to obtain average dose rates at each axial height and are stored for later use.

The gamma spectral results from the INEL gamma spectrometer are obtained after the liner survey is completed. The radiation levels dictate which aperture is used with the gamma spectrometer. The positioning system removes the shield plug from the first hole and positions the gamma spectrometer and collimator within 3/4-inch of the cask wall. Data acquisition can take up to 30 minutes (depending on source strength) at each of the five axial positions to obtain a 360 degree view of the package which is rotating at 1 rpm. When data acquisition is completed at the first location, the gamma spectrometer is withdrawn, the shield plug is replaced, and the positioning system moves to the next location to remove the shield plug. Once the sequence is completed for each of the applicable axial locations, the PCGAP software returns the normalized results for the gamma emitters detected. The package is now ready for characterization.

The gamma spectrometer results are used as inputs to the MegaShield™ point kernel code, along with the package and waste specific parameters and the dose-to-curie conversion factor is calculated for each of the G-M detector locations. The G-M survey results are then used in conjunction with the dose-to-curie conversion factors to estimate the activities of the gamma emitting nuclides detected. Hard-to-detect nuclides are scaled off the measured Co-60 activity based on the geometric averaged scaling factors in the database.

The estimated activities, by radionuclide, are used to classify the waste container based on NRC, DOT or disposal site criteria and a package characterization record is generated. The estimated package characteristics can then be compared to the manifested activities and classification results to verify the packaged waste contents. A verification report is then generated for output.

SYSTEM APPLICATIONS

The MLLWVS is designed for operation at commercial LLW disposal sites. It enables the site operator to verify that waste received for disposal meets applicable site waste acceptance criteria. The system can also be used for state verification and oversight of disposal site operations. The software is structured to be easily updated to incorporate site or state specific criteria. Fixed systems could be installed at nuclear utilities or DOE sites to provide automated waste characterization with a site specific scaling factor database.

ALARA CONSIDERATIONS

The MLLWVS is designed to handle waste packages with dose rates of 10 mR/hr to 100 R/hr. The maximum expected dose rate to an operator at the control panel is < 0.1 mR/hr. The system is designed to operate independently once the initial parameters are entered into the control system, allowing the operator to step away from the MLLWVS which thereby reduces radiation exposure to the operator.

SYSTEM REQUIREMENTS

The system operates on 112 VAC and draws approximately 20 amps. Overhead crane support is needed for lifting the lid and for inserting and retrieving waste packages. In addition, health physics support is needed for performing radiation and contamination surveys and for determining proper radiological postings.

ACKNOWLEDGMENTS

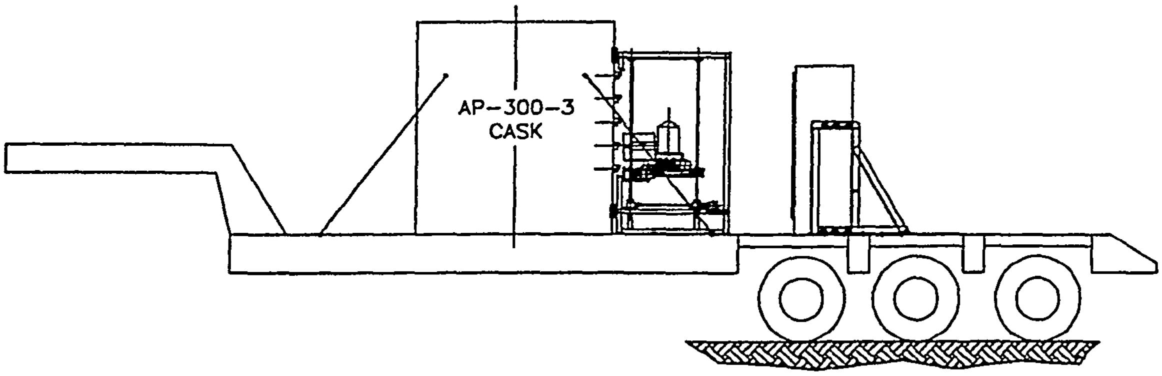
This project was undertaken as a cost-share agreement between the National Low-Level Waste Management Program at Lockheed Martin Idaho Technologies and WMG, Inc. The original project manager for this program, Mr. Michael R. Winberg of Lockheed Martin Idaho Technologies, passed away in October 1995, prior to the completion of the project, and this paper. Without Mr. Winberg's leadership, enthusiasm, and talents this project might not have become a reality.

REFERENCES

1. © Copyright 1995 ALL rights reserved

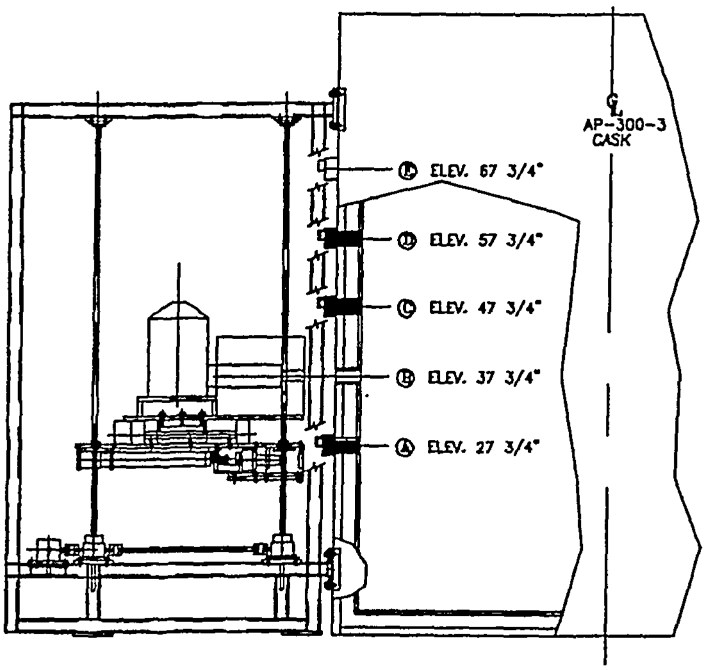
2. E. Wayne Killian, Jack K. Hartwell, "VAXGAP: a code for the Routine Analysis of Gamma-Ray Pulse-Height Spectra on a VAX Computer," INEL Formal Report EGG-2533, May 1988.

Figure 1



Trailer-Mounted MLLWVS

Figure 2



Gamma Spectrometer System