MOBILE NONDESTRUCTIVE ASSAY AND EXAMINATION INSTRUMENTS

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ABSTRACT

A compact system that evaluates radioactive materials can furnish a big savings to taxpayers by ensuring that only properly identified nuclear waste is sent to a Department of Energy (DOE) radioactive waste storage area. The Los Alamos National Laboratory's Advanced Nuclear Technology Group has developed and field tested two easily transportable, self-contained modules: one x-rays the contents of special 208-ℓ shipment containers, the other assays the contents. The assay and evaluation system is a simple, portable solution to a complex problem that ensures that only properly packaged transuranic (TRU) waste is shipped to the Department of Energy's Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico. Caustic chemicals, liquids, and other objects or materials that could cause a container leak during shipment are the objects of an x-ray and video camera used in the system. The camera inspects the contents of 208-ℓ drums that are brought into the system on a conveyor and rotated, one at a time, in front of the x-ray source. Free liquids can be detected by shaking the drum; the sloshing liquid is visible on the video screen.

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ABSTRACT

A compact system that evaluates radioactive materials can furnish a big savings to taxpayers by ensuring that only properly identified nuclear waste is sent to a Department of Energy (DOE) radioactive waste storage area. The Los Alamos National Laboratory's Advanced Nuclear Technology Group has developed and field tested two easily transportable, self-contained modules: one x-rays the contents of special 208-ℓ shipment containers, the other assays the contents. The assay and evaluation system is a simple, portable solution to a complex problem that ensures that only properly packaged transuranic (TRU) waste is shipped to the Department of Energy's Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico. Caustic chemicals, liquids, and other objects or materials that could cause a container leak during shipment are the objects of an x-ray and video camera used in the system. The camera inspects the contents of 208-ℓ drums that are brought into the system on a conveyor and rotated, one at a time, in front of the x-ray source. Free liquids can be detected by shaking the drum; the sloshing liquid is visible on the video screen.

After the drum is x-rayed, it is conveyed to the assay module where precision instruments measure the amounts of TRU isotopes present in the waste. If the drum contains fissile TRU isotopes above the safety limit, it is rejected and sent to an appropriate facility for repackaging; if the drum contains less than the 100 nCi/g lower-level limit for TRU, it is rejected and sent to a low-level nuclear waste burial site. Drums whose contents fall between these limits are accepted and certified for shipment to the WIPP. Made to fit on flatbed trailers, the entire system can be transported to a DOE facility and be ready for operations within 5 hours after arrival.

1. INTRODUCTION

An important part of any comprehensive radioactive waste management program is the ability to determine the types and amounts of radioactivity in wastes using nondestructive assay (NDA). Without such capability, it is impossible to direct cost-effective and timely waste management programs for waste generators and repositories, the decontamination and decommissioning of outdated nuclear facilities, and the exhumation of old radioactive waste burial grounds. If only administrative controls are used for radioactive waste sorting, many errors and a general overestimate of radioactive content often result, significantly increasing the amount of materials that must be handled as retrievable waste.

A comprehensive program is in progress at the Los Alamos National Laboratory for the development of sensitive, practical, portable, nondestructive techniques for the quantification of wastes containing transuranic elements (TRU). The program encompasses a broad range of equipment including a transportable active and passive neutron detector module and a transportable real-time radiography module for examination of 208-ℓ barrels. Similar equipment designed to handle large boxes of waste and high gamma output wastes are also under development. The two initial drum size modules have been built and field tested at Los Alamos and at the Nevada Test Site (NTS).

Through the use of these techniques and this equipment, the capability now exists to cost-effectively sort and segregate wastes by TRU content at the generator site.

II. NONDESTRUCTIVE ASSAY SYSTEM (NDA)

The NDA module consists of a combined passive/pulsed-active neutron assay system similar in design to other Los Alamos systems.[1-3] The unit provides a sequential set of assay measurements, with the active portion providing information on fissile TRU isotopes and the passive portion providing information on nonfissile TRU isotopes. The combined analysis of flux monitor (active) and differential neutron detector response (passive) provide self-consistent and comprehensive matrix corrections to both passive and active assays. An MA-165C/zetatron pulsed 14 MeV neutron generator system provides the interrogation source for the active portion of the assay. Graphite and polyethylene within the system walls rapidly moderate the original pulse of 14-MeV neutrons, resulting in a thermalized interrogation pulse. Fast-neutron detection packages detect the prompt neutrons produced by thermal fissions in the waste as a consequence of the interrogation. The measured sensitivity of the assay system is 1 mg of ^{235}U or ^{239}Pu placed anywhere within a standard 208-ℓ drum. Neutron-detection packages in the sides, top, and bottom of the assay unit assure uniform response (see Fig. 1). Additional ^{3}He counters are positioned in the walls to enhance the passive neutron response. The overall passive neutron detection efficiency is about 10%. The passive assay cycle quantities spontaneous fission (^{240}Pu) and (α,n) (^{241}Am, ^{238}Pu) events. Sensitivities for these passive measurements are about 5 mg of ^{240}Pu and 1 mCi of either ^{241}Am or ^{238}U.

III. FIELD TESTING

The NDA module has undergone field testing during the past year at Los Alamos and (NTS) without any major problems. System electric power at NTS was provided by a diesel-powered motor generator. More than 1500 actual assays have been performed with the unit. Some 4,000,000 neutron generator pulses have been fired. The only component replacements have been one computer floppy disk drive unit on the data acquisition system at Los Alamos and the high voltage transformer within the neutron generator package at NTS.

The latter problem was traced to a severe environmental heat loading at the NTS. The zetatron sealed neutron generator tube was not damaged nor were any other components. We have remedied the problem of heat load in the cavity by (a) providing a canopy to suppress solar heat loads and (b) piping refrigerated air into the assay chamber, to provide additional direct cooling for the neutron generator unit.

Drums are rotated during both active and passive assay cycles to enhance uniformity of response. The rotation assembly accommodates standard 208-ℓ drums up to 350 kg in total weight. Both internal and external surfaces of the assay unit are lined with aluminum. The front wall of the unit is a separate package that opens horizontally to provide loading access. A motorized conveyor system allows up to 30 drums to be loaded onto a stable platform from which an operator can load a drum into the assay unit. Assayed drums are placed on the exit side of the assay unit for removal by forklift. A small overhead crane mounted on the NDA module allows the operator to load and unload drums from the assay unit onto the conveyor system.

IV. CONTROL ROOM

The control room of the NDA module houses the system electronics, data acquisition, and archiving unit. The data acquisition unit is a LeCroy 3500 microcomputer with a floppy disk. We are currently setting up a systematic spreadsheet analysis for the assay system. We have developed a means of reading the LeCroy floppy disk directly into an IBM personal computer and from there into the well-known spreadsheet program, LOTUS 1,2,3.

When this process is streamlined, we will be able to conveniently manipulate the large amount of assay data being generated.

The spreadsheet columnar layout for our basic NDA data is shown in Fig. 2 and the NDA module layout itself in Fig. 3.

V. NONDESTRUCTIVE EXAMINATION SYSTEM

The nondestructive Examination (NDE) module consists of a 420-KeV x-ray machine and a 28" by 32" imaging screen with an image intensified isocon camera and video recording capability. We have also incorporated a Digital Image processor and a hard copy unit. The image processor is capable of a variety of real-time image enhancement techniques: image stretching, zoom, edge enhancement, pseudo-color overlays, and the capability of writing or drawing on the image. This drawing capability is especially beneficial in identifying liquids and foreign objects inside the 208-ℓ barrels. We have also used the image processor's drawing capability as a training aid. The capability to draw lines around suspect items in the video image enables the operator to recognize suspect items inside the containers. The hard copy unit will provide black and white pictures of any suspect items and can be used for reference. Both of these capabilities have been extremely valuable.

The NDE system pictures the contents of 208-ℓ barrels that are brought in on a conveyor and rotated, one at a time, in front of the x-ray video camera. The camera provides an x-ray image of the contents as the barrel rotates in real time by viewing electronic images on a screen that is located behind the rotating barrel. The revolving images are also preserved on a video recorder, which makes it possible to reinspect radiographs of the contents at a later time. The digital processor is also equipped with a floppy disk that can be used to record such information as date, time, barrel number, weight, and NDE specific information. The columnar format for this NDE data in the LOTUS 1,2,3 spreadsheet is shown in Fig. 4. Visual inspection of the contents allows the operator to confirm the packing configuration and identify any foreign objects inside the container. Free liquids and pressurized containers are of particular interest. If either of these is found, the barrel is noncertifiable for WIPP storage. A simple procedure makes liquids easy to identify: the operator stops and then restarts the rotator, which causes the liquid to slosh. Pressurized containers are easy to identify by their characteristic dome shapes.

One of the mechanical items incorporated into this examination room is a remotely operated drum loading and centering device. This device has saved many man hours because the operator is not required to enter the examination room and physically center each drum. This remote handling feature has also significantly improved personnel radiation safety. The module is flexible, portable, and meets all health and safety requirements. A schematic drawing of it is shown in Fig 5.

VI. NDA AND NDE MODULES

The nondestructive assay (NDA) instrument is housed inside an 8' by 8' by 20' container (steel transportainer). The assay chamber is located at one end of the module and a shielded control room at the other end. This module (see Fig. 3) is designed to be permanently mounted on a flatbed tractor for easy transport around the country.

The NDE module (see Fig. 5) is also housed in an 8' x 8' x 20' transportainer and consists of lead-lined examination and acclimatized control rooms. Barrels enter the examination room one at a time on a conveyor system and are automatically placed on a rotator between the x-ray source and the imaging system, which consists of a large fluorescent screen and a video camera. The control room houses the controls for the x-ray machine, the video monitors for viewing the barrels in real time, and the recording equipment for long-term storage of x-ray images.

The NDA and NDE modules are unique because they can be transported to any site where waste containers are located, to confirm the packaging and assay the amount of radioactive material inside the containers.

VII. FIELD TESTING

The NDE module has undergone testing at Los Alamos and at the NTS. The Los Alamos testing consisted of mechanical interlock check-out and operation of the computer system, the x-ray machine, and the image-processing equipment. The module was then transported to and set up at the NTS. Electric power for the NDE module was supplied by portable diesel-powered motor generators. A motorized conveyor system moved the 208-ℓ barrels. The average daily throughput was 50 waste barrels after warm-up of the x-ray machine and sensitivity check of camera system. Over 1500 barrels were examined from July 1985 through January 1986. Some minor malfunctions occurred during the 6 months primarily because of the extreme, hot and dusty environment.

VIII. CONCLUSIONS

The several months of realistic testing, including actual assay and radiographic measurements of 1500 waste drums, has demonstrated conclusively that both mobile NDA and NDE modules are suitable for field use. This instrumentation performed extremely well for an extended period under difficult environmental conditions at a remote site requiring portable motor-generator electric power. Performance was excellent and equipment problems were no different in either number or type from those routinely experienced with similar fixed-site NDA and NDE installations. We believe those modules will provide the DOE and its contractors with mobile NDA and NDE capabilities equal to those at any fixed site installation.

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FIGURE CAPTIONS

Fig. 1. Schematic drawing of cross section through the NDA unit showing disposition of graphite, polyethylene, ^{3}He counters and neutron generator.

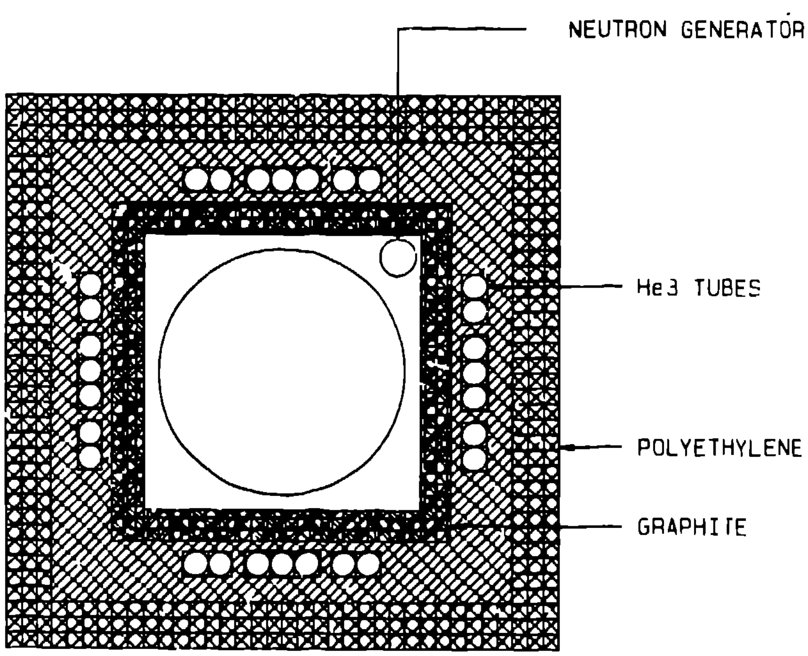
Fig. 2. Columnar layout for the basic NDA data entered into the LOTUS 1,2,3 spreadsheet. Secondary and archival data associated with each assay occupy an additional 40 columns that are not shown.

Fig. 3. Schematic drawing of the NDA housing module (8' x 8' x 20'). A drum conveyor system parallels the assay chamber door two feet in front of it and a small chain hoist mounted to the module ceiling is used to load and unload.

Fig. 4. Columnar layout for the basic NDE data entered into LOTUS 1,2,3 spreadsheet.

Fig. 5. Schematic drawing of the NDE housing module (8' x 8' x 20').

Fig 1



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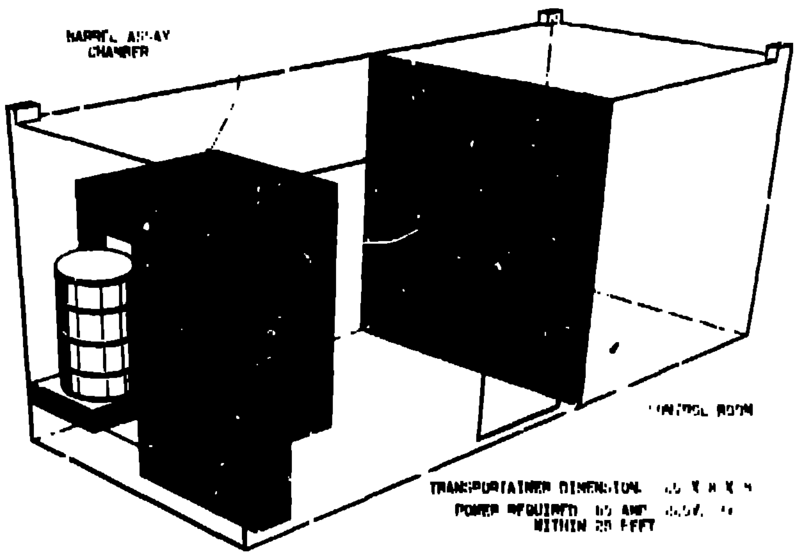

BARREL N.D.A. SYSTEM

DATE	
SITE	
FINES	
AERO	
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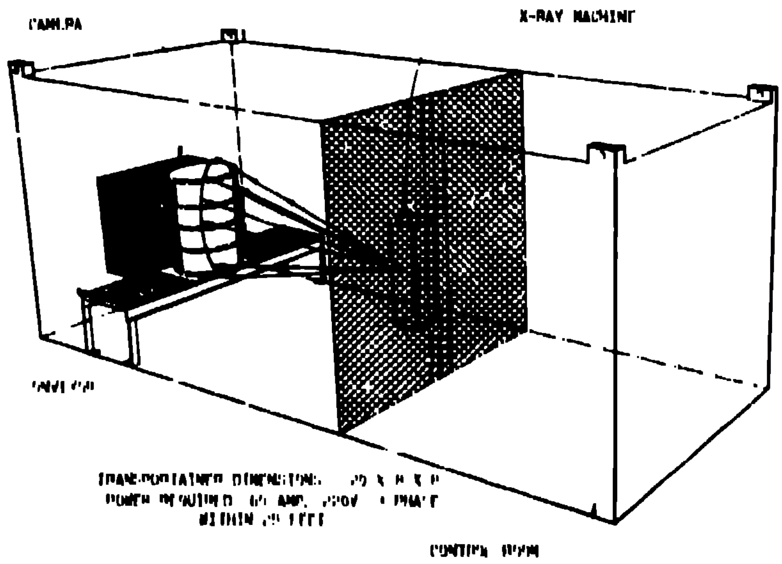
LIQ	
TRU	
CODE	
WT	
DRUM ID	



RTR TRANSPORTAINER SYSTEM